DOE/CF-0195
Volume 4

Department of Energy
FY 2024 Congressional Justification

Energy Efficiency and Renewable Energy
Electricity
Nuclear Energy
Fossil Energy and Carbon Management

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DEPARTMENT OF ENERGY
Comparative Appropriation Summary
(dollars in thousands)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 President's Budget	FY 2024 Presidents Budget vs. FY 2023 Enacted	
				$	%
Department of Energy Budget by Appropriation					
Energy Efficiency and Renewable Energy	3,200,000	3,460,000	3,826,116	+366,116	+10.58%
Electricity	277,000	350,000	297,475	-52,525	-15.01%
Cybersecurity, Energy Security and Emergency Response	185,804	200,000	245,475	+45,475	+22.74%
Strategic Petroleum Reserve	219,000	207,175	280,969	+73,794	+35.62%
Naval Petroleum and Oil Shale Reserves	13,650	13,004	13,010	+6	+0.05%
SPR Petroleum Account	7,350	-2,051,900	0	+2,051,900	+100.00%
Northeast Home Heating Oil Reserve	6,500	7,000	7,150	+150	+2.14%
Total, Petroleum Reserve Accounts	**246,500**	**-1,824,721**	**301,129**	**+2,125,850**	**+116.50%**
Total, Cybersecurity, Energy Security, and Emergency Response	**432,304**	**-1,624,721**	**546,604**	**+2,171,325**	**+133.64%**
Nuclear Energy (270) [(1), (2), (3)]	1,505,000	1,623,000	1,384,887	-238,113	-14.67%
Fossil Energy and Carbon Management	825,000	890,000	905,475	+15,475	+1.74%
Uranium Enrichment Decontamination and Decommissioning (UED&D)	860,000	879,052	857,482	-21,570	-2.45%
Defense Uranium Enrichment D&D	573,333	586,035	427,000	-159,035	-27.14%
Energy Information Administration	129,087	135,000	156,550	+21,550	+15.96%
Non-Defense Environmental Cleanup	333,863	358,583	348,700	-9,883	-2.76%
Science [(2)]	7,475,000	8,100,000	8,800,400	+700,400	+8.65%
Office of Technology Transitions	19,470	22,098	56,550	+34,452	+155.91%
Office of Clean Energy Demonstrations	20,000	89,000	215,300	+126,300	+141.91%
Federal Energy Management Program	0	0	82,200	+82,200	N/A
Grid Deployment Office	0	0	106,600	+106,600	N/A
Office of Manufacturing & Energy Supply Chains	0	0	179,490	+179,490	N/A
Office of State and Community Programs	0	0	705,000	+705,000	N/A
Advanced Research Projects Agency - Energy	450,000	470,000	650,200	+180,200	+38.34%
Nuclear Waste Fund Oversight	27,500	10,205	12,040	+1,835	+17.98%
Departmental Administration	240,000	283,000	433,475	+150,475	+53.17%
Indian Energy Policy and Programs	58,000	75,000	110,050	+35,050	+46.73%
Inspector General	78,000	86,000	165,161	+79,161	+92.05%
Title 17 Innovative Technology Loan Guarantee Program	29,000	-135,794	-126,524	+9,270	+6.83%
Advanced Technology Vehicles Manufacturing Loan Program	5,000	9,800	13,000	+3,200	+32.65%
Tribal Energy Loan Guarantee Program	2,000	4,000	6,300	+2,300	+57.50%
Total, Credit Programs	**36,000**	**-121,994**	**-107,224**	**+14,770**	**+12.11%**
Energy Projects	0	221,969	0	-221,969	-100.00%
Total, Energy Programs	**16,539,557**	**15,892,227**	**20,159,531**	**+4,267,304**	**+26.85%**
Weapons Activities	15,920,000	17,116,119	18,832,947	+1,716,828	+10.03%
Defense Nuclear Nonproliferation	2,354,000	2,490,000	2,508,959	+18,959	+0.76%
Naval Reactors [(1)]	1,918,000	2,081,445	1,964,100	-117,345	-5.64%
Federal Salaries and Expenses	464,000	475,000	538,994	+63,994	+13.47%
National Nuclear Security Administration Rescissions	-288,133	0	0	0	N/A
Total, National Nuclear Security Administration	**20,367,867**	**22,162,564**	**23,845,000**	**+1,682,436**	**+7.59%**
Defense Environmental Cleanup	6,710,000	7,025,000	7,073,587	+48,587	+0.69%
Other Defense Activities	985,000	1,035,000	1,075,197	+40,197	+3.88%
Total, Environmental and Other Defense Activities	**7,695,000**	**8,060,000**	**8,148,784**	**+88,784**	**+1.10%**
Nuclear Energy (050)	149,800	150,000	177,733	+27,733	+18.49%
Total, Atomic Energy Defense Activities	**28,212,667**	**30,372,564**	**32,171,517**	**+1,798,953**	**+5.92%**
Southeastern Power Administration	0	0	0	0	N/A
Southwestern Power Administration	10,400	10,608	11,440	+832	+7.84%
Western Area Power Administration	90,772	98,732	99,872	+1,140	+1.15%
Falcon and Amistad Operating and Maintenance Fund	228	228	228	0	0.00%
Colorado River Basins Power Marketing Fund	0	0	0	0	N/A
Total, Power Marketing Administrations	**101,400**	**109,568**	**111,540**	**+1,972**	**+1.80%**
Total, Energy and Water Development and Related Agencies	**44,853,624**	**46,374,359**	**52,442,588**	**+6,068,229**	**+13.09%**
Excess Fees and Recoveries, FERC	-9,000	-9,000	-9,000	0	0.00%
Title XVII Loan Guar. Prog Section 1703 Negative Credit Subsidy Receipt	-10,000	-14,000	-7,000	+7,000	+50.00%
UED&D Fund Offset	-573,333	-586,035	-427,000	+159,035	+27.14%
Discretionary Funding by Appropriation	**44,261,291**	**45,765,324**	**51,999,588**	**+6,234,264**	**+13.62%**

(1) Funding does not reflect the mandated transfer of $92.75 million in FY 2022 and $99.75 million in FY 2023 from Naval Reactors to the Office of Nuclear Energy for operation of the Advanced Test Reactor.

(2) Funding does not reflect the mandated transfer of $20 million from the Office of Nuclear Energy to the Office of Science for Nuclear Facilities Oak Ridge National Laboratory Operations and Maintenance.

(3) FY 2023 Enacted levels for base funding includes $300 million for the Office of Nuclear Energy that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328). This funding is a part of the total $12.5 billion governmentwide originally intended to be base appropriations that was designated as emergency requirements for purposes of the 2023 Omnibus agreement.

Energy Efficiency and Renewable Energy

Energy Efficiency and Renewable Energy

Energy Efficiency and Renewable Energy
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for energy efficiency and renewable energy activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, [$3,460,000,000]*$3,826,116,000*, to remain available until expended: Provided, That of such amount, [$223,000,000]*225,623,000* shall be available until September 30, [2024]*2025*, for program direction.

Public Law Authorizations
P.L. 93-275, "Federal Energy Administration Act" (1974)
P.L. 93-410, "Geothermal Energy Research, Development, and Demonstration Act" (1974)
P.L. 93-577, "Federal Non-Nuclear Energy Research and Development Act" (1974)
P.L. 94-163, "Energy Policy and Conservation Act" (EPCA) (1975)
P.L. 94-385, "Energy Conservation and Production Act" (ECPA) (1976)
P.L. 94-413, "Electric and Hybrid Vehicle Research, Development and Demonstration Act" (1976)
P.L. 95-91, "Department of Energy Organization Act" (1977)
PL 95-617, "Public Utility Regulatory Policies Act Of 1978" (1978)
P.L. 95-618, "Energy Tax Act" (1978)
P.L. 95-619, "National Energy Conservation Policy Act" (NECPA) (1978)
P.L. 95-620, "Power Plant and Industrial Fuel Use Act" (1978)
P.L. 95-238, Title III –"Automotive Propulsion Research and Development Act" (1978)
P.L. 96-512, "Methane Transportation Research, Development and Demonstration Act" (1980)
P.L. 96-294, "Energy Security Act" (1980)
P.L. 100-12, "National Appliance Energy Conservation Act" (1987)
P.L. 100-357, "National Appliance Energy Conservation Amendments" (1988)
P.L. 100-494, "Alternative Motor Fuels Act" (1988)
P.L. 100-615, "Federal Energy Management Improvement Act" (1988)
P.L. 101-218, "Renewable Energy and Energy Efficiency Technology Competitiveness Act" (1989)
P.L. 101-566, "Spark M. Matsunaga Hydrogen Research, Development, and Demonstration Act of 1990"
P.L. 101-575, "Solar, Wind, Waste, and Geothermal Power Production Incentives Act" (1990)
P.L. 102-486, "Energy Policy Act of 1992" (WIND)
P.L. 104-271, "Hydrogen Future Act of 1996"
P.L. 106-224, "Biomass Research and Development Act" (2000)
P.L. 109-58, "Energy Policy Act of 2005"
P.L. 110-69, "America Competes Act of 2005"
P.L. 110-140, "Energy Independence and Security Act of 2007"
P.L. 110-140, title VI, Sec. 641, "US Energy Storage and Competitiveness Act of 2007"
P.L. 110-234, "The Food, Conservation, and Energy Act of 2008"
P.L. 111-5, "American Recovery and Reinvestment Act of 2009"
P.L. 112-210, "American Energy Manufacturing Technical Corrections Act (2012)
P.L. 115-244, "Energy and Water, Legislative Branch, and Military Construction and Veterans Affairs Appropriations Act, 2019"
P.L. 115-246, "Department of Energy Research and Innovation Act" (2018)
P.L. 116-92, "National Defense Authorization Act for Fiscal Year 2020"
P.L. 116-260, "Consolidated Appropriations Act of 2020" (Section Z: Energy Act of 2020)

Energy Efficiency and Renewable Energy
($K)

FY 2022 Enacted[1]	FY 2023 Enacted[1]	FY 2024 Request	FY 2023 Request vs FY 2022 Request
3,200,000	3,460,000	3,826,116	+366,116

Overview

The Office of Energy Efficiency and Renewable Energy (EERE) is the largest investor in clean energy technology development in the Federal Government. EERE's mission is to accelerate the research, development, demonstration, and deployment (RDD&D) of technologies and solutions to equitably transition America to a carbon pollution-free electricity sector by 2035 and a net-zero emission economy by no later than 2050, creating good-paying jobs with the opportunity to join a union and bargain collectively, and ensuring the clean energy economy benefits all Americans, especially workers and communities impacted by the energy transition and those historically underserved by the energy system and overburdened by pollution.

EERE's FY 2024 investment strategy continues its focus on five programmatic priority areas[2] that are central pillars in lowering the U.S. greenhouse gas (GHG) profile:

- Decarbonizing the electricity sector: To transition to a carbon pollution-free electricity sector by 2035, EERE will support technologies that will allow the U.S. to generate all U.S. electricity from clean, renewable sources.
- Decarbonizing transportation across all modes: air, sea, rail, and road: EERE will develop, demonstrate, and deploy technologies that can cost-effectively decarbonize all modes of transportation, including electrification of on-road vehicles, sustainable aviation fuel, and hydrogen fuel cells for long-haul heavy-duty trucks.
- Decarbonizing energy-intensive industries: EERE's focus is reducing GHG emissions across the industrial sector, with an emphasis on the highest-emitting sectors (e.g., iron/steel, cement/concrete, chemicals, food production).
- Reducing the carbon footprint of buildings: EERE will use a multi-prong approach to reducing the carbon footprint of the U.S. building stock by 50 percent by 2035 while maintaining or improving affordability, comfort, and performance – first, by decarbonizing the power grid, which in turn decarbonizes the electricity that serves buildings; second, by electrifying a significant share of building end uses that currently use fossil fuels, such as space and water heating; and finally, by significantly improving the efficiency of buildings and equipment, including heating and lighting systems, as well as the building envelope.
- Decarbonizing the agriculture sector, specifically focused on the nexus between energy and water: EERE's focus is reducing GHG emissions in the agricultural sector through development of biofuels, greater efficiency of off-road agricultural vehicles, on-site production of animal waste to clean energy, and better understanding and prediction of water flow to design more water and energy efficient irrigation systems. This work will be additive and complementary to the Department of Agriculture's work.

In addition, the following four crosscutting principles, or key emphasis areas, drive EERE work:

- Building the clean energy economy in a way that benefits all Americans. The Department must address environmental injustices that disproportionately affect communities of color, low-income communities, and indigenous communities.
- Fostering a diverse STEM workforce. The Department will increase awareness of clean energy job opportunities at minority-serving institutions and ensure that organizations receiving EERE funding are thinking through diversity and equity in their own work.
- Developing more robust workforce training opportunities to build a pipeline for permanent, good-paying jobs for the clean energy workforce.
- Working closely and learning from state and local governments.

[1] Includes funding for the Office of State and Community Energy Programs (SCEP), Federal Energy Management Programs (FEMP), and the Office Manufacturing and Energy Supply Chains (MESC), appropriated to EERE but managed by the Undersecretary for Infrastructure.
[2] Please note because investments can support multiple priority areas, there is overlap among the totals.

Complementing individual program efforts, the Request includes several jointly-developed, -managed, and -funded investments designed to advance these key emphasis areas.

In FY 2024, EERE will continue partnering across the Department to provide crosscutting support for the Communities Local Energy Action Program (LEAP), an initiative designed to help low-income, energy-overburdened communities – and, in particular, communities that are experiencing direct environmental justice impacts or direct economic impacts from a shift away from historical reliance on fossil fuels – take direct control of their clean energy future.

Highlights and Major Changes in the FY 2024 Budget Request

In FY 2024, EERE will invest $3,826,116,000 to help achieve a carbon pollution-free electricity sector by 2035 and net-zero emissions, economy-wide, by no later than 2050 through investments in the five programmatic priority areas described above, and through the lens of its four key emphasis areas. The Request prioritizes increased investments to reduce emissions drastically in the near term, while investing in research to ensure American leadership and competitiveness in advanced clean energy technology. Through its Corporate Support pillar that serves as the central organization for all EERE products, services, processes, and systems, EERE will continue to streamline and enhance its operations; recruit, equip, and retain the workforce necessary to execute its mission; and conduct rigorous analysis and evaluations of its portfolio.

Sustainable Transportation & Fuels supports research, development, demonstration & deployment **(**RDD&D**)** to increase access to domestic, clean transportation fuels and improve the energy efficiency, convenience, and affordability of transporting people and goods.

Vehicle Technologies supports RD&D of efficient and sustainable transportation technologies that will improve energy efficiency, fuel economy, and enable America to use less petroleum. This Request prioritizes expanding demonstration and deployment projects to accelerate the nationwide adoption and deployment of electric vehicles and charging infrastructure, especially to benefit underserved communities. Increased funding continues research for next generation lithium-ion batteries, develops new recycling processing technologies, and scales up lithium battery recycling, and addresses decarbonizing non-road sectors.

Bioenergy Technologies advances technologies that convert domestic biomass and other waste resources into affordable, low-carbon biofuels and bioproducts. This Request increases support for Sustainable Aviation Fuel (SAF) RDD&D, including funds to construct and operate integrated biorefineries at demonstration scale that are capable of producing SAFs, and identify alternative pathways and feedstocks.

Hydrogen and Fuel Cell Technologies supports efforts to enable widespread adoption of hydrogen and fuel cell technologies. The Request focuses on RD&D to enable more affordable and durable fuel cell systems for vehicle and stationary markets. The Request increases RD&D of clean hydrogen production, delivery, and storage, including materials development, and integration with diverse net-zero emissions generation sources to support the Hydrogen Energy EarthShot and the H2@Scale initiative – this includes increased funding to demonstrate the use of low greenhouse gas (GHG) hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production.

Renewable Energy supports RDD&D to reduce the costs and accelerate the integration and utilization of renewable energy technologies as part of a reliable, secure, and resilient, fully decarbonized electricity system by 2035 and a net zero energy system by 2050.

Renewable Energy Grid Integration supports system-wide planning and operation of grids with high levels of variable renewable energy and includes improved technologies, tools, data, and operational practices as well as system-level simulations and demonstrations to validate the safety, reliability, and affordability of power systems.

Solar Energy Technologies accelerates the development and deployment of solar technologies – creating many thousands of good-paying jobs in the process – while supporting the reliability, resilience, and security of the U.S. electric grid. The Request increases funding for demonstration of technologies to operate and control a power system with

increasing levels of solar energy. It also includes investments in technologies to operate and control a power system with increasing levels of solar energy.

Wind Energy Technologies supports an updated and expanded portfolio of research and innovation designed to accelerate the advancement and deployment of offshore, land-based, and distributed wind energy technologies and their integration with the electric grid. The Request prioritizes (1) Near-term Offshore Wind (NOW) initiative, which is focused on accelerating near-term fixed-bottom offshore wind development through R&D and (2) the Floating Offshore Wind Accelerated Research and Development (FORWARD) program, a major body of R&D supporting the DOE Floating Offshore Wind EarthShot. In addition, the Request continues increased support for cross-technology investments that leverage wind energy technologies.

Water Power Technologies supports a broad portfolio of research activities to strengthen the body of scientific and engineering knowledge and support industry efforts to develop, maintain, and deploy hydropower and marine energy technologies at all scales. The Request focuses primarily on increasing hydropower flexibility for the grid. It increases funding for early-stage demonstrations in irrigation modernization and technologies to expand demonstrations and technical assistance for new, low-impact hydropower by investing in demonstration of technologies to power nonpowered dams or infrastructure. This includes the launch of one or more Regional Energy-Water Facilities to focus on validating and testing technologies and solutions to scale water and energy management solutions for potential commercial use.

Geothermal Technologies supports the deployment of geothermal energy in both the electric and non-electric sectors to help reach a carbon pollution-free electricity sector by 2035 and a net-zero economy by 2050. The Request prioritizes increased funding for the Enhanced Geothermal EarthShot as well as a new portfolio focused on advanced materials and high temperature components to enable downhole development in Enhanced Geothermal Systems (EGS) environments. Efforts will increase focus on the R&D and validation of new drilling and zonal isolation techniques that are required to reduce costs and achieve the DOE target. The Request also continues support for the Geothermal Energy from Oil and Gas Demonstrated Engineering (GEODE) consortium.

Buildings & Industry supports RDD&D of high impact technologies to increase energy efficiency, transform the grid edge to support all sector decarbonization goals, and reduce on-site emissions from our nation's homes, buildings, and industrial facilities while also strengthening U.S. manufacturing competitiveness and producing thousands of good-paying jobs.

Industrial Efficiency and Decarbonization accelerates the innovation and adoption of cost-effective technologies to increase energy efficiency and reduce GHG emissions in the U.S. industrial sector. This Request increases investment in industry-specific decarbonization RD&D with initiatives focusing on energy and emission-intensive industries. It also increases investments in priority cross-sector technologies for decarbonization based on the DOE Industrial Decarbonization Roadmap, including support of the Industrial Heat EarthShot. The Request supports continued technical assistance to increase the adoption of decarbonization technologies, including an expanded Onsite Energy program and an increased focus on energy-intensive sectors in the Better Plants and Better Climate Challenges.

Advanced Manufacturing and Materials Technologies invests in next-generation energy-related materials and manufacturing technologies needed to drive U.S. industrial competitiveness and enable economy-wide decarbonization by 2050. The Request includes an increase for advanced manufacturing and materials research to develop technologies, such as processing, separations, and recycling technologies, needed to improve the availability of critical materials and increase the resilience of materials supply chains. The Request also increases circular economy-related research supporting design for recyclability, recycling, and remanufacturing processes for multiple material classes. In addition, the Request supports advances in additive manufacturing and smart manufacturing, as well as manufacturing advances for high performance materials, emerging battery technologies, and power electronics.

Building Technologies invests in high-impact RDD&D, adoption acceleration, and regulatory mechanisms to achieve a decarbonized building sector by 2050 by reducing the energy intensity of buildings and direct emissions from buildings, while enhancing integration of buildings with a low carbon grid. The Request increases RD&D to lower the equipment and

installation cost and accelerate the adoption of heating and cooling technologies that minimize emissions. The Request increases RD&D on the transformation of the grid edge with buildings as the point of grid interaction with heat pumps, building envelope and controls, electric transportation, and on-site solar and storage through Connected Communities. The Request expands engagement and support of local communities and organizations to rapidly scale equitable building retrofits through the Buildings Upgrade Prize and expanded Better Buildings and Better Climate Challenges.

Corporate Support Programs include a range of activities to continuously improve EERE organizational efficiency, effectiveness, and responsiveness, with a focus on human capital, systems and tools, program and project management, and laboratory facilities and infrastructure as part of EERE's stewardship of the National Renewable Energy Laboratory (NREL) in Golden, Colorado. This investment also includes support for crosscutting strategic programs that advance the EERE mission.

Facilities and Infrastructure ensures that EERE fulfills its role as the steward of NREL by maintaining and upgrading key research and support infrastructure to not only enable the development of innovative technology solutions but also attract world-class research scientists**.** The Request prioritizes:

- Increased investments in the Advanced Research in Integrated Energy Systems (ARIES) initiative, focused on solving the complex problem of controlling interactions between millions of distributed assets.
- The Energy Materials and Processing at Scale (EMAPS) line-item construction project, a planned design and construction of a multi-disciplinary research capability in process integration.
- Conduct extensive planning for future construction of the 18th National Laboratory facility. DOE will apply the proposed funding to scale up an existing research facility at an Historically Black College and University (HBCU) or Minority-Serving Institution (MSI) or towards construction of an entirely new research facility at an HBCU, MSI, or consortium of such institutions, creating a pathway to National Laboratory designation.

Program Direction enables EERE to maintain and support a world-class Federal workforce. The Request provides additional resources for program and project management, oversight activities, contract administration, workforce management, data management, IT and systems support, and Headquarters (HQ) and field site non-laboratory facilities and infrastructure.

Strategic Programs support high-impact, integrative activities most efficiently executed by a single crosscutting organization, in coordination with EERE technology programs and other DOE offices. This includes support for crosscutting strategic analysis, activities that inform key audiences and stakeholders about EERE work to enable a clean energy economy, and work to address high energy costs, reliability, and inadequate infrastructure challenges faced by islands and remote communities as part of the Energy Transitions Initiative. The Request also includes funding to expand international collaboration and coordination.

Energy Efficiency and Renewable Energy
($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted	
				$	%
Sustainable Transportation & Fuels					
Vehicle Technologies	420,000	455,000	526,942	71,942	16%
Bioenergy Technologies	262,000	280,000	323,000	43,000	15%
Hydrogen and Fuel Cell Technologies	157,500	170,000	163,075	(6,925)	-4%
Renewable Energy					
Renewable Energy Grid Integration	40,000	45,000	59,066	14,066	31%
Solar Energy	290,000	318,000	378,908	60,908	19%
Wind Energy	114,000	132,000	385,000	253,000	192%
Water Power	155,300	179,000	229,769	50,769	28%
Geothermal Technologies	109,500	118,000	216,000	98,000	83%
Buildings & Industry					
Advanced Manufacturing	403,000				
Advanced Materials & Manufacturing Technologies		183,500	241,497	57,997	32%
Industrial Efficiency & Decarbonization		266,500	394,245	127,745	48%
Building Technologies	307,500	332,000	347,841	15,841	5%
Corporate Support					
Program Direction	172,184	186,000	225,623	39,623	21%
Strategic Programs	20,000	21,000	57,759	36,759	175%
Facilities and Infrastructure	148,000	205,000	277,391	72,391	35%
Operations and Maintenance	*93,590*	*102,370*	*118,865*	*16,495*	*16%*
Facility Management	*46,410*	*57,630*	*66,526*	*8,896*	*15%*
Establish DOE 18th National Laboratory	*0*	*0*	*35,000*	*+35,000*	*100%*
21-EE-001-Energy Materials and Processing at Scale (EMAPS)	*8,000*	*45,000*	*57,000*	*12,000*	*27%*
Subtotal	**2,598,984**	**2,891,000**	**3,826,116**	**935,116**	**32%**
Congressionally Directed Spending	77,047				
Total, EERE Organization	**2,676,031**	**2,891,000**	**3,826,116**	**935,116**	**32%**
Undersecretary for Infrastructure (EERE Appropriated funding)					
State and Community Energy Programs Total	453,973	493,000			
Manufacturing and Energy Supply Chains Total	15,999	19,000			
Federal Energy Management Program Total	53,997	57,000			
Grand Total, EERE Appropriation	**3,200,000**	**3,460,000**	**3,826,116**	**366,116**	**11%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $76,033,310; STTR $10,416,555
- FY 2023 Enacted: SBIR: $62,406,624; STTR $8,775,932
- FY 2024 Request: SBIR: $95,171,000; STTR: $13,385,000

Bipartisan Infrastructure Law (BIL) Investments

The Office of **Energy Efficiency and Renewable Energy (EERE)** was appropriated funds through the Infrastructure Investment and Jobs Act (IIJA) (P.L. 117-58). Not all IIJA activities will be managed by the organization to which funds were appropriated. In February 2022, the Department announced an organizational realignment, establishing new Office of the Under Secretary for Infrastructure (S3). This realignment was intended to establish a structure to effectively implement the clean energy investments provided through IIJA. In the FY 2023 Request, funding from EERE was functionally realigned to stand up four new offices: State and Community Energy Programs (SCEP), Manufacturing and Energy Supply Chains (MESC), Federal Emergency Management Program (FEMP), and Grid Deployment Office (GDO). Activities are itemized below.

Appropriated Funding Organization	FY 2022 IIJA Funding	FY 2023 IIJA Funding	FY 2024 IIJA Funding	Managing Organization
Energy Efficiency and Renewable Energy (EERE)				
Lithium-Ion Battery Recycling Prize Competition	$10,000,000			EERE
Battery and Critical Mineral Recycling - Battery Recycling RD&D	$60,000,000			EERE
Electric Drive Vehicle Battery Recycling and Second-Life Applications Program	$40,000,000	$40,000,000	$40,000,000	EERE
Clean Hydrogen Manufacturing Recycling Research, Development, and Demonstration Program	$100,000,000	$100,000,000	$100,000,000	EERE
Clean Hydrogen Electrolysis Program	$200,000,000	$200,000,000	$200,000,000	EERE
Pumped Storage Hydropower Wind and Solar Integration and System Reliability Initiative	$10,000,000			EERE
Cost-effective Codes Implementation for Efficiency and Resilience	$45,000,000	$45,000,000	$45,000,000	EERE
Hydropower Research, Development, and Demonstration	$36,000,000			EERE
Marine Energy Research, Development, and Demonstration	$70,400,000			EERE
National Marine Energy Centers	$40,000,000			EERE
Enhanced Geothermal Systems Demonstrations	$84,000,000			EERE
Wind Energy Technology Program	$60,000,000			EERE
Wind Energy Technology Manufacturing Recycling Research, Development, and Demonstration Program	$40,000,000			EERE
Solar Energy Research and Development	$40,000,000			EERE
Advanced Solar Energy Manufacturing Initiative	$20,000,000			EERE
Solar Energy Technology Recycling Research, Development, and Demonstration Program	$20,000,000			EERE
Total, EERE Program	**$875,400,000**	**$385,000,000**	**$385,000,000**	**EERE**
Office of the Under Secretary for Infrastructure (S3)				
Assisting Federal Facilities with Energy Conservation Technologies Grant Program	$250,000,000			FEMP

Appropriated Funding Organization	FY 2022 IIJA Funding	FY 2023 IIJA Funding	FY 2024 IIJA Funding	Managing Organization
Hydroelectric Efficiency Improvement Incentives	$75,000,000			GDO
Hydroelectric Production Incentives	$125,000,000			GDO
Maintaining and Enhancing Hydroelectricity Incentives	$276,800,000	$276,800,000		GDO
Advanced Energy Manufacturing and Recycling Grant Program	$150,000,000	$150,000,000	$150,000,000	MESC
Battery and Critical Mineral Recycling - Retailers as Collection Points	$15,000,000			MESC
Battery and Critical Mineral Recycling - State and Local Programs	$50,000,000			MESC
Battery Manufacturing and Recycling Grants	$600,000,000	$600,000,000	$600,000,000	MESC
Battery Material Processing Grants	$600,000,000	$600,000,000	$600,000,000	MESC
Energy Efficient Transformer Rebates	$10,000,000			MESC
Extended Product System Rebates	$10,000,000			MESC
Implementation Grants for Industrial Research and Assessment Centers	$80,000,000	$80,000,000	$80,000,000	MESC
Industrial Research and Assessment Centers	$30,000,000	$30,000,000	$30,000,000	MESC
State Manufacturing Leadership	$50,000,000			MESC
Building, Training, and Assessment Centers	$10,000,000			SCEP
Career Skills Training	$10,000,000			SCEP
Energy Auditor Training Grant Program	$40,000,000			SCEP
Energy Efficiency and Conservation Block Grant Program	$550,000,000			SCEP
Energy Efficiency Materials Pilot Program	$50,000,000			SCEP
Energy Efficiency Revolving Loan Fund Capitalization Grant Program	$250,000,000			SCEP
Grants for Energy Efficiency Improvements and Renewable Improvements at Public School Facilities	$100,000,000	$100,000,000	$100,000,000	SCEP
State Energy Program	$500,000,000			SCEP
Weatherization Assistance Program	$3,500,000,000			SCEP
Total, S3 Program	**$7,331,800,000**	**$1,836,800,000**	**$1,560,000,000**	**S3**
Total, EERE IIJA Coordination	**$8,207,200,000**	**$2,221,800,000**	**$1,945,000,000**	

Inflation Reduction Act (IRA) Investments

The Office of **Energy Efficiency and Renewable Energy (EERE)** was appropriated funds through the Inflation Reduction Act of 2022 (IRA) (PL 117-169) to support critical facilities and infrastructure activities, as shown in the table below.

Appropriated Funding Organization	FY 2022 IRA Funding	Managing Organization
Energy Efficiency and Renewable Energy (EERE)		
National Laboratory Infrastructure – Sec 50172(d)	$150,000	EERE
Total, EERE Program	**$150,000**	

Appropriated Funding Organization	FY 2022 IRA Funding	Managing Organization
Office of the Under Secretary for Infrastructure (S3)		
Domestic Manufacturing Conversion Grants – Sec. 50143	$2,000,000	MESC
Home Energy Performance-Based, Whole-House Rebates – Sec. 50121	$4,300,000	SCEP
High-Efficiency Electric Home Rebate Program, State Energy Office Grants – Sec 50122(a)(1)(A)	$4,275,000	SCEP
High-Efficiency Electric Home Rebate Program, Indian Tribes Grants – Sec. 50122 (a)(1)(B)	$225,000	SCEP
State-Based Home Efficiency Contractor Training Grants – Sec. 50123	$200,000	SCEP
Assistance for Latest Building Energy Code Adoption – Sec. 50131(a)(1)	$330,000	SCEP
Assistance for Zero Energy Code Adoption – Sec. 50131(a)(2)	$670,000	SCEP
Total, S3 Program	**$12,000,000**	
Total, EERE IRA Coordination	**$12,150,000**	

Additional Activities Managed by EERE

EERE is involved in oversight and implementation of $300 million of IIJA funds to facilitate a collaborative Joint Office between DOE and the U.S. Department of Transportation that supports the deployment of zero-emission, convenient, accessible, equitable transportation infrastructure. The Joint Office aligns and leverages resources and expertise across the two departments. It is a critical component in the implementation of the BIL, providing support and expertise to a multitude of programs that seek to deploy a network of electric vehicle chargers, zero-emission fueling infrastructure, and zero-emission transit and school buses.

Vehicle Technologies

Overview

Vehicles move our national economy. Each year in the U.S., vehicles transport 18 billion tons of freight – about $55 billion worth of goods each day[1] – and move people more than 3 trillion vehicle-miles.[2] The transportation sector accounts for approximately 27 percent of total U.S. energy demand[3] and over 17 percent of average U.S. household expenditures[4], making it, as a percentage of spending, the costliest personal expenditure after housing. Transportation is critical to the overall economy, from the movement of goods to providing access to jobs, education, and healthcare.

The transportation sector has historically relied heavily on petroleum, which supports over 90 percent of the sector's energy needs today[5] and, as a result, has surpassed electricity generation to become the largest source of CO_2 emissions in the country[6]. Transportation sector decarbonization is therefore critical to achieving the overall goal of economy-wide decarbonization by 2050. The Vehicle Technologies Office (VTO) will play a leading role in decarbonizing the transportation sector and address the climate crisis by driving innovation and deploying clean transportation technologies, all while maintaining transportation service quality and safety.

Achieving deep decarbonization in transportation will require vehicle efficiency improvements, low lifecycle carbon-intensity fuels, and overall system-wide improvements in the transportation system. VTO funds research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. VTO leverages the unique capabilities and world-class expertise of the National Laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies (including automated and connected vehicles as well as innovations in efficiency-enhancing connected infrastructure); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. Across these technology areas and in partnership with industry, VTO has established aggressive technology targets to focus RDD&D efforts and ensure there are pathways for technology transfer of Federally supported innovations into commercial application.

Highlights of the FY 2024 Budget Request

- VTO will identify new battery chemistry and cell technologies with the potential to reduce the cost of electric vehicle battery cells, in support of EVs and batteries across clean energy applications. Focus on developing processing technologies and related promising near-term approaches for reducing the cost of lithium-ion batteries; the scale-up of lithium battery technologies such as no-cobalt/no-nickel cathodes, lithium metal anodes, and solid-state systems to reduce constraints from scarce materials; and alternatives to lithium-based high-capacity batteries.
- VTO will continue to fulfill statutory requirements for providing alternative fuel information. Seek to validate data, technologies, and systems in the field, serving as an important feedback loop to inform future VTO research planning. Support national Science, Technology, Engineering, and Mathematics (STEM) education objectives through an advanced vehicle technology competition to provide hands-on training to university students and prepare them for the future workforce.
- VTO will address the challenge of transportation electrification through powertrain and vehicle charging technologies and the interaction of electrified vehicles with the overall electric grid. Emphasize work with stakeholder groups and partnerships to guide RDD&D decisions and efforts that can demonstrate benefits to all communities.
- VTO will create and deploy breakthrough modeling, simulation, and high-performance computing-enabled data analytics to support the development of new transportation-system technologies, which have the potential to improve energy productivity

[1] Bureau of Transportation Statistics, DOT, Transportation Statistics Annual Report 2020, Table 4-1. https://www.bts.gov/tsar.
[2] Transportation Energy Data Book 39th Edition, ORNL, 2021. Table 3.8 Shares of Highway Vehicle-Miles Traveled by Vehicle Type, 1970-2018.
[3] U.S. Energy Information Administration. Monthly Energy Review, 2022, https://www.eia.gov/totalenergy/data/monthly/index.php
[4] Davis, Stacy C., and Robert G. Boundy. Transportation Energy Data Book: Edition 39. Oak Ridge National Laboratory, 2020, https://doi.org/10.2172/1767864
[5] Transportation Energy Data Book 39th Edition, ORNL, 2021. Table 2.3 Distribution of Energy Consumption by Source and Sector, 1973 and 2019.
[6] Environmental Protection Agency, Draft U.S. Inventory of Greenhouse Gas Emissions and Sinks, 1990-2019, Table 2-11. Electric Power-Related

through new mobility solutions including connected, shared, and automated vehicles. Identify feasible system-level pathways to improve mobility energy productivity and support the equitable transition to a net-zero economy by 2050.

- VTO will identify novel approaches to build lightweight, multi-material structures with the potential to reduce light-duty vehicle glider (i.e., chassis, body structure, and interior) weight and develop lightweight alloys with improved strength and fatigue performance for cast and additive manufacturing methods for weight reduction and efficiency improvements in electric powertrain and suspension components.
- VTO will continue developing technologies to decarbonize off-road, rail, marine an aviation sectors by efficiently using electrification, including integration of hybrid and plug-in hybrid powertrains, and engines using renewable fuels, such as advanced biofuels, renewable hydrogen, and e-fuels, to significantly reduce GHG emissions while achieving near-zero criteria emissions.
- VTO will develop energy efficient powertrain technologies that will improve commercial vehicles through projects related to SuperTruck, a VTO crosscut, which will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.
- VTO will conduct technical-, economic-, and interdisciplinary analyses using advanced vehicle and transportation data that result in insights critical to informing Vehicle Technologies' targets and program planning.
- VTO is involved in several crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing to develop and scale up efforts related to solid state processing and new joining technologies for multi-material structures in vehicles and batteries;
    - Energy Storage including early-stage R&D of high-energy and high-power battery materials, cells, and battery development that can enable industry to significantly reduce the cost, weight, volume, and charge time of plug-in electric vehicle batteries;
    - Critical Mineral and Materials to research battery recycling and develop substitutes for graphite and nickel by enabling silicon anodes and for developing near term lithium chemistries that require very low or no cobalt; and
    - Grid Modernization to develop secure vehicle-grid connection and communication technologies, as well as high power grid-tied charging systems.

The 2024 Budget continues the process of ensuring that federal funding no longer directly subsidizes fossil fuels, as required in Section 209 of Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. The Department will ensure that, to the extent consistent with applicable law, VTO will focus on developing efficient combustion and fuels technology for hard to electrify segments of the transportation sector, such as off-road vehicles, including construction, agriculture and forestry, and rail, marine and aviation that can use renewable fuels, such as advanced biofuels, hydrogen, and e-fuels, or hybrid electric powertrains where full electrification is not yet feasible, so as to reduce GHG and criteria emissions to near-zero levels.

Vehicle Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Vehicle Technologies					
Battery and Electrification Technologies	200,000	211,500	266,016	+54,516	+26%
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies	35,000	35,000	35,579	+579	+2%
Materials Technology	45,000	42,500	45,000	+2,500	+6%
Energy Efficient Mobility Systems	54,000	54,000	54,000	+0	+0%
Technology Integration & Deployment	80,000	106,000	117,162	11,162	+11%
Data, Modeling, and Analysis	6,000	6,000	9,185	+3,185	+53%
Total, Vehicle Technologies	**420,000**	**455,000**	**526,942**	**+71,942**	**+16%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $10,519,875; STTR: $2,627,554
- FY 2023 Enacted: SBIR: $12,809,000; STTR: $1,801,000
- FY 2024 Request: SBIR: $14,942,314; STTR: $2,101,263

Vehicle Technologies
Explanation of Major Changes
($K)

	FY 2024 Request vs FY 2023 Enacted
Vehicle Technologies	
Battery and Electrification Technologies: The increase will support data and tool development, paired with technical assistance to stakeholders to enable vehicle grid integration capabilities. The Request will also continue support for R&D to reduce EV battery cell cost to achieve EV cost parity with internal combustion engine (ICE) vehicles through expanded R&D focused on lithium metal, solid state, and next generation lithium-ion battery technologies; and reduce or eliminate dependence on critical materials such as cobalt, nickel, and graphite, thereby mitigating battery supply chain risks.	**+54,516**
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies: The increase will focus on RD&D efforts to reduce GHG emissions from large vehicles that are difficult to decarbonize, and RD&D to assess the impact of renewable fuels on emission control catalyst performance and durability for medium- and heavy-duty non-road engines.	**+579**
Materials Technology: The increase will support an additional focus on R&D related to reduced embodied energy and design for recyclability across material types. FY 2024 work will inform efforts in out-years. Continue to support key advances in materials development and manufacturing to decrease lifecycle GHG emissions and manufacturing cost of electrified vehicles supporting the transition to electric light duty vehicles.	**+2,500**
Energy Efficient Mobility Systems (EEMS): No significant change.	**0**
Technology Integration & Deployment: Increase in funding will support the continued expansion and capacity building of the Clean Cities network to expand community involvement and work with underserved communities to meet Justice 40 goals. The increase will also be used to develop and implement new projects that will address barriers to accelerate vehicle electrification. Increased funding will also be used to expand technical assistance activities through Clean Cities, Communities to Clean Energy, Community-Led Innovation Center, and the Joint Office of Energy and Transportation. There will be increased support to the Clean Cities Coalition's cooperative agreements and engagement with regional and local partners.	**+11,162**
Data, Modeling, and Analysis: Increase in funding will support data collection and analysis to quantify impacts of increased electric vehicle penetration on job creation, vehicle-grid integration, and environmental justice communities. Work will continue to provide critical information and analyses to prioritize and inform Vehicle Technologies research portfolio planning through technology-, economic-, and interdisciplinary-based analysis, including target-setting and program benefits estimation. In FY 2024, projects will continue to support analytical capabilities and tools unique to DOE's National Laboratories.	**+3,185**
Total, Vehicle Technologies	**+71,942**

Vehicle Technologies
Battery and Electrification Technologies

Description

The Battery and Electrification Technologies subprogram supports the decarbonization of transportation across all modes and serves to increase American advancement/manufacturing of battery technology. Efforts continue to support R&D activities to lower the cost, improve the sustainability, and increase the convenience of plug-in electric vehicle (PEVs). Work is done with National Laboratories, academia, and industry to improve batteries and electric drive systems.

Battery R&D: The Battery R&D activity supports early-stage R&D of high-energy and high-power battery materials, cells, and battery development that can enable industry to significantly reduce the cost, weight, volume, and charge time of PEV batteries. This activity is organized into three sub-activities: advanced battery materials research, advanced battery cell R&D, and battery recycling R&D. Advanced battery materials research is coordinated with the Critical Minerals Initiative and includes early-stage research of new cathode, anode, and electrolyte materials (currently accounting for 50-70 percent of PEV battery cost) and the development of advanced high capacity battery technologies, such as lithium metal anodes, solid-state electrolytes, sulfur-based cathodes, and other alternatives to lithium-based batteries that have the potential to significantly reduce weight, volume, and cost reduction of over 85 percent compared to a 2008 baseline, with a target of $60/kWh. Advanced battery cell R&D includes early-stage R&D of new battery cell technology that contains new materials and electrodes that can reduce the overall battery cost, weight, and volume while improving energy, life, safety, and fast charging. Battery recycling R&D includes the development of innovative battery materials recycling and reuse technologies, and the Battery Recycling Prize, both of which aim to assure sustainability and domestic supplies of key battery materials and minerals.

Electric Drive R&D: The Electric Drive R&D activity supports R&D for extreme high-power density electric drive systems that have the potential to enable radical new vehicle architectures by dramatic volume/space reductions and increased durability and reliability. The cost of electric traction drive systems, including power electronics and electric motors, will be reduced through high-density integration technologies, novel circuit topologies, new materials for high-density electric motors, and leveraging high performance computing for modeling and optimization. VTO will use electric traction drive system design, integration, and testing to verify performance and progress towards meeting R&D targets.

Electrification R&D: The Electrification R&D activity supports R&D to understand the potential impacts on, and benefits of, EV charging to the Nation's electric grid. This research will inform the development of communication and cybersecurity protocols; enable industry to enhance the interoperability between charging equipment, the on-board vehicle charger, and charging networks; and foster technology innovations to improve PEV refueling through extreme fast charging. Core research focuses on developing EV charging, charge management, Distributed Energy Resources (DER) integration, grid services, and cyber-physical security technologies for reliable and cost-effective high-power and wireless charging of light-, medium-, and heavy-duty electric vehicles. This includes technical support and research for technologies related to cybersecurity for electric vehicle charging/supply equipment, and integration with the electric grid.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Battery and Electrification Technologies $211,500,000	**$266,016,000**	**+$54,516,000**
Battery R&D $146,500,000	$192,500,000	+$46,000,000
• Continue researching next generation battery materials such as lithium-ion, Lithium metal and Lithium Sulfur based chemistries, including solid-state material systems. Expand research for material processing and characterization, including high voltage, high energy cathodes. This early-stage materials research complements Infrastructure Investment and Jobs Act (IIJA) manufacturing investments by maintaining a pipeline of future technologies that will be competitive and contain less critical materials for the next generation of electric drive vehicle batteries. • Accelerate early-stage research for a new class of battery cell materials that contain no cobalt and no nickel. Work with Industry to begin cell evaluations supporting the scale-up of these new materials. This early-stage cell research complements IIJA manufacturing investments by validating battery material and materials system research at a stage that potentially could be adopted and manufactured by the same facilities. • Continue growing joint industry and lab work through the existing Recycling Center. Expand on the most promising reuse and recycling business model innovations from the Lithium-Ion Battery Recycling Prize.	• Continue research projects for next generation battery materials such as Lithium metal and Lithium Sulfur based chemistries. Research will expand to include other alternatives to lithium-based batteries that can meet key performance metrics for weight, volume, and cost, while achieving further improvements in cycle life. • Focus on improvements to lithium-ion cell materials and material processing that promises near-term impacts to battery life, energy density, fast-charge performance, and eliminates or reduces critical materials. • Grow industry and lab work on advanced battery technologies through strategic lab partnerships and open, competitively selected agreements with industry and research partners.	• The increase will focus on improving the performance and reducing the cost of critical materials free active materials. Specifically lowering the cost of silane derived silicon, enabling low-cost micro-silicon, and improving the performance of cobalt free cathodes. Additionally, the increase will support an expansion of fundamental work on sodium ion batteries while also starting to investigate full cell sodium ion electrochemical couples. • The increase will support precompetitive battery cells work specifically designed for medium and heavy-duty truck performance requirements.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Electric Drive R&D $22,500,000	$22,500,000	+$0
• Complete early-stage research targeting the development of technologies that will enable low-cost, high-power density electric drive systems. Projects will advance electric drive systems and meet development targets for lower cost and higher performance. Key research areas include wide bandgap power semiconductors, semiconductor packaging, passive devices, motor materials including improved copper conductors, and electromagnetic and thermal analysis. • Integrate disparate technical advancements into a system context. This validates vehicle-level improvements and provides critical feedback to subcomponent researchers. • SuperTruck III: Provide the second year of planned funding for projects selected in FY 2021 and support additional awards. The aim of the projects is to develop energy efficient powertrain technologies that will improve commercial vehicles. Projects will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.	• Continue research and development activities to further increase the power density and efficiency of electric drive systems while aiming for further cost reduction to drive greater technology acceptance. • Conduct competitive work with laboratories, industry, and research partners to address key technology gaps in electric drive system performance, including reducing or eliminating critical materials. • Continue support for SuperTruck projects selected in FY 2021 and support additional awards. Projects will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.	• No change.
Electrification R&D $42,500,000	$51,016,000	+$8,516,000
• Continue a laboratory research consortium to address the challenges of electric vehicle grid integration across light, medium, and heavy-duty vehicle applications. Technical focus areas include smart charge management, high power charging, wireless charging, cybersecurity, and testing standards. • In support of the Cybersecurity crosscut, continue projects to develop secure vehicle-grid	• Continue a laboratory research consortium funded in FY 2023. • Continue projects to develop lower cost and innovative vehicle charging concepts and technologies. • Work with utility and local partners to address the unique challenges and opportunities	• The increase will address technical challenges to vehicle-grid integration. This will include development and demonstration of optimized charge management technologies, adaption of grid infrastructure to support universal electrifications and bidirectional grid services capabilities, improved cyberposture of interactions within the charging ecosystem, and

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
connection and communication technologies. Additional projects will also address cybersecurity needs for vehicle charging and charging infrastructure resilience. • Working with utility and local partners, these projects will address the unique challenges and opportunities presented by the concentration of vehicle charging loads. • SuperTruck III: Develop energy efficient powertrain technologies that will improve commercial vehicles. Projects will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.	presented by the coordination and concentration of vehicle charging loads. • Continue working with utility and local partners to address the unique challenges and opportunities presented by the coordination and concentration of vehicle charging loads. • Support for SuperTruck projects selected in FY 2021 and support additional awards. Projects will pioneer electrified medium- and heavy-duty trucks and freight system concepts to achieve higher efficiency and zero emissions.	collaborative work with stakeholders to address interoperability.

Vehicle Technologies
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies

Description

The Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies subprogram supports RD&D of new propulsion and vehicle technologies in applications that reduce GHG emissions and achieve a net-zero economy by 2050. These technologies include electrified and hybrid systems as well as powertrains that can use renewable fuels, such as advanced biofuels, hydrogen, and e-fuels. The subprogram also works on optimization of high efficiency engines and emission control systems that can use low GHG, renewable fuels, and the integration of electrified and hybrid powertrains into these vehicles in furtherance of emissions reductions.

The subprogram supports a multi-lab initiative, in close collaboration with industry and academia, to achieve goals for decarbonization of the non-road sector. The subprogram will apply the unique facilities and capabilities at the National Laboratories, including high performance computing (HPC) and hardware in-the-loop resources, to create knowledge, new concepts, and research tools that industry can use to improve non-road powertrains that will provide efficiency improvements and GHG and criteria emission reductions. The subprogram will coordinate with and use expertise from other agencies, Program Offices, and VTO subprograms as needed.

The subprogram will support industry needs to develop predictive, high-fidelity sub-models and simulation tools that are scalable and can leverage future exascale computing capabilities. The activity will fund research of renewable fuel properties and utilization, in coordination with the Bioenergy Technologies Office, using chemical kinetics modeling of different molecules to determine their impact on combustion efficiency and emissions.

Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies $35,000,000	**$35,579,000**	**+$579,000**
• Commercial Off-Road Powertrains, Fuels and Emission Control R&D: Support use of advanced experimental research tools at the National Laboratories (e.g., laser, X-ray light sources), single and multi-cylinder research engines, and modeling and simulation capabilities to improve the understanding of advanced combustion processes and emissions formation inside engines using low-carbon and renewable biofuels including hydrogen and DME. Integrate hybridized/electrified powertrains to further improve efficiency and reduce GHG and criteria emissions with advanced emission control technologies. • Heavy-duty Consortium: Support a multi-lab effort focusing on improving rail, marine and aviation engine efficiency, compatibility with low-carbon and renewable fuels including hydrogen, and fuel effects on emission control systems, using experimental data and high-performance computing algorithms. Work collaboratively with BETO and HFTO to efficiently use renewable fuels such as advanced biofuels and renewable hydrogen while reducing their impact on emission control systems. Continue development of computer models to simulate the performance of multi-functional emission control systems and integration of hybrid/electric powertrains.	• Continue to support a multi-lab effort focusing on improving off-road, rail, marine and aviation engine efficiency, compatibility with renewable fuels, and fuel effects on emission control systems. Use experimental data and high-performance computing algorithms to improve combustion processes and emissions formation inside engines using renewable biofuels. Work collaboratively with BETO and HFTO to efficiently use renewable fuels such as advanced biofuels and renewable hydrogen while reducing their impact on emission control systems. Integrate hybridized/electrified powertrains to further improve efficiency and reduce GHG and criteria emissions. Conduct research to improve conversion efficiency, durability and reduce need for critical minerals (i.e., platinum group metals) in emission control systems. • Conduct competitive solicitations with industry and universities to increase the use of renewable fuels, such as advanced biofuels and hydrogen, in medium- and heavy-duty engines used in off-road, rail, marine and aviation to reduce GHG and criteria emissions. Improve potential for electrification/hybridization to further reduce emissions.	• The increase will support RD&D of non-road technologies. Some subactivities in the Heavy-duty Consortium activity merged into this activity, to include research on rail, marine and aviation technologies.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Rail, Maritime and Aviation Engine R&D: Conduct efforts with industry and universities to utilizes electrification and hybridization and to improve the efficiency of large engines and their ability to utilize low-carbon and renewable fuels such as advanced biofuels and hydrogen to reduce GHG and criteria emissions.		

Description

Materials play an important role in increasing the efficiency of electric vehicles through weight reduction as well as enabling additional functionality such as faster charging and new sensing technologies. Lighter weight vehicle structures and electric drivetrains will require less battery power to achieve the same range, which in turn reduces battery cost, material needs, and reduces the GHG emissions from battery production. Multi-functional materials with improved properties such as electrical conductivity, thermal conductivity, and unique sensing capabilities will enable innovations in charging and autonomous vehicles. The materials and manufacturing methods used to make vehicles also contribute to GHGs, and the Materials Technology subprogram supports research, development, and deployment to increase recyclability and reduce the overall embodied energy of vehicles. Materials will coordinate closely with the Battery and Electrification Technologies subprogram to support materials research and development to address key challenges in electrical conductivity, thermal conductivity, magnetic materials, and high temperature operation currently limiting advances in electric powertrain and wireless charging.

The Materials Technology subprogram goals are:

- Enable a 25 percent weight reduction for light-duty vehicles including body, chassis, and interior as compared to a 2020 baseline by 2030, at less than $5/kg-saved; and,
- Develop lightweight alloys with improved strength and fatigue performance for cast and additive manufacturing methods resulting in a 25 percent weight reduction in powertrain and suspension components by 2030.

Lightweight Materials: This activity supports research in advanced high-strength steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber composites, novel lightweight materials, and multi-material systems with potential performance and manufacturability characteristics that greatly exceed today's technologies. This includes projects addressing materials and manufacturing challenges spanning from atomic structure to assembly, with an emphasis on establishing and validating predictive modeling tools for materials applicable to light- and heavy-duty vehicles. Polymer composites have the potential to reduce component weight by up to 70 percent but suffer from high raw material and manufacturing costs. Increased use of composites in vehicles requires the development of affordable fiber, matrix, and filler materials, efficient intermediate processes, and manufacturing methods suitable for high volume production. Vehicle weight reduction and efficiency improvement will be enabled by broadening the applicability of individual joining methods, moving lab-scale joining methods towards industry readiness, addressing challenges with adhesion and corrosion, and providing the automotive industry confidence in the quality of dissimilar material joints. Overall embodied energy of vehicles will be reduced by increasing the implementation and recyclability of lightweight metals through localized processing and alloy design for recyclability.

Powertrain Materials: Research funded through this activity applies advanced characterization and multi-scale computational materials methods, including HPC, to accelerate discovery and early-stage development of cutting-edge structural and high temperature materials for lighter and more efficient powertrains. In FY 2024, a multi-lab research effort for powertrain materials research will support weight reduction and electric powertrain system efficiency improvements for heavy-, medium-, and light-duty vehicles by expanding to address the materials property requirements of challenging components such as inverters, motors, and gear-train using an integrational materials engineering approach to alloy development and innovative production techniques like additive manufacturing. This early-stage research will support the development of new alloys with improved electrical/mechanical properties and enhanced resistance to corrosion/oxidation of components operating in harsh environments such as electrical bus bars, lightweight gears, underbody suspension, and brakes. The Powertrain Materials portfolio is closely aligned with other VTO subprograms to identify critical future materials needs of next generation high-efficiency powertrains for both heavy- and light-duty vehicles that are beyond current market drivers.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Materials Technology $42,500,000	**$45,000,000**	**+$2,500,000**
Lightweight Materials $35,500,000	$38,000,000	+$2,500,000
• Complete research to broaden the applicability of individual joining methods, move lab-scale joining methods towards industry readiness, and develop AI/ML techniques to ensure quality of dissimilar material joints. • Support polymer composite materials research including the operation of the Carbon Fiber Technology Facility (CFTF) and the Composites Core Program targeting core innovation science R&D, high- volume manufacturing. • Research advanced processing techniques to tailor localized microstructure and properties of metal alloys to increase penetration of lightweight metals and address challenges for recyclability. • Competitively select and award 3-5 projects to advance the state of the art for the development and processing of lightweight metals including novel architectures and manufacturing methods to decrease weight at low cost.	• Continue to fund early stage applied research on Lightweight Metals, Polymer Composites, and Joining of Dissimilar Materials. This research will address challenges such as reducing cost, integration with high volume manufacturing, improved predictive modeling, and a new focus on reduced embodied energy and design for recyclability across all material types. • Develop and demonstrate the application of lightweight materials for Medium Duty (MD)/Heavy Duty (HD) vehicles.	• Increased funding will support a new competitive solicitation for reduction of embodied energy and recyclability focus area in addition to existing research areas.
Powertrain Materials $7,000,000	$7,000,000	$0
• Research materials development relevant to increased efficiency and decreased manufacturing cost of electric powertrain applications. Advanced characterization tools and computational methods through the National Laboratories will be maintained.	• Continue to fund research on materials development relevant to increased efficiency and decreased manufacturing cost of electric powertrain applications. This research will address the materials property requirements of challenging electric vehicle powertrain	• No change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Research affordable, recyclable, high conductivity materials for lightweight electric powertrain components. Address the materials property requirements of challenging electric vehicle powertrain components such as inverters, motors, and gear-train. • R&D to improve freight efficiency and reduce emissions from MD/HD vehicles and incorporate advanced materials for light-weighting, hybridization and electrification. This effort will support work on lightweight powertrain materials to reduce fuel consumption through more efficient operation.	components such as inverters, motors, and gear-train through research on affordable, recyclable, high conductivity materials.	

Description

The Energy Efficient Mobility Systems (EEMS) subprogram supports RDD&D of innovative mobility solutions that improve the affordability, accessibility, and energy productivity of the overall transportation system. EEMS leverages emerging disruptive technologies such as connected and automated vehicles, information-based mobility-as-a-service platforms, and artificial intelligence (AI)-based transportation control systems to accelerate the transition to a zero carbon-emission transportation future. The EEMS subprogram also develops and uses large-scale transportation modeling and simulation capabilities to evaluate the impacts of new mobility solutions across multiple geographies and populations, ensuring that all Americans, especially underserved populations and energy communities, benefit from the development and deployment of clean transportation technologies.

Computational Modeling and Simulation: Activities includes the SMART (Systems and Modeling for Accelerated Research in Transportation) Mobility National Laboratory Consortium, a multi-disciplinary approach to transportation research that is beyond the scope or capability of a single company or organization, which will assess the energy productivity impacts from future mobility technologies and transportation systems. EEMS will continue a focused effort to engage with state and local organizations to deploy systems-level tools for mobility design and planning. This activity will accelerate the transition of tools and capabilities developed through SMART Mobility and other initiatives to be used by local governments, policy makers, and transportation planners. Activities also includes the development of core evaluation tools and mobility testbed facilities to develop and maintain a critical set of experimental evaluation capabilities that support EEMS' research, development, modeling, simulation, and demonstration of advanced vehicles and transportation systems. These capabilities include vehicle and component test procedure development, highly instrumented proof-of-concept hardware evaluation, transportation system controls algorithm validation, high-fidelity physical simulation, and transportation data management.

Connectivity and Automation Technology: Activities include developing technology solutions that improve the mobility energy productivity of both passenger and freight movement through the development of connectivity, communication, automation, and other transportation solutions that are enabled by artificial intelligence and advanced computing technologies. EEMS will support national lab and industry research and development and engage with local stakeholders to conduct demonstration and deployment of advanced cooperative driving automation systems. These projects will remove technical barriers and accelerate the efficiency and mobility benefits of cooperative driving automation. EEMS will also coordinate with other VTO subprograms and the Hydrogen Fuel Cell Technologies Office to continue to support industry projects under the SuperTruck III initiative, improving the energy and operational efficiency of moving freight with medium and heavy-duty trucks. EEMS will also coordinate with other agencies to research and develop solutions to improve the efficiency and convenience of public transit systems, leveraging the benefits of this shared mode to accelerate the path to transportation decarbonization and provide mobility access.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy Efficient Mobility Systems $54,000,000	**$54,000,000**	**$0**
Computational Modeling and Simulation $28,000,000	$28,000,000	$0
• Conduct SMART Mobility research to develop a suite of transportation system-level modeling, simulation, design, and planning capabilities ready to be deployed to local stakeholders. • A new deployment emphasis on System-Level Tools for Design and Planning will focus on Transition tools developed from SMART Mobility, AI for Mobility, and other previous initiatives to local city/state transportation planners and decision-makers. • Initiate new national lab core capabilities and tools in mobility simulation, evaluation, and data selected through competitive lab call in the previous year.	• Apply high-potential SMART Mobility capabilities as part of a suite of transportation system-level modeling, simulation, design, and planning capabilities to deliver systems-level energy insights for local stakeholders. • Leverage deployment emphasis for real-world applications of System-Level Tools for Design and Planning will focus on Transition tools developed from SMART Mobility, AI for Mobility, and other previous initiatives in coordination with local city/state transportation planners and decision-makers. • Target support for new and complementary computational modeling and simulation that addresses gaps in existing modeling capability portfolio.	• No significant change • Build on and complete existing slate of computational modeling and simulation by addressing lessons learned across SMART Mobility technology suite.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Connectivity and Automation Technologies $26,000,000	$19,000,000	-$7,000,000
• Conduct demonstration and deployment of advanced Cooperative Driving Automation (CDA) systems that use vehicle-to-vehicle and vehicle-to-infrastructure communications to reduce transportation energy consumption by over 20 percent. • Conduct R&D to improve the efficiency and convenience of public transit, integrating this shared mode into the broader zero-carbon transportation system though electric-drive transit vehicles, transit system optimization, and more efficient intermodal transitions. • Continue funding selected projects previously awarded under the cross-cutting VTO and HFTO SuperTruck III solicitation.	• Continue demonstration and deployment of advanced Cooperative Driving Automation (CDA) systems that use vehicle-to-vehicle and vehicle-to-infrastructure communications to reduce transportation energy consumption by over 20 percent. • Continue RD&D to improve the efficiency and convenience of public transit, integrating this shared mode into the broader zero-carbon transportation system though electric-drive transit vehicles, transit system optimization, and more efficient intermodal transition. • Continue funding selected projects previously awarded under the cross-cutting VTO and HFTO SuperTruck III solicitation.	• Continue previous technology development, demonstration, and application efforts. • Prioritize building on previous R&D efforts while reducing stakeholder engagement efforts, which are currently in a sustainable place. • Build on previous SuperTruck III efforts.
Workforce Development and Clean Energy Mobility Solutions for Underserved Communities $0	$7,000,000	+$7,000,000
•	• Connect and enhance previous support for Clean Energy Mobility Solutions for Underserved Communities and separate complementary support for Workforce Development by targeting projects that explicitly link clean energy workforce development and clean energy outcomes in underserved communities.	• The increase will initiate a new activity to link workforce development and clean energy outcomes in underserved communities.

Vehicle Technologies
Technology Integration & Deployment

Description

The Technology Integration & Deployment subprogram supports the decarbonization of the transportation sector through various initiatives that accelerate the adoption of EVs and charging infrastructure. The program covers a broad technology portfolio that includes alternative fuels (e.g., advanced biofuels, electricity, hydrogen and, renewable natural gas) and energy efficient mobility systems. The successful deployment of these technologies can support the decarbonization of the transportation sector, strengthen national security through fuel diversity and the use of domestic fuel sources, reduce transportation energy costs for businesses and consumers, address the needs of underrepresented communities, and support energy resiliency with affordable alternatives to conventional fuels that may face unusually high demand in emergency situations.

At the national level, the Technology Integration & Deployment subprogram offers technical assistance, information resources, online training, and an array of data and analysis tools. At the local level, the subprogram manages and supports the Clean Cites coalitions that leverage these national resources to create networks of community stakeholders and provide hands-on technical assistance to communities and fleets. Clean Cities serves as a backbone for partnering with cities, towns, and rural areas across the country on clean transportation technology.

Technical Assistance and Demonstration: Support projects that provide information, insight, online tools, and technology assistance to cities, states, and regions working to implement clean transportation solutions and energy efficient mobility technologies and systems. Projects will demonstrate proof-of-concept of alternative fuel/advanced technology vehicles, charging infrastructure, new mobility systems for goods and people movement and modeling and simulation. For FY 2024, the activity will provide funding to support technical assistance activities that support the Communities to Clean Energy initiative. The activity will continue to provide technical support to the State and Alternative Fuel Provider regulatory program.

Data Collection and Dissemination: Collect and provide objective, unbiased data, information, and real-world lessons learned to inform future research needs and provide fleets and local decision makers with a suite of resources to identify and address technology barriers. This includes projects to disseminate data, information, and insights. For FY 2024, the activity will provide funding for the statutory requirements related to the Alternative Fuels Data Center and the annual Fuel Economy Guide.

STEM and Workforce Development: The EcoCar Mobility Challenge activity challenges 14 university teams to apply advanced powertrain systems, as well as connected and automated vehicle technology, to improve efficiency, safety, and consumer appeal. In FY 2024, student teams will complete and implement their vehicle design through hardware development and engineering and planning will commence for the next iteration of EcoCar with an emphasis on diversity, equity, and inclusion. The activity will continue to support and expand Workforce Development activities that address the needs of first responders, codes and safety officials, and automotive technicians.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Technology Integration & Deployment $106,000,000	**$117,162,000**	**+$11,162,000**
Technical Assistance $94,000,000	$105,162,000	+$11,162,000
• Track covered fleet compliance with annual alternative fuel vehicle acquisition requirements, in accordance with Title V of the Energy Policy Act of 1992. • Increase direct funding to expand the Clean Cities Coalition's work in communities across the country to help local decision makers and fleets understand and implement advanced technology vehicles and infrastructure, new mobility choices, and emerging transportation technologies. • Initiate funding support and technical assistance to communities in analyzing clean energy transportation needs • Initiate funding to support the Integrated Heavy-Duty ZEV Fueling Corridor Demonstration project. • Fund and implement Electric Vehicle Charging Community Partner projects to encourage strong local and/or regional partnerships to create an enduring local ecosystem to support increased consumer and business PEV use. Projects are encouraged to demonstrate various PEV applications by concentrating multiple sub-projects in a region or geographic area. Projects for consumers in underserved communities are a high priority. • New competitively awarded projects will focus on EV Charger Deployment with States to support the Administration's 500K EV Charging initiative. • Initiate a Smart Charging Vehicle-Grid Integration Project to demonstrate smart charging and business	• Track covered fleet compliance with annual alternative fuel vehicle acquisition requirements, in accordance with Title V of the Energy Policy Act of 1992. • Continue to support the Clean Cities Coalition's cooperative agreements to work in states and communities across the country to help local decision makers and fleets understand and implement advanced technology vehicles and infrastructure, new mobility choices, and emerging transportation technologies. • Fund support and technical assistance to communities in analyzing clean energy transportation needs. • No additional funds requested for Integrated Heavy Duty ZEV Fueling Corridor Initiative as it was a single year request for FY 2023. • Fund a new round competitively selected projects to engage with regional and local partners, especially underserved and energy communities, on planning, and to develop and demonstrate innovative technologies to enhance community resilience to physical hazards using distributed solar, energy storage, EVs, and other DERs (joint EERE-OE effort).	• Expand technical assistance activities to Clean Cities, Communities to Clean Energy, Community-Led Innovation Center and the Joint Office of Energy and Transportation. • Integrated Heavy Duty ZEV Fueling Corridor Initiative completed as it was a single year activity in FY 2023. • Increase Clean Cities collaboration with underserved communities to address environmental justice and meet the Justice 40 goals. • Implement projects which develop educational content and implement a brand-neutral outreach campaign to increase consumer familiarity with EV charging technology and terminology, increase consumer awareness of electric vehicle charging equipment availability, and dispel EV charger myths. • Fund a new round of competitively selected projects to address on-going barrier to the acceleration of EV's. Topic may include No Home Charing, MD/HD Fleet Electrification and EV Workforce Development.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
models that improve costs and efficiency for the acquisition and operation of new EV models for local governments, utilities, transit, schools, ports, and goods movement. • Fund competitively selected projects to engage with regional and local partners, especially underserved and energy communities, on planning, and to develop and demonstrate innovative technologies to enhance community resilience to physical hazards using distributed solar, energy storage, EVs, and other DERs (joint EERE-OE effort). • Funding for Super Truck III demonstration projects.		
Data Collection and Dissemination $8,000,000	**$8,000,000**	**+$0**
• In accordance with "Public Information Program" requirements in section 405 of the Energy Policy Act of 1992, update alternative fuel, vehicle, and infrastructure information, including station locator, cost calculator tool, incentives database, and fuel savings strategy information in the Alternative Fuels Data Center.	• In accordance with "Public Information Program" requirements in section 405 of the Energy Policy Act of 1992, continue to update alternative fuel, vehicle, and infrastructure information, including station locator, cost calculator tool, incentives database, and fuel savings strategy information in the Alternative Fuels Data Center. • In accordance with requirements in the Energy Policy and Conservation Act of 1975, publish and distribute the new model year Fuel Economy Guide, in partnership with the U.S. Environmental Protection Agency, update data and tools (e.g., Find-a-Car, Fuel Cost & Savings Calculator) and fuel economy information on www.fueleconomy.gov.	• No significant change

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• In accordance with requirements in the Energy Policy and Conservation Act of 1975, publish and distribute the new model year Fuel Economy Guide, in partnership with the U.S. Environmental Protection Agency, update data and tools (e.g. Find-a-Car, Fuel Cost & Savings Calculator) and fuel economy information on www.fueleconomy.gov	•	•
STEM and Workforce Development $4,000,000	$4,000,000	$0
• Implement the next EcoCar student competition. The EcoCar EV Challenge will challenge teams to apply innovative solutions to address equity and electrification challenges in the future of mobility, advanced powertrain, charging, and thermal systems to use grid electricity intelligently.	• Implement year 3 of the EcoCar EV Challenge.	• Teams will focus on vehicle design to develop connected and automated on-board sensors and bi-directional connectivity to implement energy efficient automated control systems.

Vehicle Technologies
Data, Modeling, and Analysis

Description

The Data, Modeling, and Analysis subprogram provides critical information and analyses to prioritize and inform Vehicle Technologies research portfolio planning through technology-, economic-, and interdisciplinary-based analysis, including target-setting and program benefits estimation. In FY 2024, projects will continue to support analytical capabilities and tools unique to DOE's National Laboratories. For data activities, trusted and public data are critical to VTO's efforts and are an integral part of transportation and vehicle modeling and simulation. For modeling activities, the subprogram supports the creation, maintenance, and use of vehicle and system models to explore energy impacts of new technologies relevant to the VTO portfolio. Finally, for analysis activities, integrated and applied analyses will bring together useful findings and analysis of the energy impacts of transportation systems through the integration of multiple models including vehicle simulation and energy accounting of the entire transportation system. The result creates holistic views of the transportation system, including the opportunities and benefits that advanced vehicle technologies create by strengthening national security, increasing reliability, and reducing costs for consumers and businesses. Overall, Data, Modeling, and Analysis activities explore energy-specific advancements in vehicles and transportation systems to inform Vehicle Technologies' early-stage research and offer analytical direction for potential and future research investments.

Data, Modeling, and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $6,000,000	**$9,185,000**	**+$3,185,000**
• Continue to support analytical capabilities and tools unique to National Laboratories, including expanding analysis to identify cost-efficient and equitable transportation decarbonization scenarios to inform and prioritize technology investments and research portfolio planning. • Solicit external (non-DOE/ Lab) perspectives, methods, and projects for increasing access to low-carbon mobility for underserved communities, through a combination of data collection, modeling, and related analysis on vehicle consumer markets with an emphasis on underserved communities and used vehicle markets, as well as EV infrastructure awareness and expected charging behavior.	• Continue to support analytical capabilities and tools unique to National Laboratories, including expanding analysis to identify cost-efficient and equitable transportation decarbonization scenarios to inform and prioritize technology investments and research portfolio planning. • Solicit external (non-DOE/ Lab) perspectives, methods, and projects for increasing access to low-carbon mobility for underserved communities, through a combination of data collection, modeling, and related analysis on vehicle consumer markets with an emphasis on underserved communities and used vehicle markets, as well as EV infrastructure awareness and expected charging behavior.	• Initiate efforts to identify cost-efficient and equitable transportation decarbonization scenarios to inform and prioritize technology investments, with emphasis on underserved communities. Increase data collection and analysis regarding increased EV penetration to quantify impacts on economy, grid, and communities.

Bioenergy Technologies

Overview

The Bioenergy Technologies Office (BETO) conducts research, development, and demonstration activities (RD&D) to enable a diverse supply of renewable waste streams and biomass as well as cost-effective conversion technologies nationwide emphasizing later stage demonstration to accelerate deployment of biofuels and bioproducts. As part of a comprehensive strategy to decarbonize all modes of transportation, BETO is primarily focused on production of "drop-in" biofuels that serve hard-to-electrify modes such as aviation and marine. The program also supports RD&D on converting biomass into high-value chemicals and products in support of decarbonizing the chemical industry, sustainable development of bioenergy crops, and the use of residues and low carbon agriculture practices to support climate smart agriculture.

The U.S. transportation sector overwhelmingly relies on petroleum, which supplies over 90 percent of its energy needs.[1] Aviation, marine, and heavy-duty vehicles account for 37 percent of transportation energy use.[2] These modes are projected to grow considerably faster than other modes and are more difficult to electrify, making drop-in biofuels a near-term option to reduce petroleum use and carbon-dioxide (CO_2) emissions. The Departments of Energy, Transportation, and Agriculture launched a government-wide Sustainable Aviation Fuel (SAF) Grand Challenge in September 2021.[3] The Grand Challenge aims to reduce cost, enhance sustainability, and expand domestic production and use of SAF to meet greater than 10 percent of domestic aviation fuel demand by 2030, and 100 percent of domestic aviation fuel demand by 2050.

The U.S. has the potential to sustainably produce enough renewable carbon resources to meet the demand for SAF and a variety of carbon-based chemicals. The availability and cost of renewable carbon resources vary geographically, and each resource type, such as agricultural waste, forestry waste, municipal solid waste, and purpose-grown energy crops, has its own unique technology challenges, market barriers and opportunities. BETO manages its R&D portfolio to enable the production of biofuels and bioproducts from the entire range of renewable carbon resources—demonstrating and supporting scale-up of the most viable, commercially-ready production systems, while continuing R&D on new production pathways that will be essential to meeting long-term decarbonization goals.

Highlights of the FY 2024 Request

- Increased funding for the scale-up of promising technical pathways that produce cost effective biofuels with a priority on the production of SAF. The major focus of the effort is to build demonstration-scale integrated biorefineries to de-risk technologies that will put the transportation sector on the trajectory for net-zero emissions by 2050. The successful scale-up and commercial deployment of these integrated biorefineries will contribute to decreasing CO_2 emissions by 450 million metric tons (MMT) per year by 2050.
- Increased funding for applied R&D on near- to mid-term technologies for production of low-carbon sustainable aviation and diesel fuels from a variety of feedstocks including through refinery integration of bio-oils derived from pyrolysis and hydrothermal liquefaction, as well as improved biological and catalytic processes for conversion of one- and two-carbon molecules (including CO_2) to fuels.
- Increased funding for RD&D to demonstrate the effectiveness of improved agronomic practices on reducing the carbon intensity of biomass resources across regional agronomic landscapes to generate predictive modeling tools and guidelines to support carbon negative feedstock supply chains.
- BETO is involved in several crosscutting initiatives, including the following:
    - Industrial Decarbonization to develop valuable chemicals and materials that can replace petrochemicals with renewable alternatives such as bioderived polymers and plastics;
    - Clean Energy Technology Manufacturing to replace petrochemicals with renewable alternatives such as bioderived polymers;
    - Energy-Water to provide technical assistance to communities on wet waste management strategies to address local challenges; and

[1] https://www.eia.gov/energyexplained/use-of-energy/transportation.php.

[2] Davis, Stacy C., and Robert G. Boundy. Transportation Energy Data Book: Edition 39. Oak Ridge National Laboratory, 2020, https://doi.org/10.2172/1767864.

[3] https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/09/fact-sheet-biden-administration-advances-the-future-of-sustainable-fuels-in-american-aviation.

- Biotechnology to develop bioengineering techniques to optimize production of fuels, chemicals, and materials in microbes.

BETO coordinates its outcome-driven applied R&D activities with the U.S. Department of Agriculture and six other agencies through the Biomass Research and Development Board to leverage resources and avoid duplication across the Federal Government. The program's transformational R&D is fostering partnerships that will support American industry and rural economies, including start-up enterprises, to create new jobs in emerging energy and manufacturing fields ultimately benefiting the U.S. economy and all Americans.

Bioenergy Technologies Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted	FY 2024 Request vs FY 2023 Enacted
Bioenergy Technologies					
System Development and Integration	70,500	92,600	145,500	+52,900	+57%
Renewable Carbon Resources (previously Feedstock and Algal System Technologies)	82,000	77,900	68,000	-9,900	-13%
Conversion Technologies	100,000	100,000	100,000	+0	+0%
Data, Modeling, and Analysis	9,500	9,500	9,500	+0	+0%
Total, Bioenergy Technologies	**262,000**	**280,000**	**323,000**	**+43,000**	**+15%**

SBIR/STTR:

- FY 2022 Transferred: SBIR $8,018,233; STTR $1,371,100
- FY 2023 Enacted: SBIR $8,643,000; STTR $1,215,000
- FY 2024 Request: SBIR $10,042,000; STTR $1,412,000

Bioenergy Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Bioenergy Technologies	
Systems Development and Integration: The increase in funding for this subprogram will support the upgrades to the Integrated Biorefinery Process Development Unit at NREL. The increase will also support pilot- and demonstration-scale biorefineries with a focus on producing sustainable aviation fuel (SAF), increasing the number of new biomass feedstocks that can be processed to final fuels, and new efforts to address persistent challenges in preprocessing and handling high-impact, biomass feedstocks such as corn stover.	**+52,900**
Renewable Carbon Resources (previously Feedstock and Algal System Technologies): Reduction in funding reflects the use of prior year funds for algae cultivar screening, optimization, and verification.	**-9,900**
Conversion Technologies: No major changes.	**+0**
Data, Modeling, and Analysis: No major changes.	**+0**
Total, Bioenergy Technologies	**+43,000**

Bioenergy Technologies
Systems Development and Integration

Description

The Systems Development and Integration subprogram (SDI) supports cost-shared RD&D with partners in industry, academia, and the National Laboratories focused on the development, testing, and verification of technologies at engineering-scale and includes integrated biorefinery process performance, development of novel methods to expand end-user acceptance of biofuel and bioproducts, and identification of new, robust market opportunities in the future bioeconomy.

Production Process R&D: This activity will fund the development, testing, and verification at engineering-scale, of new technology and feedstock pathways for integrated biorefineries to reduce technology uncertainty through cost-shared pre-pilot, pilot- and demonstration-scale biorefinery projects with industry. BETO will continue implementing its multi-year strategy to fill the pipeline as technologies are ready to scale, ultimately demonstrating enough feedstock-conversion variations, or production pathways, to support commercialization and meet the SAF Grand Challenge goal of 35 billion gallons per year SAF production by 2050.

Funds will initiate the upgrading of the integrated biorefinery process development unit at NREL to increase safety and enabling partnerships with industry to advance innovations at scale.

Fuels and Co-Products R&D: This activity area will identify fuel properties that can enhance engine efficiency and reduce emissions for multiple end uses, including SAFs, marine shipping, freight rail, medium- and heavy-duty vehicles, and non-road applications. This activity will support analysis, in coordination with the Department of Agriculture, the Department of Transportation, and other Biomass R&D Board agencies to accelerate the commercialization of SAFs.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Systems Development and Integration $92,600,000	**$145,500,000**	**+$52,900,000**
Production Process $92,368,000	$140,500,000	+$48,132,000
• Funding supports scale-up of biofuel production technologies at the pilot- and demonstration-scale with a focus on SAF. This includes algae-related demonstration activities.	• Scale-up of biofuel production technologies focusing on SAF to achieve BETO's goal for the successful construction and operation of at least four demonstration-scale integrated biorefineries by 2030.	• Increase will support the scale-up of multiple additional feedstock-conversion pathways with a focus on SAFs, including down-selects from existing awards.
• Continue work to focus primarily on process development units to verify R&D to produce drop-in biofuels from biomass feedstocks. New work will focus on technologies related to improving performance of lab capabilities to support technology scale-up, as well as the development of aviation, rail, and marine biofuels.	• Continue work using national laboratory process development units to verify R&D to produce drop-in biofuels for aviation, marine and rail from biomass feedstocks.	• Increases in this activity will support the equipment purchases and necessary improvements at the NREL Integrated Biorefinery Facility (IBRF).
• Continue efforts to demonstrate technologies and strategies to reduce greenhouse emissions from existing biofuel production, including implementation of sustainable agricultural practices and measures to improve efficiency or reduce emissions from fuel production.	• Prior year funding will support projects in this activity from previous competitive funding in 2022 and 2023.	• No funding is requested in order to prioritize development of new feedstock-conversion pathways to SAF.
• Initiate an activity to focus on challenges in processing high impact feedstocks, from the bale yard inside the plant into various types of conversion reactors. This initial effort will investigate feedstocks and conversion technologies that are expected to begin deployment post-2030.	• Address challenges in processing high impact feedstocks, from the bale yard inside the plant into various types of conversion reactors at relevant engineering scales.	• Increase will support the scaleup of technologies to process challenging feedstocks such as agricultural residues and energy crops that are essential to meet long-term goals for domestic SAF production.
Fuels and Co-Products R&D $232,000	$5,000,000	+$4,768,000

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support R&D and analysis, in coordination with the Department of Agriculture, the Department of Transportation, and other Biomass R&D Board agencies to accelerate the commercialization of SAFs.	• Continue R&D, analysis, and interagency partnerships to accelerate the commercialization of SAFs and explore non-CO_2 climate impacts of SAF formulations.	• Efforts will expand to assess how SAF blends can reduce the formation of contrails.
• Funding feasibility analyses to identify potential opportunities and challenges for the production and use of biofuels in the marine and rail sectors.	• Continue feasibility analyses for marine and rail sectors.	• No significant change

Description

To achieve SAF targets, the U.S. will need to produce enough sustainable, conversion-ready feedstocks including terrestrial-, waste, and aquatic- feedstocks. The goal of the Renewable Carbon Resources subprogram is to conduct R&D to enable the deployment of feedstocks for bioenergy applications. No single bioenergy feedstock can be sustainably produced at the volumes necessary to displace petroleum-derived fuels and chemicals. This subprogram addresses the unique technical challenges posed by each class of feedstock.

The Renewable Carbon Resources subprogram supports R&D in the following two activities:

Terrestrial and Waste Feedstocks R&D: This activity includes R&D, cross-cutting analysis, resource assessments, and workforce development efforts to lower the production costs and improve convertibility of terrestrial and waste resources. This includes: feedstock production, preprocessing, supply chain analysis, and the development of methods to identify, quantify, and mitigate supply chain risk for terrestrial and waste resources. This activity aims to increase the type and availability of feedstocks, including energy crops. This activity includes work on sustainable agriculture practices, including soil organic carbon sequestration, landscape design, and other climate-friendly soil, agriculture, and forest management work. Technoeconomic and life-cycle analysis is also supported by this activity. This R&D will lower cost and reduce risk by improving the operational reliability of equipment and process operation of integrated biorefineries, and the throughput and quality of finished products.

Aquatic Feedstocks R&D: This activity includes R&D, cross-cutting analysis, resource assessments, and workforce development activities to lower the production costs and improve yields of aquatic resources, including pond-cultivated algal systems. This includes: developing stable, high-yielding algal cultivars that resist predators suitable for farming operations; developing processes and technologies for microalgae crop protection; understanding the interface between harvested algae biomass and conversion processes, including the potential for water and nutrient recycle; improving carbon dioxide delivery and utilization; and integrating systems to optimize productivity and yield. This activity also supports technoeconomic and life-cycle analysis.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Renewable Carbon Resources $77,900,000	**$68,000,000**	**-$9,900**
Terrestrial and Waste Feedstocks R&D $45,229,000	$48,000,000	+$2,771,000
• Continue research on supply chain analysis and developing methods to identify, quantify, and mitigate supply chain risk.	• Continue research on supply chain analysis and developing methods to identify, quantify, and mitigate supply chain risk.	• No significant change
• R&D will produce a series of analyses that build upon the *Billion Ton Study* 2016 and addresses carbon sequestration, environmental justice, climate change, and end uses such as SAFs.	• Continue R&D that builds upon the Billion Ton Study.	• No significant change
• R&D will focus on the interface of carbon management and how sustainable agriculture, biogenic carbon drawdown and forestry can advance decarbonization priorities. Conduct preliminary assessment on barriers and opportunities on the use of energy crops to produce SAFs.	• Initiate R&D on employing climate smart agricultural practices across a variety of agronomic regions and energy crops to increase the amount of sustainable energy crops available for SAF.	• Increase funding for sustainable agriculture R&D and field testing of purpose-grown energy crops that are critical to reaching the Program's outyear SAF volumetric targets.
• Continue research under the Feedstock-Conversion Interface Consortium (FCIC) to improve the operational reliability of integrated biorefineries through increased understanding of biomass materials and the fundamental properties that govern feedstock behavior, energy density, and conversion performance.	• Complete research under the FCIC to improve the operational reliability of integrated biorefineries and identify future R&D strategies and priorities for FY 2025 and beyond to address challenges in feedstock handling and preprocessing.	• No significant change
• Continue research on harvest logistics and biomass analytics.	• Continue research on harvest logistics and biomass analytics.	• No significant change.
Aquatic Feedstocks $32,671,000	$20,000,000	-$12,671,000
• The Development of Integrated Screening, Cultivar Optimization, and Verification Research (DISCOVR) Consortium will focus on improving areal productivity and reducing biomass	• DISCOVR Consortium research to enable the production of sustainable, cost-effective, and conversion-ready algae feedstocks will continue using prior year funds	• No funds are requested. The DISCOVR consortium 3-year work plan was fully-funded up front in FY 2023 in order to increase funding for scale-up of integrated biorefineries.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
production costs, including developing crop protection strategies to prevent pond crashes.		
• Continue research on applications of foundational genomics for algae strains to harness algal diversity to improve productivity and quality.	• Continue research on applications of foundational genomics for algae strains to harness algal diversity to improve productivity and quality.	• No significant change
• State of technology cultivation trials will continue to verify R&D progress	• No funds are requested for state of technology cultivation trials.	• Funding for state of technology cultivation trials has been reprioritized to accomplish additional R&D to enable the production of sustainable, cost-effective, and conversion-ready algae feedstocks.
• Continue research in sustainable algae cultivation and opportunities to provide ecosystem services like wastewater treatment.	• Continue research in sustainable algae cultivation to increase sustainable energy crops available for SAF production. Algae cultivation to address ecosystem services like wastewater treatment will continue to be of interest.	• Increased focus on field testing of regionally-appropriate energy crops that are critical to reaching the Program's outyear SAF volumetric targets.

Description

The Conversion Technologies subprogram supports applied R&D to convert biomass and waste feedstocks into transportation fuels and bio-based chemicals and products. Conversion research explores concepts in both biological (using biological organisms) and thermochemical (using heat, pressure, and chemical catalysis) routes to convert biomass, waste feedstocks, and other complex organic polymers into drop-in biofuels (SAF, marine fuels, and renewable diesel), fuel components, and chemical intermediates of interest to hard-to-decarbonize areas of the economy. This research lowers technology uncertainty and establishes a knowledge base that supports industry to demonstrate and deploy novel technologies for their unique market opportunities. This applied research supports multiple biorefinery configurations that industry may pursue.

Bio-Processing R&D: Funding will continue to support R&D to reduce the time and cost for developing and implementing biological conversion of biomass and other materials into industry-relevant fuels, intermediates, and products. This includes organism development, metabolic pathway engineering and optimization, and novel approaches such as cell-free biocatalysis. One component of this effort, the Agile BioFoundry (ABF) consortium, applies synthetic biology tools and machine learning developed over the past few years to create commercial organisms for the production of SAF and bio-product intermediates.

Catalysts R&D: Funding will continue to support R&D to reduce the time and cost required to develop new inorganic catalysts for conversion of biomass and other relevant feedstocks into fuels, chemical intermediates, and products. This is being accomplished through advanced chemical and surface characterization techniques, novel and advanced catalyst preparation strategies, numerical modeling of surface chemistry and mass and heat transfer, as well as research to understand the performance and cost of various catalytic materials, support structures, and preparation methods. A principle implementing entity for the effort is the multi-lab ChemCatBio (CCB) consortium. This activity also supports research of electrocatalytic conversion of CO_2 to intermediates and use of chemical catalysis for conversion of intermediates to fuels, chemicals, and bioproducts.

Deconstruction and Synthesis R&D: This activity conducts R&D on technologies to convert biomass to fuels and products via well-defined conversion technology pathways. The activity investigates more energy efficient and cost-effective techniques for disassembling biomass feedstocks, employing the rich, functional nature of biomass, separating the constituents, and identifying catalytic, biochemical, and hybrid pathways to desired products (including those with enhanced performance characteristics). Additionally, this activity includes development of novel techniques for process measurement and control to benefit the R&D and industry.

Waste or residue materials is a widely available and relatively affordable feedstock for the production of fuels and products. Wastes such as animal waste, food waste, municipal solid waste (including plastics), and biosolids represent significant environmental challenges. The Waste-to-Energy component of this activity develops technologies to convert these wastes and residues into useful and valuable products including biofuels and bioproducts while also improving the quality of discharged water and reducing environmental impacts.

Separation processes can represent up to 40 percent of the capital and energy cost for many processes. Many separation techniques currently in use are either unsuitable for biobased processes or require costly and time-consuming trial and error approaches. The Bioprocessing Separations consortium under this activity is developing novel separation techniques specific to biorefineries.

Conversion Technologies
Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Conversion Technologies $100,000,000	**$100,000,000**	**+0**
Bio-Processing R&D $31,322,000	$34,000,000	+2,678,000
• The Agile BioFoundry will revise and implement their strategic plan to apply Design–Build–Test–Learn (DBTL) tools toward a focused set of organisms for the production of SAF via ethanol and lipids and production of chemical intermediates that can significantly reduce GHG emissions and demonstrate industrially-relevant titers, rates and yields. Continued work will expand Artificial Intelligence (AI) and machine learning and software capacity to improve the predictive design of organisms and pathways.	• Continue to execute the new strategic plan using DBTL tools, AI and machine learning to achieve commercially viable rate, titer and yield to specific product molecules using a focused set of organisms and with greater industrial partnership. Continue to expand artificial intelligence, machine learning and software capacity to improve the predictive design of organisms and pathways. The Advanced Biofuels and Bioproducts Process Development Unit (ABPDU) will continue the successful partnership with industry and other national labs to complete intermediate scale up of organisms and processes.	• The increase will explore the ABPDU's potential. R&D efforts will focus on developing specific organisms with defined products vs. generic design-build-test-learn tools and beach-head molecules.
• Biochemical conversion R&D will investigate carbon negative (or low carbon intensive) products/chemicals through the deconstruction of diverse types of biomass feedstocks.	• Biochemical conversion R&D will investigate carbon negative (or low carbon intensive) products/chemicals through the deconstruction of diverse types of biomass feedstocks.	• No significant change
Catalyst R&D $31,500,000	$33,500,000	+$2,000,000
• The Chemical Catalysis for Bioenergy (CCB) consortium will continue to accelerate catalyst and process development for bioenergy applications with a focus on SAF, marine/heavy duty fuels, and renewable chemicals. CCB will maintain and expand efforts on enabling technologies and core catalyst optimization capabilities such as ethanol and C1/C2 conversion to SAF that are instrumental in the decarbonization of transportation and industry. Catalyst	CCB will continue to accelerate catalyst and process development for bioenergy applications with a focus on SAF, marine/heavy duty fuels, and bioproducts. Enabling technologies and core catalyst optimization such as ethanol and C1/C2 conversion to SAF are instrumental in the decarbonization of transportation and industry. Catalyst performance and cost improvements should enable fuel pathways that reduce GHG emissions up to 70 percent compared to	• The increase will support research efforts focused on the most promising pathways to end-products through catalyst scale-up, syngas conditioning, and removing barriers to refinery processing of bio-derived intermediates.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
performance and cost improvements should enable fuel pathways that reduce GHG emissions up to 70 percent compared to petroleum fuels/products, at market competitive costs.	petroleum fuels/products, at market competitive costs.	
• Continue R&D on strategies to convert CO_2 to intermediates and subsequent intermediate upgrading to fuels and chemicals.	• Complete initial phase of R&D on the conversion of CO_2 to intermediates and upgrading to fuels and chemicals that could supply SAF (or other products that are difficult to decarbonize) to the market by 2050. Establish research priorities for FY 2025 and beyond.	• No significant change
Deconstruction and Synthesis R&D $37,178,000	$32,500,000	-$4,678,000
• Continue biochemical conversion R&D with focus on conversion of lignocellulosic biomass to upgradable intermediates primarily in the areas of improvements to pretreatment and hydrolysis.	• Continue biochemical conversion R&D with focus on conversion of lignocellulosic biomass to upgradable intermediates primarily in the areas of improvements to pretreatment and hydrolysis.	• No significant change
• Continue research, modeling and analysis on strategies to convert wet wastes to fuels, bio-based chemicals and products.	• Continue research, modeling and analysis on strategies to convert wet wastes to fuels, bio-based chemicals and products.	• No significant change
• Increase research under the Bioprocessing Separations Consortium to enable comprehensive and scalable bioprocess development with a focus on technologies and barriers identified as most central to value-added chemicals and fuels including separation of organic acids for conversion to aviation fuels.	• Continue research under the Bioprocessing Separations Consortium to enable comprehensive and scalable bioprocess development with a focus on technologies and barriers identified as most central to value-added chemicals and fuels including separation of organic acids for conversion to aviation fuels.	• No significant change
• Funding for industry partnerships to develop and commercialize renewable chemicals with a focus on lignin utilization.	• Projects selected in FY 2023 will continue using prior year funds.	• No funds are requested in order to prioritize funding for scale-up of integrated biorefineries.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Continue technical assistance for local governments/municipalities to address challenges related to management of organic wastes. Fund feasibility studies on the use of organic wastes to produce renewable natural gas or hydrogen for use in municipal fleets.	• Technical assistance program for local governments/municipalities to address challenges related to management of organic wastes will continue.	• No funds requested for feasibility studies to produce renewable fuels for municipal fleets. Technical assistance work will continue.
• The BOTTLE consortium, jointly funded with the Advanced Materials and Manufacturing Technologies Office, will continue to develop biobased plastics designed with superior recyclability and biodegradability as well as new methods to recycle and upcycle existing plastic waste.	• The BOTTLE consortium, jointly funded with the Advanced Materials and Manufacturing Technologies Office, will continue to develop biobased plastics designed with superior recyclability and biodegradability as well as new methods to recycle and upcycle existing plastic waste.	• No significant change
• Funding for research and testing of high-efficiency, low-emission wood stoves.	• Projects selected in FY 2023 will continue using prior year funds.	• No funds are requested for wood stoves in order to prioritize funding to address R&D challenges for the conversion of biomass to fuels and renewable chemicals.
• Performance-advantaged Bioproducts (PAB) R&D will focus on scaling up the identification and production of products that can be produced from biomass with some performance advantage over incumbent petroleum-based products with a focus on decreasing carbon intensity compared to the incumbent petroleum product by at least 20 percent while also being produced at a reduced cost.	• Performance-advantaged Bioproducts (PAB) R&D will continue to focus on scaling up the identification and production of products that can be produced from biomass with some performance advantage over incumbent petroleum-based products.	• No significant change
• Lignin valorization research to support cost effective biofuel production will continue through catalytic, solvent-assisted, and biological processes.	• Lignin valorization research to support cost effective biofuel production will continue through catalytic, solvent-assisted, and biological processes.	• Reduced funding for Lignin-to-products and fuels activities to focus on more promising pathways.

Bioenergy Technologies
Data, Modeling, and Analysis

Description

The Data, Modeling, and Analysis subprogram activities provide quantitative analysis to inform BETO's decisions regarding the future direction and scope of its RD&D portfolio. Activities include techno-economic, life-cycle, resource, impact, and risk assessments that provide the analytical basis for planning and assessing progress against program goals and cost targets. System-level analyses identify the key gaps in existing knowledge and where additional research could have the greatest impact. Decision support, data management, and analytical tools allow the program to identify and verify performance goals and measure progress toward these goals. The subprogram plays a key role in determining the most efficient ways to use bioenergy technologies to achieve the largest GHG emissions reductions for the least cost.

The subprogram's sustainability activities focus on developing science-based strategies to understand and enhance the environmental and socio-economic benefits of advanced bioenergy and bioproducts while minimizing potential negative impacts. This includes research targeting underproductive aspects of agricultural and forestry systems and leveraging the ability of biomass to improve degraded soil and water resources. Sustainability research also fills critical knowledge gaps about how to increase bioenergy production without detriment to food security, air, land, and water resources.

Data, Modeling, and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $9,500,000	**$9,500,000**	**+$0**
• Continue strategic analyses on current State of Technology and industrial pathways to optimize for GHG reduction and other key environmental factors, identifying strategies to accelerate progress toward decarbonization of transportation, industry, and agriculture.	• Continue strategic analyses on current State of Technology and industrial pathways to optimize for GHG reduction and other key environmental factors, identifying strategies to accelerate progress toward decarbonization of transportation, industry, and agriculture.	• No significant change
• Continue analysis initiated in FY 2022 to identify ways to address administration priorities in equity and environmental justice.	• No funding requested.	• Analysis completed in FY 2023. Findings from this analysis will be incorporated BETO project and portfolio management.
• Biomass can meet needs in reducing GHG This new analysis will examine the most impactful use of biomass to meet the administration goal of a 100 percent clean energy economy by 2050.	• Continue analysis on the optimal use of biomass to reduce GHG emissions across all sectors of the economy.	• No significant change
• Update models and tools (including the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies model and the Water Analysis Tool for Energy Resources model) to continue high-priority sustainability research and analyses.	• Update models and tools (including GREET and WATER) to continue high-priority sustainability research and analyses.	• No significant change
• Continue bioenergy sustainability research to quantify environmental and social sustainability benefits and identify and fill knowledge gaps related to land and water resources.	• Continue bioenergy sustainability research to quantify environmental and social sustainability benefits and identify and fill knowledge gaps related to land and water resources.	• No significant change

Hydrogen and Fuel Cell Technologies

Overview

Hydrogen and fuel cell technologies have a key role in addressing the climate crisis, enabling America's leadership in clean energy technology, and creating equitable opportunities for all Americans. Aligned with the Administration's goals for a carbon-free grid by 2035 and net-zero emissions by 2050, the benefits of hydrogen and fuel cell technologies will be significant in hard to decarbonize sectors, and span across transportation, power, industrial and chemical production applications.

In FY 2024, the Hydrogen and Fuel Cell Technologies Office (HFTO) will focus on research, development, demonstration, and deployment (RDD&D) of hydrogen production, storage and distribution, and end use technologies, including fuel cells, to make clean hydrogen affordable and accessible for all Americans. HFTO RDD&D activities align with broader programs at the HFTO and DOE Hydrogen Program level, including H2@Scale and the Hydrogen Energy Earthshot, and focus on reducing cost, achieving technology at scale, strengthening supply chain resilience, fostering workforce development, supporting environmental justice and coordinating collaborative and strategic partnerships including those with the national laboratories, the DOE Hydrogen Program Offices, Federal agencies, state and local governments, industry, and non-governmental partners.

Highlights of the FY 2024 Request

- Focus on applied fuel cell component and systems RD&D with emphasis on the Million Mile Fuel Cell Truck consortium (M2FCT) to enable fuel cells for long haul trucks.
- Emphasize applied RD&D on materials, components, systems, and process development to enable both the Hydrogen Shot goal of $1/kg of clean hydrogen and hydrogen storage and infrastructure technologies.
- No funding requested for electrolysis work, as it is funded under the Infrastructure Investment and Jobs Act's (IIJA) Clean Hydrogen Electrolysis provision.
- Focus on medium- and heavy-duty transportation, industrial and chemical applications, grid energy storage and power generation, and safety, codes, and standards. Evaluate marine, rail, aviation, and off-road equipment (e.g., mining construction, and agriculture equipment), and fuel cell systems for fast charging battery electric vehicles, steel and ammonia production, and integrate megawatt-scale electrolyzers with clean sources and store clean hydrogen for various applications.
- Focus data, modeling, and analysis on life cycle emissions and co-locating high volume hydrogen production and end use, in coordination with other DOE offices.
- Continue crosscutting initiatives, including the following:
    - Industrial Decarbonization to enable affordable carbon-free hydrogen to address hard-to-decarbonize industrial and chemical applications such as ammonia and steel production;
    - Clean Energy Technology Manufacturing to develop manufacturing processes for carbon fiber for on-board physical storage and hydrogen refueling components;
    - HFTO's entire portfolio contributes to the Hydrogen Crosscut;
    - Energy Storage including hydrogen production, hydrogen storage, advanced fuel cell technologies and systems integration RD&D;
    - Critical Minerals to reduce Platinum Group Metals (PGM) catalysts for fuel cells and hydrogen production technologies; and
    - Grid Modernization to research hybrid wind to hydrogen and includes funding for the National Renewable Energy Laboratory's Advanced Research on Integrated Energy Systems (ARIES) program.

Hydrogen and Fuel Cell Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Hydrogen and Fuel Cell Technologies					
Fuel Cell Technologies	30,000	30,000	25,000	-5,000	-17%
Hydrogen Technologies	61,000	67,000	61,000	-6,000	-9%
Systems Development & Integration	63,500	70,000	74,075	+4,075	+6%
Data, Modeling & Analysis	3,000	3,000	3,000	0	0%
Total, Hydrogen and Fuel Cell Technologies	**157,500**	**170,000**	**163,075**	**-6,925**	**-4%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $4,189,028; STTR: $704,360
- FY 2023 Enacted: SBIR: $5,024,000; STTR: $706,500
- FY 2024 Request: SBIR: $4,816,800; STTR: $677,363

Hydrogen and Fuel Cell Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Hydrogen and Fuel Cell Technologies	
Fuel Cell Technologies: Reduces R&D on materials and components to prioritize systems integration for heavy-duty transportation and stationary applications.	**-5,000**
Hydrogen Technologies: Reduces emphasis on activities related to liquid fueling components and liquid hydrogen storage tanks to prioritize gaseous hydrogen technologies in alignment with industry's near-term focus.	**-6,000**
Systems Development & Integration: Increases funding for demonstrations of new transportation applications (e.g., marine, rail, off-road, medium-duty) and heavy-duty hydrogen fueling infrastructure. Shifts focus from Grid Energy Storage and Power Generation to prioritize demonstrations of end use applications within Industrial and Chemical Applications.	**+4,075**
Data, Modeling & Analysis: No significant changes.	**0**
Total, Hydrogen and Fuel Cell Technologies	**-6,925**

Description

The Fuel Cell Technologies subprogram supports applied RD&D and innovative concepts to simultaneously reduce costs, improve durability and efficiency, and enhance performance of fuel cells (including power density, start-up time, transient response, robust operation, etc.) to enable competitiveness with incumbent and other advanced technologies. RD&D is focused on key materials and components that can have impact on a range of applications, including transportation and crosscutting applications such as stationary power (primary and backup), off-road applications, and energy storage. Because today's fuel cells rely on expensive Platinum Group Metals (PGM) as catalysts, one longer-term objective is to reduce the amount of PGMs while meeting durability, efficiency, and other performance requirements.

Materials and Component R&D: Supports membrane electrode assembly (MEA) and stack components. The primary areas of focus are catalysts, electrodes, membranes, and ionomers, which are critical to reaching the subprogram's targets. Improving fuel cell durability, efficiency, and performance will address priorities beyond transportation including grid resiliency, energy storage, and national space mission priorities. The program's M2FCT and ElectroCat National Laboratory consortia will continue to provide unique capabilities in synthesis, characterization, and computation to competitively selected projects.

Systems Integration R&D: Includes integrating MEAs and other stack components developed in the Materials and Component R&D key activity, into systems. Efforts include the developing and demonstrating fuel cell stacks and BOP components with manufacturability and sustainability in mind. Innovative concepts will be explored to enable optimal performance through better integration of components into subsystems and full systems across applications. Efforts are supported by modeling and will incorporate stack and BOP standardization approaches, and energy storage (e.g., unitized reversible fuel cells). Advances in these areas will enable the U.S. to retain global leadership, strengthen the supplier base, and expand domestic manufacturing capability.

Fuel Cell Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Fuel Cell Technologies $30,000,000	**$25,000,000**	**-$5,000,000**
Materials and Component R&D $23,000,000	$18,000,000	-$5,000,000
• Continue accelerating R&D on low-PGM MEAs with enhanced durability to enable meeting cost and durability targets across heavy-duty applications.	• Continue R&D on low-PGM MEAs with enhanced durability to enable meeting cost and durability targets across heavy-duty applications.	• No Significant Change.
• Continue R&D on PGM-free catalysts and electrodes (ElectroCat) to enable meeting cost and durability targets across applications.	• Focus R&D on most promising PGM-free catalysts and electrodes from prior year projects (ElectroCat) to enable meeting cost and durability targets.	• No Significant Change.
• Continue R&D beyond early-stage concepts, in coordination with M2FCT (e.g., gas diffusion layers) to strengthen the domestic supply base.	• Support RD&D to strengthen the domestic supply base in coordination with M2FCT.	• No Significant Change.
• Continue R&D on MEA components and MEAs to improve the durability and efficiency of MEAs for heavy-duty applications meeting ultimate targets.	• Continue R&D on MEA components and MEAs to improve durability and efficiency of MEAs for heavy-duty applications.	• Reduces activities on materials and components R&D to prioritize systems integration for heavy-duty applications while materials work from prior year projects is completed.
Systems Integration R&D $7,000,000	$7,000,000	$0
• Continue RD&D and systems integration, including stack and BOP components and manufacturing and standardization approaches to strengthen the domestic supply chain relevant to reversible and stationary fuel cells.	• Focus RD&D and systems integration relevant to stationary and transportation fuel cells to enable economies of scale across applications.	• Prioritizes R&D on reversible fuel cells and technologies for heavy-duty applications
• Demonstrate fuel cells for stationary power generation applications and reversible fuel cells for resiliency to support critical loads and disadvantaged communities	• Continue systems integration and demonstration of next generation fuel cells with potential to meet cost and durability.	• No Significant Change.
• Continue analysis on assessing hydrogen and fuel cell targets for various applications as well as status to guide future RD&D.	• Assess hydrogen and fuel cell target for various applications to guide future RD&D.	• No Significant Change

Hydrogen and Fuel Cell Technologies
Hydrogen Technologies

Description

The Hydrogen Technologies subprogram supports RD&D enabling clean, low-cost, and environmentally sustainable hydrogen production, storage, and infrastructure technologies to achieve the DOE Hydrogen Shot goal of $1/kg clean hydrogen by 2031. Key activities include addressing cost and performance of materials, components and systems related to hydrogen production, transport, storage, and dispensing across a range of technologies and applications.

Production R&D: Aligned with the Administration's climate goals and achieving the Hydrogen Shot goal, this activity addresses advanced water splitting pathways, while electrolysis activities are funded through the BIL's Clean Hydrogen Electrolysis Program. The key focus is reducing the modeled cost of clean hydrogen via direct photo-electrochemical (PEC), and high-temperature thermochemical pathways. This activity leverages the capabilities within the DOE National Laboratories through the multi-laboratory consortium HydroGEN. It also supports technologies with the potential to leapfrog those available commercially today. Approaches include dark-fermentation processes; microbial electrolysis; and hybrid systems that leverage nuclear, and renewable resources – including technologies that use biomass or industrial waste streams.

Storage R&D: This activity supports RD&D on advanced technologies for efficient, high-density, safe, and cost-effective hydrogen storage for stationary, transport, and mobile applications. RD&D activities include reducing the cost of carbon fiber composite tanks, and on advanced, innovative liquid hydrogen storage technologies. In FY 2024, activities will emphasize bulk and high-capacity storage technologies, including materials-based carriers for hydrogen transport and storage and other innovative concepts supported by the multi-laboratory Hydrogen Materials Advanced Research Consortium (HyMARC).

Infrastructure R&D: This activity supports work on materials, components, and processes to enable a low-cost, safe, and efficient hydrogen infrastructure to enable achieving the overall cost target for produced, delivered, and dispensed hydrogen across sectors. In FY 2024, emphasis will be on bulk and high-capacity delivery pathways, including pipelines. RD&D investigating and developing hydrogen compatible materials (e.g., metals, polymers) will continue in collaboration with the H-Mat consortium. Activities will be coordinated with FECM.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Hydrogen Technologies $67,000,000	**$61,000,000**	**-$6,000,000**
Production R&D $15,000,000	$15,000,000	$0
• Continue advanced water splitting R&D through HydroGEN and shift electrolysis efforts including H2NEW to BIL.	• Shift advanced non-electrolysis R&D technologies to component integration and reactor concepts as opposed to materials discovery.	• No significant change.
Storage R&D $22,000,000	$19,000,000	-$3,000,000
• Continue developing technologies to enable hydrogen use in medium- and heavy-duty transportation. Initiate activities for onboard liquid hydrogen storage and refueling for MD/HD applications.	• Focus RD&D on bulk and high-capacity materials-based carrier systems for hydrogen transport and storage and other innovative concepts.	• Reduces liquid hydrogen activities until data is collected from prior year projects. Prioritizing bulk and high-capacity technologies for storage and transport applications in alignment with industry priorities on gaseous hydrogen in the near-term.
Infrastructure R&D $30,000,000	$27,000,000	-$3,000,000
• Continue H-Mat materials compatibility RD&D, including impact of hydrogen blending on performance.	• Continue H-Mat materials compatibility RD&D.	• No significant change.
• Refocus HyMARC with a greater emphasis on higher TRL materials and system-level consideration.	• Continue HyMARC with focus on carriers that can transport hydrogen at high densities at low pressure and that do not require cryogenic temperatures, potentially for exports/alternate delivery approaches.	• Shifts focus to carriers that can transport hydrogen, potentially for applications such as export.
• Continue R&D on hydrogen fueling technologies, with an emphasis on liquid hydrogen handling, to accelerate progress on meeting needs for industrial and heavy-duty transportation applications.	• Focus on bulk and high-capacity infrastructure technologies for hydrogen transport applications, including pipelines and fueling component technologies.	• Reduces liquid hydrogen fueling component activities until data is collected from prior year projects. Prioritizing high-capacity infrastructure technologies for hydrogen transport applications, including pipelines, in alignment with industry priorities on gaseous hydrogen in the near-term.

Hydrogen and Fuel Cell Technologies
Systems Development & Integration

Description

The Systems Development and Integration subprogram focuses on technology acceleration, including integrating, developing, and demonstrating hydrogen end use technologies needed to expedite the commercialization of hydrogen and fuel cell systems, produce low cost, clean hydrogen in support of Hydrogen Shot and realize the H2@Scale vision. This includes focusing on integrating clean energy systems (i.e., grid energy storage and power generation), decarbonizing industrial and chemical processes, and demonstrating medium- and heavy-duty transportation applications. The subprogram also enables the development of codes and standards with an emphasis on large-scale hydrogen applications, developing and sharing best practices on hydrogen safety, and supporting workforce development.

Activities focus on accelerating the transition from RD&D to commercial viability by addressing the challenges of integrating components and systems for optimal performance, affordability, and durability and are coordinated with other DOE offices. For example, hybridized systems, such as coupling thermal sources with electrolyzers, can help reduce electricity requirements and improve efficiencies while the co-location of large-scale hydrogen generation with utilization can minimize the cost of transport and storage.

Transportation: Transportation activities will focus on demonstrating medium- and heavy-duty fuel cell applications. RDD&D will accelerate the development of fuel cell electric trucks and buses to reduce emissions and improve energy and operational efficiencies while providing operating range and fueling times on par with incumbent technologies. New market opportunities for hydrogen and fuel cells in heavy-duty transportation sector such as marine, rail, aviation, and off-road equipment (e.g., refuse trucks, mining vehicles) as well as modular, dispatchable fueling and fuel cell systems for fast charging battery vehicles, will continue to be evaluated and will include a demonstration. Transportation activities will be coordinated with EERE's Vehicle Technologies Office (VTO).

Industrial and Chemical Applications: Within hard-to-decarbonize industrial and chemical processes, this activity will focus RDD&D on demonstrating clean hydrogen's potential as a feedstock (e.g., ammonia production), or direct reducing agent (e.g., steel production), or to provide heat to industrial applications (e.g., steel and cement production).

Grid Energy Storage and Power Generation: This activity will focus on hybrid systems, grid integration, and energy storage of hydrogen to enable grid stability/resiliency, avoid curtailment, and produce low-cost, clean hydrogen. FY 2024 work includes integration of multi-megawatt water electrolyzers coupled with renewable energy and baseload nuclear sources.

Safety, Codes and Standards: This activity conducts R&D to enable the development of codes and standards for adoption of hydrogen and fuel cell technologies in support of H2@Scale and ensures safety considerations are incorporated into RDD&D projects, best practices are developed, and lessons learned are shared. Depending on the application, specific issues such as the amount of hydrogen that may be stored at a given location, the required hydrogen metering/flow rates, transport of hydrogen in tunnels, or the footprint restrictions onsite, must be addressed. Hydrogen behavior upon release at certain conditions (e.g., temperatures/pressures) must be understood to inform development of codes and standards. In addition, the global harmonization of codes and standards is critical to ensure a robust and competitive U.S. supply chain to serve domestic and international markets.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Systems Development & Integration $70,000,000	**$74,075,000**	**+$4,075,000**
Transportation $29,000,000	$40,000,000	+$11,000,000
• Continue funding industry-led teams focused on improving the energy and operational efficiency of moving freight with medium- and heavy-duty fuel cell electric trucks in support of SuperTruck as well as analyzing opportunities for other heavy-duty transportation sectors such as marine, rail, and off-road equipment.	• Continue funding industry-led teams focused on improving energy and operational efficiency of moving freight with medium- and heavy-duty fuel cell electric trucks in support of SuperTruck. • Support demonstration of another heavy-duty transportation application such as marine, rail, or off-road equipment. • Support fuel cell demonstrations for bus and fast charging electric vehicle applications. • Support high-flow, heavy-duty hydrogen fueling infrastructure.	• Increases funding for demonstrations of new applications (e.g., marine, rail, off-road, medium duty) and heavy-duty hydrogen fueling infrastructure.
Industrial and Chemical Applications $10,000,000	$16,000,000	+$6,000,000
• Continue industry-led projects to demonstrate use of clean hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production, in collaboration with other offices.	• Increase investment in industry-led projects to demonstrate use of clean hydrogen as a feedstock or direct reducing agent to decarbonize ammonia and steel production, and for thermal processing applications.	• Increases funding to demonstrate use of hydrogen for thermal processing required for industrial applications.
Grid Energy Storage and Power Generation $16,000,000	$8,075,000	-$7,925,000
• Continue industry-led projects for grid-integration with hydrogen technologies, including hybrid approaches, to enhance the stability/resiliency of the power grid and enable production of low cost, clean hydrogen. Specific focus will be placed on developing micro-grids for underserved communities.	• Continue industry-led projects for grid-integration with hydrogen technologies, including hybrid approaches, to enhance the stability/resiliency of the power grid and enable production of low cost, clean hydrogen.	• Reduces funding for grid integration with hydrogen technologies to prioritize demonstration for industrial end use activities.
• Continue systems integration and validations to guide R&D. Support NREL's Advanced	• Support systems integration and validation work, including ARIES effort, and net zero campus RD&D.	• Reduces systems integration to prioritize demonstration for an industrial end use application.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Research on Integrated Energy Systems (ARIES) effort and net zero campus RD&D.		
• Continue manufacturing related projects to help reduce the cost and improve the durability of fuel cells, electrolyzers, and other hydrogen components.	• No funding requested	• Transitions manufacturing related projects for fuel cells and electrolyzers to IIJA with FOA released in late FY 2023.
Codes and Standards $15,000,000	$10,000,000	-$5,000,000
• Continue R&D to enable the development of codes and standards (e.g., sensor R&D, risk assessment) with an emphasis on large-scale novel hydrogen end use applications, and ensure activities include safety considerations.	• Continue R&D that enables development of codes and standards with an emphasis on large-scale novel hydrogen end use applications, and ensure activities include safety considerations.	• No Significant Change.
• Further develop and share best practices and lessons learned by pursuing education, training, and workforce development activities.	• Continue developing and sharing best practices and lessons learned through education, training, and workforce development activities	• Reduces activities on workforce development to focus on R&D needs including sensor development, and codes and standards.
• Further develop resources to address regulatory and permitting barriers to hydrogen deployments. • Continue work on sensor development and leak quantification.	• Continue addressing regulatory barriers. • Continue work on sensor development and leak quantification.	• No Significant Change. • No significant change.

Hydrogen and Fuel Cell Technologies
Data, Modeling, and Analysis

Description

The Data, Modeling, and Analysis subprogram performs analytical research that informs HFTO's RDD&D direction and prioritization. Analyses include assessing impacts of hydrogen and fuel cell technologies on sustainability and decarbonization metrics, identifying synergies and interactions with other energy sectors, as well as assessing R&D gaps.

In FY 2024, the subprogram will increase emphasis on regional impacts and opportunities for low-cost clean hydrogen supply, including environmental justice metrics and transition scenarios, to inform targeted R&D and deployments. The subprogram develops, refines, and uses analytical models and tools, and develops program milestones and technology readiness goals. Modeling and analysis elucidate the total cost of ownership of hydrogen and fuel cell technologies in specific sectors, cost and performance requirements to displace incumbent fuels, regional impacts of deployments on criteria pollutant emissions and water resources, potential for job creation, and impacts on national climate goals.

Analysis efforts leverage outside activities, through coordination with other offices and agencies and support peer reviews and relevant activities under relevant legislation, including analyses supporting the interagency working group on hydrogen and fuel cells and public-private partnerships, such as the 21st Century Truck Partnership.

Data, Modeling and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling & Analysis $3,000,000	**$3,000,000**	**$0**
• Continue analytical research supporting national roadmap, that assesses regional impacts of hydrogen and fuel cell technologies (e.g., criteria pollutants, water).	• Perform analytical research to assess regional environmental impacts of hydrogen and fuel cell technologies and how changes in the energy system will affect future deployments.	• No significant change.
• Continue analysis of hydrogen for industrial applications, long-duration energy storage, synthetic fuels, and export opportunities, jobs, and address decarbonization and global sustainability impacts.	• Conduct analyses of hydrogen for industrial applications, long-duration energy storage, synthetic fuels, and export opportunities.	• No significant change.
• Continue to assess program milestones and technology readiness goals.	• Continue to assess program milestones and targets and refine targets as required.	• No significant change.
• Continue to assess cost and benefits of hydrogen and fuel cell technology deployments (e.g., job creation, regional emissions reduction), to inform first-of-a-kind demonstrations.	• Continue to assess cost and benefits (e.g., job creation, emission reductions) of hydrogen and fuel cell technology deployments to inform first-of-a-kind demonstrations.	• No significant change.

Renewable Energy Grid Integration

Overview

Achieving the nation's goals of a decarbonized electricity sector by 2035 and a net-zero economy by 2050 will require unprecedented increases in electricity generation from renewable energy resources, with the bulk of this new generation likely to come from wind and solar power.[1] To ensure the long-term reliability and resilience of the electricity system, the planning and operations of the power system must evolve to accommodate resources that are variable rather than dispatchable and based on power electronics rather than physically synchronized with the grid. To that end, the Renewable Energy Grid Integration (REGI) program in FY 2024 focuses on a holistic approach to grid integration challenges across many technologies and systems. These challenges include:

- Planning a Decarbonized Grid: This requires accommodating the increase of variable generation, addressing changes in system dynamic behavior, and addressing bidirectional flows of electricity from distributed energy resources and the seams between transmission and distribution.
- Developing Tools and Technologies to Operate a Decarbonized Grid: This requires determining viable pathways to a decarbonized grid; ensuring resource adequacy throughout the transition to a decarbonized power system; supporting the electrification of transportation, industrial, and other loads; and mitigating the growing threats from the impact of climate change and other physical and cyber threats.
- Addressing Infrastructure Needs and Interdependencies: This includes improving renewable energy project siting and permitting processes, as well as developing a better understanding of how to deploy additional system capacity; increase existing transmission capacity use; and account for the interdependencies between electricity, fuels, communication, and other infrastructures.
- Accommodating Diverse Markets, Policies, and Business Models: This includes supporting the development of market products and regulations that can support the integration of variable renewable energy by facilitating the mutual matching of generation and load, allowing for the optimization of energy storage, and ensure long-term incentives for power system flexibility and resource adequacy.

Addressing these challenges requires new technologies; improved data, tools, and models; and new analysis that directly supports decision-makers responsible for the planning, operation, regulation, and policies of the grid as a whole. To support system-wide decisions, it is critical that Office of Energy Efficiency and Renewable Energy's (EERE) efforts mirror the integration of the grid and themselves be developed and implemented in a way that integrates across technologies and offices.

For that reason, the EERE's REGI program-supported projects will be coordinated across the Renewable Power sector, leveraging staff and expertise within the wind, solar, geothermal, and water program offices, and coordinated closely with the grid-focused R&D in EERE's Sustainable Transportation and Energy Efficiency pillars and the Office of Electricity (OE). EERE's Grid Integration work will contribute to the Grid Modernization Initiative, focused specifically on technologies and tools that directly facilitate the integration of variable renewables and the value of dispatchable renewables like hydropower and geothermal. Further, investments in State and Local partnerships will support state and local governments with the necessary resources to be more effective in facilitating affordable and resilient clean energy and efficiency goals. Investments associated with Energy and Environmental Justice will support approaches and processes to reach new groups of Americans historically underserved by the energy system.

Highlights of the FY 2024 Budget Request

The Renewable Energy Grid Integration program will pursue the following major activities in FY 2024:

- Provide direct engagement with and support to local community organizations to help realize affordable, equitable pathways that meet local renewable energy objectives. Provide detailed planning support and simulated operations through national laboratory facilities. Cities and communities across the U.S. have committed to meeting their electricity needs with 100 percent clean energy. However, the paths to reach those goals are not always clear and will vary based on different priorities within communities (e.g., emphasis on local generation, threats to resiliency, costs, tax base needs). Successfully integrating larger amounts of renewable energy into a local power system requires both

[1] Solar Futures Study: www.energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf

deep technical expertise and local knowledge through in-depth partnerships with communities, developing cohorts to enhance peer-to-peer learning, and through short-term technical engagements.

- Scale up support for several DOE-wide crosscutting initiatives, focusing on Grid Modernization to expand power system planning and operations support to utilities and communities; provide analysis-based technical assistance to power system operators and regulators; demonstrate expanded provision of reliability services from wind and solar generation; and support the goals and objectives developed in the Grid Modernization Initiative.
- Support the transition to higher levels of variable, power-electronic-based resources, distributed generation, and electrification of load by developing and disseminating the data, modeling and simulation tools, and critical analysis required to support power system planning and operations. Analysis areas will include system interdependencies within and among power system infrastructures and other interrelated systems such as communications and transportation networks, which can have profound implications for the reliability and security of the energy system. Outputs will support a wide range of actors and institutions that shape the evolution of the U.S. electric grid. Activities will be coordinated closely with other technical assistance (TA) efforts in EERE, OE, the Office of Cybersecurity, Energy Security, and Emergency Response (CESER), and across the Department.
- Provide direct technical assistance and funding to states, local governments, tribes, and communities to build capacity for siting and permitting decisions around large-scale clean energy projects and infrastructure. Increasingly, state energy offices and commissions are being asked to address issues with local governments and communities on a suite of topics such as planning and zoning, environmental permitting, and land use. DOE will work with the National Laboratories and state government offices to create ready-to-use tools and guidance materials for stakeholders, increase access to trainings, and provide technical assistance to implement new energy initiatives.

Renewable Energy Grid Integration
Funding ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Renewable Energy Grid Integration	40,000	45,000	59,066	+14,066	+31%
Total, Renewable Energy Grid Integration	**40,000**	**45,000**	**59,066**	**+ 14,066**	**+ 31%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $0; STTR: $0
- FY 2023 Enacted: SBIR: $0; STTR: $0
- FY 2024 Request: SBIR: $256,000; STTR: $36,000[1]

Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Renewable Energy Grid Integration: Prioritize increase of FY 2024 investments to directly support decision-makers responsible for the planning, operation, regulation, and policies of the grid as a whole. This includes improved data, tools and models, new analysis, and local demonstrations, with projects focused both on common high priority technical areas and local-level system objectives. Specific projects include analysis-based technical assistance, technical assistance for siting and permitting of renewable energy projects, support for community-level grid planning, and the implementation of the Grid Modernization Initiative.	**+14,066**
Total, Renewable Energy Grid Integration	**+ 14,066**

[1] FY 2024 is the first year REGI is proposing to demonstrate expanded provision of reliability services from wind and solar generation. REGI was new in FY22, and in FY22 and FY23, has not supported projects beyond a deployment focus.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Renewable Energy Grid Integration $45,000,000	**$59,066,000**	**+$14,066,000**
• Provide detailed planning support, simulated operations through national lab facilities, and direct engagement with local community organizations through the Clean Energy to Communities Program to help integrate larger amounts of renewable energy into local power systems.	• Continue implementing the Clean Energy to Communities program to assist through community-led innovation to cities, communities, and utilities.	• Additional funding will accelerate clean energy solutions for communities in FY 2024 with a new round of community partnerships and topical cohorts.
• Develop planning tools and power electronics technologies as well as support the implementation of the Grid Modernization Initiative.	• Continued support for developing planning tools and power electronics technologies as well as support the implementation of the Grid Modernization Initiative.	• Additional funding will reinstate technical assistance for utilities to be able to analyze grid interactions.
• Support WETO and SETO to launch R-STEP (Renewable energy Siting through Technical Engagement and Planning), to provide technical assistance directly to State Energy Offices and local communities and build capacity for siting activities.	• Grow R-STEP as EERE's flagship siting program and plan for round two; continue to develop TA solutions and disseminate learnings to key energy stakeholders engaged in siting, permitting, and community acceptance.	• Additional funding will support collaboration with states and federal agencies and research on energy siting challenges, and will allow R-STEP to reach additional States and local communities to accelerate renewable energy deployment.
• Develop technical assistance solutions for a variety of stakeholders in key areas including distribution system planning, resource adequacy, electricity markets, and resilience to enhance grid reliability, decarbonization, affordability, and equity.	• Within the Department, EERE closely collaborates with OE and the Grid Deployment Office to cooperatively develop systematic solutions for emerging electricity system challenges with decision makers.	• The increase will accelerate the development of systematic solutions for emerging electricity system challenges, as well as allow the program to assist a wider array and larger number of stakeholders.
• Develop improved data, modeling and simulation tools, and provide new critical analysis required to support power system planning, operation and regulation with high levels of renewables.	• Continue funding analysis to determine the optimal path to decarbonize the electric power system while building resilience.	• Additional funding for new analysis will accelerate our clean energy analysis efforts in FY 2024 and provide guidance to industry.

Solar Energy

Overview

The Office of Energy Efficiency and Renewable Energy's (EERE) Solar Energy Technologies Office (SETO) accelerates the research, development and deployment of solar technologies while supporting the reliability, resilience, and security of the U.S. electric grid. The FY 2024 Request focuses on the complete roadmap of solar energy implementation: advanced research and development (R&D) to invigorate American technological leadership; validation of new technologies; supporting industry's development of a robust American supply chain; ensuring that there is a trained American workforce employed in the industry; reducing barriers to deployment; contributing to the decarbonization of the industrial sector and overall economy; supporting community resilience; and working to ensure the benefits of the transition to clean energy are shared with historically marginalized communities and those most affected by environmental justice inequities.

The solar resource is vast, and solar energy has the potential to be a substantial source of clean, affordable, and reliable electricity across the country. Meeting the 2035 goal for a carbon pollution-free electricity sector may require solar to supply approximately 40 percent of U.S. electricity, up from 4 percent today.[1] To reach a carbon pollution-free electricity sector, annual solar deployment needs to grow by 20 percent each year for the rest of the decade and be maintained to 2035. The domestic solar manufacturing sector likely needs to grow significantly as well. Today less than 20 percent of solar modules deployed in the U.S. are domestically made, and solar hardware installed in the U.S. averages only 40 percent domestic content, mostly in the form of the support structures (racking and trackers), not active components (e.g., photovoltaic (PV) modules and inverters). The lack of a full and robust domestic supply chain makes the U.S. reliant on China and Southeast Asia and susceptible to global supply chain disruptions from a variety of factors. Growing domestic manufacturing will create good-paying, stable jobs with the option to join a union and bargain collectively, while also increasing domestic energy security.

Currently, solar technologies can be deployed cost-effectively at both the large, utility-scale and at a smaller scale on the distribution system, where they offer opportunities for consumer choice, energy bill savings, local jobs, community ownership, and enhanced community resilience. Further unlocking solar energy's potential as an electricity source requires continued cost reductions, developing technologies to open new markets, removing barriers to deployment, growing the domestic supply chain, and enabling solar technologies to actively support the reliability, resilience, and security of the grid. Solar technology also has the potential to contribute to the decarbonization of the broader energy system through increased electrification, and the direct production of industrial process heat and solar fuels.

Today over 130 GW_{DC} of solar technology have been deployed across the U.S.,[2] a 60-fold increase since 2010. This increase in deployment has been a source of significant job growth, with the industry employing 334,000 workers in 2021.[3] Continued reductions in the cost of solar electricity are essential to enabling further growth in solar deployment and greater electricity affordability for consumers nationwide. As the regional supply of solar electricity increases, pairing solar with energy storage and other technologies becomes increasingly important to address the temporal mismatch between the supply of sunlight and shifting peak electricity loads. The costs of solar must continue to fall to make this broadly affordable. Accordingly, DOE recently accelerated its cost targets for utility-scale PV and Concentrating Solar Power (CSP) systems without subsidies – targets that could make solar electricity the lowest cost form of electricity in the U.S. with cost reductions of 50-60 percent from 2020 benchmarks for PV and CSP.[4]

As PV deployment becomes a larger share of electricity generation, it becomes critical that PV systems actively contribute to the reliability, resilience, and security of the electric grid. Already today, there are times in the year when solar and wind supply more than half of the demand for electricity in some regions. PV and wind technologies operate differently than conventional electricity generators due to their resource variability and fast power electronics. Learning to plan and reliably operate a grid with high penetrations of these resources requires R&D and demonstration. Further, PV technologies and other distributed energy resources (DERs) are fundamentally changing the distribution system. They are creating new

[1] DOE Solar Futures Study. www.energy.gov/eere/solar/solar-futures-study.
[2] Wood Mackenzie/SEIA U.S. Solar Market Insight® https://www.seia.org/us-solar-market-insight.
[3] "US Energy Employment Report," Department of Energy. USEER 2022 Main Body.pdf (energy.gov).
[4] V. Ramasamy et al., "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2021," NREL Technical Report, November 2021.

challenges related to generation and load forecasting, real time situational awareness, control coordination, system protection, and cyber-security. They also present new opportunities when coupled with energy storage and other distributed energy resources to provide grid services and enhance community resilience.

It is critical that cost reductions and other benefits from solar energy extend to all Americans, including those historically underserved by the energy system. Many of the challenges to achieving affordable, equitable deployment of solar across the country are a result of non-hardware costs (known as "soft costs"), which can include burdensome permitting; complex, lengthy, and expensive interconnection processes; lack of affordable financing; lack of locally available trained workers; and land-use competition for ground-mounted systems. In addition, nearly 50 percent of the population does not have the option to install their own solar energy system because they lack adequate roof or land space for placement or rent their housing. Addressing each of these barriers requires engaging with state and local governments, utilities, the solar industry, local communities, and other stakeholders on improved permitting and interconnection processes, innovative financing mechanisms, workforce training programs, and innovative siting strategies.

Highlights of the FY 2024 Budget Request

The Solar Energy Technologies Program will support a portfolio of research, development, demonstration, and deployment (RDD&D) activities in FY 2024, including:

- Investment to spur development across the U.S. solar supply chain and to catalyze solar innovation through the American-Made Solar Prize with the goal of growing the domestic solar manufacturing value chain.
- Development of dynamic models and tools for planning and operating a grid with rapidly increasing amounts of solar generation to enable an affordable, reliable, resilient, and secure carbon-free electric grid.
- Advancement of high efficiency PV technologies, cadmium telluride and perovskites, and improve durability and drive cost reductions toward the 2030 goal of $0.02/kWh while lasting 50 years.
- Improvement of interconnection and siting processes of solar and other clean energy technologies (with the Wind Office) and supporting growth of community solar with meaningful benefits such as low- to moderate-income access, greater household savings, resiliency, community ownership, and workforce development.
- Investment in 'Generation 3 CSP' technologies with a particular emphasis on piloting novel, large scale, autonomous heliostat fields and developing systems for use in industrial processes.
- SETO is involved in several DOE-wide crosscutting initiatives, including the following:
    - Industrial Decarbonization to support RD&D of low- and high-temperature systems difficult to decarbonize through electrification;
    - Clean Energy Technology Manufacturing to support the development of a sustainable, robust, and resilient American solar supply chain;
    - Hydrogen to support RD&D of concentrating solar thermal power systems that can be used for hydrogen production or in conjunction with hydrogen as a chemical feedstock;
    - Energy-Water to support the development of solar thermal desalination systems; Energy-Storage to focus on thermal energy storage as well as integration of battery storage and PV;
    - Critical Minerals to address potential PV deployment limitations related to materials scarcity; and
    - Grid Modernization to support RD&D of grid integration technologies at the bulk power and distribution system levels.

Within all SETO subprograms, the Solar Energy fellowship program funds emerging leaders in the field that will pursue breakthrough solar energy technologies or analysis at universities, National Laboratories, and other research facilities. In addition, funds will be used to support efforts such as merit/peer reviews, data collection and dissemination, technical assistance, and technology to market activities.

Solar Energy
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Solar Energy					
Concentrating Solar Power Technologies	60,000	60,000	70,000	+10,000	+17%
Photovoltaic Technologies	75,000	77,000	77,908	+908	+1%
Systems Integration	50,000	55,000	79,000	+24,000	+44%
Balance of Systems Soft Cost Reduction	60,000	56,000	77,000	+21,000	+38%
Manufacturing and Competitiveness	45,000	70,000	75,000	+5,000	+7%
Total, Solar Energy	**290,000**	**318,000**	**378,908**	**+60,908**	**+19%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $9,899,640; STTR: $1,339,871
- FY 2023 Enacted: SBIR: $8,092,000; STTR: $1,138,000
- FY 2024 Request: SBIR: $10,349,000; STTR: $1,455,000

Solar Energy Explanation of Major Changes ($K)	FY 2024 Request vs FY 2023 Enacted
Concentrating Solar Power Technologies: Increased funding will emphasize a pilot of advanced heliostat technologies for low-cost collection of high-temperature solar-thermal energy for electricity generation and industrial applications. Funding increase will also support additional R&D on high temperature power cycle components and processes for electricity generation.	**+10,000**
Photovoltaic Technologies: No significant net change in funding request. FY 2024 will increase funding for efficiency improvements to accelerate the next generation of solar cell devices because current structures are reaching efficiency limits. Funding for materials availability is reduced while the program awaits results of recent IIJA investments.	**+908**
Systems Integration: The FY 2024 Request increases funding for demonstration of technologies to operate and control a power system with increasing levels of solar energy. Funding for resilience and security is flat while awaiting results of projects funded in FY 2023 and prior years.	**+24,000**
Balance of Systems Soft Cost Reduction: The FY 2024 Request includes an increase in funding to research the impacts of, and equitable solutions for, large-scale solar siting. In addition, there is a requested increase in funding for the National Community Solar Partnership to expand the accessibility of solar energy to all Americans.	**+21,000**
Manufacturing and Competitiveness: The FY 2024 Request includes a modest increase to develop innovative product ideas that can substantively increase U.S. domestic manufacturing across the full solar supply chain, open new market segments, and expand private investment in America's manufacturing sector.	**+5,000**
Total, Solar Energy	**+60,908**

Solar Energy
Concentrating Solar Power Technologies

Description

The Concentrating Solar Power Technologies (CSP) subprogram works toward decarbonization of the electric power and industrial sectors by supporting RD&D of technologies that convert sunlight into thermal energy, which can be efficiently stored until it is needed for the production of electricity or for direct use in an industrial process. Because CSP technologies can efficiently incorporate long durations of thermal energy storage, they offer a path to supplying affordable and reliable solar power on demand.

Today there are nearly 2 GW of CSP technology deployed for electricity production in the U.S. Significantly increasing deployment requires cutting the costs of CSP electricity through technology improvements in the solar collector, thermal systems, and power cycles, as well as component integration and demonstrations of these advances at scale. The CSP subprogram aims to reduce the cost of CSP electricity at utility scale to help make CSP electricity cost competitive with electricity from other dispatchable sources.

CSP technologies can also provide an alternative to conventional fuels to drive industrial processes. Solar industrial process heat can be used for a range of applications including low temperature processes such as water desalination and food processing, and high temperature processes such as cement production, ammonia synthesis, steel manufacturing, and thermochemical water splitting for fuel production, among others. This subprogram coordinates its work with the Industrial Efficiency and Decarbonization Office to align with their Industrial Decarbonization Roadmap.

Thermal Systems R&D: This activity supports RD&D to test and integrate the components of a CSP thermal transport system capable of operation at substantially higher temperatures than today's commercial systems (i.e., 700 degrees Celsius or above), including the receiver, heat transport media, and thermal energy storage systems. This activity includes research into novel materials as well as manufacturing and fabrication methods of materials and components that will allow high temperature systems to be cost effective. To support the development of the Gen3 CSP megawatt-scale test facility, this activity will primarily, though not exclusively, focus on solid particles as the heat transfer medium. This activity also includes RD&D of thermal energy storage technologies in support of the Energy Storage Grand Challenge and Long Duration Storage Energy Earthshot, including work on a low-cost particle thermal storage media being developed for use in Gen3 CSP systems.

Power Cycles R&D: This activity supports RD&D of power cycles capable of net thermal-to-electric efficiency of 50 percent or greater. Support is particularly focused on power cycles that use supercritical carbon dioxide (CO_2) as the working fluid and have a capital cost of $900/kW-electric or lower, working in collaboration with FECM and NE. This activity also includes the development of primary heat exchangers that can transfer heat between high temperature thermal energy storage and supercritical CO_2.

Solar Collector R&D: This activity supports RD&D of solar collectors with installed capital costs less than $50 per square meter and the ability to maintain high accuracy through autonomous operation without the need for manual calibration. The primary activity in this area is the continuation of a National Laboratory consortium for heliostat research, development, and validation.

Industrial Applications R&D: This activity supports RD&D of industrial processes driven by solar thermal energy. Activities include both low-temperature systems focused on low-cost embodiments of existing technologies, and the development of components and system designs for high-temperature systems that are difficult to decarbonize through electrification. Low temperature systems in the range of 100 to 400 °C target a levelized cost of heat (LCOH) of 1 cent per kWh-thermal or lower, which would constitute at least a 50 percent decrease in current LCOH. This includes the development of thermal processes, including thermal desalination, which can efficiently couple with a solar thermal energy input. High temperature systems work includes the development of solar thermal pathways for the carbon-emission-free production of energy-intensive chemicals, commodities, and fuels, like ammonia, steel, cement, and hydrogen.

Concentrating Solar Power Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Concentrating Solar Power Technologies $60,000,000	**$70,000,000**	**+$10,000**
Thermal Systems R&D $20,851,000	$13,100,000	-$7,751,000
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on developing and analyzing high temperature components and systems related to Gen3 CSP and long-duration thermal storage among other projects.	• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on developing and analyzing high temperature components and systems related to Gen3 CSP and long-duration thermal storage among other projects.	• The decrease in funding reflects completion of some FY 2022-24 lab projects.
• Funding will focus on continued development of CSP systems and components, with a focus on long-duration thermal energy storage and development of solid particle-based heat transfer.	• A competitive solicitation will focus on high-temperature components and systems to enable cost-effective receivers and thermal energy storage for a range of CSP applications.	• The decrease in this program reflects a focus on a smaller subset of problems than in FY 2023 as the activity awaits results from ongoing projects.
• Support to the National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratories (SNL).	• Support to the NSTTF at SNL.	• No significant change.
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in thermal systems are eligible.	• Funding for FY 2024 competitive solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in thermal systems are eligible.	• No significant change.
Power Cycles R&D $4,794,000	$10,800,000	+$6,006,000
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on developing primary heat exchangers for advanced CO_2 power cycles.	• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on developing primary heat exchangers for advanced CO_2 power cycles.	• No significant change.
• No funds requested. Continue managing competitively selected projects from prior years to integrate high-efficiency, long-duration pumped thermal energy storage (PTES)	• A competitive solicitation will focus on continued development of materials and designs for primary heat exchangers for advanced CO_2 power cycles.	• The increase reflects new R&D awards that develop high temperature power cycle components and processes for CSP.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
technologies with advanced supercritical CO_2 power cycles.		
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in power cycles are eligible.	• Funding for FY 2024 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in thermal systems are eligible.	• No significant change.
Solar Collector R&D $15,299,000	$28,500,000	+$13,201,000
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. This work will focus on developing optical components and improved optical characterization methods for CSP collector fields.	• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. This work will focus on developing optical components and improved optical characterization methods for CSP collector fields.	• No significant change.
• Continue funding of a National Laboratory consortium test facility on heliostat development and validation.	• Continue funding of a National Laboratory consortium test facility on heliostat development and validation.	• No significant change.
	• A competitive solicitation will aim to pilot and de-risk novel, fully integrated autonomous heliostat fields, building on capabilities developed in the Heliostat Consortium	• New initiative to focus on solar collector cost and performance.
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in solar collectors are eligible.	• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in solar collectors are eligible.	• No significant change.
Industrial Applications R&D $19,056,000	$17,600,000	-$1,456,000
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on researching novel pathways for the solar thermal production of ammonia and hydrogen as a means to progress towards decarbonization of the chemical industry.	• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on researching novel pathways for the solar thermal production of ammonia and hydrogen as a means to progress towards decarbonization of the chemical industry.	• No significant change.
• Continue development of solar-thermal-driven industrial processes for decarbonizing the industrial sector. FY 2023 efforts will emphasize	• A competitive solicitation will continue to develop systems and components for solar-thermal-driven industrial processes. FY 2024 efforts will respond to strategic RD&D needs	• Decrease in funding reflects prioritization of other activity areas while SETO assesses progress of ongoing research and development supported with FY 2022 and FY 2023 funding.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
more mature demonstrations to accelerate deployment.	identified within crosscutting Energy Earthshots as well as compliment research thrusts from the awards made within the FY 2022 Solar Industrial Decarbonization FOA topic.	
• Funding for FY 2023 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in industrial applications are eligible.	• Funding for FY 2024 broad solicitation on 1-year innovative seedling R&D projects for CSP research. All topics in industrial applications are eligible.	• No significant change.

Solar Energy
Photovoltaic Technologies

Description

Achieving the President's 2035 goal for a carbon pollution-free power sector requires a large growth in total U.S. photovoltaic (PV) capacity and annual deployment rate. The Photovoltaic Technologies subprogram works to enable this acceleration by reducing the costs of PV electricity while also ensuring that deployed PV systems perform as expected and last up to 50 years. The PV subprogram supports RD&D that advances foundational knowledge and tackles scale-up and fabrication challenges for technologies that increase efficiency and durability while simultaneously reducing cost. Furthermore, the PV subprogram aggregates and analyzes performance data from PV systems deployed across the Nation to identify trends and best practices. Since 2010, the cost of PV electricity has declined over 80 percent, yet significant opportunity remains to continue to reduce costs to reach SETO's cost target for unsubsidized, utility-scale systems from today's current utility-scale benchmark. Reaching such a cost target would enable greater electricity affordability in addition to increased PV deployment.

The PV R&D subprogram advances state-of-the-art and emerging PV cells, modules, systems, and their components, spanning work from early-stage solar cell research up to commercialization. Specifically, the subprogram seeds research to advance materials processes and device design approaches that enable higher PV performance and reduced cost, as well as better predictability and understanding of long-term reliability. Key thrusts include the development and validation of perovskite technologies, a national research consortium to improve cadmium telluride (CdTe) efficiency, new tools to predict system performance through monitoring and data analysis, and a portfolio of research at the National Laboratories advancing PV cell efficiencies, understanding PV system degradation rates and lifetime performance, and developing new characterization techniques. Furthermore, the PV subprogram identifies and works to overcome material and environmental constraints that could inhibit the rapid acceleration of PV deployment such as the availability of silver (Ag), as well as the disposal and recycling of PV systems.

Conversion Efficiency R&D: This activity supports R&D to increase the power conversion efficiency and reduce the manufacturing costs of PV cells and modules, spanning established and emerging materials. Two solar cell absorber materials receive specific focus in this research area – cadmium telluride (CdTe) and perovskites. Cadmium telluride (CdTe) is the largest domestically manufactured PV technology and the second most deployed technology, behind silicon-based solar modules. Perovskites are a promising next-generation PV technology currently being researched in labs across the country with the potential to achieve high efficiencies at low costs. Strategic investments in these technologies now can reduce PV costs and position the U.S. to be a global leader in solar manufacturing for years to come. This activity also includes research in improved PV system design to increase energy production in real world operating conditions. Efforts include development of new characterization tools and techniques to build materials and device knowledge and connect with analysis of fielded systems and key performance metrics.

Durability R&D: This activity supports RD&D to better understand and mitigate performance degradation of PV systems to enable 50-year lifetimes, resilience to extreme weather conditions, and application in dual-use settings, such as PV on agricultural land and building integrated PV systems (BIPV). Activities include development of robust and reproducible accelerated degradation protocols to simulate outdoor degradation mechanisms of PV systems to predict and reduce failure and better estimate lifetime. The subprogram's support has a strong emphasis on developing test conditions that accurately reproduce degradation observed in fielded modules, and therefore includes destructive testing of harvested modules and comparison of accelerated test results.

Materials Availability R&D: This activity supports R&D to better understand how the availability and environmental impacts of key materials used in PV systems could constrain domestic PV manufacturing and deployment, and R&D to mitigate these materials constraints to enable rapid scale-up of the domestic solar industry. Activities include efforts to 1) reduce the use of silver (Ag), tellurium (Te), and indium (In) in modules; 2) advance materials recovery techniques; 3) develop PV systems that are easily recycled; and 4) improve long-term reliability and manufacturing of lead-free modules. The work in this activity is also supported by the Infrastructure Investment and Jobs Act (IIJA) (Section 41007(c)(3)).

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Photovoltaic Technologies $77,000,000	**$77,908,000**	**+$908,000**
Conversion Efficiency R&D $42,020,000	$35,288,000	-$6,732,000
• Funding to maintain FY 2022-24 projects to advance PV cell and module performance for National Laboratory research programs that were initiated in FY 2022.	• Funding to maintain FY 2022-24 projects to advance PV cell and module performance for National Laboratory research programs that were initiated in FY 2022	• The decrease reflects the completion of some FY 2022-24 lab projects.
• Funding for 1-year innovative seedling R&D projects focused on material constraints and reducing PV system waste at end of life.	• Funding for FY 2024 FOA topic on 1-year innovative projects for PV research.	• No significant change.
• Funding for FY 2023 FOA on thin film PV to increase performance.	• Funding for FY 2024 FOA Topic to address high efficiency cell and modules.	• No significant change.
• Funding for additional competitive projects to augment the CdTe consortium and maintain CdTe consortium research support at NREL.	• Funding for additional competitive projects to augment the CdTe consortium and maintain CdTe consortium research support at NREL.	• No significant change.
Durability R&D $31,194,000	$37,620,000	+$6,426,000
• Funding to maintain DuraMat consortium under new scope of work for FY 2022 – FY 2024. In FY 2023, the consortium will run an external solicitation for external participation, validate an accelerated testing approach using fielded module data, and develop a new analytical technique to support the planned work in FY 2024.	• Maintain DuraMat consortium led by NREL to perform research dedicated to modeling and measuring durable materials for PV modules including advanced encapsulants and flexible packaging concepts.	• No significant change.
• Funding to maintain FY 2022-24 projects for National Laboratory research programs that were initiated in FY 2022. Work focuses on researching PV degradation pathways, develop standard tests, and mitigation strategies.	• Funding to maintain FY 2022-24 projects to advance PV cell and module performance for National Laboratory research programs that were initiated in FY 2022.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Funding to support research building on durability work and expanding into non-destructive balance of material testing, resilient operation, durability of dual-use PV systems, and PV system power-electronics durability. An additional FOA will support funding to research thin film PV durability that focuses on perovskite and CdTe technologies.	• Funding for FY 2024 FOA Topic to address durability of high efficiency cell and modules.	• Increase in funding will focus efforts on the reliability and durability of high efficiency photovoltaic modules and cells.
• Additional competitive projects that augment the existing CdTe consortium will be funded. Funding requested to maintain CdTe consortium research support at NREL under the FY 2022-2024 core agreement.	• Additional support for the CdTe research and industrial consortium to support projects on increasing the long-term durability of the CdTe systems to enable greater LCOE reduction.	• No significant change.
Materials Availability R&D $3,786,000	$5,000,000	+$1,214,000
• Research on reducing the use of silver (Ag) and other limiting materials in modules, materials recovery techniques for PV systems, developing systems that are easily recycled, and long-term reliability and manufacturing of lead-free modules.	• Fund additional work looking at how to reduce materials usage in high efficiency PV devices.	• Increase in funding for additional R&D projects.

Solar Energy
Systems Integration

Description

The Systems Integration (SI) subprogram, in coordination with the DOE Grid Modernization Initiative (GMI) and Energy Storage Grand Challenge (ESGC), funds RD&D of technologies that better enable solar energy to support the reliability, resilience, and security of the electric power system. Meeting the President's goal for a carbon-free power sector may require solar to provide approximately 40 percent of U.S. electricity by 2035.[1] This entails continued rapid growth of solar PV deployment, which supplies only 4 percent of U.S. electricity today. PV technologies cause challenges for power system operation due to their variable nature, fast-responding power electronics, and their deployment on both the bulk power and distribution systems. There are over three million PV systems connected to the distribution system today, and this number is growing steadily. At the same time, the power system itself is evolving rapidly with the deployment of digital sensors and communication networks and the integration of new distributed energy technologies.

PV, wind, and battery storage technologies operate fundamentally differently than conventional power generators owing to the power electronics that are their interface with the grid. Already today, there are regions of the U.S. that experience times where wind and PV can supply over half of the instantaneous power. As deployment of these technologies further increases, it is critical that they can provide essential grid services such as voltage and frequency regulation. These capabilities have been demonstrated in isolated testing, but more RD&D will help grid operators and regulators to rely on these technologies to support all aspects of grid reliability.

The SI subprogram addresses the key technical challenges in solar grid integration by focusing on power system planning, generation variability, system inertia, operational flexibility, voltage and frequency control, real time situational awareness, system protection, cybersecurity, black start capability, and optimal power flow control. In addition, it advances opportunities for PV, coupled with energy storage and other distributed energy resources (DERs), to enhance community resilience through reconfiguration to supply critical loads in the event of an outage. Further, the SI subprogram supports the development of industry standards and best practices on solar interconnection requirements, testing, and validation methods.

Planning and Modeling R&D: As more PV is added onto the electric grid, utilities and power system operators need to plan for a variety of scenarios to balance electricity generation from solar and other sources with customer demand. This activity focuses on modeling and simulation methodologies and software tools for medium- to long-term planning for solar grid integration under various deployment scenarios, including optimal placement of PV and energy storage, the potential need for transmission and distribution upgrades, interconnection requirements and reliability standards. This activity supports projects that address challenges in solar generation variability and uncertainty, resource forecasting and adequacy, system control stability, system flexibility, and co-optimization.

Operation and Control R&D: As PV's share of electricity generation increases, utilities and power system operators need real-time information about and control capabilities for this generation to reliably operate the grid. This activity focuses on hardware and software technologies to enable real-time situational awareness and coordinated control to ensure system reliability during normal and abnormal operating conditions. It supports projects that address challenges in power electronic devices, sensing and communication, system protection and fault recovery, dynamic power flow control, grid services, and data analytics using artificial intelligence and machine learning.

Resilience and Security R&D: The deployment of distributed PV and other DERs can provide greater resilience to energy infrastructure and community services. This activity focuses on technologies that integrate distributed PV, energy storage, and other DERs to provide continuity of electric power service for critical infrastructure and critical loads and to reduce the magnitude and/or duration of disruptive events such cyberattacks, hurricanes, floods, and wildfires. This activity supports projects that advance the detection and situational awareness of threats and enhance PV and the power system's capabilities of anticipating, absorbing, adapting to, and/or rapidly recovering from a potentially disruptive event.

[1] DOE Solar Futures Study. www.energy.gov/eere/solar/solar-futures-study

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Systems Integration $55,000,000	**$79,000,000**	**+$24,000,000**
Planning and Modeling R&D $11,514,000	$30,000,000	+$18,486,000
• Funding to maintain FY 2022-FY 2024 lab call projects and support new lab projects. Work will focus on dynamic models for PV and power systems, high resolution measurement data, solar resource forecast and integration, reliability standards, and testing and validation.	• Funding to maintain FY 2022-FY 2024 lab call projects and support new lab projects. Work will focus on dynamic models for PV and power systems, high resolution measurement data, solar resource forecast and integration, reliability standards, and testing and validation.	• No significant change.
• Funding to support competitively selected projects to develop better methodologies and software tools for grid planners to conduct long-term power system planning for integration of high amounts of solar at the distribution and bulk grid levels. This includes the better incorporation of weather models for resource adequacy assessment during extreme events. This effort will also support innovations in grid planning process. This is an EERE and OE collaboration.	• Funding to support new competitively selected projects to develop uniform and standardized methodologies, tools, and processes for grid planners and solar project developers to interconnect and integrate high amounts of solar in near- and long-term system planning. This includes the better incorporation of weather models for resource adequacy assessment, accurate modeling of solar PV plant controllers, and stability and contingency analysis. This is an EERE and OE collaboration.	• The increase will expand this area of research with stronger focus on demonstration and collaboration with industry.
Operation and Control R&D $38,505,000	$44,000,000	+$5,495,000
• Funding to develop better tools for grid operators to reliably monitor and control a power system that has high amounts of solar generation at the distribution and bulk grid levels. This includes the better incorporation of weather forecasts and real-time measurements for predicting solar irradiance and other variable renewables generation as well as loads. This is an EERE and OE collaboration.	• Funding to support new competitively selected projects to develop and field demonstrate new tools for grid operators to reliably monitor and control a power system that has high amounts of inverter-based solar generation at the distribution and bulk grid levels. Topics may include improvement and integration of load and generation resource forecasting, enhanced situation awareness of the entire grid (including DERs), advanced sensing technologies, power electronic controls, and evaluation of the impact	• The increase will expand this area of research with stronger focus on demonstration and emphasis in advanced sensing technologies and power electronics controls.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	to market operations. This is an EERE and OE collaboration. • Fund new competitively selected projects to demonstrate the benefits of operational flexibility from multiple technologies including solar PV, electric vehicle, grid-interactive building, energy storage, and other DERs to improve clean energy deployment, grid reliability, and economic efficiency. This is an EERE and OE collaboration.	• New joint-effort which builds on the previous Connected Communities activities.
Resilience and Security R&D $4,981,000	$5,000,000	+$19,000
• Funding to maintain FY 2022-FY 2024 lab call projects and support new lab projects. Work will focus on addressing cybersecurity challenges in solar grid integration including technology development, standard development, testing and validation, and information sharing.	• Funding to maintain FY 2022-FY 2024 lab call projects and support new lab projects. Work will focus on addressing cybersecurity challenges in solar grid integration including technology development, standard development, testing and validation, and information sharing.	• No significant change.

Solar Energy
Balance of Systems Soft Cost Reduction

Description

The Balance of Systems Soft Cost Reduction (BOS) subprogram focuses on reducing the non-hardware costs of solar electricity, enabling the benefits of solar energy to reach all Americans, and developing a skilled and diverse workforce with access to good-paying jobs with the free and fair option to join a union and bargain collectively. The non-hardware, or soft costs, of solar energy include siting, permitting, inspection, interconnection, labor, project development, customer acquisition, financing, and other related costs. Taken together, soft costs constitute about 65 percent of total system prices for residential PV systems, 57 percent of commercial PV systems, and 36 percent of utility-scale systems.[1] Reaching the DOE 2030 solar cost targets will require significant reductions in soft costs without impacting the wages, benefits, safety, and quality of work.

Reducing soft costs requires engaging with community organizations, state and local governments, Tribes, developers, utilities, and other stakeholder groups to understand barriers; develop collaborative research, tools, and processes; and broadly disseminate results and best practices to enable replication and scalability. For example, improving permitting for large-scale solar development and host communities requires collaborative research and engagement on topics such as solar planning and zoning, environmental impacts and benefits, land use competition, and innovative siting practices.

Rooftop solar offers opportunities across the country for consumers to save money on electricity bills and reap other benefits such as local energy resiliency. However, about half of U.S. households cannot access rooftop solar due to roof shading, financing barriers, or lack of home ownership.[2] Community solar has the potential to overcome these barriers, and SETO aims to enable community solar to power 5 million households with one billion dollars in savings by 2025.

The solar industry has been one of the fastest growing employment sectors over the past decade, providing 334,000 jobs in 2021. SETO builds partnerships across the clean energy workforce, supports strong skills development, and increases the ease for new people to enter the clean energy workforce, with a particular focus on frontline communities, military veterans, returning citizens, and those currently or formerly working in fossil fuel industries. SETO's efforts will increase access to all clean energy workforce careers, including pathways to family-sustaining wage positions and labor organization membership. SETO coordinates with other EERE offices and the Departments of Labor and Education on shared priorities.

Data, Modeling, and Analysis: This activity focuses on foundational data collection, modeling, and analysis to benchmark soft costs, understand barriers to solar and solar plus storage deployment, and evaluate the effectiveness of proposed solutions. This includes data and analysis to increase market transparency, assess solar plus storage value in providing reliability and resiliency, expand access to solar energy, evaluate alternative siting approaches, and open new markets.

Technical Assistance and Stakeholder Tools: This activity supports technical assistance to help solar stakeholders reduce soft costs and overcome barriers to solar and solar plus storage deployment. This includes technical assistance on solar siting, interconnection, community solar, permitting, workforce training, and financing solar for low-income households. Stakeholders include state, local, and tribal governments; the solar industry; utilities; public utility commissions; community-based organizations; and others. This activity also supports the development of an online enrollment platform to facilitate low-income participation in community solar.

STEM and Workforce Development: This activity supports cross-EERE STEM and workforce programs to enable diverse workers to benefit from the clean energy economy. This activity also includes a program placing participants at organizations to conduct research and stakeholder engagement activities that facilitate the deployment and the integration of solar energy onto the electric grid, as well as a competition that prepares college students for careers in clean energy.

[1] V. Ramasamy et al., "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2021," NREL Technical Report, November 2021.
[2] D. Feldman et al. "Shared Solar: Current Landscape, Market Potential, and the Impact of Federal Securities Regulation," NREL Technical Report NREL/TP-6A20-63892 (April 2015). https://www.nrel.gov/docs/fy15osti/63892.pdf.

Balance of Systems Soft Cost Reduction

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Balance of Systems Soft Cost Reduction $56,000,000	**$77,000,000**	**+$21,000,000**
Data, Modeling, and Analysis $10,887,000	$22,000,000	+$11,113,000
• Maintain National Laboratory FY 2022-24 projects to advance data, modeling, and analysis for the reduction of solar soft costs.	• Funding to maintain FY 2022-24 national lab projects and support new competitively selected projects to advance data, modeling, and analysis for the reduction of solar soft costs.	• No significant change.
• Support EERE and cross-DOE data, tools, and analysis projects to facilitate the widespread integration of renewables in a resilient, reliable power system.	• Support competitive solicitation to research the impacts of solar energy on communities and the environment and enable innovative and equitable solutions for solar siting.	• Increase in funding reflects new projects which will focus on addressing solar siting impacts.
Technical Assistance and Stakeholder Tools $37,313,000	$49,250,000	+$11,937,000
• Expand the National Community Solar Partnership by launching the National Community Solar Partnership Community Power Accelerator prize which supports pre-development and other gap funding needs to bring community solar with local benefits to market.	• Continue to expand the National Community Solar Partnership Community Power Accelerator by providing prize funding to support pre-development and other gap funding needs for the rapid deployment of community solar that includes local benefits.	• Increase in funding to support a Prize Challenge for the Community Power Accelerator.
• Expand the National Community Solar Partnership and continue technical assistance and research to reduce barriers to rapid deployment while meeting the target of increased access to low-income households, increased energy savings, increased job creation, increased consumer awareness, and resiliency.	• Continue to expand the reach of the National Community Solar Partnership focused on capacity building and technical assistance for community-based solar and clean energy deployment with local benefits.	• New projects focused on building local capacity for community solar development.
• Develop and launch an online platform to improve and make easier low-income household enrollment in community solar programs.	• Continue support for the low-income household community solar enrollment tool.	• No significant change.
• Support additional multi-stakeholder team participation in the Solar Energy Innovation	• Support additional multi-stakeholder team participation in the Solar Energy Innovation	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Network and the replication of solutions developed in previous rounds of the program.	Network and the replication of solutions developed in previous rounds of the program.	
• Provide local governments, utilities, and other stakeholders with technical assistance on solar grid interconnection via the Interconnection Innovation Exchange (i2x).	• Support the Interconnection Innovation Exchange (i2X), a technical assistance program to enable improved interconnection of clean energy technologies to the grid (with WETO).	• Decrease in funding to focus on technical assistance while FY 2023 funded projects are carried out.
• Support technical assistance to help regulators address barriers to the affordable and equitable deployment of solar and other clean energy technologies (with EERE and OE).	• Support technical assistance to help regulators address barriers to the affordable and equitable deployment of solar and other clean energy technologies (with EERE and OE).	• No significant change.
• Provide local governments, utilities, and other stakeholders with technical assistance on solar siting.	• Support technical assistance to states, local governments, federal agencies, and other stakeholders to overcome barriers to siting solar and other renewable energy (with EERE)	• No significant change.
• Provide local governments, utilities, and other stakeholders with technical assistance on permitting via SolarAPP+.	• Support technical assistance to enable local jurisdictions to adopt the SolarAPP+, which automates permitting for residential solar and energy storage, and expand its features.	• Reduced funding required as the SolarAPP+ becomes financially self-sustaining in FY 2024.
• Projects and technical assistance to facilitate solar deployment on Tribal lands.	• Continue cross-cutting office work on energy and environmental justice initiatives.	• No significant change.
• Continued support for research into wildlife and ecosystem impacts of solar energy systems.	• No funding requested.	• Continue to monitor ongoing work to identify future opportunities.
STEM & Workforce Development $7,800,000	$5,750,000	-$2,050,000
• Fund competitive awards to advance workforce goals related to curriculum development and dissemination.	• Continue to monitor and evaluate impacts of prior year awards to advance workforce goals related to curriculum development and dissemination. • Development of a Technical Assistance program that supports the expansion of the clean energy workforce and the solar industry.	• No funding requested but will continue to monitor and evaluate impacts from prior years with the goal to identify future year opportunities for funding. • New FY 2024 program will complement FY 2023 competitive solicitation. Reduction in funding reflects the lower cost of technical assistance as compared to the regional partnerships funded in FY 2023, which will continue through completion.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support the Clean Energy Innovator Fellowship program, which funds recent graduates and energy professionals to work with public utility commissions, municipal and cooperative utilities, and grid operators to advance clean energy solutions.	• Support the Clean Energy Innovator Fellowship program, which funds recent graduates and energy professionals to work with public utility commissions, municipal and cooperative utilities, and grid operators to advance clean energy solutions.	• No significant change.

Solar Energy
Manufacturing and Competitiveness

Description

The Manufacturing and Competitiveness (MC) subprogram supports entrepreneurs and companies in developing and commercializing new and advanced solar technologies that can grow and diversify the U.S. solar industry, increase U.S. competitiveness in solar energy manufacturing, and accelerate progress toward a carbon-free power sector by 2035. The MC subprogram helps companies with promising solar technologies survive funding gaps in the development cycle of new technologies.

Today less than 20 percent of modules installed in the U.S. are manufactured domestically, leaving the domestic industry and energy consumers beholden to foreign-dominated supply chains. Increasing domestic content and supply chains for PV hardware and product components including inverters; thin film modules; and polysilicon ingots, wafers, and cells for silicon modules will keep more value in the U.S. economy and create good-paying manufacturing jobs with the free and fair option to join a union and bargain collectively. Decreasing reliance on imported goods also reduces supply uncertainty and cost sensitivity to international supply chain disruptions or cyber-security concerns while also increasing domestic energy security. The MC subprogram supports proof-of-concept development, technology demonstration and validation, and technology transfer of innovative solar technologies across the value chain. With passage of the Inflation Reduction Act of 2022 and recently granted Defense Production Act authority for DOE on PV technologies, the U.S. is poised to see substantial growth in manufacturing across the solar supply chain. This presents a unique opportunity for the Solar MC subprogram to support existing and new entrants and to accelerate time to market for innovative products and components.

The MC subprogram utilizes prize programming and the American Made Network to catalyze new businesses pursuing innovative technologies. Manufacturing and value chain RD&D efforts advance and validate technology progress to enable subsequent private sector funding to scale into production. This includes the 19th round of the successful Incubator program, which provides early-stage assistance to small businesses developing and validating technology prototypes. This Request focuses on supporting advanced solar technologies to reduce the dependence on foreign-controlled supply chain segments, particularly those with ties to unacceptable labor practices. The overall focus will be on reducing solar costs while solidifying domestic material, equipment, and product supply chains. Programming will address advanced versions of industry-leading technologies like crystalline silicon and cadmium telluride as well as emerging technologies like perovskites, while also including support for upstream and downstream components.

American-Made Challenges: This activity supports prize programming and associated support structures such as the American Made Network to seed new solar technologies and increase America's market share for added-value manufacturing. The work focuses on incentivizing the development of solutions by a diverse set of individuals and new entrants to the solar technology development space in addition to connecting these people to a network of experienced commercialization partners to accelerate the process to develop new, innovative solar products. The goal is to enable products to go from concept to pilot testing within one calendar year.

Manufacturing and Value Chain: This activity supports cooperative agreements and grants focused on developing and validating new and advanced solar technologies with a focus on those which can be domestically manufactured. Funding targets the full value chain including innovative approaches to producing solar cell components, cells, and module materials; new tracking technologies; power electronics; and technologies to reduce maintenance costs. This activity also aims to supports efforts to bring more private capital funding into solar energy technology development and ensure well trained workers are ready to enter the workforce as opportunities grow. Overall, the goal is to help companies sufficiently de-risk technologies and commercial approaches to enable investment and commercialization by private sector entities and to develop a holistic domestic supply chain that is not dependent on foreign-controlled supply chains.

Manufacturing and Competitiveness

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Manufacturing and Competitiveness $70,000,000	**$75,000,000**	**+$5,000,000**
American-Made Challenges $6,500,000	$12,000,000	+$5,500,000
• Continue to run the American-Made Solar Prize (Hardware & Software) to support innovators in launching new products that advance the solar industry and support U.S. manufacturing.	• Continue to run the American-Made Solar Prize to support innovators in launching new products that advance the solar industry and support U.S. manufacturing.	• No significant change.
	• Develop prize programming to support the domestic expansion of solar manufacturing focused on topics like manufacturing processes, manufacturing tooling, and manufacturing workforce development.	• Expanded prize awards to support U.S. solar manufacturing.
• Continue support for the American Made Network which provides support to applicants, participants, and awardees that are part of SETO funding programs via access to technical expertise, help with application construction, access to tools and equipment, and more.	• Continue support for the American Made Network.	• No significant change.
Manufacturing and Value Chain R&D $63,500,000	$63,000,000	-$500,000
• Continue support for projects focused on accelerating the commercialization of innovative product ideas that can substantively increase U.S. domestic manufacturing across the solar industry supply chain and expand private investment in America's solar manufacturing sector. This includes supply chain development for advanced versions of industry-leading technologies such as silicon and cadmium telluride, the transition of new technologies from the lab to manufacturing such as Perovskites, and support for scaling complimentary and supporting supply chain technologies like	• Continue support to accelerate the commercialization of innovative product ideas that can substantively increase U.S. domestic manufacturing across the solar industry supply chain and expand private investment in America's solar manufacturing sector. Programming will address advanced versions of industry-leading technologies like crystalline silicon and cadmium telluride and emerging technologies like perovskites, while also including support for upstream and downstream component.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
equipment and other PV module and system components.		
• Support targeted work in emerging sectors of the solar industry to include, but not exclusive to, the manufacturability and demonstration of building integrated PV, use of robotics technologies in system construction and manufacturing, floating PV, the co-location of PV with agriculture, virtual power plants, and PV applications in the transportation sector.	• Continue to support targeted work in emerging sectors of the solar industry to include, but not exclusive to, the manufacturability and demonstration of building integrated PV, use of robotics technologies in system construction and manufacturing, floating PV, the co-location of PV with agriculture, virtual power plants, and PV applications in the transportation sector.	• Slight reduction from FY 2023.

Wind Energy

Overview

The Wind Energy Technologies Office (WETO) invests in a diversified portfolio of wind energy research, development, demonstration, and deployment activities that enable and accelerate the innovations necessary to advance offshore, land-based, and distributed wind systems, reduce the cost of wind energy, drive deployment, and facilitate the integration of high-levels of wind energy with the electric grid.

With continued innovation, wind energy has the potential to cost-competitively contribute between 35 and 45 percent of U.S. electricity in less than two decades, up from about 10 percent of all U.S. electric power in 2022. Wind energy can also contribute to grid reliability and resiliency, as well as the generation of clean fuels to help transition the U.S. economy to net-zero emissions in the transportation, buildings, industrial, and agricultural sectors, supporting growth in good-paying jobs and domestic manufacturing across all regions of the country. Progress on these fronts, arising from continued innovation in technology, grid systems integration, and unique solutions to deployment challenges, can position the U.S. as a global leader in wind energy development at home and abroad.

Across all its wind energy development objectives, WETO emphasizes three common and overarching themes:

- Reduce the cost of wind energy for all wind applications (offshore, land-based utility-scale, and distributed);
- Accelerate the deployment of wind energy through siting and environmental solutions to reduce environmental impacts, minimizing timetables for wind energy project development, and facilitating responsible, sustainable, and equitable development and delivery of wind energy resources; and
- Enable and facilitate the interconnection and integration of substantial amounts of wind energy into the dynamic and rapidly evolving energy system that is cost-effective, cybersecure, reliable, and resilient, and includes systems integrated with other energy technologies and energy storage.

Highlights of the FY 2024 Request

- The Department of Energy, in partnership with the Departments of the Interior, Commerce, and Transportation, recently announced the Floating Offshore Wind EarthShot, a new initiative to strengthen U.S. leadership in floating offshore wind (OSW) design, development, and manufacturing. The Floating Offshore Wind Shot sets the ambitious goal to reduce the construction and operating cost of floating OSW energy by at least 70 percent to $45 per megawatt-hour by 2035 for deep sites far from shorelines. As part of this effort, WETO will continue and expand upon investments started in FY 2023 as part of the Floating Offshore Wind Accelerated Research and Development (FORWARD) initiative. FORWARD is a major body of R&D aimed at unlocking floating OSW in U.S. waters greater than 60 meters in depth where approximately 66 percent of the Nation's offshore resources are located.
- Continued and expanded investments proposed in FY 2023 as part of the Near-term Offshore Wind (NOW) initiative with the goal of accelerating the near-term deployment of fixed-bottom OSW through research to lower costs, build a domestic supply chain, and address challenges to siting, permitting, and offshore transmission.
- Continued R&D targeting solutions to reduce environmental and siting barriers to land-based wind development including emphasis on wildlife impact assessment and deterrent tools and technologies, specifically for bats and eagles, and wind turbine-radar interference mitigation activities.
- Continued support for social science research, community engagement, and technical assistance to identify and understand impacts of land-based and OSW energy development on inland and coastal communities, and to help those communities overcome barriers to siting and permitting wind energy projects.
- WETO is involved in several DOE-wide crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing to address the issues and challenges associated with turbine scaling for both land-based and OSW technologies;
    - Hydrogen to support multi-office collaboration in hybrid system design, hardware, control, and demonstration to hybrid systems involving combinations of technologies;
    - Energy-Storage to support multi-office collaboration in hybrid system design, hardware, control, and demonstration to hybrid systems;
    - Critical Minerals to provide funding for analysis and technology innovation efforts to both understand the vulnerabilities of the wind energy supply chain to critical materials and to mitigate those vulnerabilities; and

- Grid Modernization to prioritize RD&D in offshore transmission analysis and technology advancement, grid reliability and resilience analysis, wind control and cybersecurity research, and crosscutting demonstrations in grid operator tools and hybrid energy systems.

Wind Energy
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Wind Energy					
Offshore Wind	63,200	73,200	225,987	+152,787	+209%
Land-Based Wind	31,800	31,800	79,649	+47,849	+150%
Distributed Wind	10,000	13,000	18,161	+5,161	+40%
Systems Integration	7,113	11,000	50,972	+39,972	+363%
Data, Modeling, and Analysis	1,887	3,000	10,231	+7,231	+241%
Total, Wind Energy	**114,000**	**132,000**	**385,000**	**+253,000**	**+192%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $3,317,594; STTR: $460,432
- FY 2023 Enacted: SBIR: $3,704,000; STTR: $521,000
- FY 2024 Request: SBIR: $9,001,000; STTR: $1,266,000

Wind Energy Explanation of Major Changes ($K)	FY 2024 Request vs FY 2023 Enacted
Wind Energy	
Offshore Wind: Increased OSW funding in FY 2024 will be focused on two initiatives: the Near-term Offshore Wind (NOW) initiative, and the Floating Offshore Wind Accelerated Research and Development (FORWARD) program, WETO's primary body of work support the Floating Offshore Wind EarthShot. FORWARD is focused on critical R&D pathways to realizing floating OSW's potential as a resource for grid and economy-wide decarbonization. Additional expanded investments in FY 2024 will support atmospheric science to inform array optimization and advance extreme weather survivability; design and manufacturing of turbine platforms and blades; quieter foundation and installation techniques; expansion of research on environmental and social impacts of floating OSW development; new apprentice and pre-apprentice workforce development programs; and a new supply chain ambassadorship program.	**+152,787**
Land-Based Wind: Increased funding for land-based wind in FY 2024 will prioritize Environmental and Siting R&D and STEM and Workforce Development activities to address the most critical barriers to rapid acceleration of land-based wind deployment. Increased funding will also support a new fellowship and internship program to promote a wind energy education and training ecosystem to drive a robust and diverse workforce.	**+47,849**
Distributed Wind: Increased funding in FY 2024 will expand upon promising R&D pathways to drive innovations that will reduce overall systems cost and accelerate distributed wind deployment. The subprogram will prioritize the advancement of small- and medium-scale wind turbine technologies and development of community-based zero-carbon power plans and utility business and regulatory models that enable markets to incentivize zero-carbon distributed energy resource aggregation.	**+5,161**
Systems Integration: Increased funding in FY 2024 will support the DOE Floating Offshore Wind EarthShot through R&D on cost-effective and reliable offshore transmission access in broad coastal regions, including research to advance subsea cables and improve offshore delivery system protection. Increased funding will also enable wind hydrogen demonstration for both land-based and OSW and advanced grid operators' tools that ensure a reliable and resilient grid operation with substantial wind penetration.	**+39,972**
Data, Modeling, and Analysis: Increased funding for this subprogram will emphasize cross-sectoral analysis in collaboration with other EERE and DOE offices; further development of wind turbine, plant-level, and supply chain modeling capabilities; and increased outreach and engagement with stakeholders to increase adoption and impact of analysis tools and products.	**+7,231**
Total, Wind Energy	**+253,000**

Description

Offshore wind (OSW) development in the U.S. is underway, driven by the attraction of robust OSW resources, falling OSW wind turbine costs, technological advances, accelerated Federal OSW lease auctions, and complementary state policies and commitments. Several challenges have slowed OSW development in U.S. waters, however, including its comparatively high cost; an assortment of unique weather, wildlife, environmental, radar and other siting challenges; and no clear path yet for integrating vast amounts of new power onto an existing shore-based grid. Fixed-bottom technology, as developed abroad, can be adapted to U.S. waters, but the technology for floating OSW is a "new frontier."

In March 2021, DOE announced a joint-agency goal to deploy 30 GW of OSW by 2030, which, if realized, could unlock a pathway to 110 GW or more by 2050. Achieving these OSW goals requires a concerted effort on behalf of the Federal government, including critical R&D efforts by WETO in multiple areas with an increased emphasis on floating OSW technologies. In Fall of 2022, DOE, in partnership with other agencies, announced the Floating Offshore Wind EarthShot to drive U.S. leadership in floating OSW development, with associated targets of reaching a levelized cost of electricity (LCOE) of 4.5c/kWh and deploying 15 GW by 2035.

The OSW subprogram supports two main areas of focus, both of which support progress toward the OSW EarthShot. The first is R&D to accelerate Near-term deployment of OSW (NOW) by lowering costs (from $.08/kWh in 2019 to $.05/kWh by 2030 without subsidies), addressing barriers to siting and permitting, and addressing OSW transmission. The cost-reduction approach will analyze the current OSW turbine cost structure and identify the greatest cost reduction opportunities that can be addressed with R&D. The subprogram will also seek to address the most impactful barriers to OSW deployment through a portfolio of activities designed to ensure sustainable OSW development, promote co-use of ocean space, derive benefits to coastal communities, and result in a thriving domestic supply chain supported by a diverse, domestic workforce. NOW will largely build on the experience gained in Europe, however, the R&D needs for floating OSW are at an early stage.

The second OSW subprogram area of focus is referred to as the Floating Offshore Wind Accelerated Research and Development (FORWARD) initiative. FORWARD is a major body of R&D aimed at unlocking the roughly 66 percent of the Nation's OSW resource accessible only through the development and commercialization of affordable floating OSW technologies (mainly the West Coast and Gulf of Maine). Significant development of floating OSW in the U.S. will require a reduction in costs from the current LCOE of $.135/kWh for floating turbines. The goal requires investments in sustainable and community-compatible development; further refinement of supply chain and workforce development requirements; and advancements in transmission planning and HVDC cable technology. FORWARD will be comprised of a body of expanded and new integrated research to significantly reduce wind turbine, floating platform, and electrical connection costs, while advancing technological readiness across an array of associated systems.

Science and Technology Innovation: This activity seeks to reduce costs and risks to OSW development through advances in OSW technology and scientific understanding in three primary areas of focus: resource characterization, technology innovation, and research to reduce operations and maintenance (O&M) costs. The first of these focus areas, resource characterization, is vital to OSW resource predictability, which helps inform siting and supports whole wind plant optimization. This activity also seeks to develop technology innovations to unlock OSW in new markets, such as deep-water markets on the West Coast of the U.S., by developing floating technologies, enabling economies of scale with resultant reductions in cost, developing designs optimized for domestic supply chains, and advancing turbine and farm controls to increase output and improve predictability.

Lastly, this activity supports R&D to improve wind technology reliability by decreasing unplanned maintenance, extending the lifetime of components, and optimizing operations, thus improving overall system performance and decreasing O&M costs.

Manufacturing and Materials R&D: This activity aims to develop and build domestic capabilities for cost-effectively manufacturing, installing, and maintaining OSW plants in the U.S. to support the creation of a robust domestic manufacturing sector. Strategies to leverage the Nation's existing infrastructure to reduce the need for specialized vessels and installation equipment will reduce both capital expenditures and long-term operating costs. R&D will ease the technical challenges of installation by reducing turbine weight, finding turbine installation methods, and using advanced materials and manufacturing technologies to reduce the fabrication costs of floating offshore turbine foundations.

Environmental and Siting R&D: To support and facilitate sustainable deployment of OSW, this activity supports R&D into environmental impact assessment, minimization, and mitigation solutions for novel issues that pose unique challenges to OSW, such as the need to develop automated wildlife monitoring systems and continued innovation of tools to minimize impacts of construction noise on protected marine species. This activity also addresses siting challenges related to OSW interference to critical radar missions and operations, which are less understood than the impacts of land-based wind plants. Efforts will focus on both leveraging work in the land-based wind space for radar systems that will likely be impacted by both land-based and OSW development, such as long-range air surveillance radars, and on work focused on systems where OSW is likely to have a greater effect, such as coastal high-frequency systems for ocean wave and current measurement, and marine navigation radars. This activity also supports social science and socioeconomic research to understand impacts of OSW on communities and ocean co-users and provide technical assistance to communities considering OSW development.

STEM and Workforce Development: Growth of the American OSW industry has the potential to provide tens of thousands of well paying, union-eligible job opportunities by 2030. Ensuring there is a well-trained and ready workforce available to meet those jobs requires new training and education programs to prepare workers with applicable skills and knowledge. Workforce education and training needs will be linked to the growth of the industry. WETO will support OSW STEM and workforce development activities, including national-scale analyses to systematically identify future workforce needs, university engagement and other programming to catalyze solutions to those needs, and efforts to convene industry and educational institutions to develop workforce development solutions. WETO will increase support for the development of OSW curriculum, fellowships, and internships at universities and colleges, with a strong emphasis on ensuring the diversity of the future OSW workforce.

Offshore Wind

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Offshore Wind $73,200,000	**$225,987,000**	**+$152,787,000**
Science & Technology Innovation $49,765,000	$103,227,000	+$53,462,000
• No significant efforts	• Advanced planning for an OSW atmospheric sciences validation campaign on the Pacific coast.	• New effort to understand Pacific Coast wind behaviors and prediction tools.
•	• Conduct supply chain analysis and coordination efforts for ports needed for OSW development.	• New analyses of supply chain scenarios, gap identification, and mitigations.
• Develop Operations & Maintenance roadmap to inform technology development needs.	• Begin Operations & Maintenance Research to increase the technological maturity of advanced inspection, maintenance, and repair techniques.	• Increased efforts on application of automation techniques and technologies for OSW.
• Advanced planning, needs and feasibility assessments, and design for expansion of existing test facilities to handle 20MW+ OSW turbine components and hybrid offshore systems.	• Development or expansion of test facilities to handle 20MW+ class turbines and for other offshore test facilities (such as hybrid OSW/hydrogen, offshore research, and offshore structures).	• Increased funding for a competitive solicitation to support continued development and/or expansion of test facility(ies)
•	• Advancement of low-TRL Floating Platform Innovation. Develop high-risk innovative scale prototype designs that offer step changes in platform cost and production capability.	• New competitive solicitation focused on low-TRL innovative designs.
•	• Extreme Weather atmospheric science & turbine design efforts to enable OSW deployments in Gulf of Mexico and Southeast U.S.	• New activity builds on BIL funded efforts.
• Support for OSW energy technology demonstration projects to advance OSW development by demonstrating innovative technologies not previously commercially used in the U.S. for OSW.	• Continued support for OSW energy technology demonstration projects to advance OSW development by demonstrating innovative technologies not previously commercially used in the U.S. for OSW with emphasis on new component demonstrations.	• No significant changes
• The Enacted includes funding for National Laboratory work that will leverage existing core capabilities and facilities available through the National Laboratory network. Targeted research	• The Request includes funding for National Laboratory work that will leverage existing core capabilities and facilities available through the National Laboratory network. Targeted research	• No significant changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
areas include OSW resource characterization and forecasting.	areas include OSW resource characterization and forecasting.	
• Deploy a buoy off the coast of Hawaii in conjunction with the Bureau of Ocean Energy Management to characterize the wind energy resource and inform potential future leases.	• Continue buoy deployments to support metocean research and in conjunction with the Bureau of Ocean Energy Management to characterize the wind energy resource and inform potential future leases. Continue to develop new buoy sensor systems to enhance resource assessments.	• No significant changes
• Advance fully coupled turbine/foundation engineering design tools for fixed-bottom and floating foundations.	• Advance high-fidelity models for fully coupled turbine/foundation design and analysis.	• No significant changes
• Technology development of low-noise installation techniques for fixed foundation OSW applications.	• Technology development of low-noise installation techniques for fixed foundation OSW applications.	• No significant changes
• Continue existing Offshore Integrated Systems Engineering efforts to develop analysis and research capability to improve system-level performance and achieve system-level cost reductions.	• Continue existing Offshore Integrated Systems Engineering efforts to develop analysis and research capability to improve system-level performance and achieve system-level cost reductions.	• No significant changes
• Continue efforts to develop OSW full-farm controller using consensus control methodology. Also continues to support floating platform controls and hydro/aerodynamics with focus on advanced flow measurement, increased degrees of freedom, and high-Reynolds number aerodynamics for performance and load predictions.	• Continue efforts to develop OSW full-farm and turbine controls which optimize power output and lifecycle considerations. This effort will also support continuation of floating platform controls.	• No significant change
• Establishment of an Anchoring & Mooring Development effort to demonstrate new concepts applicable to deep-water locations at scale.	• No funding requested	• Deferred to FY 2025.
	•	•
Manufacturing and Materials R&D $5,018,000	$66,500,000	+$61,482,000
• Research effort to analyze existing available infrastructure and needs for application to OSW	• Continue research to analyze existing available infrastructure for application to OSW	• No significant change

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
manufacturing, assembly, logistics and port facilities.	manufacturing, assembly, logistics and port facilities.	
• Emphasized advanced materials and manufacturing R&D to reduce full lifecycle costs and accelerate blade/tower/nacelle factory throughput. Develop new manufacturing methodologies.	• Advanced design, materials, and manufacturing R&D to reduce full lifecycle costs and accelerate blade/tower/nacelle factory throughput. Develop new manufacturing methodologies and research efforts to understand the aerodynamics of extremely long blades required in new generation of ultra-large turbines.	• Significantly increased efforts for partial and full-scale demonstration of advanced manufacturing techniques for blades and nacelles. Increased scope will also include aerodynamics R&D associated with ultra-large turbine blades.
	• Floating Platform Industrialization development, testing, and demonstration of high-TRL concepts.	• Moved from Science & Technology Innovation to Materials & Manufacturing R&D.
• Manufacturing and additive design of electric machines enabled by three-dimensional printing (MADE3D) project to additively manufacture every part of the generator.	• No funding requested	• Project completed in FY 2023.
• Manufacture and test full scale 3D printed blade cores for static structural strength.	• No funding requested.	• Project completed in FY 2023.
Environmental and Siting R&D $13,145,000	$38,260,000	+$25,115,000
	• Research on environmental impacts of floating and fixed bottom OSW projects.	• Increase will support new research to understand before (baseline) and after (impacts) to environmental targets of concern for floating OSW development, as well as to refine our understanding of fixed impacts in the Atlantic.
	• Development and validation of environmental monitoring and mitigation tools including integrated autonomous monitoring technologies to lower costs and provide more accurate data regarding species presence and effects.	• New activity.
• Continue international research sharing and dissemination through the International Energy Agency (IEA) Wind Energy Task 34 (WREN) and the Tethys database.	• Continue international and domestic research sharing and dissemination through IEA Wind Energy Task 34 (WREN), the Synthesis of Environmental Effects Research (SEER) effort and Tethys database.	• No significant change

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Address wind/radar challenges associated with radar systems of mutual interest to land-based and OSW, while continuing to build understanding of impacts unique to OSW. Continue to facilitate the definition of next-generation radar requirements. Key partnerships with DOD, DHS, DOT, DOI and DOC.	• Address wind/radar challenges associated with radar systems of mutual interest to land-based and OSW, with an increased focus on validation of higher-readiness mitigation technologies. Continue to facilitate the definition of next-generation radar requirements. Key partnerships with DOD, DHS, DOT, DOI and DOC.	• Increased focus on validation and implementation of high-TRL mitigation measures.
• Maintain WINDExchange, to ensure use of the best available science-based technical, economic, and development information to support wind energy policy and deployment decisions.	• Maintain WINDExchange, to ensure use of the best available science-based technical, economic, and development information to support wind energy policy and deployment decisions	• No significant change.
• Provide local and regional technical assistance and knowledge sharing to coastal communities. Expand collaboration with NOAA National Sea Grant Program and other community organizations to support regional or state-level engagement with ocean users.	• Provide local and regional technical assistance and knowledge sharing to coastal communities. Expand collaboration with NOAA National Sea Grant Program and other community organizations to support regional or state-level engagement with ocean users.	• Funding increase to allow for technical assistance and meaningful engagement beyond Atlantic coast, including Pacific, Gulf of Mexico, and the Great Lakes.
	• Support research on social and socioeconomic impacts of wind energy.	• Increase supports new research that builds off of prior years' social science research.
• Continue support for the National Wind Turbine Database.	• Continue support for the National Wind Turbine Database.	• No significant change.
STEM and Workforce Development $5,272,000	$18,000,000	+$12,728,000
• Support the Collegiate Wind Competition (CWC), an annual event that challenges teams of undergraduate students to develop solutions to complex wind energy projects, as well as other OSW STEM educational opportunities.	• Continue support for the Collegiate Wind Competition (CWC), an annual event that challenges teams of undergraduate students to develop solutions to complex wind energy projects.	• No significant change.
	• Initiate programs to increase OSW curriculum, fellowships, and internships at universities and colleges, including an emphasis on ensuring diversity of the future OSW workforce.	• New activity in FY 2024.
• Initiate national-scale analyses to systematically identify future workforce needs.	• Continue to support workforce analysis on an as-needed basis to address.	• Focus will shift from national level to regional and sector specific analysis to refine understanding of workforce needs.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support the National OSW Workforce Development Roadmap and Network	• Continue support for the National OSW Workforce Development Network to meet OSW workforce needs	• Roadmapping efforts will be completed in FY 2023; FY 2024 funding will focus on continuation of Network coordination.
	• Launch initiative to provide competitive funding for pre-apprenticeship and apprenticeship programs for OSW, with an emphasis on increasing diversity in the OSW workforce and providing opportunities in underserved coastal communities.	• New activity in FY 2024.
	• Launch ambassadorship program to increase opportunities for women and minority owned businesses to enter the OSW supply chain.	• New activity in FY 2024.

Description

The Land-Based Wind subprogram emphasizes efforts to reduce the cost of wind energy to enable nationwide cost-competitiveness and to develop siting and environmental solutions to accelerate land-based wind energy development, comprising most of the country's wind resource. Rotor blade innovation in support of "Tall Wind" turbine technology is motivated by economies of scale. The quality of the wind resource (e.g., wind speed, wind shear, and wind profile) varies significantly based on location, but is almost uniformly better at greater heights above the ground. Key opportunities include taller towers with larger generators, longer blades, and larger rotor diameters, which all lead to greater energy capture and lower cost per unit of energy output and represent significant opportunities for cost reduction, as well as opportunities for domestic manufacturing in support of Buy American and well-paying jobs with the option to join a union.

Through these efforts, the subprogram seeks to reduce the LCOE for land-based wind from a 2015 benchmark of $.06/kWh to $.02/kWh, without subsidies, by 2030. Achieving this 2030 goal would represent a 50 percent reduction from today's LCOE and make wind electricity cost-competitive nationwide.

Science and Technology Innovation: This activity seeks to advance land-based wind technology innovation and scientific understanding to decrease cost and improve the performance and reliability of next-generation tall wind plants and turbine technology. The activity will shift focus to executing field experiments to validate the physics knowledge and design tools developed under the Atmosphere to Electrons (A2e) project.

Manufacturing and Materials: This activity aims to develop cost-effective, lightweight turbine components that are more efficient, stronger, and more reliable for the full life cycle of the wind turbine through advanced manufacturing, materials science, and mechanical systems R&D. The activity will also advance materials science by developing technology to mitigate bearing and gear failures through advanced lubricants, composite materials, and metallic coatings that are resistant to damage in operating conditions that benefit both land-based and OSW applications. It will also focus on research to recover critical minerals from wind turbine components.

Environmental and Siting: This activity focuses on the development of solutions, impact mitigation, and enabling the efficient siting and operation of land-based wind facilities. It will focus on developing solutions for environmental impacts of land-based wind by supporting research that informs siting decisions. Characterization of impacts will be used in the development of mitigation tools and technologies, and further research will focus on evaluating and addressing impacts on wildlife, including bats, eagles, and grouse species.

This activity also supports the interagency Wind Turbine Radar Interference Mitigation Working Group to address the impacts of land-based wind development on air surveillance and weather radar missions. Activities will include modeling, field testing, and evaluation to characterize wind turbine interference to develop and deploy high-TRL mitigation technologies that will increase the resilience of existing radar systems to wind turbines.

Finally, this activity will support social science and socioeconomic research to understand impacts of wind energy on communities and enable innovation for siting and participatory outcomes that reduce impacts and promote equitable outcomes for land-based wind energy development.

STEM and Workforce Development: Wind energy provides significant domestic job opportunities and the rapid development of additional, substantial wind energy integral to achieving the President's energy targets will provide substantially more. New education programs, such as university fellowships, to prepare workers with applicable skills and knowledge require a well-trained and ready workforce available to meet these jobs. This activity will support STEM and workforce development activities, including national scale analyses to systematically identify future workforce needs, programming to catalyze solutions to those needs, and efforts to convene industry and educational institutions to develop workforce development solutions. The work will also place a strong emphasis on ensuring the diversity, inclusion, equity, and accessibility of the future land-based wind workforce.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Land-Based Wind $31,800,000	**$79,649,000**	**+$47,849,000**
Science & Technology Innovation $14,434,000	$19,208,000	+$4,774,000
• Maintain mission readiness and operational expertise of DOE's specialized research facilities and capabilities. Initiated the procurement of a modern turbine for the NREL National Wind Technology Center (NWTC).	• Maintain mission readiness and operational expertise of DOE's specialized research facilities and capabilities for the NWTC at Flatirons and Sandia Scaled Wind Farm Technology (SWiFT) facility.	• No significant change.
• Conclude the AWAKEN field campaign and demobilize instrumentation.	• The AWAKEN project will continue data analysis and model validation studies. The project will release international benchmarks, publish both field campaign observations and international model validation studies.	• The collection of field observations concludes in FY 2023 and analysis of the gathered data continues in FY 2024.
• The Rotor Aerodynamics Aeroelastics, and Wake (RAAW) experiment will conclude. Validation of high- and mid-fidelity numerical aerodynamic and wake models will be completed using the data gathered.	• No funding requested.	• The RAAW experiment concludes in FY 2023. Analysis of the gathered data will be undertaken by other projects.
• Initiate the Wind Forecasting for Tall Turbines project.	• Continue the Wind Forecasting for Tall Turbines project. Improvements to model physics for weather forecast models developed under the Weather Forecast Improvement Project 2 (WFIP2) will be tested in other regions to provide more robust model performance statistics.	• Increased funding to include mesoscale simulations with and without improvements identified from the WFIP2.
• Initiate the Fully Coupled Wind-based Hybrid Energy Systems project to accelerate the nationwide understanding, development, and deployment of wind-based hybrid plants through a nationwide, end-to-end approach.	• Continue the Fully Coupled Wind-Based Hybrid Energy Systems project. Accelerate the nationwide understanding, development, and deployment of wind-based hybrid plants.	• Increased funding for design optimization of fully coupled systems with different objectives, such as reliability, resilience, etc.
Manufacturing and Materials R&D $3,858,000	$6,500,000	+$2,642,000
• Continue to investigate the effects of stray electrical currents on white etching cracks failures in bearings and gears, and initiate new research	Continue Drivetrain Reliability research focused on the tribological materials associated with the	• Increased funding for studies on material response to system and environmental conditions

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
focused on material characterization of main bearing and pitch bearing failures. • Continue Big Adaptive Rotor (BAR) program support. Field experiments to demonstrate the design concepts and collect validation data for the new suite of advanced non-linear engineering design tools.	predominant and unaccounted failure modes in pitch, main, and gearbox bearings. • Continue Phase II of the Big Adaptive Rotor (BAR) Program. BAR Phase II will address the science and engineering challenges of the most promising technologies identified in Phase I research.	known to be present during premature component failures. • Increased funding to explore promising research pathways initiated in Phase II of the BAR program.
	• Advanced manufacturing of large iron and steel castings and forgings for wind turbine components.	• New effort in FY 2024 to develop innovative manufacturing technology to enable competitive, domestic manufacturing of large metallic wind turbine components.
Environmental and Siting R&D $10,181,000	$43,941,000	+$33,760,000
	• Advance monitoring technologies (e.g., GPS tags, camera technology, etc.) and expand behavioral studies to better understand drivers of bat risk (e.g., time of night, weather conditions, insect prevalence, etc.).	• Increase supports a new activity that builds off prior year research.
	• Advance large scale field research to advance broader commercial deployment of deterrent and curtailment technologies across a range of geographies and bat species.	• Increase supports a new activity that builds off prior year research.
	• Research impacts and evaluating impact mitigation options related to prairie grouse species. Grouse represent a growing deployment barrier as there is significant uncertainty about the nature and scope of grouse impacts from wind facilities.	• Increase supports a new activity that builds off prior year research.
• Continue international research sharing and dissemination through IEA Wind Energy Task 34 (WREN) and the Tethys database.	• Continue international and domestic research sharing, collaboration, and dissemination through the IEA technology collaboration program.	• No significant change.
• Develop and deploy wind turbine radar interference mitigation for both land based and OSW in partnership with DOD, DHS, DOT, DOI and DOC.	• Continue development and deployment of wind turbine radar interference mitigation for both land based and OSW in partnership with DOD, DHS, DOT, DOI and DOC. Test and validate one or more mitigation measures at a radar site where	• Expanded effort to validate high TRL mitigation options.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	the mission is currently impacted by wind turbine interference.	
• Maintain WINDExchange to ensure use of the best available science based technical, economic, and development information to support wind energy policy and deployment decisions.	• Maintain WINDExchange to ensure use of the best available science based technical, economic, and development information to support wind energy policy and deployment decisions.	• No significant change
• Technical assistance and support to help communities overcome barriers to siting wind and other renewable energy. Provide funding and technical assistance to States interested in developing state and local government programs to understand, share experiences, and manage renewable energy siting in their communities.	• Technical assistance and support to help communities overcome barriers to siting wind and other renewable energy. Provide funding and technical assistance to States interested in developing state and local government programs to understand, share experiences, and manage renewable energy siting in their communities.	• Expand technical assistance funding to States to help reduce barriers to permitting at both the state and local level.
• Expand wind plant development impacts research for wind plant neighbors, with an emphasis on understanding equity and benefits for disadvantaged communities.	• Continue wind plant development impacts research for wind communities with an emphasis on understanding equity and benefits for disadvantaged communities.	• No significant change.
STEM and Information Resources $3,327,000	$10,000,000	+$6,673,000
• Support the Collegiate Wind Competition (CWC) and other STEM educational opportunities.	• Support the Collegiate Wind Competition (CWC), and other STEM educational opportunities.	• No significant change.
• Identify future workforce needs, programming solutions for those needs, and opportunities to convene industry and educational institutions to develop workforce development solutions.	• Continue analysis to Identify future workforce needs and convene stakeholders to collaborate to develop and implement workforce development solutions.	• No significant change.
	• Support wind energy fellowships and internships, with an emphasis on promoting diversity in the future wind workforce.	• New activity in FY 2024.

Wind Energy
Distributed Wind

Description

The Distributed Wind subprogram focuses on achieving breakthroughs in reducing the LCOE from $.09/kWh today to $0.05/kWh for a reference 100-kilowatt system. Achieving this goal would enable distributed wind to cost-effectively complement and integrate with other distributed energy resources (DERs), such as solar PV and storage, in hybrid plants and microgrids. The subprogram invests in activities to reduce the cost of permitting and interconnection, increase system power production, enhance grid integration improve decision support tools for distributed wind projects and test next generation technology to national standards to verify performance and safety. Activities to reduce high-cost market barriers, such as permitting and interconnection, will provide targeted technical assistance to support rural, disadvantaged, and isolated communities with planning and evaluating the opportunities and benefits of standalone and hybrid distributed wind energy systems.

Science and Technology Innovation: This activity will continue work to improve the science around rapid, computationally based wind resource, market, and site assessment tools for standalone and hybrid distributed wind systems. Current tools are too costly, uncertain, and inaccurate to support the third-party financing, grid integration, and energy transition planning at scale.

Testing and Reliability: This activity supports U.S. small and medium wind turbine technology manufacturers through a competitive solicitation to reduce turbine costs, increase system performance, enhance grid support capabilities, and test and certify turbine designs and components to national standards. Efforts will also include aeroelastic modeling tool development, refinement of test processes, and stakeholder engagement to further develop harmonize national and international wind turbine performance and safety standards to ease export market access.

Balance of Systems: This activity will focus support on reducing capital costs through standardization of project assessment, permitting, interconnection, system design, and installation of distributed wind systems. Efforts under this activity will continue to include crosscutting EERE energy transition planning and technical assistance programs for rural and disadvantaged communities. The activity will also continue to fund systems integration R&D that enhances the capabilities of wind technology, as distributed energy resource, to provide valued grid support services. Efforts will also focus on accurately representing the capabilities of wind as a DER in decision-support tools used to by utilities, communities, and industries transitioning to carbon free energy sources.

Distributed Wind

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Distributed Wind $13,000,000	**$18,161,000**	**+$5,161,000**
Science and Technology Innovation $2,551,000	$4,411,000	+$1,860,000
• Refine and integrate validated wind resource models and datasets with lab based and commercially available assessment and decision support tools.	• Continue refining and integrating validated wind resource models and datasets with lab based and commercially available opportunity assessment and decision support tools.	• No significant change.
• Conduct techno-economic and deployment analysis to resolve promising high-impact opportunities for cost reduction and deployment acceleration in support tools used by state energy offices, communities, utilities, financiers, project developers, and other stakeholders.	• Continue techno-economic, deployment scenario, and market data analysis to resolve promising high impact opportunities for cost reduction and deployment acceleration.	• Increased funding for stakeholder engagement and technical assistance.
Testing & Reliability $5,537,000	$6,750,000	+$1,213,000
• Continue Competitiveness Improvement Project with 2023 enacted for proposals to reduce distributed scale wind turbine costs, improve turbine performance and grid support capabilities, and test designs to national safety and performance standards.	• Continue competitive solicitation to reduce small and medium scale wind turbine costs, improve turbine performance and grid support capabilities, and test designs to national safety and performance standards.	• Increased funding in FY 2024 will support expansion of Competitiveness Improvement Project (CIP).
• Continue strategic and technical engagement activities in inform distributed wind R&D, increase the economic and technical viability of distributed wind energy systems, and increase understanding for equitably and justly accelerating deployment.	• Continue stakeholder engagement to inform small and medium wind turbine design, testing, and standards R&D.	• No significant change.
Balance of System R&D $4,912,000	$7,000,000	+$2,088,000
• Support development and demonstration of advanced power electronics, controls, and monitoring for wind hybrid plants and microgrids applications.	• Continue systems integration work to develop and demonstrate advanced power electronics, controls, and monitoring for wind hybrid plants and microgrids applications.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support the development of permitting and interconnection best practices for wind and wind hybrid projects.	• Continue to support the development of permitting and interconnection best practices for wind and wind hybrid projects and reduce barriers to wind deployment in rural communities.	• Increased funding for stakeholder engagement.
• Support the expansion and inclusion of wind in the EERE-funded Energy Transitions Initiative Partnership Project (ETIPP).	• Continue to partner in ETIPP.	• No significant change.
• Participate in EERE cross-cutting project providing communities and electric utilities with technical assistance for development and implementation of 100 percent clean power plans.	• Continue to participate in EERE cross-cutting projects providing communities and electric utilities with technical assistance.	• Expanded engagement and technical assistance to state, local, and tribal entities.

Wind Energy
Systems Integration

Description

The Systems Integration subprogram invests in R&D to ensure cost-effective, reliable, cybersecure, and resilient operation of the power grid with increasing levels of wind energy. Efforts will focus on strategic opportunities to ensure cost-effective and reliable transmission access for wind energy deployment at scale, maintain and increase grid reliability and resilience through the provision of grid services from wind and wind-hybrid systems, address wind-specific cybersecurity needs, and improve the understanding of electricity market operation with high penetrations of wind energy.

Considerations for wind energy systems integration include:

- Demand for Transmission Adequacy and Flexibility: wind deployment at scale requires cost-effective transmission access to deliver the wind energy to the end users. Facilitating collaborative, long-term transmission planning and accelerating generation interconnection can increase the certainty and pace of wind deployment. Advancing transmission technologies, in particular for OSW, enables cost effective wind energy integration.
- Growing Demand for Increased System Flexibility, Reliability, and Resiliency: The future generation mix is anticipated to have higher shares of variable generation sources, including wind. The combined variability and uncertainties from both generation and load require wind and wind hybrid systems to be designed to provide more system flexibility. Wind power and many energy storage options are connected to the grid through inverters. These inverter-based resources respond differently to grid balancing requirements and disturbances than conventional synchronous generators and interact rapidly with other renewable generation systems' power electronics.
- Cybersecurity: Virtually all modern sources of power depend on integrated control systems, data, monitoring, communications, and related technologies, whose security has become increasingly important. Wind energy cybersecurity will need to be strengthened to ensure a cybersecure energy system today and in the future.

The subprogram supports two OSW initiatives CONNECT and TRANSFORM that address challenges to achieving the Administration's OSW deployment goals of 30 GW by 2030 and 110 GW by 2050. CONNECT mitigates transmission constraints, including both land-based interconnections and transmission and offshore transmission. It also improves system security, reliability, and resiliency with OSW. TRANSFORM conducts RD&D to increase OSW's value to a decarbonized economy through OSW hybrid with energy storage technologies and hydrogen and renewable fuel co-generation.

The subprogram aligns with grid activities across multiple DOE initiatives such as the Grid Modernization Initiative that are necessary to enable a just transition to a grid that supports a decarbonized power system by 2035 and a net-zero-emission economy by 2050 while maintaining the reliability, affordability, security, and resilience of the energy system.

Grid integration activities aim to enable cost-effective, cybersecure, reliable, and resilient operation of the energy system with increasing levels of wind in all regions. Progress in these areas will mitigate barriers to transmission access for offshore and land-based wind. With progress, advanced technologies will enable cost-effective wind hardware and controls that will be secure, enhanced, and transformed to provide a full range of grid services for reliable and resilient grid operation.

Systems Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Systems Integration $11,000,000	**$50,972,000**	**+$39,972,000**
• Conduct a series of OSW transmission research and development to enable cost effective transmission access for OSW while maintaining reliable and resilient grid operation with large amounts of OSW.	• Research and development in subsea cable technologies and the protection of OSW delivery systems.	• Increased funding will allow expanded R&D in OSW transmission technologies with focuses on subsea cables and offshore HVDC system protection in FY 2024.
• Provide local governments, utilities, and other stakeholders with technical assistance on wind interconnections.	• Continue support the Interconnection Innovation Exchange (i2X) program to enable improved interconnection of wind and other clean energy technologies to the grid (with SETO).	• No significant change.
• Research and development to increase dispatchability of wind energy and improve wind power forecast for grid services.	• Research and development in wind controls, data, modeling, and tools that ensure reliable grid operation with increasing levels of wind.	• Increased funding will enable system operational tool development and demonstration for a reliable and resilient grid.
• Launch Wind Cybersecurity Lab Call to systematically identify solutions that effectively address wind cybersecurity challenges and increase wind energy system's cybersecurity awareness, preparedness, and responsiveness.	• Continue the National lab led Wind cybersecurity research, development, demonstration, training, and technical assistance.	• No significant change.
• Co-fund Grid Enhancing Technologies (GETs) development demonstration in partnership with industry to accelerate industry adoption of GETs and unlock transmission capacity.	• No funding requested. Continue demonstration projects using prior year funds.	• No funding requested in FY 2024.
• The Wind hybrid program will support OSW co-generation use case analyses, nationwide technoeconomic analysis of wind hydrogen production, and modular component design and control.	• Wind hybrid system demonstration will focus on wind producing hydrogen for storage or for direct industrial applications.	• Increased funding will enable wind hydrogen production demonstration for both land-based wind and OSW.

Wind Energy
Data, Modeling, and Analysis

Description

The Data, Modeling, and Analysis subprogram provides objective analysis to evaluate and prioritize wind energy technology innovation opportunities for offshore, land-based, and distributed applications, based on a solid understanding of techno-economic conditions as well as state-of-the art systems engineering, cost and deployment models, and tools. Subprogram activities of data collection, modeling, and tools development, and analysis guide Wind Program investment in R&D and highlight wind's current and potential future contributions in the U.S. energy sector for stakeholders.

Specific FY 2024 priorities include:

- Continued and expanded collection and dissemination of data on wind technology cost and performance trends to support GPRA reporting, Energy Act of 2020 reporting, and other analytical efforts to inform stakeholders.
- Continued development of capabilities to evaluate the impacts of innovations in land-based, distributed, and OSW technologies, with a focus on supporting capabilities to assess wind-hybrid applications, and the impacts of innovation in wind technologies at a high degree of spatial resolution.
- In collaboration with other EERE and DOE offices, expanded development of linkages between electricity system models and models of other energy production and use sectors.
- In collaboration with other EERE and DOE offices, expanded scenario analysis focusing on potential future wind contributions for deep decarbonization pathways across sectors and assessment of related impacts, including on land and ocean space use, impacts to wildlife, radar and communities, and the sensitivity of wind's contributions to decarbonization to different wind technology evolution pathways.

Data, Modeling and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $3,000,000	**$10,231,000**	**+$7,231,000**
Data, Modeling, and Analysis $3,000,000	$10,231,000	+$7,231,000
• Market data collection, analysis, and reporting including establishing technology baselines and industry benchmarks, tracking progress to goals, and evaluating return on investment.	• Market data collection, analysis, and reporting including establishing technology baselines and industry benchmarks, tracking progress to goals, and evaluating return on investment.	• No significant change.
• Conduct techno-economic analysis including impact evaluations of wind innovations, spatial and temporal supply curve analysis, decarbonization impacts analysis, and cost and performance analysis. Emphasis on assessing the impact of infrastructure investments and innovative operations and maintenance strategies in OSW and expanding land-based wind supply chain analysis.	• Conduct techno-economic analysis including impact evaluations of wind innovations, spatial and temporal supply curve analysis, decarbonization impacts analysis, and cost and performance analysis.	• No significant change.
• Strategic wind energy futures analysis including electric sector modeling, wind value to the grid for energy and grid services, and capacity expansion model development. Emphasis on developing linkages between electricity and other energy sector models to capture interactions between sectors in deep decarbonization scenarios, further developing spatial analysis capabilities to evaluate the impact of siting and land use constraints on wind's role in the electricity sector.	• Strategic wind energy futures analysis, including electric sector modeling, wind value to the grid for energy and grid services, and capacity expansion model development.	• Increase reflects increased emphasis on cross-sectoral analysis, in collaboration with other EERE and DOE offices.

Water Power

Overview

The Water Power Technologies Office (WPTO) administers a broad portfolio of activities to strengthen the body of technical knowledge and support for industry efforts to develop, demonstrate, and deploy hydropower and marine energy technologies at all scales. To advance water power, WPTO supports research, development, demonstration, and deployment (RDD&D) across industry, academia, and the National Laboratories through a wide variety of mechanisms and other innovative partnership approaches to accomplish its objectives.

America has vast marine energy and hydropower resources, and there is enormous potential to enhance the existing fleet, expand into new markets and applications for hydropower, increase generation and flexibility across the Nation's sizable hydropower and pumped storage fleet, and develop and demonstrate new hydropower and marine energy. In FY 2024, WPTO will focus on key areas of opportunity, include retrofitting existing hydropower facilities and powering non-powered dams to cost-effectively increase generation and flexibility; developing next generation pumped energy storage systems; launching a new effort to seed and establish Regional Energy-Water Demonstration facilities; and advancing marine energy technology to support new and growing industries utilizing waves, currents, tides, and gradient differentials (ocean thermal, pressure, and salinity).

For both marine energy and hydropower, realizing the potential of water power requires understanding how systems are changing with the climate. Climate change will affect water control, storage, management, and multiple uses of water by reservoirs, resulting in critical risks and unique opportunities for these water systems. In FY 2024, WPTO will build on its efforts to quantify hydrologic and climate change impacts to hydropower by working with local communities demonstrating and deploying advanced hydrologic sensors in watersheds across the U.S. to better characterize climate change variations on watersheds and improve ecological resilience and energy-water security. Moreover, WPTO plans to explore the potential for how oceans can be an environmentally appropriate sink for carbon, offer pathways to decarbonization through the maritime sector, and explore how marine energy can power emerging markets like kelp farming and other climate mitigation strategies.

Community-centric development is critical to advance water power systems, particularly in the instances of remote, underserved, rural, tribal, and/or isolated communities. In FY 2024, WPTO will build out its portfolio of technical assistance and demonstrations with communities and power providers, including supporting the Energy Transitions Initiative Partnership Project, supporting small hydropower developers in evaluating alternative values of hydropower, building out partnerships with local irrigation districts and municipalities to deploy digital planning tools, and partnering with communities with energy and water data needs to deploy advanced hydrologic sensors and sensor networks.

In support of both community-centric development and to field validate energy-water system technologies and approaches needed to address regional and local-scale energy-water systems in a changing climate, WPTO will establish a new subprogram, Regional Energy-Water Testing and Validation. This subprogram will focus on demonstrating technologies and solutions to scale water and energy management solutions that address needs in specific watershed regions. This subprogram will address gaps between systems-level energy-water research and field deployment and will require a combination of regional and integrated modeling assessment, as well as coordination between EERE and other DOE offices to integrate and scale existing technologies. This will also include support for advancing nationwide climate and hydrologic modeling predictions to identify and study individual regions experiencing acute energy-water issues and deploy tools to help the hydropower industry understand climate-driven impacts.

To support demonstration and deployment of water power technologies, WPTO will increase support for harnessing the broader innovation ecosystem in support of commercialization of near-term and early-stage technologies. In FY 2024, WPTO will grow its portfolio of work to support incubators and accelerators in the private sector to support commercialization of a broad range of technologies and entrepreneurs; identify options to build on National Laboratory-focused commercialization opportunities; and develop metrics to measure, track, and evaluate commercialization strategies.

As a key emphasis area, workforce training and preparedness is important across both hydropower and marine energy. Investments associated with workforce development will support training and develop good paying clean energy jobs for the American people, especially workers and communities impacted by the energy transition, and those historically underserved by the energy system and overburdened by pollution. The hydropower sector has an aging workforce but offers pathways to well paid, stable jobs. Marine energy holds promise for new jobs from ports to remote communities, to developing solutions far out at sea, as well as being an interdisciplinary hard technology field for emerging researchers and scientists. In support of both fields, in FY 2024, WPTO will support collegiate competitions to attract new students to the sectors, as well as provide funding to universities to seed new concepts in marine energy and hydropower.

Highlights of the FY 2024 Request

WPTO will pursue the following major activities in FY 2024 to support the EERE strategic priority of initiating a path to achieve a carbon pollution-free electricity sector no later than 2035:

- Demonstrate technologies to support hydropower flexibility and new pumped storage hydropower (PSH) development, and develop the tools and analysis to increase power system model enhancements to reflect hydropower more accurately.
- Develop technologies designed to lower costs while increasing the efficiency of low-head hydropower by supporting new designs and demonstrations of new and cost-effective technologies necessary for powering non-powered dams.
- Develop digital tools to assist the Nation's irrigation districts in using hydropower to support irrigation modernization and partnering with local irrigation districts.
- Fund scoping, planning grants, and ultimately selection of one or more Regional Energy-Water Demonstration Facilities focused on validating and testing technologies and solutions to scale water and energy management solutions that address needs in specific watershed regions. Develop a suite of climate and hydrologic models, advanced hydrologic sensors, and decision-making tools to provide accurate state-of-the-art climate information and diagnostic capabilities for predicting and managing water and power systems.
- Support design, fabrication, and testing of marine energy conversion devices at a range of sizes (including grid-scale and non-grid-scale technologies).
- Continue the Testing Expertise and Access for Marine Energy Research (TEAMER) initiative, a rolling test campaign developed in collaboration with U.S. universities and National Laboratories to provide technology developers with quick and economical access to marine energy testing facilities and capabilities across the U.S.
- Provide technical assistance and support demonstrations through the Energy Transition Initiative Partnership Project (ETIPP) to engage with underserved remote and islanded communities.
- WPTO is involved in several DOE-wide crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing to fund foundational and application-based research for advanced manufacturing opportunities for hydropower;
    - Energy-Water through the regional testing facilities and to support developing digital tools to assist local irrigation districts on modernization projects and advanced sensors;
    - Energy-Storage to provide funding for hydropower hybrid demonstrations and studies to quantify emission and cost reductions enabled by increased hydropower flexibility and new pumped storage hydropower (PSH) development;
    - Carbon Dioxide Removal to investigate the role of marine energy in marine carbon dioxide removal (mCDR); and
    - Grid Modernization to provide funding for hydropower hybrid demonstrations to quantify emission and cost reductions enabled by increased hydropower flexibility and new PSH development.

Water Power
Funding ($K)

	FY 2022 Enacted[1]	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Water Power					
Hydropower Technologies	43,300	59,000	74,769	+15,769	+27%
Marine Energy Technologies	112,000	120,000	105,000	-15,000	-13%
Regional Energy-Water Testing and Validation	0	0	50,000	+50,000	+100%
Total, Water Power	**155,300**	**179,000**	**229,769**	**+50,769**	**+28%**

SBIR/STTR:

- FY 2022 Transferred: SBIR $13,059,189; STTR $810,677
- FY 2023 Enacted: SBIR $5,147,000; STTR $724,000
- FY 2024 Request: SBIR $6,781,000; STTR $954,000

[1] This excludes funding for EPACT Sec 242 funding which is managed by the Under Secretary for Infrastructure

Water Power
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Water Power	
Hydropower Technologies: The FY 2024 Request increases funding for demonstrations in irrigation modernization and technologies to increase hydropower flexibility for the grid. The subprogram will expand demonstrations and technical assistance for new, low-impact hydropower by investing in demonstration of technologies to power nonpowered dams or infrastructure. Building on previous years' scoping and planning, the subprogram will expand the portfolio to analyze hydrologic and climate change impacts to hydro, as well as invest in the environmental and dam safety systems to modernize the existing hydropower fleet. The subprogram will reduce funding in hybrids systems, shifting some of the previously funded technical assistance and hybrids demonstration focus to the Renewable Energy Grid Integration program to focus efforts on grid integration and less on hydropower specific activities.	**+15,769**
Marine Energy Technologies: The FY 2024 Request prioritizes marine energy technology commercialization, including business and technology incubation support to developers and startups, offset with a reduction in funding for the construction of the open water test facility. The Request continues to support controls and advancements in materials and manufacturing, device design and fabrication to serve remote coastal and islanded communities based on outcomes of the ETIPP cohorts, as well as wave energy demonstrations at PacWave[1]. The subprogram also continues support for access to testing facilities for marine energy developers, and the design, fabrication, and testing of marine energy devices at a range of sizes, including PBE and grid-scale technologies.	**-15,000**
Regional Energy-Water Testing and Validation: The FY 2024 Request creates a new subprogram within the Water Power Program supporting regional testing and validation for energy-water technologies systems and approaches. This includes the launch of one or more Regional Energy-Water Demonstration Facilities to focus on validating and testing technologies and solutions to scale water and energy management solutions that address needs in specific watershed regions.	**+50,000**
Total, Water Power	**+50,769**

[1] PacWave (formerly known as the Pacific Marine Energy Center South Energy Test Site) is an Energy Department-funded, grid-connected, full-scale test facility for wave energy conversion technologies being constructed off the coast of Oregon by a team led by Oregon State University—the first facility of its kind in the United States. https://www.energy.gov/eere/water/pacwave

Description

As the Nation's first renewable source of electricity, hydropower has provided clean, low-cost electricity for over a century. In 2022, hydroelectricity accounted for about 6.3 percent of U.S. utility-scale electricity generation and 29.4 percent of utility-scale renewable electricity generation. Pumped storage hydropower (PSH) is the largest contributor to U.S. energy storage with an installed capacity of 21.9 GW, or roughly 93 percent of all commercial storage capacity in the U.S. The Hydropower Technologies subprogram supports the U.S. hydropower and PSH industry by supporting RDD&D that responsibly develops new low-impact hydropower; supports grid reliability and the integration of other energy resources; modernizes and safely maintains existing assets; promotes environmental sustainability; and supports energy-water systems resilience.

New Low-Impact Hydropower: Most new hydropower facilities will be smaller scale than existing systems since limited opportunities exist to develop new, large-scale conventional hydropower due to high costs and environmental concerns. These new facilities can integrate multiple social, environmental, and energy benefits, while realizing value and revenue from a variety of sources. The Hydropower Technologies subprogram supports the deployment of new hydropower by advancing technologies that can decrease costs and increase the value of powering non-powered dams, developing new stream reaches, and modernizing irrigation systems. Scientific advances associated with these technologies can allow developers and operators to more effectively identify and mitigate potential environmental impacts, ultimately allowing for more effective utilization of existing hydropower and reduced regulatory costs.

There are more than 90,000 existing dams across the Nation, of which about 2,500 have hydropower facilities for electricity generation. Retrofitting existing dams and adding generation at nonpowered dams can increase renewable energy production but advances in technologies and validation of systems are needed to incentivize deployment of hydropower. This activity builds on prior work in Standard Modular Hydropower and other designs to demonstrate new technologies for nonpowered dams and provide technical assistance for the hydropower community and developers to identify sites best suited for retrofits. This activity also supports technology validation in a field setting with a scoping assessment for building and maintaining a hydropower test facility that will increase adoption of novel technologies by the hydropower industry and increase regulatory agencies' confidence in novel technologies with validated performance data.

Besides power generation, dams provide flood control, water supply, irrigation, and recreation. Because hydropower occupies a unique position at the intersection of the energy-water nexus, it offers unique benefits through connections to the water supply and associated infrastructure. For example, cost savings from hydropower project developments have allowed irrigation districts to modernize their irrigation systems.[1] To facilitate this effort, this activity builds on prior year efforts with working with irrigations districts to inform development of digital planning tools and demonstration sites.

Grid Integration: Both hydropower and PSH can adjust their output quickly and on demand, providing a highly flexible generation source with critical services that help maintain the reliability and resiliency of the Nation's power grid. Services include quick-response dispatchable power that can be used to meet peak demand and balance variable resources, as well as a discrete set of technical capabilities ranging from sub-second frequency response to black-start (restoration) capabilities that can help the grid quickly recover from an outage. PSH provides many of these same services, along with the ability to absorb excess generation during the pumping mode and provide long-term power storage when it is needed most. However, providing these grid-responsive services can create wear and raise operational costs for hydropower and PSH facilities. This activity aims to understand and quantify the economic value of these services and the additional costs or technical requirements of operating hydropower systems to provide these services for a changing grid. This research includes understanding the value of hydropower under future electric system conditions, quantifying the effect of flexibility constraints on plant capabilities and performance, addressing critical technical barriers to effective operation of

[1] https://www.energy.gov/eere/water/articles/new-way-modernize-irrigation-infrastructure-and-generate-renewable-energy

hydropower resources, and identifying technology solutions that will preserve or enhance hydropower capabilities to deliver services or system benefits competitively.

Through its HydroWIRES Initiative, the subprogram is expanding its efforts to develop new strategies and technologies that can enhance hydropower's flexibility for facilitating deployment of wind and solar onto the U.S. electric grid—including faster and more frequent ramping, more frequent starts and stops, and enhanced frequency and voltage control to optimize the highest-value services crucial for the transition to a primarily renewable power system. This includes supporting technology advancements for flexibility, improving how hydropower is represented and understood in energy modeling, and building a national assessment of the potential for hydropower and PSH to support an evolving grid. HydroWIRES maintains support for technical assistance efforts to capture the full range of values that hydropower and PSH plants can provide to power grids, river basins, and nearby communities.

Existing Hydropower: Today the average hydropower plant is 64 years old,[1] and as the fleet continues to age, maintaining efficient and cost-effective operations and ensuring the security – including cybersecurity – of our critical energy infrastructure becomes increasingly challenging. Building on previous efforts, this activity advances digital tools to support modernizing the fleet. To support the existing fleet, this activity also assesses and addresses climate change impacts, environmental sustainability, and relicensing. The Office's work on existing hydropower reservoir management can create opportunities to advance climate resilience and adaptation for remote or socioeconomically vulnerable communities by analyzing infrastructure design and water management, enhancing environmental sustainability, and ultimately building socioeconomic resilience in these communities. To advance a framework for understanding climate change at the local level, this activity supports work with communities on energy and water data needs, including identifying up to three sites for deploying advanced hydrologic sensors and sensor networks.

Environmental sustainability is another critical challenge that requires fundamental research to understand hydropower's effects on the environment. Improving the environmental performance of hydropower facilities requires novel monitoring and mitigation technologies, particularly related to fish passage. Since 2005, the Federal Energy Regulatory Commission (FERC) has ordered mandatory fishway prescriptions for project relicenses for upstream or downstream passage in approximately 27 percent of hydropower facilities. To meet this order, WPTO has initiated high-priority fundamental research on fish passage at hydropower dams to understand fish behavior, movement, and lifecycles and to create information and tools to increase fish survival through hydropower structures.

Finally, non-federally owned hydropower facilities require a license from FERC to operate with license terms that typically last for 30-50 years. Relicensing provides communities opportunities to redefine goals for recreation, environmental impacts and mitigation, energy production, and revenue. Environmental measures can account for up to 30 percent of the Federal wholesale power rate, and solutions for effective environmental outcomes and cost reductions are essential. This activity develops tools and analyses that can assist applicants for FERC licenses and other hydropower stakeholders.

Data, Modeling, and Analysis: To advance the state of the hydropower industry, a robust innovation ecosystem must exist to support developers in commercialization, a strong workforce, engagement among a broad set of stakeholders, and publicly available data to inform scientists and market forces alike. This activity seeks to broaden the base of innovators who can address technical challenges in hydropower and support the industry's need to recruit given its aging workforce. The work builds on prior efforts to commercialize promising hydropower technologies, including transitioning lab-developed technologies to industry and carrying out market analyses to identify and engage with relevant end-users. Additionally, this activity supports technology transitions in the private sector through funding a network of incubator and accelerators that mentor promising startups and technology developers in hydropower.

[1] https://www.eia.gov/todayinenergy/detail.php?id=30312#

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Hydropower Technologies $59,000,000	**$74,769,000**	**+$15,769,000**
New Low Impact Hydropower $11,000,000	$24,500,000	+$13,500,000
• Support access to the Manufacturing Demonstration Facility at ORNL or other facilities to support advanced manufacturing, as well as launch. Launch a solicitation focused on advanced manufacturing techniques applied to hydropower.	• Fund projects to leverage advancements in advanced manufacturing to address the key challenges in maintaining the existing fleet infrastructure and enabling new small hydropower designs.	• Funding will provide a more specific and targeted focus for manufacturing opportunities identified through extensive stakeholder engagement.
• Support designs for powering nonpowered dams (NPDs), with the intent of leading into a demonstration funding opportunity to support the advancement of these designs. Assess costs and benefits of adding hydropower to NPDs. Partner with private sector developers and municipalities to implement demonstration projects.	• Fund demonstrations of technologies based on previous year designs and new designs and technical assistance for industry and community partners to utilize lab developed tools for identifying hydropower development opportunities at key NPD sites. Partner with private sector developers and municipalities to demonstrate concepts through real-world hydropower projects.	• Increased funding to expand on past work in conceptual designs for NPD technologies and establishing framework for assessing costs and benefits of adding hydropower to NPDs.
• Partner with Bureau of Reclamation, Army Corps of Engineers, and the Tennessee Valley Authority to begin a 2- to 3-year effort to fund the construction of a hydropower test facility or facilities that will incentivize developers to design and develop new hydropower technologies by reducing financial risk and providing access to technical expertise inherent in the testing process. WPTO will release a competitive funding opportunity in FY 2023 to support the search for a network director to manage the hydropower test facility or facilities.	• Fund beginning of Phase II of the Hydropower Test Facility Development to include pre-engineering design of multiple test sites and implementation of the network director based on a FY 2023 competitive funding opportunity.	• Building on the scoping study performed by Oak Ridge National Laboratory, continued funding will support completion of pre-engineering designs for a potential Federal Hydropower Test Facility site(s).
Grid Integration $22,000,000	$23,000,000	+$1,000,000

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Provide funding to support research into new component-level technology advancements to increase hydropower flexibility.	• Provide funding to demonstrate new component-level technology advancements to increase hydropower flexibility.	• New funding in FY 2024 will help advance the technologies necessary to increase hydropower's flexibility for future grid resiliency.
• Commence a comprehensive, national-scale study on hydropower and PSH's evolving role in the power system and future potential, taking advantage of significant modeling enhancements and including technology opportunities. After the publication of the study, next steps would be developing regional roadmaps—through state and local-scale stakeholder workshops—to map out opportunities for hydropower in different U.S. geographic, hydrologic, and market regions.	• Continue national-scale study on hydropower and PSH's evolving role in the power system and future potential, taking advantage of significant modeling enhancements, and including technology opportunities.	• Reduced funding in FY 2024 to continue the Hydropower Futures Study on using new modeling capabilities to understand hydropower's evolving role in the power system and prioritize technology improvements.
• Continue PSH technology R&D to advance promising concepts to the testing phase to demonstrate PSH's contribution to hydropower's flexibility potential.	• No funding requested in FY 2024.	• Projects will be selected and funded in FY 2023 and will not require funding in FY 2024.
• Expand the PSH Valuation Guidebook framework to accommodate non-power values such as those resulting from water use for multiple purposes, and would include broader economic, health, and cultural values defined by relevant communities.	• No funding requested in FY 2024.	• Funding is not requested as technical assistance provided in FY 2023 will continue with prior year funding in FY 2024.
• Not funded in FY 2023 Enacted.	• Fund development of new model enhancements to better capture hydropower's capabilities and application of these capabilities to utility operations and planning processes.	• New funding in FY 2024 will aid in achieving utility-, state-, or regional-level renewable deployment or decarbonization goals through enhanced representation in models used in planning.
• Support technical assistance to the broader hydropower community, including collaboration with cross-office initiatives on remote communities and broader generation and transmission planning processes.	• Continue technical assistance to the broader hydropower community, including collaboration with cross-office initiatives on remote communities and broader generation and transmission planning processes.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Existing Hydropower $14,000,000	$19,769,000	+$5,769,000
• Establish the tools and partnerships necessary to build toward an Intelligent Watersheds major initiative, which includes 1) advancing monitoring technology through smart environmental sensors and sensor networks, 2) building capacity that will seed future Intelligent Watersheds focused on environmental resilience, and 3) pursing joint work with the Office of Science that expands and applies research to watershed planning.	• Partner with communities with energy and water data needs to identify three sites for deployment of advanced hydrologic sensors and sensor networks.	• Funding in FY 2024 will continue to support work that improves interagency coordination of applied R&D focused on response and adaptation to climate extremes like drought.
• Launch demonstrations, like self-powered Fish Tag lab project and eDNA Demo for FERC relicensing lab project.	• No funding requested in FY 2024.	• Demonstrations will continue with prior year funds.
• Develop and deploy a pilot program(s) of the digital twin capability focused on O&M reduction and market optimization in order to refine the concept and further develop industry confidence in the technology benefit and value.	• Complete Digital Twin pilot study focused on O&M market optimization.	• Funding in FY 2024 will complete industry partnerships to demonstrate effectiveness in reducing O&M costs and market optimization.
• Leverage the SCADA mapping and controls monitoring capability of the Digital Twin effort to help detect abnormal activity in the OT network.	• Fund development of cyber-digital surrogates to detect abnormal activity in hydropower operational network.	• Funding in FY 2024 will continue partnering with industry to leverage actual operational data to allow for physics-based monitoring for a more accurate assessment of network intrusion.
• Competitive funding opportunity on fish passage for restoration to support design and deployment of solutions to move fish above and below dams, evaluate environmental effects, or develop comprehensive technical restoration plans include partnering with tribal communities where species maintain economic and cultural importance.	• R&D to advance innovative fish passage and protection technologies developed in FY 2022 with an emphasis on demonstrations. Initiate work to advance water quality modeling and mitigation with inputs from novel tools and data streams.	• Funding in FY 2024 will support development and validation of novel fish and environmental monitoring tools with hydropower partners with an emphasis on technology transfer and commercialization.
• Not funded in FY 2023 Enacted.	• Initiate work on advanced sensors and artificial intelligence for improved dam safety and dam inspections processes.	• New funding supports advanced sensors with respect to dam safety will lead to much needed data on effects of climate change on water infrastructure.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $10,000,000	$7,500,000	-$2,500,000
• Updates to the Hydropower Vision Roadmap, which lays out strategic R&D needs to advance the hydropower industry towards a 100 percent clean energy economy.	• Complete work on a "reimagined" Hydropower Vision Roadmap. Monitor progress toward goals in the Hydropower Vision Roadmap.	• Reduced funding level reflects the lower level of effort necessary to support completion of work started and carried out in FY 2023.
• Support certification programs, curricula sharing, and provide training and other development opportunities to minority workforce entrants, vets, and transitioning workers from adjacent sectors. Support a new hydropower collegiate competition as well as analysis to inform a new/updated hydro workforce report.	• Support certification programs, curricula sharing, and provide training and other development opportunities to minority workforce entrants, vets, and transitioning workers from adjacent sectors. Support hydropower collegiate competition. Conduct analysis to inform a new/updated hydro workforce report.	• Funding will support the second year of the Hydropower Collegiate Competition and will support evaluation of other opportunities to support industry workforce needs and skills development, such as through a hydropower fellowship program or a certification program.
• Develop analysis and programs to commercialize promising hydropower technologies, including supporting National Laboratory research and private sector industry technologies.	• Develop analysis and programs to commercialize promising hydropower technologies, including supporting National Laboratory research and private sector industry technologies.	• Continue to develop programs to fund technology transitions, including in the private sector through funding a network of incubator and accelerators that mentor promising startups and technology developers in hydropower.
• Continue to expand and improve HydroSource. Support, a publicly available database to support improved decision-making and basin-wide management of river resources.	• Add/update datasets and perform maintenance to existing tools. Develop Climate Vulnerability Tool from 9505 data. Support existing maintenance of platform and conduct stakeholder engagement to increase usage.	• No significant change.
EPAct Section 242/243 $2,000,000	$0	-$2,000,000
• Funding supports the Congressionally directed implementation of the Energy Policy Act of 2005, Sections 242 & 243.	• No funding requested	• Administration of the Hydropower Incentives program now resides with the Grid Deployment Office within DOE.

Water Power
Marine Energy Technologies

Description

Marine energy technologies convert the energy of waves, tides, river and ocean currents, ocean thermal gradients, and salinity and pressure gradients into electricity and have the potential to provide millions of Americans with locally sourced, clean, and reliable energy. Resource assessments show that the total marine energy technical resource in the 50 U.S. states is 2,300 TWh/yr, equivalent to 56 percent of the electricity generated by those states in 2021. The Nation's Pacific and Caribbean territories and freely associated states add an additional 4,100 TWh/yr of ocean energy resource.[1] Developing just one-sixth of the available wave energy in the five Pacific states could power more than five million homes. Marine energy – particularly tidal energy – can serve as a predictable, forecastable resource with a generation profile complementary to the seasonal or temporal variations of other resources such as onshore wind and solar, which can enhance its contributions to grid resilience and reliability.

Marine energy offers both a future opportunity to supply electricity to a deeply decarbonized national grid and a near-term solution for distributed energy for isolated and islanded communities. Through the Powering the Blue Economy (PBE) initiative, the subprogram is demonstrating that marine energy technologies also have the potential to provide cost-effective energy for emerging at-sea and coastal distributed applications, including power for remote coastal communities with high electricity costs, charging for ocean-based sensors and underwater vehicles, and non-electric uses like desalination. Successfully serving these markets provides industry with opportunities to develop and deploy marine energy technologies in the near-term while reducing costs for larger utility-scale markets that are still developing. These real in-water experiences allow the industry to drive down learning curves and increase near term investment in the sector.[2]

Marine energy technologies are at an early stage of development due to the fundamental scientific and engineering challenges of generating power from dynamic, low-velocity and high-density waves and currents while surviving in corrosive ocean environments. Significant engineering, operational, economic, and regulatory challenges exist. The Marine Energy subprogram invests in RDD&D to develop innovative components, structures, materials, systems, and manufacturing approaches and to support development and utilization of testing infrastructure for systematic validation by industry at multiple scales. The subprogram aggregates, analyzes, and disseminates data to enable industry to develop cheaper and more effective monitoring instrumentation and ultimately to increase permitting and regulatory process efficiencies.

Materials and Components R&D: Marine energy technologies face difficult engineering challenges specific and inherent to the marine energy environment. This activity supports RDD&D to tackle these challenges to rapidly improve and reduce costs. Advanced controls is a major programmatic focus, as improvements in advanced controls can provide significant increases in energy capture, and recent advances have doubled the energy capture of previous methods. Research will continue to support DOE's commitment to a joint DOE-Navy project targeting advanced controls, National Laboratory support for competitively selected industry awards that develop new marine energy control systems, and foundational research at the Nation's universities into advanced materials, components, operations, and maintenance.

This activity is also developing the first-ever national wave classification metrics and site-specific marine energy characterization, akin to what DOE has provided historically for the wind and solar industries, which will refine and expand on the high-resolution wave and tidal resource data that assist in identifying project sites, inform design requirements, maximize energy capture, reduce project uncertainty and risk, and thereby reduce LCOE.

[1] Kilcher, Levi, Michelle Fogarty, and Michael Lawson. 2021. Marine Energy in the United States: An Overview of Opportunities. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5700-78773. https://www.nrel.gov/docs/fy21osti/78773.pdf

[2] "Powering the Blue Economy, Exploring Opportunities for Marine Renewable Energy" U.S. Department of Energy. April, 2019. https://www.energy.gov/sites/prod/files/2019/09/f66/73355-v2.pdf

System Integration and Validation: Research, design, and validation are needed to reduce cost and improve performance of marine energy technologies at a range of sizes and technology readiness. Investment in design concepts that have the potential to serve existing or emerging ocean-based technologies that can advance the Nation's military, commercial, and scientific capabilities include power for remote coastal communities and Department of Defense installations with high electricity costs, charging for ocean-based sensors and underwater vehicles, and non-electric uses like desalination.

Support for the PBE initiative will continue, including desalination systems for remote communities and disaster relief and recovery; demonstration of marine-energy-powered ocean observing systems; and, through ETIPP, on-the-ground assistance on resource assessment, grid integration analyses, and vetting of technology fit to help communities chart pathways to energy resiliency. In addition, this activity supports deployable systems to address plastics waste in U.S. rivers and waterways and investigation into marine-powered carbon dioxide removal (CDR) and aquaculture opportunities. Finally, this activity will demonstrate and deploy grid-scale marine energy projects to validate performance toward a fully decarbonized electric grid. This includes a focus on building systems that use the PacWave open-ocean wave energy test facility to advance wave energy system demonstration.

Testing & Reliability: To accelerate deployment, strategic investment into infrastructure access at the National Laboratories and other marine energy test sites is needed to de-risk technologies through in-water validation of prototype performance, efficiency, and reliability across a wide range of sea states including extreme conditions. This involves testing proof-of-concept systems in laboratory and ocean settings to understand performance characteristics, identifying and mitigating reliability risks, and providing data to inform future RDD&D of next-generation designs across the industry. The Office partners with industry to enable the development and testing of these prototypes through programs such as TEAMER (Testing Expertise and Access for Marine Energy Research) and enable access to dedicated testing infrastructure, such as PacWave, to reduce the inefficiency associated with each developer investing in testing cables and permits. This activity supports analysis and prediction of the environmental effects of marine energy devices through research that simulates device-ecosystem interactions and industry efforts to develop new technologies that more accurately monitor in-water devices.

Data, Modeling, and Analysis: To accelerate the development of marine energy, there is a need for new commercialization approaches, strategic engagement mechanisms with industry and new entities, new approaches to reach universities and students with potential concepts to advance the state of marine energy. There is also a need to make marine energy data public while ensuring database integrity. To enable commercialization in the blue economy, WPTO will fund a network of incubators and accelerators to support developers and startups and better connect end users to the market. Recognizing the need to engage underserved universities, the Office continues to seed promising research pathways and support more undergraduate and graduate research students in marine energy. Finally, this activity will continue to maintain and improve its public databases, web tools, and analytical reports, ensuring DOE marine energy informational resources are easily accessible and usable by all potential users.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2023 Request vs FY 2024 Enacted
Marine Energy Technologies $120,000,000	**$105,000,000**	**-$15,000,000**
Materials and Components R&D $23,000,000	$21,988,000	-$1,012,000
• Continued National Laboratory R&D into controls and power take-offs for marine devices following up on the strategy developed in recent FYs to dramatically reduce costs and/or increase energy capture R&D on controls and power take-offs for MHK devices.	• Continued National Laboratory R&D into controls and power take-offs for marine devices to dramatically reduce costs and/or increase energy capture R&D on controls and power take-offs for marine energy devices.	• Reduced funding to shift to university-focused research.
• Continue support with and increased focus on foundational R&D modeling tools and methodologies for device and array performance. R&D of advanced materials and components and new approaches for O&M of marine energy projects.	• Fund foundational modeling tools and methodologies, advanced materials, and components. Strengthen and engage universities and marine centers identifying capability gaps broadly affecting industry.	• Increased focus on foundational R&D supporting a balanced approached at universities and national labs.
• Continue development of the first-ever national wave classification metrics and site-specific wave energy characterization, with a focus on new sites and locations applicable to Powering the Blue Economy (PBE) technologies.	• Continue development of the first-ever national wave classification metrics and site-specific marine energy characterization, with a focus on new sites and locations applicable to Powering the Blue Economy (PBE) technologies.	• Reduced funding with an overall focus on characterization of new sites such as remote coastal communities.
Systems Integration & Validation $32,000,000	$40,682,000	+$8,682,000
• Continue to advance the state of the art and push high potential designs of marine energy devices, in particular those serving the blue economy. Support will continue for the OceanObs Prize as well as innovative research at small businesses.	• Demonstration of grid-scale systems from designs funded in prior years for wave energy systems at PacWave and assistance in scoping from ETIPP communities to in-water tests, with a particular focus on wave energy systems. Continued advancement of design and build of systems developed by small businesses with end users.	• Increased funding for in-water demonstrations of grid-scale devices at PacWave and for small businesses and support for co-developed marine energy systems for blue economy purposes.
• Design and develop flexible material Wave Energy Conversion (WEC) and support the INnovating Distributed Embedded Energy Prize (InDEEP) Prize to validate and demonstrate novel concepts. Continue to build on flexible material WEC design	• Design and develop flexible materials and support the InDEEP Prize to validate and demonstrate novel concepts. Execute the InDEEP Prize (prize scoping launched in FY 2022; prize opening FY 2023) to validate and	• Reduced funding for the second phase of the prize for teams to build and assess performance of concepts developed in the previous phase launched in FY 2023.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2023 Request vs FY 2024 Enacted
and development as well as continued WaveSparc work to develop novel concepts.	demonstrate the potential of novel concepts developed.	
• Research potential marine energy solutions for aquaculture and CDR, continuing the strategy and roadmap development of supporting blue economy applications, and continued support of the Pioneer Array.	• Advance systems aligned with the Powering the Blue Economy initiative. In partnership with Woods Hole Oceanographic Institution complete design, build, and test of a small electricity producing wave energy converter (WEC) test article to augment the solar and wind energy powering an oceanographic buoy in the Pioneer Array. Fund wave powered desalination R&D. Develop resilient design pathways through analyzing and potentially prototyping integrated coastal breakwater WECs.	• Increased funding for testing and design of systems aligned with Powering the Blue Economy.
Testing & Reliability $49,000,000	$21,990,000	-$27,010,000
• As directed by FY 2023 Enacted Appropriations, fund the costs of construction of the PacWave Open Water Test Facility.	• No funding requested.	• Funds for construction of the facility were provided in prior fiscal years.
• Continue support of TEAMER, a rolling test campaign supported in collaboration with U.S. universities and National Laboratories for early-stage marine energy systems.	• Expand the TEAMER program facility network through additional network organizations and capabilities upgrades, as well as increasing and diversifying the applicant pool.	• FY 2024 funding will result in access to new network facilities and capabilities by a larger number of developers and researchers.
• Continued National Laboratory work on large-scale field study to evaluate environmental effects of marine energy devices, including strike-risk to fish from tidal turbines and acoustic and other environmental impacts of wave energy devices, resulting in reduced cost and timelines associated with permitting.	• Assist industry developers during in-water deployments by collecting robust environmental data around operating marine energy devices.	• No significant change.
• Continue support for upgrades to test infrastructure at marine energy technology testing sites based on the testing needs roadmap.	• Support for upgrades to test infrastructure at marine energy technology testing sites based on a testing needs roadmap.	• No significant change.
Data, Modeling, and Analysis $16,000,000	$20,340,000	+$4,340,000
• Begin support of commercialization assistance through development of a network of incubators	• Build on initial investments made in prior years to advance commercialization assistance	• Increased funding in FY 2024 supports marine energy technology commercialization; business

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2023 Request vs FY 2024 Enacted
and accelerators for blue economy and marine energy innovation and entrepreneurship, support technology transfer at national labs; and broaden support for researchers – particularly disadvantaged students and universities – through projects at universities.	through marine energy and blue economy incubator networks and accelerators, national lab technology transfer; and support disadvantaged students and universities.	and technology incubation support to developers and startups; and seeding promising research pathways at universities.
• Continue the Marine Energy Collegiate Competition to identify promising, near-term blue economy applications and develop tabletop-scale prototypes.	• Support marine energy workforce development, including the Marine Energy Collegiate Competition and Graduate Student Research Program.	• No significant change.
• Continue to support National Laboratory analysis of R&D challenges and opportunities for remote and coastal communities (Powering the Blue Economy).	• Fund National Laboratory analysis of R&D challenges and opportunities for remote and coastal communities (Powering the Blue Economy).	• No significant change.
• Make program-funded research and testing results widely accessible through databases and tools such as PRIMRE.	• Make program-funded research and testing results widely accessible through databases and tools such as PRIMRE.	• Increased funding to maintain and improve upon marine energy program public databases, web tools, and analytical reports, ensuring DOE marine energy informational resources made easily accessible and usable.

Water Power
Regional Energy-Water Testing and Validation

Description

Energy security and water resilience are increasingly challenged by a changing climate and growing pressures from agricultural, industrial, and community demands. Climate change is manifested in the water cycle through events that include droughts, floods, melting snowpack, fire, and more, which create stress in the Nation's aging water and energy systems as they are currently designed. Intensifying water scarcity and overabundance across watersheds impact these systems in ways that are region-specific.

To advance technologies and approaches that ameliorate regional water challenges, in-field validation, testing, and pre-commercial demonstration of technology solutions are needed. Validation of technologies requires testing at a regional and subregional scale. This includes technology solutions that can simultaneously address water quantity and quality, wastewater, energy, and terrestrial and aquatic ecosystem issues within a given catchment area, while strengthening local communities with emphasis on those underserved.

Within regions and watersheds, diverse stakeholders, including local utilities and regulators, industry, agriculture, and communities, exert energy and water demands that shift and grow over time in response to economic, social, and policy pressures. But historically, research at the nexus of energy and water has focused on piecemeal case studies or one-size fits all national assessments without either in-field demonstration or integration of actual solutions. Creating regionally-focused, stakeholder-intensive development and demonstration of energy-water systems is critical for adopting water-smart technologies, advancing place-based solutions that allow for better watershed-level decision-making, and increasing confidence in performance of novel research while developing a local and diverse workforce.

WPTO's existing investments in infrastructure, regional climate and hydrologic modeling, and integrated energy-water assessments make regional energy-water testing and validation a logical next step in the translation and deployment of R&D into pre-commercial demonstration. WPTO's existing portfolio of R&D has advanced climate and hydrologic modeling predictions nationwide, identified and studied regions experiencing acute energy-water issues, and deployed tools to help the water power industry understand climate-driven impacts. This regionalized, systems perspective approach will integrate not only energy and water management, but also enhance communities' climate resilience and build on WPTO's mission to advance water power technologies.

Regional Energy-Water Demonstration Facilities: To address the need for pre-commercial testing and validation of technologies and approaches to deepen understanding of energy-water connections, the primary activity proposed is a multi-year investment in Regional Energy-Water Demonstration Facilities. One or more facilities are envisioned as transdisciplinary and interagency efforts designed around the needs of stakeholders in defined watersheds or regions. Each facility will focus on translating recent R&D outcomes – from hydroclimate prediction to novel desalination and treatment technologies to integrated systems management – to demonstration and scale water management solutions according to the needs of a specific region. A regional facility would develop new business models for solving water challenges that incorporates stakeholders like local utilities and regulators, industries, and communities in the earliest phase of system design. The demonstration facilities will provide multi-stakeholder partnership environments to de-risk and test technologies for pre-commercial demonstrations at scale and reduce costs for local utilities and governments. The training and education components of each facility will also enable the development of a diverse and local workforce ready to manage 21st century water systems.

Regional Energy-Water Testing and Validation

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2023 Request vs FY 2024 Enacted
Regional Energy-Water Testing and Validation $0	**$50,000,000**	**+$50,000,000**
Regional Energy-Water Demonstration Facilities $0	$50,000,000	+$50,000,000
• Not funded in FY 2023 Enacted.	• Launch scoping and first solicitation to establish one of more Regional Energy-Water Demonstration Facilities. This includes funding scoping through the National Laboratories, a workshop series with the National Academies, scoping grants to up to 20 regional parties nationwide, and ultimately down-selecting to one of more Regional Energy-Water Demonstration Facilities.	• New effort to test and validate energy-water focused technologies and approaches at the regional and subregional scale, leveraging prior work and current efforts to translate climate and hydrologic modeling to actionable science and local decision-making, integrate early- to late-stage technologies at scale, collect data using real-time smart sensors, and enhance local and regional economies and workforces with the overall goal of building resilient water and energy systems.

Geothermal Technologies

Overview

The mission of EERE's Geothermal Technologies Office (GTO) is to drive increased deployment of geothermal energy to enhance exploration and production. The GTO FY 2024 Request supports RDD&D to meet cost targets and make geothermal energy competitive nationwide. GTO's technology portfolio prioritizes investments in three closely related geothermal categories: Enhanced Geothermal Systems (EGS), Hydrothermal Resources, and Low Temperature and Coproduced Resources. This portfolio addresses technology barriers that industry may not have the technical capabilities or institutional knowledge to address.

Geothermal energy is a reliable, secure, clean, firm, and flexible domestic energy source. Geothermal addresses environmental justice because its high-capacity factor, small physical footprint, and wide-ranging application in the built environment ensure that it can be utilized in urban centers, rural areas, and remote communities where geothermal has high technical and economic potential and can reduce dependence on fossil fuels.

The geothermal industry often operates in a harsh subsurface environment with unique technical and operational challenges. Foremost among those challenges is that the resource is "out of sight" at a depth of approximately two to five kilometers, in hard, abrasive rock formations at elevated temperatures and pressures well beyond those typically encountered in oil, gas, or other subsurface operations. Built on the analysis from the 2019 DOE study, *GeoVision: Harnessing the Heat Beneath Our Feet* (GeoVision)[1], and presented in the 2022 Geothermal Technologies Office Multi-Year Program Plan[2], GTO has adopted the following Strategic Goals to reach geothermal energy's full potential: Goal 1: Drive toward a carbon-free electricity grid by supplying 60 gigawatts (GW) of EGS and hydrothermal resource deployment by 2050; Goal 2: Decarbonize building heating and cooling loads by capturing the economic potential for 17,500 geothermal district heating (GDH) installations and by installing geothermal heat pumps (GHPs) in 28 million households nationwide by 2050; Goal 3: Deliver economic, environmental, and social justice advancements through increased geothermal technology deployment.

Highlights of the FY 2024 Request

The Geothermal Technologies Program will pursue the following major activities in FY 2024:

- Launched in FY 2022, the Enhanced Geothermal Shot is a whole-of-DOE effort to dramatically reduce the cost of enhanced geothermal systems by 90 percent to $45 per megawatt hour (MWh) by 2035. The Enhanced Geothermal Shot will work toward this goal by aggressively accelerating RD&D focused on EGS, and in technology areas relevant to hydrothermal development as well.
- The EGS Well Construction initiative began in FY 2023 and included the development of a roadmap on technology advancements necessary to reduce costs associated with this capital-intensive aspect of EGS development. In FY 2024, a funding opportunity will be developed on EGS Well Construction that will address the unique barriers that the harsh high-temperature environment of EGS resources pose to cost-effective wellbore completion and production technologies. Significant progress in EGS Well Construction through this funding will enable more rapid commercialization of EGS resources by lowering overall lifecycle well costs.
- The Frontier Observatory for Research in Geothermal Energy (FORGE) initiative, started in FY 2014, has drilled several major wells on the Utah site, including the first-ever highly deviated geothermal well, drilled at 8000+ foot depth at a rate twice the industry standard. In FY 2024, GTO will stimulate a third, long-reach horizontal well, providing an opportunity to further advance stimulation technologies for EGS and enable additional zonal isolation testing.
- The Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE) consortium will continue to prepare solicitations and other activities focused on each GEODE facet, building off the FY 2023 GEODE Roadmap to make immediate progress in modernizing geothermal drilling, deploying O&G technologies to lower geothermal development costs, and standing up workforce development programs that attract, train, and utilize highly skilled workers displaced from the O&G industry.

[1] GeoVision: Harnessing the Heat Beneath Our Feet (energy.gov)

[2] GTO Multi-Year Program Play (FY 2022-2026 (energy.gov)

- The Exploration RD&D program will focus on exploring and characterizing geothermal resource potential in areas that have demonstrated the promise of hydrothermal resources. The need for exploration and test drilling, validation of new technologies, and improving the utilization of new data sets will be addressed through this work.
- GTO will continue to emphasize funding for demonstrations of community heating and cooling systems and direct use heating and cooling, including consideration of agricultural applications, through the Community Geothermal Heating & Cooling initiative. This program will continue to prioritize building local coalitions and developing a vocational workforce to deploy and install geothermal heating systems.
- GTO is involved in several DOE-wide crosscutting initiatives, including the following:
  - Industrial Decarbonization: to support demonstrations of thermal energy storage for manufacturing applications;
  - Energy-Storage to support the assessment of deep, low temperature resources in the U.S. for thermal energy storage as well as continue its Reservoir Thermal Energy Storage (RTES) initiative;
  - Critical Minerals: to support technology and process solutions to our Nation's critical minerals supply through geothermal brine and produced water extraction and processing; and
  - Subsurface Energy Innovation: to support RD&D that focuses on exploration, characterization, reservoir monitoring, and drilling-based verification of advanced technologies and methods.

Geothermal Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Geothermal Technologies					
Enhanced Geothermal Systems	52,143	57,500	129,033	+71,533	+124%
Hydrothermal Resources	22,984	24,000	34,787	+10,787	+45%
Low Temperature and Coproduced Resources	22,234	24,000	34,787	+10,787	+45%
Data, Modeling, and Analysis	12,139	12,500	17,393	+4,893	+39%
Total, Geothermal Technologies	**109,500**	**118,000**	**216,000**	**+98,000**	**+83%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $3,210,510; STTR: $548,990
- FY 2023 Enacted: SBIR: $3,146,000; STTR: $442,000
- FY 2024 Request: SBIR: $8,796,384; STTR: $1,236,992

Geothermal Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Geothermal Technologies	
Enhanced Geothermal Systems: The increase will support the Enhanced Geothermal Shot effort in various technical areas with a focus on learning-by-doing and well construction cost reductions, as well as a new portfolio focused on advanced materials and high temperature components to enable downhole development in EGS environments.	**+71,533**
Hydrothermal Resources: The increase will support Exploration and Characterization R&D for a new initiative focused on exploring and characterizing geothermal resource potential, offset by a slight reduction of funding for critical materials work in Resource Maximization R&D.	**+10,787**
Low Temperature and Coproduced Resources: The increase will support Resource Maximization R&D Activity including a strong focus on assessments for thermal energy storage and direct use systems as well as system deployments through the Community Geothermal Heating and Cooling initiative.	**+10,787**
Data, Modeling, and Analysis: The increase will support cross-EERE analysis and demonstration and increased analysis for streamlining geothermal permitting on Federal lands and improved data ingestion, processing, and dissemination. The Request also provides funding for Geothermal Grid Valuation Technical Assistance and Clean Energy to Communities capacity building.	**+4,893**
Total, Geothermal Technologies	**+98,000**

Description

To ensure the U.S. stays on track for 60 GW deployment of geothermal power by 2050, the FY 2024 Budget Request will support a wide variety of RD&D investments related to nearly every aspect of EGS resource development. The research supported under these activities will reduce costs and advance technologies needed for newly developed enhanced geothermal systems. The focus of the EGS subprogram is to gain an evidence-based understanding of basic and applied science challenges surrounding long-term subsurface heat flow, permeability enhancement, and stress evolution to enable development of sustainable, man-made heat exchangers. In the long term, strengthening the body of EGS knowledge through RD&D will enable industry to develop a baseload energy resource as shown in the GeoVision report, which will be the major contributor to achieving a potential geothermal power capacity of 60 GW by 2050.

The EGS subprogram is focused on characterizing, accessing, creating, and sustaining EGS reservoirs and is categorized into the following activities: Exploration and Characterization R&D; Subsurface Accessibility R&D; Subsurface Enhancement & Sustainability R&D; Resource Maximization R&D; and Data, Modeling, and Analysis.

In 2022, DOE launched an Enhanced Geothermal Shot, which is a whole-of-DOE effort to dramatically reduce the cost of EGS by 90 percent to $45 per megawatt hour (MWh) by 2035. Capturing even a small fraction of the U.S.' five Terawatts of available heat resource via widescale commercial deployment could affordably power over 40 million American homes and businesses, exponentially increasing deployment of conventional geothermal and geothermal heating and cooling solutions nationwide. All FY 2024 EGS RD&D will seek to make progress towards this EGS Shot target.

Exploration and Characterization R&D: Subsurface characterization technologies seek to track and understand the conditions in the subsurface such that we can design and develop optimized EGS reservoirs to maximize heat extraction, thereby reducing risks and costs of EGS development and the levelized cost of energy (LCOE) of produced energy. Ultimately, success in this space includes remote assessment capabilities and characterization technologies incorporated in real-time into fully coupled 3D reservoir models. In FY 2024, as part of the Enhanced Geothermal Shot, GTO will launch new R&D efforts in hardened materials, electronics, and components to enable subsurface characterization and operation in high temperature, corrosive environments.

Subsurface Accessibility R&D: Guided by a roadmap created in FY 2023, GTO will develop an EGS Well Construction funding opportunity in FY 2024 that will address technical challenges in cost-effective well construction to enable faster commercialization of EGS resources. Opportunities exist for the reduction of well construction costs across a wide range of areas that are not directly related to the drilling of EGS wells, including casing, cement-like materials, new well designs, wellbore integrity monitoring tools, etc.

Subsurface Enhancement & Sustainability R&D: EGS reservoir enhancement and sustainability funds will be directed to early career researchers to foster new ideas in the field of EGS. GTO will conduct this effort in collaboration with the National Science Foundation (NSF) and will focus on attracting new researchers from academia to the field of geothermal energy to expand the collective brain power focused on increasing geothermal energy deployment.

Frontier Observatory for Research in Geothermal Energy (FORGE): FORGE enables scientists and engineers to conduct transformative and high-risk science and engineering, moving EGS toward commercial viability. FORGE technical successes have positively influenced countless start-up designs and geothermal industry practices in the last five years, directly facilitating increased deployment. FORGE was extended via language in the Energy Act of 2020, and FY 2024 funding will support the stimulation of an additional well and a third competitive solicitation.

Data, Modeling, and Analysis for EGS: Data best practices, techno-economic modeling, and strategic analysis underpin RD&D conducted across all GTO Subprogram Research Areas. Ongoing analysis and work in each of these areas is critical to ensure program-wide progress toward meeting EGS specific metrics and goals.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Enhanced Geothermal Systems $57,500,000	**$129,033,000**	**+$71,533,000**
Frontier Observatory for Research in Geothermal Energy (FORGE) $22,952,000	$ 40,000,000	+$17,048,000
• FORGE: R&D focused on developing alternative completion techniques, adopting relevant unconventional O&G stimulation methods, and identifying links between completion techniques and reservoir development and operation. A portion of these funds will enable the drilling of an additional highly deviated well.	• FORGE authorization was extended via language in the Energy Act of 2020, and FY 2024 funding will support the stimulation of an additional well and a third competitive solicitation.	• The increase will fund the commercial scale stimulation of a third highly deviated well, which will advance EGS technology toward commercialization in support of GTO goals for widespread firm, flexible, geothermal power deployment.
Subsurface Enhancement & Sustainability R&D $34,548,000	$30,000,000	-$4,548,000
• EGS STEM Early Career Awards: Issue small seedling grants that allow participants to develop and pursue geothermal-relevant ideas. This will increase awareness of geothermal benefits and resources and attract researchers and other interested parties to the geothermal field.	• Continuing a successful effort started in FY 2022 in collaboration with NSF, GTO will continue to fund seedling grants that allow participants to develop and pursue geothermal-relevant ideas. This will increase awareness of geothermal benefits and resources and attract researchers and other interested parties to the field.	• Funding for EGS STEM Early Career Awards will remain at the same level as FY 2023.
• EGS Greenfield Demonstration: EGS Greenfield Demonstration will target shallow to mid-depth, geothermal temperature anomalies for clean, renewable, geothermal power production. Projects will build on the zonal isolation and stimulation learnings of previous GTO initiatives such as Wells of Opportunity (WOO) and FORGE.	• No funding requested.	• Deferral of funding request in FY 2024 for EGS Greenfield Demonstrations will allow time for IIJA demonstrations to develop so that those projects can inform optimal target for an EGS Greenfield Demonstrations funding opportunity in FY 2025.
• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): Select GEODE Team and prepare solicitations to modernize geothermal drilling, deploy O&G technologies to lower geothermal development costs, and stand-up workforce development	• Funds year 3 of the GEODE consortia, including solicitations that will further the research, development, and demonstration of how oil and gas assets, technologies, and workforce can help solve geothermal's toughest challenges.	• Funding for GEODE remains at the same level as FY 2023.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
programs to attract, train, and utilize highly skilled workers displaced from O&G.		
• EGS Well Construction: Research, develop, and demonstrate well construction technologies that will accelerate commercialization of EGS resources by lowering lifecycle development costs.	• The Request will allow GTO to research, develop and demonstrate well construction techniques and tools to enable more cost-effective development of EGS resources.	• Increased support combined with funds from FY 2023 will be used to develop a funding opportunity on EGS well construction RD&D based a roadmap developed in collaboration with National Laboratory partners.
Subsurface Accessibility R&D $0	$30,000,000	+$30,000,000
• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): Select GEODE Team and prepare solicitations to modernize geothermal drilling, deploy O&G technologies to lower geothermal development costs and stand-up workforce development programs to attract, train, and utilize highly skilled workers displaced from O&G.	• Funds year 3 of the GEODE consortia, including solicitations that will further the research, development, and demonstration of how oil and gas assets, technologies, and workforce can help solve geothermal's toughest challenges.	• Beginning in FY 2024, the GEODE initiative was added to the Subsurface Accessibility R&D category because it is a wide-ranging initiative that spans multiple categories. Funding for GEODE was previously provided through the Subsurface Enhancement & Sustainability R&D activity and the overall funding for GEODE remains at the same level as FY 2023.
• EGS Well Construction: Research, develop and demonstrate well construction technologies that will accelerate commercialization of EGS resources by lowering lifecycle development costs.	• We will seek to research, develop and demonstrate well construction techniques and tools to enable more cost-effective development of EGS resources.	• Increased support combined with funds from FY 2023 will be used to develop a funding opportunity on EGS well construction RD&D based a roadmap developed in collaboration with National Laboratory partners. The EGS Well Construction initiative was added to the Subsurface Accessibility R&D category because it is a wide-ranging initiative that spans multiple categories.
Exploration and Characterization R&D $0	$27,000,000	+$27,000,000
• EGS Near-Field Monitoring & Characterization R&D: Support new near-field EGS demonstrations through the WOO effort.	• Support EGS pilot demonstrations and other EGS activities. • Launch new R&D efforts in collaboration with other DOE partners focused on hardened materials and components to enable subsurface characterization and operation in high temperature, corrosive environments.	• Additional funding will support required monitoring of induced seismicity associated with any pilot stimulation demonstrations. • Increased funding for materials and component focused work that was a major part of Enhanced Geothermal Shot RD&D proposals and underpins all EGS RD&D.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $0	$2,033,000	+$2,033,000
	• EGS-Focused Techno-Economic Tools & Data: Conduct critical power sector analysis and modeling relevant to EGS.	• This represents a new activity in FY 2024, dedicated to analysis and modeling specifically focused on Enhanced Geothermal EarthShot targets.

Geothermal Technologies
Hydrothermal Resources

Description

The FY 2024 Request supports RD&D that can lower cost and risk throughout the lifecycle of a hydrothermal project to bring more hydrothermal power online, from exploration and resource confirmation, to drilling and field development, to reservoir management over multi-decadal timescales. The subprogram also supports R&D for extracting critical materials or other strategic minerals from geothermal brines to maximize the ancillary benefits of geothermal resources.

Hydrothermal resources are currently the primary source of geothermal power and heat worldwide, and the GeoVision study indicates that technology innovation can help unlock additional hydrothermal resources to contribute to the potential 60 GW of geothermal power capacity by 2050. Hydrothermal resources can also support the nearer-term Administration goal of a carbon pollution-free electricity sector by 2035.

Because cost and risk are both concentrated in the early phases of a geothermal resource development, many of the biggest opportunities for advancement relate to the exploration and drilling phases of a project. Improving capabilities for characterization of both known and "hidden" hydrothermal resources will encourage geothermal development by reducing project cost and risk through improved drilling success rates. Novel exploration technologies can reduce project risk by greatly reducing the number of unsuccessful wells that are drilled. Advanced drilling technologies have the potential to improve project economics significantly by attaining improved rates of penetration, reducing delays, avoiding problems with surface and downhole equipment, and offering low-cost, high-performance materials for well construction. Other paths to improved economics focus on sustaining the resource and maximizing its value; efforts include the application of machine learning and artificial intelligence (e.g., big-data techniques and autonomous systems) in field management, and the implementation of newer energy applications and business models, e.g., mineral recovery, grid-scale energy storage, and dispatchable power generation.

Research in the Hydrothermal Resources subprogram is categorized into the following activities: Exploration and Characterization R&D, Subsurface Accessibility R&D, and Resource Maximization R&D.

Exploration and Characterization R&D: This activity focuses largely on capabilities for locating and mapping the extent of the requisite components of a resource: heat, fluids, and permeable pathways; as well as high-resolution subsurface imaging that is needed to develop an identified resource. These technologies can reduce the levelized cost of electricity (LCOE) primarily by lowering the capital cost of a geothermal project. Most of the remaining undiscovered hydrothermal resources in the U.S. are difficult to identify with existing exploration technologies and methods, largely because these resources lack the traditional surface manifestations that indicate resource potential. Advanced techniques that work reliably in oil and gas exploration do not yet perform similarly in a geothermal setting but are of high interest for technology transfer efforts.

Subsurface Accessibility R&D: The activity focuses on developing capability to access the subsurface effectively and is critical to hydrothermal development. Integrating improved drilling and well-completion technology, better well designs and construction materials, and improved decision-making can help industry realize better drilling efficiencies and effectiveness. Newly developed drilling techniques deployed in a hydrothermal setting can have spillover benefits to the development of less commercialized EGS and low-temperature systems.

Resource Maximization R&D: This activity focuses on how R&D can help overcome the challenges of proving extraction technologies and scaling them up to commercial levels. R&D can improve tools and techniques for characterizing provenance and sustainability of these types of mineral resources. In particular, the ability to harvest critical minerals such as lithium and manganese, as well as other valuable minerals such as zinc and silica, from geothermal brines can help maximize the value of the country's geothermal resources.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Hydrothermal Resources $24,000,000	**$34,787,000**	**+$10,787,000**
Subsurface Accessibility R&D $11,369,000	$12,000,000	+$631,000
• Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE): Select GEODE Team and prepare solicitations to modernize geothermal drilling, deploy O&G technologies to lower geothermal development costs, and stand up workforce development programs to attract, train, and utilize highly skilled workers displaced from O&G.	• Funds year 3 of the GEODE consortia, including solicitations that will further the research, development, and demonstration of how oil and gas assets, technologies, and workforce can help solve geothermal's toughest challenges.	• Provides year 3 of funding for a 5-year initiative.
Exploration and Characterization R&D $8,676,000	$20,000,000	+$11,324,000
• FedGeo Power: Conduct feasibility studies and site characterization for geothermal power generation opportunities at Federal and military installations with a large electricity demand and/or strong energy security and resiliency mandates.	• No funding requested.	• No additional funding is needed for FedGeo Power in FY 2024.
	• Exploration RD&D: Building on a decade of R&D from Play Fairway Analyses and Hidden Systems initiatives, this program will focus on exploring and characterizing the geothermal resource potential in areas that have demonstrated the promise of hydrothermal resources. This work will address the need for exploration and test drilling, validation of new technologies, identifying new survey areas, and improving the utilization of new data sets.	• The increase will support a new initiative that will directly enable identification of geothermal systems that will lead to deployment of carbon-free geothermal power production, contributing 30 additional GW by 2050, and aiding the U.S. transition to 100 percent clean energy economy.
• Machine Learning for Geothermal: Identify hidden geothermal resources in the U.S. using machine learning in conjunction with data gathered through geophysical surveys in partnership with USGS (GeoDAWN; GeoFlight).	• No funding requested.	• Partnerships with USGS in this space continue to provide critical data on hydrothermal resources; Needs for additional survey(s) are expected to be incorporated in the Exploration RD&D initiative (above) for FY 2024.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Resource Maximization R&D $3,955,000	$2,787,000	-$1,168,000
• Critical Materials: Scale up technical solutions for geothermal brine and produced water extraction and processing. Demonstrate technologies in the Salton Sea area of California.	• Initiative to scale-up technologies related to lithium extraction from geothermal brines and identification of additional resources and geographies with high potential for mineral extraction from geothermal brines or waters.	• Funding will be used for R&D for mineral extraction technologies and analyses to serve the administration priorities in critical minerals.

Geothermal Technologies
Low Temperature and Coproduced Resources

Description

The FY 2024 Request supports targeted RDD&D for technologies applicable to geothermal resources below a temperature of 300°F (150°C) as well as geothermal resources, including hybrid energy designs, that can be co-developed with other clean energy technologies. The subprogram also supports R&D on the direct use of thermal resources for process and space heating applications, geothermal heat pumps, district-scale geothermal heating and cooling systems, and deep direct use geothermal resource development. These technologies have the potential to provide cost-effective, renewable thermal energy in large portions of the U.S.

A U.S. Geological Survey (USGS) assessment estimates 46,500 MW thermal (MWth) of total beneficial heat could be extracted from geothermal resources below 90°C in the U.S. using currently available technologies.[1] The GeoVision study estimates that through the adoption of advanced technology scenarios, geothermal district-heating installations could increase to 17,500 nationwide and 28 million U.S. households could realize cost-effective heating and cooling solutions through geothermal heat pumps. The U.S. has an opportunity to leverage existing HVAC and piping infrastructure for low-temperature resources, lowering the effective levelized cost of electricity or heat. Improving the efficiency of low-temperature geothermal systems, and expanding their utility through value-added commercial opportunities, such as storing thermal energy in underground reservoirs, can facilitate near-term development of innovative geothermal technologies in geographically diverse areas of the U.S.

Resource Maximization R&D: This activity supports research that enables maximization of low temperature geothermal resources to develop effective and affordable direct-use systems. This research includes understanding temperature gradients at varying depths and in varying environments (urban/rural, residential/industrial, etc.) and will help the geothermal industry better understand where these low-temperature resources can most effectively be harnessed.

The activity also supports crosscutting efforts in energy storage and industrial decarbonization through standalone funding opportunities for large-scale resource assessment and feasibility research across a diverse group of institutions pursuing geothermal system installation with a goal to develop the ubiquitous thermal energy storage available in the Earth for a variety of direct-use and grid applications. This can significantly enable new, more resilient energy services that not only provide an effective alternative to grid-dependent heating and cooling but that also add resilience to the broader energy system.

The activity also supports district- and community-scale geothermal heating and cooling systems and geothermal heat pumps (also known as “ground-source heat pumps”) that make use of near-constant year-round temperatures in the shallow subsurface to heat communities and infrastructure in the winter and cool them in the summer. Geothermal resources can provide a range of benefits, including grid stability, reliability, resiliency, and partnership with other energy resources for even greater return.

[1] https://www.usgs.gov/programs/energy-resources-program/science/geothermal#overview.

Low Temperature and Coproduced Resources

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Low Temperature and Coproduced Resources $24,000,000	**$34,787,000**	**+$10,787,000**
Resource Maximization R&D $24,000,000	$34,787,000	+$10,787,000
• Energy Storage Grand Challenge: Develop pilots and demonstrations of Reservoir Thermal Energy Storage to demonstrate technical feasibility, grid integration, and opportunities for systems that leverage more than one type of renewable energy or energy storage.	• Thermal Energy Storage Assessments: Develop a partnership to assess deep, low temperature resources in the U.S. for thermal energy storage and industrial direct use systems.	• The increase will support resource assessments to identify promising areas for thermal energy storage deployment.
• Community Geothermal Heating & Cooling Technical Assistance & Deployment: Build on FY 2022 initiative to demonstrate geothermal heating and cooling for communities in a variety of living environments. Build state and local partnerships to develop a vocational workforce to deploy and install geothermal heating systems.	• Community Geothermal Heating & Cooling: Funding for demonstrations of community heating and cooling system and direct use heating and cooling, including agricultural applications. This program will prioritize building local coalitions and developing a vocational workforce to deploy and install geothermal heating systems.	• Increase will expand the community geothermal initiative to additional high-value application spaces and seeks to double the over 3,000 TJ/year of direct-use geothermal energy that is already used in the U.S. agricultural sector for fish farms, greenhouses, and animal farming while also creating net-zero agricultural heating systems and increase deployment of community geothermal systems.
	• New program seeks to develop and fund local and regional outreach-focused partnerships to increase local stakeholder engagement and education related to geothermal heat pumps and community-scale geothermal heating and cooling systems. Regional partnerships will provide tailored information on technologies and opportunities to different regions of the U.S., resulting in increased deployment of geothermal heating and cooling systems.	• Regional deployment partnerships are key to meeting the administration's goal of 28 million geothermal heat pumps in the U.S. by 2050.

Geothermal Technologies
Data, Modeling, and Analysis

Description

FY 2024 activities in the Data, Modeling, and Analysis (DMA) subprogram provide a critical supporting and enabling function toward advancing the entire GTO research portfolio. DMA takes a holistic analytical approach across the GTO's technology portfolio with the aim of improving the state of the art of complex geothermal technologies and to enable further deployment of geothermal resources. The goal of the DMA subprogram is to identify and address barriers to geothermal adoption in the U.S. and validate and assess technical progress across the geothermal sector to inform the direction and prioritization of GTO RDD&D.

DMA conducts analyses in the following areas: resource assessments; assessments of the economic, environmental, system-level, and grid integration impacts and value of geothermal technologies; the policy and regulatory barriers to geothermal development; and techno-economic modeling and validation of geothermal technology cost and performance. DMA supports the collection and dissemination of data for stakeholder use to spur geothermal development. DMA also leverages these data and analyses to support programmatic strategic planning and to either validate or refine the program's overall RDD&D. DMA conducts these activities in partnership with the DOE National Laboratories, Federal agencies, academic institutions, and industry stakeholders to maximize interagency coordination to compound and amplify impact.

In FY 2019, DMA released *GeoVision: Harnessing the Heat Beneath Our Feet*. Based on rigorous modeling and simulation, the GeoVision analysis addresses gaps in understanding the potential of geothermal resources and provides a case for geothermal energy to have a sizable role in meeting the Nation's 21st-century energy demands. Leveraging the results from the GeoVision analysis, the program published a GTO Multi-Year Program Plan in FY 2022. The GTO Multi-Year Program Plan provides additional RDD&D objectives and associated performance goals through FY 2026 for accelerating towards the outcomes identified in the GeoVision analysis.

Data, Modeling, and Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Data, Modeling, and Analysis $12,500,000	**$17,393,000**	**+$4,893,000**
Data, Modeling, and Analysis $12,500,000	$17,393,000	+$4,893,000
Techno-Economic Tools & Data: Critical analysis, modeling, and storage of project data. Funding for the second year of development of major analytic capacity building for geothermal at NREL and other laboratories to expand geothermal modeling capacity and representation, power sector analysis on hybridizing geothermal power with other renewables, and heating and cooling sector impact analysis.	• Build on FY 2023 successes by funding the third year of development of major analytic capacity building for geothermal at NREL and other laboratories in FY 2024, focused on representing geothermal technologies in key modeling platforms and leveraging those models to conduct value and impact analyses of geothermal power generation and heating and cooling technologies.	• No significant change.
• Cross-EERE Analysis, Technical Assistance, and Demonstration: Data, tools, analysis to support integrating renewables to the power system. Includes partnering with EERE Offices and the Office of Electricity to expand technical assistance for decision makers, including field demonstration of hybrid geothermal technology applications, designing deployment programs, evaluating electrification and decarbonization pathways, developing market and policy solutions, and planning transmission and distribution upgrades.	• Build upon the FY 2023 successes of projects funded by the FY 2022 lab call "Evaluation of Geothermal Hybrids for Near-Term Commercial Deployment" to implement commercialization pathways for hybrid opportunities. Build on FY 2023 cross-EERE analysis of grid impacts and value of geothermal heating and cooling through continued analysis and stakeholder and utility engagement to expand geothermal heating and cooling adoption. Work with Federal partners to improve leasing, permitting, and siting of geothermal technologies on public lands.	• The increase will support expanded stakeholder outreach and integration with cross-EERE initiatives and to provide geothermal subject matter expertise to interagency partners in geothermal siting, leasing, and permitting.
• Clean Energy to Communities (C2C): Over 170 cities have committed to 100 percent clean energy. GTO will contribute to C2C to provide support mechanisms including analysis of decarbonization strategies, lab demonstrations of technologies and best practices, measurement and verification processes, workforce development pipelines, and disseminating outcomes and lessons learned.	• Increased support to the C2C to provide technical assistance supporting energy assessment, planning, and operations to achieve energy-resilient communities while fostering cross-technology collaboration, planning and solutions.	• The increase will expand cohorts.

Advanced Materials and Manufacturing Technologies

Overview

The Advanced Materials and Manufacturing Technologies Office (AMMTO) supports innovation for advanced materials and manufacturing technologies that drive competitive domestic manufacturing for products needed to decarbonize the economy. AMMTO has three subprograms focusing on next-generation materials and processes, secure and sustainable materials, and energy technology manufacturing and its workforce.

AMMTO plays a strategic role in building a strong, revitalized domestic manufacturing sector through investments in research, development and demonstration (RD&D) activities, as well as technical assistance and workforce training. AMMTO actively partners with the Nation's manufacturing innovation community, including companies (for-profit and not-for-profit), individuals, universities, laboratories, state/local governments, and consortia. AMMTO activities depend on merit-based selection and peer-reviewed results.

In the FY 2023 Budget Request, EERE's manufacturing and industry sector-related activities were structured across four technical subprograms: Industrial Efficiency and Decarbonization; Clean Energy Manufacturing; Material Supply Chains; and Technical Assistance and Workforce Development in a single Advanced Manufacturing Office (AMO). In the FY 2024 Request, EERE further sharpens and focuses its manufacturing portfolio, reorganizing the Advanced Manufacturing Office into two programs with associated control points aligned with the two organizational offices established in FY 2023: the AMMTO and the Industrial Efficiency and Decarbonization Office (IEDO). This reorganization was performed to position the two new organizations to better achieve the goals and purposes articulated for manufacturing and industry programs in the Energy Act of 2020. As part of the reorganization process, DOE considered input from external stakeholders and prior peer review feedback. IEDO focuses on RD&D for technologies that reduce emissions in the industrial sector for globally competitive decarbonized manufacturing in the U.S. AMMTO focuses on RD&D for advanced materials, advanced devices, and new processing technologies. These investments foster competitive U.S. manufacturing that delivers the products and technologies to decarbonize multiple end-use sectors in the full economy (buildings, industry, transportation, electric power). In addition to increasing U.S. manufacturing competitiveness, AMMTO's work results in more secure and resilient supply chains.

To strengthen the competitiveness of the U.S. manufacturing enterprise, AMMTO proposes a three-pillar budget structure: Next-Generation Materials and Processes; Secure and Sustainable Materials; and Energy Technology Manufacturing and Workforce. Within each subprogram, AMMTO focuses on the advancement of technology with high potential for impact, identified through engagement with stakeholders, informed by strategic analysis, and guided by roadmaps to target knowledge gaps and barriers, ultimately providing a pathway to adoption by industry.

Much of the work within AMMTO impacts and connects to other offices throughout DOE. AMMTO collaborates and coordinates with offices within the Office of the Under Secretary for Science and Innovation, including the Office of Fossil Energy and Carbon Management (FECM) on critical materials; the Office of Electricity (OE) on energy storage; and the Office of Science (SC) on semiconductors and microelectronics. The office also collaborates with other EERE offices on specific technology applications, including the Bioenergy Energy Technologies Office, Vehicle Technologies Office, the Wind Power Technologies Office, and IEDO. In addition, AMMTO collaborates with Offices within the Office of the Under Secretary for Infrastructure (S3) on RD&D and workforce development efforts to maximize economy-wide decarbonization and energy efficiency and enable secure, sustainable, and resilient domestic supply chains.

Highlights of the FY 2024 Request

The AMMTO Budget Request supports key efforts that contribute to achieving its high-level goals:

- Invest in research and develop advanced manufacturing technologies such as additive manufacturing, forging, casting and other processes and techniques that enable a competitive U.S. manufacturing sector, particularly for clean energy applications such as large near net shape metal components used in offshore wind, water power, and other energy applications.
- Invest in RD&D on highly conductive materials that drive efficiency gains in several applications, including motors, electrical delivery systems, waste heat recovery, and others.

- Continue funding the Critical Materials Collaborative, as authorized in the Energy Act of 2020, to provide a centralized entity for multidisciplinary, collaborative, critical materials R&D, including pilot projects and testbeds, to reduce supply risk and improve supply resilience for materials and technologies necessary for the clean energy transition.
- Expand circular economy support to advance design for recyclability, efficient material use, recycling technologies, and reuse of raw materials in manufacturing for materials and products, including polymers, metals, fibers, and electronics.
- Research and develop manufacturing innovations to address technical challenges and barriers to achieve lower cost, higher performance, and accelerated deployment of clean energy technologies, such as long duration energy storage systems, wide bandgap semiconductors, and highly efficient semiconductors.
- Train the manufacturing workforce of the future through regional education initiatives, Manufacturing USA Institute education and workforce development programs, and the Lab Embedded Entrepreneurship Program (LEEP).
- AMMTO is involved in several crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing crosscut through RD&D to develop manufacturing technologies for long duration storage, power electronics and highly efficient microelectronics; composite wind turbine blades and other clean energy technologies; new materials for high conductivity application and harsh service conditions, smart manufacturing, additive manufacturing, and roll-to-roll manufacturing, recycling, design for recyclability, and other circular economy approaches;
    - Critical Minerals crosscut through R&D and pilot projects and testbeds that verify economics of scaled continuous operations in real world conditions needed to diversify supply, developing substitutes, improving reuse/recycling, and more efficient use;
    - Energy-Storage crosscut through investments on innovation related to incorporating energy storage into manufacturing processes and/or facilities to manage power and thermal energy and reduce industrial greenhouse gas (GHG) emissions;
    - Grid Modernization crosscut through investments in the development and demonstration of highly-conductive materials that can provide significant efficiency improvements to the grid and grid-connected applications; and Industrial Decarbonization crosscut through a variety of R&D investments.

Advanced Materials and Manufacturing Technologies
Funding ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Advanced Materials and Manufacturing Technologies (AMMTO)					
Next-Generation Materials & Processes	103,544	90,000	90,000	0	0%
Secure & Sustainable Materials	66,530	40,000	91,497	+51,497	+78%
Energy Technology Manufacturing & Workforce	50,444	53,500	60,000	+6,500	+12%
Total, Advanced Materials and Manufacturing Technologies	**220,518**	**183,500**	**241,497**	**+57,997**	**+32%**
Industrial Efficiency & Decarbonization Office (IEDO)					
Energy- and Emission-Intensive Industries	98,790	131,000	195,000	+64,000	+49%
Cross-Sector Technologies	52,709	90,500	141,245	+50,745	+56%
Technical Assistance & Workforce Development	30,983	45,000	58,000	+13,000	+29%
Total, Industrial Efficiency & Decarbonization Office	**182,482**	**266,500**	**394,245**	**+127,745**	**+48%**

Note: Industrial Efficiency and Decarbonization Office (IEDO) added to the table to show the Request to re-organize Advanced Manufacturing Office (AMO) Budget into two control points aligned with the two organizational offices established in FY 2023: the AMMTO and the IEDO. Numbers in FY 2023 and earlier are estimates prior to the bifurcation of the office.

SBIR/STTR:
FY 2022 Transferred: SBIR: $7,451,207; STTR: $972,809
FY 2023 Enacted: SBIR: $4,453,741; STTR: $588,929
FY 2024 Request: SBIR: $6,717,000; STTR: $945,000
Note: Please see Industrial Efficiency and Decarbonization Technologies (IEDO) for the balance of AMO SBIR/STTR funding

Proposed FY 2024 Budget Structure

	Advanced Materials and Manufacturing Technologies (AMMTO)			
	Next-Generation Materials & Processes	**Secure & Sustainable Materials**	**Energy Technology Manufacturing & Workforce**	**Total**
FY 2023 Budget Structure				
Advanced Manufacturing (AMO)				
Industrial Efficiency and Decarbonization				**0**
Clean Energy Manufacturing	55,000		42,000	**97,000**
Material Supply Chains	35,000	91,497		**126,497**
Technical Assistance and Workforce Development			18,000	**18,000**
Total	**90,000**	**91,497**	**60,000**	**241,497**

Note: Please see Industrial Efficiency and Decarbonization Technologies (IEDO) for the balance of AMO funding

Advanced Materials and Manufacturing Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Next-Generation Materials & Processes: The Request prioritizes the development of manufacturing processes, such as those advanced by DOE's Manufacturing Demonstration Facility (MDF). Resources emphasize support for technologies to produce cost-effective near net-shape objects needed for multiple clean energy technologies. The Request also supports additional work to address smart manufacturing throughout the manufacturing sector. Materials and processing RD&D also will focus on highly conductive materials for efficiency improvements across the economy and structural materials for clean energy technologies.	0
Secure & Sustainable Materials: The Request includes an increase that will prioritize research to advance manufacturing and materials technologies relevant to the circular economy. RD&D activities emphasize manufactured materials design with consideration of their full life, developing new recycling processes, and addressing circular supply chain challenges for materials important to clean energy technologies. The Request also increases AMMTO critical materials investments, with focus on research, development and pilot scale demonstrations aimed at increasing availability and resiliency of critical materials used in clean energy application.	+51,497
Energy Technology Manufacturing & Workforce: This Request increases investment in RD&D for the manufacture of long duration storage technologies, power electronics needed for electrification, and highly efficient microelectronics. The subprogram will continue to support workforce development programs and technical assistance, as well as the Lab Embedded Entrepreneurship Program, which provides innovators with lab access and entrepreneurship training.	+6,500
Total, Advanced Materials and Manufacturing Technologies	**+57,997**

Advanced Materials and Manufacturing Technologies
Next-Generation Materials & Processes

Description

The Next-Generation Materials & Processes subprogram will focus RD&D support on evolving advanced manufacturing materials and processes that increase U.S. manufacturing competitiveness in clean energy technologies, with an emphasis on materials and manufacturing processes that benefit multiple energy technology applications. This work will support economy-wide decarbonization. Key materials and processes include structural composites, high conductivity materials, materials for harsh service conditions, additive manufacturing, smart manufacturing, and high performance computing. This subprogram will support applied RD&D projects and consortia—cost-shared with companies and research organizations—that focus on generating solutions to specific materials and technology challenges to advance domestic manufacturing while reducing our Nation's carbon footprint. This RD&D will be selected through competitive solicitations using merit review.

Advanced Manufacturing Processes and Systems: This activity will support foundational manufacturing processes such as additive manufacturing, roll-to-roll manufacturing, automation, digitalization, and cybersecurity. These manufacturing process innovations can improve U.S. competitive advantage across a variety of industries important to manufacturing of clean energy technologies. The Manufacturing Demonstration Facility (MDF) works on additive manufacturing and related processes for clean energy technologies. Casting and forging processes will be worked on to revitalize domestic supply chains, particularly for large, near net shape components needed in clean energy applications. Manufacturing digitalization, made secure by cybersecurity advancements, will be essential to U.S. manufacturing competitiveness and resilient supply chains. In addition, high-performance computing for manufacturing (HPC4Mfg) programs enable direct access to high-performance computing assets and expertise at national laboratories to U.S. manufacturers (with a focus on small and medium sized firms) to accelerate scale-up and adoption of new material and process technologies with high impact potential in clean energy applications.

High Performance Materials: This activity will support materials with improved performance necessary for decarbonization and clean energy. Specific RD&D will enable advancements high conductivity metals, and high-strength and low-weight materials. The activity will also support RD&D for composite materials for wind energy and other clean energy applications. Additional work will focus on developing materials used in extreme or harsh conditions, with a focus on high temperature service environments required for decarbonized heat, thermal storage, and other clean energy applications.

Next-Generation Materials & Processes

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Next-Generation Materials & Processes **$90,000,000**	**$90,000,000**	$0
Advanced Manufacturing Processes and Systems $64,500,000	$55,000,000	-$9,500,000
• Continue additive manufacturing and carbon fiber composites research through the MDF.	• Leverage MDF to address cross-cutting manufacturing challenges and enable a domestic supply chain for clean energy technologies such as wind and hydropower. Pursue joint funding from other DOE offices (WETO, NE), agencies (DOD) and private partners that benefit from MDF work.	• Reduction of funding for demonstrations in the use of nanocellulosic feedstocks to manufacture clean energy components and building technologies to prioritize funding for RD&D that addresses challenges in cross-cutting manufacturing technologies. Modest reduction in funding for MDF.
• Support new methods for manufacturing products such as agile manufacturing, additive manufacturing, and the manufacture of carbon fiber from low-cost precursors, and support innovative Advanced Materials and Manufacturing Technologies to enable manufacturing supply chains to be nimble, responsive, and adaptive to disruption, change and opportunity.	• Use the National Smart Manufacturing Strategic Plan[1] and proceedings from the Workshop series on Options for a National Plan for Smart Manufacturing[2] to guide funding of RD&D in manufacturing digitalization technology that improves energy efficiency, reduces emissions, and improves supply chain resilience.	• No change in funding.
• Support high performance computing-based solutions that apply modeling, simulation, and data analysis to industrial processes and products to improve energy performance and substantially reduce carbon.	• Support HPC4Mfg program that provides access to leading edge national lab capabilities in modeling, simulation, and data analysis for industrial processes, materials, and products to improve energy performance and/or improve other dimensions of manufacturing performance	• No change in funding. Will support computational models and analysis for materials design and manufacturing performance and scale up for clean energy technologies.

[1] DOE National Smart Manufacturing Strategic Plan (2022), https://www.energy.gov/sites/default/files/2022-07/National%20Smart%20Manufacturing%20Strategic%20Plan%20-%202022_0.pdf

[2] National Academies of Sciences Engineering and Medicine, Workshop Series on Options for a National Plan on Smart Manufacturing (2023), https://www.nationalacademies.org/our-work/options-for-a-national-plan-for-smart-manufacturing

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	and scale up, such as quality, yield, and throughput.	
• No funding	• Fund RD&D that addresses challenges in cross-cutting manufacturing technologies, such as castings and forgings of large, near net shape components and roll-to-roll manufacturing, that have the potential for high impact across multiple clean energy technology sectors.	• Increase will support priority cross cutting manufacturing technologies that have high impact across multiple clean energy technology sectors.
• Fund development of advanced tooling for lightweight automotive components	• No funding	• Deprioritizing work on automotive components.
High Performance Materials $25,500,000	$35,000,000	+$9,500,000
• Fund competitively selected R&D projects to develop improved performance for materials necessary for decarbonization and clean energy, such as high conductivity metals and industrial materials that can operate in harsh service environments. Continue to support CABLE high conductivity materials activities. to help build an equitable, clean-energy future.	• In support of economy-wide decarbonization, fund R&D on materials with high thermal and/or electrical conductivity with a broad range of applications, including motors, CHP systems, and waste heat recovery.	• Modest increase in funding in high conductivity materials in support of economy-wide decarbonization.
	• Funding for R&D to develop materials that enable energy efficiency improvements and emissions reduction through their use in harsh service environments, particularly high temperature applications that are needed for decarbonized heat and thermal storage.	• Modest increase in funding for materials for high temperature and other harsh service environments needed for economy-wide decarbonization.
	• Fund work on structural composites for clean energy applications, including for offshore wind	

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Fund composite materials R&D in collaboration across EERE and DOE for technologies including wind.	blades and platforms. Manage the Carbon Fiber Technology Facility (CFTF) in conjunction with this work.	• Modest decrease in funding for composites for technologies that have matured to commercial viability to prioritize efforts described above.

Advanced Materials and Manufacturing Technologies
Secure & Sustainable Materials

Description

The Secure and Sustainable Materials subprogram focuses on the advancement of material supply chains and process technologies that promote economy-wide decarbonization. This includes addressing the critical materials supply chain challenges by developing alternatives to reduce their demand and by promoting pathways for domestic supply, recycling, and processing of these materials. The subprogram also invests in supply chain sustainability through circular economy approaches, including advancing recycling processes and design for recyclability. RD&D in this subprogram will support secure decarbonized supply chains, advance environmental justice by reducing environmental emissions, and drive improvements in energy and resource efficiency for a competitive U.S. manufacturing sector. AMMTO will coordinate and collaborate across DOE offices and participate in interagency coordination in both of these areas.

Critical Materials: This activity continues funding for a centralized entity, created in FY 2023, for multidisciplinary, collaborative, critical materials R&D as required in Section 7002 (g) of the Energy Policy Act of 2020. The Critical Materials Collaborative will support RD&D investments to reduce supply risk and improve supply chain resilience for materials and technologies necessary for the clean energy transition. Critical materials to be addressed include rare earths, lithium, cobalt, and gallium, with applications such as magnets in electric vehicles and wind turbines, batteries, efficient lighting, and semiconductors. Strategies include diversifying supply, developing substitutes, material efficiency, and improving reuse/recycling. The activity will also support pilot projects and testbeds that verify economics of continuous operations in real world conditions. Areas of interest for these projects include highly selective separation, metal reduction, magnet manufacturing, materials recovery from secondary and unconventional sources, material reuse, more efficient use, and balanced coproduction. These activities create and advance technologies that are the pipeline into the demonstration programs supported by Manufacturing and Energy Supply Chains (MESC), Fossil Energy and Carbon Management (FECM) and other DOE offices and funded in Base and Infrastructure Investment and Jobs Act appropriations. As such, AMMTO has strong coordination with these offices on critical materials activities.

Circular Economy Technologies: The circular economy—an economy that keeps materials, products, and technologies in circulation for as long possible—is essential for economy-wide decarbonization and material security. This activity will support RD&D that advances the circular economy of materials important for clean energy technologies through design for recyclability, new material development, reuse and recycling, with a particular focus on energy- and emissions-intensive materials. These approaches have the potential to mitigate up to 40 percent of global GHG emissions and can reduce other environmental impacts as well. Material classes include metals, polymers, fibers, fiber reinforced polymer (FRP) composite materials, and e-waste. RD&D efforts will be guided by consistent life cycle analysis methodology to inform high impact opportunities to reduce carbon and other emissions across product life cycles. In addition, this effort will support the development of life cycle embodied carbon analysis tools for use by industry and other partners.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Secure & Sustainable Materials $40,000,000	**$91,497,000**	**+$51,497,000**
Critical Materials $26,0000,000	$50,000,000	+$24,000,000
• Establish Critical Materials Collaborative for high priority critical materials, including pilot projects and testbeds to reduce supply risk and improve supply resilience for materials and technologies necessary for the clean energy transition.	• Continue funding of the Critical Materials Collaborative, which includes activities that span research, development, and pilot demonstration. Work will advance technologies that reduce supply chain risk and increase supply resilience for materials needed for clean energy applications.	• Increase in funding supports the Critical Materials Institute and additional activities under the Critical Materials Collaborative that span research, development, and pilot demonstration for efficient material production and recycling, as well as production of alternatives.
Circular Economy Technologies $14,000,000	$41,497,000	+$27,497,000
• Continuation of the BOTTLE Consortium and the expansion of R&D projects to address recycling challenges such as sorting and separations; along with efforts to apply circular economy principles to polymers and fiber reinforced polymer (FRP) composite materials.	• Significant additional funding to advance RD&D for the circular economy across more material classes, including recycling and design for recycling of composites, plastics, fibers, e-waste, and metals, aligned with EPA's National Recycling Strategy[3]. Funding also to support tools for embedded carbon life cycle analysis. Building on the BOTTLE Consortium's success and industry interest, and guided by the Strategy for Plastics Innovation[4], support technologies needed to adopt plastic recycling and sustainable design solutions, with a focus on sorting and separation issues.	• New RD&D investments for circular economy-related efforts across composites, plastics, fibers, e-waste, and metals leveraging prior investments in Manufacturing USA Institutes and regional solutions. New work on tools for embedded carbon life cycle analysis, in support of industrial decarbonization.

[3] EPA National Recycling Strategy 2023, https://www.epa.gov/recyclingstrategy

[4] DOE Strategy for Plastics Innovation 2023, https://www.energy.gov/entity%3Anode/4394292/strategy-plastics-innovation

Advanced Materials and Manufacturing Technologies
Energy Technology Manufacturing and Workforce

Description

This subprogram will focus on advancements in manufacturing research and demonstration for technologies—such as energy storage systems, power electronics, and highly efficient microelectronics—that are critical for achieving economy-wide decarbonization. Investments will support manufacturing innovations to improve performance and address barriers to achieve lower manufacturing cost that can accelerate the path of these technologies to market. The subprogram will also support the formation of entrepreneurial ecosystems to nurture emerging industries, as well as multilevel workforce development. This approach to manufacturing innovation supports the Administration's commitment to ensuring the clean energy future is Made in America by workers with good jobs and fair opportunity, with an emphasis on benefiting disadvantaged communities and underrepresented populations. Investments will be prioritized based on analysis, cross-DOE planning, and input from industry to accelerate the path to deployment in support of economy-wide decarbonization.

Semiconductors, Electronics, and Other Technology Manufacturing: Cross-cutting technologies enable clean energy technologies to be deployed in multiple industrial sectors. Informed by analysis and stakeholder engagement, this activity will invest in development of lower cost, higher efficiency wide bandgap semiconductors that are critical to power management of industrial motors and electric vehicle motors. In addition, the activity is investing in manufacturing technologies needed to produce high efficiency microelectronics.

Energy Conversion and Storage Manufacturing: Supporting a decarbonizing grid requires long duration storage technologies. Achieving cost and performance targets of the Department of Energy's (DOE) long duration storage shot requires manufacturing advances. This activity will invest in flow battery manufacturing across various chemistries, such as in electrolyte processing technologies to extend the operational lifetime and electrode engineering to increase the power density.

Entrepreneurial Ecosystems and Advanced Manufacturing Workforce: Diverse networks of manufacturers in emerging technology areas and/or across supply chains can help accelerate innovation and manufacturing scale up. This activity will support people and communities to catalyze expertise in information systems, and to business and entrepreneurial ecosystems This activity will support technical assistance for development of clean energy manufacturing capacity. It will be informed by a roadmap, currently under development by AMMTO, and will support participants at varying career levels, engage underserved communities, and integrate activities across EERE programs. All educational and workforce development activities will include a focus on diversity and inclusion.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy Technology Manufacturing and Workforce $53,500,000	**$60,000,000**	**+$6,500,000**
Energy Conversion and Storage Manufacturing $20,500,000	$24,000,000	+$3,500,000
• Develop manufacturing innovations to improve performance of energy storage systems and to address technical challenges and manufacturing barriers to achieve lower manufacturing cost to make storage systems more accessible.	• This activity focuses on RD&D investments to catalyze manufacturing scale up of emerging battery technologies. For flow batteries, the focus will be on electrolyte processing technologies to extend the operational lifetime and electrode engineering to increase the power density. For solid state batteries, the focus will be on processing thin lithium metal layers, developing standard fixturing, and standard testing protocols.	• Modest increase in funding of battery manufacturing RD&D to increase the range of emerging chemistries addressed.
Semiconductors, Electronics, and Other Technology Manufacturing $15,500,000	$18,000,000	+$2,500,000
• Clean energy manufacturing R&D in collaboration across EERE and DOE for technologies including highly efficient semiconductors, power electronics.	• Manufacturing RD&D for the high voltage power electronics needed for transportation and other applications. Manufacturing RD&D for high efficiency microelectronics.	• Modest increase in funds to address manufacturing barriers for power electronics.
Entrepreneurial Ecosystems and Advanced Manufacturing Workforce $17,500,000	$18,000,000	+$500,000
• Train the clean energy innovators and manufacturing energy management workforce of the future. Provide additional resources and trainings to increase the impact of existing workforce-related programs, including within energy communities, underserved communities, and tribal communities. Expand programs targeted at community colleges and technical schools, apprenticeship programs, and resources focused on reskilling and upskilling existing workers. Support projects led by early-career	• Train the clean energy innovators of the future through the Lab-Embedded Entrepreneurship Program. Provide technical assistance resources and related investment to support scaling up manufacturing of emerging high-impact clean energy and energy efficiency technologies and related innovation ecosystems. Begin to implement a manufacturing workforce development program guided by a roadmap that AMMTO is developing. The roadmap supports participants at varying career levels, engages	• No significant funding change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
post-doctoral researchers to address fundamental manufacturing decarbonization challenges.	underserved communities, and integrates activities.	

Industrial Efficiency and Decarbonization

Overview

The Industrial Efficiency and Decarbonization Office (IEDO) accelerates the innovation and adoption of cost-effective technologies to increase energy efficiency and reduce greenhouse gas (GHG) emissions in the U.S. industrial sector (non-power sectors). IEDO has three subprograms focusing on sector-specific technology innovation, cross-sector decarbonization technologies, and technical assistance and workforce development.

IEDO plays a strategic role in building a strong decarbonized economy through investments in research, development and demonstration (RD&D) activities, as well as technical assistance and workforce development. IEDO partners with corporations, nonprofits, individuals, universities, laboratories, state/local governments, and consortia. IEDO activities depend on merit-based selection and peer-reviewed results.

In the FY 2023 Budget, EERE's manufacturing and industry sector-related Budget Request was structured across four technical subprograms: Industrial Efficiency and Decarbonization; Clean Energy Manufacturing; Material Supply Chains; and Technical Assistance and Workforce Development under a single Advanced Manufacturing Office (AMO). In the FY 2024 Request, EERE further sharpens and focuses its manufacturing portfolio, reorganizing the Advanced Manufacturing Office into two programs with associated control points aligned with the two organizational offices established in FY 2023: the Advanced Materials and Manufacturing Technologies Office (AMMTO) and IEDO. This reorganization was performed to position the two new organizations to better achieve the goals and purposes articulated for manufacturing and industry programs in the Energy Act of 2020. As part of the reorganization process, DOE considered input from external stakeholders and prior peer review feedback. AMMTO focuses on RD&D for technologies that foster competitive U.S. manufacturing for clean energy products to decarbonize multiple end-use sectors in the economy (buildings, industry, transportation, electric power). IEDO focuses on RD&D for technologies that decarbonize manufacturing in the U.S. and globally, as well as technical assistance to support manufacturers in operational improvements and implementation of new technologies.

To achieve decarbonization in the industrial sector, IEDO is organized into three subprograms: Energy- and Emissions-Intensive Industries; Cross-Sector Technologies; and Technical Assistance and Workforce Development. Within each subprogram, IEDO focuses on technical areas with high potential for impact and leverages all four strategies outlined in the DOE Industrial Decarbonization Roadmap.[1] The technical focus areas are identified through engagement with stakeholders, and supported by strategic analysis to target knowledge gaps and barriers that, if addressed through RD&D or other investments, can be adopted by industry to achieve cost-effective decarbonization of the industrial sector.

Strongly informed by input from industrial partners in the private sector, IEDO coordinates its RD&D efforts across the Department, particularly with the Office of Clean Energy Demonstrations (OCED), which delivers clean energy technology demonstration projects at scale in partnership with the private sector to accelerate deployment, market adoption, and the equitable transition to a decarbonized energy system.

Robust two-way engagement with industry stakeholders, research institutions, states, communities, and workforce representatives (e.g., unions) informs future investments and program activities in the areas of decarbonization, workforce development, underserved communities, communities negatively impacted by industrial emissions, and others.

Highlights of the FY 2024 Request

The IEDO Budget Request supports key efforts that contribute to achieving its high-level goals:

- Increased industry-specific decarbonization investments with initiatives focusing on the chemicals, forest products, iron and steel, cement, and other high carbon-emitting industries such as food processing, including a newly expanded effort to utilize carbon dioxide (CO_2) as a feedstock for commodity chemicals, through processes like the electrochemical production of ethylene.
- Ramped up investments in priority cross-sector technologies for decarbonization based on the DOE Industrial Decarbonization Roadmap, including thermal-process electrification, in support of the Industrial Heat EarthShot initiative.

[1] DOE Industrial Decarbonization Roadmap. Report to Congress, September 2022. https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.

- Increased investment in applied R&D for water and wastewater treatment technologies that reduce GHG emissions.
- Continue technical assistance to increase the adoption of decarbonization technologies and advanced energy and water efficiency technologies and practices across the industrial sector. Expanded programs include an Onsite Energy program that will assist manufacturers in assessing the cost-effectiveness of a broad range of onsite energy resources (e.g., photovoltaics, solar thermal, geothermal, bioenergy, distributed wind, battery storage, thermal energy storage) at their facilities.
- IEDO is involved in several crosscutting initiatives, including the following:
  - Carbon Dioxide Removal crosscut which includes work in a new FY 2024 effort focused on utilization of CO_2 as a feedstock for commodity chemicals such as ethylene;
  - Hydrogen crosscut through investment in process innovations to advance the economic use of low-carbon hydrogen for industrial processes;
  - Energy-Water crosscut through advancements in decarbonization of water and wastewater treatment systems through R&D and pilot scale demonstration;
  - Energy Storage crosscut through innovation related to incorporating energy storage into manufacturing processes and/or facilities to manage power and thermal energy and reduce industrial GHG emissions.
  - Industrial Decarbonization crosscut through industry-specific decarbonization investments focused on the chemicals, forest products, iron and steel, cement, and food and beverage productions, ramped up investments in priority cross-sector technologies, and expanded technical assistance programs including DOE's Better Climate Challenge.

Industrial Efficiency & Decarbonization
Funding ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Industrial Efficiency & Decarbonization (IEDO)					
Energy- and Emissions-Intensive Industries	98,790	131,000	195,000	+64,000	+49%
Cross-Sector Technologies	52,709	90,500	141,245	+50,745	+56%
Technical Assistance and Workforce Development	30,983	45,000	58,000	+13,000	+29%
Total, Industrial Efficiency & Decarbonization	**182,482**	**266,500**	**394,245**	**127,745**	**+48%**
Advanced Materials and Manufacturing Technologies (AMMTO)					
Next-Generation Materials & Processes	103,544	90,000	90,000	0	0%
Secure & Sustainable Materials	66,530	40,000	91,497	+51,497	+129%
Energy Technology Manufacturing & Workforce	50,444	53,500	60,000	+6,500	+12%
Total, Advanced Materials and Manufacturing Technologies	**220,518**	**183,500**	**241,497**	**+57,997**	**+32%**

Note: Advanced Materials and Manufacturing Technologies (AMMTO) added to the table to show the Request to re-organize Advanced Manufacturing Office (AMO) budget into two control points aligned with the two organizational offices established in FY 2023: the AMMTO and the IEDO. Numbers in FY 2023 and earlier are estimates prior to the bifurcation of the office,

SBIR/STTR:
FY 2022 Transferred: SBIR: $6,289,000; STTR: $765,000
FY 2023 Enacted: SBIR: $6,139,259; STTR: $901,071
FY 2024 Request: SBIR: $11,224,000; STTR: $1,578,000
Note: Please see Advanced Materials and Manufacturing Technologies (AMMTO) for the balance of AMO SBIR/STTR funding

Proposed FY 2024 Budget Structure

	Industrial Efficiency & Decarbonization (IEDO)			
	Energy- and Emissions-Intensive Industries	**Cross-Sector Technologies**	**Technical Assistance and Workforce Development**	**Total**
FY 2023 Budget Structure				
Advanced Manufacturing (AMO)				
Industrial Efficiency and Decarbonization	195,000	141,245	13,000	**349,245**
Clean Energy Manufacturing	0	0	0	**0**
Material Supply Chains	0	0	0	**0**
Technical Assistance and Workforce Development	0	0	45,000	**45,000**
Total	**195,00**	**141,245**	**58,000**	**394,245**

Industrial Efficiency & Decarbonization
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Energy- and Emissions-Intensive Industries: The increase will focus on reducing GHG emissions from energy- and emissions-intensive industries through RD&D for next generation low carbon technologies in industry-specific applications. The subprogram increases the research portfolio focused on utilization of CO_2 as a feedstock for chemicals production efforts while continuing to prioritize efforts in four other key industries.	+64,000
Cross-Sector Technologies: The Request increases investments in solving manufacturing challenges that are critical for achieving industrial decarbonization across multiple sub-sectors, informed by the industrial decarbonization roadmap and thermal process intensification analyses. The Request prioritizes RD&D to address decarbonization of industrial process heating, efforts to utilize low carbon fuels and feedstocks, and other emerging energy efficiency technologies. The Request increases RD&D investments in high priority thermal process and systems efficiency innovation, and increases funding to develop equipment and related technologies to advance industrial capabilities to use low carbon fuels and feedstocks.	+50,745
Technical Assistance and Workforce Development: The Request increases technical assistance for the accelerated implementation of decarbonization technologies and water efficiency projects and practices with an increased focus on energy-intensive industries.	+13,000
Total, Industrial Efficiency & Decarbonization	**+127,745**

Description

The Energy- and Emissions-Intensive Industries subprogram targets subsectors of U.S. industry with the highest energy consumption and the highest emissions. The subprogram features sector-focused RD&D activities to accelerate the commercial readiness of emerging, net-zero emissions technologies for the most energy- and carbon-intensive industries. The subprogram identifies specific RD&D challenges based on the DOE Industrial Decarbonization Roadmap, stakeholder input, alignment with the program's key activity areas, and potential energy, carbon, and economic impacts related to subsequent industrial adoption.

Chemicals, Forest Products, and Related Industries: This activity will address energy use and carbon emissions from chemicals, paper and forest products, and related industries, which rely heavily on process heating as well as separation processes to produce a wide variety of products. Example topic areas include novel reactor, process, and catalyst designs; use of alternative feedstocks and electrochemical processes; and drying methods. Technology advancements can enable energy and cost savings, reduce water usage, and lower carbon footprints. This activity supports RD&D for industry-specific technologies to improve energy efficiency; eliminate process emissions; pursue electrification; and integrate clean fuels, feedstocks, and energy sources. Specifically, the program pursues an initiative focusing on the underlying RD&D challenges to effectively use CO_2 as a feedstock in place of fossil resources. The program will advance processes like the electrochemical production of ethylene from CO_2, replacing incumbent processes, in which ethylene ranks as the building block with the highest carbon emissions. RD&D focuses on the underlying challenges to scale-up including product selectivity, mass transfer limitations, electrode stability, ion conductivity, catalyst durability, and reactor design. If these foundational barriers can be overcome, future electrochemical production of fuels, nitrogen-based fertilizers, and commodity chemicals can substantially contribute to decarbonization of the chemicals industry and enable a circular economy.

Iron and Steel, and Other Metals Industries: This activity will address energy use and carbon emissions from iron and steel manufacturing, which rely on high temperatures and carbon as a reductant in production processes. Example topic areas include novel melting and heating approaches and alternative reductants for iron production. Technology advancements to be explored include alternative injection and plasma-heating technologies in the blast furnaces and high efficiency steel reheating coupled with recycling heat and waste energy. This activity supports RD&D for industry-specific technologies to improve energy efficiency; eliminate process emissions; pursue electrification; and integrate clean fuels, feedstocks, and energy sources.

Cement, Food Products, and Other Industries: This activity will address energy use and carbon emissions from other energy-intensive industrial sub-sectors, with the cement and concrete industry, and food and beverage production/processing, as the highest emitting and therefore highest priorities for this activity. Example topic areas include exploring zero carbon cement production routes, CO_2 mineralization in building materials, alternative cement/concrete formulations, and novel heating and drying technologies in food and beverage processing. Technology advancements can enable energy and cost savings, reduced water usage and a lower carbon footprint. This activity supports RD&D for industry-specific technologies to improve energy efficiency; eliminate process emissions; pursue electrification; and integrate clean fuels, feedstocks, and energy sources.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy- and Emission-Intensive Industries **$131,000,000**	**$195,000,000**	**+$64,000,000**
Chemicals, Forest Products, and Related Industries $53,000,000	$85,000,000	+$32,000,000
• Support industrial decarbonization activities, including research, development and pilot-scale demonstrations, to rapidly advance technologies and enable an accelerated timeline for achieving carbon emission reductions. Focus on decarbonization of the chemicals, iron and steel, cement, and food products industries.	• Support RD&D projects to evaluate the use of alternative chemical feedstocks and advanced separations to address chemical industry priorities in the Industrial Decarbonization Roadmap. Pursue RD&D efforts in forest products industries such as efficient paper drying technologies and valorization of industry waste streams.	• Increase will initiate a new and expanded focus on utilization of carbon dioxide focus for production of fuels, and other commodity chemicals, especially through the use of electrochemical methods.
Iron and Steel, and Other Metals Industries $38,000,000	$50,000,000	+$12,000,000
• Support industrial decarbonization activities, including research, development and pilot-scale demonstrations, to rapidly advance technologies and enable an accelerated timeline for achieving carbon emission reductions. Focus on decarbonization of the chemicals, iron and steel, cement, and food products industries.	• Support RD&D projects to explore innovative routes to produce carbon reductants using low-carbon methods for iron production, and address production system integration challenges. Begin development of lower carbon process heating solutions specific to steel industry such as increasing renewable hydrogen composition in blast furnaces and improvements in electric induction reheating furnace designs.	• Increase will support innovative technologies that enable deep decarbonization for both ore-based and scrap-based iron and steelmaking operations.
Cement, Food Products, and Other Industries $40,000,000	$60,000,000	+$20,000,000
• Support industrial decarbonization activities, including research, development and pilot-scale demonstrations, to rapidly advance technologies and enable an accelerated timeline for achieving carbon emission reductions. Focus on decarbonization of the chemicals, iron and steel, cement, and food products industries.	• Conduct RD&D on the use of low carbon fuels and electrification technologies to decarbonize heat required for calcination in cement manufacturing; and investigate new cement formulations and aggregate production from various ore carbonates. For food manufacturing, pursue R&D to evaluate a suite of electrification technologies for drying, dewatering and heating for energy- and carbon-intensive food production processes.	• Increase will support innovative technologies to address decarbonization opportunities in additional industry sectors such as glass and other energy intensive industries.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	Conduct RD&D efforts to advance novel melting technologies and utilize low carbon fuels in glass and other industries.	

Industrial Efficiency & Decarbonization
Cross-Sector Technologies

Description

The Cross-Sector Technologies subprogram supports RD&D addressing energy efficiency and emissions reduction technologies and approaches with broad application across the industrial sector. These include thermal processes and systems, enabling technologies for low carbon fuels and feedstocks, and emerging efficiency and other decarbonization technologies. Process and equipment technologies were identified as priorities in the DOE Industrial Decarbonization Roadmap, DOE's Thermal Process Intensification Workshop, and DOE's Industrial Decarbonization Request for Information. The subprogram also supports RD&D for energy and emissions reductions from water and wastewater treatment. The subprogram continues to identify the specific research challenges based on stakeholder input, alignment with the program's key technology areas and analytical assessments, and potential energy, carbon, and economic impacts.

Thermal Processes and Systems: This activity will address opportunities to reduce energy consumption and GHG emissions in process heating operations for the industrial sector. In 2018, process heating in manufacturing was estimated to account for over 7 quads of energy use and nearly 300 million metric tons of onsite GHG emissions.[2] Informed by analysis and stakeholder engagement, this activity invests in a suite of targeted technology RD&D for highest cross-sector decarbonization impact. Example topic areas include advances in membranes and other efficient separation technologies, furnace and process control technologies, high-temperature industrial heat pumps, process intensification that contributes energy efficiency improvements, and electrification for thermally intensive operations. This activity is closely coordinated with the Industrial Heat EarthShot initiative.

Energy & Emissions Reductions from Water and Wastewater Treatment: Water and wastewater treatment produce significant GHG emissions from energy use as well as non-energy related emissions; the latter accounted for over 40 million metric tons of CO_2-equivalent emissions in 2020.[3] This activity supports RD&D of technologies that reduce CO_2, CH_4, and N_2O GHG emissions and recover resources from municipal wastewater treatment processes and systems. Areas of focus for RD&D investment include technologies to replace secondary aeration such as anaerobic membrane bioreactors, alternative forms of nitrogen removal, and technologies to reduce sludge formation. In addition to reducing emissions, these technologies lower energy requirements and reduce energy costs.

Emerging Efficiency and Other Decarbonization Technologies: This activity will explore innovative energy efficiency and decarbonization technology concepts with applications in multiple industrial sectors to improve industrial production system efficiencies, process yield, and recovery of thermal energy. Additional activities include energy systems analysis and modeling to inform improvements in industrial production system and process efficiency, and smart manufacturing technical assistance to facilitate operational energy efficiency improvements and decarbonization across industrial production operations in multiple sectors.

Enabling Technologies for Low Carbon Fuels and Feedstock: This activity will address opportunities to facilitate the use of low carbon solutions in industry and replace existing carbon-based fuels and feedstocks in multiple industrial sectors. Informed by analysis and stakeholder engagement, this activity invests in a suite of targeted technology RD&D for highest decarbonization impact. Example topic areas include development of advanced controls, burners, and other industrial furnace equipment capable of utilizing bio-derived fuels, hydrogen, or low carbon wastes and byproducts. Efforts also include development of industrial onsite energy storage systems and flexible combined heat and power (CHP) systems that rely on low carbon fuels.

[2] 2018 Manufacturing Energy and Carbon Footprints, All Manufacturing Sector. DOE AMO. December 2021. https://www.energy.gov/sites/default/files/2022-01/2018_mecs_all_manufacturing_energy_carbon_footprint.pdf.
[3] See Table 7.7 in "Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2020." EPA 2022. https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf.

Cross-Sector Technologies

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Cross-Sector Technologies $90,500,000	**$141,245,000**	+$50,745,000
Thermal Processes and Systems $38,500,000	$71,245,000	+$32,745,000
• Pursue priority cross-cutting technologies for decarbonization based on industrial decarbonization roadmap and analyses, potentially including electrochemical processes, innovative separations and CO_2 reuse.	• Fund RD&D activities informed by the industrial decarbonization roadmap, thermal process intensification analyses, and the Industrial Heat EarthShot. These RD&D areas include advanced membranes and other efficient separation technologies, advanced furnace and process control technologies, high-temperature industrial heat pumps, and electrification of thermally intensive industrial processes.	• Increase will support RD&D for high priority thermal process and systems efficiency innovation, such as advanced non-thermal separation processes and electric thermal process equipment technologies.
Energy & Emissions Reductions from Water and Wastewater Treatment $20,000,000	$30,000,000	+$10,000,000
• Fund the third year of the five-year Energy Water Hub. Fund competitively selected, merit-based research projects to decarbonize water and wastewater treatment, with a focus on agricultural waters.	• Fund RD&D projects to decarbonize water and wastewater treatment, including technologies that are alternatives for secondary aeration and nitrogen removal.	• Increase will allow for an expansion of focus to support a portfolio of water and wastewater research, development, and pilot-scale demonstration projects to drive water sector decarbonization. No additional funds are required for the Energy Water Desalination Hub, which is already funded through FY 2024.
Emerging Efficiency and Other Decarbonization Technologies $17,000,000[4]	$20,000,000	+$3,000,000
• Pursue priority cross-cutting technologies for decarbonization based on industrial decarbonization roadmap and analyses, potentially including electrochemical processes, innovative separations and CO_2 reuse.	• Pursue RD&D on emerging efficiency and decarbonization technology concepts to significantly improve industrial production system efficiencies, process yield, and recovery of thermal energy. Conduct analysis and modeling to inform innovations and improvements in	• Increase will allow funding to advance ambitious technology concepts and increase capabilities to utilize associated modeling and analysis to significantly improve energy efficiency and reduce emissions in industrial production systems.

[4] Numbers in FY 2023 and earlier are estimates prior to the bifurcation of the office

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	industrial production system and process efficiency in multiple industry sectors.	
Enabling Technologies for Low Carbon Fuels and Feedstock $15,000,000	$20,000,000	+$5,000,000
• Decarbonized combined heat and power: RD&D and technical assistance for hydrogen or renewably fueled CHP for industry.	• Fund RD&D projects to rapidly advance technologies to enable cross-sector use of low carbon fuels and feedstocks, including development of process control and combustion equipment capable of utilizing bio-derived fuels, hydrogen, or other low carbon wastes and byproducts.	• Increase will allow funding to develop combustion equipment and related technologies to advance industrial capabilities to utilize low carbon fuels and feedstocks.

Industrial Efficiency & Decarbonization
Technical Assistance and Workforce Development

Description

This subprogram supports technical assistance and development of transformational tools to help manufacturers reduce their energy and carbon intensity, adopt energy management programs, and develop targets for energy efficiency, productivity, carbon reductions, and waste/water use reduction. Core programs include the Better Plants Challenge, Better Climate Challenge, Energy Management Programs (50001[5] Ready and Superior Energy Performance), and the Combined Heat and Power (CHP) Deployment Program. The subprogram identifies the specific technology deployment challenges and workforce development opportunities for focus based on stakeholder input, alignment with the program's technology areas, and potential energy, carbon, and economic impacts.

Increasing the adoption of decarbonization technologies and advanced energy and water efficiency technologies and practices across the industrial sector is accelerated by technical assistance, including promoting the adoption of energy management programs that feature targets for energy efficiency, productivity, carbon reductions, and waste/water use reduction practices. In FY 2024, the Better Plants Challenge and Better Climate Challenge are supporting initiatives for energy-intensive manufacturers, peer exchange working groups, and training opportunities. The Industrial Technology Validation (ITV) initiative partners with DOE's National Labs to objectively validate performance in dynamic industrial environments in order to de-risk implementation of emerging technologies. Additional activities include the extension of existing publicly available state-of-the-art tools for manufacturers including the 50001 Ready Navigator[6] and MEASUR energy calculator and analysis tool suite to address emerging topics such as carbon reduction, resiliency, and cybersecurity. All technical assistance activities will include targeted support for disadvantaged communities to support the Justice40 initiative and ensure technical assistance is equitably and openly available.

Industrial partners are increasingly seeking technical assistance to identify and deploy technology solutions that can reach clean energy targets, replace outdated equipment, and balance resilience requirements. To meet these evolving needs, the subprogram will leverage and adapt the successful CHP Deployment Program model to incorporate a broader range of onsite energy resources (such as photovoltaics, solar thermal, geothermal, bioenergy, distributed wind, battery storage, thermal energy storage, etc.). The CHP Technical Assistance Partnerships (TAPs) will shift into the Onsite Energy TAPs in order to bring expanded expertise and analytical capabilities to assist manufacturers with a more comprehensive set of onsite energy solutions.

Advanced manufacturing processes are demanding more from workers in the form of technical skills, experience with computer-automated processes, and expertise in energy information management systems. This subprogram includes a focused workforce development program that provides support for reskilling and upskilling workers through mentoring and on-the-job training to increase the number of qualified technical employees with skills operating and maintaining new decarbonization technologies. All educational and workforce development activities include a focus on diversity and inclusion, and reskilling programs that will be specifically targeted toward underserved communities, energy communities, and tribal communities to aid in their transition to the clean energy economy. IEDO is actively coordinating on workforce development activities with Department of Labor (DOL) and Department of Commerce (DOC), including a strong collaboration with DOC's Manufacturing Extension Partnerships.

[5] https://www.iso.org/iso-50001-energy-management.html

[6] The 50001 Ready Navigator is an online application that provides step-by-step guidance for implementing and maintaining an energy management system in conformance with the ISO 50001 Energy Management System Standard.

Technical Assistance and Workforce Development

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Technical Assistance and Workforce Development $45,000,000	**$58,000,000**	**+$13,000,000**
Technical Assistance and Workforce Development $45,000,000	$58,000,000	+$13,000,000
• Provide technical assistance for the implementation of energy and water efficiency projects and practices, including increased technical assistance to disadvantaged communities, Equity, Environmental and Energy Justice communities, and areas with high industrial emissions. Expand the Better Plants Challenge and Energy Management Programs to include initiatives related to energy-intensive manufacturers, carbon reduction, technology validation, and training opportunities.	• Provide technical assistance to support the adoption of decarbonization technologies and advanced energy and water efficiency technologies and practices across the industrial sector, including targeted assistance to disadvantaged communities with high industrial emissions. Leverage the Better Climate Challenge to augment technical assistance opportunities for energy-intensive manufacturers that are pursing decarbonization. Efforts will target technology validation of emerging decarbonization technologies and approaches, as well as tool and resource development.	• Increase will support an expansion of the Industrial Technology Validation (ITV) initiative from a pilot scale activity into a full program that engages with manufacturers to validate emerging efficiency and decarbonization technologies in real-world settings.
• Provide technical resources, tools, and implementation guidance to manufacturers that are pursuing onsite renewable energy generation or energy storage projects.	• Scale-up onsite energy initiative from pilot activities to full-scale program implementation. Complete the transition of the CHP Deployment Program and CHP Technical Assistance Partnerships (TAPs) into the Onsite Energy Program and Onsite Energy TAPs.	• Increase will support the expansion of the CHP TAP program into the Onsite Energy TAP program, which expands technical assistance beyond CHP systems to other types of onsite energy systems, with a focus on renewable thermal technologies.
• Train the clean energy innovators and manufacturing energy management workforce of the future. Focus on programs targeted at community colleges, technical schools, and apprenticeship programs within underserved communities.	• Fund workforce development activities focused on reskilling and upskilling workers to operate and maintain emerging decarbonization technologies.	• Increase will support the scaling of regional workforce development programs to have broader national level impacts and focus on workers from disadvantaged communities.

Building Technologies Office

Overview

The Building Technologies Office's (BTO) FY 2024 Request prioritizes accelerating the most impactful emission reductions from building end uses, placing an additional emphasis on space heating, cooling, and water heating, and increasing the focus on market priming and cost suppression for the accelerated adoption of these technologies. This includes prioritization of low-income household impacts, such as projects that reduce costs and increase accessibility. The U.S. building sector is comprised of over 100 million buildings where people spend most of their time every day. These buildings account for 75 percent of total U.S. electricity use, 40 percent of all energy use, 35 percent of energy-related carbon dioxide emissions, and unfortunately about 30 percent of the $400 billion in energy use is currently wasted. BTO is focused on reducing the energy wasted in buildings while also reducing the associated onsite greenhouse gas (GHG) emissions, currently around 13 percent of total U.S. GHG emissions.

Our work to improve energy performance in buildings increases productivity while reducing electricity demand, and along with initiatives to increase energy demand flexibility, this makes it easier, faster, and cheaper to decarbonize the power sector. Buildings are increasingly hosting carbon-free energy generation, such as PV and geothermal systems, which also can reduce consumer costs and increase energy reliability and resilience. Much of the electric transportation charging infrastructure is directly associated with buildings, and BTO is working on ways to optimize this energy load with other behind the meter resources to reduce utility and consumer costs. Buildings are at the intersection of these important investments to improve energy efficiency, decarbonization, and electrification, and therefore have a critical role in helping to reduce the trillions of dollars of future electricity system infrastructure upgrades. BTO's work in the building sector includes the goals of energy security, resilience, indoor air quality and other public health priorities, community rebuilding, energy equity, and environmental justice.

Throughout the stages of a building's lifecycle, there are multiple opportunities to enhance energy performance, energy security and resilience while reducing the emissions related to homes and commercial buildings, and each must be addressed if we are to achieve our goals and bring benefits to all energy users, especially those from marginalized and other hard to reach communities. BTO works across technologies and sub-sectors to lower the cost of no/low-emission solutions to reduce the energy burden on all American households.

Commercial Building Integration (CBI) and Residential Building Integration (RBI) have updated activity categories in FY 2024 to clarify where their activities align all along the technology validation and adoption spectrum. The new categories are: Technology Validation and Demonstration, Technology Adoption and Technical Assistance, and Enabling Tools and Resources. The previous Equipment and Building Standards subprogram is replaced with two subprograms in FY 2024, one focused on Appliance and Equipment Standards and the other focused on Building Energy Codes to return these subprograms to their historical alignment and add greater focus on the importance of BTO's Codes work.

Highlights of the FY 2024 Budget Request

BTO is focused on activities that will help achieve a built environment with zero net carbon emissions by 2050. To accomplish this long-term goal, BTO aims to reduce total energy use and onsite emissions in buildings while reducing the cost of building decarbonization, enabling decarbonization in disadvantaged communities using a "whole of government" approach, and reducing the need for a larger and more expensive grid by managing demand and developing strategic behind-the-meter investments.

Highlights of the BTO's program to address these goals include:

- Develop and field test more energy efficient heating systems and appliances that reduce energy use and cost as well as the need for grid related upgrades.
- Develop and deploy clean energy technologies specifically targeted at multifamily buildings and manufactured homes such as window and wall mount heat pumps and lower cost 120V heat pumps for affordable housing.
- Coordinate the Better Buildings Initiative (including the Better Buildings Challenge and the Better Climate Challenge), wherein BTO is working with hundreds of organizations that have made ambitious portfolio wide commitments to improve energy efficiency and/or reduced GHG emissions. Partners share successful strategies, report progress annually provide real world feedback on solutions, barriers and opportunities.

- Support innovations in building construction and retrofits across a broad spectrum of building types, such as through the Advanced Building Construction Collaborative, Building America, and the Buildings Upgrade Prize (Buildings UP).
- Enable optimization of a lower carbon grid through demonstration and deployment of connected communities integrating operation of EV chargers, PV, and large building loads that also reduce customers' energy bills and impacts on the utility.
- Support advancements in building codes and building performance standards that enable buildings to be more energy efficient with lower emission impacts.
- Advance appliance standards to reduce energy burden and customer cost through adoption of higher minimum efficiency standards.
- Leverage several crosscutting initiatives, including the following:
    - Clean Energy Technology Manufacturing crosscut through investments to accelerate advanced manufacturing for new low to no global warming potential refrigerants and highly efficient cost-effective heat pumps, advanced heating, ventilation, and air conditioning (HVAC) and dehumidification technologies including new membrane or chemical based and require very different manufacturing processes and equipment compared to regular vapor compression-based air conditioning and refrigerant equipment, and advanced dehumidification;
    - Energy-Storage crosscut through research that can support cost reduction and deployment of heat pumps with thermal energy storage, and sophisticated controls for grid-interactive buildings; and
    - Grid Modernization crosscut through RDD&D on advanced and grid-interactive technologies, such as controls, interoperability, and energy storage.

Building Technologies
Funding ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Building Technologies					
Emerging Technologies	120,000	117,000	115,841	-1,159	-1%
Commercial Buildings Integration	57,500	70,000	81,000	+11,000	+16%
Residential Buildings Integration	55,000	70,000	81,000	+11,000	+16%
Appliance and Equipment Standards	62,000	60,000	55,000	-5,000	-8%
Building Energy Codes	13,000	15,000	15,000	0	0%
Total, Building Technologies	**307,500**	**332,000**	**347,841**	**+15,841**	**+5%**

SBIR/STTR:

- FY 2022 Transferred: SBIR: $10,079,034; STTR: $815,762
- FY 2023 Enacted: SBIR: $5,191,000; STTR: $730,000
- FY 2024 Request: SBIR: $5,416,416; STTR: $761,184

Funding ($K)
(Non-Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Building Technologies				
Emerging Technologies	120,000	117,000	115,841	-1,159
Commercial Buildings Integration	57,500	70,000	81,000	+11,000
Residential Buildings Integration	55,000	70,000	81,000	+11,000
Appliance and Equipment Standards	73,500	60,000	55,000	-5,000
Building Energy Codes	-	-15,000	15,000	0
Total, Building Technologies	**307,500**	**332,000**	**347,841**	**+15,841**

Proposed FY 2024 Budget Structure

	Emerging Technologies	Commercial Buildings Integration	Residential Buildings Integration	Appliance and Equipment Standards	Building Energy Codes	Total
FY 2023 Budget Structure						
Emerging Technologies	115,841					**115,841**
Commercial Buildings Integration		81,000				**81,000**
Residential Buildings Integration			81,000			**81,000**
Appliance and Equipment Standards				55,000	15,000	**70,000**
Total, Building Technologies	**115,841**	**81,000**	**81,000**	**55,000**	**15,000**	**347,841**

Building Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Emerging Technologies (ET): The decrease in this subprogram allows for crucial R&D around electrical systems integration in buildings to support EV charging, heat pumps, and demand flexibility. The Request also includes significant new research supporting high temperature heat pumps, low-GWP and natural refrigerants, cold climate heat pump performance validation, advanced controls, and electric optimization solutions to address control panel upgrades. The Request will also foster the next generation of connected communities to enable the future low carbon grid working in conjunction with other offices including the Office of Electricity.	-1,159
Commercial Buildings Integration (CBI): The increase in this subprogram prioritizes RD&D for energy efficiency and emissions-reduction technologies for commercial buildings. The Request will expand the number of technology validations and demonstrations for commercial heat pump, energy efficiency, and grid-connected building technologies. The Request supports the launch of Connected Communities 2.0, and will increase the amount of technical assistance provided and teams funded through programs that accelerate market acceptance and uptake such as the Better Buildings Initiative and Buildings Upgrade Prize (Buildings UP).	+11,000
Residential Buildings Integration (RBI): The increase in this subprogram prioritizes activities that focus on improving the effectiveness and affordability of energy efficient retrofit technologies as well as highly efficient new construction for American homes. The Request will increase competitive awards for building decarbonization technologies, supports the launch of Connected Communities 2.0, and will accelerate technology validation and demonstration for residential heat pump, energy efficiency, and grid-connected building technologies.	+11,000
Appliance and Equipment Standards: The Request continues support for BTO's analytical and economic capacity to implement cost-effective appliance and equipment standards and accelerate the realization of net social benefits. DOE's commitment to the appliance and equipment standards program is a fundamental building block to improving efficiency in buildings that contributes to DOE's decarbonization goals. The Request proposes a small reduction in the number of standards rulemakings in 2024.	-5,000
Building Energy Codes: The Request continues activities directed by statute for rulemaking, technical analysis, and technical assistance for the advancement and successful implementation of building energy codes.	0
Total, Building Technologies	**+15,841**

Description

In FY 2024, the Emerging Technology program (ET) will focus on RDD&D to address deployment challenges, including cost, footprint, and grid impacts of the most impactful technologies for reducing emissions, such as space and water heating, in order to reduce costs and accelerate adoption. The Request includes significant new research supporting low-GWP and natural refrigerants, cold climate heat pump performance validation, advanced controls, and electric optimization solutions to address control panel upgrades. The ET program also supports the buildings-and-grid integration work in conjunction with other offices in Renewable Power, Vehicles, and the Office of Electricity to address edge of grid challenges. This applied RD&D portfolio collaborates with industry and academia and leverages the National Laboratories' researchers, computing capabilities, and other unique facilities that are critical for BTO to support efforts to significantly reduce emissions from buildings. ET conducts research in the following technology areas: heating, ventilation, and air conditioning (HVAC), water heating, refrigeration, energy storage, buildings-and-grid integration, lighting, building envelope, and building energy modeling. ET's work enables innovation and job creation in a range of U.S. industries, including building equipment, component manufacturing, distributed energy resources and research including academia.

HVAC, Water Heating, and Refrigeration (HVAC&R) R&D: This activity focuses on improving market uptake of low-emission heating systems through R&D on technical solutions to improve performance and reduce cost as well as overcoming installation barriers. The portfolio will support innovative technologies such as variable speed drives and sophisticated controls to help tailor the equipment usage to the load being delivered in an efficient manner. This activity will prioritize critical R&D needs such as: cold climate heat pumps; high temperature heat pumps, heat pumps for affordable housing that address energy use, indoor air quality and comfort issues; Central and 120V heat pump water heaters; and low GWP and natural refrigerants for refrigeration systems, both packaged as well as for large warehouses.

Thermal Systems and Energy Storage R&D: This activity focuses on management of the building load to enable better operation of the HVAC&R systems and integration with the electricity system, while also enhancing occupant comfort and indoor air quality. This activity includes investments in building envelopes, including air and duct sealing, insulation, and windows, as well as thermal and electrical energy storage. These investments seek to reduce and shift major energy loads that will help us overcome electric infrastructure constraints, both within the building and on the grid. Building envelope R&D supports the development of next-generation technologies and solutions that reduce the energy required to heat and cool a building, contribute to improved occupant comfort, building flexibility, and resilience, and have reduced costs and installation challenges to enable widespread market adoption.

Electrical and Whole Building System R&D: This activity includes Building Energy Modeling, analysis, large building controls, lighting, and integration of buildings with the grid. Building Energy Modeling R&D focuses on integrated, performance-driven design in new construction and major retrofits, and uses analyses to inform BTO program and market priorities. BTO will continue work in buildings-and-grid integration R&D with a focus on demand flexibility of end use systems and optimizing energy use at both the building level and the overall electricity system, including electrical upgrade costs within building footprints. Lighting R&D will focus on implementation and new applications of solid-state lighting, such as connected lighting, mitigating airborne pathogens, and controlled environment agriculture.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Emerging Technologies		
$117,000,000	**$115,841,000**	**-$1,159,,000**
HVAC, Water Heating, and Refrigeration R&D		
$51,000,000	$51,000,000	$0
• Support research to accelerate performance improvement and field validation of cold climate heat pumps, technology advancements to reduce heat pump soft costs, and advanced fault detection and diagnostics that improves heat pump operational performance.	• Advance performance improvement of cold climate and high temperature heat pumps for space and water heating, invest in new HVAC technology architectures to reduce ex-factory gate costs, improve fault detection and diagnostics (FDD), and reduce operational energy waste.	• BTO's focus on HVAC R&D reflects the need to rapidly advance high temperature heat pumps for large commercial and industrial applications. Heat pumps utilizing higher temperature need significant R&D but can have a significant impact on expanding the market applications of this technology.
• Support research to advance heat pump water heaters that can be "ready" replacements for existing water heaters and boilers such as low power (120V) and central heat pump water heaters.	• Advance heat pump technology with a focus on affordable housing (multifamily and manufactured) that incorporate low-GWP, non-HFC refrigerants while reducing physical size and power draw.	• No significant change.
• Conduct projects that accelerate development and validation of non-HFC low-GWP refrigeration technologies for comfort and product refrigeration to reduce energy use, improve safety and support future regulations.	• Advance technologies for non-HFC, low-GWP and natural refrigerants in buildings, while enhancing operating efficiency and managing safety and serviceability of new refrigerants.	• No significant change.
Thermal Systems and Energy Storage		
$27,000,000	$27,000,000	$0
• Advance building energy storage by launching Thermal Energy Storage (TES) National Laboratory Consortium and support work to integrate electric storage and thermal energy storage at equipment and building levels.	• Advance optimization of battery and thermal energy storage, supporting innovations such as tunable materials and equipment-integrated storage through the Thermal Energy Storage (TES) National Laboratory Consortium.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Support projects to reduce heating and cooling load through advanced envelope retrofit technologies, such as thin triple pane, high efficacy retrofit windows, geospatial identification of thermal leakage, and robotic construction of retrofit facades.	• Advance innovations that overcome long term challenges in building envelope retrofits (including windows, air sealing and high- performance tunable insulation) using cutting edge technologies such as robotics and digitization to reduce need for human intervention and improving worker health and safety.	• No significant change.
Electrical and Whole Building Systems $39,000,000	$37,841,000	-$1,159,000
• Continue development and maintenance of open-source models and analysis to support evaluation of technologies, systems, and strategies and build confidence in building efficiency and flexibility measures among BTO itself, utilities, states, and other organizations.	• Enhance work in building energy modeling and analysis for heat pumps in residential and commercial buildings, quantify cost and emissions impact of energy efficiency and decarbonization measures, and support performance-based measurement and verification (M&V).	• The decrease reflects significant refocusing on R&D around electrical systems integration in buildings to support EV charging, heat pumps, and demand flexibility.
• Support research on controls for whole buildings, as well as connected plug loads, and lighting and how these can enable greater demand flexibility and lower costs for markets that have been left behind.	• Expand and accelerate work in connected communities to advance integrated energy efficiency and renewable energy elements such as solar, batteries and electric vehicles so that they connect into and support the future low carbon, affordable electric grid.	• The increase supports connected communities research, research on building and equipment resilience, and analysis of grid impacts of behind the meter resources such as EV chargers, HVAC, and storage.

Building Technologies
Commercial Buildings Integration

Description

In FY 2024, Commercial Buildings Integration (CBI) will prioritize investments in demonstrations, deployment, and the associated market transformation work necessary to support commercial building efficiency and emissions reductions. As part of DOE's Better Buildings Initiative, DOE is working to highlight successful strategies and develop new resources that contribute to lower costs and a cleaner, more resilient and decarbonized energy system. Through the Better Climate Challenge, launched in FY 2022, CBI is working with more than 100 leaders in the commercial sector to reduce the emissions footprint of their portfolio and highlight the best practices necessary to reduce emissions across the entire commercial building stock. CBI activities will focus on streamlining and scaling adoption through technology demonstrations, procurement best practices, adoption campaigns, and recognition of exemplary practices. CBI will invest in programs to accelerate deployment of efficiency and decarbonization technologies and retrofits in commercial buildings, including multifamily buildings, leveraging the work of the cross-cutting initiatives from ET and RBI.

Technology Validation and Demonstration: This activity works across a broad group of industry representatives to demonstrate and deploy solutions that enable and scale ways to meet energy efficiency and decarbonization goals in new and existing commercial buildings. CBI works with third party verifiers to validate technology solutions for low-emission heating and cooling packages that are efficient and effective. CBI demonstrates and deploys these solutions via voluntary partnerships under the Better Buildings Initiative and through multi-agency collaboration.

CBI will collaborate in FY 2024 with ET and RBI to launch Connected Communities 2.0, which will select a second group of projects to demonstrate how groups of buildings can work together to reliably and cost-effectively serve as assets to the grid. These projects will test how well envelope and equipment technologies work in new and existing commercial buildings to reduce energy use, increase comfort, and integrate with the grid, providing real world case studies for CBI and stakeholders.

Technology Adoption and Technical Assistance: CBI actively provides technical assistance to identify and scale best practices through partnerships, including the Better Buildings Initiative. CBI's efforts include resources and support to deploy easy-to-install and use efficiency technologies, building envelope upgrades, renewables integration and demand flexibility technologies in commercial buildings. CBI will highlight the best practices and pathways to strategically overcome technical and structural barriers and to leverage other drivers to accelerate adoption. This effort feeds directly into rapid R&D within BTO and other EERE organizations to help solve critical technical and cost barriers. CBI will continue support for growth in skilled building efficiency and decarbonization jobs through capacity building activities. CBI will continue collaborating with RBI on Buildings UP, which aims to spur new partnerships to develop and implement innovative approaches to rapidly scaling the delivery of building upgrades. In collaboration with the Building Energy Codes Program, CBI will further support the development and implementation of building performance standards through demonstration of decarbonization pathways and technical assistance for local governments.

In FY 2024 CBI will invest in a cross-BTO strategy to work with utilities to accelerate adoption of energy efficiency, demand flexibility and electrification technologies to achieve BTO goals for decarbonizing the built environment by 2050. BTO enable utilities through technologies, tools, analysis, data and information to support more effective energy management and grid planning of changing electric and gas loads, considering customer costs, environmental management, resilience, reliability and cybersecurity. CBI leverages utilities' existing energy efficiency programs and relationship with commercial customers to disseminate information and spur uptake of commercial energy efficiency technologies.

Enabling Tools and Resources: CBI maintains and continuously improves a suite of user-accessible, packaged tools to enable the affordable evaluation of commercial building energy use, emissions reduction, demand flexibility, and performance investments. This work is founded on the physics-based computational simulations supported through the BTO BEM portfolio. CBI's design and decision support tools and resources can evaluate efficiency investments for one building or across a portfolio of buildings at various phases of a building's life cycle–design, operation, renovation, and resale. CBI will also develop software and analysis to support Building Performance Standards.

Commercial Buildings Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Commercial Buildings Integration $70,000,000	**$81,000,000**	**+$11,000,000**
Technology Validation and Demonstration $23,000,000	Technology Validation and Demonstration $34,000,000	+$11,000,000
• Support for the deployment of heat pumps and grid flexible technologies to reduce the carbon footprint of the existing commercial building stock.	• Invest in validation and deployment of energy efficiency, heat pumps and grid flexible technologies to reduce the emissions footprint of existing commercial buildings.	• Increase reflects higher number of technology validations and demonstrations for commercial heat pump, energy efficiency, and grid-connected building technologies
• Expansion of portfolio of efficiency work with small and medium businesses through demonstration, and deployment of turnkey efficiency and climate-responsive technology packages, scaled in partnership with community-level organizations.	• Focus on identifying sector-specific technology barriers and validating technology solutions that address key efficiency and climate-responsive technologies.	• Increase sector-focused validations to address identified barriers and validate turnkey solutions increase
	• Launch Connected Communities 2.0 to test how well envelope and equipment technologies work in new and existing commercial applications to reduce energy use, increase comfort, and integrate with the grid	• Launch Connected Communities 2.0
Technology Adoption and Technical Assistance $37,000,000	Technology Adoption and Technical Assistance $37,00,000	$0
• Increase emphasis on decarbonization of commercial buildings including support for implementing decarbonization policies and pathways in multiple commercial use cases.	• Provide technical assistance to partners who are developing innovative building decarbonization approaches that can rapidly scale retrofits across a variety of building and community types.	• No significant change.
	• Provide technical assistance to the cohort of teams selected in Buildings UP to enable scaling	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	of building retrofit programs that deliver decarbonization, comfort, improved indoor air quality, energy equity and resilience benefits.	
	• Develop a cross-BTO strategy to work with utilities to accelerate adoption of energy efficiency, demand flexibility and electrification technologies	• No significant change.
Enabling Tools and Resources $10,000,000	Enabling Tools and Resources $10,000,000	$0
• Maintain and continuously improve suite of user-accessible, used, and useful packaged tools, to enable the affordable evaluation of commercial building energy, emissions reduction, demand flexibility, and performance investments.	• Maintain and improve the suite of user-accessible packaged tools to support evaluation of commercial building energy use, emissions reductions, demand flexibility and performance investments.	• No significant change.
• Develop and maintain design and decision support tools and resources that can be used to evaluate efficiency and decarbonization investments for one building or across a portfolio of buildings at various phases of a building's life cycle.	• Develop and maintain decision support tools and resources that can be used across a portfolio of buildings to evaluate efficiency and decarbonization investments.	• No significant change.

Building Technologies
Residential Buildings Integration

Description

In FY 2024, Residential Buildings Integration (RBI) will invest in residential solutions with the greatest promise for delivering energy, cost, climate, and other benefits at scale. RBI's investments focus on developing building technologies and approaches that are affordable, require minimal onsite construction and installation time, appeal to a wide range of consumers and users, and can be broadly applied to the multitude of residential building types and climates in the U.S. With the Inflation Reduction Act (IRA) providing significant funding for rebates and tax incentives for residential energy efficiency, RBI will focus on leveraging these financing opportunities and filling in gaps.

Technology Validation and Demonstration: Through its Building America program and other efforts, RBI has a successful track record working with builders, contractors, manufacturers, program implementers and others to validate and demonstrate new efficiency technologies and integration approaches in real world (non-laboratory) homes; develop solutions to application and integration issues; disseminate resulting "best practice" technical guidance; and provide technical expertise to early adopters. RBI prioritizes demonstration and validation of innovative technologies and practices that offer a multitude of benefits, including energy efficiency, emissions reductions, indoor air quality, affordability, scalability, simplified installation and maintenance that reduces inconvenience to tenants and homeowners, and greater reliability.

RBI will collaborate in FY 2024 with ET and CBI to launch Connected Communities 2.0, which will select a second group of projects to demonstrate managing building energy loads can reliably and cost-effectively provide benefits to the grid. These projects will test building envelope, equipment and control technologies in new and existing homes reduce energy use, increase comfort, and integrate with the electricity grid to enable the transition to renewable energy. These innovative test beds will provide real world examples that RBI and stakeholders can learn from and replicate across the country.

Technology Adoption and Technical Assistance: RBI works with industry, state and local governments, utilities, residential contractors (including home performance, HVAC, renovation, and other contractors), builders, building owners and operators, and training entities among other key stakeholders to address the barriers hindering widespread uptake of efficiency measures in new and existing single and multifamily homes, including manufactured homes. RBI supports the development, dissemination, and implementation of programs, tools, and resources dedicated to addressing needs beyond technology that are essential to scaling efficiency and meeting decarbonization goals. RBI will continue collaborating with CBI on the Buildings UP Prize, announced January 2023, which aims to spur new partnerships to develop and implement innovative approaches to rapidly scaling the delivery of building upgrades, including streamlining incentives, greater leveraging of financing and other value streams, including those made available through the IRA, and improved community engagement.

In FY 2024, RBI will invest in a cross-BTO strategy to work with utilities to accelerate adoption of energy efficiency, demand flexibility and electrification technologies to achieve BTO goals for decarbonizing the built environment by 2050. In partnership with utilities BTO will demonstrate technologies, tools, analysis, and information that support more effective energy management and grid planning while considering customer costs, environmental management, resilience, reliability and cybersecurity. RBI can leverage utilities' existing energy efficiency programs and relationship with residential customers to disseminate information and spur adoption of residential energy efficiency technologies.

Enabling Tools and Resources: Given the complexity and diversity of the U.S. housing stock, as well as the challenges associated with ensuring affordable and decarbonized homes for all Americans, RBI relies on robust analysis and modeling to inform its work. In addition, RBI refines and applies building energy models, data systems, and other tools to assist builders, contractors, homebuyers, utilities, state and local governments, and other decision-makers to consistently and accurately estimate energy use, savings and costs; to inform investment decisions and maximize benefits; to assess the impact of different technologies on demand and on the grid; and, to apply best building science practices as well as the most up-to-date information on new technologies and approaches.

Residential Buildings Integration

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Residential Buildings Integration $70,000,000	**$81,000,000**	**+$11,000,000**
Technology Validation & Demonstration $29,000,000	Technology Validation & Demonstration $34,500,000	+$5,500,000
• Continue investment in development and demonstration of deep energy retrofit solutions for all types of residential buildings, with a priority placed on approaches and technologies that offer additional value add (e.g., non-disruptive installation, greater resiliency) and can be readily scaled.	• Continue investment in development and demonstration of scalable retrofit solutions for all types of residential buildings, with a priority placed on approaches and technologies that offer additional value add (e.g., non-disruptive installation, greater resiliency) and can be readily scaled.	• Increased funding for technology validation and demonstration for residential heat pump, energy efficiency, and grid-connected building technologies. • No significant change.
• Expanded field validation of technologies and installation practices, particularly with greater emphasis on testing and improving these innovations in actual existing residential buildings. Select multi-disciplinary teams to address the hard-to-solve technical challenges most common in retrofitting existing residential buildings across various climate zones and building types	• Continue field validation of technologies and installation practices in existing residential buildings. Assess progress made by multi-disciplinary teams in deciding whether to fund this activity in future years. • Launch Connected Communities 2.0 to test how well envelope and equipment technologies work in new and existing homes to reduce energy use, increase comfort, and integrate with the grid.	• Launch of Connected Communities 2.0.
Technology Adoption and Technical Assistance $25,000,000	Technology Adoption and Technical Assistance $30,500,000	+$5,500,000
• Provide technical assistance to public and private organizations, including affordable housing organizations, state and local governments, builders, trades, and others to promote best practices in building construction and retrofit and support workforce recruitment and training.	• Provide technical assistance to public and private organizations to promote best practices in building construction, retrofit, and workforce, including a focus on scaling heat pump and energy-efficiency upgrades with available incentives.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Provide technical assistance to program implementers for the scaling of heat pump deployment as well as key energy-efficiency measures with particular emphasis on upgrades with available incentives.	• Continue to provide technical assistance to program implementers for the scaling of heat pump deployment as well as key energy-efficiency measures with particular emphasis on upgrades with available incentives	• No significant change
	• Invest in a cross-BTO strategy to work with utilities to accelerate adoption of energy efficiency, demand flexibility and electrification technologies	• Increase in funding to implement utility strategy.
• Conduct a large-scale competitive prize for communities across the U.S. to spur and support innovative approaches aimed at scaling the use of highly efficient technologies in the residential sector and leverage outside investment.	• Provide technical assistance to a cohort of teams selected in the Buildings UP to enable scaling of building retrofit programs that deliver decarbonization, comfort, improved indoor air quality, energy equity and resilience benefits.	• No significant change.
• Conduct 2023 Solar Decathlon Design Challenge as well as first-of-its-kind all local 2023 Solar Decathlon Build Challenge, to help develop our Nation's next generation of building scientists, architects, engineers, and other experts needed to attain a clean energy economy.	• Conduct 2024 Solar Decathlon Design Challenge and assess possible shift in focus to targeted workforce development efforts focused on energy efficiency workforce gaps.	• Updated portfolio of programs focused on energy efficiency workforce gaps.
Enabling Tools & Resources $16,000,000	Enabling Tools & Resources $ 16,000,000	$0
• Continue refinement of analytical tools and models to accurately characterize the U.S. housing stock, to identify promising opportunities for cost compression, and to support utilities and other primary stakeholders in measuring the effectiveness of energy efficiency investments, including nonenergy benefits.	• Continue refinement of analytical tools and models to accurately characterize the U.S. housing stock, to identify promising opportunities for cost compression, and to support stakeholders in measuring the effectiveness of energy efficiency investments, including nonenergy benefits.	• Utility work shifted to Technology Adoption and Technical Assistance.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Apply analytical tools to assist state and local governments, utility programs and other efficiency program implementers in optimizing efficiency packages to meet the needs of their specific housing stock and their policy goals.	• Invest in analytical tools to assist state and local governments, utility programs and other efficiency program implementers in optimizing efficiency packages to meet the needs of their specific housing stock and their goals.	• No significant change.
• Sunset over extended time period the Home Performance with Energy Star (HPwES) Program, given nationwide incentives provided in the Inflation Reduction Act for whole home efficiency upgrades.	• Work with partners and SCEP to ensure no gaps between sunset of HPwES and launch of IRA rebates.	• No significant change.

Buildings Technologies
Appliance and Equipment Standards

Description

Appliance and Equipment Standards (AES) develops new or amended energy standards and test procedures, as directed by statute. AES currently sets policy regulations for more than 60 products, representing about 90 percent of home energy use, 60 percent of commercial building energy use, and 30 percent of industrial energy use. AES establishes Federal minimum energy efficiency standards based on DOE's prescribed test procedures to lock in energy savings for consumers. AES develops and updates test procedures to ensure they remain technologically relevant and provide manufacturers with a level playing field and a platform to bring to market new product innovations. AES enforces the energy conservation standards to prevent any manufacturer from undercutting those complying with the rules. AES also supports other Federal initiatives to help consumers make more energy-efficient purchasing decisions, including the ENERGY STAR program and Energy Guide labeling program.

DOE is committed to meeting its legislatively mandated deadlines for covered appliances and equipment. The rulemaking schedule is directed by Congress, and thus the level of program activity is mostly determined by existing statute. DOE will also be completing rulemakings to expand the covered products to lock in additional energy and emissions savings opportunities for consumers. DOE will continue its efforts to support the implementation of negotiated and consensus-based rulemakings, when represented by a cross-section of representative stakeholders.

Energy Conservation Standards: The AES develops and adopts energy conservation standards for all covered products and equipment in the program under a pre-determined cadence prescribed in statute for the purpose of saving the Nation energy and water. As part of its international engagement on standards, AESP participates in international programs and committees to minimize regulatory burden by ensuring regulatory harmonization to the greatest extent practicable and allowed by law.

Test Procedures: AES is legally required to review test procedures for covered equipment every seven years and either publish amended test procedures or publish a determination that existing test procedures do not need to be amended. In addition, AES is also required to develop new test procedures where they do not exist for newly covered appliances and equipment for which standards will be proposed. Test procedures are developed to provide additional rigor, consistency and accuracy during testing, to address testing requirements necessary to support DOE's certification and enforcement activities, and to better address or clarify testing of additional product designs within a given equipment type. This includes the need to respond to products and equipment for which testing waivers have been provided in the past. DOE will continue to prioritize the development of next generation text procedures for priority technologies for efficiency and decarbonization identified by BTO programs. In addition to its regulatory work on test procedures, AES supports the ENERGY STAR Program by amending and developing new test procedures for ENERGY STAR products and providing technical input on specification development.

Certification, Compliance, and Enforcement: To ensure the energy savings are realized and a level-playing field is maintained for manufacturers, AES actively enforces the energy conservation standards through certification, outreach, surveillance testing, and enforcement investigations. As part of its verification testing program, AES also supports EPA by working with the Association of Home Appliance Manufacturers on their ENERGY STAR verification program.

Appliance and Equipment Standards

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Appliance and Equipment Standards $60,000,000	**$55,000,000**	**-$5,000,000**
Energy Conservation Standards $38,000,000	$33,000,000	-$5,000,000,
• Expand the development of appliance and equipment standards. By establishing national minimum energy efficiency standards, AES's Federal standards preempt product efficiency regulations at the state and local level, reduce regulatory burden for manufacturers and provide them with a larger national marketplace.	• By establishing national minimum energy efficiency standards, the program's Federal standards preempt product efficiency regulations at the state and local level, reduce regulatory burden for manufacturers and provide manufacturers with a consistent national marketplace. Energy savings achieved through new or amended standards will contribute to reducing utility bills and emissions as old appliances are replaced with more efficient products.	• This change represents a reduction in the number of DOE standards rulemaking efforts.
Test Procedures $17,500,000	$17,500,000	$0
• Develop and update test procedures to ensure they remain technologically relevant and provide manufacturers with a level playing field and a platform to bring to market new product innovations.	• Continue to develop and update test procedures to ensure they remain technologically relevant and provide manufacturers with a level playing field and a platform to bring to market new product innovations. For consumers, the program's periodic review of test procedures lays the foundation for reliable and comparable operating cost information for the most common household and business appliances. Purchase and test appliances and equipment to explore the energy use.	• No significant change.
Certification, Compliance and Enforcement $4,500,000	$4,500,000	$0
• Ensure products sold in the U.S. meet energy and water conservation standards so that all Americans save money on their utility bills when purchasing new appliances and equipment.	• Continue to ensure products sold in the U.S. meet energy and water conservation standards so that all Americans save money on their utility bills when purchasing new appliances and equipment.	• No significant change.

Buildings Technologies
Building Energy Codes

Building Energy Codes: BTO's Building Energy Codes provides rulemaking and technical support for building energy efficiency, emission reductions, and increased resilience and comfort through the advancement and successful implementation of building energy codes. BTO's Building Energy Codes portfolio supports all U.S. states and local governments and also provides foundational support for the rapid and successful deployment of Infrastructure Investment and Jobs Act (IIJA), P.L. 117-58 and Inflation Reduction Act of 2022 P.L. 117-169 (IRA) funds, which will provide awards to only a select number of states and local governments. This Request will continue supporting all the States and local jurisdictions per statute.

DOE is directed by statute to review the technical and economic basis of building energy codes, and participate in processes for their review and modification, including seeking adoption of all technologically feasible and economically justified energy efficiency measures. In addition, DOE is directed to review published editions of the International Energy Conservation Code (IECC) and ANSI/ASHRAE/IES Standard 90.1, and issue Determinations as to whether the updated edition will increase energy efficiency in residential and commercial buildings, respectively, which triggers state building energy code review and update activities. BTO also supports rulemakings as required by statute to advance cost-effective energy codes for Federal facilities, along with the development of a rulemaking to support the statutory directive of reducing and ultimately eliminating fossil fuel use in Federal buildings.

DOE is also directed by statute to provide support for code implementation, including technical analysis to assess energy and environmental impacts and research to support states in evaluating how their codes are applied in practice. BTO will provide education, training, outreach, and tools to help increase compliance in the field and ensure the benefits of building energy codes are realized by American homes and businesses. BTO also will support technical assistance forums that enable the effective exchange of information and successful practices surrounding code implementation. In addition, BTO will provide technical support and guidance for federal, state, and local governments on advanced model codes and stretch codes focused on low-emission, grid-interactivity, advance energy-efficiency, and integrative solutions as well as emerging and innovative concepts, including Building Performance Standards (BPS) to improve energy efficiency in existing buildings. Given the goals for funds appropriated under IIJA and IRA, the BTO Building Energy Codes activities included in the Request are important foundational work needed for ensuring the program can meet the needs of awardees pursuing code updates, code adoption, and code implementation and compliance activities.

Building Energy Codes

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Building Energy Codes $15,000,000	**$15,000,000**	**$0**
Building Energy Codes $15,000,000	$15,000,000	$0
• Continue participation in the industry code processes, including reviewing and modifying national model energy codes. Develop and implement building energy codes for the Federal building fleet, including analysis, rulemakings, and implementation support.	• Continue participation in the industry code processes, including reviewing and modifying national model energy codes. Develop and implement building energy codes for the Federal buildings, including analysis, rulemakings, and implementation support.	• No significant changes.
• Provide technical assistance and analysis (including REScheck and COMcheck software) to States and localities to support their building codes and building performance standards.	• Provide technical assistance and analysis (including REScheck and COMcheck software) to States and localities to support their building codes and building performance standards.	• No significant changes.

Program Direction

Overview

Program Direction enables EERE to maintain and support a world-class Federal workforce and the necessary internal infrastructure to execute the EERE mission. The FY 2024 Program Direction Request provides resources for the EERE workforce; program and project management; oversight activities; contract administration; IT equipment, systems, and support; and Headquarters (HQ) and field site non-laboratory facilities and infrastructure.

Highlights of the FY 2024 Budget Request

The FY 2024 EERE Program Direction Budget Request will:

- Support 710 FTEs at Headquarters, the Golden Field Office, and the National Energy Technology Laboratory.
- Support efficient, effective, and responsive EERE operation, including IT, data, financial, and facilities management; and
- Support project management, oversight, and procurement across EERE's full portfolio of projects, including closing out completed financial assistance awards.

Salaries and Benefits: Hiring and retaining staff needed to achieve EERE's mission continues to be a priority, and the Request also provides increased funding for activities associated with attracting a diverse workforce and onboarding staff in a functional and efficient manner. The Request assumes a 5.2 percent federal staff pay increase, annualization of increase from 2023, as well as increased funding to support up to 710 FTEs. This FTE level reflects the shift of the Federal Energy Management Program (FEMP) and the Weatherization and Intergovernmental Programs (WIP) to the new Undersecretary for Infrastructure and additional transfers of smaller programs from within Water Power Technology Office and the Advanced Manufacturing Office.

Support Services: The Request includes funds for contract support to implement programmatic priorities across the EERE portfolio.

Other Related Expenses: The Request includes funding for information technology systems development and continued improvements to data management capabilities that enable data-driven decision-making. The Request also provides an increase for information technology needs to ensure that the EERE workforce can execute its mission efficiently and effectively in a hybrid work environment.

Program Direction
Funding ($K)

	FY 2022 Enacted[1]	FY 2023 Enacted[2]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Program Direction					
Washington Headquarters					
Salaries and Benefits	87,905	92,259	99,497	+7,238	8%
Travel	2,685	2,917	4,278	+1,361	47%
Support Services	5,561	7,563	9,076	+1,513	20%
Other Related Expenses	30,682	32,873	51,708	+18,835	57%
Total, Washington Headquarters	**126,833**	**135,612**	**164,559**	**+28,947**	**21%**
Golden Field Office					
Salaries and Benefits	19,943	20,931	22,574	+1,642	8%
Travel	575	625	917	+292	47%
Support Services	3,835	5,216	6,259	+1,043	20%
Other Related Expenses	3,452	3,698	5,817	+2,119	57%
Total, Golden Field Office	**27,806**	**30,471**	**35,566**	**+5,096**	**17%**
National Energy Technology Laboratory					
Salaries and Benefits	6,903	7,245	7,814	+568	8%
Travel	192	208	306	+97	47%
Support Services	4,391	5,971	7,165	+1,194	20%
Other Related Expenses	6,060	6,492	10,212	+3,720	57%
Total, National Energy Technology Laboratory	**17,546**	**19,917**	**25,497**	**+5,580**	**28%**
Total Program Direction					
Salaries and Benefits	114,751	120,436	129,885	+9,449	8%
Travel	3,452	3,750	5,500	+1,750	47%
Support Services	13,787	18,750	22,500	+3,750	20%
Other Related Expenses	40,194	43,064	67,738	+24,674	57%
Total, Program Direction	**172,184**	**186,000**	**225,623**	**+39,623**	**21%**

[1] The FY 2022 Enacted appropriations for EERE included a total of $209.45 million for Program Direction. The total in this table excludes funding transferred to the Undersecretary for Infrastructure for the Office of State and Community Energy Programs (SCEP), Federal Energy Management Programs (FEMP), and the Office of Manufacturing and Energy Supply Chains (MESC).

[2] The FY 2023 Enacted appropriations for EERE included a total of $186.0 million for Program Direction. The total in this table excludes funding for the Office of State and Community Energy Programs (SCEP), Federal Energy Management Programs (FEMP), and the Office of Manufacturing and Energy Supply Chains (MESC), which was managed by the Undersecretary for Infrastructure.

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Federal FTEs	**585**	**681**	**667**		
Additional Office of Fossil Energy's FTEs at NETL	44	42	**43**		
Total EERE-funded FTEs[1]	**629**	**723**	**710**	**+35**	**5%**
Support Services					
Technical Support	9,419	9,649	11,579		
Management Support	8,884	9,101	10,921		
Total, Support Services	**18,303**	**18,750**	**22,500**	**+3,750**	**20%**
Other Related Expenses					
Other Services	25,029	23,766	37,383		
Working Capital Fund (WCF)	20,324	19,298	30,355		
Total, Other Related Expenses	**45,353**	**43,064**	**67,738**	**+24,674**	**57%**

[1] Includes FTEs supported within the Office of State and Community Energy Programs (SCEP), Federal Energy Management Programs (FEMP), and the Office of Manufacturing and Energy Supply Chains (MESC) in FY 2022 and FY 2023.

Program Direction
($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Program Direction $186,000	**$225,623**	**+$39,623**
Salaries and Benefits $120,436	$129,885	+$9,449
• The Request will support a Federal workforce of 675 FTE, provide resources for program and project management, administrative support, contract administration, and human capital management. S&B estimates take into consideration grade/step levels for the current workforce and the programmatic needs the FY 2023 workforce level.	• The Request will support 710 FTEs by providing resources for program and project management, administrative support, contract administration, and human capital management.	• The slight increase accounts for a planned 5.2 percent pay raise and associated costs for the planned FTE level.
• The Request also will support costs associated with Federal employee benefits, including health insurance costs and retirement allocations in FERS.	• The Request also will support costs associated with Federal employee benefits, including health insurance costs and retirement allocations in FERS	• No significant change.
Travel $3,750	$5,500	+$1,750
• The Request will support travel funding in support of project management and close-outs where the use of virtual meeting technologies or other telepresence is not practical for oversight of EERE funded projects.	• The Request will support travel funding in support of project management and close-outs where the use of virtual meeting technologies or other telepresence is not practical for oversight of EERE projects.	• The increase (2 percent) is to account for increasing travel costs across the board.
Support Services $18,750	$22,500	+$3,750
• Support services funding provides technical and administrative contract support, and information technology services. This funding also contributes to training, education, safety, health support, safeguards and security, computer configuration, and maintenance. This includes operation and maintenance costs associated with EERE's IT modernization project, EPIC.	• Support services funding provides technical and administrative contract support, and information technology services. This funding also contributes to training, education, safety, health support, safeguards and security, computer configuration, and maintenance. This includes operation and maintenance costs associated with EERE's IT modernization project, EPIC.	• The increase represents the expected increase in labor rates for all three of EERE's three main support service contracts. The level of support will be roughly equivalent to FY 2023.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Other Related Expenses $43,064	$67,738	+$24,674
• The Request will provide funds for overhead at DOE Headquarters and the Golden Field Office through EERE's contribution to the WCF and through direct payments in the field. Expenses covered include building operations, telecommunications, network connectivity, supplies/equipment, printing/graphics, mail, contract closeout, purchase card surveillance, computer equipment, utilities, postage, administrative expenses, security, and publications. Also includes funding for EERE's IT modernization project (i.e., EPIC).	• The Request will provide funds for overhead at DOE Headquarters and the Golden Field Office through EERE's contribution to the WCF and through direct payments in the field (NETL). Expenses covered include building operations, telecommunications, network connectivity, supplies/equipment, printing/graphics, mail, contract closeout, purchase card surveillance, computer equipment, utilities, postage, administrative expenses, security, and publications.	• The increase mirrors the planned increase in personnel and increasing automation efforts around budget and operations systems. The increase also reflects an increase in EERE's contribution to the WCF.

Strategic Programs

Overview

Strategic Programs funds high-impact and crosscutting activities most efficiently executed by a single crosscutting organization, in coordination with EERE technology programs and other DOE offices. Strategic Programs consists of four subprograms: Technology-to-Market and Communities, Strategic Analysis, Communications and Outreach, and International. Investments in these programs ensure that all EERE technology advancements support consistent approaches and processes to reach key stakeholders to address high energy costs, reliability, and inadequate infrastructure challenges.

The Program also supports the EERE key emphasis areas. Investments associated with Good Jobs & Workforce Development will support training and continue to develop good paying clean energy jobs for the American people, especially workers, communities impacted by the energy transition, and those historically underserved by the energy system and overburdened by pollution. Investments associated with Diversity, Equity, Inclusion and Accessibility in STEM Fields support outreach and will raise awareness of clean energy research and job opportunities at minority-serving institutions and minority-focused professional organizations and ensure that organizations receiving EERE funding are thinking through outreach opportunities in diversity and equity in their own work. Investments in Communities and Energy Transitions will support community-based organizations, regional partners, and state and local governments with the necessary resources to be more effective in facilitating affordable and resilient clean energy and efficiency goals. Investments associated with Energy Equity and Environmental Justice will support approaches and processes to reach new groups of Americans historically underserved by the energy system, and ensure funding is addressing community needs in the manner most appropriate for their space.

Highlights of the FY 2024 Request:

This Request supports key efforts that contribute to achieving its high-level goals:

- In FY 2024, EERE will continue to administer Energy Transitions Initiative (ETI) activities and expand the scale and impact of ETI investments to apply the lessons learned from island and remote communities to a broader set of underserved, disadvantaged, and historically hard to reach communities.
- Increases in Good Jobs & Workforce Development and Diversity, Equity, Inclusion, and Accessibility in STEM Fields are responsive to demonstrated Congressional interest in expanding and increasing EERE's investment in developing a diverse clean energy workforce for the future and will fund several Prizes and a Workforce Development program.
- EERE Strategic Analysis programs will shift toward a model where equity and environmental justice are integral to funded analysis work; Strategic Analysis will continue its emphasis on the Decarbonizing Energy through Collaborative Analysis of Routes and Benefits (DECARB) program, which aims to conduct analysis at the intersections between key emissions sectors; and Strategic Analysis will continue work on innovative cross-cutting analyses of advanced technologies and systems.
- EERE will build off the FY 2023 international program to focus on multilateral engagements to provide technical assistance to, and research collaboration with, countries and regions as efficiently as possible.
- EERE will increase outreach and engagement opportunities aligned with clean energy programs highlighted in the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA); the Request includes increased support for collaboration and outreach to disadvantaged and energy communities in line with the objectives of the Justice40 Initiative.
- EERE will contribute to the establishment of a Foundation for Energy Security and Innovation to engage with the private sector to raise funds that support the creation, development, and commercialization of innovative technologies that address tomorrow's energy challenges.
- Strategic Programs is involved in several additional crosscutting initiatives, including the following:
    - Industrial Decarbonization crosscut through investments to develop data and analysis tools for difficult to decarbonize sectors of the economy, such as industry, and identify key opportunities for economic growth and job creation in the decarbonized U.S. economy; and
    - Energy-Storage crosscut through investments to support the Energy Storage Grand Challenge (ESGC) Policy & Valuation Track, which provides data, tools, and technical analysis that help policymakers and other energy system decision-makers maximize the value of energy storage.

Strategic Programs
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Strategic Programs					
Technology-to-Market and Communities	3,000	5,500	35,759	+30,259	+550%
Strategic Analysis	10,000	8,500	11,000	+2,500	+29%
Communications and Outreach	7,000	5,500	7,000	+1,500	27%
International	0	1,500	4,000	+2,500	+167%
Total, Strategic Programs	**20,000**	**21,000**	**57,759**	**+36,759**	**+175%**

Strategic Programs
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Strategic Programs	
Technology-to-Market and Communities: The increase supports ETI activities to expand the base suite of models to account for a broader set of community contexts identified by the expanded communities brought into the portfolio. The increase will also support efforts in Good Jobs & Workforce Development and Diversity, Equity, Inclusion and Accessibility in STEM Fields. The increase will also support EERE's contribution to the Foundation for Energy Security and Innovation.	**+30,259**
Strategic Analysis: The increase will support the development of new cross-sectoral decarbonization analysis capabilities and build upon a new program evaluation data platform.	**+2,500**
Communications and Outreach: Funding will increase communications and outreach activities to achieve greater impact on target audiences and expanded reach, including outreach to disadvantaged and energy communities.	**+1,500**
International: The increase is due to substantial growth in opportunities to collaborate internationally to expand U.S. clean energy technologies. The Request includes funding to support consultation and coordination with DOE International Affairs and international partners to meet key Secretarial and Administration priorities and commitments to fight climate change.	**+2,500**
Total, Strategic Programs	**+36,759**

Strategic Programs
Technology-to-Market and Communities

Description

The Request supports the Energy Transitions Initiative (ETI) and other activities in EERE key emphasis areas. ETI's core mission is to facilitate self-reliant communities by addressing high energy costs, reliability concerns, and inadequate infrastructure challenges faced by islands and remote communities. These activities target both resiliency and first-market adopters of modular emerging technologies across the EERE portfolio in America's hardest to reach communities. Investments associated with Good Jobs & Workforce Development will support training and develop good paying clean energy jobs for the American people – especially workers and communities impacted by the energy transition and those historically underserved by the energy system and overburdened by pollution. Investments associated with Diversity, Equity, Inclusion and Accessibility in STEM Fields support outreach and will raise awareness of clean energy research and job opportunities at minority-serving institutions and minority professional organizations and ensure that organizations receiving EERE funding are thinking through diversity and equity in their own work.

The Request also supports EERE's contribution to the Foundation for Energy Security and Innovation to engage with the private sector to raise funds that support the creation, development, and commercialization of innovative technologies that address tomorrow's energy challenges.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Technology-to-Market $5,500,000	**$35,759,000**	**+$30,259,000**
• Funding for successful Energy Transitions Initiative and the Energy Transition Initiative Partnership Program.	• Continue to administer ETI activities and expand the scale and impact of ETI investments to apply the lessons learned from island and remote communities to a broader set of underserved, disadvantaged, and historically hard to reach communities. In addition, EERE will collaborate with other DOE elements on the Communities Local Energy Action Program (Communities LEAP) started in 2021. This opportunity for community-driven clean energy transitions is specifically open to low-income, energy-burdened communities that are also experiencing either direct environmental justice impacts, or direct economic impacts from a shift away from historical reliance on fossil fuels. • Support two Prizes and a pilot research program to address complex clean energy R&D challenges. Expand Community Energy Coalition Prize to provide 15-20 awards for building capacity within communities to improve community representation in energy decision-making. Additional 5-10 awards through a Prize for addressing clean energy challenges using approaches based on citizen science. Additional funding for 1-3 competitive awards focused on public health implications of clean energy development, integrated with multi-agency approaches to public health. • Support Prizes that focus on diversity in STEM in clean energy industries. The HBCU Inspire,	• Increased funding will continue support for ETI and include new Prizes and a Workforce Development program. The increases in these areas are responsive to Congressional interest in expanding and increasing EERE's investment in developing a diverse clean energy workforce for the future. • Increased funding for Foundation for Energy Security and Innovation to engage with the private sector to raise funds that support the creation, development, and commercialization of innovative technologies that address tomorrow's energy challenges.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	Initiate, and Integrate Prize will support between 2-4 awards to fund research infrastructure and capability improvements at HBCU recipients. The Clean Energy Careers for All Prize will support multiple organizations in the implementation of various programming that will lead to increasing the diversity of the future STEM clean energy workforce. • Continued support for the Clean Energy Innovators Fellows Program, and new support for a Workforce Accelerator Program to expand and standardize training activities for high-skill, high-wage, or in-demand industry sectors related to clean energy and climate mitigation developing national training standards leading to industry-recognized credentials, and place-based labor-management training pilots.	

Strategic Programs
Strategic Analysis

Description

The Strategic Analysis (SA) subprogram performs gap-filling and corporate analyses associated with EERE technologies and systems; developing tools and methods that enable consistent evaluation and analysis across EERE; and providing analytical thought leadership across DOE, other government agencies, and external stakeholders.

In FY 2024, SA will support analyses to evaluate a wide array of potential integrated technical pathways – across the electricity, buildings, industrial, transportation and agricultural sectors – to achieve key milestones toward the Administration's decarbonization goals. Analytical efforts will focus on developing tools and using a variety of metrics to determine a pathway's viability, the potential impact of EERE R&D, and the implications for how the clean energy economy benefits all Americans, creating good paying jobs for the American people – especially workers and communities impacted by the energy transition and those historically underserved by the energy system and overburdened by pollution. These analyses will inform EERE R&D planning and serve as a resource for EERE stakeholders involved in the unprecedented deployment of clean energy technologies.

To focus on execution of EERE analytical work, SA created DECARB, a multi-lab coordination team to implement a multi-year work plan that outlines what new capabilities are required to comprehensively address economy-wide decarbonization. In FY 2024, the multi-lab team will continue to conduct cross-sectoral analysis and develop new analytical capabilities while coordinating with activities happening across DOE, as well as engage external stakeholders to ensure that strategies can inform EERE and real-world planning.

SA will continue to support cross-cutting DOE initiatives. Specifically, a joint EERE, Office of Electricity, and Grid Deployment Office "Grid Solutions" effort, which aims to systematically provide support across several critical topic areas: integrated distribution system planning, resource adequacy, electricity markets, and regional planning. SA will support this program by developing foundational capabilities (data, tools, analysis) that can be used to increase the effectiveness of the technical assistance provided by other program offices or used directly by a wide array of electricity decision makers. SA will also continue to support analysis used to inform the Energy Storage Grand Challenge and Energy Earthshots.

Additionally, in FY 2024, SA will continue to lead efforts to ensure that EERE is maximizing the impact of its research dollars, tracking the impacts of EERE investments relative to priority metrics, and striving to ensure that the clean energy economy benefits all Americans. Efforts will be coordinated with the Department's larger efforts to meet the goals of the Justice40 Initiative, address workforce needs, and examine the potential for good paying jobs.

Strategic Analysis

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Strategic Analysis $8,500,000	**$11,000,000**	**+$2,500,000**
• Finalize analysis of comprehensive nationwide analysis of pathways to carbon free electricity and integrate with analysis of pathways to decarbonize transportation, buildings, and industry.	• Build upon decades of investments in analysis of renewable power and develop new high-resolution capabilities to examine economy-wide (both supply- and demand-side) decarbonization pathways, with a focus on improving analyses of cross-sectoral interactions for energy cost, deployment, environmental impact, and equity.	• Increase in funding will support the development of new cross-sectoral decarbonization analysis capabilities and build upon a new program evaluation data platform. Strategic Analysis will also continue to fund the compilation of new data sets, enhance and integrate models/tools, and conduct analysis to address remaining research gaps.
• Support technical assistance efforts for renewable integration and grid modernization to enable stakeholders to make data-driven decisions around clean energy pathways, transmission buildouts, and market as well as policy solutions.	• Continue to invest in key analytical capabilities to enable best-in-class technical assistance, including making tools and models widely usable by others and publishing foundational datasets with high leverage across a broad array of analytical use cases. • Expand data and analysis tools for difficult to decarbonize sectors of the economy, especially agriculture, industry, and freight transportation modes, identifying key opportunities for economic growth and job creation in the decarbonized U.S. economy.	
• Complete development of analytical tools to enable EERE programs and external stakeholders to maximize U.S. energy job creation and minimize job transitions.	• Leverage capabilities to support EERE programs and external stakeholders and take lessons learned from key use cases to support continual improvement in analytical capabilities. Build upon a new evaluation data platform with EERE program metrics, data pipelines, analytics, and automation to improve data collection practices and data aggregation systems.	

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Continue to provide analytical support for the Energy Storage Grand Challenge in coordination with cross sector analysis examining pathways to decarbonization.	• Continue to provide analytical support for the Energy Storage Grand Challenge in coordination with cross sector analysis examining pathways to decarbonization.	
• Support Justice40 Initiative by initiating the development of tools and methodologies to measure and inform EERE efforts to foster equity and environmental justice. These tools and methodologies will help EERE quantify progress against established EERE priority metrics and collect qualitative information to help inform planning and decision making.	• Continue to support Justice40 initiative by integrating equity and environmental justice priorities across the analysis portfolio.	

Strategic Programs
Communications and Outreach

Description

The Communications and Outreach subprogram provides strategic communications leadership, coordination, and operation support for EERE and the Department by developing and disseminating information and associated impacts to key stakeholders, media, and the public on EERE programs, activities, and technologies. In addition, this subprogram supports investments to raise awareness and understanding of EERE technologies and inform key stakeholders and audiences of EERE resources and opportunities. The Communications and Outreach subprogram activities in FY 2024 will focus on:

- Informing key EERE audiences and stakeholders about the work that EERE is doing to transition the Nation to a clean energy economy and fight the climate crisis. This includes increased support for collaboration with tribal communities as well as disadvantaged and energy burdened communities in line with the objectives of the Justice40 Initiative. In addition, EERE will increase outreach efforts to raise awareness of clean energy research and career opportunities at minority-serving institutions and minority professional organizations.
- Supporting outreach and engagement opportunities aligned with clean energy programs highlighted in IIJA and IRA.
- Developing and implementing strategic communications plans and messages that reflect EERE's mission, vision, and goals.
- Supporting EERE's programs in communicating the impacts of their work and why it matters.
- Working across EERE technology offices and programs to develop and execute effective communications narratives and campaigns that inform about EERE opportunities and resources and highlight EERE's accomplishments and successes.
- Supporting EERE's senior leaders to communicate EERE's message through engagements with internal and external stakeholders as well as the public.
- Developing targeted stakeholder engagement and outreach campaigns that leverage a wide range of virtual and live event platforms and communications tactics to engage with a wide range of EERE audiences and stakeholders.
- Executing a wide range of events, conferences, workshops, roundtables, and other means of data exchange (both in-person and virtual) to inform crosscutting initiatives and organizational and executive priorities.
- Improving the functionality and effectiveness of EERE's digital, web-based, social media products with the end-user, the American people, in mind. These efforts will prioritize:
  - Improving the functionality of EERE's website and digital communications products to make them more user-friendly and accessible;
  - Increasing engagement and effectiveness of EERE social media content and campaigns;
  - Improving the analysis and reporting of metrics to measure the effectiveness and engagement of communications products and campaigns; and
  - Utilizing videography, photography, animation, commercial art, and graphic design to tell EERE's story and more effectively engage with online audiences on social media and digital/web-based platforms.

Communications and Outreach

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Communications and Outreach $5,500,000	**$7,000,000**	**$1,500,000**
• Continue EERE's focus on strategic communications planning and implementation to have a greater impact on target audiences. Create new language and messaging that is easily accessible to audiences. Increase analysis and reporting of metrics to measure and improve the effectiveness and engagement of communications products and campaigns. • Expand EERE's digital, web-based, graphic, video, and social media products to inform and engage target audiences of EERE's efforts and impact in advancing the transition to a clean energy economy and tackling the climate crisis. Support the development of virtual events and roundtables, strategic communications campaigns, and stakeholder engagement initiatives that highlight progress made towards EERE's strategic goals and tell the story of EERE's successes in an engaging, impactful, and meaningful way; provide information and resources on how to engage with EERE and the work the organization is doing; and convey why EERE's work matters.	• Continue to increase EERE's focus on strategic, proactive media engagement, including regional and local outlets, to ensure communities are seeing the positive impacts of EERE's work. • Continue to expand capabilities in social media, website, and graphic design to ensure expanded reach and accessibility of EERE news, successes, activities, and programs. • Demonstrate the benefits of EEREs work through various communications channels—utilizing metrics and analysis to inform future outreach and engagement strategies. • Continue to engage with, assemble, and educate stakeholders about EERE's priorities and investments by hosting events with key stakeholders and tribes. • Continue to develop strategies and implement proactive communications and stakeholder engagement activities—focusing on EERE funding activities, as well as programs and successes, and their positive impacts on Americans.	• Increased outreach to bilingual audiences and more documents produced that are in Spanish as well as English. • Increase outreach and engagement opportunities aligned with clean energy programs highlighted in IIJA and IRA; the increase supports collaboration and outreach to tribal governments as well as disadvantaged and energy communities in line with the objectives of the Justice40 Initiative. • Provide website enhancements and upgrades, including search engine optimization, user experience, Google Analytics and metrics reporting, and overall website design, including web best practices, information architecture, and technologies to ensure user-centered content and design. • Expand on stakeholder email strategy and capabilities, building templates, and identifying best practices. • Provide training opportunities to technology offices on communications strategy and best practices, media engagement, and more.

Strategic Programs
International

Description:
The International subprogram aims to increase the speed and scale of clean energy deployment to promote deep decarbonization through international collaboration with strategic partners. Activities under this subprogram lead to deep decarbonization efforts in partner countries to meet the climate challenge, with opportunities for exports of U.S. clean energy technology and services.

The subprogram's activities coordinate with DOE's Office of International Affairs and the Departments of State, Commerce, and Transportation, to implement expert-driven technical assistance in the areas of sustainable transportation, renewable power, and energy efficiency that otherwise does not exist in the Federal government. The subprogram also coordinates and collaborates with U.S. clean energy technology manufacturers and service providers when appropriate.

The International subprogram's market priming activities focus on economies and regions that are significant emitters of greenhouse gases and have great opportunities for emissions reductions across major sectors: electric power, commercial buildings, residential buildings, industrial facilities, and transportation. These activities include technical collaborations to establish business cases for adopting codes, standards, and advanced EERE technologies. The subprogram also supports efforts to demonstrate and deploy emerging U.S. products and services, enabling early commercial success and facilitating U.S. companies competing in global markets.

The International subprogram encourages and arranges coordination between the U.S. and developed nations (e.g., the UK, France, Japan, and Germany) to leverage clean energy technology research, development, and innovation to encourage and speed deployment of such technologies.

The International subprogram measures impacts of collaborative engagement activities designed to deliver decarbonization solutions by tracking their effect on real or projected GHG emissions, investment in clean energy projects in partner countries, and/or renewable energy or energy efficiency policy changes (such as adoption of U.S. industry-preferred standards or rating systems for technologies such as windows or solar photovoltaics; successful development and implementation of more stringent building codes, etc.).

International

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
International Coordination $1,500,000	**$4,000,000**	**+$2,500,000**
• The Request will allow EERE to implement technical assistance projects with target countries in areas of geothermal energy and energy efficiency, and to coordinate research, development, and innovation collaboration with developed and developing countries, in consultation and coordination with DOE International Affairs to meet key Secretarial and Administration priorities and commitments to fight climate change.	• The Request will allow EERE to implement technical assistance projects with an increased number of countries, including via multilateral fora, on a wider range of clean energy needs; and to coordinate research, development, and innovation collaboration with developed and developing countries. The Request also includes funding to support consultation and coordination with DOE International Affairs to meet key Secretarial and Administration priorities and commitments to fight climate change.	• The increase supports greater international and federal government needs for EERE's areas of technical expertise, necessitating more capacity to engage in international technical assistance than in FY 2023, as well as an FY 2024 approach with greater engagement with multilateral fora to provide efficient technical assistance and research collaboration that supports as many countries and regions as possible.

Facilities and Infrastructure

Overview

The National Renewable Energy Laboratory (NREL) is the Office of Energy Efficiency and Renewable Energy's (EERE) Federally Funded Research and Development Center (FFRDC). EERE is NREL's steward and primary sponsor. NREL serves as the Nation's preeminent institution for delivering impactful scientific knowledge and technology innovations that transform renewable energy technologies, systems, and markets. NREL's research advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies, and provides the scientific knowledge to integrate and optimize energy systems. NREL supports the DOE Energy Planning Guide (EPG) Goal1: Drive U.S. energy innovation and deployment on a path to net-zero emissions by 2050.

The objectives of the F&I Program are to:

- Develop and steward grid modernization and broader energy systems integration capabilities at the Energy Systems Integration Facility (ESIF), a DOE-designated user facility designed to inform early-stage research, utilizing high performance computing capabilities.

- Ensure continuity of essential lab operations by:
  - Providing the laboratory with a safe, secure work environment for the protection of personnel, partners, and the public and acquiring new mission-critical science and technology capabilities when warranted.
  - Providing NREL with secure information networks with strong cybersecurity protocols.
  - Maintaining and upgrading NREL's science and support infrastructure through regular reinvestments determined by age, condition, risk, and DOE and industry standards, ensuring the availability of a world-class Research and Development (R&D) environment for ongoing EERE mission activities and emerging areas of R&D of interest throughout all of government and industry.
  - Providing direct funding for operational activities of major facilities and infrastructure and site-wide investments.

Highlights of the FY 2024 Request

To posture NREL's capabilities to support emerging technologies and future requirements, the FY 2024 F&I Budget Request focuses on sustaining NREL's world-class R&D environment by maintaining and upgrading its capabilities, equipment, and facilities. This request also leverages the Investment Reduction Act (IRA) infrastructure funds, allowing NREL to prioritize Capital Investment Needs to accelerate by 3+ years the Administration's R&D and Infrastructure Priorities. This Request supports key efforts that contribute to achieving its high-level goals:

- Fund the second segment of the construction phase of the Energy Materials and Processing at Scale (EMAPS). The project addresses the full lifecycle of our products, materials, and energy economy to enable partnerships with U.S. and industry to incentivize waste reduction, reuse, and reduced persistence in the environment, accelerates innovations to market viability, which will enable critical research activities for a more rapid transition to a circular economy for energy-relevant and energy-intensive materials and processes. The plan is to projected to achieve CD-2, and *Approve Performance Baseline,* is expected in the third quarter FY 2024.
- Fund the operations, maintenance, equipment, and a refresh/upgrade of the High-Performance Computer (HPC) at the ESIF. The HPC will enable large-scale numerical models for studying and simulating material properties, processes, and fully integrated energy systems. It will also reduce expenses, risks, and uncertainty that are often barriers to industry-adopting new and innovative technologies.
- Support the Advanced Research on Integrated Energy Systems (ARIES) to address the challenges of designing and constructing future energy systems, by operating large-scale hybrid energy systems that interconnect multiple generation, storage, and end-use technologies. Research focus areas include energy storage, power electronics, hybrid energy systems, future energy infrastructure, and cybersecurity.
- Fund investments in Diversity, Equity, Inclusion and Accessibility (DEIA) by prioritizing infrastructure and information technology projects to serve a Historically Black College/University (HBCUs) or Minority-Serving Institution (MSIs).
- Invest $35 million to conduct extensive planning for future construction of the 18th National Laboratory facility. DOE will apply the proposed funding to scale up an existing research facility at a Historically Black College/University (HBCU) or Minority Serving Institution (MSI) or towards construction of an entirely new research facility at an HBCU or MSI, or consortium of such institutions, creating a pathway to National Laboratory designation.

Facilities and Infrastructure
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Facilities and Infrastructure					
Operations and Maintenance	93,590	102,370	118,865	+16,495	+16%
Facility Management	46,410	57,630	66,526	+8,896	+15%
Establish DOE 18th National Laboratory	0	0	35,000	+35,000	+100%
Construction					
21-EE-001, Energy Materials Processing at Scale (EMAPS)	8,000	45,000	57,000	+12,000	+27%
Total, Facilities and Infrastructure	**148,000**	**205,000**	**277,391**	**+72,391**	**+35%**

Facilities and Infrastructure
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Facilities and Infrastructure	
Operations and Maintenance: The Request prioritizes an increase for ARIES investments as well as investments to support the expansion of the NREL campuses.	+16,495
Facility Management: The Request prioritizes an increase in ESIF infrastructure and equipment investments, which are slightly offset by the de-commissioning of the Eagle High Performance Computer (HPC).	+8,896
Establish DOE 18th National Laboratory: The increase is to conduct planning for future construction of the 18th National Laboratory facility. DOE will apply the proposed funding to assess options including scaling up an existing research facility at an HBCU or MSI or constructing an entirely new research facility at an HBCU, MSI, or consortium of such institutions, creating a pathway to National Laboratory designation.	+35,000
Construction: The Request prioritizes a funding increase for second segment of construction of EMAPS.	+12,000
Total, Facilities and Infrastructure	**+72,391**

Facilities and Infrastructure
Operations and Maintenance

Description

The Operations and Maintenance subprogram provides the program planning and implementation required by DOE Order 430.1C, *Real Property and Asset Management*, to maintain real property assets at NREL. The subprogram includes:

- Minor Construction Projects (i.e., General Plant Projects [GPP])
- General Plant Equipment (GPE)
- Maintenance and Repair (M&R)
- Safeguards and Security (S&S)
- Site-Wide (SW)

Minor Construction investments maintain and enhance the real property portfolio, renovate general science capabilities and buildings, and upgrade laboratories for technical advancements. Examples of Minor Construction Projects are laboratory refurbishments, laboratory reconfigurations, utility enhancements, facility additions, and small (<$25 million) projects to accommodate new research capabilities.

Major GPP activities:

- ARIES investments that work toward getting the most value from the millions of new devices—such as electric vehicles, renewable generation, hydrogen, energy storage, and grid-interactive efficient buildings—that are being connected to the grid daily.
- Investments in the laboratory campus necessary to ensure continuity of operations, such as South Table Mountain (STM) Substation and Distributed Energy Grid investments.

GPE investments acquire and maintain shared science and support equipment to meet research mission needs, replace outdated technology, and provide for emergent research opportunities.

Major GPE activity:

- The Request provides funding for equipment in support of the Digital Real Time Simulation (DRTS) integration.
- The Request also supports additional high-priority ARIES research platform GPE investments that support the energy storage, power electronics, hybrid energy systems, future energy infrastructure, and cybersecurity research areas.

M&R funding sustains real property equipment, systems, and facilities in a condition suitable to ensure their availability for research activities and their effectiveness in supporting the safety and security of the personnel and DOE-owned assets on the campus. The FY 2024 Request ensures NREL will remain within the DOE control standard of two to four percent of Replacement Plant Value (RPV).

S&S funding provides for physical security and cyber protection of NREL personnel, information, and property from threats and hazards, including the capability to respond to emergencies as well as protecting networks and information resources.

SW funding provides for site management of both campuses which includes fire and emergency services, environment, safety and health compliance, hazardous waste management, health programs, medical services, safety programs including electrical safety, energy intelligent campus, shipping/receiving, facility and space planning, facility condition assessment inspections, and database management of DOE's Facilities Information Management System.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Operations and Maintenance $102,370,000	**$118,865,000**	**+$16,495,000**
• The Request prioritizes continued support GPE ARIES investments in the five research areas of the initiative: Cybersecurity, Future Energy Infrastructure, Energy Storage, Hybrid Energy Systems, and Power Electronics. Includes final funding for the RAIL, the Waste Handling Facility, and Solar Energy Research Facility (SERF)/ Science and Technology Facility (S&TF) Ventilation projects.	• Continued support for GPE ARIES investments in the five research areas of the initiative: Cybersecurity, Future Energy Infrastructure, Energy Storage, Hybrid Energy Systems, and Power Electronics.	• Reprioritized funding in support of STM Substation and STM Distributed Energy Grid investments.
• M&R funding enables continuation of the DOE control standard of two to four percent of RPV, with increased investments in M&R.	• Maintains M&R investments and includes investment in the South Table Energy Park (STEP) campus.	• The increase supports M&R for the STEP campus, deferring other GPP/GPE investments.
• Maintains operational readiness for S&S activities.	• Maintains operational readiness for S&S activities.	• No significant change.
• Maintained operational readiness for SW activities, with increased investments for additional facility management, maintenance, chemical management, industrial hygiene, electricians, fire systems technicians, and health and safety initiatives as NREL's three-campuses build-out to ensure the level of services necessary to keep the Laboratory running safely, securely, and effectively.	• Maintains operational readiness for SW activities, with increased investments for additional facility management, maintenance, chemical management, industrial hygiene, electricians, fire systems technicians, and health and safety initiatives as NREL's three-campuses build-out to ensure the level of services necessary to keep the Laboratory running safely, securely, and effectively.	• Increases investments in SW activities.

Facilities and Infrastructure
Facility Management

Description

The Facility Management subprogram provides funding for core operations at the Energy Systems Integration Facility (ESIF), keeping the facility and research assets of this world-class DOE user facility as state-of-the-art and available to support research across EERE's portfolio and with EERE's partners in other DOE offices, at other Federal agencies, at universities, and in the private sector. The FY 2024 Request continues the research-readiness efficiency-charge for users of the ESIF.

ESIF is a unique national asset that provides the public and private sectors with the ability to conduct critical R&D on multiple technologies and energy sources in integrated energy systems. ESIF provides state-of-the-art laboratories and support infrastructure to advance innovation that enables energy systems design and performance optimization. A priority focus is to enable a resilient, secure, modern grid that can accommodate a variety of domestic energy resources.

ESIF investments continue relevance of ESIF laboratory facilities and capabilities, and advance multi-program focused cross-cutting integration research in Energy Storage, Cybersecurity, Hydrogen and Renewable Fuel Systems, Thermal Systems, Future Energy Infrastructure, Hybrid Energy Systems, Power Electronics, Transportation, Autonomous Energy Systems, and Buildings.

ESIF's High Performance Computer (HPC) supports research across nine EERE programs as well as ARIES' research platform and produces computational experiments that advance critical NREL research efforts at temporal and spatial scales that evade direct observation. In addition, the HPC establishes a foundational scientific and engineering capability that attracts leading talent, collaborators, and partners, and demonstrates the world's most efficient HPC data center technologies. The FY 2024 Request provides funding that supports operations, maintenance, equipment, and a refresh/upgrade of the ESIF HPC.

The FY 2024 Request emphasizes investments in ARIES equipment and infrastructure within ESIF.

ESIF investments also fund a user program (e.g., user outreach, engagement, and education; development of calls for proposals; conduct of technical peer reviews of proposals; scheduling of R&D projects and reporting on ESIF status and progress); the maintenance and safety envelope of the ESIF; and technical support to research activities. Funding also implements Integrated Safety Management, Environmental Management, and Hazard Management requirements within the ESIF; maintains, repairs, and modifies connection for SCADA, laboratory safety, research chiller/boiler; research project equipment receiving, placement, setup, fabrication, and decommissioning; gas distribution, fuel distribution, and gas detection; and general logistics support (consumables procurement, equipment storage, material handling, and general maintenance activities).

ESIF-dedicated technical staff support users in designing, setting-up, and conducting experiments in the ESIF. In the user-facility model, peer reviewed, and selected projects receive facility-funded support for equipment and experimental configuration design, set-up, problem solving, and operation.

ESIF investments also fund HPC refresh/upgrade and expansion; HPC operations, HPC cybersecurity, HPC user operations, data center operations, and HPC project management/scheduling.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Facility Management $57,630,000	**$66,526,000**	**+$8,896,000**
• Provides for a refresh/upgrade cycle of the Kestrel High Performance Computer.	• Continues the Kestrel High Performance Computer as year 3 of a planned 4-year refresh/upgrade.	• Increase reflects full operations of the Kestrel High Performance Computer.
• Provides for systems engineers, area supervisors, health and safety personnel, and management for ESIF research activities.	• Provides for systems engineers, area supervisors, health and safety personnel, and management for ESIF research activities. Increases funding in ESIF equipment.	• Increases funding in ESIF equipment investments.
• Increases ARIES equipment and infrastructure investments.	• Continues ARIES equipment and infrastructure investments.	• No significant change.
• Continues research-readiness efficiency- charge for users of the ESIF.	• Continues research-readiness efficiency- charge for users of the ESIF.	• No significant change.
• Provides for energy system security and resilience to ensure that activities at ESIF meet all cybersecurity requirements and needs of users.	• Provides for energy system security and resilience to ensure that activities at ESIF meet all cybersecurity requirements and needs of users.	• No significant change.
• Continues charging prorated share of site operating costs and utilities to indirect funding.	• Continues charging prorated share of site operating costs and utilities to indirect funding.	• No significant change.

Facilities and Infrastructure
Establish DOE 18th National Laboratory

Description

This Request will provide $35 million to conduct extensive planning for future construction of the 18th National Laboratory facility. The goal would be to stand up a new laboratory to serve as the nation's premier research organization focused on modeling, observations, analysis, and multidisciplinary synthesis that are necessary to evaluate heterogeneous regions down to community scales.

For generations, the nation's Historically Black Colleges and Universities (HBCUs) have anchored Black communities by broadening educational opportunities and creating pathways for economic mobility, while minority serving institutions (MSIs) have provided similar opportunities to a diverse range of Americans. There are a number of multidisciplinary analyses to be conducted and assessed, including both opportunities and impacts, that will fall disproportionately on communities of color and low-income Americans.

Because the interdisciplinary social sciences are so well studied by multiple departmental elements, such as the Office of Science's (SC) Office of Biological and Environmental Research (BER) and the Office of Economic Impact and Diversity (ED), and because EERE is primarily an energy technology research office, these decisions and selections will be made in deep consultation with SC/BER, ED, the HBCUs and MSIs seeking this funding, and relevant community partners.

Facilities and Infrastructure
Construction

Description

This subprogram supports line-item construction projects associated with EERE's mission. The Request provides funding for the second segment of the construction phase of the Energy Materials and Processing at Scale (EMAPS) line-item construction project.

EMAPS is envisioned to address the full lifecycle of our products, materials, and energy economy to enable partnerships with U.S. industry to incentivize waste reduction, reuse, and reduced persistence in the environment, as well as accelerate innovations to market viability. Such a capability will enable research activities critical for a more rapid transition to a circular economy for energy-relevant and energy-intensive materials and processes. Construction segment 1 provided sitework, water and sewer taps, foundations, and construction of core and shell dried-in building. Segment 2 will provide completed interior and exterior finishes plus purchase and installation of long-lead equipment. Segment 3 will provide completion of hardscape/landscape, lab fit-out, test and balance, and building commissioning that will lead to Beneficial Occupancy and Certification of Final Completion.

The most recent DOE Order 413.3B Critical Decision (CD) is CD-0, Approve Mission Need, was approved on December 20, 2019. The preliminary estimate for CD-1, Approve Alternative Selection and Cost Range, is anticipated in the fourth quarter of FY 2023. This project is pre-CD-1; therefore, schedule estimates are preliminary and subject to change. The current preliminary Total Estimated Cost (TEC) range for this project is $130,000,000 to $160,000,000 and the preliminary Total Project Cost (TPC) range is $135,000,000 to $165,000,000. These cost ranges encompass the most feasible preliminary current alternatives.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Construction $45,000,000	**$57,000,000**	**+$12,000,000**
• Provides funding for the first segment of the construction phase for the EMAPS line-item construction project.	• Provides funding for the second segment of the construction phase for the EMAPS line-item construction project.	• The increase funds the second segment of construction phase for EMAPS.

Facilities and Infrastructure
Capital Summary ($K)

	Total[1]	Prior Years	FY 2022 Enacted	FY 2022 Actuals	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Capital Summary (including Major Items of Equipment (MIE))							
Capital Equipment > $5M (including MIE)	-	0	12,360	12,360	7,220	19,612	+12,392
Minor Construction	-	41,310	25,110	25,110	29,544	63,000	+33,516
Major Construction	-	4,000	8,000	8,000	45,000	57,000	+12,000
Total, Capital Summary	**-**	**45,310**	**45,470**	**45,470**	**81,764**	**139,672**	**+57,908**
Capital Equipment > $5M (including MIE)							
Total Non-MIE Capital Equipment (< $5M)	-	0	12,360	12,360	7,220	19,612	12,392
Total, Capital Equipment (including MIE)	**-**	**0**	**12,360**	**12,360**	**7,220**	**19,612**	**12,392**
Minor Construction Projects							
Total Direct Funded Minor Construction Projects (TEC <$5M)	-	-	5,690	5,690	14,144	55,060	+40,916
Research and Innovation Laboratory (DF)	24,910	19,910	3,000	3,000	2,000	0	-2,000
ARIES 34.5kV Infrastructure Upgrade (DF)	8,000	1,600	6,400	6,400	0	0	0
Waste Handling Facility (DF)	13,350	0	10,350	10,350	3,000	0	-3,000
CFE - Distributed Energy Grid East STM Campus (DF)	19,500	0	0	0	0	3,000	+3,000
SERF/S&TF Ventilation (DF)	14,700	9,300	0	0	5,400	0	-5,400
Flatirons Control Center (DF)	15,500	10,500	0	0	5,000	0	-5,000
STM Substation (DF)	24,900	0	0	0	0	5,000	5,000
Total, Minor Construction Projects	**120,860**	**41,310**	**25,440**	**25,440**	**29,544**	**63,060**	**+33,516**
21-EE-001, Energy Materials and Processing at Scale, TEC[2],[3]	160,000	4,000	8,000	8,000	45,000	57,000	+12,000
Total, Construction	**280,860**	**45,310**	**33,110**	**33,110**	**74,544**	**120,060**	**+12,000**
Total, Capital Summary	**285,860**	**45,310**	**45,470**	**45,470**	**81,764**	**139,672**	**+57,908**

[1] Dashes (-) in the Total column indicates a broad category where totaling would not be applicable as it would be for an individual investment.
[2] This project has not received CD-2 approval; therefore, preliminary estimates are shown for TEC.
[3] Indicates a project where the cost of the Conceptual Design Report is estimated to exceed $3 million.

Outyears ($K)

	FY 2025 Estimate	FY 2026 Estimate	FY 2027 Estimate	FY 2028 Estimate
Capital Summary (including Major Items of Equipment (MIE))				
Capital Equipment > $5M (including MIE)	38,753	50,200	54,305	30,800
Minor Construction	61,213	111,743	132,072	211,871
Major Construction	46,000	0	0	0
Total, Capital Summary	**145,966**	**161,943**	**186,377**	**242,671**
Capital Equipment > $5M (including MIE)				
Total Non-MIE Capital Equipment (< $5M)	31,253	42,700	48,705	30,800
EMAPS Equipment (DF)	7,500	7,500		
Large-Format Stationary Battery Cycling Units (DF)	0	0	5,600	0
Total, Capital Equipment (including MIE)	**38,753**	**50,200**	**54,305**	**30,800**
Minor Construction Projects				
Total Direct Funded Minor Construction Projects (Total Estimated Cost (TEC) <$5M)	9,313	77,243	70,072	207,371
Total Indirect Funded Minor Construction Projects (Total Estimated Cost (TEC) <$5M)	0	0	0	0
Non-Carbon Wastewater Treatment at Flatirons Campus (DF)	7,000	0	0	0
CFE - Distributed Energy Grid East STM Campus (DF)	16,500	0	0	0
STM Substation (DF)	19,900	0	0	0
Future Tech ready Interconnected Research Platforms (DF)	4,000	4,000	0	0
Flatirons Campus Utility Distribution Duct Work (DF)	4,500	4,500	0	4,500
STM Power Plant Upgrade (DF)	0	15,000	0	0
Flatirons Campus Infrastructure Upgrade (DF)	0	5,000	0	0
Electric Heating for all New Buildings (DF)	0	6,000	0	0
Flatirons Campus (FC) Carbon-free Backup Power Technologies (DF)	0	0	19,500	0
STM Carbon-free Backup Power Technologies (DF)	0	0	19,500	0
Onsite Renewable Energy (DF)	0	0	17,000	0
Flatirons Campus (FC) Electrical Distribution Infrastructure (DF)	0	0	6,000	0
Total, Minor Construction Projects	**61,213**	**111,743**	**132,072**	**211,871**
Major Construction Projects				
EE-21-001, Energy Materials Processing at Scale[1] Total Estimated Cost (TEC)	46,000	0	0	0
Total, Construction	**46,000**	**0**	**0**	**0**
Total, Capital Summary	**145,966**	**161,943**	**186,377**	**242,671**

[1] This project has not received CD-2 approval; therefore, preliminary estimates are shown for TEC. Indicates where a project where the cost of the Conceptual Design Report is estimated to exceed $3 million. Other Project Costs (OPC) are funded through laboratory overhead.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	Research and Innovation Laboratory (RAIL)
Project Location/Site:	NREL South Table Mountain Campus:
Type:	Minor Construction (Direct funded)
Total Estimated Cost:	$24,910
Construction Design:	$1,650
Project Start:	FY 2020
Design Complete:	FY 2022
Construction Complete:	FY 2023
Project Description:	This project provides flexible laboratory space for highly integrated, interdisciplinary research open to support active collaboration across disciplines with enhanced types of ventilation required to keep researchers safe and to enable conducting diverse experiments compatibly and safely in proximity with each other. Design of the laboratories will enable adapting quickly to new research opportunities with state-of-the-art capabilities to attract and collaborate with industry to move knowledge and knowhow from proof-of-principle experiments to co-development and initial experimentation at a scale that catalyzes commercial investment. In addition to typical building and site improvements, the project scope accommodates lab equipment fit out, design, procurement and installation for major lab equipment items which requires infrastructure modifications, site improvements and features that will support external collaboration activities, access roadway improvements, and pedestrian scale improvements including walkways, hardscaping, and ramps to enhance ADA accessibility. The project will employ a design-build contract estimated to take nearly 27 months to complete from design through beneficial occupancy. Estimated facility size is approximately 15,000 square feet. Useful segments: Design FY 2021 $1,650; Construction FY 2022 $21,260; Construction FY 2023 $2,000 Extension for added scope for $5,000 budget increase: SC – 6/15/23; FC – 8/15/23
Prior Year Accomplishments:	• Groundbreaking in October 2021 • Building “Topping Out” achieved in March 2022 • Building “Dry-In” achieved in July 2022
Planned Activities:	• Substantial Completion planned to be achieved in June 2023 • Commissioning of Facility and installed equipment planned to be completed in July 2023 • Final Construction Completion (Construction of the project up to final payment as defined in the construction subcontract; construction oversight by NREL) planned to be completed in August 2023 • Project Management, Laboratory Services, and Government Furnished Equipment (Project management; independent testing/inspection, commissioning, and other third-party services; technical oversight during design and construction; IT and other laboratory provided services; procurement and installation of Government Furnished Equipment)
Significant Changes from original plan:	A $400,000 budget and scope increase was approved in FY 2021 that directly supports the decarbonization efforts of the NREL STM campus. The change in budget and scope incorporates microgrid infrastructure capabilities, an Emergency Branch Backup Inverter, and provides a service upgrade to enable renewable technology power sources for the RAIL, in lieu of diesel generation, for back-up power. A $5M budget and scope increase was approved in FY 2022 for modifications, site improvements and features that will support external collaboration activities, access roadway improvements, and pedestrian

	scale improvements including walkways, hardscaping, and ramps to enhance ADA accessibility.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	ARIES 34.5kV Grid Infrastructure
Location/Site:	NREL Flatirons Campus
Type:	Minor Construction (Direct funded)
Total Estimated Cost:	$8,000
Construction Design:	$1,600
Project Description:	This project includes an expansion to the substation, 34.5kV transformers, switchgear, and underground cable Installation. The 34.5kV is required to support next generation wind turbines and the second Controllable Grid Interface (CGI) connectivity bus expected to be completed in FY 2023. Useful segments: • Design FY 2021-2022 $1.60 million; • Construction $3.80 million and switchgear and transformer $2.60 million FY 2023-2024 for a total of $6.40 million.
Prior Year Accomplishments:	• The design has reached the 100% level.
Planned Activities:	• Construction (Construction of the project up to final payment as defined in the construction subcontract, construction administration by the design team) • Project Management, Laboratory Services (project management, independent testing/inspection, commissioning, and other third-party services, technical oversight during design and construction)
Significant Changes from original plan:	N/A

Facilities & Infrastructure Operations & Maintenance	
Project Name:	Waste Handling Facility
Location/Site:	NREL STM Campus
Type	Minor Construction (Direct funded)
Total Estimated Cost	$13,350
Construction Design	$1,000
Project Start	FY 2022
Design Complete	FY 2023
Construction Complete	FY 2024

Project Description:

The lab proposes to construct an 8,000 sq. ft. facility to store, stage, and process hazardous wastes to support R&D and operational activities. Additional space and facility attributes are required to manage hazardous wastes and support the lab's mission effectively and efficiently. The facility would: 1) allocate space for materials, supplies, and equipment, 2) allow for forklift access, 3) incorporate a transport truck dock, 4) provide separate processing and storage areas to allow for continued acceptance of wastes while others are being processed for offsite shipment, 5) co-locate a portion of the lab's hazardous materials preparedness and response activities (such as spill control materials, chemical response team equipment, SCBA bottle refilling), 6) provide a small office area for waste management administrative activities, 7) provide locker room and shower facilities for worker health and safety, 8) centralize industrial hygiene equipment calibration and respiratory fit testing.

Supporting Information

The current 1000 sq. ft. Waste Handling Facility is not adequately sized to meet the lab's current or reasonably foreseeable level of activities. The current size and configuration requires waste acceptance to be paused while stored items are packaged and processed for offsite shipment. The lack of sufficient storage and adequate aisle space requires just-in-time procurement of containers and supplies which leads to inefficiencies in removal of wastes from R&D labs. NREL has encountered significant growth throughout the last 8 years with a corresponding increase in research staff and laboratory space generating a variety of hazardous waste streams. To optimize packaging, transportation, and cost-effective disposal, working floorspace which can accommodate physical segregation of cubic yard containers and drums up to 55-gallons in size is necessary to support expanding laboratory R&D operations. The project will utilize a design-build delivery method through the CCCA partner. Award is expected around 3Q of FY 2023. Useful segments: Design FY 2023 $1,000; Construction FY 2024 – FY 2025 $11,349.

Prior Year Accomplishments:	• Preliminary project planning completed in FY 2022 • Finalized technical requirements for a design-build project in FY 2023
Planned Activities:	• Design (Preparing and finalizing drawings, specifications, and other documents describing the work to allow construction of the project) • Construction (Construction of the project up to final payment as defined in the construction subcontract; construction oversight by NREL) • Project Management, Laboratory Services, and Government Furnished Equipment (Project management; independent testing/inspection, commissioning, and other third-party services; technical oversight during design and construction; IT and other laboratory provided services; procurement and installation of Government Furnished Equipment)
Significant Changes from original plan:	Budget increased from $9,350 to $13,350. $1.0 million of the increase is decarbonization efforts for hydrogen fuel cell for backup power and the remainder is due to supply chain delays, and material cost inflation.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	Distributed Energy Grid East STM Campus Integrating CFE Resources
Project Location/Site:	NREL STM Campus
Type:	Minor Construction (Direct-funded)
Total Estimated Cost:	$19,500
Construction Design:	$3,000
Project Start:	FY 2024
Design Complete:	FY 2024
Construction Complete:	FY 2026
Project Description:	As NREL expands its facilities at the STM Campuses, it should take advantage of the opportunity to develop distributed renewable energy districts, leveraging NREL's own research expertise on the subject. Alternative thermal energy sources such as ground-source heat pumps, air- source heat pumps, geothermal energy, other electric HVAC technologies, energy storage, and hydrogen fuel cells that reduce emissions will be evaluated for their potential to support buildings that serve simultaneously as research projects and operational assets. This is a shift in the operational behavior and performance from being only consumptive to a Grid-interactive Efficient Building (GEB) with dynamic capability modes of demand management and islanding. Implementing an autonomous (islanded) distributed energy district on an NREL campus is a long-term goal that requires a phased approach to manage risks associated with disconnecting from the electrical grid. At the STM Campus, which is capacity and export constrained, a distributed energy district would investigate behind-the-meter design and control strategies to minimize utility energy costs and maximize flexibility within interconnection constraints. Estimate includes assessment of technologies, project costs and capital installation and infrastructure costs. Technology solutions and processes achieved will additionally benefit DOE program offices for replicable applications. This technology demonstration serves as proof of concept for 5th generation district energy systems and fortifies NREL's role as a living laboratory. This project will be significant for DOE to extend interoperable strategies illustrating deployable operational integration processes and future performance outcomes that can shape industry technologies.
Prior Year Accomplishments:	Initial analysis has been conducted for the STM Campus. NREL researchers are currently finalizing the scope of an assessment for the eastern expansion of the STM Campus to determine the most efficient options for a distributed energy district given NREL's programmatic and infrastructure needs. Modeling will utilize NREL platforms such as Urban Opt and Modelica. NREL will additionally engage industry partners for commercial ready technologies. The aggregation, instrumentation, interoperability, and implementation of an ambient loop for dynamic demand management and resilience is the novelty to demonstrate.
Planned Activities:	• Project scope definition • PMP preparation and approval • Project management • Design • Equipment procurement • Equipment Installation and Commissioning

	• Construction • Equipment Installation and Commissioning • Case study for technology interoperability
Significant Changes from original plan:	N/A

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	SERF/S&TF Ventilation
Project Location/Site:	NREL STM Campus
Type:	Minor Construction (Direct funded)
Total Estimated Cost:	$14,700
Construction Design:	$600
Project Start	FY 2020
Design Complete	FY 2021
Construction Complete	FY 2025
Project Description:	Multi-phased project to upgrade and improve aging and degraded exhaust ventilation infrastructure and fume hoods; phased in a manner that minimizes impact to the ongoing facility work. Work includes: • Adding dedicated exhaust and corrosive etching stations to both the SERF and STF, splitting the SERF center wing exhaust ventilation system and adding additional exhaust capacity to provide redundancy and increased capacity. • Replacing aging fume hoods in SERF center wing, both floors • Replacing aging fume hoods in SERF West wing, both floors
Prior Year Accomplishments:	•
Planned Activities:	• Construction (Construction of the project up to final payment as defined in the construction subcontract; construction oversight by NREL) • Project Management, Laboratory Services, and Government Furnished Equipment (Project management; independent testing/inspection, commissioning, and other third-party services; technical oversight during design and construction; IT and other laboratory provided services; procurement and installation of Government Furnished Equipment)
Significant Changes from original plan:	Budget increased from $9,300 to $14,700 due to delays in project execution of construction phase and construction cost escalation

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	FC Control Center
Project Location/Site:	NREL Flatirons Campus
Type:	Minor Construction (Direct funded)
Total Estimated Cost:	$15,500
Construction Design:	$800
Project Start	FY 2020
Design Complete	FY 2022
Construction Complete	FY 2025
Project Description:	A control center at the Flatirons Campus serves a dual function for enabling remote data collection and analysis involving diverse research portfolios while also conducting grid integration research. The center would accommodate space to allow for multiple parallel project field campaigns; a visualization room capable of providing state of the art, high-resolution visual imagery that will illustrate research findings to stakeholders; a conference room and offices. This control center will serve as the hub for all grid/energy research at the site and coordinate multiple level energy integration and cybersecurity experiments with both local and remote facilities. The visualization room will be connected to the Energy Systems Integration Facility and other National Laboratories through a high-speed data connection. Useful segments: Design FY 2020 - 2022: $800 Construction FY 2023 – 2025: $14,700
Prior Year Accomplishments:	• The Integrated Project Team (IPT) for NREL has been formed. • The PMP has been reviewed and approved by the IPT. • The design phase is complete. • The Environmental Assessment for the project is complete.
Planned Activities:	• Construction (Construction of the project up to final payment as defined in the construction subcontract; construction oversight by NREL) • Project Management, Laboratory Services, and Government Furnished Equipment (Project management; independent testing/inspection, commissioning, and other third-party services; technical oversight during design and construction; IT and other laboratory provided services; procurement and installation of Government Furnished Equipment)
Significant Changes from original plan:	Construction is delayed due to incoming bids being significantly higher than budget.

Minor Construction Projects ($K)

Facilities & Infrastructure Operations & Maintenance	
Project Name:	STM Substation
Project Location/Site:	NREL South Table Mountain Campus
Type:	General Plant Projects (Direct funded)
Total Estimated Cost:	$24,900
Construction Design:	$5,000
Project Start	FY 2024
Design Complete	FY 2025
Construction Complete	FY 2026

Project Description:	The STM Substation is planned to be built on the Northeast corner of the STM campus. Interconnection is planned to the existing STM medium voltage loops and feeders with the existing Xcel Energy distribution feed disconnected once the substation is online and operational. Substation initial size to be capable of 30MW to meet the planned needs of the STM Campus. Useful Segments:
	• Design and Xcel Coordination FY 2024 - 2025 $7M
	  ○ Substation Design $5M
	  ○ Xcel Interconnection $2M
	• Construction and Equipment FY 2025 – 2026 $17.9M

Prior Year Accomplishments:	• N/A
Planned Activities:	• RFP • Award of Contract • Design (Preparing and finalizing drawings, specifications, and other documents describing the work to allow construction of the project) • Construction (Construction of the project up to final payment as defined in the construction subcontract; construction oversight by NREL) Project Management, and Government Furnished Equipment (Project management; independent testing/inspection, commissioning, and other third-party services; technical oversight during design and construction; IT and other laboratory provided services; procurement and installation of Government Furnished Equipment to include long lead items.)
Significant Changes from original plan:	N/A

21-EE-001, Energy Materials and Processing at Scale, TEC
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary: The FY 2024 Budget Request proposes to fund $57,000,000 (of the Total Estimated Cost (TEC)) toward the second segment of the final design and construction phase after the Critical Decision 2/3 Project Baseline using a task order acquisition strategy for a firm fixed price Design/Build project approach under a DOE approved Cooperative Construction Contracting Authority pilot contract for the Energy Materials and Processing at Scale project. The FY2023 funding of $45,000,000 was the first segment to complete the final design, initial sitework, and foundation. This second segment would fund the building core, shell, and associated infrastructure. The current, preliminary Total Estimated Cost (TEC) range is $130,000,000 to $160,000,000 and the preliminary Total Project Cost (TPC) range is $135,000,000 to $165,000,000 per preliminary conceptual Architect/Engineering support estimates. The TEC and TPC estimates are consistent with the DOE Cost Estimating Guide 413.3-21A. The DOE 413.3B Critical Decision 0 (CD-0) approval was obtained on 12/9/19. The preliminary estimate for CD-1, Approve Alternative Selection and Cost Range, is anticipated in the fourth quarter of FY 2023. This project is expected to have approval of CD-1 in 4Q 2023 therefore, schedule estimates are preliminary and subject to change. The FPD for this project is PMCDP certified level 2 working toward level 3 of the Golden Field Office. The Approval of CD-0 in December 2019 target Project Completion range was 2024 to 2026. The currently approved CD-4 date estimate of 2Q 2026 is still on track to the CD-0 Approval letter from Undersecretary of Energy expected CD-4 Project Completion range.

Significant Changes:
The estimated dates for Concept Design completion and CD-1 have slipped a quarter due to the efforts required to integrate the Cooperative Construction Contracting Approach (CCCA) task order agreement procurement strategy with the EMAPS project. There were no cost impacts incurred, only review time for the contracting officer board review approving contract language for the release of the request for proposal.

Critical Milestone History

Fiscal Quarter or Date

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	D&D Complete	CD-4
FY 2021	12/16/2019	2Q FY2022	3Q FY2022	3Q FY2023	4Q FY2023	3Q FY2023	NA	2QFY2025
FY 2022	12/16/2019	4Q FY2022	1Q FY2023	4Q FY2023	1Q FY2024	4Q FY2023	NA	3Q FY2025
FY 2023	12/16/2019	2Q FY2023	3Q FY2023	3Q FY2024	4Q FY2024	3Q FY2024	NA	1Q FY2026
FY 2024	12/16/2019	2Q FY2023	4Q FY2023	3Q FY2024	1Q FY2025	3Q FY2024	NA	2Q FY2026

Note: preconceptual timeline to provide a rough order of magnitude for milestones

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range
Conceptual Design Complete – Actual date the conceptual design was completed (if applicable)
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
Final Design Complete – Estimated/Actual date the project design will be/was complete (d)
CD-3 – Approve Start of Construction
D&D Complete – Completion of D&D work
CD-4 – Approve Start of Operations or Project Closeout

Project Cost History

(Dollars in Thousands)							
Fiscal Year	**TEC, Design**	**TEC, Construction**	**TEC, Total**	**OPC, Except D&D**	**OPC, D&D**	**OPC, Total**	**TPC**
FY 2021	12,000	148,000	160,000	5,000	0	5,000	165,000
FY 2022	12,000	147,000	159,000	6,000	0	6,000	165,000
FY 2023	12,000	148,000	160,000	5,000	0	5,000	165,000
FY 2024	12,000	148,000	160,000	5,000	0	5,000	165,000

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 square feet.

2. Project Scope and Justification

Scope

As advanced energy generation technologies including photovoltaics, wind, and batteries approach terawatt scale, end-of-life and supply chain management becomes increasingly important. The challenge requires much more than end-of-life recycling for complex components, devices, and systems deployed at large scales. Design is required for maximum economic useful life, reuse, refurbishment, repair, remanufacturing, and then recycling, all of which require multi-disciplinary research and scalable research facilities. These technologies may also utilize new recyclable polymers and composites as their scalability and durability are established. To advance this critical need to address end-of-life considerations for energy-related technologies, a multi-disciplinary research capability in process integration that draws on bench scale innovations from multiple institutions and transforms them into integrated and scalable "hybrid technology processes" is needed to ready Department of Energy innovations for commercial development. The Financial Schedule provides an initial rough order of magnitude, assuming the high end of the rough order magnitude cost estimate with a 110,000-125,000 square foot research facility.

Justification

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets. The TEC and TPC estimates used in this document are the high end of the Rough Order of Magnitude (ROM) cost range developed. The estimate was based on a new facility which conservatively bounds the potential alternatives. An Analysis of Alternatives (AoA) to include a justification of the alternative to be selected was be conducted prior to CD-1 approval and endorsed by the Acting Assistant Secretary of Office of Energy Efficiency and Renewable Energy to proceed with conceptual planning.

With decarbonization efforts, as well as many energy technologies, it is becoming clear that the United States needs to increase efficiencies for energy-relevant and energy-intensive materials and processes incorporating other more traditional attributes such as high performance, affordability and reliability into new energy technologies at the start rather than dealing with future legacies. There are now major opportunities at the interfaces of biology, chemistry and materials science and engineering to develop hybrid processes to couple abiotic (e.g., chemical, catalytic, electrochemical) and biological (e.g., enzymatic or organism-based) processes for chemical synthesis, polymer deconstruction and carbon dioxide reduction to useful products and materials.

Addressing the full lifecycle of our materials, products, and energy economy is important for the U.S. to maintain global economic competitiveness. This project allows DOE to lead innovation at the interfaces of biology, physics, chemistry and materials science and engineering to develop hybrid processes to couple abiotic and biological processes for synthesis, polymer deconstruction, and carbon dioxide reduction to useful products and materials.

Key Performance Parameters (KPPs)

The Key Performance Parameters (KPPs) are preliminary and derived from a pre-CD-1 draft Analysis of Alternatives (AoA) report. KPPs may change as the project continues through CD-1. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve, are high-level screening criteria that must be met to satisfy the mission need and determine viability or non-viability. The Objective KPPs represent the desired project performance. Threshold and Objective KPP descriptions are currently the same (to be later refined). Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
1 – Electrons to Molecules	Laboratory facilities to allow research disciplines to achieve capability to produce multi-disciplinary capabilities that integrate electricity-driven processes with both biotic and abiotic processes that enable net zero fuels and deep CFE of transportation and industrial sectors. Key elements include novel electrochemistry, H2 production, CO2 conversion, rapid membrane electrode assembly, multi-scale hybrid processing (e.g., electrochemical/bio) from g to kg scale.	Multi-disciplinary capabilities that integrate electricity-driven processes with both biotic and abiotic processes that enable net zero fuels and deep CFE of transportation and industrial sectors. Key elements include novel electrochemistry, H2 production, CO2 conversion, rapid membrane electrode assembly, multi-scale hybrid processing (e.g., electrochemical/bio) from g to kg scale.
2 – Green Process Integration	Laboratory facilities to allow research disciplines to achieve capability to produce multi-disciplinary research capabilities for process innovation and integration to create scalable processes including hybrid concepts that accelerate sustainable manufacturing. Key elements included: synthesis and scalable processing of complex and hybrid (e.g., organic/inorganic perovskites) materials, components, and multifunctional structures for photovoltaics, electrochemical systems (membrane electrode assemblies, battery electrodes, separation membranes, catalysts), photonics, and buildings.	Multi-disciplinary research capabilities for process innovation and integration to create scalable processes including hybrid concepts that accelerate sustainable manufacturing. Key elements included: synthesis and scalable processing of complex and hybrid (e.g., organic/inorganic perovskites) materials, components, and multifunctional structures for photovoltaics, electrochemical systems (membrane electrode assemblies, battery electrodes, separation membranes, catalysts), photonics, and buildings.
3 – Advanced Electrification	Laboratory facilities to allow research disciplines to achieve capability to produce next-generation batteries and power electronics that leapfrog state-of-the-art to achieve low- cost, safety, long-life goals while being inherently scalable, manufacturable, and free of critical materials to enable integration of electrified mobility (e.g., fast EV charging), buildings, grid,	Next-generation batteries and power electronics that leapfrog state-of-the-art to achieve low- cost, safety, long-life goals while being inherently scalable, manufacturable, and free of critical materials to enable integration of electrified mobility (e.g., fast EV charging), buildings, grid, and renewable energy generation. Key elements include advanced materials and devices, thermal

	and renewable energy generation. Key elements include advanced materials and devices, thermal management, beyond Li-ion battery chemistries, prototype development, characterization, and manufacturing	management, beyond Li-ion battery chemistries, prototype development, characterization, and manufacturing.
4 – Advanced Bio and Chemical Processing	Laboratory facilities to allow research disciplines to achieve capability to develop robust scalable bio and chemical processes that are scalable and demonstrate use of novel systems that apply advanced bioprocessing technologies to produce biofuels, bio-based chemicals, and value added bioproducts from renewable sources. This includes cost effective bio-based chemicals and polymer composites.	Develop robust scalable bio and chemical processes that are scalable and demonstrate use of novel systems that apply advanced bioprocessing technologies to produce biofuels, bio-based chemicals, and value added bioproducts from renewable sources. This includes cost effective bio-based chemicals and polymer composites.
5 – Pilot-Scale Process Integration and Scale-up	High Bay Laboratory facilities to allow research disciplines to achieve Integrated, modular, pilot-scale capabilities that provide interchangeable configurations for g-kg per day production equipment for intermediate chemicals, polymers, and composites as well as energy device fabrication and electricity-driven process scale-up capabilities.	Integrated, modular, pilot-scale capabilities that provide interchangeable configurations for g-kg per day production equipment for intermediate chemicals, polymers, and composites as well as energy device fabrication and electricity-driven process scale-up capabilities.

3. Financial Schedule

(Dollars in Thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2021	4,000	0	0
FY 2022	8,000	0	0
FY 2023	0	12,000	8,000
FY 2024	0	0	4,000
FY 2025	0	0	0
Total Design	12,000	12,000	12,000
Construction			
FY 2021	0	0	0
FY 2022	0	0	0
FY 2023	45,000	0	0
FY 2024	57,000	0	92,070
FY 2025	46,000	117,700	55,930
FY2026	0	30,300	
Total Construction	148,000	148,000	148,000
Total Estimated Costs (TEC)			
FY 2021	4,000	0	0
FY 2022	8,000	0	4,730
FY 2023	45,000	57,000	33,640
FY 2024	57,000	57,000	82,330
FY 2025	46,000	31,000	39,300
Total TEC	**160,000**	**160,000**	**160,000**
Other Project Costs (OPC)			
FY 2021	2,000	1,500	750
FY 2022	0	500	750
FY 2023	0	0	500
FY 2024	0	0	0
FY 2025	3,000	3,000	3,000
Total OPC	**5,000**	**5,000**	**5,000**
Total Project Costs (TPC)			
FY 2021	6,000	1,500	750
FY 2022	0	500	750
FY 2023	45,000	8,000	8,500
FY 2024	57,000	121,700	96,070
FY 2025	49,000	33,300	58,930
Grand Total	**165,000**	**165,000**	**165,000**

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 square feet.

4. Details of Project Cost Estimate

(Budget Authority in Thousands of Dollars)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	10,000	10,000	N/A
Contingency	2,000	2,000	N/A
Total, Design	12,000	12,000	N/A
Construction			
Site Work	1,250	1,250	N/A
Equipment	15,300	15,300	N/A
Construction	97,450	97,450	N/A
Other, as needed	4,700	4,700	N/A
Contingency	29,300	29,300	N/A
Total, Construction	148,000	148,000	N/A
Other TEC (if any)			
Cold Startup	0	0	N/A
Contingency	0	0	N/A
Total, Other TEC	0	0	N/A
Total Estimated Cost	**160,000**	**160,000**	N/A
Contingency, TEC	*31,300*	*31,300*	N/A
Other Project Cost (OPC)			
OPC except D&D			
R&D	0	0	N/A
Conceptual Planning	1,000	1,000	N/A
Conceptual Design	2,000	2,000	N/A
Other OPC Costs	2,000	2,000	N/A
Contingency	0	0	N/A
Total, OPC	**5,000**	**5,000**	N/A
Contingency, OPC	*0*	*0*	N/A
Total Project Cost	**165,000**	**165,000**	N/A
Total Contingency (TEC+OPC)	**31,300**	**31,300**	N/A

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 square feet.

5. Schedule of Appropriations Requests

(Dollars in Thousands)

Request Year	Type	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	Total
FY 2022	TEC	4,000	8,000	0	151,000	0	159,000
	OPC	2,000	0	0	4,000	0	6,000
	TPC	6,000	8,000	0	151,000	0	165,000
FY 2023	TEC	4,000	8,000	45,000	57,000	46,000	160,000
	OPC	2,000	0	0	0	3,000	5,000
	TPC	6,000	8,000	45,000	57,000	49,000	165,000
FY 2024	TEC	4,000	8,000	45,000	57,000	46,000	160,000
	OPC	2,000	0	0	0	3,000	5,000
	TPC	6,000	8,000	45,000	57,000	49,000	165,000

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 square feet. FY 2022 was the first-year funding is requested. In FY 2021, Congress appropriated $6,000 for OPC of which only $2,000 is needed for preliminary engineering design. The remaining $4,000 of OPC funds will be used for the testing/acceptance and commissioning of the facility after construction is completed.

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	1QFY2026
Expected Useful Life (number of years)	50
Expected Future Start of D&D of this capital asset (fiscal quarter)	1QFY2076

Related Funding Requirements

(Budget Authority in Millions of Dollars)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations and Maintenance	5.4	5.4	270	270

Note: preconceptual amounts to provide an initial rough order of magnitude, assuming a research facility at the high end of 110,000 to 125,000 square feet.

7. D&D Information

If the preferred alternative is a new Federal facility, then this new facility will not replace existing facilities. The applicability of the "one-for-one" offset requirement will be assessed after CD-1 once conceptual design has a square footage footprint.

8. Acquisition Approach

An Acquisition Approach/Plan will be developed post CD-1 approval in accordance with DOE O 413.3B.

Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by this budget and displayed below are intended to halt asset condition degradation and increase the NREL facilities and infrastructure resilience to climate risks. This excludes maintenance of excess facilities (including high-risk excess facilities) necessary to minimize the risk posed by those facilities prior to disposition.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2022 Actual Cost	FY 2022 Planned Cost	FY 2023 Planned Cost	FY 2024 Planned Cost
National Renewable Energy Laboratory	19,662	18,550	22,129	23,014
Total, Direct-Funded Maintenance and Repair	**19,662**	**18,550**	**22,129**	**23,014**

Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2022 Actual Cost	FY 2023 Planned Cost	FY 2024 Planned Cost
National Renewable Energy Laboratory	0	0	0
Total, Indirect-Funded Maintenance and Repair	**0**	**0**	**0**

Report on FY 2022 Expenditures for Maintenance and Repair

This report responds to explanatory language set forth in Conference Report (H.R. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2022 to the amount planned for FY 2022.

Energy Efficiency and Renewable Energy
Total Costs for Maintenance and Repair ($K)

	FY 2022 Actual Cost	FY 2022 Planned Cost
National Renewable Energy Laboratory	19,662	18,550
Total, Maintenance and Repair	**19,662**	**18,550**

Energy Efficiency and Renewable Energy
Safeguards and Security ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted, $	FY 2024 Request vs FY 2023 Enacted, %
Protective Forces	3,470	3,600	3,890	+290	+8.1%
Physical Security Systems	875	925	1,000	+75	+8.1%
Information Security	550	575	620	+45	+7.8%
Cybersecurity	9,200	10,500	11,200	+700	+6.7%
Personnel Security	230	240	260	+20	+8.3%
Material Control and Accountability	0	0	0	0	
Program Management	690	720	780	+60	+8.3%
Security Investigations	185	190	200	+10	+5.3%
Transportation Security	0	0	0	0	
Construction	0	0	0	0	
Total, Safeguards and Security	**15,200**	**16,750**	**17,950**	**+1,200**	**+7.2%**

Energy Efficiency and Renewable Energy
Research and Development ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Basic	0	0	0	0
Applied	676,784	836,967	1,275,590	+438,623
Development	1,378,725	607,327	817,959	+210,632
Subtotal, R&D	**2,055,509**	**1,444,291**	**2,093,549**	**+649,255**
Equipment	20,262	38,775	66,526	+27,751
Construction	73,421	1,688	57,000	+55,312
Total, R&D	**2,149,192**	**1,484,754**	**2,217,075**	**+732,218**

Energy Efficiency and Renewable Energy Research and Development
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Vehicles Technologies				
SBIR	11,734	12,809	14,942	+2,133
STTR	1,650	1,801	2,101	+ 300
Bioenergy Technologies				
SBIR	8,131	8,643	10,042	+1,399
STTR	1,143	1,215	1,412	+197
Hydrogen and Fuel Cell Technologies				
SBIR	4,776	5,024	4,817	-207
STTR	672	707	677	-30
Solar Energy				
SBIR	7,387	8,092	10,349	+2,257
STTR	1,039	1,138	1,455	+317
Wind Energy				
SBIR	2,837	3,704	9,001	+5,297
STTR	399	521	1,266	745
Water Power				
SBIR	4,627	5,147	6,781	+1,634
STTR	651	724	954	+ 230
Geothermal Technologies				
SBIR	3,146	3,146	5,231	+2,085
STTR	442	442	736	+294
Industrial Efficiency & Decarbonization				
SBIR	0	0	11,224	NA
STTR	0	0	1,578	NA
Advanced Materials & Manufacturing Technologies				
SBIR	0	0	6,717	NA
STTR	0	0	945	NA
Advanced Manufacturing				
SBIR	11,238	10,651	0	-10.651
STTR	1,580	1,498	0	-1,498
Building Technologies				
SBIR	5,830	5,191	5416	+225
STTR	820	730	762	+32
Total, SBIR	59,706	62,407	84,520	+22,113
Total, STTR	8,396	8,776	11,886	+3,110

DEPARTMENT OF ENERGY

Funding by Site

TAS_0321 - Energy Efficiency and Renewable Energy - FY 2024

(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Ames Laboratory			
Vehicle Technologies	1,100	1,600	1,100
Hydrogen and Fuel Cells Technologies	42	200	100
Sustainable Transportation	1,142	1,800	1,200
Industrial Efficiency & Decarbonization Office	11,400	0	0
Advanced Materials & Manufacturing Technologies Office	11,400	28,730	46,500
Buildings & Industry (formerly Energy Efficiency)	22,800	28,730	46,500
Total Ames Laboratory	**23,942**	**30,530**	**47,700**
Argonne National Laboratory			
Vehicle Technologies	66,030	64,000	70,000
Bioenergy Technologies	12,000	11,000	10,000
Hydrogen and Fuel Cells Technologies	6,713	7,300	9,000
Sustainable Transportation	84,743	82,300	89,000
Renewable Energy Grid Integration	1,650	2,000	4,000
Solar Energy Technologies	900	1,000	1,000
Wind Energy Technologies	2,536	1,622	7,402
Water Power Technologies	2,446	1,529	200
Geothermal Technologies	0	30	0
Renewable Power	7,532	6,181	12,602
Advanced Materials & Manufacturing Technologies Office	3,652	15,000	10,000
Building Technologies	2,211	1,300	2,465
Buildings & Industry (formerly Energy Efficiency)	5,863	16,300	12,465
Strategic Programs	800	713	1,599
Corporate Support	800	713	1,599
Total Argonne National Laboratory	**98,937**	**105,494**	**115,666**
Brookhaven National Laboratory			
Vehicle Technologies	4,825	3,175	5,500
Bioenergy Technologies	500	0	0
Hydrogen and Fuel Cells Technologies	200	200	400
Sustainable Transportation	5,525	3,375	5,900
Geothermal Technologies	150	230	0
Renewable Power	150	230	0
Building Technologies	0	57	0
Buildings & Industry (formerly Energy Efficiency)	0	57	0
Total Brookhaven National Laboratory	**5,675**	**3,662**	**5,900**
Golden Field Office			
Vehicle Technologies	5,000	0	25,000
Bioenergy Technologies	99,200	155,350	202,850
Hydrogen and Fuel Cells Technologies	83,350	85,700	83,400
Sustainable Transportation	187,550	241,050	311,250
Renewable Energy Grid Integration	5,350	0	0
Solar Energy Technologies	164,000	178,500	221,908
Wind Energy Technologies	15,435	32,822	157,045
Water Power Technologies	48,087	66,022	87,630
Geothermal Technologies	89,135	66,464	147,000
Renewable Power	322,007	343,808	613,583
Industrial Efficiency & Decarbonization Office	119,154	184,900	301,745
Advanced Materials & Manufacturing Technologies Office	123,147	92,313	145,997
Federal Energy Management Program (EERE)	40,000	43,000	0
Building Technologies	30,668	50,000	85,000
Training and Technical Assistance (EERE)	2,400	3,800	0
Weatherization Readiness	15,000	30,000	0
State Energy Program Grants (EERE)	800	3,800	0

DEPARTMENT OF ENERGY
Funding by Site
TAS_0321 - Energy Efficiency and Renewable Energy - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Local Government Energy Program	10,000	12,000	0
Energy Future Grants (EERE)	20,000	27,000	0
Weatherization and Intergovernmental Programs	48,200	76,600	0
Buildings & Industry (formerly Energy Efficiency)	361,169	446,813	532,742
Establish DOE 18th National Laboratory	0	0	35,000
Facilities and Infrastructure	0	0	35,000
Program Direction - Energy Efficiency and Renewable Energy	27,806	30,471	35,566
Corporate Support	27,806	30,471	70,566
Congressional Directed Spending - EERE	77,047	0	0
Facility and Workforce Assistance (MESC)	13,590	15,000	0
Total Golden Field Office	**989,169**	**1,077,142**	**1,528,141**
Idaho National Laboratory			
Vehicle Technologies	14,598	10,500	16,000
Bioenergy Technologies	17,200	12,500	12,500
Hydrogen and Fuel Cells Technologies	6,065	8,100	8,900
Sustainable Transportation	37,863	31,100	37,400
Renewable Energy Grid Integration	70	100	1,000
Solar Energy Technologies	900	1,000	1,500
Wind Energy Technologies	1,680	1,140	4,898
Water Power Technologies	4,855	4,593	4,400
Geothermal Technologies	461	30	0
Renewable Power	7,966	6,863	11,798
Advanced Materials & Manufacturing Technologies Office	425	0	0
Building Technologies	815	35	0
Buildings & Industry (formerly Energy Efficiency)	1,240	35	0
Total Idaho National Laboratory	**47,069**	**37,998**	**49,198**
Lawrence Berkeley National Laboratory			
Vehicle Technologies	21,665	18,200	24,000
Bioenergy Technologies	10,700	6,500	6,500
Hydrogen and Fuel Cells Technologies	5,798	4,800	4,900
Sustainable Transportation	38,163	29,500	35,400
Renewable Energy Grid Integration	3,520	4,000	6,000
Solar Energy Technologies	2,300	2,500	3,000
Wind Energy Technologies	3,913	3,010	4,837
Geothermal Technologies	2,077	1,930	0
Renewable Power	11,810	11,440	13,837
Industrial Efficiency & Decarbonization Office	7,300	9,900	9,000
Advanced Materials & Manufacturing Technologies Office	1,625	0	0
Building Technologies	47,810	38,800	42,000
Training and Technical Assistance (EERE)	200	300	0
State Energy Program Grants (EERE)	800	800	0
Weatherization and Intergovernmental Programs	1,000	1,100	0
Buildings & Industry (formerly Energy Efficiency)	57,735	49,800	51,000
Strategic Programs	1,300	1,890	2,475
Corporate Support	1,300	1,890	2,475
Facility and Workforce Assistance (MESC)	900	1,000	0
Total Lawrence Berkeley National Laboratory	**109,907**	**93,630**	**102,712**
Lawrence Livermore National Laboratory			
Vehicle Technologies	3,277	2,600	3,400
Bioenergy Technologies	1,800	725	725
Hydrogen and Fuel Cells Technologies	1,055	2,000	2,000
Sustainable Transportation	6,132	5,325	6,125
Solar Energy Technologies	900	1,000	1,500
Wind Energy Technologies	1,841	1,619	3,321

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Geothermal Technologies	33	30	0
Renewable Power	2,774	2,649	4,821
Industrial Efficiency & Decarbonization Office	5,375	5,000	5,000
Advanced Materials & Manufacturing Technologies Office	5,375	0	0
Buildings & Industry (formerly Energy Efficiency)	10,750	5,000	5,000
Total Lawrence Livermore National Laboratory	**19,655**	**12,974**	**15,946**
Los Alamos National Laboratory			
Bioenergy Technologies	7,300	3,000	3,000
Hydrogen and Fuel Cells Technologies	4,447	5,000	4,700
Sustainable Transportation	11,747	8,000	7,700
Renewable Energy Grid Integration	50	50	100
Wind Energy Technologies	464	117	1,166
Geothermal Technologies	12	30	0
Renewable Power	526	197	1,266
Industrial Efficiency & Decarbonization Office	475	0	0
Advanced Materials & Manufacturing Technologies Office	475	0	0
Buildings & Industry (formerly Energy Efficiency)	950	0	0
Total Los Alamos National Laboratory	**13,223**	**8,197**	**8,966**
National Energy Technology Lab			
Vehicle Technologies	140,142	213,300	208,242
Bioenergy Technologies	800	550	550
Hydrogen and Fuel Cells Technologies	7,511	16,100	16,500
Sustainable Transportation	148,453	229,950	225,292
Renewable Energy Grid Integration	835	1,450	1,450
Geothermal Technologies	0	20,928	40,000
Renewable Power	835	22,378	41,450
Building Technologies	2,378	0	0
Buildings & Industry (formerly Energy Efficiency)	2,378	0	0
Program Direction - Energy Efficiency and Renewable Energy	17,546	19,917	25,497
Strategic Programs	1,500	0	0
Corporate Support	19,046	19,917	25,497
Total National Energy Technology Lab	**170,712**	**272,245**	**292,239**
National Renewable Energy Laboratory			
Vehicle Technologies	50,527	38,000	52,000
Bioenergy Technologies	61,500	46,000	40,000
Hydrogen and Fuel Cells Technologies	23,279	21,500	14,400
Sustainable Transportation	135,306	105,500	106,400
Renewable Energy Grid Integration	24,387	30,000	35,000
Solar Energy Technologies	90,000	100,000	110,000
Wind Energy Technologies	56,855	45,688	115,470
Water Power Technologies	21,346	27,509	17,019
Geothermal Technologies	9,712	7,983	24,000
Renewable Power	202,300	211,180	301,489
Industrial Efficiency & Decarbonization Office	8,676	5,000	9,000
Advanced Materials & Manufacturing Technologies Office	7,470	900	0
Building Technologies	68,227	56,661	55,000
Training and Technical Assistance (EERE)	1,000	1,700	0
State Energy Program Grants (EERE)	800	800	0
Weatherization and Intergovernmental Programs	1,800	2,500	0
Buildings & Industry (formerly Energy Efficiency)	86,173	65,061	64,000
Facilities and Infrastructure - NREL	148,000	205,000	277,391
Facilities and Infrastructure	148,000	205,000	277,391
Strategic Programs	5,500	9,550	21,543
Corporate Support	153,500	214,550	298,934

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Energy Sector Industrial Base (MESC)	0	2,000	0
Total National Renewable Energy Laboratory	**577,280**	**598,291**	**770,823**
Oak Ridge Institute for Science & Education			
Vehicle Technologies	1,126	850	1,200
Bioenergy Technologies	1,100	500	500
Hydrogen and Fuel Cells Technologies	1,285	1,000	1,150
Sustainable Transportation	3,511	2,350	2,850
Solar Energy Technologies	900	1,000	1,000
Wind Energy Technologies	786	0	0
Geothermal Technologies	380	0	0
Renewable Power	2,066	1,000	1,000
Industrial Efficiency & Decarbonization Office	1,962	3,000	3,500
Advanced Materials & Manufacturing Technologies Office	5,052	2,900	2,000
Building Technologies	4,978	7,500	7,500
Training and Technical Assistance (EERE)	400	500	0
State Energy Program Grants (EERE)	1,000	1,000	0
Weatherization and Intergovernmental Programs	1,400	1,500	0
Buildings & Industry (formerly Energy Efficiency)	13,392	14,900	13,000
Strategic Programs	0	160	1,207
Corporate Support	0	160	1,207
Total Oak Ridge Institute for Science & Education	**18,969**	**18,410**	**18,057**
Oak Ridge National Laboratory			
Vehicle Technologies	47,464	35,500	50,000
Bioenergy Technologies	13,000	10,500	10,000
Hydrogen and Fuel Cells Technologies	3,781	3,600	3,725
Sustainable Transportation	64,245	49,600	63,725
Renewable Energy Grid Integration	800	2,000	4,000
Solar Energy Technologies	900	1,000	1,000
Wind Energy Technologies	2,991	1,724	6,239
Water Power Technologies	9,018	10,959	5,715
Geothermal Technologies	2,270	2,204	0
Renewable Power	15,979	17,887	16,954
Industrial Efficiency & Decarbonization Office	11,125	18,150	20,000
Advanced Materials & Manufacturing Technologies Office	31,373	0	0
Building Technologies	30,359	33,083	35,000
Training and Technical Assistance (EERE)	1,000	1,800	0
State Energy Program Grants (EERE)	100	100	0
Weatherization and Intergovernmental Programs	1,100	1,900	0
Buildings & Industry (formerly Energy Efficiency)	73,957	53,133	55,000
Total Oak Ridge National Laboratory	**154,181**	**120,620**	**135,679**
Pacific Northwest National Laboratory			
Vehicle Technologies	33,432	31,000	34,000
Bioenergy Technologies	21,500	12,000	12,000
Hydrogen and Fuel Cells Technologies	6,350	6,500	6,000
Sustainable Transportation	61,282	49,500	52,000
Renewable Energy Grid Integration	3,083	5,000	6,000
Wind Energy Technologies	7,218	7,517	19,499
Water Power Technologies	21,732	20,610	9,388
Geothermal Technologies	1,620	330	0
Renewable Power	33,653	33,457	34,887
Industrial Efficiency & Decarbonization Office	300	1,000	0
Advanced Materials & Manufacturing Technologies Office	30	0	0
Building Technologies	46,432	39,724	40,000
State Energy Program Grants (EERE)	400	400	0

DEPARTMENT OF ENERGY
Funding by Site
TAS_0321 - Energy Efficiency and Renewable Energy - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Weatherization and Intergovernmental Programs	400	400	0
Buildings & Industry (formerly Energy Efficiency)	47,162	41,124	40,000
Strategic Programs	350	770	1,673
Corporate Support	350	770	1,673
Facility and Workforce Assistance (MESC)	600	0	0
Total Pacific Northwest National Laboratory	**143,047**	**124,851**	**128,560**
Sandia National Laboratories			
Vehicle Technologies	8,745	6,700	9,000
Bioenergy Technologies	7,500	4,000	4,000
Hydrogen and Fuel Cells Technologies	7,624	7,300	7,300
Sustainable Transportation	23,869	18,000	20,300
Renewable Energy Grid Integration	0	400	1,516
Solar Energy Technologies	6,600	7,000	8,000
Wind Energy Technologies	11,662	12,264	32,239
Water Power Technologies	8,340	9,618	7,101
Geothermal Technologies	750	1,158	0
Renewable Power	27,352	30,440	48,856
Industrial Efficiency & Decarbonization Office	1,200	0	0
Advanced Materials & Manufacturing Technologies Office	1,200	25,000	25,000
Building Technologies	293	150	150
Buildings & Industry (formerly Energy Efficiency)	2,693	25,150	25,150
Strategic Programs	250	500	0
Corporate Support	250	500	0
Total Sandia National Laboratories	**54,164**	**74,090**	**94,306**
Savannah River National Laboratory			
Vehicle Technologies	500	200	500
Hydrogen and Fuel Cells Technologies	0	200	100
Sustainable Transportation	500	400	600
Advanced Materials & Manufacturing Technologies Office	0	2,000	2,000
Buildings & Industry (formerly Energy Efficiency)	0	2,000	2,000
Total Savannah River National Laboratory	**500**	**2,400**	**2,600**
SLAC National Accelerator Laboratory			
Vehicle Technologies	4,350	7,000	5,000
Bioenergy Technologies	400	375	375
Hydrogen and Fuel Cells Technologies	0	500	500
Sustainable Transportation	4,750	7,875	5,875
Industrial Efficiency & Decarbonization Office	463	0	0
Advanced Materials & Manufacturing Technologies Office	462	5,000	5,000
Buildings & Industry (formerly Energy Efficiency)	925	5,000	5,000
Total SLAC National Accelerator Laboratory	**5,675**	**12,875**	**10,875**
Washington Headquarters			
Vehicle Technologies	17,220	22,375	22,000
Bioenergy Technologies	7,500	17,000	20,000
Sustainable Transportation	24,720	39,375	42,000
Renewable Energy Grid Integration	255	0	0
Solar Energy Technologies	22,600	25,000	30,000
Wind Energy Technologies	8,620	24,477	32,884
Water Power Technologies	39,476	38,160	98,316
Geothermal Technologies	2,900	16,653	5,000
Renewable Power	73,851	104,290	166,200
Industrial Efficiency & Decarbonization Office	15,052	39,550	46,000
Advanced Materials & Manufacturing Technologies Office	28,832	11,657	5,000
Building Technologies	73,329	104,690	80,726

DEPARTMENT OF ENERGY

Funding by Site

TAS_0321 - Energy Efficiency and Renewable Energy - FY 2024

(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Training and Technical Assistance (EERE)	1,000	1,900	0
State Energy Program Grants (EERE)	2,600	2,600	0
Weatherization and Intergovernmental Programs	3,600	4,500	0
Buildings & Industry (formerly Energy Efficiency)	120,813	160,397	131,726
Program Direction - Energy Efficiency and Renewable Energy	168,711	172,612	164,560
Strategic Programs	10,300	7,417	29,262
Corporate Support	179,011	180,029	193,822
Total Washington Headquarters	**398,395**	**484,091**	**533,748**
Grants			
Weatherization Assistance Program (EERE)	313,000	326,000	0
State Energy Program Grants (EERE)	56,500	56,500	0
Weatherization and Intergovernmental Programs	369,500	382,500	0
Buildings & Industry (formerly Energy Efficiency)	369,500	382,500	0
Total Grants	**369,500**	**382,500**	**0**
Total Funding by Site for TAS_0321 - Energy Efficiency and Renewable Energy	**3,200,000**	**3,460,000**	**3,861,116**

Electricity

Electricity

Electricity
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for electricity activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, **[**$350,000,000**]** *$297,475,000,* to remain available until expended: Provided, That of such amount, **[**$23,000,000**]** *$18,675,000* shall be available until September 30, **[**2024**]** *2025*, for program direction. *(Energy and Water Development and Related Agencies Appropriations Act, 2023)*

[For an additional amount for the "Electricity", $1,000,000,000, to remain available until expended, to carry out activities to improve the resilience of the Puerto Rican electric grid, including grants for low income households and households that include Individuals with disabilities for the purchase and installation of renewable energy, energy storage, and other grid technologies: Provided, That the Department of Energy shall coordinate with the Federal Emergency Management Agency and the Department of Housing and Urban Development on these activities.**]** *(Disaster Relief Supplemental Appropriations Act, 2023)*

Explanation of Changes

The Energy and Water Development and Related Agencies Appropriation Act, 2023, appropriations for the Electricity account supports both the Office of Electricity and the Grid Deployment Office. Of the $350,000,000 appropriated in FY 2023 in the Electricity account, $285,293,000 supports the Office of Electricity and $64,707,000 supports the Grid Deployment Office. Within those amounts, of the $23,000,000 provided for program direction, $17,793,000 supports Office of Electricity program direction and $5,207,000 supports Grid Deployment Office program direction. The FY 2024 Request in the Electricity account supports only the Office of Electricity, with Grid Deployment Office activities requested under the Grid Deployment appropriations account.

The Disaster Relief Supplemental Appropriations Act, 2023, appropriations in the Electricity account were designated as an emergency requirement under Section 21104 of the Act and are one-time funding exclusively supporting Grid Deployment Office activities.

Public Law Authorizations

- Public Law 95–91, "Department of Energy Organization Act", 1977
- Public Law 109-58, "Energy Policy Act of 2005"
- Public Law 110-140, "Energy Independence and Security Act, 2007"
- Public Law 114-94, "Fixing America's Surface Transportation Act," 2015
- Public Law 116-260, Division Z, "Energy Act of 2020"

Electricity / Office of Electricity
($K)

FY 2022 Enacted	FY 2022 Enacted (Comparable)[a]	FY 2023 Enacted	FY 2023 Enacted (Comparable)[a]	FY 2024 Request
277,000	266,000	350,000	285,293	297,475

Overview

The ability to move abundant clean electricity from where it is produced to where and when it is needed is the cornerstone of a reliable electric grid. The electricity delivery system must be capable of supporting all types of generation resources and loads, and ensure reliable, resilient grid operations under all conditions. The Office of Electricity (OE) leads the Department's efforts in developing new technologies to strengthen, transform, and improve electricity delivery infrastructure so new generation and loads can be fully integrated into the energy ecosystem and consumers have access to resilient, secure, and clean sources of electricity. OE provides solutions to technical, market, institutional, and operational challenges that go beyond any one utility's ability to solve.[b] To accomplish this critical mission, OE engages stakeholders throughout the sector on a variety of innovative technology solutions to modernize the electric grid.

A dramatic structural transformation of the electricity delivery system is underway to ensure that reliability is maintained during the rapid integration of renewable generation and customer-based technologies, including distributed generation and the electrification of transportation and building infrastructures. America's grid is transforming into a more dynamic and structurally complex system, with bidirectional power flows. Managing this transition will require significant reengineering and advancements in grid technology and system architectures.

Proactive, coordinated, and innovative steps are needed to lay the foundation for economic growth, workforce development, and the creation of good-paying jobs for American workers, as well as to ensure benefits accrue to marginalized and overburdened communities while addressing four critical challenges:

- Increasing threats and risks to the reliability and security of energy infrastructure
- Changes in demand driven by population growth, adoption of more energy efficient technologies, dynamic economic conditions, and broader electrification
- Changes in the supply mix and location (centralized, distributed, and offshore) of the Nation's generation portfolio
- Increasing variability and uncertainty from both supply and demand, including integration of variable renewables, more active consumer participation, and accommodating new technologies and techniques

Due to the critical role that the electric grid plays across Federal, State, Tribal, territorial, and regional jurisdictions, OE programs work in an integrated manner in partnership with industry and other stakeholders, as well as other DOE offices, to improve and enhance the following key characteristics of the U.S. electric transmission and distribution systems:

- Reliability—consistent and dependable delivery of high-quality power
- Resilience—the ability to withstand and quickly recover from disruptions and maintain critical function
- Security—the ability to protect system assets and critical functions from unauthorized and undesirable actors
- Flexibility—the ability to accommodate changing supply and demand patterns and new technologies
- Affordability—more optimal deployment of assets to meet system needs and minimize costs
- Efficiency—low energy losses in electricity delivery and more optimal use of system assets

[a] The FY 2024 Budget Request to Congress proposes to split the Electricity appropriation account into two accounts: Electricity and Grid Deployment. To allow an apples-to-apples comparison with FY 2024, the FY 2022 and FY 2023 comparable amounts for OE exclude funding for GDO activities, equivalent to what would have been in the Grid Deployment account had the proposed structure been in place since FY 2022. Detailed adjustments are shown below in the Comparability Matrices section.

[b] Examples include wide-area visibility, identified from the 2003 Northeast blackout, and faster modeling and analysis, identified in the 2011 Southwest blackout.

- Energy Justice—achieving equity in both the social and economic participation in the energy system, while also considering and mitigating detrimental effects on disadvantaged and energy-burdened communities

Within the Request, OE funds:

- Research, Development and Demonstration (RD&D)—pursuing and executing R&D programs and pilot demonstrations for technologies that improve grid reliability, resilience, efficiency, flexibility, and functionality.
- Power Grid Modeling and Analytics—developing and validating core analytic, assessment, and engineering capabilities that characterize the reliability and performance of the electricity system. These analyses will explore complex interdependencies among infrastructure systems across a rapidly evolving operational/threat environment.
- Cyber Resilience—designing next-generation grid-communications systems that are built from inception through final implementation to automatically detect, reject, and withstand cyber incidents. These efforts will include designing, building, and executing hardware-in-the-loop testing and model-based systems analyses capable of identifying shortfalls in grid communications, technology development priorities, and mitigation strategies.
- Market Design and Distribution Planning—conducting research on electricity market designs and distribution planning processes, particularly at state and community levels, that increase the reliability, social equity, and efficiency related to the electricity delivery system.

The proposed investment continues to support OE's mission of reliability, security, and resilience through six key priorities:

- Grid Flexibility through Megawatt-Scale Grid Storage—pursuing megawatt-scale storage capability(s) that support voltage and frequency regulation, ramping, and energy management for bulk and distribution power systems.
- Improving Observability and Deep Learning via Sensing Technology Utilization—driving integration of high-fidelity sensing technology (and associated data analytics) to support the integration of distributed energy resources (DERs) and reliable operations under normal and extreme conditions.
- Driving Modeling Advancements to Elucidate Uncertainty—leading research to better understand the structural, operational, and contextual issues affecting the current and future electric grid, and to enable development of robust toolsets for operators and planners to assess emerging risks to reliability and system performance.
- Building in Cybersecurity—accelerating and expanding cybersecurity and resilient communications for electricity infrastructure and mitigating vulnerabilities.
- Expanding Functionality of Grid Components—accelerating development and use of advanced grid technologies and national technology testing facilities to demonstrate technologies in a controlled environment supporting the adoption of modular designs and standards to facilitate manufacturing supply chain and rapid replacement.
- Integrated Grid Planning to Ensure Coherence—formulating coherent grid strategies and pathways that apply advanced technologies for meeting reliability, resilience, decarbonization, efficiency, equity, and flexibility objectives through the advancement of integrated planning practices in concert with states and the electric industry.

OE's Budget Request will extend the impact of our RD&D funding by leveraging creative funding mechanisms—such as prizes, competitions, and coordination, collaboration, and partnerships with other DOE programs and Federal agencies—to maximize scope and reach. The objective is to enable the commercialization of clean energy innovations that stimulate job creation, expand other public impact outcomes, and yield a more geographically diverse and impactful research portfolio.

Energy Storage Grand Challenge (ESGC): DOE is taking a holistic approach to accelerate the development, commercialization, and utilization of next-generation energy storage technologies. The ESGC will deploy the Department's extensive resources and expertise to address technology development, commercialization, manufacturing, valuation, and workforce challenges. The vision for the ESGC is to create and sustain global leadership in energy storage utilization and exports, with a secure domestic manufacturing supply chain that is independent of foreign sources of critical materials, by 2030.

OE's Energy Storage program's request supports grid-related ESGC objectives along with other OE R&D efforts that will complement ESGC goals.

Grid Modernization Initiative and Grid Modernization Laboratory Consortium: The Grid Modernization Initiative (GMI) is a crosscutting strategic partnership between DOE and the national laboratories to bring together leading experts, technologies, and resources to collaborate on the goal of modernizing the Nation's grid. The benefits of the GMI include

more efficient use of resources; shared networks; improving learning and preservation of knowledge; enhanced lab coordination and collaboration; and regional perspective and relationships with local stakeholders and industry. The GMI portfolio features multiple Grid Modernization Lab Calls to ensure comprehensive grid research efforts across 14 national laboratories that are coordinated through the Grid Modernization Laboratory Consortium (GMLC).[a]

Highlights and Major Changes in the FY 2024 Budget Request

Transmission Reliability and Resilience (TRR) ($42,500,000; +$10,913,000) is focused on ensuring the reliability and resilience of the U.S. electric grid through R&D on system observability and control capabilities. TRR also develops and validates models to characterize evolving system needs, identifies pathways to achieve an equitable transition to decarbonization and electrification, addresses ongoing industry challenges related to relay misoperations and identification and isolation of faults, and mitigates risks across integrated energy systems through data fusion and tool development. The Request supports modernizing transmission system tools through human factor and cognitive science research for system operations, increasing net power flowing through transmission lines, developing analytical methods to manage uncertainties of bulk power system grid reliability impacts associated with increased deployment of renewables, developing new models and tools to help the electric industry understand and maintain reliability as supply and load change to meet the decarbonization and electrification targets, and increasing the level of understanding and industry awareness related to energy justice.

Energy Delivery Grid Operations Technology (EDGOT) ($30,000,000; -$614,000) enhances the analytical capability needed to ensure reliable and resilient energy delivery and provides the architecture and process for identifying a range of scalable mitigation solutions to changing climate conditions and other emerging threats. The core of the EDGOT portfolio is the North American Energy Resilience Model (NAERM), a hybrid data/model platform for the quantitative assessment of the significant interdependencies that have evolved within the energy sector and that could affect reliability. NAERM will provide for enhanced planning and analysis capabilities that can be leveraged to facilitate grid investments to address these threats. The Request focuses on developing and enhancing the portfolio of tools that are needed to address grid reliability in a system with pervasive and evolving threats and challenges. NAERM will improve capability limitations and transition the underlying capabilities to a robust, secure operational state that prioritizes “what if” scenarios affecting reliability, which is essential for maintaining OE’s ability to identify and advance solutions for America’s grid.

Resilient Distribution Systems (RDS) ($47,300,000; -$6,248,000) develops transformative technologies, tools, and techniques that enable industry to keep pace with emerging and evolving conditions that necessitate modernization of the distribution network to ensure continued reliability and resilience. RDS pursues strategic investments in innovative technologies and practices that improve reliability, increase resilience, support vehicle electrification, integrate clean DERs, and provide consumers with more choices for managing their energy consumption. The Request expands microgrid building block development to advance virtual prototype design performance and sector coupling analysis to look at structural and architectural aspects as well as control and coordination approaches addressing vehicle–grid integration issues.

Cyber Resilient and Secure Utility Communications Networks (SecureNet) ($15,000,000; +$409,000) develops solutions to strengthen the security and resilience of the electricity delivery system against cyber-related threats to operational data, communications networks, and control systems. Our Nation’s energy system is heavily dependent on data communications and cyber-physical controls for operational reliability and resilience. More integration of distributed assets on the grid increases this dependency and presents a broader attack surface for increasingly sophisticated adversaries to exploit. Funding this R&D effort to design security into the future grid is essential to extend the Department’s focus beyond today’s challenges and ensure the efficient, reliable, and resilient operation of the electric power system in tomorrow’s even more complex and dynamic risk landscape. The Request’s core focus supports research on secure and resilient utility communications networks, including the development of an architectural framework for communications infrastructure, an associated technology roadmap for communications infrastructure that meets utility systems’ functional and performance requirements, and key technologies such as synchronization, timing, and blockchain. The Request also supports modeling cyber aspects of future grid scenarios, researching cyber-hardening new grid technologies, and providing cyber design inputs, testing capabilities, and cyber vulnerability assessments to other OE programs.

[a] https://www.energy.gov/grid-modernization-initiative

Energy Storage ($78,600,000; -$10,365,000) accelerates bi-directional electrical energy storage technologies as a key component of a reliable, resilient, and affordable future-ready grid. OE Storage research, development, demonstration, and deployment efforts accelerate the development of long duration grid storage technologies through increasing amounts of stored energy and operational durations, reducing technology costs, de-risking technologies to ensure safe long-term reliability, developing analytic models to uncover technical and economic benefits, and demonstrating how storage can provide clean and equitable energy access for consumers and communities. The Request launches a new cohort for the Energy Storage for Social Equity Technical Assistance and Pilot Program, supporting an additional 5–10 communities in the technical assistance phase with 2–4 of those communities continuing to the pilot demonstration phase, and expands the Rapid Operational Validation Initiative to improve the performance projection methodologies of 2–3 new non-lithium electrochemistries. To respond to the rapidly growing number of energy storage installations, the Request also expands outreach to key deployment stakeholders, including fire safety, codes and standards, and other groups.

Transformer Resilience and Advanced Components (TRAC) ($21,700,000; -$4,915,000) develops innovations to carry, control, convert, and condition electricity, equipping the future-ready grid to achieve decarbonization goals while enhancing its reliability and resilience. The TRAC scope encompasses materials research, exploratory concepts, and modeling and analysis to address the range of challenges associated with transformers and other grid components. Program activities, developed in close coordination with industry, aim to fill fundamental R&D gaps and encourage the adoption of new technologies and approaches. The Request accelerates addressing high voltage direct current (HVDC) hardware technical challenges to perform a field validation of the Smart Universal Power Electronics Regulators device and expands the development of modular and scalable transformers.

Applied Grid Transformation Solutions (AGTS) ($29,700,000; +$19,827,000) addresses the pressing need for rapidly assessing new grid systems and subsystems (including energy storage, transmission, distribution, and power control and conversion hardware and associated software) by testing integrated technology suites in pilot environments prior to the hardware and software being deployed by industry in operational environments. These assessments provide utilities with the information they need to quantify and validate functionality, performance, and economic benefits before deploying new technologies. The results of pilot demonstrations will validate the techno-socio-economic performance of the systems and accelerate the adoption of new technology by the industry. The Request supports at least two new pilots to validate technological maturity and show how new technologies achieve desired environmental, societal, policy, and market outcomes and will be targeted to provide regional diversity.

Electricity Innovation and Transition (EIT) ($14,000,000; +$2,293,000) is a new program in FY 2024 consolidating all OE funding for Small Business Innovation Research (SBIR), Technology Commercialization Fund (TCF), and workforce development activities. The reorganization of these efforts provides a more flexible, streamlined, and transparent approach for OE to support innovators, small businesses, and researchers moving grid technologies forward.

FY 2022 Key Accomplishments

Flexible Transformer Validation: OE, GE, and Cooperative Energy have completed field validation of the world's first flexible transformer that adapts to a range of voltage ratios and impedance levels. Results include over 99.5% efficiency with size and weight within 120% of comparable conventional large power transformers (LPTs). Flexible transformers have enhanced capabilities, reduce the need for custom-designed transformers, and will lead to significantly reduced manufacturing costs and timeframes relative to custom-made transformers. By allowing damaged transformers to be replaced more quickly, flexible transformers will be an important tool in increasing the grid's resilience to extreme weather events or cyber incidents.

- **Cost Competitive and Long Duration Storage technologies:**
  - Achieved OE's FY 2022 Energy Storage milestone to demonstrate an enhanced novel aqueous soluble organic flow battery with a projected system cost of less than $175 per kWh for a projected 1MW/4MWh system.
  - Developed new materials and processes to advance sodium-based technologies—from novel sodium conducting membranes to sodium-based flow battery catholytes.
  - Developed novel freeze-thaw technology enabling batteries to potentially operate as seasonal storage assets.
  - Received R&D 100 award for developing the world's first iron nitride soft magnetic cores for power converters.
- **Learning to Adapt and Control for Complex Power Systems (LACC):** A framework for controlling utility-scale renewable assets was developed under this OE-supported project to adaptively ride through system disturbances and increase the security and reliability of modern power grids. Compared to traditional controllers, LACC is faster, more reliable, and

less expensive, while reducing impacts of current introduced by outages during a severe fault by more than 40%. Ultimately, the LACC controller will allow more renewable resources to connect to the grid.

- **Chronological AC Power Flow Automated Generation (C-PAGE):** The C-PAGE tool advances renewable integration efficiency by automatically creating realistic, reliable, and economic planning models for long-term planning studies of renewable integrations and reducing the model preparation time from months to minutes. This OE-supported tool has been recognized by industry, was used by Western Electric Coordinating Council to develop 2032 renewable planning base cases, and has been selected by the Power Company of New Mexico to support transmission planning studies.
- **Validated resilient operations of networked microgrids software capabilities:** The resilience benefit from the software solution for networking microgrids was clearly quantified during a simulated outage event on a distribution utility feeder circuit serving a remote community, which showed that close to two-thirds of the load can be supported. This is a significant increase, as only about 22% of the load could be supported with the same microgrids operating in isolation. The software has been deployed on an industry-sponsored platform to transition its use by utilities in rapid recovery during extreme weather events.
- **Holistic platform to plan for and manage behind-the-meter DERs to support grid services:** A platform for distribution utilities demonstration of aggregated DER use cases for peak load reduction, load shaping, distribution network management, and ancillary services showed the platform can provide utilities with a visibility and management tool for DERs to relieve congestion while also delivering grid services to markets. This promising platform was acquired by a commercial entity, anticipating that a greater industry impact will result.
- **Grid Deployments and Field Validations:**
  - OE-supported staff co-led IEEE 1547.9, the first standard for grid interconnection of energy storage systems.
  - Published the first comprehensive review paper on cyber-physical security of energy storage systems.[a]
  - Commissioned a microgrid with new zinc-manganese dioxide batteries in the Navajo Nation (in collaboration with the Navajo Tribal Utility Authority).
  - Developed a dispatchable working prototype of a power electronic system to support multiple secondary use energy storage technologies.
- **U.S.-India Collaborative for Smart Distribution System with Storage (UI-ASSIST):** OE is supporting Washington State University and their 15 U.S. university and industry partners in a joint research project with India to advance the development of the electric distribution systems in both the United States and India. UI-ASSIST focuses on providing affordable, clean energy while maintaining grid reliability and resiliency, and is promoting grid innovations that will promote economic growth and energy security in both countries.
- **Advanced Conductors SBIR Projects:** OE and the Advanced Manufacturing Office co-funded several SBIR projects under the Conductivity-enhanced materials for Affordable Breakthrough Leapfrog Electric and thermal applications initiative. Two OE-led projects under the Electricity Delivery System SBIR subtopic were successfully completed: QuesTek Innovations, developing advanced aluminum conductors for overhead transmission applications, and Mainstream Engineering, developing advanced copper conductors for underground and undersea applications.
- **SBIR Phase III Wildfire Mitigation:** In May 2022, OE awarded a Phase III SBIR cooperative agreement to Brains4Drones (Plano, TX) to apply their AI technology on drones to mitigate against wildfires. The Brains4Drones project focused on adapting drone-based solutions to mitigate fire risks at distribution lines in hard-to-access terrain by performing powerlines, equipment, and vegetation inspections. Brains4Drones developed AI algorithms, integrated the necessary sensors for defect detection and developed prototypes that specifically gathered and curated real-time information on potential hazards. The technology was adapted to utility needs and was field demonstrated in September 2022 by Consumers Power, an electric cooperative utility in Oregon.

[a] https://ieeexplore.ieee.org/document/9787060

Electricity
Funding by Congressional Control ($K)

	FY 2022 Enacted	FY 2022 Enacted (Comparable)[a]	FY 2023 Enacted	FY 2023 Enacted (Comparable)[a]	FY 2024 Request	FY 2024 vs FY 2023 Enacted (Comp) ($)	FY 2024 vs FY 2023 Enacted (Comp) (%)
Grid Controls and Communications							
Transmission Reliability and Resilience	26,000	24,941	34,000	31,587	42,500	+10,913	+34.5%
Energy Delivery Grid Operations Technology	23,000	12,791	31,000	30,614	30,000	-614	-2.0%
Resilient Distribution Systems	55,000	53,500	55,000	53,548	47,300	-6,248	-11.7%
Cyber Resilient and Secure Utility Communications Networks (SecureNet)	11,150	20,372	15,000	14,591	15,000	+409	+2.8%
Total, Grid Controls and Communications	115,150	111,604	135,000	130,340	134,800	+4,460	+3.4%
Grid Hardware, Components, and Systems							
Energy Storage							
Research	73,000	70,684	95,000	88,965	78,600	-10,365	-11.7%
Construction: 20-OE-100 Grid Storage Launchpad	47,000	47,000	0	0	0	0	N/A
Total, Energy Storage	120,000	117,684	95,000	88,965	78,600	-10,365	-11.7%
Transformer Resilience and Advanced Components	11,000	10,636	27,500	26,615	21,700	-4,915	-18.5%
Applied Grid Transformation Solutions	0	0	10,000	9,873	29,700	+19,827	+200.8%
Total, Grid Hardware, Components, and Systems	131,000	128,320	132,500	125,453	130,000	+4,547	+3.6%
Electricity Innovation and Transition	0	6,226	0	11,707	14,000	+2,293	+19.6%
Transmission Permitting and Technical Assistance (TPTA)	8,000	0	0	0	0	0	N/A
Grid Deployment Office (GDO)	0	0	59,500	0	0	0	N/A
Congressionally Directed Spending	2,850	2,850	0	0	0	0	N/A
Program Direction (PD)	20,000	17,000	23,000	17,793	18,675	+882	+5.0%
Total, Electricity	**277,000**	**266,000**	**350,000**	**285,293**	**297,475**	**+12,182**	**+4.3%**
Federal Full Time Equivalent Employees (FTEs)	**70**	**63**	**82**	**63**	**64**	**+1**	**+1.6%**
Additional FECM FTEs at NETL supporting OE[b]	12	11	13	10	10	0	0.0%
Total OE-funded FTEs	82	74	95	73	74	+1	+1.4%

SBIR/STTR:
FY 2022 Enacted: SBIR: $4,581
FY 2023 Request: SBIR: $5,589
FY 2024 Request: SBIR: $6,407

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[a] The FY 2024 Request proposes to split the Electricity appropriation account into two accounts: Electricity and Grid Deployment. To allow an apples-to-apples comparison with FY 2024, the comparable amounts for Electricity in FY 2022 and FY 2023 exclude all funding for GDO activities that would have been in the Grid Deployment account under the proposed structure. Within OE, the Request proposes to consolidate all SBIR, TCF, and workforce development activities under EIT. The FY 2023 enacted appropriation moved DarkNet funding within OE from EDGOT to SecureNet. FY 2022 and FY 2023 are also shown as if these changes had been in place since FY 2022. Detailed adjustments are shown below in the Comparability Matrices section.

[b] OE funds FTEs at the Office of Fossil Energy and Carbon Management's (FECM's) National Energy Technology Laboratory that are FECM employees, but support OE activities. The FTEs are included in FECM's FTE totals and not in the OE FTE totals shown on the "Federal Full Time Equivalent Employees (FTEs)" line.

Comparability Matrices

The FY 2024 Request proposes to split the Electricity appropriation account into two accounts: Electricity and GDO. The Request also proposes an internal shift within OE to consolidate all funding for SBIR, TCF, and workforce development activities into a new Electricity Innovation and Transition (EIT) program. The FY 2023 appropriation also moved Darknet funding from Energy Delivery Grid Operations Technology to SecureNet.

The tables below show the how funding would move between the original budget structure (the table rows) and the proposed budget structure (the table columns) in FY 2022 and FY 2023 if the proposed FY 2024 budget structure had been in place since FY 2022. More detailed comparability matrices are shown after each program budget narrative.

FY 2022 Enacted Appropriation Comparability Matrix

	Proposed Budget Structure ($K)							
	OE						GDO	Total
	EDGOT	SecureNet	EIT	PD	Other OE	Total		
Original Budget Structure								
TRR	0	0	1,059	0	24,941	26,000	0	26,000
EDGOT	12,791	9,672	537	0	0	23,000	0	23,000
RDS	0	0	1,500	0	53,500	55,000	0	55,000
SecureNet	0	10,700	450	0	0	11,150	0	11,150
Energy Storage	0	0	2,316	0	117,684	120,000	0	120,000
TRAC	0	0	364	0	10,636	11,000	0	11,000
TPTA	0	0	0	0	0	0	8,000	8,000
Congressionally Directed Spending	0	0	0	0	2,850	2,850	0	2,850
PD	0	0	0	17,000	0	17,000	3,000	20,000
Total	**12,971**	**20,372**	**6,226**	**17,000**	**209,611**	**266,000**	**11,000**	**277,000**

FY 2023 Enacted Appropriation Comparability Matrix

	Proposed Budget Structure ($K)					
	OE				GDO	Total
	EIT	PD	Other OE	Total		
Original Budget Structure						
TRR	2,413	0	31,587	34,000	0	34,000
EDGOT	386	0	30,614	31,000	0	31,000
RDS	1,452	0	53,548	55,000	0	55,000
SecureNet	409	0	14,591	15,000	0	15,000
Energy Storage	6,035	0	88,965	95,000	0	95,000
TRAC	885	0	26,615	27,500	0	27,500
AGTS	127	0	9,873	10,000	0	10,000
GDO	0	0	0	0	59,500	59,500
Program Direction	0	17,793	0	17,793	5,207	23,000
Total	**11,707**	**17,793**	**255,793**	**285,293**	**64,707**	**350,000**

Future Years Energy Program
($k)

	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
Electricity	297,475	304,000	311,000	318,000	325,000

This future years energy program shows outyear funding for FY 2025–2028. Actual future budget request levels will be determined as part of the annual budget process.

OE priorities in the outyears include the following activities aimed at maintaining the reliability, resilience, security, and affordability of America's electricity delivery system:

- Developing data and analytical tools necessary to assess the reliability and performance of the electricity system
- Accelerating development of modular and flexible next-generation technologies, such as HVDC, solid state power substations (SSPS), and power electronics, to enable advanced grid capabilities and more fully unlock the value of storage and renewables
- Developing long duration energy storage technologies consistent with the 2030 Long Duration Storage Shot goal of $0.05/kwh Levelized Cost of Storage for 10+ hour systems
- Architecting next-generation grid-communications systems that are built from inception to mitigate communication failures and automatically detect, reject, and withstand cyber incidents
- Conducting research on electricity market designs and distribution planning processes that increase the reliability, social equity, and efficiency of the electricity delivery system

Transmission Reliability and Resilience

Overview

The Transmission Reliability and Resilience (TRR) program collaborates with the electric industry to research and develop system monitoring, data analytics, and control technologies that are critically needed to assess the reliability and performance of the electricity system, to mitigate large-scale blackouts and respond to natural disasters, and to adapt to evolving system needs and interdependencies. TRR focuses on:

- Ensuring the reliability and resilience of the U.S. electric grid through research and development (R&D) on system observability and control capabilities
- Developing and validating models to characterize evolving system needs and the emerging operational landscape, and identifying pathways for achieving an equitable transition towards decarbonization and electrification
- Addressing ongoing industry challenges related to relay misoperations and identification and isolation of faults
- Mitigating risks across integrated energy systems through data fusion and tool development

TRR brings together energy stakeholders from government, industry, and academia to generate ideas and develop solutions to address the Nation's energy infrastructure challenges, including both natural and man-made hazards.

Transmission Reliability and Renewable Integration (TRRI) develops transmission system operations tools and data analytics to inform decisions that maintain and improve system reliability while accelerating the integration of renewable energy. Data analytics and visualization advancements ensure utilities obtain full value from new and existing sensor capabilities and enable inference of complex underlying dynamics and diagnosis of system behavior and abnormalities, while providing situational awareness for operators to make informed and equitable decisions. TRRI develops tools that help system operators understand and respond to reliability events like wildfires, heatwaves, and cold snaps, all while adapting to growth in clean power generation, decarbonization, distributed energy resources, and increased electrification. The program works to modernize transmission system tools through human factor and cognitive science research for system operations to allow for more timely mitigation of reliability events, such as blackouts, and allow for the development of training simulators for operator workforce development. TRRI R&D will improve the speed, accuracy, and precision of power system state determinations required to manage the increasing complexity of grid operations and assets and to monitor and manage the interconnected and interdependent effects among the Nation's critical infrastructures.

Advanced Grid Modeling (AGM) supports building electricity sector capacity and capability to analyze the electricity delivery system using Big Data, advanced mathematical theory, and high-performance computing to assess the current state of the grid, mitigate reliability risks, and understand future needs. AGM leads research activities to better understand issues surrounding the current and future electric power grid and develop robust model-based solutions, resulting in new software and analytical toolsets for operators and planners. Successful research enables grid operators and planners to optimize decision-making, giving the electric industry sophisticated tools to dramatically improve electric delivery system efficiency, reliability, resilience, and security.

Protective relaying is required at all levels of the electric grid to quickly identify and isolate faults so the remaining system will continue to operate under normal conditions. This prevents or reduces equipment damage and potential injury to utility personnel and the public. Protective relaying is increasingly integrated with normal grid operations such as stabilizing voltage and frequency. The Protective Relaying subprogram addresses ongoing industry issues, such as relay misoperations, while advancing state-of-the-art technology related to bi-directional power flow, faster response times, and enhanced detection methods. The subprogram also develops guidelines, best practices, and toolsets to support workforce development of relaying professionals across the Nation.

Building and maintaining effective public-private partnerships is a key strategy for the TRR program. In achieving its vision, TRR fosters strategic, university-based power system research. Partnerships with universities focus on developing state-of-the-art tools and analytic methods, while simultaneously providing important opportunities for the next generation of scientists and researchers in power systems. Such partnerships facilitate innovations in R&D and enable industry (and ultimately consumers) to capitalize on the outcomes. TRRI, for example, continues work to develop research datasets and data platforms that reduce utility burden from data requests and facilitate tool development with real data. This sets the groundwork for catalyzing artificial intelligence and machine learning in the transmission system. Advancing analytics to be

capable of fully capturing and understanding new system dynamics from the integration of renewable energy, inverter-based technologies, and advanced transmission control schemes (such as dynamic line rating and transmission topology control) further develops the electricity system as a resource.

TRR directly engages energy stakeholders and decision makers to disseminate research results and promote innovation, and risk-informed energy system decisions. TRR activities also focus on advancing university-based power systems research, helping ensure an enduring strategic national capability for innovation in this essential area.

Highlights of the FY 2024 Budget Request
The TRR program continuously investigates ways to make the present and future grid resilient, reliable, efficient, and secure. In FY 2024, TRR will concentrate on:

- Developing high-fidelity sensing technologies and analytics that manage uncertainty associated with data and decision support capabilities
- Advancing the application of cognitive science and human factors to identify and develop tools needed for robust decision making and training for system operators
- Advancing protective relaying methods to improve the functional integrity and effectiveness of corrective actions to prevent misoperations and mitigate power outages
- Continuing research on the impact of grid changes with a concentration on transmission planning to accommodate large renewable deployments to facilitate decarbonization
- Identifying and mitigating risk resulting from supply and demand changes and integration of large numbers of inverter-based resources (IBRs) across the integrated energy system
- Developing models and tools to help the electric industry understand and maintain reliability as the supply and load change to meet decarbonization and electrification targets
- Increasing collaboration between OE and other public and private entities
- Continuing the partnership with the National Science Foundation (NSF) on the Algorithms for Modern Power Systems (AMPS) program targeting university-based research to improve grid reliability, resilience, and security
- Managing and understanding the impact of changes in the grid amid increasing complexity and accelerated grid technology development
- Developing integrated risk-based, measurement-model approaches to improve detection, mitigation, and recovery/ restoration from system failure, weather events, and man-made attacks to the electric power system, and plans to enable the operation of degraded or damaged electricity systems while sustaining critical functionality
- Advancing tools for transmission and distribution systems operations and control to rapidly mitigate reliability events and for developing training simulators for operators to improve reliability outcomes

Technology, tools, and applications developed under TRR will be evaluated for security risks including cybersecurity. Testing and evaluations will be conducted in coordination with OE's SecureNet program to ensure that security is built into these technologies and new security risks are not being introduced into the electric sector.

Support of R&D activities through the Grid Modernization Initiative, including the Grid Modernization Laboratory Consortium (GMLC) will continue.

Centers[a]
The Request includes planned DOE support for a new university-based Engineering Research Center (ERC), which would be jointly funded by NSF and the Department. Through the ERC, DOE would seek to develop fundamental knowledge in different aspects of the Electric Power System, contributing to a reliable, resilient, and secure electric power grid, while educating a new generation of electric power and energy systems engineering leaders.

[a] Per the guidance on inclusion of centers in budget justifications in H.Rpt. 113–135, the House report for the FY 2014 Energy and Water Development appropriations.

Transmission Reliability and Resilience
Funding ($K)

	FY 2022 Enacted (comparable)[a]	FY 2023 Enacted (comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Transmission Reliability and Resilience					
Transmission Reliability and Renewable Integration	4,686	8,815	13,500	+4,685	+53.1%
Advanced Modeling Grid Research	15,613	18,925	24,000	+5,075	+26.8%
Protective Relaying	3,655	3,847	5,000	+1,153	+30.0%
Transmission Sensors	987	0	0	0	N/A
Total, Transmission Reliability and Resilience	**24,941**	**31,587**	**42,500**	**+10,913**	**+34.5%**

Transmission Reliability and Resilience
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• **Transmission Reliability and Renewable Integration**: Supports modernization of transmission system tools through human factor and cognitive science research for system operations to allow for more timely mitigation of reliability events, such as blackouts, and allow for the development of training simulators for operator workforce development	+4,685
• **Advanced Modeling Grid Research**: Supports R&D to increase the net power flowing through transmission lines, develop analytical methods to manage the impact of uncertainty associated with increased renewable sources on the bulk power system to maintain the reliability of the grid, develop new models and tools that can help the electric industry understand and maintain reliability as supply and load change to meet decarbonization and electrification targets, and increase the level of understanding and industry awareness related to energy justice	+5,075
• **Protective Relaying**: Supports understanding and better management of misoperations of relays while advancing state-of-the-art technology related to bi-directional power flow, faster response times, and enhanced detection methods	+1,153
Total, Transmission Reliability and Resilience	**+10,913**

[a] The FY 2024 Request proposes to consolidate all Small Business Innovation Research, Technology Commercialization Fund, and workforce development activities under the new Electricity Innovation and Transition (EIT) program. To allow an apples-to-apples comparison, FY 2022 and FY 2023 are shown as if this approach had been in place since FY 2022, moving $1,059,000 in FY 2022 and $2,413,000 in FY 2023 from TRR to EIT. Details of these adjustments are shown in the Comparability Matrix section below.

Activities and Explanation of Changes

FY 2023 Enacted (comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Transmission Reliability and Resilience $31,587,000	**$42,500,000**	**+$10,913,000**
Transmission Reliability and Renewable Integration $8,815,000	*$13,500,000*	*+$4,685,000*
• Continue technical support for NASPI to conduct competitions, information sharing and joint problem solving among utilities, vendors, universities, and the Federal Government • Develop and demonstrate management tools for grid enhancing technologies like dynamic line rating and power flow control to facilitate integration of renewable energy and better utilize existing transmission infrastructure • Support operating strategies, dynamic load modeling, contingency analysis, and control approaches that recognize and incorporate the control capabilities offered by, and attributes of, wind and solar generation • Develop transmission system data modernization of for wide area situational awareness, to prevent cascading power outages, through prizes, data set creation, and artificial intelligence (AI)/machine learning (ML) research • Advance cognitive science and human factors research to catalyze development and adoption of new tools for workforce training and development, control room application improvements, and robust decision making	• Advance the application of cognitive science and human factors to identify and develop tools needed for decision making and training. Use this to develop training simulators for operators to improve reliability outcomes • Continue technical support for NASPI to conduct competitions, information sharing and joint problem solving among utilities, vendors, universities, and the Federal Government • Support operating strategies, decision analysis, contingency analysis, and control approaches that recognize and incorporate the control capabilities offered by, and attributes of, wind and solar generation • Develop transmission system data modernization of for wide area situational awareness, to prevent cascading power outages, through prizes, data set creation, and AI/ML research • Advance cognitive science and human factors research to catalyze development and adoption of new tools for workforce training and development, control room application improvements, and robust decision making	• Increase in work related to mitigation of pressing challenges to the power system, including heat waves, wildfires, and rapid decarbonization • Additional industry engagement and tool demonstrations for system operators to fully utilize new energy resources while responding and preventing reliability events • Increase development of operational strategies that increase transmission infrastructure utilization and reliability through advances in power flow and topology control strategies • Increase industry demonstrations and research for new dashboards and decision processes for reliability events

FY 2023 Enacted (comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Advanced Modeling Grid Research $18,925,000	*$24,000,000*	*+$5,075,000*
• Continue mathematical and computational research to manage uncertainty, associated with data, modeling, and model validation • Continue development, co-funded with NSF's AMPS program, of next-generation mathematical and statistical algorithms to improve the security, reliability, and resilience of the electric power system • Continue studying of the impact of grid changes with a limited concentration on transmission planning to accommodate deployment of limited level of renewables to facilitate decarbonization • Increase the level of understanding and awareness in National Laboratories related to energy justice while exploring a limited level of mitigation through R&D • Identify grid risk to accommodate increasing levels of renewables and explore a limited level of mitigation to facilitate decarbonization while ensuring grid reliability, resiliency, security, and efficiency	• Identify and mitigate risk from changes in supply and demand and integration of large number of IBRs across the integrated energy system • Develop models and tools to help the electric industry understand and maintain reliability as the supply and load change to meet decarbonization and electrification targets • Advance tools for transmission and distribution systems operations and control to rapidly mitigate reliability events • Develop new models and tools that can help the electric industry understand and maintain reliability by managing the system as supply and load change to meet the decarbonization and electrification targets • Continue mathematical and computational research to manage uncertainty, associated with data, modeling, and model validation • Continue development, co-funded with NSF's AMPS program, of next-generation mathematical and statistical algorithms to improve the security, reliability, and resilience of the electric power system • Continue exploring alternative methods for transmission planning to increase the amount of energy delivered using existing rights of way • Continue exploring the impact of changes in the grid with a concentration on transmission planning to accommodate large deployment of renewables to facilitate decarbonization	• Increase the level of stakeholder engagement on IBRs to better understand issues and explore mitigating actions, as the integration of more renewables makes the system more complex where existing control strategies may not be adequate to ensure the reliability of the system • Support R&D to understand the changes and develop mitigating actions to ensure the reliable operation of the grid

FY 2023 Enacted (comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
	• Identify and mitigate grid risk to accommodate increasing levels of renewables to facilitate decarbonization while ensuring grid reliability, resiliency, security, and efficiency	
Protective Relaying $3,847,000	*$5,000,000*	*+$1,153,000*
• Develop mitigations that reduce misoperations at transmission levels • Develop solutions to distinguish between momentary and permanent faults for reclosers at the distribution level at the test level • Develop cybersecurity solutions for protective relaying at the transmission levels • Continue research on adaptive relay settings that address bi-directional power flow • Address best practices and toolsets that will support the protective relaying workforce in an evolving grid environment	• Develop solutions for a faster response time and enhanced detection method for relay operation • Advance protective relaying methods to improve the functional integrity and effectiveness at preventing and mitigating power outages • Develop mitigations that reduce misoperations at both transmission and distribution levels • Develop solutions to distinguish between momentary and permanent faults for reclosers at the distribution level • Develop cybersecurity solutions for protective relaying at both the transmission and distribution levels • Continue research on adaptive relay settings that address bi-directional power flow • Address best practices and toolsets that will support the protective relaying workforce in an evolving grid environment	• Continue advancing protective relaying to avoid cascading outages and system blackouts • Expand the work done at the transmission level to the distribution system

Comparability Matrix

The table below shows the Small Business Innovation Research (SBIR), Technology Commercialization Fund (TCF), and workforce development funding associated with TRR in FY 2022 and FY 2023 under both the prior budget structure, where these activities were funded within TRR, and the proposed budget structure, where these activities are consolidated across OE under the new Electricity Innovation and Transition (EIT) program.

	FY 2024 Proposed Budget Structure ($K)					
	FY 2022 Enacted			FY 2023 Enacted		
	TRR	EIT	Total	TRR	EIT	Total
FY 2022 and FY 2023 Budget Structure						
Transmission Reliability & Resilience						
Transmission Reliability & Renewable Integration						
SBIR	0	160	160	0	302	302
TCF	0	44	44	0	83	83
Other TRRI	4,686	0	4,686	8,815	0	8,815
Total, TRRI	4,686	204	4,890	8,815	385	9,200
Advanced Modeling Grid Research						
SBIR	0	565	565	0	707	707
TCF	0	132	132	0	168	168
Workforce Development	0	0	0	0	1,000	1,000
Other AMGR	15,613	0	15,613	18,925	0	18,925
Total, AMGR	15,613	697	16,310	18,925	1,875	20,800
Protective Relaying						
SBIR	0	111	111	0	117	117
TCF	0	34	34	0	36	36
Other Protective Relaying	3,655	0	3,655	3,847	0	3,847
Total, Protective Relaying	3,655	145	3,800	3,847	153	4,000
Transmission Sensors						
SBIR	0	4	4	0	0	0
TCF	0	9	9	0	0	0
Other Transmission Sensors	987	0	987	0	0	0
Total, Transmission Sensors	987	13	1,000	0	0	0

	FY 2024 Proposed Budget Structure ($K)					
	FY 2022 Enacted			FY 2023 Enacted		
	TRR	EIT	Total	TRR	EIT	Total
Total, TRR	24,941	1,059	26,000	31,587	2,413	34,000
SBIR Recap	*0*	*840*	*840*	*0*	*1,126*	*1,126*
TCF Recap	*0*	*219*	*219*	*0*	*287*	*287*
Workforce Development Recap	*0*	*0*	*0*	*0*	*1,000*	*1,000*
Other TRR Recap	*24,941*	*0*	*24,941*	*31,587*	*0*	*31,587*

Energy Delivery Grid Operations Technology

Overview

The Nation's energy resilience strategy would benefit from advancements in national-scale energy analytics, including short-term (operational) and long-term (infrastructure) planning capabilities, to better characterize risk and uncertainty across multiple utility and infrastructure boundaries. Built around rigorous and quantitative assessment, sensing, prediction, and deep learning, the Energy Delivery Grid Operations Technology (EDGOT) program enhances the analytical capability needed to ensure reliable and resilient energy delivery and provides the architecture and process for identifying a range of scalable mitigation solutions to changing climate conditions and other emerging threats.

The core of the EDGOT portfolio is the North American Energy Resilience Model (NAERM). NAERM is a hybrid data/model platform for the quantitative assessment of the significant interdependencies that have evolved within the energy sector and that could affect reliability. NAERM allows for the simulation of impacts to the energy system from natural and manmade events and through collaborative partnerships, strategic insights will be accessible to utilities and other Federal agencies. NAERM will provide for enhanced planning and analysis capabilities that can be leveraged to facilitate grid investments to address these threats.

The NAERM activities focus on developing and enhancing the portfolio of tools that are needed to address grid reliability in a system with pervasive and evolving threats and challenges. NAERM will improve capability limitations and transition the underlying capabilities to a robust, secure operational state and prioritizes "what if" scenarios affecting reliability, which is essential for maintaining OE's ability to identify and advance solutions for America's grid. EDGOT's tools will support private and public efforts by:

- Utilizing a systems perspective to compare and collectively plan for impacts across organizational, geographic, sector, and jurisdictional boundaries
- Targeting collaboration on mitigations with the Department's Power Marketing Administrations (PMAs) and other energy infrastructure owners and operators to effectively address multi-regional-scale natural threats and national security concerns

The EDGOT portfolio leverages previous national laboratory efforts to fully understand the resilience risks associated with the regionally diversified North American electric system and associated infrastructure systems. National laboratories, including Argonne, Idaho, Lawrence Livermore, Los Alamos, National Renewable Energy, Oak Ridge, Pacific Northwest, Sandia, and Savannah River, have a long history of developing system-wide modeling and analysis tools, as well as transformational sensing and communications technology.

Highlights of the FY 2024 Budget Request

Predicting the impact of a specific event on energy system operations, restoration, and recovery is vexing due to the scale of the North American energy system—crossing organizational, geographic, sector, and jurisdictional boundaries—and the underlying physics of energy transport. Our current ability to analyze extreme events in this context is limited due to the lack of key information and capabilities:

- Unclassified details regarding potential threats
- Data and predictions on resulting impacts
- Tools and expertise to characterize and analyze the relationships between electricity and associated infrastructures, such as natural gas, communications, transportation, carbon management, and water
- Scripting interfaces to allow users to quickly build co-simulations and planning models
- Data availability to support infrastructure grid planning across seams, including transmission and distribution as well as grid-edge devices such as customer-owned distributed energy resources (DERs) and electric vehicles (EVs)

The Request focuses on developing and enhancing the portfolio of tools to help address these limitations and to transition the underlying capabilities to a robust, secure operational state:

- Incorporating the best available information on threat characteristics and their evolution over time
- Integrating near-real-time data feeds into the NAERM platform

- Hardening and integrating research innovations in advanced analytics to rapidly identify system vulnerabilities and enhance decision support for system analysis
- Initiating development of complex multi-infrastructure contingency analyses providing snapshots of the national resilience posture
- Enhancing and updating the infrastructure models and facilitating their integration into the NAERM architectural framework
- Expanding NAERM's operational capability in protecting and supporting the increase in data sources and access to the NAERM
- Formalizing procedures and establish partnerships for sharing data with industry stakeholders
- Engaging with industry stakeholders to get a better understanding of issues and practices on a regional basis to ensure that threat and consequence models are realistic and representative of actual system responses
- Supporting other government offices and agencies, including the Grid Deployment Office, to assess structural, operational, and contextual changes on the power grid on a regional and national level as well as identifying mitigation approaches to potential reliability concerns
- Supporting short- and long-term planning activities necessary to achieve a significant and early decarbonization of the power sector on a pathway to a net-zero carbon economy while addressing emerging threats. Activities could include optimal siting and expanded use of DERs such as energy storage, transportation electrification, and transformative resilience-by-design system solutions

Technology, tools, and applications developed under the EDGOT program will be evaluated for security risks including cybersecurity. Testing and evaluations will be conducted in coordination with OE's SecureNet program to ensure that security is embedded within these technologies.

Energy Delivery Grid Operations Technology
Funding ($K)

	FY 2022 Enacted (comparable)[a]	FY 2023 Enacted (comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Energy Delivery Grid Operations Technology					
North American Energy Resilience Model (NAERM)					
NAERM Operations	8,000	14,000	14,000	0	0.0%
NAERM Upgrades	0	16,614	16,000	-614	-3.7%
Total, NAERM	8,000	30,614	30,000	-614	-2.0%
Silicon Carbide Semiconductors	4,791	0	0	0	N/A
Total, Energy Delivery Grid Operations Technology	**12,791**	**30,614**	**30,000**	**-614**	**-2.0%**

Energy Delivery Grid Operations Technology
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• NAERM Upgrades: The reduction results from the completion of data access and system architecture efforts using FY 2023 funding, allowing prioritization in FY 2024 on the development of "what if" scenarios affecting reliability	-614

[a] The FY 2024 Request proposes to consolidate all Small Business Innovation Research, Technology Commercialization Fund, and workforce development activities under the new Electricity Innovation and Transition (EIT) program. To allow an apples-to-apples comparison, FY 2022 and FY 2023 are shown as if this approach had been in place since FY 2022, moving $537,000 in FY 2022 and $386,000 in FY 2023 from EDGOT to EIT. Details are shown under the Comparability Matrix section below.

Activities and Explanation of Changes

FY 2023 Enacted (comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy Delivery Grid Operations Technology $30,614,000	**$30,000,000**	**-$614,000**
NAERM Operations $14,000,000	*$14,000,000*	*$0*
• NAERM begins operations in FY 2023	• Expand the users of NAERM to include industry stakeholders • Shift NAERM concentration from real-time situational awareness to the short- and long-term planning time frame	• Expand the user group beyond National Laboratories and government agencies to include industry stakeholders such as NERC
NAERM Upgrades $16,614,000	*$16,000,000*	*-$614,000*
• Create transmission/distribution planning tool • Create DER network planning tool • Expand climate change natural threat modeling to include climate change awareness impact to the grid	• Enhance the already-developed tools to support short- and long-term planning activities necessary to significantly accelerate decarbonization of the power sector in the context of emerging threats	• A number of models and tools developed for NAERM are fully developed and integrated into NAERM such as a static gas model and a static gas-electricity simulation tool • Data access and system architecture that enables additional tools to be easily integrated into NAERM will be completed with FY 2023 funding

Comparability Matrix

The table below shows the Small Business Innovation Research (SBIR) and Technology Commercialization Fund (TCF) funding associated with EDGOT in FY 2022 and FY 2023 under both the prior budget structure, where these activities were funded within EDGOT, and the proposed budget structure, where these activities are consolidated across OE under the new Electricity Innovation and Transition (EIT) program. It also shows a comparability adjustment from the FY 2022 structure to the FY 2023 structure, to reflect Congress moving the DarkNet activity from EDGOT in the FY 2022 enacted appropriation to SecureNet in the FY 2023 enacted appropriation.

	FY 2024 Proposed Budget Structure ($K)						
	FY 2022 Enacted				FY 2023 Enacted		
	EDGOT	SecureNet	EIT	Total	EDGOT	EIT	Total
FY 2022 and FY 2023 Budget Structure							
Energy Delivery Grid Operations Technology							
NAERM Operations	8,000	0	0	8,000	14,000	0	14,000
NAERM Upgrades							
SBIR	0	0	0	0	0	248	248
TCF	0	0	0	0	0	138	138
Other NAERM Upgrades	0	0	0	0	16,614	0	16,614
Total, NAERM Upgrades	0	0	0	0	16,614	386	17,000
Darknet							
SBIR	0	0	238	238	0	0	0
TCF	0	0	90	90	0	0	0
Other Darknet	0	9,672	0	9,672	0	0	0
Total, Darknet	0	9,672	328	10,000	0	0	0
Silicon Carbide Semiconductors							
SBIR	0	0	164	164	0	0	0
TCF	0	0	45	45	0	0	0
Other SiC Semiconductors	4,791	0	0	4,791	0	0	0
Total, SiC Semiconductors	4,791	0	209	5,000	0	0	0
Total	12,791	9,672	537	23,000	30,614	386	31,000
SBIR Recap	*0*	*0*	*402*	*402*	*0*	*248*	*248*
TCF Recap	*0*	*0*	*135*	*135*	*0*	*138*	*138*
Other Activities Recap	*12,791*	*9,672*	*0*	*22,463*	*30,614*	*0*	*30,614*

Resilient Distribution Systems

Overview

Resilient, reliable, and affordable electricity is a cornerstone for equitable economic growth and job creation, a critical platform to address climate change, and a foundation for communities to grow and attract new businesses and meet energy demands. Much of the electrical distribution system—infrastructure delivering power from the transmission system to individual businesses and homes—was designed and built using engineering principles established over 100 years ago. Yet this same distribution system is facing dramatic changes: accelerated distribution of energy supply, increased electrification, growing consumer participation, and continued energy efficiency and conservation. The growing convergence of transmission and distribution (T&D) systems requires new architectural, control, and operational approaches. Along with significant benefits and opportunities, these changes also present significant operational challenges. As the electricity distribution system continues to evolve and its complexity increases, new technologies are needed that enable changes to the way the electric grid is planned and operated. For utilities to collaborate with an increasingly capable grid edge and maintain reliable and resilient operations, they require tools and capabilities to enhance observability, control, and dynamic protection across all distribution system assets.

The Resilient Distribution Systems (RDS) program focuses on addressing electric grid challenges by developing transformative technologies, tools, and techniques to enable industry to keep pace with emerging and evolving conditions that necessitate modernization of the distribution network to ensure continued reliability and resilience. It also coordinates the planning, design, and operations with transmission and distributed energy resources (DERs). RDS activities assist in increasing electrification of the economy and integrating multiple grid edge resources that improve the reliability and resilience of the system. RDS pursues strategic investments in innovative technologies and practices that improve reliability, increase resilience, support vehicle electrification, integrate clean DERs, and provide consumers with more choices for managing their energy consumption.

Microgrid research and development (R&D) focuses on developing and validating new technologies and methods to improve grid reliability and resilience under both normal and disruptive conditions while enabling distributed energy resource (DER) integration, enhancing consumer participation and choice, and driving grid technology innovation. Microgrid investments have successfully enhanced reliability, resilience, and efficiency, particularly at the community level, and continue to be an RDS focus area. As microgrid technology evolves to further improve grid performance, microgrids are envisioned to be essential building blocks of the future electric grid.

Dynamic Controls R&D investigates new approaches and technologies to enhance the electric distribution grid's ability to harness flexibility across all distribution assets. This includes expanded sensor research to increase situational awareness at the distribution level, which provides the ability to withstand and recover from disruptions caused by extreme weather events and man-made events, as well as supporting normal operations. In addition, Dynamic Controls explores the local, regional, and structural implications of transportation electrification, among other transformative grid edge influences.

The integrated planning component of the program develops transformative methods, tools, and guidelines through collaborative efforts with the electric utility industry, including regulators and consumer advocates, that enable the formulation of staged strategies for transitioning to an advanced, decarbonized, and resilient electric grid. These strategies will address technological and institutional issues associated with the implementation of advanced grid capabilities by the industry. They will also include advancing integrated planning practices leading to coherent grid investment strategies that apply advanced technologies to meet reliability, resilience, decarbonization, efficiency, equity, and flexibility objectives.

RDS research results will enable the industry to strengthen electrical infrastructure reliability and resilience and support the ongoing evolution of the electric grid in a manner that supports a just transition to a decarbonized economy.

Highlights of the FY 2024 Budget Request

<u>Microgrids</u>

- Microgrid Building Blocks (MBBs): This subprogram will continue development of MBBs as the fundamental base to reduce microgrid deployment costs and time. Going beyond current microgrid functionalities, such as supporting local resilience and integrating distributed generation, the virtual MBB prototype designs developed in FY 2023 will feature

functions for a wide range of microgrids and provide modular and standard interfaces to generation, load, control facilities, and the utility system. Modeling and simulation activities will validate the performance of the virtual MBB prototype performance designs in FY 2024.

- Networked Microgrids: Developing modeling and simulation capabilities for optimal system design and operations of networked microgrids continues. Networking two or more microgrids that share loads and complementary power resources can increase their combined resilience during power outages, while lowering capital and operational costs for normal operations. FY 2024 work will apply advanced modeling and simulation capabilities developed in FY 2023 in the use case to support a range of resiliency and decarbonization operations at U.S. ports. Networked microgrid R&D will focus on enabling DynaGrid, a concept to enable dynamic formation of microgrid boundaries for optimized operations under both normal and emergency conditions, laying the foundation for a future fractal grid composed of dynamically formed microgrids in a repetitive pattern. Realistic use cases developed in FY 2023 will be evaluated and demonstrated in FY 2024. This activity is expected to accommodate larger-scale integration of DERs and electrification envisioned for the future grid.
- Development of protection schemes for microgrids with high penetration of inverter-based resources (IBRs) and development of new microgrid fault location algorithms using real-time sensor data and analytics will continue for both singular and networked microgrids. Protection research for secondary networks involving DERs and microgrids will also continue.
- Net-Zero Microgrids (NZMs): NZM activity will follow its Technical Studies Guidance report published in 2021. Work will continue on modeling and simulation of a microgrid design with integrated small modular reactors as part of the generation mix to investigate power system engineering issues involving microgrid operations and integrated operations with the grid to provide grid services.

Dynamic Controls

Dynamic Controls R&D activities will support priorities on grid resilience and dynamically sourced grid support services to transform distribution grid infrastructure. FY 2024 activities will be supported in the following areas:

- Dynamic Controls: Research will expand on grid service guarantees matching the level of certainty for centralized single-owner control systems. Blockchain and other digital-ledger technology concepts will be explored through public–private partnerships in academia and industry for the purposes of secure peer-to-peer transactions, high integrity distributed data stores, and secure computing platforms in untrusted environments.
- Grid Data Science: R&D activities will develop highly resilient distribution designs accommodating evolving electricity supply and adapting to extreme events and disruptions. Data flow across ownership boundaries creates the need for new data integrity methods, data sharing agreements, and coordination frameworks. The effort will also extend the linkage between secure distributed compute environments and their associated impacts on data transport architectures within the utility environment.
- Transport Electrification: The increased linkage between the electric and transportation sectors creates interdependencies that can have both positive and negative effects. Sector Coupling Analysis will look at structural and architectural aspects, seeking to establish a converged perspective on reliability, sustainability, and resilience across both transportation and electricity. In parallel, the subprogram will develop control and coordination approaches that address vehicle grid integration issues through both nodal and network solution paths, encompassing all grid and DER assets and their incentive mechanisms.

Sensors

Sensors activities will support the development of increasingly diverse information-gathering devices and systems, advanced data analytics, and their integration into the power grid.

The Sensors subprogram seeks to revolutionize the use of these technologies in electricity operations and delivery—from transmission to distribution to end-use load, including behind-the-meter DER—for improved diagnostics and prediction of system variables and assets during normal and extreme-event conditions. Distribution system visibility is lagging transmission-level visibility, and reducing this asymmetry is important for the full participation of distribution in markets and system planning. Distribution system sensing advancements will facilitate better two-way power flow across the T&D system. Tools developed for sensor management and data analytics will enable utilities to better forecast and react to changes in generation from DERs and load to maintain reliability and reduce costs. This could include advanced contingency

analysis and improved simulations of dynamic behavior, such as those related to IBRs in the distribution system. Distribution sensors, and their associated tools and analytics, provide the foundation for enhanced observability, predictability, and flexibility—from advanced distribution management systems to microgrid controllers to distributed controls.

Electricity Delivery Systems

RDS works closely with industry stakeholders, including regulators, utilities, states, and communities, through the integrated planning component of the program to address both technological and institutional issues and develop strategies to enable a just transition to a modern electricity delivery system. This aspect of the program is focused on the formulation of coherent strategies for achieving needed functional and structural features of the electric grid through the application of grid architecture and the advancement of integrated grid planning practices. Efforts include:

- Working collaboratively with various associations (NARUC, NASEO, NRECA, APPA, NGA, and NCSL) through formal arrangements to engage their respective stakeholders to advance methods for incorporating resilience, decarbonization, and energy justice into utility planning practices; undertake demonstration projects that apply renewable and advanced grid technologies within underserved communities; address interjurisdictional oversight issues related to grid and market operations that cross transmission, distribution, and behind-the-meter domains; and institute practical grid modernization strategies, including the provision of training to inform state officials of best practices.
- Developing reference design architectures for the distribution system that can accommodate many forms of distributed IBRs, ownership models, and market structures, and ensuring an effective transfer of know-how to the industry, including regulators.
- Producing Voluntary Model Pathways (per Section 8008 of the Energy Act of 2020) in concert with the industry to identify technological and institutional barriers to the attainment of a resilient, decarbonized, and equitable electricity delivery system, and developing transitional, coordinated strategies for addressing them.
- Evolving integrated distribution system planning practices with regulators and utilities that begin to address myriad issues associated with the integration and utilization of DERs, as well as how to develop rational, staged technology investment strategies that incorporate multiple objectives, including decarbonization, resilience, flexibility, and energy justice with traditional planning objectives, in a balanced, holistic manner.
- A set of practical design guidelines that address operational coordination requirements to enable evolving industry, business, and market structures at the grid edge (e.g., community microgrids, virtual power plants, and electric vehicle infrastructure) to interface with the electric grid, as well as share services across T&D system domains.

Technology, tools, and applications developed under RDS will be evaluated, in conjunction with SecureNet testbed capabilities, for security risks including cybersecurity. Testing and evaluations will be conducted to ensure that security is built into these technologies and new security risks are not being introduced into the electric sector.

OE coordinates with the Office of Energy Efficiency and Renewable Energy (EERE) and other relevant DOE programs through the Grid Modernization Initiative and regular programmatic outreach to ensure the programs support complementary R&D and avoid duplication.

Resilient Distribution Systems
Funding ($K)

	FY 2022 Enacted (comparable)[a]	FY 2023 Enacted (comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Resilient Distribution Systems					
Microgrids	7,711	5,782	14,000	+8,218	+142.1%
Dynamic Controls & Communications	11,539	8,652	20,000	+11,348	+131.2%
Sensors	9,910	0	6,800	+6,800	N/A
Electricity Delivery Systems	4,812	4,877	6,500	+1,623	+33.3%
Modeling Distributed Energy Resources	0	4,836	0	-4,836	-100.0%
Sensors Demonstration	0	14,701	0	-14,701	-100.0%
COMMANDER National Testbed Laboratory	9,654	4,827	0	-4,827	-100.0%
Underserved & Indigenous Community Microgrids	9,874	9,873	0	-9,873	-100.0%
Total, Resilient Distribution Systems	**53,500**	**53,548**	**47,300**	**-6,248**	**-11.7%**

Resilient Distribution Systems
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• Microgrids: The increase supports MBB development, advancing the performance of the virtual prototype designs	+8,218
• Dynamic Controls & Communications: The increase expands sector coupling analysis to look at structural and architectural aspects as well as control and coordination approaches addressing vehicle grid integration issues through both nodal and network solution paths encompassing all grid and DER assets and their incentive mechanisms. The increase also supports research related to data flow across ownership boundaries, addressing the need for new data integrity methods, data sharing agreements, and coordination frameworks	+11,348
• Sensors: The increase supports the development and integration of increasingly diverse information-gathering devices and systems and advanced data analytics into the electricity delivery system	+6,800

[a] The FY 2024 Request proposes to consolidate all Small Business Innovation Research, Technology Commercialization Fund, and workforce development activities under the new Electricity Innovation and Transition (EIT) program. To allow an apples-to-apples comparison, FY 2022 and FY 2023 are shown as if this approach had been in place since FY 2022, moving $1,500,000 in FY 2022 and $1,452,000 in FY 2023 from RDS to EIT.

	FY 2024 Request vs FY 2023 Enacted
• Electricity Delivery Systems: Supports more robust stakeholder engagement to vet and share guidelines around integrated distribution system planning (IDSP), operational coordination and distribution system reference designs	+1,623
• Modeling Distributed Energy Resources: Planned activities for this congressionally directed activity are completed with funding provided in FY 2023	-4,836
• Sensors Demonstration: Planned activities for this congressionally directed activity are completed with funding provided in FY 2023	-14,701
• COMMANDER National Testbed Laboratory: Planned activities for this congressionally directed activity are completed with funding provided in FY 2023	-4,827
• Underserved & Indigenous Community Microgrids: Planned activities for this congressionally directed activity are completed with funding provided in FY 2023	-9,873
Total, Resilient Distribution Systems	**-6,248**

Resilient Distribution Systems

Activities and Explanation of Changes

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Resilient Distribution Systems $53,548,000	**$47,300,000**	**-$6,248,000**
Microgrids $5,782,000	*$14,000,000*	*+8,218,000*
• Conduct R&D on the DynaGrid concept to enable dynamic formation of microgrid boundaries for optimized operations of networked microgrids, building on the RONM capabilities developed for static-boundary applications	• Conduct R&D on the DynaGrid concept to enable dynamic formation of microgrid boundaries for optimized operations of networked microgrids, building on the RONM capabilities developed for static-boundary applications	• Increase support of the multi-lab MBB development to advance the performance of the virtual prototype designs
• Develop modeling and simulation capabilities for optimal system design and operation of networked microgrids for decarbonization and resilience of critical infrastructure with a focus of the use case on ports	• Apply modeling and simulation capabilities for optimal system design and operations of networked microgrids for decarbonization and resilience of critical infrastructure in a use case on ports	
• Complete the design of virtual MBB prototypes for microgrid communications and control	• Conduct modeling and simulation to validate the performance of the virtual MBB designs and performance	

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Develop modeling and simulation of a small-modular-reactor-integrated microgrid design to examine power system engineering issues and operational challenges for providing grid services • Develop protection schemes for microgrids (singular and networked) with high penetration of IBRs and for secondary networks with DERs and microgrids	• Develop modeling and simulation of a small-modular-reactor-integrated microgrid design to examine power system engineering issues and operational challenges for providing grid services • Develop protection schemes for microgrids (singular and networked) with high penetration of IBRs and for secondary networks with DERs and microgrids	
Dynamic Controls & Communications $8,652,000	*$20,000,000*	*+$11,348,000*
• Develop data efficient operations approach with increased reliance on combinations of distributed control and incentivization of flexible DER for reliability and resilience • Develop a broad framework for data sharing across ownership and responsibility boundaries that assures data security, integrity, and privacy while ensuring operational objectives of all stakeholders are attained • Extend Sector Coupling Analysis of the transportation and electricity sectors including structural and architectural aspects, seeking to establish a converged perspective on reliability, sustainability, and resilience across both transportation and electricity • Develop control and coordination approaches that address vehicle grid integration issues through nodal and network solution paths, encompassing all grid and DER assets and their incentive mechanisms	• Publish a data efficient operations methodology with increased reliance on combinations of distributed control and incentivization of flexible DER for reliability and resilience • Overcome value stacking barriers associated with current T&D operational and market structures to maximize utilization of grid edge resources • Drive industry consensus on complex data sharing challenges across ownership and responsibility boundaries that assures data security, integrity, and privacy while ensuring operational objectives of all stakeholders are attained • Apply the Sector Coupling Analysis of the transportation and electricity sectors to propose new reliability index targets for existing metrics and construct new metrics where these newly interdependent systems require them • Develop coordinated control options that reduce distributions system upgrade capital requirements by 25%, utilizing grid and DER asset combinations and their incentive mechanisms • Engage digital ledger technology (DLT) industry in generating testable pilots applying DLT to operational challenges	• The combination of electrification and decarbonization requires transformative control approaches to keep electricity affordable, reliable, and resilient; more aggressive efforts are required in both R&D and demonstration • Expand data science approaches in the rapidly expanding grid-edge, collaborative control frontier, strengthening coordination capabilities and enabling decarbonized and resilient systems • Anticipate the substantial impact of transportation electrification through increased research on interdependency, adaptation of distribution systems, and coordination of optimizations across new and legacy participants in the electric system

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Sensors $0	*$6,800,000*	*+$6,800,000*
	• Develop approaches and tools that will accurately detect, characterize, and forecast DER behavior and its impacts on electric power systems at high penetration levels • Expand sensor research related to enhanced power system resilience, enabling better prediction of, response to, and recovery from critical events • Investigate, develop, and demonstrate sensor technologies applicable to real-time monitoring of critical infrastructure interdependencies, including development and promotion of methodologies for improved sensor selection, valuation assessment, and cost/benefit allocation • Support a prize program for data analytics tool development utilizing utility data sets, to catalyze independent and academic research into equity and integration of DERs	• Develop and integrate high-fidelity, fast-acting sensor technologies and advanced data analytics into the electricity delivery system
Electricity Delivery Systems $4,877,000	*$6,500,000*	*+$1,623,000*
• Advance ISDP practices with regulators and the industry that enable the formulation of holistic technology investment strategies that address multiple objectives (including resilience, energy justice, and decarbonization) and enable the utilization of DERs • Develop architecture-based guidelines to enable DER coordination to support grid and market operations across the transmission, distribution, and behind-the-meter domains	• Continue development of IDSP practices with the development of guidelines, vetted through stakeholder processes with regulators and utilities, in several key areas including cost-effectiveness frameworks, resilience planning, and multi-objective prioritization • Continue to work with the national associations to vet and advance this this work for practical applications by States	• Supports more robust stakeholder engagement to vet and share guidelines around IDSP, operational coordination and distribution system reference designs, and additional efforts to work directly with states through direct technical assistance, education, and training activities to advance these emerging, leading practices

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Apply key grid architecture principles to develop reference designs for a distribution system to address the application of DERs in T&D markets, reliability, and resilience through the use of microgrids and power flow requirements to enable the real-time application of all grid assets • This begins in FY 2023 and is expected to continue through FY 2025 • Establish and use formal working groups with several national associations (NARUC, NASEO, NRECA, NGA, NCSL, and APPA) to vet and disseminate advanced practices and guidelines for integrated distribution system planning and operational coordination, as well as to provide technical assistance in these areas	• Complete reference architectures for use of DERs in T&D markets and for improving reliability and resilience using microgrids and continue work on a reference design for controlling power flow in a highly dynamic grid • Develop staged approaches for deploying these capabilities through focused efforts with the industry • Finalize guidelines for the operational coordination of DERs in T&D markets and develop grid codes to set roles and responsibilities among all participants	
Modeling Distributed Energy Resources $4,836,000	*$0*	*-$4,836,000*
• Explore existing DER modeling and develop standardized approaches to facilitate improvements in resilience and reliability metrics for utilities and regulators to inform short- and long-term planning efforts		• Planned activities for this congressionally directed activity are completed with funding provided in FY 2023
Sensors Demonstration $14,701,000	*$0*	*-$14,701,000*
• Demonstrate sensor analytics with industry to allow for better utilization of existing sensors, facilitate data integration from disparate sensors, and inform sensor placement • Demonstrate sensor analytic tools to help accelerate industry utilization of advanced sensor data, improving resilience and operations • Demonstrate grid models and tools to optimize the monitoring effectiveness and cost of sensor placements		• Planned activities for this congressionally directed activity are completed with funding provided in FY 2023

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Continue to fund a prize program for data tool demonstrations in partnership with utilities and their system data sets to catalyze independent academic research into equity and integration of DERs		
COMMANDER National Testbed Laboratory *$4,827,000*	*$0*	*-$4,827,000*
• Activities include evaluating the current and future role of microgrids and DERs in distribution system operation • Enhancement of testbed resources, data flows and exchanges, and understanding the impacts of ownership boundaries in coordinated operation, system security, and economic optimization		• Planned activities for this congressionally directed activity are completed with funding provided in FY 2023
Underserved & Indigenous Community Microgrids Delivery Systems $9,873,000	*$0*	*-$9,873,000*
• Release the Underserved and Indigenous Community Microgrids (UICM) funding opportunity announcement (FOA) to seek projects providing replicable microgrid solutions for underserved and Indigenous communities • Award competitively selected projects under the UICM FOA		• Planned activities for this congressionally directed activity are completed with funding provided in FY 2023

Comparability Matrix

The table below shows the Small Business Innovation Research (SBIR) and Technology Commercialization Fund (TCF) funding associated with RDS in FY 2022 and FY 2023 under both the prior budget structure, where these activities were funded within RDS, and the proposed budget structure, where these activities are consolidated across OE under the new Electricity Innovation and Transition (EIT) program.

	FY 2024 Proposed Budget Structure ($K)					
	FY 2022 Enacted			FY 2023 Enacted		
	RDS	EIT	Total	RDS	EIT	Total
FY 2022 and FY 2023 Budget Structure						
Resilient Distribution Systems						
Microgrids						
SBIR	0	217	217	0	164	164
TCF	0	72	72	0	54	54
Other Microgrids	7,711	0	7,711	5,782	0	5,782
Total, Microgrids	7,711	289	8,000	5,782	218	6,000
Dynamic Controls & Communications						
SBIR	0	358	358	0	271	271
TCF	0	103	103	0	77	77
Other DC&C	11,539	0	11,539	8,652	0	8,652
Total, DC&C	11,539	461	12,000	8,652	348	9,000
Sensors						
TCF	0	90	90	0	0	0
Other Sensors	9,910	0	9,910	0	0	0
Total, Sensors	9,910	90	10,000	0	0	0
Electricity Delivery Systems						
SBIR	0	143	143	0	78	78
TCF	0	45	45	0	45	45
Other EDS	4,812	0	4,812	4,877	0	4,877
Total, EDS	4,812	188	5,000	4,877	123	5,000

	FY 2024 Proposed Budget Structure ($K)					
	FY 2022 Enacted			FY 2023 Enacted		
	RDS	EIT	Total	RDS	EIT	Total
Modeling Distributed Energy Resources						
SBIR	0	0	0	0	119	119
TCF	0	0	0	0	45	45
Other MDER	0	0	0	4,836	0	4,836
Total, MDER	0	0	0	4,836	164	5,000
Demo Sensors						
SBIR	0	0	0	0	164	164
TCF	0	0	0	0	135	135
Other Demo Sensors	0	0	0	14,701	0	14,701
Total, Demo Sensors	0	0	0	14,701	299	15,000
COMMANDER National Testbed Laboratory						
SBIR	0	256	256	0	128	128
TCF	0	90	90	0	45	45
Other COMMANDER	9,654	0	9,654	4,827	0	4,827
Total, COMMANDER	9,654	346	10,000	4,827	173	5,000
Underserved & Indigenous Community Microgrids						
SBIR	0	36	36	0	37	37
TCF	0	90	90	0	90	90
Other Underserved & Indigenous Community Microgrids	9,874	0	9,874	9,873	0	9,873
Total, Underserved & Indigenous Community Microgrids	9,874	126	10,000	9,873	127	10,000
Total, RDS	53,500	1,500	55,000	53,548	1,452	55,000
SBIR Recap	*0*	*1,010*	*1,010*	*0*	*961*	*961*
TCF Recap	*0*	*490*	*490*	*0*	*491*	*491*
Other Activities Recap	*53,500*	*0*	*53,500*	*53,548*	*0*	*53,548*

Cyber Resilient and Secure Utility Communications Networks

Overview

Our Nation's energy system is heavily dependent on data communications and cyber-physical controls for operational reliability and resilience. The evolution of the electric grid to include more distributed assets increases demands on this infrastructure to enable observability under more dynamic conditions. At the same time, these distributed assets present a broader cyberattack surface for increasingly sophisticated adversaries to exploit. The modernization of communications and control systems—to include integrated cybersecurity—is essential to ensure the efficient, reliable, and resilient operation the electrical power system in a complex and dynamic risk landscape.

The Cyber Resilient and Secure Utility Communications Networks (SecureNet) program develops solutions to strengthen both the security and resilience of the electricity delivery system against cyber-related threats through a security-by-design approach for operational data, communications networks, and control systems.

The program pursues this goal in three ways:

- Supporting next-generation grid communications research and development (R&D) for systems built from inception to mitigate communication failures and detect, reject, and withstand cyber incidents and other disruptions
- Applying a cybersecurity lens to relevant OE R&D activities, ensuring that they have an embedded security-by-design philosophy throughout development and address cybersecurity concerns through design modifications or operational change
- Engaging with the Department's cyber-related operational activities, including those in the Office of Cybersecurity, Energy Security, and Emergency Response (CESER) and the Office of Intelligence and Counterintelligence, to ensure OE's R&D activities are responsive to operational needs, develop a broad base of scientific and technical expertise in grid communications and controls cybersecurity to support of the Department's national security mission, and strengthen public-private sector outreach, information sharing, and training in this area

Highlights of the FY 2024 Budget Request

The SecureNet program will develop technical solutions to accelerate and expand efforts to strengthen electricity communications infrastructure against cyber threats. The program's core R&D focus is on cybersecurity and resilience for grid communications and data networks, including enabling components and technologies such as synchronization/timing and blockchain. The program also includes collaboration across the OE R&D portfolio to ensure cybersecurity is considered in those activities and partnership and outreach with other DOE, Federal, and public stakeholders. SecureNet will also be a key element of the Grid Modernization Initiative, including the Grid Modernization Laboratory Consortium (GMLC).

The Request includes two categories of R&D activities:

- Secure Communications Network R&D: the Request supports continued research on secure utility communications, including the development of an architectural framework and technology roadmap for communications infrastructure that meets utility systems' functional and performance requirements. This architecture and roadmap will be informed by utility stakeholder feedback and model-based analysis and will in turn be the foundation for university research, pilot demonstrations with industry, other technology R&D activities, and standards development. This activity also includes information sharing and training to help develop the next generation of secure grid communications specialists.
- Grid Technology Cyber Resilience R&D: the Request includes R&D activities in support of other programs in the OE portfolio to ensure cybersecurity and cyber-resilience are built into new technologies for grid coordination, operation, and control. Activities may include modeling cyber aspects of future grid scenarios, researching cyber-hardening new grid technologies, and providing cyber design inputs, testing capabilities, and cyber vulnerability assessments to other OE R&D programs.

Cyber Resilient and Secure Utility Communications Networks (SecureNet)
Funding ($K)

	FY 2022 Enacted (Comparable)[a]	FY 2023 Enacted (Comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Cyber Resilient and Secure Utility Communications Networks (SecureNet)					
Secure Communications Network R&D	9,000	0	10,000	+10,000	N/A
Grid Technology Cyber Resilience R&D	1,700	0	5,000	+5,000	N/A
Darknet	9,672	9,673	0	-9,673	-100.0%
Distribution Communications and Control Technologies	0	4,918	0	-4,918	-100.0%
Total, Cyber Resilient and Secure Utility Communications Networks (SecureNet)	**20,372**	**14,591**	**15,000**	**+409**	**+2.8%**

Cyber Resilient and Secure Utility Communications Networks (SecureNet)
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• Secure Communications Network R&D: Builds on FY 2022 grid communications architecture development, technology R&D, and stakeholder partnership activities	+10,000
• Grid Technology Cyber Resilience R&D: Supports addressing cybersecurity and resilience considerations in existing OE research, development, and demonstration programs, with particular focus on communications-enabled, highly distributed components	+5,000
• Darknet: Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023	-9,673
• Distribution Communications and Control Technologies: Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023	-4,918
Total, Cyber Resilient and Secure Utility Communications Networks (SecureNet)	**+409**

[a] The FY 2024 Request proposes to consolidate all Small Business Innovation Research, Technology Commercialization Fund, and workforce development activities under the new Electricity Innovation and Transition (EIT) program. Additionally, FY 2022 activities for University Research and Cyber Assessments and Technology are consolidated in FY 2024 under the Secure Communications Network R&D subprogram and the FY 2023 appropriation moved Darknet activities from Energy Delivery Grid Operations Technology to SecureNet. To allow an apples-to-apples comparison, FY 2022 and FY 2023 are shown as if these structure changes had been in place since FY 2022. Details of these adjustments are shown in the Comparability Matrices section below.

Cyber Resilient and Secure Utility Communications Networks (SecureNet)

Activities and Explanation of Changes

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Cyber Resilient and Secure Utility Communications Networks (SecureNet) $14,591,000	**$15,000,000**	**+$409,000**
Secure Communications Network R&D $0	*$10,000,000*	*+$10,000,000*
	• Develop an architectural framework and technology roadmap for grid communications infrastructure • Improve communications technology development related to the electricity delivery system through research partnerships • Build knowledge and capacity through stakeholder engagement	• Continue and build on grid communications R&D activities funded in FY 2022
Grid Technology Cyber Resilience R&D $0	*$5,000,000*	*+$5,000,000*
	• Support cybersecurity research related to existing OE R&D programs, including those featuring communications-enabled, highly distributed components	• Continue and build on cybersecurity and resilience R&D activities funded in FY 2022
Darknet $9,673,000	*$0*	*-$9,673,000*
• Continue R&D activities to shield the Nation's electricity infrastructure from disruptive cyber penetration, including expansion of the communications network architecture and development of cutting-edge networking technologies		• Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023
Distribution Communications and Control Technologies $4,918,000	*$0*	*-$4,918,000*
• Research, evaluate, and commission new distribution communications and control technologies for a secure smart grid		• Planned activities for this congressionally directed activity will be completed with funding provided in FY 2023

Comparability Matrices

The tables below show Small Business Innovation Research (SBIR) and Technology Commercialization (TCF) funding associated with SecureNet in FY 2022 and FY 2023 under both the prior budget structure, where these activities were funded within SecureNet, and the proposed budget structure, where these activities are consolidated across OE under the new Electricity Innovation and Transition program. Additionally, they show the reallocation within SecureNet from the subprograms proposed in FY 2022 to the subprograms proposed in FY 2024, and the change in the FY 2023 appropriation to move funding for DarkNet from Energy Delivery Grid Operations Technology (EDGOT) to SecureNet.

FY 2022 Enacted Appropriation Comparability Matrix

	FY 2024 Proposed Budget Structure ($K)						
	SecureNet				EDGOT	EIT	Total
	Secure Comms. Network R&D	Grid Tech Cyber Resilience R&D	Darknet	Total			
FY 2022 Budget Structure							
SecureNet							
University Research							
SBIR	0	0	0	0	0	98	98
TCF	0	0	0	0	0	26	26
Other University Research	2,339	537	0	2,876	0	0	2,876
Total, University Research	2,339	537	0	2,876	0	124	3,000
Cyber Assessments and Technology							
SBIR	0	0	0	0	0	253	253
TCF	0	0	0	0	0	73	73
Other Cyber Assessments and Technology	6,661	1,163	0	7,824	0	0	7,824
Total, Cyber Assessments and Technology	6,661	1,163	0	7,824	0	326	8,150
Total, SecureNet	9,000	1,700	0	10,700	0	450	11,150
SBIR Recap	*0*	*0*	*0*	*0*	*0*	*351*	*351*
TCF Recap	*0*	*0*	*0*	*0*	*0*	*99*	*99*
Other Activities Recap	*9,000*	*1,700*	*0*	*10,700*	*0*	*0*	*10,700*

	FY 2024 Proposed Budget Structure ($K)						
	SecureNet				EDGOT	EIT	Total
	Secure Comms. Network R&D	Grid Tech Cyber Resilience R&D	Darknet	Total			
Energy Delivery Grid Operations Technology							
DarkNet	0	0	9,672	9,672	0	0	9,672
Other EDGOT	0	0	0	0	12,791	0	12,791
Total, EDGOT	0	0	9,672	9,672	12,791	0	22,463
Total, FY 2022 Budget Structure	9,000	1,700	9,672	20,372	12,791	450	33,613

FY 2023 Enacted Appropriation Comparability Matrix

	FY 2024 Proposed Budget Structure ($K)		
	SecureNet	EIT	Total
FY 2023 Budget Structure			
SecureNet			
Darknet			
SBIR	0	237	237
TCF	0	90	90
Other Darknet	9,673	0	9,673
Total, Darknet	9,673	327	10,000
Distribution Communications & Control Technology			
SBIR	0	37	37
TCF	0	45	45
Other Distribution Comms & Control Tech	4,918	0	4,918
Total, Distribution Comms & Control Tech	4,918	82	5,000
Total, SecureNet	14,591	409	15,000
SBIR Recap	*0*	*274*	*274*
TCF Recap	*0*	*135*	*135*
Other Activities Recap	*14,591*	*0*	*14,591*

Energy Storage

Overview

The Energy Storage program accelerates bi-directional electrical energy storage technologies as a key component of a reliable, resilient, and affordable future-ready grid. Energy storage is the major enabler of a 100% carbon pollution-free electricity grid; provides new tools to improve grid resiliency, especially in underserved communities; and creates new options for infrastructure planning, from deferral to rapid expansion.

While pumped-storage hydropower (PSH) and lithium-ion batteries are already common on the grid, new technologies with more flexible siting, more modularity, and lower marginal duration cost attributes will dramatically expand where storage can be beneficially deployed. OE Storage research, development, demonstration, and deployment (RDD&D) efforts accelerate the development of long duration grid storage technologies through increasing amounts of stored energy and operational durations, reducing technology costs, de-risking technologies to ensure safe long-term reliability, developing analytic models to uncover technical and economic benefits, and demonstrating how storage provide clean and equitable energy access for consumers and communities. The program has four primary focus areas:

- Cost-Competitive and Long-Duration Technology Development
  - This focus area resolves key cost and performance challenges for earth-abundant, domestically available storage technologies with an emphasis on longer-duration (10+ hour) technologies.
  - OE supports flow, sodium, zinc manganese dioxide, and lead-based batteries as part of a portfolio of the most promising innovative battery chemistries for cost reduction. Under the Long Duration Energy Storage Earthshot's target to reduce the cost of grid-scale energy storage by 90% for systems that deliver 10+ hours of duration within the decade, OE is seeking to realize a 5¢/kWh levelized cost basis for stationary, 10+ hour duration applications.
  - Within each chemistry, major improvements are anticipated in electrode materials, membranes, and electrolytes. Additional crosscutting research and development (R&D) areas include interconnections, power electronics, and power conversion systems.
- Validated Reliability and Safety
  - This focus area improves the understanding and predictability of energy storage systems and components under realistic grid use cases, fostering greater confidence in the safety and reliability of energy storage systems.
  - Major stakeholders in this focus area include fire departments, building managers, and other approval authorities.
- Analytics for an Equitable Regulatory and Social Environment
  - This focus area assists stakeholders, including small end users, utilities, regulatory agencies, and investors, in understanding optimal storage sizing, placement, operation, and valuation, as well as quantifying environmental and social impacts.
  - These assistance activities are enabled through the development of new analytical and open-source tools, performance protocols, and advanced control systems.
- Grid and Field Validation
  - This focus area helps end users gain confidence in the economic viability of storage through real-world validation of storage tools and models.
  - Similarly, the Rapid Operational Validation Initiative (ROVI), a cross-cutting performance analytical framework, will help users build confidence in the long-term operational reliability of new storage technologies.

Highlights of FY 2024 Budget Request

The Request continues support for the program's core R&D focus areas in Cost-Competitive and Long-Duration Technology Development, Validated Reliability and Safety, Analytics for an Equitable Regulatory and Social Environment, and Grid and Field Validation.

The Request will also launch a new cohort for the Energy Storage for Social Equity (ES4SE) Technical Assistance and Pilot Program.[a] Communities across the country face significant energy challenges but may not fully understand how energy storage can be a solution. This program is designed to provide a range of defined, community-centered energy storage analyses including valuation, grid services, system resilience, and equity to measure the relationship between storage investments and community benefit outcomes. The program offers assessments on energy storage feasibility, design,

[a] https://www.pnnl.gov/projects/energy-storage-social-equity/technical-assistance-program

application, operations, and maintenance in support of disadvantaged communities. This Request enables the launch of a new ES4SE cohort with an additional five to ten communities in the technical assistance phase and two to four of those communities continuing to the pilot demonstration phase.

The Request expands ROVI to improve the performance projection methodologies of two to three new non-lithium electrochemistries to deliver performance projections of up to five years. Nascent technologies lack a long-term operational track record, impeding wide commercial deployment. Traditional calendar-life-based validation methods today require longer to develop, validate, and install these systems than the time available to meet the Administration's 2035 decarbonization goals. ROVI aims to provide at least a 15-year technology life and performance prediction using one year or less of data. ROVI enables faster validation of storage technologies through a combination of physical characterization and performance data, data generated from physics-based models and digital twins, and deployments. This Request extends the framework to cover additional technologies that are suitable candidates for long-duration (10+ hour) applications.

To respond to the rapidly growing number of energy storage installations, this Request also expands outreach to key deployment stakeholders (including fire safety, codes and standards, and other groups) as part of the Validated Reliability and Safety subprogram.

Continuing activities under Cost-Competitive and Long-Duration Technology Development include advanced materials R&D and power conversion systems. Advanced materials R&D is focused primarily on improving the cost and performance of earth-abundant, domestically available storage technologies with an emphasis on longer-duration (8–12 hour) technologies, including systems based on sodium, zinc, and lead chemistries. The program will collaborate with counterpart offices to identify supply chain requirements for these advanced materials. Power electronics and power conversion systems can represent up to 30% of an installed storage system's cost. In contrast to high-voltage power electronics for grid enhancing technologies, storage has specialized requirements for low-voltage, high-current capabilities. The program's leadership in advanced power electronics will continue with anticipated improvements in wide-bandgap materials; advanced dielectric materials for high voltage capacitors; new topologies for optimal control and safety; and architectures that address stranded energy, improve battery failure diagnostics, and integrate highly accurate state-of-charge and state-of-health monitoring.

Continuing activities under Validated Reliability and Safety include testing, data collection, standards development, and outreach. The program continues to facilitate knowledge exchanges between research and industry for energy storage safety, working closely with fire departments, building managers, and other approval authorities to understand the critical R&D needs of end users. Knowledge from safety R&D in turn forms the basis for strong safety standards at organizations such as the Institute of Electrical and Electronics Engineers (IEEE), National Fire Protection Association (NFPA), and UL (formerly Underwriters Laboratories). Examples of activities include root cause failures analysis and facilitating uniformity of safety codes and standards. Establishing a validated and referenceable database of energy storage degradation and expected lifetimes, in collaboration with industry, will help new storage technologies gain market acceptance.

Continuing activities under Analytics include model and tool development as well as outreach. Uncertainty on the economic viability of energy storage technologies can impede adoption of grid energy storage, especially for smaller utilities and end users. The program will continue to support the development of open-source analytic tools for the North American electric utility industry to ensure availability of tools required for greater adoption of flexible energy storage assets. In addition to quantifying the economic benefits of storage technologies, these new models identify the societal and environmental benefits of storage, such as improving electrical reliability in underserved communities and improvements in air-quality through reduction of fossil generation. The program will also continue to develop robust open-source user tools for optimal sizing and placement, optimal control and coordination, cyber-threat analysis and protection, and techno-economic assessment. The Request also continues the program's outreach to the energy storage community through workshops with public utility commissions (PUCs), educational programs and materials for code officials and first responders, technical conferences for the industry, and facilitating investment industry familiarity with energy storage through OE's annual workshop series on storage finance.

Continuing activities under Grid and Field Validation include efforts to validate both the business case and operational reliability of storage. Real-world validation of storage tools and models can greatly lower the barrier for acceptance by stakeholders by enabling them to fully understand how integrating storage into the grid can lower energy prices, secure their electrical supply, and solve a variety of reliability and equity challenges faced by specific localities. Providing technical assistance to states and regional stakeholders in the use of these analytical tools and how to safely install, integrate, and

operate deployed energy storage systems will continue to be a vital element of the program. The program's support of energy storage installations to enhance resilience will continue through projects with local communities and rural utilities.

Support for the OE Grid Storage Launchpad (GSL) construction project, which is aimed at accelerating materials development, testing, and independent evaluation of battery materials and battery systems for grid applications, was fully funded through the completion of construction by FY 2022 appropriations. Beneficial occupancy is planned for early 2024 and start of operations (CD-4) in 2025. GSL will:

- Focus on materials development and prototype battery systems (up to 100 kW, rather than megawatt-scale systems integration and testing), to identify and solve issues before moving to larger-scale systems
- Standardize grid performance testing across the spectrum of battery materials, battery systems, inverters, auxiliary power, and battery management systems under grid use-case conditions
- Provide an objective national resource to report battery testing performance under grid conditions
- Integrate and coordinate researchers from universities and national labs together to rapidly solve crosscutting science and technology challenges
- Develop new capabilities to rapidly scale-up new materials for grid scale storage and deliver dedicated state of the art characterization capabilities that do not exist
- Conduct realistic testing of design options in a laboratory environment

The GSL mission directly supports the Energy Storage Grand Challenge (ESGC) crosscut, the Long Duration Energy Storage Earthshot, and the ROVI. Project Engineering and Design (PED) funds were used in FY 2020 and FY 2021 to complete the DOE O 413.3B requirements leading up to Critical Decision (CD)–2/3. FY 2021 funding was used to initiate a design-build acquisition strategy in which design and construction services are secured together, including start of construction. The FY 2022 appropriation supports final construction and commissioning of the GSL facility. CD-4 (to approve start of operations) is planned in the last quarter of FY 2025 (including schedule contingency for risk mitigation). The FY 2024 Request includes operational support for activities at the GSL as applicable across the four energy storage program focus areas.

Support of R&D activities through the Grid Modernization Initiative (GMI), including the Grid Modernization Laboratory Consortium (GMLC), will continue.

Energy Storage Grand Challenge: ESGC is a crosscutting effort managed by DOE's Research and Technology Investment Committee (RTIC) and co-chaired by OE and the Office Energy Efficiency and Renewable Energy (EERE). ESGC coordinates R&D across DOE, including complementary R&D investments beyond the applied energy offices, to advance energy storage and technologies that provide similar capabilities. OE's Energy Storage program's request supports grid-related ESGC objectives and other OE R&D efforts are also complementary to ESGC goals. DOE is taking a holistic approach to accelerate the development, commercialization, and utilization of next-generation energy storage technologies. The Department integrated the existing disparate storage efforts from the GMI, Advanced Energy Storage Initiative (AESI), Beyond Batteries (BB), and others into the ESGC, an integrated, comprehensive DOE-wide strategy. The ESGC is deploying the Department's extensive resources and expertise to address technology development, commercialization, manufacturing, valuation, and workforce challenges. The vision for the ESGC is to create and sustain global leadership in energy storage utilization and exports, with a secure domestic manufacturing supply chain that is independent of foreign sources of critical materials, by 2030.

Energy Storage
Funding ($K)

	FY 2022 Enacted (Comparable)[a]	FY 2023 Enacted (Comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Energy Storage					
Research					
Cost-Competitive and Long-Duration Technology Development	18,575	34,493	28,000	-6,493	-18.8%
Validated Reliability and Safety	13,939	11,947	15,000	+3,053	+25.6%
Analytics for an Equitable Regulatory and Social Environment	7,065	8,113	11,600	+3,487	+43.0%
Grid and Field Validation	6,421	9,728	24,000	+14,272	+146.7%
Section 3201 Pilot Demonstration Grants	19,820	19,747	0	-19,747	-100.0%
Resilience Projects	4,864	0	0	0	N/A
Storage and Microgrid Deployment Assistance	0	4,937	0	-4,937	-100.0%
Total, Research	70,684	88,965	78,600	-10,365	-11.7%
Construction	47,000	0	0	0	N/A
Total, Energy Storage	**117,684**	**88,965**	**78,600**	**-10,365**	**-11.7%**

Energy Storage
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• Cost-Competitive and Long-Duration Technology Development: the emerging technology FOA is fully funded in FY 2023 and FY 2024 funding is reallocated to support activities in the Analytics and Field Validation subprograms	-6,493
• Validated Reliability and Safety: increase reflects rising costs of continuing activities and expanded outreach to key stakeholders (including fire safety, codes and standards, and other groups) given the growing number of energy storage installations	+3,053

[a] The FY 2024 Request proposes to consolidate all Small Business Innovation Research, Technology Commercialization Fund, and workforce development activities under the new Electricity Innovation and Transition (EIT) program. To allow an apples-to-apples comparison, FY 2022 and FY 2023 are shown as if this approach had been in place since FY 2022, moving $2,316,000 in FY 2022 and $6,035,0000 in FY 2023 from Storage to EIT. Details are shown below under the Comparability Matrix heading.

	FY 2024 Request vs FY 2023 Enacted
• Analytics for an Equitable Regulatory and Social Environment: launch a new ES4SE cohort with five to ten communities in the initial technical assistance phase	+3,487
• Grid and Field Validation: expand ROVI to improve the performance projection methodologies of two to three new non-lithium electrochemistries and launch a new ES4SE cohort with two to four communities reaching the second, pilot phase	+14,272
• Section 3201 Pilot Demonstration Grants: planned activities for this congressionally directed activity are completed with funding provided in FY 2022 and 2023	-19,747
• Storage and Microgrid Deployment Assistance: planned activities for this congressionally directed activity are completed with funding provided in FY 2023	-4,937
Total, Energy Storage	**-10,365**

Energy Storage

Activities and Explanation of Changes

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Research $88,965,000	**$78,600,000**	**-$10,365,000**
Cost-Competitive and Long-Duration Technology Development $34,493,000	*$28,000,000*	*-$6,493,000*
• Initiate new emerging technology FOA focused on ultra-low-cost chemistries and consistent with goals of the Long Duration Energy Storage Earthshot. Multi-year consortium targeting progress toward the 5¢/kWh levelized cost of storage (LCOS) goal with intermediate targets of 30¢/kWh, 20¢/kWh, etc. • Continue focused development programs on other earth-abundant materials systems (sodium, zinc, sulfur, etc.) with potential to meet the 2030 LCOS target	• Accelerate development programs on other earth-abundant materials (sodium, zinc, sulfur, etc.) with the potential to meet the 2030 LCOS target • Develop and test prototype packs for one to two additional cell chemistries in the 1–5 kW, 5–10 kWh scale • Integrate power electronics and power converter designs into prototype systems capable of operating under simulated grid environments	• The emerging technology FOA is fully funded in FY 2023 • FY 2024 funding is reallocated to support activities in the Analytics and Field Validation subprograms

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Demonstrate prototype pack architectures with capacities greater than 5 kWh based on 300 Ah zinc-manganese dioxide batteries and projected cell level costs below $50 per kWh when produced in volume • Migrate new power electronics and power converter topologies from R&D to scalable prototype formats and demonstrate efficient coupling between batteries and power electronics		
Validated Reliability and Safety $11,947,000	*$15,000,000*	*+$3,053,000*
• Expand training and technical assistance to fire officials and safety code officials for energy storage best practices • Continue development and validation of novel control strategies and architectures with industry for distributed control of energy storage for improved grid stability, economic dispatch, and system reliability and safety • Expand reliability testing of new battery chemistry under defined grid use cases and develop comprehensive grid scale storage system reliability metrics with industry for use at GSL	• Continue training and technical assistance to fire officials and safety code officials for energy storage best practices • Continue development and validation of novel control strategies and architectures with industry for distributed control of energy storage for improved grid stability, economic dispatch, and system reliability and safety • Continue reliability testing of new battery chemistry under defined grid use cases and develop comprehensive grid scale storage system reliability metrics with industry for use at GSL	• Increase reflects rising costs of continuing activities and expanded outreach to key stakeholders (including fire safety, codes and standards, and other groups) given the growing number of energy storage installations
Analytics for an Equitable Regulatory and Social Environment $8,113,000	*$11,600,000*	*+3,487,000*
• Continue support for execution of projects selected under FY 2022 FOA • Continue engagement with PUC's and States developing energy storage policy and integrated resource planning • Continue Energy Storage for Social Equity Technical Assistance (ES4SE) Program	• Launch a new ES4SE cohort with five to ten communities in the initial technical assistance phase • Continue outreach to end users, utilities, regulators, the financial industry, and other storage decisionmakers	• Expansion of activities under ES4SE

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Grid and Field Validations $9,728,000	*$24,000,000*	*+14,272,000*
• Develop ROVI, to incorporate data and models for one to two additional chemistries or storage technology types • Continue development of higher fidelity software tools and analytical models for the optimal value and sizing based on storage location • Add additional functionality to tools to quantify environmental (e.g., greenhouse gas reduction) and social benefits storage provides	• Expand ROVI to improve the performance projection methodologies of two to three non-lithium electrochemistries • Launch a new ES4SE cohort with two to four communities reaching the second, pilot phase • Continue development of software tools and analytical models for the optimal value, sizing, and location of storage resources, as well as quantifying environmental and social benefits	• Expansion of activities under ROVI and ES4SE
Section 3201 Pilot Demonstration Grants $19,747,000	*$0*	*-$19,747,000*
• New competitive opportunity to accelerate large scale commercial development and deployment of energy storage technologies, including for long-cycle-life lithium grid-scale batteries		• Planned activities for this congressionally directed activity are completed with funding provided in FY 2022 and 2023
Storage and Microgrid Deployment Assistance $4,937,000	*$0*	*-$4,937,000*
• Support electric cooperatives and municipal power utilities in the analysis and deployment of energy storage technologies		• Planned activities for this congressionally directed activity are completed with funding provided in FY 2023

Construction Projects Summary ($K)

	Total Project Cost (TPC)	Prior Years	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted	Future Years
20-OE-100 Grid Storage Launchpad							
Total Estimated Cost (TEC)	75,000	28,000	47,000	0	0	0	0
Other Project Costs (OPC)	2,000[a]	1,000[a]	0	1,000[a]	0	-1,000	0
TPC	77,000	29,000	47,000	1,000	0	-1,000	0

[a] OPC is funded through laboratory overhead.

Comparability Matrix

The table below shows the Small Business Innovation Research (SBIR), Technology Commercialization Fund (TCF), and workforce development funding associated with Energy Storage in FY 2022 and FY 2023 under both the prior budget structure, where these activities were funded within Energy Storage, and the proposed budget structure, where these activities are consolidated across OE under the new Electricity Innovation and Transition (EIT) program.

	FY 2024 Proposed Budget Structure ($K)					
	FY 2022 Enacted			FY 2023 Enacted		
	Energy Storage	EIT	Total	Energy Storage	EIT	Total
FY 2022 and FY 2023 Budget Structure						
Energy Storage						
Cost-Competitive & Long-Duration Technology Development						
SBIR	0	703	703	0	1,279	1,279
TCF	0	122	122	0	228	228
Workforce Development	0	0	0	0	3,000	3,000
Other Cost-Competitive & Long-Duration Technology Development	18,575	0	18,575	34,493	0	34,493
Total, Cost-Competitive & Long-Duration Technology Development	18,575	825	19,400	34,493	4,507	39,000
Validated Reliability & Safety						
SBIR	0	529	529	0	441	441
TCF	0	132	132	0	112	112
Other Validated Reliability and Safety	13,939	0	13,939	11,947	0	11,947
Total, Validated Reliability & Safety	13,939	661	14,600	11,947	553	12,500
Analytics for an Equitable Regulatory & Social Environment						
SBIR	0	268	268	0	310	310
TCF	0	67	67	0	77	77
Other Analytics for an Equitable Regulatory & Social Environment	7,065	0	7,065	8,113	0	8,113
Total, Analytics for an Equitable Regulatory & Social Environment	7,065	335	7,400	8,113	387	8,500
Grid Deployment & Field Validations						
SBIR	0	120	120	0	182	182
TCF	0	59	59	0	90	90
Other Grid Deployment & Field Validations	6,421	0	6,421	9,728	0	9,728
Total, Grid Deployment & Field Validations	6,421	179	6,600	9,728	272	10,000

	FY 2024 Proposed Budget Structure ($K)					
	FY 2022 Enacted			FY 2023 Enacted		
	Energy Storage	EIT	Total	Energy Storage	EIT	Total
Section 3201 Pilot Demonstration Grants						
SBIR	0	0	0	0	73	73
TCF	0	180	180	0	180	180
Other Section 3201 Pilot Demonstration Grants	19,820	0	19,820	19,747	0	19,747
Total, Section 3201 Pilot Demonstration Grants	19,820	180	20,000	19,747	253	20,000
Resilience Projects						
SBIR	0	91	91	0	0	0
TCF	0	45	45	0	0	0
Other Resilience Projects	4,864	0	4,864	0	0	0
Total, Resilience Projects	4,864	136	5,000	0	0	0
Storage & Microgrid Deployment Assistance						
SBIR	0	0	0	0	18	18
TCF	0	0	0	0	45	45
Other Storage & Microgrid Deployment Assistance	0	0	0	4,937	0	4,937
Total, Storage & Microgrid Deployment Assistance	0	0	0	4,937	63	5,000
Construction	47,000	0	47,000	0	0	0
Total, Energy Storage	117,684	2,316	120,000	88,965	6,035	95,000
SBIR Recap	*0*	*1,711*	*1,711*	*0*	*2,303*	*2,303*
TCF Recap	*0*	*605*	*605*	*0*	*732*	*732*
Workforce Development Recap	*0*	*0*	*0*	*0*	*3,000*	*3,000*
Other Energy Storage Recap	*117,684*	*0*	*117,684*	*88,965*	*0*	*88,965*

Transformer Resilience and Advanced Components

Overview

The Transformer Resilience and Advanced Components (TRAC) program identifies and addresses issues facing the electric transmission system due to the rapid changes challenging the system. The TRAC program develops innovations to carry, control, convert, and condition electricity to ensure the system is future ready. These innovations equip the future-ready grid to achieve decarbonization goals while enhancing its reliability and resilience. As every aspect of daily life increasingly depends on the grid, legacy approaches to power conversion and delivery will no longer be sufficient. TRAC principles—to incorporate flexible, modular, and data-driven approaches—will ensure that every component of the grid will be ready to serve the clean energy future.

Flexibility will be a major advantage of new critical grid components. For example, a large power transformer (LPT) failure could disrupt power to a half million homes. Even prior to recent supply chain disruptions, a replacement could take over 12 months to procure, transport, and install in large part because LPTs are nearly always custom-made. TRAC supports innovative transformer designs that are more flexible and adaptable, enabling fewer standardized designs to be used in more locations, which decreases manufacturing lead times while increasing the applicability of spare inventory. The program covers full range of electric power transformers from LPTs to distribution service transformers.

Modularity will be an essential part of grid infrastructure planning. Trends such as the increasing adoption of rooftop solar and electric vehicles will introduce new uncertainties in load growth projections. Consumer behaviors and technological improvements could require new grid capacity in increasingly unpredictable ways. Legacy grid expansion approaches, with long lead times and large, lumpy installations, are insufficient in this new environment. TRAC supports innovative grid-enhancing technologies (GETs), High Voltage Direct Current (HVDC) technologies, and solid-state power substations (SSPS) to enable faster capacity additions at a smaller, granular scale. In the near term, HVDC technologies and GETs, including dynamic line ratings and power flow controllers, will help unlock more capacity from existing and future infrastructure. In the medium to long term, the SSPS building block concept will allow for nearly on-demand capacity additions or reallocations. These modular and scalable designs enable greater standardization and allow for more cost-effective capacity expansion. Additional benefits include smaller module sizes for ease of transport and lower power ratings to reduce criticality.

Data-driven approaches will be necessary for a resilient and efficient grid. For example, transmission and distribution (T&D) equipment such as transformers, power lines, and substation equipment are often exposed to the elements and are vulnerable to adverse conditions, which are occurring increasingly often. The next generation of these grid hardware technologies will need to anticipate, withstand, and rapidly recover from the impact of extreme events, including from terrestrial and space weather events, other electrical disturbances, equipment failures, accidents, deliberate attacks, and other unknowns. Local intelligence with embedded sensors, data processing, and communications would enable real-time health monitoring, reducing maintenance costs and enhancing system reliability. Leveraging results from other OE activities, including phasor measurement units (PMUs) and other sensors, and incorporating emerging technologies, including unmanned aerial vehicles (UAVs), TRAC technologies will proactively respond to a changing threat landscape to enhance the security, reliability, and resilience of the electric power system.

The TRAC scope encompasses materials research, exploratory concepts, and modeling and analysis to address the range of challenges associated with transformers and other grid components. Specific technologies include transformers, cables and conductors, power flow and voltage controllers, protection equipment and switchgear, and equipment sensors. Program activities, developed in close coordination with industry, aim to fill fundamental research and development (R&D) gaps and encourage the adoption of new technologies and approaches.

Applied Material R&D targets the use of advanced materials for improvements in magnetics, packaging, and insulation to increase voltage and power capability while withstanding more rigorous environments, including for use in HVDC technologies. Component Design and Development addresses critical GET and SSPS research needs with an emphasis on embedded intelligence for equipment monitoring, validation of prototype converter building blocks, and medium voltage

converter building block development.[a] Market and System Impact Analysis supports high-fidelity modeling and simulation to help the grid community understand the value and impact of these improved grid component capabilities.

Highlights of the FY 2024 Budget Request

The Request continues materials, component, and system development to enable next-generation transformers and converters. Major technology focus areas in FY 2024 include:

- Market and System Impact Analysis: The Request supports developing a framework for a distribution-scale pilot for advanced power electronic systems, and the continued development of characterization methods and tools to evaluate reliability, transient stability, and economics of large-scale direct current (DC) architectures in alternating current (AC) grids. The Request also supports the development of a next-generation transformer technology roadmap structured to provide the context, rationale, and potential benefits of utilizing the next-generation of transformers and articulates a research, development, and demonstration pathway to accelerate maturation. It aims to capture the state of the art in critical enabling technologies, highlight research gaps and opportunities, and align disparate activities across stakeholder communities to realize the next-generation transformer vision.
- Component Design and Development: The Request supports continued device and operational improvements for SSPS technologies as identified in the 2020 SSPS roadmap. The high-voltage, high-power, and high-reliability requirements of grid applications present unique challenges for SSPS technologies, especially when operating at higher frequencies. Greater utilization of high-voltage power electronic converters within substations, including in hybrid and solid-state transformer applications, can provide power flow control capabilities and reactive power support, limit fault currents, and increase system flexibility, reliability, and resilience. The Request advances modular, scalable, and flexible transformers from early concept prototypes systems to larger systems suitable for field validation, enabling standardized designs to increase grid resilience. The Request also supports the development of HVDC and medium voltage DC (MVDC) hardware components, controls, testbeds, and advanced concepts to address technical challenges of HVDC deployment.
- Applied Material R&D: The Request supports continued improvements in magnetics, conductors, packaging, and insulation, targeting increases in heat dissipation, electrical and thermal conductivity, mechanical strength, voltage limits, and operational durability.
- Equipment and system condition monitoring: The Request supports the continued development of technologies to improve situational awareness of the condition of the power grid systems, subsystems, and components. This will include the development and application of sensing technologies and the utilization of emerging platforms such as robotics and UAVs.
- Technology, tools, and applications developed under TRAC will be evaluated for security risks including cybersecurity, electromagnetic pulses, and geomagnetic disturbances. Testing and evaluations will be conducted to ensure that security is built-in and new security risks are not being introduced into the electric sector.

Support of R&D activities through the Grid Modernization Initiative, including the Grid Modernization Laboratory Consortium (GMLC), will continue.

[a] https://energy.gov/oe/downloads/solid-state-power-substation-roadmapping-workshop-june-2017

Transformer Resilience and Advanced Components
Funding ($K)

	FY 2022 Enacted (Comparable)[a]	FY 2023 Enacted (Comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Transformer Resilience and Advanced Components					
Market and System Impact Analysis	1,435	4,773	3,000	-1,773	-37.1%
Component Design and Development	2,442	14,591	15,800	+1,209	+8.3%
Applied Material R&D	959	2,424	2,900	+476	+19.6%
Grid Research Integration & Design Center	4,827	4,827	0	-4,827	-100.0%
Composite Utility Pole Assessment	973	0	0	0	N/A
Total, TRAC	**10,636**	**26,615**	**21,700**	**-4,915**	**-18.5%**

Transformer Resilience and Advanced Components
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• Market and System Impact Analysis: reduction reflects tapering of market and system analysis phase of Smart Universal Power Electronics Regulators (SUPER) and SSPS development	-1,773
• Component Design and Development: increases to accelerate addressing HVDC hardware technical challenges, to perform a field validation of the SUPER device, and to further expand the development of modular and scalable transformers	+1,209
• Applied Material R&D: advanced materials, embedded intelligence for equipment monitoring, validation of prototype converter building blocks, and medium voltage converter building block development	+476
• Grid Research Integration & Design Center: planned activities for this congressionally directed activity are completed with funding provided in FY 2023	-4,827
Total, TRAC	**-4,915**

[a] The FY 2024 Request proposes to consolidate all Small Business Innovation Research, Technology Commercialization Fund, and workforce development activities under the new Electricity Innovation and Transition (EIT) program. To allow an apples-to-apples comparison, FY 2022 and FY 2023 are shown as if this approach had been in place since in FY 2022, moving $364,000 in FY 2022 and $885,000 in FY 2023 from TRAC to EIT.

Activities and Explanation of Changes

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Transformer Resilience and Advanced Components **$26,615,000**	**$21,700,000**	**-$4,915,000**
Market and System Impact Analysis $4,773,000	*$3,000,000*	*-$1,773,000*
• Develop the Smart Universal Power Electronics Regulators (SUPER) library, the SSPS controller for the consumer end node and validate the use case • Develop characterization methods and tools to evaluate reliability, transient stability, and economics of large-scale DC architectures in AC grids	• Develop a framework and analysis to evaluate the future architecture impact of advanced power flow controllers and distribution scale components • Develop a framework for a distribution scale architecture pilot for advanced power electronic systems • Develop the next-generation transformer technology roadmap structured to provide the context, rationale, and potential benefits of utilizing the next-generation of transformers	• Tapers off market and system analysis phase of SUPER and SSPS development
Component Design and Development $14,591,000	*$15,800,000*	*+$1,209,000*
• Develop reliable medium voltage power stages with advanced features for SSPS • Develop advanced medium voltage to high voltage semiconductor modules • Develop advanced gate driver technologies to support advanced semiconductor switches • Develop high voltage auxiliary power supply stages • Develop subsystems to support electromagnetic interference (EMI) mitigation and thermal limitations • Develop advanced features for diagnostics and prognostics of future grid interfaces	• Develop a prototype to initiate a field demonstration activity of new modular power conversion devices such as the SUPER device at the low-voltage levels • Develop HVDC and MVDC hardware components, controls, testbeds, and advanced concepts to address technical challenges of HVDC deployment • Continue the development of reliable medium-voltage SUPERs with advanced features for SSPS, including advanced features for diagnostics and prognostics	• Accelerates addressing HVDC hardware technical challenges to perform a field validation of the SUPER device and to further expand the development of modular, flexible, and scalable transformers

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Test and validate Grid Enhancing Technologies (GETs) by conducting a full scale, multi-faceted field exercise	• Develop and expand modular, scalable, and flexible transformers from early-concept prototypes systems to larger systems suitable for field validation	
Applied Material R&D $2,424,000	*$2,900,000*	*+$476,000*
• Develop magnetics and passives to advance basic insulation level and high-frequency requirements for power electronic systems and future grid infrastructure • Develop high voltage and high current interconnects to support the integration of subsystems for large-scale power electronic systems • Research to address critical needs in packaging for the high voltage, high current, and high-temperature environments associated with power electronic systems, transmission, distribution • Address insulation issues associated with transmission, sub-transmission, and distribution voltage grid systems • Fund a prize program to demonstrate Power Electronic Systems (PES) developed using recycled/refurbished parts	• Develop soft magnetics to fill a gap in commercially available core materials for power conversion applications • Improvements in core materials are needed to achieve the efficiencies, power densities, and reliabilities required for emerging power conversion applications • Continue the development of advanced materials with improved performance for overhead transmission cables • Develop packaging solutions to enable high voltage, high power wide bandgap modules • Develop and demonstrate mechanical bushing isolator solutions to address seismic vulnerabilities and reduce outage risk from LPT failure	• Addresses LPT seismic vulnerabilities and further develops packaging solutions
Grid Research Integration & Demo Center $4,827,000	*$0*	*-$4,827,000*
• Validate a 480 V SSPS 1.0 node which aggregates multiple downstream SUPERs connected to assets/loads • Develop and demonstrate the SSPS controller capable of coordinating the downstream resources (nodes or hubs) using a Controller-Hardware-in-the-Loop (CHIL) test bed in GRID-C		• Planned activities for this congressionally directed activity are completed with funding provided in FY 2023

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Develop a baseline IPS using 3.3 kV semiconductor devices for medium voltage (MV) DC–DC applications, and validate at GRID-C • Continue the development of the GRID-C facility by providing support on the operation, purchase, and maintenance of infrastructure and equipment.		

Comparability Matrix

The table below shows the Small Business Innovation Research (SBIR) and Technology Commercialization Fund (TCF) funding associated with TRAC in FY 2022 and FY 2023 under both the prior budget structure, where these activities were funded within TRAC, and the proposed budget structure, where these activities are consolidated across OE under the new Electricity Innovation and Transition (EIT) program.

	FY 2024 Proposed Budget Structure ($K)					
	FY 2022 Enacted			FY 2023 Enacted		
	TRAC	EIT	Total	TRAC	EIT	Total
FY 2022 and FY 2023 Budget Structure						
Transformer Resilience & Advanced Components						
Market and System Impact Analysis						
SBIR	0	52	52	0	182	182
TCF	0	13	13	0	45	45
Other Market and System Impact Analysis	1,435	0	1,435	4,773	0	4,773
Total, Market and System Impact Analysis	1,435	65	1,500	4,773	227	5,000
Component Design and Development						
SBIR	0	35	35	0	274	274
TCF	0	23	23	0	135	135
Other Component Design and Development	2,442	0	2,442	14,591	0	14,591
Total, Component Design and Development	2,442	58	2,500	14,591	409	15,000

	FY 2024 Proposed Budget Structure ($K)					
	FY 2022 Enacted			FY 2023 Enacted		
	TRAC	EIT	Total	TRAC	EIT	Total
Applied Material R&D						
SBIR	0	34	34	0	56	56
TCF	0	7	7	0	20	20
Other Applied Material R&D	959	0	959	2,424	0	2,424
Total, Applied Material R&D	959	41	1,000	2,424	76	2,500
Grid Research Integration & Design Center						
SBIR	0	128	128	0	128	128
TCF	0	45	45	0	45	45
Other Grid Research Integration & Design Center	4,827	0	4,827	4,827	0	4,827
Total, Grid Research Integration & Design Center	4,827	173	5,000	4,827	173	5,000
Composite Utility Pole Assessment						
SBIR	0	18	18	0	0	0
TCF	0	9	9	0	0	0
Other Composite Utility Pole Assessment	973	0	973	0	0	0
Total, Composite Utility Pole Assessment	973	27	1,000	0	0	0
Total, TRAC	10,636	364	11,000	26,615	885	27,500
SBIR Recap	*0*	*267*	*267*	*0*	*640*	*640*
TCF Recap	*0*	*97*	*97*	*0*	*245*	*245*
Other TRAC Recap	*10,636*	*0*	*10,636*	*26,615*	*0*	*26,615*

Applied Grid Transformation Solutions

Overview

America's grid is transforming into a more dynamic and structurally complex system. This complexity includes bidirectional power flows, increasing sources of renewable energy, and the electrification of the transportation and building sector, all while contending with varied threat challenges. Managing this transition will require significant reengineering and advancements in grid technology and system architectures. Innovative technological advances are needed to accomplish these changes while still meeting the strict performance requirements of a safety- and reliability-focused industry that requires high confidence to consider new solutions. The performance and benefits of these innovative grid technologies, systems, and subsystems must be assessed and validated for their ability to meet evolving demands, their integrability into an increasingly complex legacy system, and their compatibility with very diverse operational, institutional, and regulatory contexts.

The Applied Grid Transformation Solutions (AGTS) program addresses the pressing need for rapidly assessing new grid systems and subsystems (including energy storage, transmission, distribution, and power control and conversion hardware and associated software) by testing the integrated technology suites in pilot environments prior to the hardware and software being deployed by industry in operational environments. These assessments provide utilities with the information they need to quantify and validate functionality, performance, and economic benefits before deploying new technologies. Today, the benefits of new grid technologies are difficult to extrapolate when tested in isolation and difficult to quantify when measuring some socio-economic benefits such as resilience. AGTS pilot integrations will yield the actionable information desired by utilities and regulators to drive new technology adoption, including performance under various conditions and specific validated data on technology costs, uses, and capabilities; investment value and feasibility; cost recovery during changing times; and requirements for integration with other systems. The results of the pilot demonstration will validate the techno-socio-economic performance of the systems and will help to accelerate the adoption of new technology by industry.

AGTS will work with national laboratories, private industry, and academia to develop national electrical grid advanced testing capabilities. To meet the Administration's goals of 100% carbon pollution-free electricity by 2035 and net zero-emissions by 2050, advanced grid hardware and software will be needed and test beds where these new technologies can be safely tested are a key to providing industry confidence and enabling industry adoption.

AGTS will coordinate with other R&D programs and build on previous Grid Modernization Laboratory Consortium (GMLC) devices and integrated system projects.

Highlights of the FY 2024 Budget Request

Initiated in FY 2023, AGTS assesses how new grid technologies can help achieve stakeholder objectives. For each applied demonstration area, AGTS will consult stakeholders to ensure that the project scope and outputs will be immediately useful to targeted decision makers. AGTS will identify the most suitable pilot environments to conduct testing and demonstration, and then select a suite of technologies that can be used to achieve the desired functionality. These technologies could include:

- High voltage direct current (HVDC) systems
- Advanced conductors
- Advanced transformers including flexible and modular large power transformers (LPTs), hybrid and solid-state transformers, and distribution service transformers
- Dynamic line rating, dynamic transformer rating systems
- Power flow controllers (PFCs)
- Sensors and system and equipment condition monitoring solutions
- Dynamic topology configuration solutions
- Energy storage systems
- Advanced alternating current (AC) and direct current (DC) microgrids
- Power-electronics-based systems
- Other hardware and associated software and controls and communications technologies

The technologies will be integrated into the pilot environments and operated to validate the performance and operational capabilities of the new technologies for a variety of use cases. Results from the AGTS hardware-in-the-loop and other types of demonstrations will be shared with broader decision makers, such as planners, operators, manufacturers, investors, regulators, and ratepayers. Coordinating with stakeholders to quantify and disseminate the measured benefits is essential to a successful demonstration, as is understanding the alignment of benefits and incentives as it relates to these new technologies. At the conclusion of the project, decision makers should have sufficient information to evaluate new transmission and distribution approaches alongside legacy solutions. Project results can also inform manufacturers in addressing new or emerging market opportunities.

In FY 2024, AGTS will:

- Continue stakeholder-focused Grid Transformation Summits to show how new technologies enable community, state, and regional goals
- Continue technical assistance through modeling, analysis, and use case validation by leveraging existing OE and Grid Modernization Initiative (GMI) tools and utilizing pilot projects to test stakeholder-focused hardware-in-the-loop use cases
- Support at least two new pilots to validate technological maturity and show how new technologies achieve desired environmental, societal, policy, and market outcomes, and will be targeted to provide regional diversity
- Develop national electrical grid advanced testing capabilities in collaboration with national laboratories, private industry, and academia
- Continue working groups for industry outreach to gather feedback and target new grid technology demonstration needs
- Create workshops for information sharing, education, and support adoption
- Create demonstration and deployment pathways for multiple advanced grid technologies, to build a shared DOE-and-industry perspective on requirements to achieve private sector lift-off for key grid technology areas

AGTS will include coordination with the GMLC on shared technology development objectives. FY 2024 integrated pilots will showcase resiliency and renewable integration objectives aligned with the GMI and other DOE crosscutting efforts.

Applied Grid Transformation Solutions
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted (Comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted	FY 2024 Request vs FY 2023 Enacted (%)
Applied Grid Transformation Solutions					
Scoping, Design, and Stakeholder Collaboration	0	1,945	9,880	+7,935	+408.0%
Demonstrations	0	7,928	19,820	+11,892	+150.0%
Total, AGTS	**0**	**9,873**	**29,700**	**+19,827**	**+200.8%**

Applied Grid Transformation Solutions
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• Scoping, Design, and Stakeholder Collaboration: Create workshops for information sharing, education, and supporting adoption of new technologies; scope an electrical grid national test bed in collaboration with national laboratories, academia, and private industry; and create demonstration and deployment pathways for multiple advanced grid technologies	+7,935
• Demonstrations: Develop electrical grid national test beds to support advance grid technology validation	+11,892
Total, AGTS	**+19,827**

[a] The FY 2024 Request proposed to consolidate all Small Business Innovation Research, Technology Commercialization Fund, and workforce development activities under the new Electricity Innovation and Transition (EIT) program. To allow an apples-to-apples comparison, FY 2023 is shown as if this approach had been in place, moving $127,000 in FY 2023 from AGTS to EIT. Detailed adjustments are shown in the Comparability Matrix section below.

Activities and Explanation of Changes

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Applied Grid Transformation Solutions $9,873,000	**$29,700,000**	**+$19,827,000**
Scoping, Design, and Stakeholder Collaboration *$1,945,000*	*$9,880,000*	*+$7,935,000*
• Conduct stakeholder-focused grid transformation working groups • Provide technical assistance to State and local governmental entities, Tribal nations, and others through modeling, analysis, and use case validation	• Continue stakeholder-focused grid transformation working groups • Continue technical assistance to State and local governmental entities, tribal nations, and others through modeling, analysis, and use case validation • Scope an electrical grid national test bed in collaboration with national laboratories, academia, and private industry and in coordination with GMLC and DOE offices/programs • Create workshops with industry to support information sharing and adoption, each working group will be a case-by-case activity • Create demonstration and deployment pathways for multiple advanced grid technologies, to build a shared DOE-and-industry perspective on requirements to achieve private sector lift-off for key grid technology areas	• Create workshops for information sharing, education, and supporting adoption • Scope an electrical grid national test bed in collaboration with national laboratories, academia, and private industry • Create demonstration and deployment pathways for multiple advanced grid technologies

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Demonstrations $7,928,000	*$19,820,000*	*+$11,892,000*
• Support an advanced conductor/cable pilot for reconducting existing power lines with double capacity conductor/cable, without the need to rebuild existing infrastructure, to increase grid efficiency and allow for more renewable connections to the grid • Support a grid enhancing technology pilot for increased capacity, resiliency, and reliability using existing energy delivery pathways • Support an advanced modular/flexible transformer pilot to reduce long transformer lead times, provide system flexibility, and help move the industry to a smarter grid	• Support at least 2 large-scale demonstrations and validations with an emphasis on regional diversity • Provide demonstration and validation of new grid technologies building on FY 2023 pilots • Based on the results of scoping, design, and stakeholder collaboration, develop test beds in collaboration with national laboratories, academia, and private industry to support advanced grid components	• Develop national electrical grid test beds to support advanced grid technology validation • Support large-scale demonstration and validation activities with regional diversity

Comparability Matrix

The table below shows the Small Business Innovation Research (SBIR) and Technology Commercialization Fund (TCF) funding associated with AGTS in FY 2023 under both the prior budget structure, where these activities were funded within AGTS, and the proposed budget structure, where these activities are consolidated across OE under the new Electricity Innovation and Transition (EIT) program.

	FY 2024 Proposed Budget Structure ($K)		
	FY 2023 Enacted		
	AGTS	EIT	Total
FY 2023 Budget Structure			
Applied Grid Transformation Solutions			
Scoping, Design, and Stakeholder Collaboration			
SBIR	0	37	37
TCF	0	18	18
Other Scoping, Design, and Stakeholder Collaboration	1,945	0	1,945
Total, Scoping, Design, and Stakeholder Collaboration	1,945	55	2,000

	FY 2024 Proposed Budget Structure ($K)		
	FY 2023 Enacted		
	AGTS	EIT	Total
Demonstrations			
TCF	0	72	72
Other Demonstrations	7,928	0	7,928
Total, Demonstrations	7,928	72	8,000
Total, AGTS	9,873	127	10,000
SBIR Recap	*0*	*37*	*37*
TCF Recap	*0*	*90*	*90*
Other AGTS Recap	*9,873*	*0*	*9,873*

Electricity Innovation and Transition

Overview

The global electricity sector is undergoing a profound transformation. The nation that leads the transformation will be a leader in the global economy and create economic prosperity for its citizens. The Electricity Innovation and Transition (EIT) program integrates a broader cross-section of the U.S. workforce into America's electricity innovation through its strategy to bring new talent and organizations into the electricity innovation sector in areas relevant to OE's mission. EIT provides competitive opportunities for researchers, students, small businesses, and other innovators and supports partnerships to promote workforce development and higher education within the OE's mission. This program seeks to ensure that access to these opportunities and benefits are equitably provided, specifically seeking ways to include communities that have historically faced limits in access to such capabilities, such as students and faculty at minority-serving institutions (MSIs).

The EIT program will be implemented by consolidating OE funding for Small Business Innovation Research (SBIR) and Technology Commercialization Fund (TCF) activities as well as workforce development activities: the Grid Storage Launchpad (GSL) Fellowship Program and workforce development through strategic partnerships with the National Science Foundation (NSF).

SBIR and TCF were previously funded within each of OE's other research and development (R&D) programs. The GSL Fellowship Program was previously funded within the Energy Storage program. Strategic partnerships with NSF were previously funded within Transmission Reliability and Resilience.

The reorganization of these efforts into a new program in FY 2024 provides a more flexible, streamlined, and transparent approach for OE to support innovators, small businesses, and researchers moving grid technologies forward and advancing workforce outcomes.

Under the Small Business Innovation Development Act of 1982, as amended, at least 3.2% of the Department's extramural basic research, applied research, and development funding each year is set aside for competitive SBIR awards. Under the Small Business Technology Transfer Act of 1992, as amended, at least a further 0.45% of this funding is also set aside for competitive Small Business Technology Transfer (STTR) awards, for a total set aside of at least 3.65%. Within DOE, smaller research programs such as OE provide all 3.65% to support SBIR awards, while other offices support a larger share of STTR awards to ensure DOE meets the agency-wide 3.2% SBIR and 0.45% STTR requirements.

Highlights of the FY 2024 Budget Request

The Request includes support to continue the GSL Fellowship program, initiated in FY 2023. The GSL Fellowship promotes stakeholder and energy community familiarity with storage technologies and operations by leveraging the hands-on space and realistic simulation capabilities at DOE's GSL facility. Initial program design and recruitment have begun in FY 2023. FY 2024 funding will provide for ongoing support of the first cohorts as well as preparations for subsequent cohorts in FY 2024 or later.

This Request also includes support for the OE partnership with the NSF Division of Engineering Education and Centers (EEC) to invest in undergraduates through the Research Experiences for Undergraduates (REU) Program, as well as supporting non-academic graduate student internships for power systems through the NSF's INTERN Program to support workforce development in power systems to support the reliability, resilience, security, and efficiency of the electric power grid. REU programs helps facilitate undergraduate exposure to advanced topics, and this partnership will provide experiences to foster student interest in applying their interdisciplinary skills towards power sector applications. The INTERN program fosters long term partnerships between academic insutitions and industry, and will benefit the power sector by faciliating the application of research funded by NSF to the power system.

Electricity Innovation and Transition
Funding ($K)

	FY 2022 Enacted (Comparable)[a]	FY 2023 Enacted (Comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Electricity Innovation and Transition					
Small Business Innovation Research	4,581	5,589	6,407	+818	+14.6%
Technology Commercialization Fund	1,645	2,118	2,190	+72	+3.4%
Workforce Development	0	4,000	5,403	+1,403	+35.1%
Total, Electricity Innovation and Transition	**6,226**	**11,707**	**14,000**	**+2,293**	**+19.6%**

SBIR/STTR:

- FY 2022 Enacted: SBIR: $4,581
- FY 2023 Enacted: SBIR: $5,589
- FY 2024 Request: SBIR: $6,407

Electricity Innovation and Transition
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• Small Business Innovation Research: A minimum of 3.65% of extramural basic, applied, and development R&D across OE is assessed for SBIR, and the increase over FY 2023 reflects changes in the overall OE request	+818
• Technology Commercialization Fund: A minimum 0.9% of applied, development, and demonstration activities across OE is assessed for TCF and the increase over FY 2023 reflects changes in the overall OE request	+72
• Workforce Development: Funding for GSL Fellowship program increases in FY 2024, and for a new workforce development effort for non-academic internships in power systems for graduate students associated with OE's electricity distribution activities in FY 2024	+1,403
Total, Electricity Innovation and Transition	**+2,293**

[a] The FY 2024 Request proposes to consolidate all SBIR, TCF, and workforce development activities under the new EIT program. To allow an apples-to-apples comparison, FY 2022 and FY 2023 are shown as if this approach had been in place since FY 2022, moving $6,226,000 in FY 2022 and $11,070,000 in FY 2023 from OE's other R&D programs to EIT. Details of the funding sources are shown below in the Comparability Matrices section.

Activities and Explanation of Changes

FY 2023 Enacted (Comparable)	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Electricity Innovation and Transition $11,707,000	**$14,000,000**	**+$2,293,000**
Small Business Innovation Research $5,589,000	*$6,407,000*	*+818,000*
• At least 3.65% of OE's extramural basic and applied research and development funding is set aside for competitive awards to small businesses	• At least 3.65% of OE's extramural basic, applied, and development research funding is set aside for competitive awards to small businesses	• Overall extramural basic and applied research and development funding increases in OE's Request
Technology Commercialization Fund $2,118,000	*$2,190,000*	*+$72,000*
• At least 0.9% of OE's applied research, development, and demonstration funding is set aside for the TCF to promote promising energy technologies for commercial purposes	• At least 0.9% of OE's applied research, development, and demonstration funding is set aside for the TCF to promote promising energy technologies for commercial purposes	• Overall applied research, development, and demonstration funding increases in OE's Request
Workforce Development $4,000,000	*$5,403,000*	*+$1,403,000*
• Partnerships with NSF's EEC division support REU programs focused on the electric power system modeling reliability research • The GSL Fellowship begins in FY 2023 to support early-stage entities and early-career innovators of GSL's testing and validation capabilities for storage development	• Expansion of the NSF EEC partnership supports non-academic graduate student internships for power systems through the NSF's INTERN Program • Continued partnership with NSF on REU programs for power systems supports workforce development in power systems to support the reliability, resilience, security, and efficiency of the electric power grid • The GSL Fellowship supports the 2023 cohort as well as preparations for a second cohort in FY 2024 or later	• Funding increases for NSF partnerships to include non-academic internships to support industry workforce, as well as expansions of the REU programs to promote higher education in power systems applied research • Funding increases for new electricity distribution workforce activities and increased energy storage workforce activities

Comparability Matrices

The tables below show the SBIR, TCF, and workforce development funding in FY 2022 and FY 2023 under both the prior budget structure, where these activities were funded across OE's R&D programs, and the proposed budget structure, where these activities are consolidated under EIT across OE under the new EIT program.

FY 2022 Enacted Comparability Matrix

	FY 2024 Proposed Budget Structure ($K)							
	TRR	EDGOT	RDS	SecureNet	Energy Storage	TRAC	EIT	Total
FY 2022 and FY 2023 Budget Structure								
Transmission Reliability & Resilience								
SBIR	0	0	0	0	0	0	840	840
TCF	0	0	0	0	0	0	219	219
Other TRR	24,941	0	0	0	0	0	0	24,941
Total, TRR	24,941	0	0	0	0	0	1,059	26,000
Energy Delivery Grid Operations Technology								
SBIR	0	0	0	0	0	0	402	402
TCF	0	0	0	0	0	0	135	135
Darknet	0	0	0	9,672	0	0	0	9,672
Other EDGOT	0	12,791	0	0	0	0	0	12,791
Total, EDGOT	0	12,791	0	9,672	0	0	537	23,000
Resilient Distribution Systems								
SBIR	0	0	0	0	0	0	1,010	1,010
TCF	0	0	0	0	0	0	490	490
Other RDS	0	0	53,500	0	0	0	0	53,500
Total, RDS	0	0	53,500	0	0	0	1,500	55,000
Cyber Resilient & Secure Utility Communication Networks (SecureNet)								
SBIR	0	0	0	0	0	0	351	351
TCF	0	0	0	0	0	0	99	99
Other SecureNet	0	0	0	10,700	0	0	0	10,700
Total, SecureNet	0	0	0	10,700	0	0	450	11,150

	FY 2024 Proposed Budget Structure ($K)							
	TRR	EDGOT	RDS	SecureNet	Energy Storage	TRAC	EIT	Total
Energy Storage								
SBIR	0	0	0	0	0	0	1,711	1,711
TCF	0	0	0	0	0	0	605	605
Other Energy Storage	0	0	0	0	117,684	0	0	117,684
Total, Energy Storage	0	0	0	0	117,684	0	2,316	120,000
Transformer Resilience & Advanced Components								
SBIR	0	0	0	0	0	0	267	267
TCF	0	0	0	0	0	0	97	97
Other TRAC	0	0	0	0	0	10,636	0	10,636
Total, TRAC	0	0	0	0	0	10,636	364	11,000
Total	24,941	12,791	53,500	20,372	117,684	10,636	6,226	246,150
SBIR Recap	*0*	*0*	*0*	*0*	*0*	*0*	*4,581*	*4,581*
TCF Recap	*0*	*0*	*0*	*0*	*0*	*0*	*1,645*	*1,645*
Other Recap	*24,941*	*12,791*	*53,500*	*20,372*	*117,684*	*10,636*	*0*	*239,924*

FY 2023 Request Comparability Matrix

	FY 2024 Proposed Budget Structure ($K)								
	TRR	EDGOT	RDS	SecureNet	Energy Storage	TRAC	AGTS	EIT	Total
FY 2022 and FY 2023 Budget Structure									
Transmission Reliability & Resilience									
SBIR	0	0	0	0	0	0	0	1,126	1,126
TCF	0	0	0	0	0	0	0	287	387
Workforce Development	0	0	0	0	0	0	0	1,000	1,000
Other TRR	31,587	0	0	0	0	0	0	0	31,587
Total, TRR	31,587	0	0	0	0	0	0	2,413	34,000
Energy Delivery Grid Operations Technology									
SBIR	0	0	0	0	0	0	0	248	248
TCF	0	0	0	0	0	0	0	138	138
Other EDGOT	0	30,614	0	0	0	0	0	0	30,614
Total, EDGOT	0	30,614	0	0	0	0	0	386	31,000

	FY 2024 Proposed Budget Structure ($K)								
	TRR	EDGOT	RDS	SecureNet	Energy Storage	TRAC	AGTS	EIT	Total
Resilient Distribution Systems									
SBIR	0	0	0	0	0	0	0	961	961
TCF	0	0	0	0	0	0	0	491	491
Other RDS	0	0	53,548	0	0	0	0	0	53,548
Total, RDS	0	0	53,548	0	0	0	0	1,452	55,000
Cyber Resilient & Secure Utility Communication Networks (SecureNet)									
SBIR	0	0	0	0	0	0	0	274	274
TCF	0	0	0	0	0	0	0	135	135
Other SecureNet	0	0	0	14,591	0	0	0	0	14,591
Total, SecureNet	0	0	0	14,591	0	0	0	409	15,000
Energy Storage									
SBIR	0	0	0	0	0	0	0	2,303	2,303
TCF	0	0	0	0	0	0	0	732	732
Workforce Development	0	0	0	0	0	0	0	3,000	3,000
Other Energy Storage	0	0	0	0	88,965	0	0	0	88,965
Total, Energy Storage	0	0	0	0	88,965	0	0	6,035	95,000
Transformer Resilience & Advanced Components									
SBIR	0	0	0	0	0	0	0	640	640
TCF	0	0	0	0	0	0	0	245	245
Other TRAC	0	0	0	0	0	26,615	0	0	26,615
Total, TRAC	0	0	0	0	0	26,615	0	885	27,500
Applied Grid Transformation Solutions									
SBIR	0	0	0	0	0	0	0	37	37
TCF	0	0	0	0	0	0	0	90	90
Other AGTS	0	0	0	0	0	0	9,873	0	9,873
Total, AGTS	0	0	0	0	0	0	9,873	127	10,000

	FY 2024 Proposed Budget Structure ($K)								
	TRR	EDGOT	RDS	SecureNet	Energy Storage	TRAC	AGTS	EIT	Total
Total	31,587	30,614	53,548	14,591	88,965	26,615	9,873	11,707	267,500
SBIR Recap	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*5,589*	*5,589*
TCF Recap	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2,118*	*2,118*
Workforce Development Recap	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*4,000*	*4,000*
Other Recap	*31,587*	*30,614*	*53,548*	*14,591*	*88,965*	*26,615*	*9,873*	*0*	*255,793*

Program Direction

Overview

Program Direction provides for the costs associated with the Federal workforce, including salaries, benefits, travel, training, building occupancy, IT services, security clearance, and other related expenses. It also provides for the costs associated with contractor services that, under the direction of the Federal workforce, support the Office of Electricity (OE) mission.

Salaries and Benefits support Federal employees who provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program. This includes staff at Headquarters and at the National Energy Technology Laboratory (NETL). While OE funds NETL staff within its budget, the NETL Federal employees are included within the full-time equivalent (FTE) total for the Fossil Energy and Carbon Management (FECM) account.

Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively manage research and development programs and projects in the field; to provide the Department's electricity-related outreach to regions, States, Territories, and Tribes regarding planning needs and issues, policies, siting protocols, and new energy facilities.

Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analyses to management. These efforts include:

- Issue-oriented support on science, engineering, environment, and economics that benefit strategic planning
- Technology and market analysis to improve strategic and annual goals
- Development of management tools and analyses to improve overall office efficiency
- Assistance with communications and outreach to enhance OE's external communication and responsiveness to public needs
- Development of program-specific information tools that consolidate organizational knowledge, track performance and inventory data, and facilitate staff use of the information

Other Related Expenses includes corporate IT support (DOE's Energy Information Technology Services [EITS] desktop services and IT equipment) and working capital fund (WCF) expenses, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes office safety requirements, equipment upgrades and replacements, commercial credit card purchases using simplified acquisition procedures where possible, security clearance expenses, and other needs.

Highlights of the FY 2024 Budget Request

The Program Direction Request reflects a small increase in Headquarters staffing to support the growing portfolio of activities in OE's programs. The increases also address promotions and within-grade increases in some program areas. With the heightened attention and priority of OE's mission to accelerate the transformation of our Nation's power grid, proper staffing levels are crucial to expeditiously meet our goals and objectives. This Request also supports staffing to address skill gaps and succession planning.

Program Direction
Funding ($K)

	FY 2022 Enacted	FY 2022 Enacted (Comparable)[a]	FY 2023 Enacted	FY 2023 Enacted (Comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Comp. Enacted ($)	FY 2024 Request vs FY 2023 Comp. Enacted (%)
Program Direction Summary							
Washington Headquarters							
Salaries and Benefits	11,137	9,177	13,542	10,182	10,927	+745	+7.3%
Travel	460	410	430	400	430	+30	+7.5%
Support Services	1,312	949	2,290	1,179	1,186	+7	+0.6%
Other Related Expenses	3,643	3,346	3,132	2,897	2,910	+13	+0.4%
Total, Washington Headquarters	**16,552**	**13,882**	**19,394**	**14,658**	**15,453**	**+795**	**+5.4%**
National Energy Technology Laboratory							
Salaries and Benefits	1,734	1,502	1,953	1,511	1,595	+84	+5.6%
Travel	74	44	49	45	50	+5	+11.1%
Support Services	376	325	324	324	340	+16	+4.9%
Other Related Expenses	1,264	1,247	1,280	1,255	1,237	-18	-1.4%
Total, National Energy Technology Laboratory	**3,448**	**3,118**	**3,606**	**3,135**	**3,222**	**+87**	**+2.8%**
Total Program Direction							
Salaries and Benefits	12,871	10,679	15,495	11,693	12,522	+829	+7.1%
Travel	534	454	479	445	480	+35	+7.9%
Support Services	1,688	1,274	2,614	1,503	1,526	+23	+1.5%
Other Related Expenses	4,907	4,593	4,412	4,152	4,147	-5	-0.1%
Total, Program Direction	**20,000**	**17,000**	**23,000**	**17,793**	**18,675**	**+882**	**+5.0%**
Federal FTEs	**70**	**63**	**82**	**63**	**64**	**+1**	**+1.6%**
Additional FE FTEs at NETL supporting OE[b]	12	11	13	10	10	0	0.0%
Total OE-funded FTEs	82	74	95	73	74	+1	+1.4%

[a] The FY 2023 Budget Request to Congress proposed to split the Electricity appropriation account into two accounts: Electricity and Grid Deployment. To allow an apples-to-apples comparison with FY 2024, the comparable amounts for FY 2022 and 2023 exclude a portion of Program Direction funding equivalent to what would have been in the Grid Deployment Office had the proposed structure been in place since FY 2022.

[b] OE funds FTEs at FECM's NETL that support OE activities. The FTEs are included in FECM's FTE totals and not in the OE FTE totals shown on the "Federal FTEs" line.

	FY 2022 Enacted	FY 2022 Enacted (Comparable)[a]	FY 2023 Enacted	FY 2023 Enacted (Comparable)[a]	FY 2024 Request	FY 2024 Request vs FY 2023 Comp. Enacted ($)	FY 2024 Request vs FY 2023 Comp. Enacted (%)
Support Services and Other Related Expenses							
Support Services							
Technical Support	927	707	1,421	844	853	+9	+1.1%
Management Support	761	567	1,193	659	673	+14	+2.1%
Total, Support Services	**1,688**	**1,274**	**2,614**	**1,503**	**1,526**	**+23**	**+1.5%**
Other Related Expenses							
Other Services	1,488	1,472	1,515	1,319	1,208	-111	-8.4%
EITS Desktop Services	714	652	736	672	440	-232	-34.5%
WCF	2,705	2,469	2,161	2,161	2,499	+338	+15.6%
Total, Other Related Expenses	**4,907**	**4,593**	**4,412**	**4,152**	**4,147**	**-5**	**-0.1%**

Program Direction

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Program Direction $17,793,000	**$18,675,000**	**+$882,000**
Salaries and Benefits $11,693,000	*$12,522,000*	*+$829,000*
• Salaries and Benefits support 73 FTEs at Headquarters and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program	• Salaries and Benefits support 74 FTEs at Headquarters and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program	• Supports 1 additional FTE and the 2024 Federal pay increase
Travel $445,000	*$480,000*	*+$35,000*
• Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively facilitate its mission	• Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively facilitate its mission	• Supports additional laboratory and site visits to oversee OE's research portfolio

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Support Services $1,503,000	*$1,526,000*	*+$23,000*
• Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management • Support Services may include support for post-doctoral fellows and IPA assignments	• Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management • Support Services may include support for post-doctoral fellows and IPA assignments	• Increase reflects contract cost escalation
Other Related Expenses $4,152,000	*$4,147,000*	*-$5,000*
• Other Related Expenses includes EITS desktop services and WCF expenses, such as rent, supplies, copying, graphics, mail, printing, and telephones • It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, security clearances, and other needs	• Other Related Expenses includes EITS desktop services and WCF expenses, such as rent, supplies, copying, graphics, mail, printing, and telephones • It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, security clearances, and other needs	• WCF increases are offset by reduced equipment purchases

Electricity
Research and Development ($K)[a]

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Basic	9,055	13,363	12,117	-1,246	-9.3%
Applied	63,980	66,498	74,589	+8,091	+12.2%
Development	63,917	86,292	104,224	+17,932	+20.8%
Total, R&D	136,952	166,153	190,930	+24,777	+14.9%
R&D-related construction	50,658	0	0	0	N/A
Total, R&D and related facilities	187,610	166,153	190,930	+24,777	+14.9%

Electricity
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2022 Enacted Transfer	FY 2023 Enacted Projected Transfer	FY 2024 Request Projected Transfer[b]	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Transmission Reliability and Resilience	840	1,126	0	-1,126	-100.0%
Energy Delivery Grid Operations Technology	402	248	0	-248	-100.0%
Resilient Distribution Systems	1,010	961	0	-961	-100.0%
Cyber Resilient and Secure Utility Communication Networks (SecureNet)	351	274	0	-274	-100.0%
Energy Storage	1,711	2,303	0	-2,303	-100.0%
Transformer Resilience and Advanced Components	267	640	0	-640	-100.0%
Applied Grid Transformation Solutions	0	37	0	-37	-100.0%
Electricity Innovation and Transition[b]	0	0	6,407	+6,407	N/A
Total, SBIR/STTR	4,581	5,589	6,407	+818	+14.6%

[a] R&D reporting includes a proportional share of program direction funding in addition to direct R&D funding.
[b] The FY 2024 Request transfers all SBIR funding, along with technology transition and workforce development funding, from OE R&D programs to the new Electricity Innovation and Transition program.

DEPARTMENT OF ENERGY
Funding by Site
TAS_0318 - Electricity - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Ames Laboratory			
Resilient Distribution Systems	25	0	0
Grid Controls and Communications	25	0	0
Transformer Resilience and Advanced Components	250	250	300
Grid Hardware, Components, and Systems	250	250	300
Total Ames Laboratory	**275**	**250**	**300**
Argonne National Laboratory			
Transmission Reliability and Resilience	2,407	2,700	4,100
Energy Delivery Grid Operations Technology	715	2,580	2,660
Resilient Distribution Systems	1,698	2,100	5,200
Grid Controls and Communications	4,820	7,380	11,960
Energy Storage R&D	1,358	1,500	1,700
Energy Storage	1,358	1,500	1,700
Grid Hardware, Components, and Systems	1,358	1,500	1,700
Grid Planning and Development (formerly, Transmission Permitting & Tech Assist.)	350	0	0
Grid Technical Assistance (GDO)	0	500	0
Total Argonne National Laboratory	**6,528**	**9,380**	**13,660**
Brookhaven National Laboratory			
Transmission Reliability and Resilience	1,080	1,100	1,700
Grid Controls and Communications	1,080	1,100	1,700
Energy Storage R&D	20	50	50
Energy Storage	20	50	50
Grid Hardware, Components, and Systems	20	50	50
Total Brookhaven National Laboratory	**1,100**	**1,150**	**1,750**
Idaho National Laboratory			
Transmission Reliability and Resilience	2,794	2,600	4,000
Energy Delivery Grid Operations Technology	500	1,500	1,550
Resilient Distribution Systems	2,705	2,000	2,700
Cyber Resilient & Secure Utility Communications Network (SecureNet)	1,485	0	0
Grid Controls and Communications	7,484	6,100	8,250
Energy Storage R&D	265	300	350
Energy Storage	265	300	350
Transformer Resilience and Advanced Components	540	500	700
Applied Grid Transformation Solutions	0	120	0
Grid Hardware, Components, and Systems	805	920	1,050
Total Idaho National Laboratory	**8,289**	**7,020**	**9,300**
Lawrence Berkeley National Laboratory			
Transmission Reliability and Resilience	1,616	1,300	2,000
Resilient Distribution Systems	1,344	2,050	4,200
Grid Controls and Communications	2,960	3,350	6,200
Energy Storage R&D	20	50	50
Energy Storage	20	50	50
Grid Hardware, Components, and Systems	20	50	50
Electricity Innovation and Transition	557	0	0
Grid Planning and Development (formerly, Transmission Permitting & Tech Assist.)	200	0	0
Grid Planning & Development (GDO)	0	2,000	0
Grid Technical Assistance (GDO)	0	2,500	0
Wholesale Electricity Market Technical Assistance and Grants	0	3,500	0
Total Lawrence Berkeley National Laboratory	**3,737**	**11,400**	**6,250**

DEPARTMENT OF ENERGY
Funding by Site
TAS_0318 - Electricity - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Lawrence Livermore National Laboratory			
Transmission Reliability and Resilience	1,523	2,200	3,400
Energy Delivery Grid Operations Technology	1,726	8,000	8,300
Resilient Distribution Systems	1,444	1,700	1,200
Cyber Resilient & Secure Utility Communications Network (SecureNet)	400	0	0
Grid Controls and Communications	5,093	11,900	12,900
Total Lawrence Livermore National Laboratory	**5,093**	**11,900**	**12,900**
Los Alamos National Laboratory			
Transmission Reliability and Resilience	2,000	2,200	3,400
Energy Delivery Grid Operations Technology	1,037	2,580	2,660
Resilient Distribution Systems	1,322	1,600	350
Grid Controls and Communications	4,359	6,380	6,410
Total Los Alamos National Laboratory	**4,359**	**6,380**	**6,410**
National Energy Technology Lab			
Applied Grid Transformation Solutions	0	0	500
Grid Hardware, Components, and Systems	0	0	500
Grid Planning and Development (formerly, Transmission Permitting & Tech Assist.)	1,785	0	0
Program Direction - GDO	330	471	0
Total Program Direction (OE)	330	471	0
Total National Energy Technology Lab	**2,115**	**471**	**500**
National Renewable Energy Laboratory			
Transmission Reliability and Resilience	2,568	2,000	3,000
Energy Delivery Grid Operations Technology	3,925	2,700	2,770
Resilient Distribution Systems	6,428	5,500	7,800
Cyber Resilient & Secure Utility Communications Network (SecureNet)	1,350	0	0
Grid Controls and Communications	14,271	10,200	13,570
Energy Storage R&D	545	600	700
Energy Storage	545	600	700
Transformer Resilience and Advanced Components	1,238	865	1,200
Grid Hardware, Components, and Systems	1,783	1,465	1,900
Grid Planning and Development (formerly, Transmission Permitting & Tech Assist.)	2,193	0	0
Grid Planning & Development (GDO)	0	5,500	0
Grid Technical Assistance (GDO)	0	3,600	0
Interregional and Offshore Transmission Planning	0	1,500	0
Total National Renewable Energy Laboratory	**18,247**	**22,265**	**15,470**
Oak Ridge National Laboratory			
Transmission Reliability and Resilience	1,370	3,800	5,900
Energy Delivery Grid Operations Technology	890	3,000	3,100
Resilient Distribution Systems	13,440	6,700	4,200
Cyber Resilient & Secure Utility Communications Network (SecureNet)	8,954	14,591	0
Grid Controls and Communications	24,654	28,091	13,200
Energy Storage R&D	2,762	3,000	3,500
Energy Storage	2,762	3,000	3,500
Transformer Resilience and Advanced Components	6,723	5,250	2,000
Applied Grid Transformation Solutions	0	450	0
Grid Hardware, Components, and Systems	9,485	8,700	5,500
Grid Planning and Development (formerly, Transmission Permitting & Tech Assist.)	80	0	0
Total Oak Ridge National Laboratory	**34,219**	**36,791**	**18,700**

DEPARTMENT OF ENERGY
Funding by Site
TAS_0318 - Electricity - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Pacific Northwest National Laboratory			
Transmission Reliability and Resilience	5,279	4,300	6,600
Energy Delivery Grid Operations Technology	1,968	6,200	6,430
Resilient Distribution Systems	10,293	11,400	17,300
Cyber Resilient & Secure Utility Communications Network (SecureNet)	1,524	0	0
Grid Controls and Communications	19,064	21,900	30,330
Energy Storage R&D	18,287	21,000	36,000
20-OE-100 Grid Storage Launchpad	46,600	0	0
Energy Storage	64,887	21,000	36,000
Transformer Resilience and Advanced Components	638	500	700
Grid Hardware, Components, and Systems	65,525	21,500	36,700
Electricity Innovation and Transition	799	2,000	3,000
Grid Planning and Development (formerly, Transmission Permitting & Tech Assist.)	2,073	0	0
Grid Planning & Development (GDO)	0	5,500	0
Grid Technical Assistance (GDO)	0	3,000	0
Total Pacific Northwest National Laboratory	**87,461**	**53,900**	**70,030**
Sandia National Laboratories			
Transmission Reliability and Resilience	1,292	2,100	3,250
Energy Delivery Grid Operations Technology	1,530	1,950	2,000
Resilient Distribution Systems	1,930	1,300	2,000
Cyber Resilient & Secure Utility Communications Network (SecureNet)	250	0	0
Grid Controls and Communications	5,002	5,350	7,250
Energy Storage R&D	24,576	25,500	35,500
Energy Storage	24,576	25,500	35,500
Transformer Resilience and Advanced Components	125	250	250
Grid Hardware, Components, and Systems	24,701	25,750	35,750
Grid Technical Assistance (GDO)	0	400	0
Total Sandia National Laboratories	**29,703**	**31,500**	**43,000**
SLAC National Accelerator Laboratory			
Transmission Reliability and Resilience	700	1,025	1,600
Resilient Distribution Systems	75	0	0
Grid Controls and Communications	775	1,025	1,600
Energy Storage R&D	20	50	50
Energy Storage	20	50	50
Grid Hardware, Components, and Systems	20	50	50
Total SLAC National Accelerator Laboratory	**795**	**1,075**	**1,650**
Undesignated Lab/Plant/Installation			
Energy Delivery Grid Operations Technology	0	1,604	30
Grid Controls and Communications	0	1,604	30
Total Undesignated Lab/Plant/Installation	**0**	**1,604**	**30**
Washington Headquarters			
Resilient Distribution Systems	1,515	1,500	400
Grid Controls and Communications	1,515	1,500	400
Energy Storage R&D	330	350	350
20-OE-100 Grid Storage Launchpad	400	0	0
Energy Storage	730	350	350
Transformer Resilience and Advanced Components	0	1,000	700
Applied Grid Transformation Solutions	0	0	500
Grid Hardware, Components, and Systems	730	1,350	1,550

DEPARTMENT OF ENERGY
Funding by Site
TAS_0318 - Electricity - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Grid Planning and Development (formerly, Transmission Permitting & Tech Assist.)	1,319	0	0
Grid Planning & Development (GDO)	0	3,000	0
Grid Technical Assistance (GDO)	0	5,000	0
Interregional and Offshore Transmission Planning	0	500	0
Wholesale Electricity Market Technical Assistance and Grants	0	1,000	0
Program Direction - OE	11,477	14,003	14,773
Program Direction - GDO	2,670	4,736	0
Total Program Direction (OE)	14,147	18,739	14,773
Total Washington Headquarters	**17,711**	**31,089**	**16,723**
Grants			
Transmission Reliability and Resilience	2,058	3,610	2,360
Energy Delivery Grid Operations Technology	500	500	500
Resilient Distribution Systems	11,281	13,330	1,800
Cyber Resilient & Secure Utility Communications Network (SecureNet)	1,673	0	9,500
Grid Controls and Communications	15,512	17,440	14,160
Energy Storage R&D	20,147	35,170	170
Energy Storage	20,147	35,170	170
Transformer Resilience and Advanced Components	115	17,000	12,500
Applied Grid Transformation Solutions	0	7,635	20,000
Grid Hardware, Components, and Systems	20,262	59,805	32,670
Electricity Innovation and Transition	4,870	9,707	11,000
Grid Technical Assistance (GDO)	0	10,000	0
Wholesale Electricity Market Technical Assistance and Grants	0	12,000	0
Congressional Directed Spending - Electricity	2,850	0	0
Program Direction - OE	5,523	3,790	3,902
Total Program Direction (OE)	5,523	3,790	3,902
Total Grants	**49,017**	**112,742**	**61,732**
Undesignated LPI			
Transmission Reliability and Resilience	254	2,652	1,190
Resilient Distribution Systems	0	4,368	150
Cyber Resilient & Secure Utility Communications Network (SecureNet)	4,736	0	5,500
Grid Controls and Communications	4,990	7,020	6,840
Energy Storage R&D	2,354	1,395	180
Energy Storage	2,354	1,395	180
Transformer Resilience and Advanced Components	1,007	1,000	3,350
Applied Grid Transformation Solutions	0	1,668	8,700
Grid Hardware, Components, and Systems	3,361	4,063	12,230
Total Undesignated LPI	**8,351**	**11,083**	**19,070**
Total Funding by Site for TAS_0318 - Electricity	**277,000**	**350,000**	**297,475**

Nuclear Energy

Nuclear Energy

Nuclear Energy
($K)

FY 2022 Enacted[1,2]	FY 2023 Enacted[1,3,4,5]	FY 2024 Request
1,654,800	1,773,000	1,562,620

Overview

Nuclear energy underpins the President's plan to put the United States (U.S.) on a path to net-zero emissions by 2050. With 92 operating units in 28 states, the U.S. nuclear reactor fleet already helps mitigate the worst impacts of the climate crisis by providing half of the nation's carbon-free electricity with firm power that complements renewables. Expanded deployment of advanced nuclear power, a Net Zero Game Changer, promises to minimize land-use and transmission requirements while offering regional economic benefits, equitable job transitions, and unique capabilities to decarbonize myriad non-electric applications. U.S. nuclear energy leadership also plays key national security and global strategic roles for the U.S., including supporting the highest international standards for safety, security, and nonproliferation while countering the coercive policies of authoritarian regimes.

The U.S. pioneered the development and peaceful use of nuclear power and the nuclear fuel cycle to produce around-the-clock, emissions-free baseload electricity generation. The Office of Nuclear Energy now leads and supports research, development, demonstration, and deployment (RDD&D) enabling (1) continued operation of existing reactors, (2) deployment of new reactors, (3) a secure and sustainable nuclear fuel cycle, and (4) expansion of U.S. international nuclear energy cooperation. NE executes its mission through investments in early-stage RDD&D that leverage the tremendous innovation capacity of the United States' national laboratories, universities, and advanced nuclear technology developers to transform the global energy landscape. Through coordination and engagement with the public, Congress, regional governments, and Tribes, NE also incorporates crosscutting initiatives to advanced diversity in nuclear energy, energy and environmental justice, and jobs and the American workforce. NE is also responsible for ensuring the secure operational availability of Idaho National Laboratory (INL) as a national asset supporting a broad range of civilian and national security research.

The FY 2024 Request helps to advance U.S. leadership in critical technologies, invest in our workforce, and upgrade America's research infrastructure. It supports the diverse civilian nuclear energy programs of the U.S. Government to research and develop nuclear energy technologies, including generation, safety, and security technologies, to assist in unleashing the clean energy transition through strategic, innovative RDD&D. The NE FY 2024 Request will expand the impact of our RDD&D funding through modern, innovative funding mechanisms - such as prizes, competitions, technical assistance, and programs targeted to small businesses.

Additionally, the FY 2024 Request strives to develop and demonstrate the advanced fuel cycle technologies needed to place the United States in a global leadership position of the nuclear industry by addressing gaps in the domestic nuclear fuel supply chain for both existing and advanced nuclear reactors to assure the supply of low enriched uranium (LEU), including high assay low enriched uranium (HALEU), needed by U.S. reactors and those of our allies. The FY 2024 Request also supports spent nuclear fuel management activities, including a consent-based approach to siting interim used nuclear fuel storage which centers energy and environmental justice.

Finally, the FY 2024 Request supports U.S. nuclear energy leadership that enables our bilateral and multilateral civil nuclear energy engagements to promote global decarbonization, achieve energy security, and create synergies for civil nuclear RDD&D cooperation with like-minded partners across the globe.

[1] Funding does not reflect the transfer of SBIR/STTR to the Office of Science.
[2] Funding does not reflect the FY 2022 mandatory transfer of $91.0 million from Naval Reactors for operation of the Advanced Test Reactor.
[3] Funding does not reflect the FY 2023 mandatory transfer of $92.7 million from Naval Reactors for operation of the Advanced Test Reactor.
[4] Funding does not reflect the mandatory transfer of $20 million to the Office of Science for ORNL Nuclear Facilities O&M.
[5] Funding reflects $300 million appropriated under the Ukraine Supplemental Act, 2023 (P.L. 117-180): Advanced Nuclear Fuel Availability ($100 million), National Reactor Innovation Center ($20 million), Risk Reduction for Future Demonstration ($120 million), and ARDP Demonstration Reactors ($60 million).

Highlights and Major Changes in the FY 2024 Congressional Budget Request

The NE Budget Requests $1.56 billion to support the President's commitment to put America on a path to achieve net-zero emissions no later than 2050 by investing in resilience, clean energy innovation, and U.S. competitiveness. These investments will leverage the tremendous innovation capacity of the National Laboratories, universities, and advanced reactor developers to transform America's power sector.

- **NEUP, SBIR/STTR and TCF** requests $146.7 million for expanded competitive university led research at universities. The program also provides NE's support for the Small Business Innovation Research and Small Business Technology Transfer SBIR/STTR) programs, the Technology Commercialization Fund (TCF) program, the University Nuclear Leadership Program (UNLP), and University Fuel Services (UFS). Funding levels for SBIR, STTR and TCF are based on legally required percentages of NE's total research, development and Demonstration budgets. Funding for university-led R&D and infrastructure also meets legally required levels, the maximum extent practicable.
- **Advanced Small Modular Reactor RD&D** requests $20.0 million, including $10 million to support the Carbon Free Power Project's commercial demonstration of the NuScale SMR technology.
- **Advanced Nuclear Fuel Availability** requests $120.0 million to fund the near-term activities already underway for the recovery and downblending of DOE material, and enrichment operations at the Piketon facility. The subprogram complements the Inflation Reduction Act activities that will primarily be used to support a long-term, sustainable, diverse, market-driven commercial HALEU supply. Accelerated efforts to prepare EBR-II used as a HALEU feedstock are continued under Material Recovery and Waste Form Development.
- Within its **Infrastructure** Program, NE is requesting $318.9 million for **INL Facilities Operations and Maintenance (IFM)** subprogram. The request will focus on maintaining mission critical facilities to support technical advancements in existing nuclear fleet, reactors, and nuclear fuel cycle. It will also focus on investing in the Advanced Test Reactor (ATR) Complex and the Materials and Fuels Complex to improve reliability and modernize capabilities in support of nuclear energy R&D objectives. Funding for the **ORNL Nuclear Facilities O&M subprogram** is included in the Office of Science Request.
- **Idaho Sitewide Safeguards and Security** requests $177.7 million, an increase of $27.7 million above the FY 2023 enacted level. The additional funding will provide enhanced cybersecurity capabilities at the Idaho National Laboratory as well as initiating replacement of the Entrance Control Facility at the Materials and Fuels Complex.
- The **International Nuclear Energy Cooperation** program requests $13.0 million to provide funding to educate and familiarize small and emerging nuclear states with U.S. nuclear technology and best practices; initiating one or more Front-End Engineering Design studies supporting U.S. nuclear builds in partner countries; and increasing U.S. presence in Eastern Europe, the Baltic States, Southeast Asia, and the Americas, through nuclear workforce capacity building, academic and professional training, joint studies, and regional technical events.

Nuclear Energy
Funding by Congressional Control ($K)

	FY 2022 Enacted[6,7]	FY2023 Enacted[6,8,9,10]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
NEUP, SBIR/STTR and TCF	**100,000**	**130,276**	**146,710**	**+16,434**	**+13%**
Nuclear Leadership Development Program	**6,000**	**0**	**0**	**0**	**0%**
Reactor Concepts Research, Development & Demonstration (RD&D)					
Advanced SMR RD&D	150,000	165,000	20,000	-145,000	-88%
Light Water Reactor Sustainability	48,000	45,000	35,000	-10,000	-22%
Advanced Reactor Technologies	59,000	49,000	43,200	-5,800	-12%
Reactor Concepts RD&D	**257,000**	**259,000**	**98,200**	**-160,000**	**-62%**
Fuel Cycle Research and Development					
Mining, Conversion and Transportation	2,000	2,000	1,500	-500	-25%
Materials Recovery and Waste Form Development	30,000	45,000	39,000	-6,000	-13%
Accident Tolerant Fuels	115,000	114,000	108,900	-5,100	-5%
TRISO and Graphite Qualification	37,000	32,000	25,000	-7,000	-22%
Fuel Cycle Core R&D	23,150	29,000	29,000	0	0%
Advanced Nuclear Fuel Availability	45,000	100,000	120,000	+20,000	+20%
Used Nuclear Fuel Disposition R&D	50,000	47,000	46,875	-125	-0%
Integrated Waste Management System	18,000	53,000	53,000	0	0%
Fuel Cycle R&D	**320,150**	**422,000**	**423,275**	**+1,275**	**+0%**

[6] Funding does not reflect the transfer of SBIR/STTR to the Office of Science.
[7] Funding does not reflect the FY 2022 mandatory transfer of $91.0 million from Naval Reactors for operation of the Advanced Test Reactor.
[8] Funding does not reflect the FY 2023 mandatory transfer of $92.7 million from Naval Reactors for operation of the Advanced Test Reactor.
[9] Funding does not reflect the mandatory transfer of $20 million to the Office of Science for ORNL Nuclear Facilities O&M.
[10] Funding reflects $300 million appropriated under the Ukraine Supplemental Act, 2023 (P.L. 117-180): Advanced Nuclear Fuel Availability ($100 million), National Reactor Innovation Center ($20 million), Risk Reduction for Future Demonstration ($120 million), and ARDP Demonstration Reactors ($60 million).

Nuclear Energy
($K)

	FY 2022 Enacted[1,2]	FY2023 Enacted[6,8,9,10]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Nuclear Energy Enabling Technologies					
Crosscutting Technology Development	29,000	32,000	32,778	+778	+2%
Joint Modeling and Simulation Program	30,000	28,500	28,500	0	0%
Nuclear Science User Facilities	33,000	35,000	35,000	0	0%
Transformational Challenge Reactor	25,000	0	0	0	0%
Nuclear Energy Enabling Technologies	**117,000**	**95,500**	**96,278**	**+778**	**+1%**
Advanced Reactor Demonstration Program					
National Reactor Innovation Center[3]	53,000	70,000	34,000	-36,000	-51%
Demonstration 1	30,000	0	0	0	0%
Demonstration 2	30,000	0	0	0	0%
ARDP Demonstration Reactors	0	60,000	0	-60,000	-100%
Risk Reduction for Future Demonstrations	115,000	120,000	120,000	0	0%
Regulatory Development	15,000	10,250	11,000	+750	+7%
Advanced Reactor Safeguards	5,000	4,750	6,000	+1,250	+26%
23-E-200, LOTUS[3]	2,000	20,000	32,000	+12,000	+60%
Subtotal, Advanced Reactors Demonstration Program	**250,000**	**285,000**	**203,000**	**-82,000**	**-29%**
Infrastructure					
INL Facilities Operations & Maintenance	295,000	318,924	318,924	0	0%
ORNL Infrastructure Facilities O&M	20,000	20,000	0	-20,000	-100%
University Fuel Services	15,000	0	0	0	0%
Construction					
16-E-200, Sample Preparation Laboratory	41,850	7,300	0	-7,300	-100%
Subtotal, Infrastructure	**371,850**	**346,224**	**318,924**	**-27,300**	**-8%**

Nuclear Energy
($K)

	FY 2022 Enacted[1,2]	FY2023 Enacted[6,8,9,10]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Idaho Sitewide Safeguards and Security	**149,800**	**150,000**	**177,733**	**+27,733**	**+19%**
International Nuclear Energy Cooperation	**3,000**	**0**	**13,000**	**+13,000**	**+100%**
Program Direction	**80,000**	**85,000**	**85,500**	**+500**	**+1%**
Total, Nuclear Energy R&D	**1,654,800**	**1,773,000**	**1,562,620**	**-210,380**	**-12%**
Federal FTEs	265	294	320		

SBIR/STTR:

- FY 2022 Transferred: SBIR $24,997; STTR $3,515
- FY 2023 Transferred: SBIR $23,385; STTR $3,288
- FY 2024 Request: SBIR $21,314; STTR $2,997

Future-Years Energy Program

($K)

	FY 2024 Request	FY 2025	FY 2026	FY 2027	FY 2028
Nuclear Energy (Non 050)	1,384,887	1,417,000	1,449,000	1,483,000	1,517,000
Nuclear Energy (050) S&S	177,733	182,000	186,000	191,000	192,000

Outyear Priorities and Assumptions

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2024 - FY 2028. The outyear funding levels use the growth rates from and match the outyear account totals published in the FY 2024 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

Nuclear Energy priorities in the outyears include the following:

- Supporting the five Risk Reduction for Future Demonstration awards and the National Reactor Innovation Center under the Advanced Reactor Demonstration Program.
- Providing limited quantities of HALEU for NE research and demonstration requirements.
- Providing for the secure availability of Idaho National Laboratory for NE, DOE and other U.S. government requirements.
- Expanding access to university based nuclear energy science and engineering opportunities.

Infrastructure and Investment Jobs Act (IIJA) Investments

NE was appropriated funds through the Infrastructure and Investment Jobs Act (IIJA) (P.L. 117-58). Not all IIJA activities will be managed by the organization to which funds were appropriated. Activities that will be managed by other organizations are discussed below.

($K)

Nuclear Energy	FY 2022 IIJA Funding	FY 2023 IIJA Funding	FY 2024 IIJA Funding	Managing Organization
Civil Nuclear Credit Program	1,200,000	1,200,000	1,200,000	GDO
Total, Nuclear Energy	**1,200,000**	**1,200,000**	**1,200,000**	

- **Civil Nuclear Credit Program:** The goal of this investment is to help preserve the existing U.S. reactor fleet and save thousands of high-paying jobs across the country. Under the new program, owners or operators of commercial U.S. reactors can apply for certification to bid on credits to support their continued operations. An application must demonstrate the reactor is projected to close for economic reasons and that closure will lead to a rise in air pollutants and carbon emissions. The program is available for plants that are certified as safe to continue operations and prioritizes plants that use domestically produced fuel. Although funds were appropriated to NE, the Grid Deployment Office (GDO) will continue to execute the Civil Nuclear Credit Program in FY 2024.

Inflation Reduction Act (IRA) Investments

Nuclear Energy was appropriated funds through the Inflation Reduction Act of 2022 (IRA). Not all IRA activities will be managed by the organization to which funds were appropriated. Activities that NE will manage, including those appropriated to other organizations, are itemized below.

($K)

Appropriated Funding Organization	FY 2022 IRA Funding	Managing Organization
Nuclear Energy		
Sec. 50172 National Laboratory Infrastructure (c) Office of Nuclear Energy	150,000	Nuclear Energy
Sec. 50173 Availability of High-Assay Low-Enriched Uranium	700,000	Nuclear Energy
Total, Nuclear Energy	**850,000**	

- **Sec. 50172 National Laboratory Infrastructure:** The goal of this investment is to accelerate infrastructure upgrades at the Idaho National Laboratory. FY 2024 activities will see ongoing efforts on general plant projects initiated in FY 2023.
- **Sec. 50173 Availability of High-Assay Low-Enriched Uranium**: The goal of this investment is to accelerate the availability of HALEU to fuel advanced demonstration and commercial reactors. FY 2024 activities will include supporting the U.S. Nuclear Regulatory Commission with criticality benchmark data, assisting industry with transportation package development, and working toward supplying HALEU to industry in coordination with a HALEU Consortium.

NEUP, SBIR/STTR, and TCF

Overview

The NEUP, SBIR/STTR, and TCF program consolidates and focuses support to universities and small businesses in areas relevant to the Office of Nuclear Energy's (NE) mission. This program funds university research, infrastructure support and revitalization, workforce development, and commercialization efforts for nuclear energy. Efforts are largely awarded through competitive opportunities for researchers, students, faculty, and small businesses. Additionally, the program provides fuel services, maintenance support, reactor sharing, and safety upgrades of fuel fabrication equipment and facilities for United States (U.S.) university research reactors. This program seeks to ensure equitable access to these opportunities and benefits, specifically seeking ways to include communities that have historically faced limits in access to such capabilities, such as students and faculty at minority serving institutions (MSIs), including Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities (TCUs).

Highlights of the FY 2024 Budget Request

Consistent with the FY 2023 appropriation, the NEUP, SBIR/STTR, and TCF program includes support for the following: Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs, the Technology Commercialization Fund (TCF) program, the Nuclear Energy University Program (NEUP), the University Nuclear Leadership Program (UNLP), and University Fuel Services (UFS).

Under NEUP, the Infrastructure Revitalization element supports competitively awarded, consortium-led efforts to establish and/or enhance nuclear research capabilities at U.S. universities. These activities will not include construction of new reactors, but they may include enhancements to existing reactors and addition of related capabilities such as simulators. This support will help U.S. universities (1) develop a workforce with hands-on experience with commercially relevant advanced reactor concepts, reflective of those being deployed by industry; (2) offer research capabilities that address emerging technical challenges; and (3) ensure that access to the opportunities and benefits of these capabilities are equitably provided, specifically seeking ways to include communities that have historically faced limits in access to such capabilities. These activities are expected to be led by one or more diverse consortia with appropriate expertise to ensure that the new capabilities will support these goals. A goal is to maximize the research and educational value and the broad accessibility of these resources in an equitable and inclusive manner.

A reactor sharing program will be implemented to increase the use of university research reactors through support of expanded partnering and public outreach. The program will increase public engagement with nuclear energy, improve public familiarity with nuclear reactor technologies, enable mutual learning with communities that house research reactors, and stimulate undergraduate and graduate enrollment in nuclear energy related fields. All activities will focus on expanding access to research reactors with a specific emphasis on serving traditionally underserved communities and MSIs.

Under UFS, funding will be used to continue fabrication of 25 new fuel assemblies for the North Carolina State University (NCSU) PULSTAR reactor, which is reaching the end of its current core life. It is estimated that a new fuel core and fuel boxes will be needed by the end of FY 2025 for this reactor to remain operational.

NEUP, SBIR/STTR, and TCF
Funding ($K) (Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
NEUP, SBIR/STTR, and TCF					
NEUP, SBIR/STTR, and TCF	100,000[1]	106,276	119,858	+13,582	+12.8%
University Nuclear Leadership Program	6,000[2]	6,500	6,630	+130	+2%
University Fuel Services	15,000[3]	17,500	20,222	+2,722	+15.6%
Total, NEUP, SBIR/STTR and TCF Programs	**121,000**	**130,276**	**146,710**	**+16,434**	**+12.6%**

SBIR/STTR:

- FY 2022 Transferred: SBIR $24,997; STTR $3,515
- FY 2023 Enacted: SBIR $23,385; STTR $3,288
- FY 2024 Request: SBIR $21,314; STTR $2,997

[1] FY 2022 funding for Directed Research and Development reflects actual appropriated amount for "NEUP, SBIR/STTR, and TCF".
[2] FY 2022 funding for University Nuclear Leadership Program appropriated as Integrated University Program.
[3] FY 2022 funding for University Fuel Services appropriated as Research Reactor Infrastructure within Infrastructure program.

NEUP SBIR/STTR and TCF
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
NEUP, SBIR/STTR, and TCF:	**+13,582**
The increase from $106,276,000 to $119,858,000 reflects the selection and initiation of projects to revitalize existing university nuclear research infrastructure, a university reactor sharing program, and additional university-led R&D awards.	
University Nuclear Leadership Program:	**+130**
The increase from $6,500,000 to $6,630,000 reflects continued support for awards and an exchange opportunity with the United Kingdom for fellowship awardees.	
University Fuel Services:	**+2,722**
The increase from $17,500,000 to $20,222,000 reflect additional Training, Research, Isotopes, General Atomics (TRIGA) fresh fuel orders to ensure that a maximum number of fuel elements can be purchased per year, resulting in the lowest average price per element. The increase funding will also be used to continue fabrication of new fuel assemblies in support of the North Carolina State University (NCSU) PULSTAR reactor.	
Total, NEUP, SBIR/STTR, and TCF	**+16,434**

NEUP, SBIR/STTR, and TCF

Description

The NEUP, SBIR/STTR, and TCF subprogram includes competitively awarded opportunities for small businesses, national laboratories, and universities. The university program seeks to support cutting-edge, innovative research at U.S. universities, with the goal to expand participation with minority serving institutions (MSIs), including Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities (TCUs). Having a single program funding line provides more flexibility to Nuclear Energy's (NE) competitive award process; streamlines program execution; and provides enhanced transparency for small businesses, universities, and other stakeholders.

The principal focus areas for FY 2024 include four elements: (1) Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR); (2) Technology Commercialization Fund (TCF); (3) University-led Research and Development; and (4) University Infrastructure.

1. **SBIR/STTR –** NE supports small business through the Department's SBIR/STTR program. The SBIR/STTR reauthorizing language (Reauthorization Act of 2011 (P.L. 112-81, 125 STAT 1822)) directs the Department to spend not less than 3.2 percent of its extramural research and development (R&D) budget for SBIR and not less than 0.45 percent of its extramural R&D budget for STTR. NE's contribution supports scope relevant to NE's R&D mission, for example technologies for improvements of existing reactors, advanced reactors, and fuel cycle systems.
2. **TCF –** NE supports the transfer of promising nuclear energy technologies developed at the Department's national laboratories to the nuclear industry for commercialization through TCF. The TCF was established under 42 U.S. Code § 16391, which directed the Secretary to "establish an Energy Technology Commercialization Fund, using 0.9 percent of the amount made available to the Department for applied energy research, development, demonstration, and commercial application for each fiscal year based on future planned activities and the amount of the appropriations for the fiscal year, to be used to provide matching funds with private partners to promote promising energy technologies for commercial purposes."
3. **University-led Research and Development –** NE supports the U.S. university community with competitive research and development through yearly competitive solicitations. The program's goal is to support outstanding, cutting-edge, and innovative research at U.S. universities in the areas of nuclear energy science, technology and social impacts through the following funding opportunities:
    a. **Consolidated Innovative Nuclear Research (CINR):** NE will continue to utilize the CINR funding opportunity to align nuclear energy research being conducted at U.S. colleges and universities with DOE's mission, focusing on mission-supporting research as well as the needs and priorities of key NE programs including fuel cycle, reactor concepts, and spent fuel management research. This opportunity will also include Integrated Research Projects (IRPs), which are multi-disciplinary and multi-institutional projects that address near-term nuclear energy research challenges, technology innovation needs, or capability gaps. IRPs are intended to integrate across disciplines to achieve solutions to complex research challenges that cannot be addressed by a less comprehensive team.
    b. **Distinguished Early Career Program (DECP):** NE will continue to utilize its most prestigious opportunity for faculty members, DECP. This program will focus on early career faculty conducting transformative research, education, and leadership aligned with the Office of Nuclear Energy's mission. It will enable awardees to develop innovative, cutting-edge research programs in nuclear energy relevant areas, not only recognizing their demonstrated potential as outstanding researchers but also as transformative educators. This opportunity will support the development of the most promising faculty members nationwide as they advance novel nuclear energy research and train the next generation of nuclear energy professionals. DECP aims to recognize distinguished researchers at the pivotal initial stage of their careers and to support high-impact contributions to nuclear energy research, innovation, discovery, leadership, and dissemination of knowledge.

c. **Innovations in Nuclear Energy Research and Development (R&D) Student Competition:** NE will support four competitions under this student opportunity, which recognizes, and awards published graduate and undergraduate students for innovative nuclear energy research. The competition is a continuation of the "Innovations in Nuclear Technology R&D Awards Program" supported since 2010 by the Office of Nuclear Fuel Cycle and Supply Chain and administered by the University Research Alliance.

4. **University Infrastructure –** Nuclear Energy (NE) supports the infrastructure needed at universities to conduct cutting-edge research and to educate and train the next generation nuclear workforce.

   NE provides competitively awarded funding to universities through solicitations that will include the following elements to revitalize the existing university nuclear research infrastructure.

   a. **General Scientific Infrastructure –** to focus on equipment, instrumentation, and associated non-reactor upgrades that significantly improve or expand research, instruction, and training capabilities at individual universities and colleges.
   b. **Reactor Upgrades –** to improve existing nuclear research and training reactors at individual universities and colleges. It includes the purchase and maintenance of equipment to enhance the safety, security, performance, control, or operational reliability of the research reactor.
   c. **Reactor Sharing Program –** to provide a competitive opportunity to increase the use of university research reactors through support of expanded partnering and public outreach. The program will improve public understanding of nuclear energy, increase public acceptance of nuclear reactor technologies, and build goodwill with communities that house research reactors while also stimulating undergraduate and graduate enrollment in nuclear energy related fields.
   d. **Infrastructure Revitalization –** to competitively award consortium-led efforts toestablish and/or enhance nuclear research infrastructure capabilities at U.S. universities. These activities will not include construction of new reactors, but they may include enhancements to existing reactors and addition of related capabilities such as simulators. This support will helpU.S. universities (1) develop a workforce with hands-on experience with commercially relevant advanced reactor concepts, reflective of those being deployed by industry; (2) offer research capabilities that address emerging technical challenges; and (3) ensure that access to the opportunities and benefits of these capabilities are equitably provided, specifically seeking ways to include communities that have historically faced limits in access to such capabilities. These activities are expected to be led by one or more diverse consortiawith appropriate expertise to ensure that the new capabilities will support these goals. A goal is to maximize the research and educational value and the broad accessibility of these resources in an equitable and inclusive manner.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
SBIR/STTR **$26,673,000**	**$24,311,000**	**-$2,362,000**
• In FY 2023, Nuclear Energy (NE) plans to provide $26,673,000 for Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) through allocated charges to other research and development (R&D) programs. Awards will be made in areas such as advanced technologies for nuclear energy and used fuel.	• Support competitively awarded nuclear science and engineering small business and technology awards focusing in the areas of advanced technologies for nuclear energy and used fuel.	• The decrease is due to decreased Nuclear Energy research and development funding.
Technology Commercialization Fund **$8,602,000**	**$5,931,000**	**-$2,517,000**
• In FY 2023, NE will provide $8,602,000 for the Technology Commercialization Fund (TCF) through allocated charges to other R&D programs. Awards will be made in areas such as advanced technologies for nuclear energy and used fuel.	• Supports competitive laboratory funding opportunity designed to help commercialize promising nuclear energy related technologies developed at the national laboratories.	• The decrease is due to decreased Nuclear Energy research and development funding.
University Led Research & Development **$59,001,000**	**$77,873,000**	**+$18,461,000**
• In FY 2023, NE will provide $59,001,000 for university led R&D through allocated charges to other R&D programs. Awards will be made for research in areas such as fuel cycle, reactor concepts, and mission supporting research.	• Supports competitively awarded, university-led nuclear energy R&D that focus on the priorities of NE programs, including fuel cycle, reactor concepts, and mission supporting research. • Supports early career awards focused on faculty conducting transformative research, education, and leadership aligned with the NE mission. • Support Innovations in Nuclear Energy Technology R&D Publication Competition focused on graduate and undergraduate students' research published through journal publications and conference proceedings.	• The increase is due to increased Nuclear Energy research and development funding. • The increase will support the Innovations in Nuclear Energy Technology R&D Publication Competition for undergraduate and graduate students.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
University Infrastructure		
$12,000,000	**$12,000,000**	**+$0**
• In FY 2023, NE used $12,000,000 for university infrastructure Awards supported general scientific infrastructure, reactor upgrades at U.S. universities, and revitalization of existing university nuclear research infrastructure, especially in support of nuclear cyber-physical protection, new digital technologies in advanced nuclear reactors, and the development and safety assessments of small modular reactors.	• Supports general scientific infrastructure, reactor upgrades, reactor sharing, and infrastructure revitalization through competitive solicitations. • Supports competitively awarded, consortium-led activities to enhance nuclear research capabilities at U.S. universities, including establishment of new non-reactor capabilities such as simulators and relevant improvements to existing research reactors.	• No change.

University Nuclear Leadership Program

Description

The University Nuclear Leadership Program (UNLP) provides undergraduate scholarships and graduate fellowships to students attending two and four-year institutions and supports other internship programs that assist disadvantaged communities.

The Office of Nuclear Energy (NE) UNLP subprogram supports the next generation of the nuclear energy workforce. The subprogram provides important educational support to bolster scientific discovery and innovation in nuclear science and engineering (NS&E) at U.S. universities and colleges.

The subprogram is intended to attract qualified students to nuclear energy professions by providing single-year undergraduate scholarships and multi-year graduate fellowships. Scholarships are awarded for undergraduate study at two and four-year institutions leading to a major or minor degree or certificate and fellowships are awarded for graduate-level work leading to a masters or doctoral degree in the fields or disciplines of NS&E relevant to the NE mission. NS&E disciplines of interest include nuclear engineering, mechanical engineering, electrical engineering, chemistry, health physics, nuclear materials science, radiochemistry, applied nuclear physics, nuclear policy, radiation protection technology, nuclear power technology, nuclear maintenance technology, and nuclear engineering technology work leading to a masters or doctoral degree in the fields or disciplines of NS&E relevant to the NE mission.

In FY 2024, UNLP will expand the opportunity for graduate fellowship students to compete for an opportunity to tour nuclear facilities in the United Kingdom (UK) under the United States (US) / UK bilateral collaboration.

NE has awarded more than $60 million for 1,017 nuclear energy-related scholarships and fellowships at 77 universities and colleges—13 of which are MSIs, including 2 HBCUs—in 32 states since the program was initiated in 2009 under the Integrated University Program. Currently, scholarships are offered at $10,000 for one year to students attending four-year institutions and $5,000 to students attending two-year trade schools and community colleges. The maximum award for a fellowship is $54,000 per year for three years, with an additional one-time $7,000 allotment to fund a minimum 10-week internship at a DOE national laboratory or other designated facility.

All scholarship and fellowship awards are competitively awarded to students attending U.S. institutions of higher education offering NS&E educational programs, including MSIs, HBCUs, and TCUs. Emphasis is placed on increasing the involvement of MSIs, resulting in direct and meaningful investments in the areas of clean energy training and workforce development in support of the administration's goals for equity and inclusion.

<u>OMNI Internships</u>

OMNI Internships, a DOE Office of the Chief Information Officer-led effort, help to build careers for talented cybersecurity and information technology professionals to strengthen the security of the Department, the national laboratories, and the nuclear industry.

University Nuclear Leadership Program
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
University Nuclear Leadership Program		
$6,500,000	**$6,630,000**	**+$130,000**
• Support nuclear science and engineering study and research by fully funding approximately 30 or more multi-year student fellowships and 45 or more single-year scholarships in the nuclear energy field of study. • Support a new scholarship program opportunity that targets two-year applied technical degree programs focused on nuclear energy-related topics, all with an increased emphasis on capacity-building and education at MSIs, and institutions in disadvantaged communities. This opportunity will focus on workforce development for nuclear relevant technician training, including nuclear operations, mechanical maintenance, electrical maintenance, chemistry, health physics and other nuclear energy-related topics. • Bolster outreach efforts focused on increasing MSI involvement to include website resources, conference promotion, and university visits. • Support an OMNI internship program that will help build careers for talented cybersecurity and information technology professionals to strengthen the security of the Department, the national laboratories, and the nuclear industry.	• Support nuclear science and engineering study and research by fully funding approximately 30 multi-year student fellowships and 60 single-year scholarships in the nuclear energy field of study. • Support competitive exchange opportunity for University Nuclear Leadership Program (UNLP) fellows to tour nuclear facilities under the bilateral collaboration with the United Kingdom (UK). • Bolster outreach efforts focused on increasing MSI involvement to include website resources, conference promotion, and university visits. • Support an OMNI internship program that will help build careers for talented cybersecurity and information technology professionals to strengthen the security of the Department, the national laboratories, and the nuclear industry.	• The increase reflects fully funding single-year scholarships and multi-year fellowships and maintaining or increasing the number of such awards. • The increase will provide support for a competitive exchange opportunity with the UK for graduate fellowship students, under our bilateral collaboration, which will strengthen students' nuclear international experience.

University Fuel Services

Description

University Fuel Services (UFS) provides fuel services for U.S. university research reactors. These activities were previously funded within the Research Reactor Infrastructure (RRI) subprogram.

UFS provides fresh reactor fuel to, and removes used fuel from, 25 operating university research reactors at 24 U.S. universities to support their continued operation. This provides continued research and training reactor capability to U.S. universities to ensure their continued ability to support U.S. nuclear energy initiatives in the areas of research, development, and educational opportunities.

The continued operation of U.S. university research reactors directly supports the successful execution of the nuclear energy research mission and plays an important role in developing future scientists and engineers in the U.S. These research reactors provide irreplaceable training, education, and research support to hundreds of students annually, and many hosting universities expand access to these reactors through partnerships with minority serving institutions in underserved or disadvantaged communities, including innovative online opportunities providing direct access to reactor operating data. UFS support ensures continued reactor operations that directly expand diversity of Science, Technology, Engineering and Math (STEM) opportunities. This subprogram sustains unique capabilities for research and development and educational opportunities supporting U.S. energy initiatives. Used nuclear fuel shipments support U.S. and Department of Energy non-proliferation and national security objectives.

UFS provides project management, technical support, quality engineering and inspection, and nuclear material support. Major program deliverables include procuring new plate fuel elements and shipping them to select universities; transporting used fuels from U.S. universities to a DOE site; procuring High Assay Low Enriched Uranium (HALEU) and shipping it to the Training, Research, Isotopes, General Atomics (TRIGA) Fuel Fabrication Facility (TFFF) in Romans, France, for fabrication of TRIGA fuel and procuring new TRIGA fuel elements from the TFFF; and reusing lightly-irradiated TRIGA fuel currently in inventory at Idaho National Laboratory (INL) by retrieving, inspecting and shipping it to universities with the most urgent need.

Commercial TRIGA fuel element production at the TFFF started in FY 2022. In FY 2024, UFS will provide $9.24 million for the procurement of TRIGA fresh fuel elements, to meet the increased fresh fuel requests from the 12 TRIGA research reactors located at U.S. universities, and to take advantage of the significant fuel cost discount provided to the Department if full orders are placed annually. UFS will also continue to ship used plate and TRIGA reactor fuel elements from supported universities to DOE used fuel receipt facilities. The Department will continue its policy, initiated in FY 2017, of reusing lightly irradiated TRIGA fuel in the DOE inventory and will evaluate additional alternative sources.

The existing North Carolina State University PULSTAR reactor fuel is reaching end of its current core life. It is estimated that a new fuel core and fuel boxes will be needed by the end of FY 2025 for this reactor to remain operational. In FY 2024, funding will be used to continue fabrication of 25 new fuel assemblies. Work will include initiating contracts to fabricate 750 fuel pins, to manufacture 25 fuel assembly zircaloy fuel boxes, and to manufacture fuel assembly end fittings.

University Fuel Services
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
University Fuel Services **$17,500,000**	**$20,222,000**	**+$2,722,000**
• Procure 40 and deliver 36 plate fuel elements required annually by University of Missouri (MU) and Massachusetts Institute of Technology (MIT) as determined by need and fuel availability. • As needed, ship up to two cask loads of lightly irradiated 8.5 wt% standard Training, Research, Isotopes, General Atomics (TRIGA) fuel elements from the Irradiated Fuel Storage Facility at Idaho National Laboratory (INL) to select U.S. university research reactor facilities. • Procure up to 90 TRIGA fuel elements annually after the first year from the TRIGA Fuel Fabrication Facility (TFFF). As needed, procure and ship High Assay Low Enriched Uranium (HALEU) metal to the TFFF in Romans, France, to support procurement of TRIGA fuel elements, and ship fuel elements to TRIGA reactor facilities as determined by need and fuel availability. • Complete up to five used fuel shipments to Savannah River Site (SRS) and the INL, pending resolution of moratorium on such shipments to the INL. • Initiate fuel design and engineering studies; modeling, design and licensing of a shipment package, and procurement of fuel assembly boxes and end fittings for the North Carolina State University (NCSU) PULSTAR reactor. • Continue University Fuel Services (UFS) project management, quality assurance, nuclear material accountability, and transportation cask maintenance.	• Procure 40 and deliver between 33 and 36 plate fuel elements required annually by MU and MIT as determined by need and fuel availability. • As needed, ship up to two cask loads of lightly irradiated 8.5 wt% standard TRIGA fuel elements from the Irradiated Fuel Storage Facility at INL to select U.S. university research reactor facilities. • Procure up to 90 TRIGA fuel elements annually after the first year from TFFF. As needed, procure and ship HALEU metal to the TFFF in Romans, France, to support procurement of TRIGA fuel elements, and ship fuel elements to TRIGA reactor facilities as determined by need and fuel availability. • Complete up to five used fuel shipments to SRS and the INL, pending resolution of moratorium on such shipments to the INL. • Procure fuel pins, fuel assembly boxes, and end fittings for the NCSU PULSTAR reactor. • Continue UFS project management, quality assurance, nuclear material accountability, and transportation cask maintenance.	• The increase reflects additional TRIGA fresh fuel orders to ensure that a maximum number of fuel elements can be purchased per year, resulting in the lowest average price per element. • The increase provides funding to initiate contracts for the fabrication of the fuel pins, fuel assembly boxes, and end fittings.

Reactor Concepts Research, Development, and Demonstration

Overview

The Reactor Concepts Research, Development, and Demonstration (RD&D) program supports conducting RD&D on existing and advanced reactor designs and technologies. This RD&D enables industry to address technical and regulatory challenges associated with maintaining the existing fleet of nuclear reactors; promoting the development of a robust pipeline of advanced reactor designs, technologies, and associated supply chains; and progressing these advanced reactor designs and technologies towards demonstration when appropriate. Program activities are focused on addressing technical, economic, safety, and security enhancement challenges associated with the existing commercial light water reactor fleet and advanced reactor technologies, covering large, small, and micro-sized designs across an array of reactor types including fast reactors using liquid metal coolants and high temperature reactors using gas or molten salt coolants.

To maximize the benefits of nuclear power, the following challenges must be addressed:

- improving affordability of nuclear energy technologies;
- enhancing safety and reducing technical and regulatory risk;
- minimizing proliferation risks of nuclear materials; and
- improving the economic outlook for the United States (U.S.) nuclear industry.

Reactor Concepts RD&D is key to enabling the industry to reverse the downward market trajectory of our nation's nuclear energy sector by regaining a technological and market leadership role. Through cost-shared RD&D activities, related technical assistance, and cross-cutting innovative research and development (R&D), the Department will enable industry to accelerate the timeline for commercialization of new, advanced, and more economic reactor technologies that will help revive and expand the domestic nuclear industry while advancing America's leadership role in the global nuclear sector and meeting our nation's clean energy goals. Reactor Concepts RD&D also makes these technology advancements accessible to the U.S. industry through the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative.

The Reactor Concepts RD&D program continues to support RD&D efforts focused on small modular reactors (SMRs) in FY 2024. The Advanced SMR RD&D subprogram supports cost-shared RD&D activities that accelerate the domestic demonstration of U.S. SMR technologies to facilitate further deployment of U.S. technologies in domestic and international markets, including countries that have expressed interest in near-term SMR deployment. In FY 2024, the program will prioritize supporting the Carbon Free Power Project's commercial demonstration of the NuScale SMR technology.

The Light Water Reactor Sustainability (LWRS) subprogram conducts research in support of light water reactor (LWR) technologies so that LWR-based commercial nuclear power plants can continue to provide safe, clean, and reliable energy. The goal is to enable industry to enhance the efficient and economic performance of current nuclear power plants while enabling their extended operation. A critical element of the subprogram is cost-shared, private-public partnerships to help industry resolve its highest priority and highest uncertainty technical issues where U.S. government partnership is appropriate.

The Advanced Reactor Technologies (ART) subprogram conducts targeted R&D on advanced reactor technologies, including molten salt reactors, liquid metal-cooled reactors, high temperature gas-cooled reactors, and microreactors. The subprogram also supports work on cross-cutting R&D that can be applied to multiple advanced reactor concepts, including non-light water reactor SMRs. This subprogram focuses on efforts in the following areas: fundamental technologies and design methods for advanced reactors, interactions of diverse reactor coolants with materials and components, advanced energy conversion, analysis of reactor response to severe accidents, research to enhance safety and reduce regulatory risk, experimental validation of models, advanced materials development and qualification, and continued international collaborations. Funding will also support competitively awarded projects to assist the progression of emerging advanced reactor designs and technologies.

Highlights of the FY 2024 Budget Request

The Advanced SMR RD&D subprogram has successfully completed federal support for the NuScale SMR First-of-a-Kind Nuclear Demonstration Readiness Project and will transition towards supporting the Carbon Free Power Project's commercial demonstration of the NuScale SMR technology.

The Reactor Concepts RD&D program will continue to conduct RD&D activities to address technical, cost, safety, and security enhancement challenges associated with the existing commercial light water reactor fleet and advanced reactor technologies.

Reactor Concepts Research, Development, and Demonstration
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Reactor Concepts Research, Development and Demonstration					
Advanced Small Modular Reactor RD&D	150,000	165,000	20,000	-145,000	-87.9%
Light Water Reactor Sustainability	48,000	45,000	35,000	-10,000	-22.2%
Advanced Reactor Technologies	59,000	49,000	43,200	-5,800	-11.8%
Total, Reactor Concepts Research, Development and Demonstration	**257,000**	**259,000**	**98,200**	**-160,800**	**-62.1%**

Reactor Concepts Research, Development and Demonstration
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Advanced Small Modular Reactor RD&D:	**-145,000**
The decrease from $165,000,000 to $20,000,000 reflects the completion of federal support for the development of a U.S. SMR technology for deployment in domestic and international markets and the prioritization of programmatic efforts supporting the Carbon Free Power Project's commercial demonstration of the NuScale SMR technology.	
Light Water Reactor Sustainability:	**-10,000**
The decrease from $45,000,000 to $35,000,000 reflects the conclusion of several laboratory projects that are now being adopted by industry and a reduction in competitively selected industry cost shared awards.	
Advanced Reactor Technologies:	
The decrease from $49,000,000 to $43,200,000 reflects completion of funding for the Advanced Reactor Concepts-2020 (ARC-20) awards in FY2023.	**-5,800**
Total, Reactor Concepts Research, Development & Demonstration	**-160,800**

Reactor Concepts Research, Development and Demonstration
Advanced Small Modular Reactor RD&D

Description

The Advanced Small Modular Reactor (SMR) Research, Development and Demonstration (RD&D) subprogram supports enabling industry to reverse the downward market trajectory of our nation's nuclear energy sector, reestablishing U.S. leadership in the nuclear technology development and demonstration arena and meeting our nation's climate change and clean energy goals. A range of significant technological challenges remain in developing advanced SMR designs. The Department intends to leverage its appropriate federal role and notable expertise to facilitate industry's development and demonstration of advanced SMR designs that have the potential to provide safe, clean, and affordable energy generation options.

The Advanced SMR RD&D subprogram will support RD&D to assist in maturing SMR concepts toward commercial readiness, including supply chain development. Results will be widely applicable and can be adopted by domestic nuclear reactor vendors for the purpose of accelerating the development and demonstration of their technologies. Funding will support an ongoing award to continue only the most critical activities required to accelerate the domestic demonstration of an SMR technology. Demonstration of the SMR technology will facilitate further deployment of U.S. technologies in domestic and international markets, including countries that have expressed interest in near-term SMR deployment.

The subprogram will leverage ongoing and planned R&D activities supported by the related Advanced Reactor Technologies subprogram.

Advanced Small Modular Reactor RD&D

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Advanced Small Modular Reactor RD&D **$165,000,000**	**$20,000,000**	**-$145,000,000**

• Completed federal financial support for the NuScale SMR First-of-a-Kind Nuclear Demonstration Readiness Project, which supports the development of a U.S. SMR technology for deployment in domestic and international markets. Specific project activities include:
  ○ Completion of a Standard Plant Design, which will support deployments both domestically and abroad.
  ○ Submission of the Standard Design Approval Application (SDAA) to the Nuclear Regulatory Commission (NRC) for review and approval.
• Continued support for the Carbon Free Power Project, the first domestic demonstration of the NuScale SMR technology, on a timeline to achieve commercial operation of the first module by 2029 and the remaining five modules by 2030. Specific project activities include:
  ○ Completion of a Class 3 project cost estimate.
  ○ Collection of site environmental data needed for licensing.
  ○ Preparation of a Combined License Application (COLA) for submittal to the NRC in January 2024.
  ○ Initiation of a Class 2 project cost estimate and site-specific preliminary engineering.
	• Supports the Carbon Free Power Project's commercial demonstration of the NuScale SMR technology such that the technology will be considered for future deployments both domestically and abroad.
	• Competitively supports the nuclear industry in addressing the highest priority design maturation and supply chain needs necessary for the successful deployment of advanced reactors.
		• The decrease reflects the completion of federal support for the NuScale SMR First-of-a-Kind Nuclear Demonstration Readiness Project. and continued support for the Carbon Free Power Project's commercial demonstration of the NuScale SMR technology

Reactor Concepts Research, Development and Demonstration
Light Water Reactor Sustainability

Description

The Light Water Reactor Sustainability (LWRS) subprogram conducts research and development (R&D) on technologies and other solutions that can improve economics, sustain safety, and maintain the technical reliability of the current domestic fleet of commercial nuclear power plants.

The focus of the subprogram is on conducting R&D that addresses the nuclear industry's economic challenges that have led to premature plant shutdowns. LWRS will continue to collaborate with nuclear power plant owner-operators, vendors, suppliers, industry support organizations, other research organizations, and the Nuclear Regulatory Commission (NRC) to closely coordinate research that both supports industry needs and maximizes taxpayer benefit.

Currently, the LWRS subprogram consists of the following R&D areas:

- Plant Modernization: R&D to address nuclear power plant economic viability in current and future energy markets by increasing efficiency through the implementation of digital technologies. The R&D products will enable modernization of plant systems and processes across the industry by enabling a shift from a labor centric to a technology-centric business model that supports improved performance at a lower cost.
- Flexible Plant Operations and Generation: R&D to establish the technical feasibility and economic potential of dispatching thermal and electrical energy to diversify and increase revenue of commercial light water reactors in the U.S. The R&D products, including hydrogen production demonstration activities, will allow the existing fleet of nuclear reactors to readily respond to rapid changes in electricity supply and demand due to the widespread adoption of variable renewable energy resources and demonstrate the ability to repurpose nuclear power reactors into flexible energy sources for low-carbon industrial commodity production.
- Risk-Informed Systems Analysis: R&D to support decision-making related to the economics, reliability, and safety of the existing fleet by providing analysis solutions for integrated plant systems. By applying advanced quantitative methods, these activities support the improvement of plant operational procedures, plant asset management, and operations and maintenance activities. In addition, the R&D products in this area will be used to optimize plant economic performance and safety by incorporating the impacts of physical aging and degradation processes.
- Physical Security Research: R&D that will validate methods and tools which can be used to implement an updated, cost-effective physical security regime. The R&D products are expected to enable companies across the industry to reduce excessive conservatisms in security modeling, leverage automation as force multipliers, optimize security postures, and develop additional means to risk-inform approaches to evaluate security changes.
- Materials Research: R&D to develop the scientific basis for understanding and predicting long-term environmental degradation behavior of materials in nuclear power plants. The R&D products will be used to define operational limits and aging mitigation approaches for materials in nuclear power plant systems, structures, and components (SSC) subject to long-term operating conditions, providing key input to both regulators and industry.

In FY 2024, the LWRS subprogram continues to leverage cost-shared, private-public partnerships and our national laboratory system to conduct R&D to resolve industry's highest priority and highest uncertainty challenges where U.S. government partnership is appropriate. These high priority areas include providing science and technology-based solutions to improve the current business model and associated practices of the current fleet and develop the scientific bases for managing the aging of SSCs to allow existing nuclear power plants to continue to operate safely and cost-effectively.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Light Water Reactor Sustainability **$45,000,000**	**$35,000,000**	**-$10,000,000**
• Plant Modernization - Completed development of the Integrated Operations for Nuclear business operating model and demonstrate its use with an operating nuclear power plant which will allow utilities to shift their operations from a labor centric to a technology centric business model. Produced an Artificial Intelligence/Machine Learning methodology to achieve a fully automated risk-informed predictive maintenance strategy. • Flexible Plant Operation and Generation - Developed the methods and licensing approach for thermal extraction, thermal energy storage, and distribution. Engineer and simulate operations and control systems for direct use of heat generated from the existing light water reactor fleet. Developed architectural and engineering models, and investor-grade reports to detail the opportunities for providing clean thermal and electrical energy for industrial applications (e.g., hydrogen, ammonia, metals, chemicals, and fuels production). • Risk-Informed Systems Analysis – Enhanced the algorithm used to optimize the reactor core reload process and enable crediting Terry Turbines for extended operation, which will expand the mitigation options available to operators under both normal and emergency conditions.	• Plant Modernization – Collaborate with a partner utility to implement digital infrastructure upgrades and conduct an assessment of the adoption of advanced automation at a nuclear power plant. Develop and demonstrate a set of tools to digitalize work processes at nuclear power plants to streamline the regulatory compliance process and reduce administrative burden. • Flexible Plant Operation and Generation – Conduct regulatory research and risk assessments to support a preliminary Front End Engineering Design for thermal energy extraction and storage systems supporting 50% and 70% of the reactor's output. Evaluate components and processes that enable the end use of nuclear energy in industrial and transportations sectors. Develop a human-machine interface to allow for the dynamic dispatch of heat and electricity from a boiling water reactor to secondary applications • Risk Informed Systems Analysis – Perform an assessment of the economic benefits derived from the extended burnup times and smaller fuel batch size enabled by accident tolerant fuels. Enhance and demonstrate the risk analysis and reliability assessment framework for safety-critical nuclear digital instrumentation and control (DI&C) systems and extend it to incorporate software failures in intelligent DI&C systems.	The decrease from $45,000,000 to $35,000,000 reflects the conclusion of several laboratory projects that are now being adopted by industry and a reduction in competitively selected industry cost shared awards.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Physical Security - Delivered guidance to industry on the use and implementation of dynamic risk analysis tools to support dynamic physical security risk assessments, reducing utility security cost burdens and improving market competitiveness. • Materials Research - Implemented the reactor pressure vessel predictive embrittlement model through American Society for Testing and Materials (ASTM) and American Society of Mechanical Engineers (ASME) for code acceptance and wide industry use. Published a methodological guideline on concrete degradation for industry and accompany with the public release of Microstructure Oriented Scientific Analysis of Irradiated Concrete (MOSAIC) for industry use.	• Physical Security – Develop and deploy technology to improve the efficiency of the physical security posture at commercial nuclear power plants. Finalize the evaluation of a secure wireless capability during normal, abnormal, and malicious events and its ability to identify the location of jamming sources. Conduct nuclear utility pilot studies which leverage dynamic risk assessment methods to select cost reducing physical security technologies and estimate costs of security system upgrades. • Materials Research – Validate the image construction algorithm used for non-destructive examination of concrete structures. Complete material harvesting from the reactor pressure vessel at the Palisades Nuclear Generating Station to support validation of materials degradation models.	

Reactor Concepts Research, Development and Demonstration
Advanced Reactor Technologies

Description

The Advanced Reactor Technologies (ART) subprogram conducts essential research and development (R&D) activities to reduce technical risks associated with advanced reactor technologies and systems. The subprogram R&D scope reflects input from advanced reactor stakeholders with a goal of enabling industry to mature and ultimately demonstrate advanced reactor technologies in the 2030s. Innovative advanced reactor concepts have the potential to offer significant benefits versus existing technologies, including possible lower costs, enhanced safety and security, greater resource utilization, and simplified operations. Such advantages could allow nuclear energy to increase its contributions to domestic clean and resilient energy sources and to support the growth of high-paying U.S. jobs. The ART subprogram conducts R&D that can help reduce long-term technical barriers for multiple reactor technology concepts. This subprogram will address the full range of high-value R&D to advance technologies that benefit multiple advanced reactor concepts, including microreactor designs, and stimulate new ideas for transformational future concepts. The ART subprogram supports the Microreactor Applications, Research, Validation and Evaluation (MARVEL) project. MARVEL will be a nuclear microreactor test platform operated at the Idaho National Laboratory (INL) to test microreactor technologies and end-use applications.

ART R&D efforts support innovative reactor concepts, including high temperature gas-cooled reactors (HTGR), fast reactors, and molten salt reactors (MSR) using liquid salt coolants and/or fuels. The ART subprogram focuses on industry-informed R&D priorities that would provide widely-applicable benefits across many different advanced reactor concepts including: fundamental technologies and design methods for advanced reactors; interactions of advanced reactor coolants with materials and components; advanced systems and components that can operate in extreme high temperature environments; research to enhance safety; advanced materials development and codification; cross-cutting areas of support in advanced energy conversion technologies; and research to support microreactors for remote and micro-grid commercial applications. The ART subprogram conducts R&D to enhance the likelihood of future demonstration and commercialization of emergent advanced reactor technologies. The ART subprogram continues support for international collaborations on advanced materials, advanced reactor operations, and safety promoting the development of advanced reactors in the United States (U.S.) and supporting deployment of U.S. technologies in the global marketplace.

Industry-led, cost-shared R&D activities are supported through competitively selected industry awards to reduce technical and regulatory risks associated with advanced reactor designs. Specifically, in FY2021, DOE announced the selection of three awards to support the development of designs that could have significant impact on the energy market in the mid-2030s or later. These projects continue to meet project milestones. The three concepts selected for award were:

- Development of a conceptual design of a seismically isolated advanced sodium-cooled reactor facility - Advanced Reactor Concepts, LLC;
- Development of a fast modular reactor conceptual design with verifications of key metrics in fuel, safety, and operational performance - General Atomics; and
- Maturing the Modular Integrated Gas-Cooled High Temperature Reactor (MIGHTR) concept from a pre-conceptual stage to a conceptual stage - Massachusetts Institute of Technology (MIT).

FY 2024 activities for the ART subprogram will focus on essential research to address the highest priority challenges facing advanced reactor technologies and continued support for innovation through cost-shared partnerships with industry.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Advanced Reactor Technologies **$49,000,000**	**$43,200,000**	**-$5,800,000**
• Fast Reactor Technologies – Performed additional testing of the Thermal Hydraulic Experiment Test Article (THETA) in the Mechanisms Engineering Test Loop (METL) to generate data for fast reactor design and safety code validation. Performed model development and experimental validation activities to support development and licensing activities for fast reactors. • Gas Reactor Technologies – Performed additional experimental validation of normal operation and transient conditions and supported modeling and simulation activities using the water-based reactor cavity cooling system at the natural convection shutdown heat removal test facility (NSTF) at the Argonne National Laboratory (ANL). Supported long term testing to characterize creep behaviors of high temperature alloys. • Molten Salt Reactor (MSR) Technologies – Maintained and expanded the molten salt thermal properties database to aid in the design and licensing of MSRs. Developed and demonstrated online monitoring technologies to meet deployment process control needs with the transition from laboratory scale experiments to the Liquid Salt Test Loop at the Oak Ridge National Laboratory • Microreactor Technologies – Continued qualification and testing of high temperature moderator materials that have the broadest	• Fast Reactor Technologies – Assemble the Gripper Test Article, which simulates the fuel assembly gripper in a compact in-vessel fuel handling mechanism, and initiate preparations for testing in METL. Commission the Flow Sensor Test Article, which is needed for testing flow sensor technologies, for testing in the METL facility and initiate sodium testing. • Gas Reactor Technologies – Complete the full test matrix for the water-based reactor cavity cooling system at the NSTF at ANL**.** Support continued long term testing to characterize creep behaviors of high temperature alloys, such as Alloy 617, necessary for code case acceptance. • Molten Salt Reactor (MSR) Technologies – Develop a roadmap focused on conducting engineering scale molten salt spill tests to validate accident progression models for MSR licensing. Further expand the molten salt thermal properties database to aid in the design and licensing of MSRs. • Microreactor Technologies –Complete construction of the Microreactor Applications, Research, Validation and Evaluation (MARVEL) test platform to enable demonstration of microreactor technologies and end-use applications. Begin testing first non-nuclear power cycle test to provide valuable data on integrated microreactor system operation. Continue production of high-quality data on	• The decrease reflects the completion of funding for the ARC-20 awards in FY 2023 balanced by a greater emphasis on essential research to address the highest priority industry identified challenges associated with advanced reactor technologies and systems.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
potential application for microreactor applications. Complete design of nonnuclear integrated testing and validation capabilities for microreactor systems and operation. Began installation of the Microreactor Applications, Research, Validation and Evaluation (MARVEL) test platform (nuclear microreactor test platform to demonstrate the integration of commercial end-user applications). • Industry Awards (ARC-20) – Supported execution of the three ARC-20 projects per established project plans and using current and prior year carryover funds. Specific project activities include: o For the Advanced Reactor Concepts, LLC award: Conducted further pre-application engagement with the NRC. Completed conceptual design report. Initiated activities to support design and licensing. o For the General Atomics award: Conducted further pre-application engagement with the NRC. Completed report documenting analysis of reactor passive safety. Initiated irradiation testing of fuel in INL's Advanced Test Reactor. o For the MIT award: Completed preliminary manufacturing and licensing assessments for the modular integrated gas-cooled high temperature reactor (MIGHTR). Completed reports documenting layout of reactor internal structures, reactor pressure vessel design, reactor building layout and design criteria, and construction sequence.	performance of microreactor technologies to enhance the viability of microreactor concepts and drive down cost. • Industry Awards (ARC-20) – Support execution of the three ARC-20 projects per established project plans and using prior year carryover funds. Specific project activities include: o For the Advanced Reactor Concepts, LLC award: Complete the preliminary design, start detailed final design, and document Preliminary Safety Analysis Report (PSAR) for a generic site. Prepare design specifications for long lead components and develop a procurement schedule. o For the General Atomics award: Complete preliminary cost analysis for the General Atomics fast modular reactor concept. Conduct further pre-application engagement with the NRC. Continue fuel irradiation testing in INL's Advanced Test Reactor and complete fuel testing in INL's Transient Reactor Test Facility. o For the MIT award: Complete MIT ARC-20 project including completion of report documenting the cost basis for the MIGHTR design, completion of assessments of reactor performance during steady power operations, load following, and accident scenarios, and completion of seismic analysis of the reactor building.	

Fuel Cycle Research and Development

Overview

The Fuel Cycle Research and Development (FCR&D) program conducts applied research and development (R&D) on advanced fuel cycle technologies that have the potential to accelerate progress on managing and disposing of the nation's spent fuel and high-level waste, improve resource utilization and energy generation, reduce waste generation, and limit proliferation risk. Advancements in fuel cycle technologies support the enhanced availability, economics, and security of nuclear-generated electricity in the U.S., further enhancing U.S. energy independence and economic competitiveness. The FCR&D program also contributes to the Department's policies and programs for ensuring a secure reliable and economic nuclear fuel supply for both existing and future reactors.

The FCR&D program participates in world-class R&D and employs internationally renowned technical experts. FCR&D subprograms leverage their technical expertise by participating in international collaborations through bilateral and multilateral technical agreements. The program also participates in projects sponsored by the International Atomic Energy Agency and the Organization for Economic Cooperation and Development/Nuclear Energy Agency which provides further leverage in key technical areas.

The program supports R&D and evaluation of spent fuel and high-level waste disposition pathways, covering storage, transportation, and disposal technologies. The program also supports R&D on multiple advanced fuel technologies that hold promise for enhanced performance and improved economics or are an important element in the development of the next generation of reactor designs; making available small quantities of High Assay Low Enriched Uranium (HALEU) in the short term and work with industry to build out commercial HALEU production in the long term to support demonstration of advanced reactor technologies.

Highlights of the FY 2024 Budget Request

The Advanced Nuclear Fuel Availability subprogram includes limited production of HALEU at Piketon. The FY 2024 Request continues funding the near-term activities already underway including recovery and downblending DOE material and enrichment operations at the Piketon facility. The subprogram complements the Inflation Reduction Act activities that will primarily be used to support a long-term, sustainable, diverse, market-driven commercial HALEU supply. Accelerated efforts to prepare EBR-II used as a HALEU feedstock are continued under Material Recovery and Waste Form Development.

Fuel Cycle Research and Development
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Fuel Cycle Research and Development					
Material Recovery and Waste Form Development	30,000	45,000	39,000	-6,000	-13.3%
Mining, Conversion, and Transportation	2,000	2,000	1,500	-500	-25.0%
Accident Tolerant Fuels	115,000	114,000	108,900	-5,100	-4.5%
TRISO Fuel and Graphite Qualification	37,000	32,000	25,000	-7,000	-21.9%
Fuel Cycle Laboratory R&D	23,150	29,000	29,000	0	0.0%
Advanced Nuclear Fuel Availability	45,000	100,000[1]	120,000	+20,000	+20.0%
Used Nuclear Fuel Disposition R&D	50,000	47,000	46,875	-125	-0.3%
Integrated Waste Management System	18,000	53,000	53,000	0	0.0%
Total, Fuel Cycle Research and Development	**320,150**	422,000	**423,275**	+1,275	**+0.3%**

[1] Funded by Ukraine Supplemental Appropriations Act, 2023 (P.L. 117-180)

Fuel Cycle Research and Development
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Material Recovery and Waste Form Development Funding decrease from $45,000,000 to $39,000,000 reflects a reduced effort on hybrid ZIRCEX demonstration.	**-6,000**
Mining, Conversion, and Transportation Funding decrease from $2,000,000 to $1,500,000 reflects a shift to focus on a limited number of separation technologies to improve in-situ uranium extraction efficiency and resource utilization for the mining industry.	**-500**
Accident Tolerant Fuels Funding decrease from $114,000,000 to $108,900,000 reflects focus on meeting industry's objectives for developing the near-term ATF concepts.	**-5,100**
TRISO Fuel and Graphite Qualification Funding decrease from $32,000,000 to $25,000,000 reflects the TRISO fuel qualification program ramping down as it nears successful completion and high-cost activities such as irradiation experiments have been completed.	**-7,000**
Advanced Nuclear Fuel Availability Funding increase from $100,000,000 to $120,000,000 reflects expanding recovery and downblending at Savanah River Site and limited HALEU production at Piketon of at least 900 kg per year.	**+20,000**
Used Nuclear Fuels Disposition R&D Funding from $47,000,000 to $46,875,000 reflects a continuation of activities to conduct scientific research and technology development to enable long term storage, transportation, and disposal of spent nuclear fuel and wastes.	**-125**
Total, Fuel Cycle R&D	**+1,275**

Fuel Cycle Research and Development
Material Recovery and Waste Form Development

Description

The Material Recovery and Waste Form Development (MRWFD) subprogram conducts applied research and development (R&D) on advanced fuel recycle technologies that have the potential to improve resource utilization and energy generation, reduce waste generation, and limit proliferation risk. The subprogram focuses on developing advanced fuel recycling technologies and addressing fundamental materials separations and recovery challenges that present significant degrees of technical risks and financial uncertainties.

MRWFD provides unique nuclear chemistry expertise and technical capabilities in separation technologies to a broad range of applications by seeking a fundamental understanding of various chemical challenges related to civil nuclear applications. MRWFD stewards the capabilities and knowledge relied upon by policy makers to make informed decisions regarding nuclear fuel cycle options. Such decisions in turn rely on the development of efficient and economical separation methods that can accept the used nuclear fuel containing actinides and fission products to recycle selected actinides, recover valuable by-products, and deliver waste streams that are suitable for disposal. For example, MRWFD supports molten salt chemistry research to support advanced nuclear technologies using molten salts as electrolytes, fuel solvent and coolants. MRWFD funds research on integrated advanced technologies encompassing R&D on off gas capture and immobilization and advanced robust waste form development. The subprogram employs a science-based approach to foster innovative and transformational technology solutions to achieve this objective. Specifically, the MRWFD subprogram will continue to:

- Exploit principles of coordination chemistry to simplify actinide separations;
- Understand and manage radiation effects on materials and processes;
- Develop next generation pyroprocessing technologies and operations;
- Develop advanced salt waste forms to efficiently immobilize fission products; and
- Design robust materials for separation of gas-phase species.

The MRWFD subprogram also supports the development and demonstration of various recycling technologies to make available small quantities of high-assay low enriched uranium (HALEU) materials for advanced reactor fuel-fabrication R&D needs. HALEU can be recovered from feedstock that contains highly-enriched uranium (HEU) by using the molten salt and hybrid Zirconium Extraction (ZIRCEX) processes. Specifically, MRWFD supports the development of simplified salt process and advanced solid cathode technology which improve operations efficiency. The subprogram continues to evaluate the feasibility of recycling federally owned HEU fuels for HALEU production by developing hybrid ZIRCEX technology using a ¼-scale vapor phase demonstration pilot facility at the Idaho National Laboratory. In FY 2024, the hybrid ZIRCEX activity will continue supporting R&D in advanced chlorination agents to improve the economic and efficiency of the process and demonstrating the feasibility of aluminum extraction using unirradiated fuel from the Advanced Test Reactor.

Material Recovery and Waste Form Development
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Material Recovery and Waste Form Development		
$45,000,000	**$39,000,000**	**-$6,000,000**
• Developed innovative fuel recycling technologies targeting high-value used fuels. • Supported fundamental aqueous and molten salt separation chemistries to address challenges related to civil nuclear energy applications. • Determined efficiency of advanced complexants for simplified uranium recovery. • Developed advanced salt waste form and off-gas technologies. • Continued the accelerated EBR-II fuel treatment to fully fund an anticipated expansion of fuel treatment operations starting in FY 2024. • Continued hybrid ZIRCEX process focusing on cold pilot plant studies and advanced chlorination agents development.	• Continue the acceleration of EBR-II used fuel treatment. • Conduct lab scale demonstration of an innovative aqueous separation technology for simplified uranium recovery. • Determine efficiency of advanced complexants for improved actinide separations. • Initiate a simplified lithium chloride based single salt flowsheet for pyroprocessing technology. • Demonstrate a new salt waste form baseline using iron phosphate technology. • Continue developing innovative sorbent materials for off-gas technologies. • Continue vapor phase extraction and hybrid ZIRCEX technology development.	• Funding decrease reflects a reduced scope in hybrid ZIRCEX technology demonstration.

Fuel Cycle Research and Development
Mining, Conversion, and Transportation

Description

This subprogram supports R&D that enables technological advances in uranium mining, conversion, and transportation capabilities in the United States as well as conducting evaluations and assessments related to these areas. This subprogram supports activities related to the front end of the nuclear fuel cycle and supply chain.

Mining sites are often located in underserved communities and locations with limited water resources. Improvements to mining technology spurred by R&D may enable local economic opportunities and include environmental justice equities while reducing the amount of water used during uranium production.

In FY 2024, this subprogram will support technical experts at national labs to develop innovative separation technologies to improve in-situ uranium extraction efficiency and resource utilization for mining industry. Site-specific technical support will be provided to the U.S. mining industry.

Mining, Conversion, and Transportation
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Mining, Conversion, and Transportation		
$2,000,000	**$1,500,000**	**-$500,000**
• Continued R&D for uranium mining and processing technologies that reduce water usage and/or improve extraction efficiency and resource utilization for uranium production.	• Continue R&D for uranium mining and processing technologies that reduce water usage and/or improve extraction efficiency and resource utilization for uranium production.	• In FY 2024, this subprogram will focus on a limited number of innovative separation technologies to improve in-situ uranium extraction efficiency and resource utilization for the mining industry.

Fuel Cycle Research and Development
Accident Tolerant Fuels

Description

The subprogram mission is enabling industry's development of one or more light water reactor (LWR) fuel concepts with significantly enhanced accident tolerance through cost shared research and development (R&D).

Following the accident at Fukushima, the Office of Nuclear Energy responding to Congressional guidance initiated a program in collaboration with LWR fuel suppliers, national laboratories, and universities to explore advanced LWR fuel with enhanced accident tolerance, including under severe accidents, to benefit the existing U.S. commercial nuclear power reactor fleet. After five years of feasibility studies, industry interactions, and assessments of potential fuel concepts, the industrial program participants identified promising concepts that have the potential to significantly enhance accident tolerance. To implement the industrial collaboration, competitively-awarded, cost-shared cooperative agreements were established with three fuel vendors and the Department. The program has progressed to testing fuel within operating commercial reactors and in parallel analyzing the performance of vendor selected test fuels at the national laboratories, primarily to address data needed to support licensing.

The U.S. fuel suppliers are developing accident tolerant fuel concepts that the owner/operators of commercial U.S. reactors anticipate will provide substantial performance improvements during accidents and under normal operations. The enhanced performance expected of the accident tolerant fuel may also enable the fuel to operate for a longer period of time in the reactor. This would allow reactors to operate for longer times between refueling outages. Many reactors would be able to increase their cycle lengths from 18 to 24 months, and less fuel would be needed to generate the same amount of electricity resulting in substantially reduced spent nuclear fuel storage and disposal requirements. The use of ATF will also enable utilities to consider additional power uprates, a significant potential for improved utility economics.

This subprogram continues to support the industry's objective to initiate installing the first commercial quantities of accident tolerant fuel by the mid-2020s and also qualify the fuel for use at higher burnup levels. The many facets of the program are progressing at different timelines. These include near-term concepts such as coated cladding, high burnup fuel, higher enrichment levels, and long-term concepts such as fuel with silicon carbide cladding and also the use of higher density fuels. All of this involves cost-shared testing and examination of fuel and cladding material performance to generate data that can be used by industry partners to support: their Nuclear Regulatory Commission (NRC) licensing efforts, research and development of pilot fuel pellet and cladding manufacturing equipment, analysis and redesign of fuel fabrication processes, and revising fuel performance codes and methods.

This subprogram is primarily using the experimental and advanced analytical capabilities, only found at the Department of Energy (DOE) National Laboratories, to provide the U.S. nuclear industry with the data needed to qualify the accident tolerant fuel concepts. This includes fuel use at higher burnup levels, and demonstrating the performance of the fuel to take advantage of the safety and economic benefits that come with these more robust fuel designs. In FY 2024, this includes continuing the modifications at Idaho National Laboratory to expand its experimental capabilities. This involves: (1) the design, fabrication, and testing of experimental capsules to house irradiated fuel samples to simulate loss of coolant accident conditions in the INL transient reactor test facility (TREAT) and (2) the design and installation of a new test loop (I-Loop) in the Advanced Test Reactor (ATR). Both provide world-class experimental capabilities that were lost when the Halden test reactor in Norway shut down. These capabilities involve simulating boiling and pressurized water reactor conditions, highly-instrumented test trains, ramp testing, and dry-out testing. In addition, enhancements of the ORNL Severe Accident Test Station (SATS) will continue to provide licensing data. Also, in FY 2024, the partnership with industry to implement the necessary test plans to develop the data needed to qualify the Accident Tolerant Fuel concepts for higher burnup will continue.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Accident Tolerant Fuels $114,000,000	**$108,900,000**	**-$5,100,000**
• Continued irradiations of fuel rodlets in the central water loop of the ATR. Initiated advanced instrumented tests to expand data generation for real time fuel performance under irradiation. • Continued partnership with industry to support the Fuel Performance and Testing Technical Experts Group for burnup extension. This includes examination of high burnup fuel rods, furnace testing, re-irradiation of test samples in ATR, and loss of coolant tests in TREAT. • Conducted advanced LWR fuel technology research on ceramic fuel and cladding concepts. This includes fabrication technology development, separate effects irradiation tests in High Flux Isotope Reactor (HFIR) and ATR, and advanced characterization of properties and irradiation performance. • Continued to advance the accident tolerant fuel concepts under development by the three fuel vendor teams under cooperative agreements with the Department. This involves cost-shared testing and examination of fuel and cladding material performance, research and development of pilot fuel pellet and cladding manufacturing equipment, analysis and redesign of fuel fabrication processes, and revising fuel performance codes and methods.	• Continue to support the accident tolerant fuel concepts under development by the three fuel vendor teams under cooperative agreements with the Department. This involves cost-shared testing and examination of fuel and cladding material performance, and appropriate research and development support. • Continue irradiations of fuel rodlets in the central water loop of the ATR. • Continue in partnership with industry to support the Fuel Performance and Testing Technical Experts Group for burnup extension. This includes examination of high burnup fuel rods, furnace testing, re-irradiation of test samples in ATR, and loss of coolant tests in TREAT and SATS. • Perform TREAT tests that: investigate fuel fragmentation, relocation, and dispersal phenomena; investigate reactivity insertion accident induced clad burst performance; and demonstrate power ramp testing in a flowing water loop. • Continue work on the ATR I-Loop to provide vendors with needed testing capabilities, with planned initiation of operation in 2025. • Increase shipments of irradiated fuel from commercial reactors to the national labs for post-irradiation examination to provide data needed to qualify the fuel for use.	• Activities in FY 2024 will continue to focus on meeting industry's objectives for developing the near-term ATF concepts. Support for the development of long-term concepts will be reduced.

Fuel Cycle Research and Development
TRISO Fuel and Graphite Qualification

Description

The Tristructural-isotropic (TRISO)-coated particle fuel and graphite subprogram includes activities for fuel and material irradiation, post-irradiation examination (PIE) and safety testing, fuel performance modeling, and fission product transport and source term research.

TRISO particle fuel development and qualification activities support prismatic and pebble-bed high temperature fuel designs. Since the onset of the TRISO Fuel Program in 2002, the program has focused on qualification of the fuel design for high temperature gas reactor concepts; However, TRISO fuel also has applications for other reactor concepts such as molten salt-cooled high temperature reactors, and microreactors. Irradiation, safety testing, and PIE of TRISO fuel will provide data for fuel development and qualification in support of industry efforts to establish a domestic commercial TRISO fuel fabrication capability.

The graphite development and qualification efforts provide data to support the use of graphite in high temperature reactor environments. Since historical grades of graphite used in previous high temperature reactors are no longer available, graphite development includes efforts to characterize and irradiate new grades of graphite. These efforts provide non-irradiated and irradiated properties so that the thermomechanical design of the structural graphite in advanced high temperature reactors can be validated. The irradiation experiments span the proposed temperature and dose envelope for prismatic high temperature gas reactors, but also apply to pebble-bed and possibly molten salt-cooled high temperature reactors.

TRISO Fuel and Graphite Qualification
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
TRISO Fuel and Graphite Qualification $32,000,000	**$25,000,000**	**-$7,000,000**
• Performed further post-irradiation examination (PIE) of the Advanced Gas Reactor (AGR) -3/4 and AGR-5/6/7 TRISO fuel experiments to characterize fission product inventory and fuel performance in response to varying reactor fluence and temperature to support industry TRISO fuel qualification efforts. • Performed additional safety testing of TRISO fuel to characterize performance in elevated temperatures and fission product transport. • Performed facility modifications and air/moisture ingress experiment (AMIX) furnace installation in the hot cell at the Fuel Conditioning Facility (FCF) at the Materials and Fuels Complex at INL. • Further irradiated high dose graphite experiment in INL's ATR to subject graphite to doses that more closely reflect what would be experienced in pebble bed type reactors. • Performed additional characterization and PIE of graphite specimens to provide qualification data of various grades of graphite for use in high temperature reactors. • Supported additional testing and activities to American Society of Mechanical Engineers (ASME) code qualify nuclear grade graphite and establish design rules for use in high temperature reactors.	• Complete AGR-3/4 PIE and issue final report that will assess fission product retention and transport in reactor graphite and fuel matrix. • Perform further PIE of the AGR-5/6/7 TRISO fuel experiment to support qualification of TRISO fuel for use in demonstration and commercial high temperature reactors. • Perform testing of TRISO fuel in the AMIX furnace to understand performance in a transient scenario. • Complete advanced graphite creep (AGC-4) PIE to provide an understanding of graphite behavior under high temperature irradiation conditions. • Continue to support additional testing and activities to ASME code qualify nuclear grade graphite and establish design rules for use in high temperature reactors.	• Funding decrease from $32,000,000 to $25,000,000 reflects the TRISO fuel qualification program ramping down as it nears completion and high-cost activities such as irradiation experiments have been completed.

Fuel Cycle Research and Development
Fuel Cycle Laboratory R&D

Description

This subprogram supports research activities that advance knowledge of nuclear fuel cycles and provide transformative innovations to accelerate development of civil nuclear technologies, including consideration of fuel cycle impacts from the potential deployment of advanced reactor technologies. It includes activities in Materials Protection, Accounting and Control Technologies (MPACT), Systems Analysis and Integration (SAI), Innovative Nuclear Materials (INM), Innovative Process Control Capabilities (IPCC) and advanced reactor fuels R&D.

MPACT develops innovative technologies, analysis tools, and advanced integration methods to enable U.S. domestic nuclear materials management and safeguards for emerging nuclear fuel cycles. It also includes assessing vulnerabilities in current nuclear systems while minimizing proliferation risks. Addressing U.S. energy security needs requires innovative approaches to material control and accounting to ensure that nuclear material is not misused, diverted, or stolen.

SAI activities include strategic planning and analysis as well as integrated evaluation of program activities. It provides the critical capability needed to analyze complex fuel cycle system options, assess overall performance under various scenarios, and improve understanding of the interdependencies between various subsystems and associated technologies. In FY 2024, SAI activities will be expanded to support nuclear energy's role in enhancing energy security and achieving a net-zero economy. This includes assessing the impacts of nuclear-sourced clean hydrogen production, deeper assessments of coal to nuclear conversion opportunities, and broad analysis of fuel cycle impacts of HALEU usage in existing and future reactors.

INM activities focus on longer-term materials discovery and development for advanced nuclear energy systems applications. INM seeks innovative experimental approaches to understand, predict, and ultimately discover functional materials targeted for nuclear fuel and fuel recycle applications. The goals are to develop new tools, techniques, and capabilities at national laboratories to accelerate the pace of new materials discovery, building on recent advances in artificial intelligence, machine learning, theory, modeling, and computing, and advanced characterizations. For example, innovative approaches are needed to develop advanced metallic alloys and composite materials that are optimized to meet new reactor performance targets within the reactor core and fuel cladding. It also includes recycling of zircaloy cladding material, which is the second largest mass in used fuel assemblies. Developing recovery process with sufficient Zr purity to permit re-use will reduce the waste quantity as well as enhance resource utilization. Similar recycling approaches will be developed for other high value nuclear materials.

IPCC activities support foundational research to innovate include the development of innovative fuel cycle process control technologies, to enhance process controllability, and to enable predictive modeling capability in advanced nuclear separation systems. For example, a significant fraction of the space in a nuclear fuel recycling plant is occupied by large tanks—used for surge capacity or system redundancy. Implementing advanced process control and modeling technologies into the recycling plant design will reduce the size of such tanks, or even eliminate the need for this tank space. This in turn would directly reduce the cost of plant construction and operations. Many advanced reactor developers are using molten salt based technologies. The activity also supports fuel development and capabilities using advanced processing control technologies in molten salt recycling at the national laboratories. Specifically, IPCC supports innovative process monitoring and performance modeling capabilities for recycling of transuranic-bearing fuel salts.

Advanced reactor fuels activities include continued advances in accelerated fuel qualification activities to support advanced reactor development. In FY 2024 we will propose to build upon the advanced irradiation testing techniques recently developed at the national labs. Those techniques are the Fission Accelerated Steady-State Testing (FAST) approach at INL and MiniFuel separate effects testing at ORNL. Both techniques allow for much shorter irradiation times to gather meaningful data on fuel performance.

In support of advanced reactor developers proposing to use metallic fuel, topical reports for U.S. Nuclear Regulatory Commission review and approval will be developed on the fuel performance of reference metallic fuel alloys and on an

assessment of the BISON fuel performance code for metallic fuel performance. This program will establish a reference fuel performance baseline using legacy data and analyses, improve performance modeling capability in the BISON fuel performance code, and prepare for transient experiments in Transient Reactor Test Facility (TREAT) on legacy EBR-II reactor fuel.

Fuel Cycle Laboratory Research & Development
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Fuel Cycle Laboratory R&D $29,000,000	**$29,000,000**	**$0**
• Continued developing innovative technologies, analysis tools, and advanced integration methods for material control and accounting applications. • Continued innovative on-line process monitoring capabilities for advanced reactors fuel recycling. • Demonstrated high resolution microcalorimeter measurements at INL. • Deployed an acoustic system to monitor uranium and plutonium mass values in aqueous processing. • Continued to conduct performance assessments and economic and market analyses of promising advanced nuclear energy systems and their role in achieving a net-zero economy by 2050. • Continued accelerated irradiation experiments using the ATR and HFIR using Fission - Accelerated Steady-State Testing (FAST) and Mini-fuel Testing, respectively. Continue U.S./Japan joint transient testing of advanced reactor fuel concepts in TREAT. • Initiated a metallic fuel qualification program that supports advanced reactor developers using metallic fuel. This includes establishing a reference fuel baseline, improving performance modeling capability, and preparing for future transient experiments. • Supported molten salt recycling for salt fuels development capabilities at the national laboratories.	• Continue innovative on-line process monitoring capabilities for advanced reactors fuel recycling. • Complete development of nuclear materials accounting and control training curricula that fills gaps identified by industry stakeholders. Document state-of-the-science for molten salt purification, sampling and analysis R&D needs. • Continue national/regional assessments of the role of nuclear energy in achieving a net-zero economy, including providing clean firm electricity and clean energy for decarbonizing the industrial and transportation sectors. • Assess methods to reduce nuclear capital costs, including coal to nuclear infrastructure reuse, factory and supply chain efficiencies, and improved learning rates. • Continue accelerated irradiation experiments using the ATR and HFIR using Fission -Accelerated Steady-State Testing (FAST) and Mini-fuel Testing, respectively. Continue U.S./Japan joint transient testing of advanced reactor fuel concepts in TREAT. • Develop topical reports on the fuel performance of reference metallic fuel alloys and on an assessment of the BISON fuel performance code for metallic fuel performance. • Demonstrate first-of-a-kind probes for quantitative measurement of molten salt basicity. • Complete initial fabrication and screening test of promising new cladding materials and initiate irradiation studies.	• No funding change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Initiated cladding materials recycling and develop innovative new materials for next generation fuel cladding materials.		

Fuel Cycle Research and Development
Advanced Nuclear Fuel Availability[1]

Description

Advanced reactors are being developed for flexible baseload power generation, providing U.S. leadership in nuclear technology, enabling new markets for export, and reducing greenhouse gas emissions. Many of these reactors are expected to require high-assay, low-enriched uranium (HALEU) fuel. HALEU is uranium with the fissionable isotope U-235 enriched to between greater than 5 and less than 20 percent. Current commercial light water reactors use uranium enriched to up to 5 percent U-235. There are no commercial suppliers of HALEU in the U.S. and advanced reactor developers will need small quantities of HALEU in the near term to support the qualification of their fuel and larger quantities for the first demonstration reactors. Much larger quantities of HALEU will be needed when advanced reactors requiring HALEU fuel are commercialized.

This subprogram will work to make available small quantities of HALEU from limited DOE uranium inventories and leverage the HALEU enrichment demonstration capability in the short term, in coordination with the National Nuclear Security Administration (NNSA), and work with the private sector to establish a commercial U.S. HALEU production and supply chain capability for the long term.

Subprogram activities include initiating the recovery and down-blending of limited excess quantities of DOE uranium inventories to HALEU for DOE's use in research, development, and demonstration programs. In coordination with NNSA, NE will recover and downblend highly-enriched uranium from existing inventories located at the Savannah River Site and NNSA will identify and repurpose unused or scrap material at Y-12 under their Convert subprogram. The NE project initiated in FY 2023 continues in FY 2024, focusing on completing restart preparations for a downblending startup test and meeting regulatory requirements including NEPA compliance. FY 2024 milestones will include a startup test for downblending. Additionally, NE will contract with a conversion or fuel fabricator to procure equipment and plan for the receipt and processing of HALEU shipped from Savannah River Site beginning in late FY 2025 and FY 2026.

DOE transitioned the HALEU enrichment activities in Piketon, Ohio in November 2022, to a new competitively awarded, cost-share program to complete the HALEU Enrichment Demonstration and operate the 16-centrifuge cascade to produce a limited quantity of HALEU by no later than December 31, 2023. Once the initial quantity is produced, DOE will reimburse the contractor to immediately begin producing a minimum of 900 kg of HALEU within one year. Future options to continue the operation of the cascade beyond FY 2024 are subject to the annual budget process. The limited quantity of HALEU produced under this contract will be used for DOE's research, development, and demonstration programs, including to provide blend stock for HALEU fuel produced through the recovery and downblending activities described above.

This subprogram complements the activities funded under Section 50173 of the Inflation Reduction Act of 2022. Inflation Reduction Act activities include supporting the U.S. Nuclear Regulatory Commission with criticality benchmark data, assisting industry with transportation package development, supplying HALEU to industry in coordination with a HALEU Consortium, and providing other supporting activities.

[1] This subprogram complements the activities funded under Section 50173 of the Inflation Reduction Act of 2022. Inflation Reduction Act activities include supporting the U.S. Nuclear Regulatory Commission with criticality benchmark data, assisting industry with transportation package development, supplying HALEU to industry in coordination with a HALLEU Consortium, and providing other supporting activities.

Advanced Nuclear Fuel Availability
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Adv Nuclear Fuel Availability $100,000,000	**$120,000,000**	**+$20,000,000**
• Initiated the project for recovery and down-blending of limited excess quantities of DOE uranium inventories to HALEU. In coordination with NNSA, NE will recover and downblend highly-enriched uranium from existing inventories located at the Savannah River Site. FY23 activities include project planning, regulatory compliance activities, and the beginning of equipment reconstitution and flowsheet development. • Continued activities under a new competitively awarded cost share program to operate the 16-centrifuge cascade in Piketon to produce a limited quantity of HALEU for research, development, and demonstration use for one year, with the option to extend in future years. The private sector partner awarded the contract will operate the facility and produce HALEU for DOE's use. • Developed and begin to execute a strategy to address the National Environmental Policy Act requirements.	• Continue the project for recovery and down-blending of limited excess quantities of DOE uranium inventories to HALEU. • Finalize regulatory compliance activities including NEPA, complete most restart preparations, begin a startup test for downblending, contract with a conversion or fuel fabricator to procure equipment and plan for the receipt and processing of HALEU shipped from Savannah River Site. • Continue activities under a new competitively awarded cost share program to operate the 16-centrifuge cascade in Piketon. Produce a limited quantity of HALEU by no later than December 31, 2023, then begin producing a minimum of 900 kg of HALEU within one year. • Complete an Environmental Impact Statement for HALEU Availability Program activities in Support of Commercial Production of HALEU Fuel.	• In FY 2024, recovery and downblending at Savanah River Site will expand and HALEU production at Piketon will shift to a cost-plus incentive fee production effort of at least 900 kg per year.

Fuel Cycle Research and Development
Used Nuclear Fuel Disposition R&D

Description
The Used Nuclear Fuel Disposition Research and Development (R&D) subprogram conducts scientific research and technology development to enable long term storage, transportation, and disposal of spent nuclear fuel and wastes. The primary focus of this subprogram supports the development of disposition-path-neutral waste management systems and options in the context of the current inventory of spent nuclear fuel and waste.

Research and Development
Full-Scale Storage Cask Demonstration – Although the nuclear power industry has used dry storage for many years, this storage option has been for low-burnup fuel; therefore, there is limited data available on the degradation of more contemporary high-burnup fuels. To address this data gap, the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and nuclear industry are cooperating to investigate extended storage of high-burnup fuels (≥ 45 GWd/MTHM). DOE, in cooperation with the NRC and industry, is conducting a full-scale demonstration of storage for high-burnup fuel that will be beneficial by: 1) benchmarking the predictive models and empirical conclusions developed from short-term laboratory testing, and 2) building confidence in the ability to predict the performance of these systems over extended time periods.

Storage and Transportation R&D – In addition to the Full-Scale Storage Cask project, DOE will continue to support other lab testing, field studies, and both numerical and physical modeling R&D related to the storage and transport of high-burnup fuel to include: testing of cladding response with hydride reorientation and embrittlement; the effects of atmospheric corrosion on storage welds; measuring the embrittlement of elastomer seals; determining thermomechanical degradation of bolts, welds, seals and poisons; analyzing thermal profiles of stored fuels; determining the stress profiles of fuels and casks; evaluating cask drying processes; laboratory post-irradiation examination and testing of the fuel from the cask demonstration project at the North Anna Generating Station in Mineral, Virginia; and the development of sensors for internal and external cask monitoring. R&D will focus on contributing to the technical knowledge to support long-term storage and eventual transportation of high-burn-up fuels. As the DOE continues to make progress on the accident tolerant fuels and advanced reactor fuels, research will be done to ensure that data are gathered on the new/modified cladding and fuel materials to ensure that they can be stored and transported in the future. Current work also indicates that burnup rates for accident tolerant fuels could go up to 75 to 80 GWD/MTU for which very little if any data exists, so additional R&D will be done to address this gap.

Disposal R&D – Activities continue to further the understanding of long-term performance of disposal systems in three main geologic rock types: clay/shale, salt, and crystalline rock. These activities include collaborations with international partners to leverage and integrate applicable R&D being conducted by other countries into the U.S. disposal R&D portfolio. Also, evaluations will continue to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) used-fuel canisters in a mined repository. Evaluate the disposal performance characteristics of new accident tolerant fuels and any new high-level radioactive waste glass compositions. Support a pilot program to increase participation of underrepresented groups in research activities related to management and disposal of radioactive wastes.

Used Nuclear Fuel Disposition Research & Development (R&D)
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request Level vs FY 2023 Enacted
Used Nuclear Fuel Disposition Research & Development $47,000,000	**$46,875,000**	**-$125,000**
• Continued ongoing disposal R&D. • Evaluated the storage, transportation, and disposal performance characteristics of new accident tolerant fuels and high-level radioactive waste glass compositions. • Supported pilot program to increase participation of underrepresented groups in research activities related to management and disposal of radioactive wastes. • Consistent with the results of an Independent Technical Review continue evaluations to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) used-fuel canisters in a mined repository. • Continued destructive testing on sibling rods. • Worked with SONGS to install instrumentation on typical canisters used by the nuclear power plant industry. • Continued work to clear hot cells and prepare for acceptance of new accident tolerant fuels.	• Continue ongoing disposal R&D to further advance process and total system performance models for generic geologic repositories. • Evaluate the storage, transportation, and disposal performance characteristics of new accident tolerant fuels and any new high-level radioactive waste glass compositions. • Support pilot program to increase participation of underrepresented groups in research activities related to management and disposal of radioactive wastes. • Consistent with the results of an Independent Technical Review continue evaluations to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) used-fuel canisters in a mined repository. • Continue Phase I of destructive testing on sibling rods and begin Phase II which is testing on heated rods to bound rod conditions. • Work with SONGS to install instrumentation on typical canisters used by the nuclear power plant industry. • Continue research on Stress Corrosion Cracking for the canisters already loaded and future cans. • Continue work to clear hot cells and prepare for acceptance of new accident tolerant fuels and high burnup advanced reactor fuels.	• No significant funding change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request Level vs FY 2023 Enacted

Fuel Cycle Research and Development
Integrated Waste Management System

Description

The Nuclear Waste Policy Act of 1982 (NWPA) assigns the Department of Energy the responsibility for disposition of U.S. spent nuclear fuel (SNF) and high-level radioactive waste (HLW), and the Department remains committed to fulfilling the Federal Government's legal obligations to properly manage and dispose of that material. The Integrated Waste Management System (IWMS) subprogram supports efforts to develop and implement a Federal interim storage program that uses a consent-based approach to siting as part of an overarching waste management system, as well as storage, transportation, and systems engineering and analysis activities. The activities of this subprogram include developing a consent-based siting process, executing the first phase of consent-based siting for interim spent fuel storage. This phase focuses on capacity building through broad public outreach and engagement, preparing for large-scale transportation of spent nuclear fuel, and working with communities, stakeholders, and governmental entities in the more than 30 states where SNF and HLW is currently stored.

The IWMS subprogram's FY 2024 Budget Request funds critical activities required for effective implementation of consolidated Federal interim storage of the nation's nuclear waste using a consent-based approach. As part of its efforts, the Department will work collaboratively with the public, communities, stakeholders, and governments at the Tribal, state, and local levels to inform and refine a consent-based siting process. Toward this end, the Department will continue to support interested groups, communities, states, and Tribes to explore consent-based siting and interim storage, support mutual learning, and reduce barriers to participation in the consent-based siting process. This work will aim to build public participation into the consent-based siting process, improve the consent-based siting process through mutual learning, and continue development of communications materials and tools. Based on these engagements, the Department will develop a waste management system that incorporates social equity and environmental justice.

In parallel, the IWMS subprogram will continue technical preparations for site characterizations, facility designs, license applications, equipment acquisition, and emergency response training for future transportation routes. Transportation-focused activities include:

- A full-scale package performance test of a rail-sized SNF cask to help build public trust and confidence in the safety of SNF transport to Federal storage and disposal facilities;
- Engaging with State and Tribal partners to cooperatively plan for large-scale SNF transportation, including approaches to emergency response training and vehicle safety inspections;
- Developing purpose-built railcars and security and safety monitoring equipment to support large-scale SNF transport; and
- Beginning acquisition path for transportation casks for SNF, which may require moderate lead times to update cask certificates of compliance and initiate commercial fabrication capacity;
- Evaluating transportation infrastructure at nuclear power plant sites to identify options for removing SNF from the sites.

Meanwhile, other technical preparations will include:

- Developing a project management plan and supporting technical documentation to site, design, license, construct, and operate Federal interim storage facilities and an associated SNF transportation system;
- Analyzing regulatory considerations applicable to interim storage facility design options and siting processes;
- Updating and analyzing detailed data on quantities and characteristics of relevant nuclear waste inventories to inform options analyses and transportation planning; and

- Evaluating the costs and benefits of interim storage facility approaches.

The IWMS subprogram is identifying a Federal interim storage capability for commercial SNF following a consent-based siting process. In FY 2024, IWMS will continue planning and capacity building, including a broad public outreach effort, continuing to provide funding to interested groups and communities through cooperative agreements and sub-grants, engaging in mutual learning, and gathering feedback to further refine the consent-based siting process. Continued development of digital information and communications resources and planning for implementation of future phases of consent-based siting will also occur.

Along with consent-based siting activities, IWMS will continue technical engineering and analysis work on siting, facility design, licensing, construction, and operations of Federal interim storage facilities and associated SNF transportation capabilities. Preparations for large-scale transportation of SNF and HLW include development of purpose-built railcar equipment, design of a safety and security monitoring system for rail shipments, analyzing alternatives for shipment security escort services, assessment of transportation infrastructure and transport options at nuclear power plant sites, employment of state-of-the-science data and software tools to support decision-making and communications, thorough analysis of transportation system operational elements and dependencies, active engagement with State and Tribal government representatives through the Department's National Transportation Stakeholders Forum and associated working groups, and coordination with appropriate Federal agencies on safety and security considerations. These efforts build on successes and lessons learned from previous Departmental radioactive materials transportation programs and campaigns as identified through knowledge management activities.

Integrated Waste Management System
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Integrated Waste Management System $53,000,000	**$53,000,000**	**+$0**
• Awarded funding to interested groups, communities, States, or Tribes exploring the consent-based siting process and interim storage. • Developed a prototype siting analysis tool to assist interested communities in exploring interim storage. • Continued development of a plan, schedule, and cost estimate for a full-scale package performance test, including input from State and Tribal partners. • Conducted a demonstration run and deliver one Atlas 12-axle cask-carrying railcar, two buffer railcars, and one rail escort vehicle. • Provided one complete rail consist approved by the Association of American Railroads (AAR) ready to transport SNF in accordance with AAR Standard S-2043. • Began fabrication of one Fortis 8-axle cask-carrying railcar prototype. • Finalized the railcar safety inspection protocol developed in coordination with States and Tribes. • Began work to update DOE's proposed Section 180(c) Policy to provide emergency response training funds and technical assistance to States and Tribes. • Continued and expand upon existing planning, analysis, and outreach work for large-scale SNF transportation. • Started work on a concept of operations for SNF shipment security escort services. • Applied a systems engineering approach to IWMS	• Continue funding to interested groups, communities, States, or Tribes exploring the consent-based siting process and interim storage. • Enhance consultations and cooperation for consent-based siting through funding awardees (consortia), community liaisons, town halls, technical presentations, and other venues. • Prepare initial site suitability analysis resources for future volunteer sites, including digital tools for siting analysis. • Initiate cask acquisition and establish a testing plan for a full-scale package performance test of a rail-sized transportation cask, including avenues to engage the public in the project (the package performance testing is expected to be conducted over a subsequent 5-year period). • Complete fabrication of one Fortis 8-axle cask-carrying railcar prototype and begin performance testing. • Continue work to update DOE's proposed Section 180(c) Policy to provide emergency response training funds and technical assistance to States and Tribes. • Continue and expand upon existing planning, analysis, and outreach work for large-scale SNF transportation. • Continue working on a concept of operations for SNF shipment security escort services, including possible new agency directives, training requirements, and standard operating procedures.	• No funding change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
planning efforts, factoring in early feedback from consent-based siting activities. • Updated computational analysis tools to support systems engineering analyses for an integrated waste management system. • Provided technical information on interim storage and operations to support consent-based siting communications. • Started collecting data on proposed advanced reactor SNF forms and characteristics. • Developed an updated reference concept for a generic Federal consolidated Interim storage facility (CISF), including functions and requirements for facility operations. • Began assembling technical documentation to prepare for Critical Decision 0 - Mission Need for federal consolidated interim storage through the Department's Program and Project Management for the Acquisition of Capital Assets process (Order 413.3B). • Procured a pressure vessel to test inspection procedures for SNF casks. • Developed a NEPA strategy and analysis approach for interim storage and associated transportation.	• Perform additional systems analysis to support expanded siting, transportation, and storage work and associated interfaces. • Update computational analysis tools to include advanced reactor SNF information. • Study the feasibility of using standardized triple-purpose (transportation, aging/storage, and disposal) canisters for Accident Tolerant SNF and TRISO-based advanced reactor SNF. • Refine interim storage facility design concepts based on consent-based siting engagement and feedback, and considerations for cask-handling and receipt volume options. • Pursue Critical Decision 0 - Mission Need for federal consolidated interim storage through the Department's Program and Project Management for the Acquisition of Capital Assets process (Order 413.3B). • Begin evaluating implications for advanced reactor SNF and wastes into the integrated waste management system. • Begin the NEPA process and issue a Notice of Intent for an environmental impact statement (EIS).	

Nuclear Energy Enabling Technologies

Overview

The Nuclear Energy Enabling Technologies (NEET) program conducts research and development (R&D) and makes strategic investments in research capabilities to develop innovative and crosscutting technologies that resolve nuclear technology development issues. The Crosscutting Technology Development (CTD) subprogram focuses on innovative research that directly supports the existing fleet of nuclear reactors and enables the development of advanced reactors and fuel cycle technologies, including topical areas such as advanced sensors and instrumentation; nuclear cybersecurity; advanced materials and manufacturing technologies; and integrated energy systems. Also, NEET invests in modeling and simulation tools for existing and advanced reactors and fuel system technologies. The program also provides industry, universities, and national laboratories with access to unique nuclear energy research capabilities through the Nuclear Science User Facilities (NSUF) subprogram. By delivering innovative clean energy and advanced manufacturing technologies for nuclear energy systems, NEET-sponsored activities collectively support the Department's priorities to combat the climate crisis, create clean energy jobs with the free and fair chance to join a union and bargain collectively, and promote equity and environmental justice. NEET also makes these technology advancements accessible to the U.S. industry through the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative and private-public partnerships.

Highlights of the FY 2024 Budget Request

- The Crosscutting Technology Development subprogram is enhancing its focus on advanced manufacturing technologies of use for advanced reactors, particularly accelerated efforts to support the regulatory approval of additively-manufactured 316 stainless steel.

Nuclear Energy Enabling Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Nuclear Energy Enabling Technologies					
Crosscutting Technology Development	29,000	32,000	32,778	+778	+2.4%
Joint Modeling and Simulation Program	30,000	28,500	28,500	0	0%
Nuclear Science User Facilities	33,000	35,000	35,000	0	0%
Transformational Challenge Reactor	25,000	0	0	0	0%
Total, Nuclear Energy Enabling Technologies	**117,000**	**95,500**	**96,278**	**+778**	**+0.8%**

Nuclear Energy Enabling Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Crosscutting Technology Development: The increase from $32,000,000 to $32,778,000 reflects acceleration of efforts to qualify additively-manufactured 316 stainless steel with elevated temperatures for nuclear energy applications.	**+778**
Joint Modeling and Simulation Program: No significant changes.	**0**
Nuclear Science User Facilities: No significant changes.	**0**
Total, Nuclear Energy Enabling Technologies	**+778**

Crosscutting Technology Development

Description

The Crosscutting Technology Development (CTD) subprogram develops innovative solutions to crosscutting nuclear energy technology challenges. The CTD subprogram focuses on foundational research on transformative technologies to maintain the current fleet of nuclear reactors and support the development of advanced reactors and fuels. CTD research and development (R&D) projects include industry, universities, and national laboratory collaborations and it is closely coordinated with the Office of Nuclear Energy's other R&D programs to ensure that developed technologies and capabilities are part of an integrated investment strategy aimed at improving reliability and economics of U.S. nuclear technologies.

Activities within this subprogram include:

- developing new capabilities needed for domestic nuclear energy R&D, with focus on gaps to commercial deployment of advanced reactors;
- conducting high-risk research that could overcome current technological limitations;
- developing enabling technologies that have applicability across multiple technical areas; and
- conducting leading-edge R&D to improve the economics, quality, security, and efficiency of nuclear technologies.

The principal focus areas for FY 2024 include advanced sensors and instrumentation, nuclear cybersecurity research, advanced materials and manufacturing technologies, and integrated energy systems as follows:

- Advanced Sensors and Instrumentation supports R&D of unique sensor and instrumentation technologies that provide enhanced monitoring and control capabilities to the existing reactor fleet, adapt novel sensor types for advanced reactor development and demonstration, and provide expanded capability to fuel cycle and advanced materials development;
- Nuclear Cybersecurity Research develops technologies and methods to address cyber threats to the U.S. nuclear power infrastructure, in coordination with the Department's Cybersecurity, Energy Security, and Emergency Response office, and supports secure implementation of advanced technologies such as wireless control and remote or autonomous operations;
- Advanced Materials and Manufacturing Technologies supports the development of technology-based solutions for advanced materials and manufacturing technologies for use in the deployment of advanced nuclear reactors and sustainment of the existing fleet. This consolidated focus area integrates the cutting-edge research formerly pursued through the Advanced Methods for Manufacturing topic area, the Nuclear Materials Discovery and Qualification Initiative, and the crosscutting research previously performed under the Transformational Challenge Reactor subprogram; and
- Integrated Energy Systems supports R&D to expand the role of nuclear energy, both on and off the electricity grid, to support the industrial, transportation, and commercial sectors. Successful integration of nuclear energy systems will allow the electric grid to continue to rely on the economic benefits, reliability, and emissions-free electricity from nuclear energy while also enabling nuclear energy to contribute to broader decarbonization goals. Integrated nuclear systems will allow clean, affordable nuclear energy to decarbonize industrial, chemical, and transportation applications that currently rely on other energy sources.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Crosscutting Technology Development **$32,000,000**	**$32,778,000**	**+$778,000**
• Conducted research on Advanced Sensors and Instrumentation to address future capabilities needed for advanced reactor demonstrations, fuel cycle and materials testing, and modernization of the existing fleet. Program activities will include development of temperature compensated neutron flux sensors, radiation drift compensated thermocouples, linear variable differential transformer (LVDTs), acoustic-based structural health monitoring, and process control algorithm and instrumentation integration in nuclear digital twin (NDT) platforms. • Developed cybersecurity standards and reference architectures for wireless communication and autonomous control and zero-trust implementation. Pursue additional real-world pilot opportunities for the application of cyber-informed engineering and advanced risk management techniques for advanced reactors under development. • Accelerated the development of advanced materials and manufacturing technologies in support of the existing reactor fleet as well as the deployment of advanced reactors. Program activities will include improvement and optimization of existing materials with minor chemistry modifications to improve use for advanced reactors; development of technical basis for regulatory approval of additively-manufactured	• Develop advanced sensors and instrumentation to enhance existing and novel instrumentation technologies such as temperature compensated neutron flux sensors, radiation drift compensated thermocouples, linear variable differential transformer (LVDTs), and acoustic-based structural health monitoring. These technologies address future capabilities needed for advanced reactor demonstrations, fuel cycle and materials testing, and modernization of the existing fleet. Expand the development of nuclear digital twin (NDT) technologies in partnership with industry stakeholders. • Supports implementation methods for advanced reactor control systems cybersecurity features, such as zero trust architectures, secure wireless architectures, and methods for applying consequence-driven, cyber-informed engineering techniques. • Optimize existing materials and manufacturing technologies to improve use for advanced reactors; accelerate development of technical basis for regulatory approval of additively-manufactured 316 stainless steel; initiate an ASME code qualification plan for Laser	• The increase reflects acceleration of efforts to qualify additively-manufactured 316 stainless steel with elevated temperatures for nuclear energy applications.

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
316 stainless steel; initiation of ASME Code case development for additively-manufactured 316 stainless steel for elevated temperatures; and identification of specific reactor components with industry that could take advantage of new AM technologies. • Developed integrated energy systems techno-economic assessments; thermal storage and distribution, dynamic controls, and site integration technology for using clean nuclear heat and electricity from advanced reactors to decarbonize distributed industrial applications. Develop thermal quantity and quality requirements, engineering requirements, and safety basis for industrial applications including refining, combined heat and power, hydrogen and synthetic fuels production, and ammonia production. Complete modeling tool development for modeling dynamic integrated energy systems.	Powder Bed Fusion additively-manufactured 316 stainless steel for elevated temperatures; component manufacturing with industrial partners. • Refine economic analyses of integrated energy systems for nuclear energy applications, accounting for requirements developed for each application. Characterize thermal capabilities for a variety of reactor types and configurations to optimize the use of thermal energy. Develop and test thermal distribution components and systems for a variety of heat transfer fluids and validate chemical synthesis or process parameters for economically feasible nuclear energy pathways.	

Joint Modeling and Simulation

Description

The Joint Modeling and Simulation subprogram, as implemented through the Office of Nuclear Energy's Nuclear Energy Advanced Modeling and Simulation (NEAMS) program, develops and deploys a set of predictive modeling and simulation tools to support and, in some cases, enable improved operation of the current fleet and the development and deployment of advanced reactors. NEAMS engages scientists and engineers in developing state-of-the-art, multi-scale models of physics and chemistry that drive advanced computational methods for simulations of advanced nuclear energy systems. NEAMS empowers researchers and designers to gain fundamental insights that are unattainable through experiment alone, inform experiment selection, drive design, and minimize the cost of research and development. Advanced modeling and simulation capabilities also support the Office of Nuclear Energy (NE) program priorities, such as the development of fuels with enhanced accident tolerance.

The NEAMS has developed a set of analytic modeling and simulation tools that is flexible and able to accommodate different reactor types and designs. Through an enhanced programmatic framework, NEAMS tools support NE's mission priority areas: continued operation of the existing fleet of U.S. nuclear reactors; enable deployment of advanced nuclear reactors; develop advanced nuclear fuel cycles; and maintain U.S. leadership in nuclear energy technology.

For the existing fleet, NEAMS tools address core performance optimization issues and accelerate development of fuels with enhanced accident tolerance to help assure the long-term availability and market competitiveness of nuclear energy. The Bison fuel performance code, and the lower-length scale work that underpins it, helps to provide fundamental insight into how nuclear fuel behaves under normal and extreme reactor conditions, as well as higher fuel "burnup." When coupled with experimental work performed under the Fuel Cycle Research & Development program, this has the potential to accelerate the design and licensing of new fuel forms that can improve or extend the operation of existing reactors.

For advanced reactor technologies, NEAMS tools help industry accelerate development and meet otherwise cost-prohibitive data needs. These tools also help support Nuclear Regulatory Commission (NRC) efforts to address its confirmatory analysis needs. While many existing industry software tools are designed for specific reactor designs, primarily light-water reactors, NEAMS has developed and continues to add capabilities to a suite of tools for reactor physics, thermal hydraulics, fuel performance, materials, chemistry, and system modeling that flexibly accommodate the range of reactor designs currently being considered by industry. Several of these tools are being used, adopted, and modified by industry, universities, and NRC to meet their needs, consistent with the FY 2023 Congressional direction. NEAMS incorporates feedback and inputs from these stakeholders to ensure proper focus on relevant capabilities.

For fuel cycle technologies, continued modeling and simulation tool development provide capabilities that can support future used nuclear fuel research and development, including development of strategies to burn less fuel, and high-fidelity analysis and prediction of fuel and cladding performance through the storage cycle.

Joint Modeling and Simulation

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Joint Modeling and Simulation **$28,500,000**	**$28,500,000**	**+$0**

• Enable and accelerate industry's advanced reactor deployment efforts through advanced multiscale and multi-physics modeling and simulation approaches.
  ○ Develop fully coupled, full-core simulation of entire microreactor to demonstrate self-regulation and load-following, during transient scenarios.
  ○ Conduct graphite structural analysis and behavior for gas-cooled reactors during steady-state and transient conditions including swelling and oxidization as well as multiscale structural materials modeling for metallic structures including piping, heat exchangers, and reactor vessel.
  ○ Develop and assemble molten salt reactor modeling capability and data sufficient to support the development of a mechanistic source term to support data safety and licensing.
• Implement and demonstrate use of mechanistic tools to assess high-burnup fuel pulverization and burst potential for Light Water Reactor fuels to support licensing process associated with extending fuel burnup limits.
• Maintain software tools with strong software quality assurance such that the tools can be used by industry and research institutions in research, design, and ultimately commercial deployment.
	• Enable and accelerate industry's advanced reactor deployment efforts through advanced multiscale and multi-physics modeling and simulation approaches.
	  ○ Increase the capability of steady-state and transient modeling for high-temperature gas reactors with a pebble-shuffler capability for core start-up, steady-state, and transient scenarios.
	  ○ Develop thermal-hydraulics modeling capabilities for the simulation of fluoride salt-cooled high-temperature reactor (i.e., molten salt reactor with solid fuel) under transient conditions, including system-level fidelity, porous media modeling for pebble bed designs, and computational fluid dynamics for fluid closures.
	• Complete development of initial light-water reactor high-burnup and accident tolerant fuel modeling capabilities to support industry licensing needs, with full implementation and systematic assessment for impact of high-burnup on fuel reliability in FY 2025.
	• Maintain software tools with strong software quality assurance such that they can be used by industry and research institutions in research, design, and ultimately commercial deployment.
	• Continue to provide access to modeling and simulation tools on high-performance computing systems at the Idaho National Laboratory through the Nuclear Computational Resource Center.
		• No significant changes.

Nuclear Science User Facilities

Description

The Nuclear Science User Facilities (NSUF) subprogram is the Nation's designated program to gain access to user facilities for nuclear energy research. As a consortium of partner facilities, the NSUF connects a broad range of nuclear research capabilities, expert mentors, and experimenters. The NSUF represents a "prototype laboratory for the future," promoting the use of unique nuclear research facilities located at multiple sites across the Nation and encouraging active university, industry, and laboratory collaboration in relevant nuclear science research. The NSUF, through competitive solicitations, provides a mechanism for research organizations to collaborate, conduct experiments and post-experiment analysis, and utilize high performance computing at facilities not normally accessible to these organizations. On an annual basis, researchers propose projects to be conducted at these unique facilities, with timelines ranging from a few months to several years. When projects are awarded, the NSUF subprogram pays for experiment support and laboratory services at the partner user facilities. In this manner, researchers benefit from the introduction to new techniques, equipment, and personnel. In FY 2022, the NSUF program supported 108 researchers from 24 different States and three other countries through awards and 892 researchers across 32 States and 13 other countries through access to high performance computing capabilities. Emphasis is placed on increasing the involvement of minority serving institutions, including Historically Black Colleges and Universities and Tribal Colleges and Universities, and institutions in underserved communities, resulting in direct and meaningful investments through project selection and NSUF partnership agreements in support of the Administration's Justice40 Initiative.

The principal focus areas in NSUF for FY 2024 includes irradiation and post-irradiation examination of fuels and materials, high performance computing, and maintenance of the Nuclear Fuels and Materials Library as follows:

- The NSUF program competitively supports all pertinent irradiation and post-irradiation examination activities by providing researchers with access to unique nuclear research facilities. Support includes access to research reactors, hot cells, beam-line capabilities, irradiation capabilities, and irradiation experiment design and fabrication support, expert support, and community outreach.
- High Performance Computing (HPC) supports INL scientific computing capabilities to enable advanced modeling and simulation. These resources support a wide range of research activities, including performance of materials in harsh environments (such as the effects of irradiation and high temperatures), performance of existing light water and advanced nuclear reactors, and multiscale multi-physics analysis of nuclear fuel performance. HPC capabilities are available to industry, universities, national laboratories, and federal agencies to support research and development. Three HPC supercomputers are currently in operation at the Idaho National Laboratory: Sawtooth, Hoodoo, and Lemhi.
- The Nuclear Fuels and Materials Library supports the maintenance of a collection of specialized information and material specimens from past and ongoing irradiation test campaigns, real-world components retrieved from decommissioned power reactors, and donations from other sources. Everything in the Nuclear Fuels and Materials Library is available to the nuclear research community, either through a peer-reviewed proposal process or through direct programmatic request.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Nuclear Science User Facilities **$35,000,000**	**$35,000,000**	**+$0**
• Competitively solicit and award a limited number of new, fully-funded facility access awards. • Award more than 75 Rapid Turnaround Experiment projects through three competitive proposal periods. • Continue NSUF partnership agreements with universities, industry, and national laboratories to support ongoing irradiation experiments ranging from neutron, gamma, and ion irradiation to post-irradiation examination and incorporate new irradiation capabilities as needs are identified. • Enhance the Nuclear Fuels and Materials Library through the addition of irradiated fuels and materials. • Operate three supercomputers totaling more than 120,000 processor cores and 7 Petaflops of computational performance. Support more than 800 users by providing training, user support, and code optimization. Ensure effective cybersecurity, user access controls, and data collection.	• Competitively solicit and award new, fully-funded facility access awards to accelerate the development of fuels and materials for nuclear energy applications. • Award more than 75 Rapid Turnaround Experiment projects through three competitive proposal periods for prompt NSUF partner facilities access to support emergent and innovative nuclear science and materials research. • Continue NSUF partnership agreements with universities, industry, and national laboratories to support ongoing irradiation experiments ranging from neutron, gamma, and ion irradiation to post-irradiation examination and incorporate new irradiation capabilities as needs are identified. • Enhance the Nuclear Fuels and Materials Library through the addition of irradiated fuels and materials. • Operate three supercomputers totaling more than 120,000 processor cores and 7 Petaflops of computational performance. Support more than 800 users by providing training, user support, and code optimization. Ensure effective cybersecurity, user access controls, and data collection.	• No significant changes.

Transformational Challenge Reactor

Description

The Transformational Challenge Reactor (TCR) subprogram provided a revolutionary platform to help demonstrate the ability to reduce the deployment costs and timelines for nuclear energy systems and enhanced the development of breakthrough technologies that could manufacture small/micro advanced reactor components using additive manufacturing techniques. A central goal of the TCR subprogram was to demonstrate the ability to exploit advanced manufacturing techniques and digital predictive analysis capabilities to deliver a new approach to nuclear design and qualification for advanced reactor technologies. TCR combined advanced manufacturing with materials and computational sciences to predict optimal performance of components to enable faster innovation and certification.

Highlights of the FY 2024 Budget Request

No funding is requested in the FY 2024 Budget for the Transformational Challenge Reactor subprogram. In FY 2024, crosscutting research initiated under the TCR subprogram will continue under the Crosscutting Technology Development subprogram to consolidate all relevant technologies under a coordinated management structure.

Transformational Challenge Reactor

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Transformational Challenge Reactor		
$0	**$0**	**$0**
• No funding was provided for this program in FY 2023.	• No funding is requested to continue this program in FY 2024.	• No funding is requested to continue this program in FY 2024.

Advanced Reactor Demonstration Program

Overview

The Advanced Reactor Demonstration Program (ARDP) focuses Departmental and non-federal resources on supporting the development of commercially promising advanced reactors that have the potential for near and mid-term demonstration and commercial deployment and addressing challenges hindering their deployment.

In the FY 2020 Further Consolidated Appropriations Act, Congress established ARDP to demonstrate multiple advanced reactor designs. In the Bipartisan Infrastructure Law (Infrastructure Investment and Jobs Act, P.L. 117-58), multi-year funding for the reactor demonstration elements of this program was provided under the new Office of Clean Energy Demonstrations (OCED). The ARDP research and development elements leading to demonstration remain with Nuclear Energy and include these four major elements:

- National Reactor Innovation Center (NRIC) – Supports testing, demonstration, and performance assessment to accelerate deployment of advanced reactors through development of advanced nuclear energy technologies by utilizing the unique DOE national laboratory facilities and capabilities;
- Risk Reduction for Future Demonstrations – Supports cost-shared (up to 80% government, not less than 20% industry) partnerships with U.S.-based teams to address technical, operational, and regulatory challenges to enable development of a diverse set of advanced nuclear reactor designs for future demonstration;
- Regulatory Development – Coordinates activities with the Nuclear Regulatory Commission (NRC) and U.S. industry to address and resolve key regulatory framework and licensing technical issues that directly impact the "critical path" to advanced reactor demonstration and deployment; and
- Advanced Reactor Safeguards – Evaluates safeguards and security issues that are unique to advanced reactors to help reduce roadblocks by solving regulatory challenges, reducing safeguards and security costs, and utilizing the latest technologies and approaches for plant monitoring and protection.

In FY 2024, the Department focuses on the execution of the Risk Reduction projects selected in FY 2021. For the Risk Reduction projects, funding supports five domestic advanced reactor development partners in resolving technical, operational, and regulatory challenges to enable future demonstration of their concepts. Efforts initiated under the NRIC, Regulatory Development, and Advanced Reactor Safeguards subprograms continue in FY 2024.

The two ongoing ARDP Demonstration projects (funded in the Office of Clean Energy Demonstrations, OCED) and the five Risk Reduction projects (in NE) are working to overcome barriers to future deployments and have the potential to create substantial numbers of new skilled, good-paying domestic jobs with the free and fair choice to join a union. For example, in the early stages of design development and licensing, the reactor demonstration vendors are adding many technical and professional employees to address design, engineering, testing, procurement, and licensing requirements. The construction phase of each reactor is expected to result in hundreds of short-term construction jobs. The eventual operation of these reactors will require the creation of additional long-term operations, maintenance, and security positions with the utility owners. Overall, the deployment and operation of these reactors are expected to have significant positive, long-term, economic impacts on the communities in which they operate.

Highlights of the FY 2024 Budget Request

A key FY 2024 activity for NRIC includes support for establishing infrastructure for the testing of multiple advanced reactor concepts. FY 2024 capital line-item funding is requested for the Laboratory for Operations and Testing in the United States (LOTUS) Project (23-E-200, LOTUS) for construction activities.

Funding for the two advanced reactor demonstrations previously included in this budget are now funded, per the Infrastructure Investment and Jobs Act (IIJA), within OCED.

Advanced Reactor Demonstration Program
Funding ($K)

	FY 2022 Enacted[1]	FY 2023 Enacted[2]	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Advanced Reactor Demonstration Program					
National Reactor Innovation Center	53,000	70,000	34,000	-36,000	-51.4%
Demonstration 1	30,000	0	0	0	0%
Demonstration 2	30,000	0	0	0	0%
ARDP Demonstration Reactors	0	60,000	0	-60,000	-100%
Risk Reduction for Future Demonstrations	115,000	120,000	120,000	0	0%
Regulatory Development	15,000	10,250	11,000	+750	+7.3%
Advanced Reactor Safeguards	5,000	4,750	6,000	+1,250	+26.3%
Construction: 23-E-200, LOTUS	2,000	20,000	32,000	+12,000	+60%
Total, Advanced Reactor Demonstration Program	**250,000**	**285,000**	**203,000**	**-82,000**	**-28.8%**

[1] Funding reflects the movement of $2 million from NRIC to 23-E-200, LOTUS per approved PDS.

[2] FY 2023 Enacted levels for base funding include $20 million for the National Reactor Innovation Center, $120 million for Risk Reduction for Future Demonstrations, and $60 million for ARDP Demonstration Reactors that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328). This funding is a part of the total $12.5 billion governmentwide originally intended to be base appropriations that was designated as emergency requirements for purposes of the 2023 Omnibus agreement.

Advanced Reactor Demonstration Program
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
National Reactor Innovation Center: The decrease from $70,000,000 to $34,000,000 reflects a ramp-down in funding required for the Demonstration of Microreactor Experiments (DOME) test bed project as it nears completion of construction in early FY 2025.	**-36,000**
Demonstration 1: No funding is requested for the X-energy advanced reactor demonstration within Nuclear Energy. IIJA provided multi-year funding for this demonstration under the Office of Clean Energy Demonstrations.	**+0**
Demonstration 2: No funding is requested for the TerraPower advanced reactor demonstration within Nuclear Energy. IIJA provided multi-year funding for this advanced reactor demonstration under the Office of Clean Energy Demonstrations.	**+0**
ARDP Demonstration Reactors: No funding is requested for the two ARDP demonstration reactor efforts (Demonstration 1 and Demonstration 2) as IIJA provided multi-year funding for both demonstrations under the Office of Clean Energy Demonstrations.	**-60,000**
Risk Reduction for Future Demonstration: No change.	**+750**
Regulatory Development: The increase from $10,250,000 to $11,000,000 reflects a ramp-up in activities to help reduce the regulatory risks for advanced reactors as we move closer to the demonstration phase of these concepts.	**+1,250**
Advanced Reactor Safeguards: The increase from $4,750,000 to $6,000,000 reflects additional funds to accelerate advanced reactor physical protection systems (PPS) and material control and accountability (MC&A) activities and expand vendor engagements.	**+12,000**
Construction:	

	FY 2024 Request vs FY 2023 Enacted
The increase from $20,000,000 to $32,000,000 supports completion of design activities and initiation of construction related activities for the LOTUS project (23E-200).	
Total, Advanced Reactor Demonstration Program	**-82,000**

National Reactor Innovation Center

Description

The National Reactor Innovation Center (NRIC) mission enables and accelerates the testing and demonstration of advanced reactors by utilizing the unique capabilities of U.S. national laboratories. NRIC provides private sector technology developers with access to the strategic infrastructure and assets of the national laboratories to enable physical validation of advanced nuclear reactor concepts, resolve technical uncertainties, and generate data relevant to safety, resilience, security, and functionality of advanced nuclear reactor concepts. NRIC works closely with R&D programs within the Office of Nuclear Energy to avoid duplication. NRIC does not conduct R&D; it facilitates information sharing and connectivity necessary to enable the demonstration of selected nuclear reactor designs.

The NRIC subprogram activities include interactions with reactor developers who are considering options for demonstrating their reactor technologies as well as development of national laboratory capabilities for hosting advanced reactor demonstrations and tests. While NRIC is led by the Idaho National Laboratory (INL) with significant activities at the INL Site as well as resources at other national laboratories and potential nuclear reactor demonstration sites will play an important role in achieving NRIC's objectives.

NRIC is expected to help accelerate technology readiness from proof of concept through proof of operations. Key support to be provided by NRIC includes:

- Facilitating industry access to key resources, such as materials needed for nuclear reactor fuel, facilities for fabrication of fuel for demonstrations, test reactors such as the Advanced Test Reactor and Transient Reactor Test Facility at the INL and High Flux Isotope Reactor at the Oak Ridge National Laboratory, characterization capabilities such as INL's Irradiated Materials Characterization Laboratory, and access to advanced modeling and simulation codes and high performance computers through the INL Collaborative Computing Center;
- Providing access to national laboratory experts to support technology development;
- Developing complementary technologies, in conjunction with relevant Nuclear Energy R&D programs, such as application of digital engineering philosophies and development and proof of concept of advanced construction technologies, to reduce the cost and schedule risks associated with the deployment of advanced reactors;
- Assisting with National Environmental Policy Act (NEPA) evaluations and DOE authorization related to nuclear facility operations;
- Providing resources for cost-share grants to applicants for the purpose of funding a portion of NRC fees for pre-application and licensing application review activities.
- Developing a resource network of sites, facilities, and capabilities suitable for performing key R&D, experiments, tests, or fabrications, and for hosting advanced reactor demonstrations; and
- Identifying and facilitating resolution of experimental capability gaps which are vital to advanced reactor development and demonstration.

A key FY 2024 activity for NRIC includes support for establishing infrastructure for the testing of multiple advanced reactor concepts. The Demonstration and Operation of Microreactor Experiments (DOME) test bed will be capable of hosting experiments to support testing and development of microreactor technologies. DOME will be located at the former Experimental Breeder Reactor II facility at the INL to support this new mission. Several microreactor developers have expressed interest in using DOME to test their technologies and generate data to support design and licensing activities. Activities to support establishment of the LOTUS test bed are described in the Construction section of the ARDP program. It should be noted that Other Project Costs (OPCs) for the LOTUS project are reflected in the NRIC subprogram, while Total Estimated Costs (TECs) are reflected in line item 23-E-200, LOTUS.

National Reactor Innovation Center

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
National Reactor Innovation Center $70,000,000[3]	**$34,000,000**	**-$36,000,000**
• Continued support for establishment of the Molten Salt Thermophysical Examination Capability (MSTEC) at INL to close a vital experimental gap for molten salt reactors (MSRs). • Completed Phase I of the Advanced Construction Initiative (ACT) Initiative to enable development of advanced construction technologies that may reduce the cost and schedule risks associated with advanced reactor construction. • Initiated Phase II of the ACT Initiative to support proof of concept of advanced construction technologies. • Engaged with key stakeholders such as the Nuclear Regulatory Commission (NRC), advanced reactor developers, and potential end-users. • Continued evaluating capabilities and gaps and working with R&D programs to facilitate. coordinated actions to address critical needs. • Initiated construction of the DOME test bed to enable development and demonstration of microreactor technologies. • Initiated the Advanced Nuclear Energy Cost-Share Grant Program, including industry outreach and issuance of solicitation. • Continued OPC activities for the LOTUS project per DOE Order 413.3B.	• Initiate operation of MSTEC at INL to close a vital experimental gap for MSRs. • Continue Phase II of the ACT Initiative to support proof of concept of advanced construction technologies. • Further engage with key stakeholders such as the NRC, advanced reactor developers, and potential end-users. • Continue construction of the DOME test bed to enable development and demonstration of microreactor technologies. • Facilitate access to infrastructure, materials, and expertise to support advanced reactor demonstration. • Continue the Advanced Nuclear Energy Cost-Share Grant Program, including initial award selections. • Continue OPC activities for the LOTUS project, including planning for transition to operations in FY 2026.	• The decrease reflects a ramp down in funding for the DOME project as it nears completion of construction in early FY 2025.

[3] FY 2023 Enacted levels include $20 million for the National Reactor Innovation Center that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

Demonstration 1; Demonstration 2; ARDP Demonstration Reactors

Description

These subprograms focused efforts on the execution of two cost-shared projects for the eventual construction of advanced reactor demonstrations. In FY 2020, DOE announced awards to X-energy and TerraPower LLC to design, license, construct, and start up advanced nuclear reactors that can be operational within seven years. The awards are cooperative agreements between DOE and the awardee companies with up to 50% cost-shared by DOE. The demonstration projects will deliver first-of-a-kind advanced reactors to be licensed for commercial operations. X-energy's Xe-100 reactor is a high temperature gas reactor that produces 80 MWe and leverages the TRISO fuel particle technology that was developed by DOE. Xe-100 reactor units can be deployed as a "four-pack" to supply 320 MWe and can provide process heat as well as electricity production. X-energy will announce a commercial partner and site selection for the demonstration reactor plants in early 2023. TerraPower's Natrium reactor is a sodium cooled fast reactor that produces 345 MWe and can supply up to 500 MWe with thermal energy storage that is being deployed as part of the plant design. The Natrium demonstration reactor will be located in Kemmerer, WY, providing an energy transition from a retiring coal plant.

The Bipartisan Infrastructure Law provides multi-year funding for the X-energy and TerraPower demonstrations under the Office of Clean Energy Demonstrations. As such, no FY 2024 funding is requested for these efforts within Nuclear Energy.

Demonstration 1; Demonstration 2; ARDP Demonstration Reactors

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Demonstration 1 $0 **Demonstration 2 $0** **ARDP Demonstration Reactors $60,000,000**[4]	**$0** **$0** **$0**	**+$0** **+$0** **-$60,000,000**
• No funding was requested for the X-energy and TerraPower advanced reactor demonstrations within Nuclear Energy.	• No funding is requested for the X-energy and TerraPower advanced reactor demonstrations within Nuclear Energy.	• This reflects the transfer of the X-energy and TerraPower advanced reactor demonstrations to the Office of Clean Energy Demonstrations.

[4] FY 2023 Enacted levels include $60 million for the ARDP Demonstration Reactors that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

Risk Reduction for Future Demonstrations

Description

The Risk Reduction for Future Demonstrations subprogram supports advanced reactor concepts with the potential for future demonstration through cost-shared (up to 80% government, not less than 20% industry) competitively awarded (through a financial assistance solicitation) projects that are designed to maximize the utility of the results across the nuclear energy industry. The projects are aimed at reducing risk and technical uncertainty for a broad range of advanced reactor designs. Project activities may include R&D to address technical challenges associated with development of technologies and methods to improve the timelines for advanced reactor deployments, the cost and schedule for delivery of nuclear products, services, and capabilities supporting these nuclear technologies, design and engineering processes, and resolution of certification challenges potentially impeding the introduction of these technologies into the marketplace. This subprogram coordinates closely with the Reactor Concepts Research, Development & Demonstration program and other relevant programs to avoid duplication, leverage existing expertise, and maximize synergies.

In FY 2021, DOE announced the selection of five projects to aid advanced reactor developers in resolving technical, operational, and regulatory challenges to enable potential future demonstration of a diverse set of advanced reactor designs. The Risk Reduction projects support the development of safe and affordable advanced reactor technologies that may have the potential to be licensed and deployed by 2035. Industry partners are providing at least 20 percent in matching funds for their cost share of the program.

The five projects are:

- Kairos Power, LLC (Alameda, CA) will work to design, construct, and operate its Hermes reduced-scale test reactor. Hermes is intended to lead to the development of Kairos Power's commercial-scale fluoride salt-cooled high temperature reactor (FHR), a novel advanced nuclear reactor technology that leverages TRI-structural ISOtropic particle fuel (TRISO) fuel in pebble form combined with a low-pressure fluoride salt coolant;
- Westinghouse Electric Company, LLC (Cranberry Township, PA) will advance the design of a heat pipe-cooled microreactor;
- BWXT Advanced Technologies, LLC (Lynchburg, VA) will mature a commercially viable transportable microreactor conceptual design focused on using TRISO fuel particles to achieve higher uranium loading and an improved core design using a silicon carbide (SiC) matrix;
- Holtec Government Services, LLC (Camden, NJ) will focus on early-stage design, engineering, and licensing activities to accelerate the development of its light water-cooled small modular reactor (SMR); and
- Southern Company Services Inc. (Birmingham, AL) will lead a project to design, construct, and operate the Molten Chloride Reactor Experiment (MCRE), a critical nuclear test bed supporting molten salt reactor systems and components demonstrations.

FY 2024 activities focus on continuing design activities; supporting further interactions with the NRC on high impact regulatory related topics; conducting activities to resolve technical, operational, and regulatory challenges; and developing and executing plans for establishing infrastructure and support capabilities to enable execution of the Risk Reduction projects and future commercialization activities.

Risk Reduction for Future Demonstrations

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Risk Reduction for Future Demonstrations **$120,000,000**[5]	**$120,000,000**	**$0**
• Support execution of the Risk Reduction projects per established project plans and using current and prior year carryover funds. Specific project activities include: o For the Kairos project: Conducted activities to support the design, licensing, construction, and operation of an FHR test reactor. o For the Westinghouse project: Scaled-up and enhanced heat pipe manufacturing operations to enable design, procurement, and manufacturing of a microreactor demonstration unit. o For the BWXT project: Continued fabrication of TRISO fuel specimens to support irradiation testing in INL's Advanced Test Reactor (ATR). o For the Holtec project: Initiated long lead procurement activities by selecting the Control Rod Drive Mechanism subcontract supplier which will demonstrate the capability of the existing supply chain. o For the Southern Company Services project: Completed design of the fuel salt synthesis line (FSSL). Continued procurement of long-lead equipment for	• Support execution of the Risk Reduction projects per established project plans and using current and prior year carryover funds. Specific project activities include: o For the Kairos project: Initiate construction activities. Completion of all commissioning and operational milestones for the second Engineering Test Unit (ETU). Completion of all construction milestones for the third ETU. o For the Westinghouse project: Enhance manufacturability of heat pipes. Design capsule for thermal testing of moderator material. Use NRC feedback on white papers and through regulatory engagement to identify future licensing actions and reduce regulatory risk. o For the BWXT project: Initiate irradiation of fuel specimens in INL's ATR. Submit the Fuel Qualification Technical Report to the NRC. o For the Holtec project: Complete the SMR-160 Preliminary Safety Analysis Report. o For the Southern Company Services project: Complete MCRE final design. Complete assembly of a non-nuclear mock-	• No change.

[5] FY 2023 Enacted levels include $120 million for Risk Reduction for Future Development that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
FSSL. Conducted MCRE preliminary design review. Continued to support the development of nuclear safety basis documentation to enable DOE authorization of MCRE and ensure safe operations.	up of MCRE to de-risk operation of the fueled reactor experiment.	

Regulatory Development

Description

The Regulatory Development subprogram coordinates with the Nuclear Regulatory Commission (NRC) and industry to address and resolve key regulatory framework issues that directly impact the "critical path" to advanced reactor demonstration and deployment. Part of the subprogram focuses on regulatory modernization activities such as developing adaptations of light water reactor (LWR)-based regulations for non-LWR advanced reactors, finalizing the establishment of risk-informed and performance-based license application guidance, and establishing clear expectations for license application content and review criteria. Other regulatory development activities include resolving the technical basis to support NRC endorsement of codes and standards important for the manufacture of advanced reactor components and expanding access to priority material property data to be used in safety codes and models in support of licensing. The Regulatory Development subprogram supports limited R&D aimed at producing broadly applicable results than can be used by an array of private sector companies to inform their regulatory requirements. Design-specific regulatory gaps for advanced reactors, including fast reactors, gas-cooled reactors, and molten salt reactors, are also addressed.

Regulatory Development

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Regulatory Development $10,250,000	**$11,000,000**	**+$750,000**
• Provided support for industry and NRC interactions that are establishing the advanced non-light water reactor regulatory framework. • Continued efforts to address unresolved and high impact NRC regulatory policy issues impacting advanced reactor licensing. • Developed the technical basis for material surveillance technologies to be used by owner/operators to implement a materials degradation management program for MSRs. • Utilized the Liquid Salt Test Loop (LSTL) at the Oak Ridge National Laboratory to test sensors and demonstrate tools in support of MSR development and deployment. • Developed and maintained the fast reactor database to archive historical data for fast reactor fuels and materials to preserve data, knowledge and experience. • Continued development and testing to support inclusion of Alloy 709 (alloy with increased materials performance in high temperature advanced reactor operating environments) in the American Society of Mechanical Engineers (ASME) Code.	• Continue to coordinate with industry and the NRC to identify and resolve technology gaps and high impact challenges associated with advanced reactor regulation. • Continue efforts to establish a risk-informed and performance based advanced reactor regulatory framework. • Submit industry-driven proposals to the NRC on key advanced reactor regulatory topics such as Accelerated Materials Qualification, Establishing the Requirements for Emergency Planning Zones, and Technology Inclusive Risk Informed Change Evaluation. • Complete the quality assurance of the data within the Fuels Irradiation and Physics Database to support fast reactor licensing activities. • Complete the Alloy 709 conservative design guide to help inform industry partners on conceptual component sizing. • Complete construction, dry shakedown, and salt commissioning of the Molten Salt Tritium Transport Experiment (MSTTE) to understand and mitigate tritium migration in MSRs related to permeation through structural materials, evolution into cover gas, and other associated phenomena.	• The increase reflects a ramp-up in activities to help reduce the regulatory risks for advanced reactors as we move closer to the demonstration phase of these concepts.

Advanced Reactor Safeguards

Description

The Advanced Reactor Safeguards (ARS) subprogram evaluates safeguards and security issues unique to advanced reactor designs and informs and improves advanced reactor designs by addressing issues such as diversion of advanced fuel forms, protection of remotely operated plants, and other proliferation and security concerns. Broadly, the ARS subprogram also helps to reduce security costs by utilizing the latest technologies and approaches for plant monitoring and protection.

The ARS subprogram focuses on six major elements: physical protection systems, pebble bed reactor material control and accountability (MC&A), microreactor physical protection systems and MC&A, liquid fueled reactor MC&A, international cooperation, and vendor engagements.

- Physical Protection Systems (PPS) – targets issues such as reducing number of on-site responders and upfront costs and evaluating enhanced safety systems and unique sabotage targets.

- Pebble bed reactor MC&A – focuses on evaluating the regulatory approach and determining the driving requirements, as well as evaluating new monitoring technologies.

- Microreactor PPS and MC&A – works on developing a licensing framework, developing approaches appropriate to the very small scale, and evaluating new monitoring technologies.

- Liquid fueled MC&A – targets evaluating regulatory approach, developing baseline accountancy approaches, and evaluating new measurement and monitoring technologies.

- International Cooperation – focuses on considering and incorporating international safeguards requirements, interfacing with international safeguards and security programs, and supporting the Gen-IV Proliferation Resistance & Physical Protection (PR&PP) Working Group.

- Vendor Engagements – addresses design-specific MC&A and PPS challenges for vendors through direct engagements with DOE national laboratories and generates lessons learned and/or generic deliverables to share information broadly with the advanced reactor community.

The ARS subprogram also coordinates with the Nuclear Regulatory Commission (NRC), the Department of Energy's National Nuclear Security Administration (NNSA), and the nuclear industry to avoid duplication of activity and leverage nationwide expertise. Together, these safeguards and security activities help further advanced reactors development and deployment.

Advanced Reactor Safeguards

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Advanced Reactor Safeguards $4,750,000	**$6,000,000**	**+$1,250,000**
• Refined and expanded physical protection design alternatives for a diverse set of advanced reactors, to support cost effective, market competitive designs. • Developed a pebble bed burnup measurement strategy and experimental plan to assist pebble bed reactor vendors to meet key monitoring and accountancy requirements. • Engaged with advanced reactor vendors, in coordination with NNSA, to advance both domestic and international safeguards and security by design.	• Incorporate sabotage scenario analysis into the PPS design for multiple classes of advanced reactors to improve security designs. • Demonstrate burnup measurements on short-cooled TRI-structural ISOtropic particle (TRISO) fuel to advance MC&A technologies and techniques. • Develop recommendations for NE and NNSA on integrated domestic and international safeguards equipment to reduce costs and improve efficiencies. • Expand vendor engagements to examine design-specific MC&A and PPS issues and generate lessons learned for the advanced reactor community.	• The increase reflects additional funds to accelerate advanced reactor PPS and MC&A activities and expand vendor engagements.

Construction

Description

Line-item capital projects are sometimes required to maintain the ability to support mission goals. These projects help achieve the Department's and Nuclear Energy (NE)'s strategic objectives by maintaining site services and providing critical information for future decisions. These activities are focused on two primary objectives: (1) identification, planning, and prioritization of projects required to meet NE program objectives, and (2) development and execution of these projects within approved cost and schedule baselines. While the Department's acquisition management process does not guarantee that a project will be completed once the initial information gathering and preliminary design phase are complete, it does provide an important decision-making framework that, when well executed, allows only the most critically necessary, cost-effective projects to proceed to construction.

23-E-200, Laboratory for Operations and Testing in the U.S. (LOTUS)

The LOTUS Project will enable and support the development and deployment of advanced nuclear systems by providing the infrastructure for advanced reactor developers to test and operate experimental reactors that utilize Safeguards Category I materials for operation. First-of-a-kind nuclear technology developers need a location for testing, validating, and maturing new reactor technologies or concepts, and for validating the safety and workability of systems or components individually or as part of the overall reactor system. Advanced reactor developers also need to generate data on key phenomena relevant to the design and safe operation of their designs to aid in future licensing and commercial deployment of these technologies. Although not required for the commercial concepts, some reactor demonstrations and experiments require higher enrichment fuel to keep the size of the reactor small while ensuring that neutronics and thermal hydraulics are representative of commercial designs. The LOTUS Project will ensure safety of initial reactor operations by making available a robust facility that can provide the appropriate containment capabilities and supporting infrastructure.

On March 8, 2022, DOE Order 413.3 B, *Program and Project Management for the Acquisition of Capital Assets*, Critical Decision (CD)-0, Approve Mission Need, was approved for the LOTUS Project, with a current cost range of $28,000,000 to $97,000,000. The approved Mission Need Statement identified the critical need for a test bed capability to conduct reactor experiments requiring appropriate safeguards and security consistent with DOE safety and security requirements. Consistent with Congressional guidance provided in the FY22 Omnibus Appropriation, the Department initiated conceptual design activities in FY 2022.

The FY2024 budget request supports completion of design and initiation of construction activities following CD-1, including construction award and long lead procurement of facility systems such as control room components, electrical and ventilation equipment, and fire suppression systems.

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Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Change FY 2024 Request vs FY 2023 Enacted
Construction **$20,000,000**	**$32,000,000**	**+$12,000,000**
Laboratory for Operations and Testing in the U.S. (23-E-200) • Initiate preliminary design activities.	Laboratory for Operations and Testing in the U.S. (23-E-200) • Complete preliminary and final design activities and initiate construction related activities.	Laboratory for Operations and Testing in the U.S. (23-E-200) • The increase reflects completion of design and initiation of construction related activities.

Advanced Reactor Demonstration Program
Construction Projects Summary ($K)

	Total	Prior Years	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
23-E-200, LOTUS, INL						
Total Estimated Cost (TEC)	49,000	0	2,000	20,000	32,000	+12,000
Other Project Costs (OPC)[1]	13,557	3,957	600	1,000	8,000	+7,000
Total Project Cost (TPC) Project Number 23-E-200	**62,557**	**3,957**	**2,600**	**21,000**	**40,000**	**+19,000**
Total All Construction Projects						
Total Estimated Cost (TEC)	49,000	0	2,000	20,000	32,000	+12,000
Total Other Project Costs (OPC)	13,557	3,957	600	1,000	8,000	+7,000
Total Project Cost (TPC) All Construction Projects	**62,557**	**3,957**	**2,600**	**21,000**	**40,000**	**+19,000**

[1] OPC funding for 23-E-200, LOTUS is included within the National Reactor Innovation Center subprogram line.

23-E-200, Laboratory for Operations and Testing in the United States
Idaho National Laboratory
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The fiscal year (FY) 2024 Budget Request for the Laboratory for Operations and Testing in the United States (LOTUS) project is $32,000,000. The most recent Department of Energy (DOE) Order 413.3 B Critical Decision (CD)-0, *Approve Mission Need*, was approved on March 8, 2022, with a Total Project Cost (TPC) range of $28,000,000 to $97,000,000. The approved Mission Need Statement identified the critical need for a test bed capability to conduct reactor experiments requiring appropriate safeguards and security consistent with DOE safety and security requirements.

LOTUS is a physical structure in which reactor prototypes can be tested safely and securely. The requested capital funding in FY 2024 supports completion of design and initiation of construction activities following CD-1 including preliminary design, final design, construction award and long lead procurement of facility systems such as control room components, electrical and ventilation equipment, and fire suppression systems. In FY 2023, the project will initiate design activities. Based on Congressional direction to establish test bed capabilities at Idaho National Laboratory (INL) to support advanced reactor demonstration activities, the project's acquisition strategy will utilize a tailored approach per DOE Order 413.3B. The LOTUS project will provide a dynamic test bed to support testing of advanced reactor concepts.

A Level 2 Federal Project Director (FPD) has been assigned to this project.

Significant Changes

This Construction Project Data Sheet (CPDS) is the first official datasheet for this construction line item. The LOTUS project was initiated in FY 2022 as a non-major acquisition and received its first direct appropriations in FY 2023.

Critical Milestone History

(Fiscal Quarter or Date)

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	Final Design Complete	CD-1/2/3	D&D Complete	CD-4
FY 2022	3/8/2022	1/13/2022	TBD	TBD	TBD	N/A	TBD
FY 2023	3/8/2022	1/13/2022	TBD	TBD	TBD	N/A	TBD
FY 2024	3/8/2022	1/13/2022	TBD	TBD	TBD	N/A	TBD

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range
Conceptual Design Complete – Actual date the conceptual design was completed (if applicable)
CD-1 – Approve Alternative Selection and Cost Range
Final Design Complete – Estimated/Actual date the project design will be/was complete(d)
CD-2/3 – Approve Alternative Selection, Approve Performance Baseline, and Approve Start of Construction
Construction Complete – Completion of construction
CD-4 – Approve Start of Operations or Project Closeout

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2022	TBD	TBD	N/A
FY 2023	TBD	TBD	N/A
FY 2024	TBD	TBD	N/A

CD-3A – Approve Long-Lead Procurements, Original Scope
CD-3B – Approve Long-Lead Procurements, Revised Scope (as needed)

Project Cost History

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Total	TPC
FY 2022	10,992	52,231	63,223	33,777	97,000
FY 2023	10,992	52,231	63,223	33,777	97,000
FY 2024	10,992	52,231	63,223	33,777	97,000

2. Project Scope and Justification

Scope

LOTUS will provide a dynamic test bed to support testing of advanced reactor concepts. The test bed will be designed and constructed to meet the following minimum requirements:

- The test bed capability must have the supporting infrastructure to safely test advanced reactor concepts up to 500 kilowatts thermal (kW_{th}) and interface, as necessary, with reactor support systems.
- The test bed capability must be able to satisfy Natural Phenomena Hazard (NPH) criteria. As a Hazard Category 2 nuclear facility, the test bed must meet the NPH requirements of DOE Order 420.1C, "Facility Safety," including seismic, wind, flood, and volcanic hazards. Design and construction must ensure that systems, structures, and components will perform safety functions during and after design basis NPH events.
- The test bed capability must be able to provide confinement capability during postulated accident and design basis events. Specifically, it must prevent or control radioactive material release to the environment either in operation or from an accident; and it must ensure air supply and exhaust are controlled, and typically filtered. Confinement may be provided by some combination of leak tightness in the structure and active ventilation to maintain a negative pressure.
- The test bed capability must have the infrastructure (physical and resource) to appropriately control safeguards category I materials.
- The test bed capability must provide the minimum features necessary to conduct an experiment to validate an advanced reactor design starting in FY 2026.
- The test bed capability must be available for advanced reactor testing for a minimum of 20 years from the start of operation.

Key Performance Parameters (KPPs)

A KPP is a vital characteristic, function, requirement, or design basis that, if changed, would have a major impact on the facility or system performance, scope, schedule, cost, risk, or the ability of an interfacing project to meet its mission requirements. The preliminary threshold KPPs represent the minimum acceptable scope for successful delivery of the LOTUS project. Achievement of KPPs will be a prerequisite for approval of CD-4. The project anticipates identifying Objective KPPs that will provide expanded capabilities to meet R&D objectives, if needed. If project performance warrants, management reserve and/or contingency funds can be allocated to Objective KPP scope or infrastructure enhancements to improve facility performance. Final KPPs will be established at CD-2/3 when the project's Performance Baseline is established.

Preliminary Threshold and Objective KPPs

Performance Measure	Threshold	Objective*
Provide the facility infrastructure to support the operation of up to 500 kW_{th} experimental reactors	Establishment of core infrastructure needed to support advanced reactor tests in the test bed, with clearly defined boundaries: • Electrical supply and back-up power (as necessary) • 500 kW_{th} direct reactor cooling system • Ventilation/exhaust for test bed cell • Support systems (e.g., compressed air, argon, fire protection, oxygen monitoring, criticality monitoring) • Establishment of control room area with appropriate data connections	TBD
Establish a Hazard Category-2 nuclear facility capable of supporting tests using safeguards category I quantities of material	Establishment of equipment access capability with required confinement and security features Approved Safety Analysis Report addressing test bed capability Completion of DOE Operational Readiness Review for the test bed capability in accordance with DOE Order 425.1D Completion of Vulnerability Assessment demonstrating compliance with applicable security requirements	N/A

* LOTUS will be baselined to the Threshold Measure. Objective KPPs will be executed if funding is available after Threshold KPPs are achieved.

Completion of operational readiness activities for first reactor tests utilizing LOTUS will not be requisite for determining successful project completion.

As applicable, LOTUS will be constructed using sustainable building considerations per Department of Energy Guide 413.3-6B, dated 4-5-2020, "High Performance Sustainable Buildings." The design will include provisions for meeting the 2016 and 2020 Guiding Principles for Sustainable Federal Buildings, as applicable. Design, construction, and documentation of the Guiding Principles ensure compliance with DOE Order 436.1, Departmental Sustainability.

Funds appropriated under this data sheet may be used to provide independent assessments related to project planning and execution.

Justification

Nuclear power remains an important part of our Nation's energy portfolio, as we strive to reduce carbon emissions and address the threat of global climate change. Following the advent of nuclear power generation, the U.S. was an international leader in the development and testing of advanced nuclear reactor technologies. DOE and its predecessor organizations appropriately provided nuclear fuels and materials development capabilities and large-scale demonstration facilities in support of currently deployed nuclear reactor technologies. However, the U.S. has not sufficiently maintained this domestic capability for over two decades. The existing industrial and DOE test bed facilities are not currently capable of supporting fueled advanced reactor tests and international facilities are not an option due to concerns with access, transportation, and technical equivalencies. Lack of domestic advanced reactor test bed capabilities is hampering the U.S. ability to move forward in the development of next generation nuclear reactors and equally impacts the Nation's ability to regain technological leadership in this arena.

Based on the tremendous potential value of improved nuclear energy technology, private-sector investment in nuclear innovation has increased in recent years. Currently there are dozens of U.S. companies pursuing advanced reactor concepts that potentially offer enhanced safety, improved efficiency, and reduced costs. In addition, DOE's national laboratories,

other federal agencies, and universities, are actively pursuing the development of next generation advanced reactor technologies.

The Nuclear Energy Innovation Capabilities Act of 2017 (P.L. 115-248) (NEICA), Section 958, Enabling Nuclear Energy Innovation, authorized the National Reactor Innovation Center (NRIC) as a program to enable the testing and demonstration of reactor concepts to be proposed and funded, in whole or in part, by the private sector. As a result, the DOE Office of Nuclear Energy launched the NRIC in August 2019. NRIC is charged with developing the infrastructure needed for the testing and demonstration of multiple advanced reactor concepts. To fulfill that charge, NRIC has been exploring options to develop test bed capabilities to provide industry partners the infrastructure to startup, test, and operate experimental reactors in a safe and economical manner.

The approved Mission Need Statement for the LOTUS project provides the basis for establishing a safeguards category I advanced reactor test bed capability at INL to support DOE, industry, and other government agency advanced reactor testing needs. Establishment of the LOTUS capability will provide industry with the infrastructure necessary to support development and testing of experimental reactors requiring safeguards category I materials for operation. Testing of these reactor concepts will provide real data that can be used to validate models and support subsequent licensing activities to bring the reactors to market. Advanced reactor communities that are supported by several DOE programs are key to providing a flexible portfolio of energy supply sources. This will ensure national security through energy independence and will re-energize the U.S. nuclear industrial sector for deployment of advanced reactors. This infrastructure will further demonstrate DOE's commitment and support of advanced reactor technologies consistent with NEICA.

Establishment of this test bed is consistent with Congressional direction provided as part of the Consolidated Appropriations Acts of 2021 and 2022.

3. Financial Schedule

(Dollars in Thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2022	2,000	2,000	500
FY 2023	8,992	8,992	9,500
FY 2024	0	0	992
Total, Design (TEC)	**10,992**	**10,992**	**10,992**
Construction			
FY 2023	11,008	11,008	1,500
FY 2024	32,000	32,000	20,500
Outyears	9,223	9,223	30,231
Total, Construction (TEC)	**52,231**	**52,231**	**52,231**
Total Estimated Costs (TEC)			
FY 2022	2,000	2,000	500
FY 2023	20,000	20,000	11,000
FY 2024	32,000	32,000	21,492
Outyears	9,223	9,223	30,231
Total TEC	63,223	63,223	63,223
Other Project Costs			

	Budget Authority (Appropriations)	Obligations	Costs
FY 2021	3,957	3,957	1,037
FY 2022	600	600	1,973
FY 2023	1,000	1,000	750
FY 2024	8,000	8,000	8,000
Outyears	20,220	20,220	22,017
Total OPC	33,777	33,777	33,777
Total Project Costs (TPC)			
FY 2021	3,957	3,957	1,037
FY 2022	2,600	2,600	2,473
FY 2023	21,000	21,000	11,750
FY 2024	40,000	40,000	29,492
Outyears	29,443	29,443	52,248
Grand Total	**97,000**	**97,000**	**97,000**

4. Details of Project Cost Estimate

(Budget Authority in Thousands of Dollars)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	6,281	N/A	TBD
Contingency	4,711	N/A	TBD
Total, Design	10,992	N/A	TBD
Construction			
Site Work	5,272	N/A	TBD
Equipment	0	N/A	TBD
Construction	24,577	N/A	TBD
Other, as needed	0	N/A	TBD
Contingency	22,382	N/A	TBD
Total, Construction	52,231	N/A	TBD
Other TEC (if any)			
Cold Startup	N/A	N/A	--
Contingency	N/A	N/A	N/A
Total, Other TEC	N/A	N/A	N/A
Total **Estimated Cost**	63,223	N/A	N/A

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Contingency, TEC	27,093	TBD	TBD
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Design/Planning	4,303	N/A	TBD
Other OPC Costs	15,001	N/A	TBD
Contingency	14,473	N/A	TBD
Total, OPC	33,777	N/A	TBD
Contingency, OPC	14,473	N/A	TBD
Total Project Cost	97,000	N/A	TBD
Total Contingency (TEC+OPC)	41,566	N/A	TBD

5. Schedule of Appropriation Requests

(Dollars in Thousands)

Request Year	Type	Prior Years	FY 2021	FY 2022	FY 2023	FY 2024	Outyears	Total
FY 2022	TEC	N/A	0	2,000	20,000	32,000	9,223	63,223
	OPC	N/A	3,957	600	1,000	8,000	20,220	33,777
	TPC	N/A	3,957	2,600	21,000	40,000	29,443	97,000
FY 2023	TEC	N/A	0	2,000	20,000	32,000	9,223	63,223
	OPC	N/A	3,957	600	1,000	8,000	20,220	33,777
	TPC	N/A	3,957	2,600	21,000	40,000	29,443	97,000
FY 2024	TEC	N/A	0	2,000	20,000	32,000	9,223	63,223
	OPC	N/A	3,957	600	1,000	8,000	20,220	33,777
	TPC	N/A	3,957	2,600	21,000	40,000	29,443	97,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	4Q FY 2026
Expected Useful Life (number of years)	20
Expected Future Start of D&D of this capital asset (fiscal quarter)	1Q FY 2047

Related Funding Requirements
(Budget Authority in Thousands of Dollars)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations and Maintenance	N/A	TBD	N/A	TBD

Development of life-cycle operations and maintenance costs pending selection of a preferred alternative.

7. D&D Information

The new area being constructed in this project is modifying an existing facility.

	Square Feet
New area being constructed by this project at INL	TBD
Area of D&D in this project at INL	0
Area at INL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	0
Area of D&D in this project at other sites	0
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	0
Total area eliminated	0

Site location, building name or numbers, and square footages of existing facilities to be replaced: N/A

As an advanced reactor test bed (laboratory facility), the proposed LOTUS is not subject to Freeze the Footprint (>50% lab space).

8. Acquisition Approach

Based on Congressional direction to establish test bed capabilities at INL to support advanced reactor demonstration activities, the project's acquisition strategy will utilize a tailored approach under DOE Order 413.3B. This tailoring approach allows for timely movement into capital design activities following selection of a preferred alternative for meeting the identified capability gap.

As a Hazard Category 2 nuclear facility, design, and construction of the LOTUS must be integrated with ongoing nuclear operations activities. Design and construction must also be coordinated/integrated with nuclear research and development programs. A design-bid-build project delivery method managed by the INL management and operating contractor will be used for the design and construction of LOTUS. LOTUS construction subcontract is anticipated to be a firm, fixed-price contract.

Infrastructure

Overview

Infrastructure consists of the Idaho National Laboratory (INL) Facilities Operations and Maintenance (IFM) subprogram and Construction subprogram.

The mission of the IFM subprogram is to manage the planning, acquisition, operation, maintenance, and disposition of the multi-program nuclear facilities and capabilities owned by the Office of Nuclear Energy (NE) along with the supporting infrastructure at INL. The IFM subprogram maintains the Department of Energy (DOE) mission-supporting facilities and capabilities at INL in a safe and compliant status (with DOE Orders, federal laws and regulations, and state agreements) to enable technological advancement in the existing nuclear fleet, advanced reactor pipeline, and fuel cycle missions. These key facilities and capabilities support NE research and development (R&D) necessary to revitalize nuclear energy in the U.S. These INL facilities and capabilities also support testing of naval reactor fuels, reactor core components and a diverse range of national security technology programs for the National Nuclear Security Administration (NNSA), isotope production for the Office of Science, and other federal agencies in critical infrastructure protection, nuclear nonproliferation, and incident response. The IFM subprogram integrates and closely coordinates with research programs to ensure proper alignment and prioritization of infrastructure investments, as well as availability of infrastructure for programmatic work.

The Construction subprogram plays a critical role in revitalizing the NE infrastructure. The subprogram focuses on addressing identified gaps created by either deteriorating critical infrastructure or evolving NE missions.

Highlights of the FY 2024 Budget Request

Oak Ridge National Laboratory (ORNL) Nuclear Facilities are fully funded in the Office of Science FY 2024 Request.

The IFM subprogram maintains focus on the safe and compliant operation of INL nuclear research reactors, non-reactor nuclear facilities, and radiological research facilities while continuing to realize improvements in the condition of aging INL infrastructure. In FY 2024, the IFM subprogram will focus on:

- Funding the established annual increases consistent with negotiated labor wage agreements and reliability improvements to keep facilities at INL operational for NE's research and development missions.
- Continued support of regulatory compliance program to ensure compliance with the State and Federal environmental laws and regulations.
- Continued support of environmental surveillance and monitoring activities including environmental review and data collection activities to support future permits and National Environmental Policy Act (NEPA) documentation.
- Initiating pre-planning for modernizing or replacing end-of-life capabilities.

In FY 2024, there are no new construction line items under the Construction subprogram. The Sample Preparation Laboratory (SPL) project will continue construction activities per the approved project baseline.

Infrastructure
Funding ($K) (Non-Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Infrastructure					
INL Facilities Operations and Maintenance[1]	295,000	318,924	318,924	0	0%
ORNL Nuclear Facilities O&M	20,000	20,000	0	-20,000	-100%
Research Reactor Infrastructure	15,000	0	0	0	0%
Construction: Sample Preparation Laboratory	41,850	7,300	0	-7,300	-100%
Total, Infrastructure	**371,850**	**346,224**	**318,924**	**-27,300**	**-7.9%**

[1] Funding does not reflect the transfer of $92,747,000 in FY 2022 and $99,747,000 in FY 2023 from Naval Reactors for maintenance and operation of the Advanced Test Reactor.

Infrastructure
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
INL Facilities Operations and Maintenance:	
No Change.	**0**
ORNL Nuclear Facilities O&M:	
No funding requested in FY 2024. ORNL Nuclear Facilities are fully funded within the Office of Science FY 2024 Request.	**-20,000**
Research Reactor Infrastructure:	
No change. Consistent with FY 2023 Enacted, Research Reactor Instructure, also known as "University Fuel Services," is included in the NEUP, SBIR/STTR and TCF program.	**0**
Construction:	
The decrease from $7,300,000 to $0 reflects meeting established baseline funding requirements for the Sample Preparation Laboratory (SPL) project.	**-7,300**
Total, Infrastructure	**-27,300**

INL Facilities Operations and Maintenance

Description

INL Nuclear Research Reactor Operations and Maintenance

This subcategory supports operations and maintenance of the nuclear research reactors at the Advanced Test Reactor (ATR) Complex and the Materials and Fuels Complex (MFC), including the ATR, the ATR Critical Facility (ATRC), the Transient Reactor Test Facility (TREAT), and the Neutron Radiography Reactor (NRAD).

The ATR is the primary research reactor at the Idaho National Laboratory (INL). The ATR supports the majority of the Office of Nuclear Energy (NE) research and development (R&D) programs, as well as the Naval Reactors (NR) Program in support of the U.S. Navy nuclear fleet and National Nuclear Security Administration (NNSA) programs. The ATR is also used by universities, laboratories, and industry and is the primary scientific capability of the Nuclear Science User Facilities (NSUF). R&D demand for thermal neutron irradiation at ATRC and neutron radiography and small component test irradiation at NRAD continues to be significant. The TREAT reactor, an air-cooled thermal spectrum test facility, continues to address technical challenges for reactor fuels related to nuclear fuel performance and qualification. All programmatic work is funded by the sponsoring federal programs. The cost to other users is determined in accordance with Department of Energy (DOE) regulations and depends upon the demands on the reactor and the nature of the user.

To satisfy the irradiation needs of ATR users, efforts will continue in FY 2024 to improve the availability and reliability of the ATR. Continued investments in ATR infrastructure are still needed to sustain the improvements that have been made to date. Funding is identified in FY 2024 to support planning for Long-Term Asset Management requirements including repairs of heat exchanger units and replacement of regulating rod control systems. Additionally, in FY 2024 pre-planning will be initiated for modernizing or replacing end of life capabilities.

Operations at TREAT and NRAD will continue in FY 2024 to support a wide range of customers including NE R&D programs, commercial industry, and other Federal Agencies.

INL Non-Reactor Nuclear Research Facility Operations and Maintenance

This subcategory provides funding for operations, maintenance, and support of non-reactor nuclear and radiological research facilities primarily located at the MFC. Activities within this category sustain unique nuclear and radiological capabilities essential to multiple NE R&D programs. This includes maintaining a safe operating envelope by conducting maintenance (preventative and corrective) and refurbishments to sustain or improve core infrastructure capabilities. The non-reactor nuclear research facilities support core programmatic capabilities for inspecting, fabricating, and processing a myriad radioactive and non-radioactive materials including:

- Post-Irradiation Examination (PIE) and Fresh Fuel Characterization – Receipt of irradiated fuels and materials, non-destructive examinations, destructive examinations and analyses, and mechanical testing of highly radioactive materials.
- Experimental Fuel Fabrication – R&D on fabrication of multiple fuel types at various enrichment levels.
- Advanced Separation and Waste Forms – Separation, pre-treatment technology development, electrochemical separation, and engineering scale waste form development.

To enable R&D activities at the MFC, efforts will continue in FY 2024 to ensure facility availability and equipment reliability is as high as feasible. In FY 2022, the cumulative facility availability for MFC was 94%. In FY 2024, MFC Plant Health investments will continue to focus on improving throughput in MFC mission facilities, such as hot cell window and manipulator refurbishments and replacements at the Hot Fuels Examination Facility (HFEF), Fuel Conditioning Facility (FCF), and Analytical Laboratory (AL); multi-zone system overhaul at AL; MFC plant cooling water system refurbishment; hot cell HEPA replacements at HFEF; and fuel procurement for the NRAD reactor.

This subprogram also provides funding for the management of Nuclear Energy (NE)-owned special nuclear material (SNM), operation and maintenance of the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility and the Radioactive Waste

Scrap Facility (RSWF), support for Nuclear Regulatory Commission cask certifications and Other Project Costs (OPCs) for the Sample Preparation Laboratory (SPL) Project.

INL Engineering and Support Facility Operations and Maintenance

This subcategory provides funds for community and technical support activities including support for the Shoshone-Bannock Tribes, Idaho Department of Environment Quality, and environmental reviews and data collection to support future permits and NEPA reviews. It also supports environmental surveillance and monitoring activities in accordance with State and Federal regulations. This subcategory also funds Payment in Lieu of Taxes (PILT), Institute of Nuclear Power Operations, and other Departmental cross-cutting infrastructure reporting requirements.

Department of Energy (DOE) has had a formal relationship via an Agreement in Principle (AIP) with the Shoshone-Bannock Tribes since 1992 in recognition of the Tribes' connection and vested interest in the land upon which INL is located. Support is provided to the Tribes to participate in the review of Environmental Impact Statement and Environmental Assessments, cultural resource surveys and protection, environmental surveillance, and emergency response and preparedness.

INL Regulatory Compliance

This subcategory supports activities for continual compliance with the State and Federal environmental laws and other regulations applicable to INL. Compliance activities focus on air, soil, and water monitoring and waste disposal consistent with Federal and State permit requirements and agreements such as the INL Site Treatment Plan. Regulatory activities also include efforts that support compliance with the 1995 Settlement Agreement with the State of Idaho, which governs management and disposition of spent nuclear fuel and transuranic wastes at the INL. In November 2019, DOE and the State of Idaho signed a Supplemental Agreement to the 1995 Idaho Settlement Agreement that reaffirms DOE's and Idaho's commitment to remove Cold War legacy waste and special nuclear materials from Idaho. The FY 2024 funds will support material stabilization and legacy material packaging consistent with approved plans.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
INL Nuclear Research Reactor Operations and Maintenance $119,362,000	**$126,070,000**	**+$6,708**
• Maintained Advanced Test Reactor (ATR) availability at 60% with 120 irradiation days in the first full year of operations following completion of the Core Internals Change-out (CIC) in FY 2022. • Continued investments to improve ATR availability and reliability through refurbishments and replacements of reactor systems and components such as warm waste pond liner replacement, canal bulkhead replacements, and console display systems. • Initiated planning for major maintenance and repair activities required to sustain ATR operations through 2040 such as replacement of the primary heat exchangers. • Continued transient testing operations at the Transient Reactor Test Facility (TREAT) facility. • Continued operations of the Neutron Radiography Reactor (NRAD).	• Maintains ATR availability at 78% with a target of 154 irradiation days during FY 2024. • Continues investments per the Long-Term Asset Management (LTAM) plan to improve ATR availability and reliability through refurbishments and replacements of reactor systems and components such as, flux wire scanner, and regulating rod control system upgrades. • Initiates preplanning activities for future thermal irradiation capabilities. • Continues transient testing operations at the TREAT facility. • Continues operations of the NRAD.	• The increase supports ATR base operations including labor wage agreements and repairs or replacement of heat exchangers.
INL Non-Reactor Nuclear Research Facility Operations and Maintenance $180,005,000	**$178,148,000**	**-$1,857,000**
• Operated and maintained Materials and Fuels Complex (MFC) infrastructure, facilities, and equipment to support facility operations and programmatic work activities. • Performed maintenance and refurbishment activities within the Materials and Fuels Complex (MFC) nuclear facilities and infrastructure consistent with the approved safety basis. • Performed maintenance and refurbishment on the radiological and balance-of-plant facilities	• Operates and maintains MFC infrastructure, facilities, and equipment to support facility operations and programmatic work activities. • Performs maintenance and refurbishment activities within the MFC nuclear facilities and infrastructure consistent with the approved safety basis. • Performs maintenance and refurbishment on the radiological and balance-of-plant facilities	• The decrease reflects completion of the MFC Analytical Laboratory (AL) HVAC project and in-cell lighting upgrades at Fuel Conditioning Facility (FCF).

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
necessary to support the Materials and Fuels Complex (MFC) nuclear facilities and core missions. • Continued off-site disposition of surplus Nuclear Energy (NE)-owned special nuclear material (SNM) consistent with programmatic needs and approved nuclear material allotment forecasts. • Operated and maintained the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility to provide legacy and newly - generated waste disposal capability. • Conducted construction oversight activities for the Sample Preparation Laboratory (SPL) Project. • Continued to support activities to maintain Idaho National Laboratory (INL) operations such as Nuclear Regulatory Commission (NRC) certificates for cask. • Continued MFC infrastructure investments to improve reliability and availability of key facilities: Hot Fuels Examination Facility (HFEF), Fuel Conditioning Facility (FCF), Neutron Radiography Reactor (NRAD), and Analytical Laboratory (AL).	necessary to support the MFC nuclear facilities and core missions. • Continues MFC infrastructure investments to improve reliability and availability of key facilities: Hot Fuels Examination Facility (HFEF), Fuel Conditioning Facility (FCF), Neutron Radiography Reactor (NRAD), and Analytical Laboratory (AL). • Initiates pre-planning for future capabilities. • Continues off-site disposition of surplus NE-owned SNM consistent with programmatic needs and approved nuclear material allotment forecasts. • Operates and maintains the RHLLW Disposal Facility to provide legacy and newly - generated waste disposal capability. • Conducts construction oversight activities for the Sample Preparation Laboratory (SPL) Project. • Continues to support activities to maintain INL operations such as NRC certificates for cask.	
INL Engineering and Support Facility Operations and Maintenance $5,743,000	**$4,500,000**	**-$1,243,000**
• Continued to support federally funded activities to maintain operations at the INL such as Payment in Lieu of Taxes (PILT); environmental review and data collection to support future permits/NEPA assessments; and community support activities for local Shoshone- Bannock Tribes including review of Environmental Impact Statement and Environmental Assessments, cultural resource surveys and protection, environmental surveillance, and emergency response and preparedness.	• Continues to support federally funded activities to maintain operations at the INL such as PILT; environmental review and data collection to support future permits/NEPA assessments; and community support activities for local Shoshone-Bannock Tribes including review of Environmental Impact Statement and Environmental Assessments, cultural resource surveys and protection, environmental surveillance, and emergency response and preparedness.	• The decrease reflects anticipated costs to support planned assessments and surveys.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
INL Regulatory Compliance $13,814,000	**$10,206,000**	**– $3,608,000**
• Continued regulatory compliance program management. • Met Idaho National Laboratory (INL) Site Treatment Plan milestones for treatment of two cubic meters of mixed low-level waste (MLLW) annually based on a three-year rolling average. • Completed receipt of minimum of 12 transfers of used nuclear fuel from wet storage at Fuel Conditioning Facility (FCF) in accordance with the 1995 Idaho Settlement Agreement and consistent with material requirements for the treatment of Experimental Breeder Reactor (EBR)-II used nuclear fuel. • Completed transfer of Advanced Test Reactor (ATR) spent fuel into dry storage configuration consistent with State agreements. • Processed a minimum of 8 treatment batches of EBR-II fuel through FCF pyro-processing. Beginning in FY24, EBR-II Driver fuel to be treated will be retrieved from Radioactive Waste Scrap Facility (RSWF). • Continued to coordinate activities and operations for the direct shipment of EBR-II fuel from the Idaho Nuclear Technology and Engineering Center to the Materials and Fuels Complex. • Conducted environmental surveillance and monitoring activities.	• Continues regulatory compliance program management. • Meets INL Site Treatment Plan milestones for treatment of two cubic meters of MLLW annually based on a three-year rolling average. • Processes a minimum of 8 treatment batches of EBR-II fuel through FCF pyro-processing. Beginning in FY24, EBR-II Driver fuel to be treated will be retrieved from RSWF. • Continues to coordinate activities and operations for the direct shipment of EBR-II fuel from the Idaho Nuclear Technology and Engineering Center to the Materials and Fuels Complex. • Conducts environmental surveillance and monitoring activities. • Continues shipment of contact handled transuranic waste stored at MFC to WIPP.	• The decrease reflects completion of transfer of used nuclear fuel from wet storage to dry per the Idaho Settlement Agreement.

ORNL Nuclear Facilities O&M

Description

Consistent with congressional direction, this program provided funds in FY 2023 to support Oak Ridge National Laboratory (ORNL) hot cells, managed by the Office of Science. In FY 2024 full funding for the ORNL Nuclear Facilities is included in the Office of Science Request.

ORNL Nuclear Facilities O&M
Funding ($K)

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Oak Ridge Nuclear Infrastructure $20,000,000	**$0**	**-$20,000,000**
• Consistent with the FY 2023 Appropriation, the Oak Ridge Nuclear Facilities are managed by the Office of Science. FY 2023 accomplishments are captured in the Office of Science FY 2024 Request.	• No funding is requested.	• No funding is requested in FY 2024 as full funding for the ORNL Nuclear Facilities are included in the Office of Science Request.

Construction

Description

Line-item capital projects are sometimes required at the Idaho National Laboratory (INL) to maintain its ability to support mission goals. These projects help achieve the Department's and Nuclear Energy (NE)'s strategic objectives by maintaining site services and providing critical information for future decisions. This activity is focused on two primary objectives: (1) identification, planning, and prioritization of projects required to meet NE program objectives, and (2) development and execution of these projects within approved cost and schedule baselines.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Construction $7,300,000	**$0**	**-$7,300,000**
Sample Preparation Laboratory (16-E-200) ($7,300,000) • Continued Sample Preparation Laboratory (SPL) construction activities consistent with approved baseline including completion of the construction and installation of scientific equipment such as interior of hot cell and experiment spaces, manipulator repair space, glove box and other service areas.	*Sample Preparation Laboratory (16-E-200) ($0)* • No additional funding is required to complete the Sample Preparation Laboratory.	*Sample Preparation Laboratory (16-E-200) (-$7,300,000)* • The decrease reflects meeting established baseline funding requirements.

Infrastructure
Construction Projects Summary ($K)

	Total	Prior Years	FY 2022 Enacted	FY 2022 Actuals	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
16-E-200, Sample Preparation Laboratory, INL							
Total Estimated Cost (TEC)	144,600	95,450	41,850	41,850	7,300	0	-7,300
Other Project Costs (OPC)	21,400	5,147	2,500	2,500	6,903	6,000	-903
Total Project Cost (TPC) Project Number 16-E-200	**166,000**	**100,597**	**44,350**	**44,350**	**14,203**	**6,000**	**-8,203**
Total All Construction Projects							
Total Estimated Cost (TEC)	144,600	95,450	41,850	41,850	7,300	0	-7,300
Total Other Project Costs (OPC)	21,400	5,147	2,500	2,500	6,903	6,000	-903
Total Project Cost (TPC) All Construction Projects	**166,000**	**100,597**	**44,350**	**44,350**	**14,203**	**6,000**	**-8,203**

Idaho Sitewide Safeguards and Security

Overview

The Idaho Sitewide Safeguards and Security (S&S) program supports the Office of Nuclear Energy (NE) assets at the Idaho National Laboratory (INL) and enables NE to conduct research and development (R&D) missions that utilize nuclear materials and protected information.

The FY 2024 Budget Request provides direct funding for the NE's S&S base program. Strategic Partnership Projects (SPP) will continue to fund an allocable share of the S&S base program through full cost recovery. Extraordinary security requirements, such as dedicated security for non-NE infrastructure, special projects or exercises, will be a direct charge to SPP customers. Other DOE programs at the Idaho Site are responsible for directly funding their S&S costs.

Highlights of the FY 2024 Budget Request

In FY 2024, the S&S program will sustain program functionality at the level necessary to assure high confidence in the protection of NE-owned INL assets and a high degree of customer service by maintaining effective staffing levels, proactive preventive and corrective maintenance programs, and a robust cybersecurity program. The FY 2024 Budget Request will focus on continued implementation of physical security infrastructure investments, capital improvements, emerging security technology investments, and enhanced cybersecurity program capabilities, including:

- Maintaining protective force staff levels required to ensure an effective S&S program consistent with evolving Departmental requirements;
- Initiating a new general plant project to replace the existing personnel entry building at the Materials and Fuels Complex (MFC) to meet increased operational tempo stemming from growing NE programs focused on fuel and reactor research and development, including expanding the number of entry portals, enhancing personnel screening capabilities, and improving safety by providing internal shelter for personnel waiting to enter MFC;
- Supporting physical security systems life-cycle replacement including preventive and corrective maintenance on critical security systems, subsystems, and components such as lights, sensors, entry/access control devices, locks, and explosives detection equipment;
- Supporting continued implementation of the Design Basis Threat and Departmental Orders; and
- Maintaining an effective cybersecurity program through the addition of lifecycle hardware/software upgrades and replacements including continuous monitoring, maintaining Industrial Control Systems, essential cybersecurity positions, and associated training.

Idaho Sitewide Safeguards and Security
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted($)	FY 2024 Request vs FY 2023 Enacted(%)
Idaho Sitewide Safeguards and Security					
Protective Forces	85,356	88,497	92,922	+4,425	+5.0%
Security Systems	11,575	12,203	12,853	+650	+5.3%
Security Infrastructure	3,518	950	18,020	+17,070	+1,797%
Information Security	6,174	5,016	5,748	+732	+14.6%
Personnel Security	4,714	5,593	5,953	+360	+6.4%
Material Control & Accountability	6,376	5,825	6,525	+700	+12.0%
Program Management	10,175	8,000	8,100	+100	+1.3%
Cybersecurity	21,912	23,916	27,612	+3,696	+15.5%
Total, Idaho Sitewide Safeguards and Security	**149,800**	**150,000**	**177,733**	**+27,733**	**+18.5%**

Idaho Sitewide Safeguards and Security
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Protective Forces:	**+4,425**
The increase from $88,497,000 to $92,922,000 reflects costs to train, equip, and maintain the Protective Force personnel staffing levels and associated equipment consistent with Departmental requirements and existing labor wage agreements.	
Security Systems:	**+650**
The increase from $12,203,000 to $12,853,000 supports planned maintenance and end-of-life replacement of security systems and components.	
Security Infrastructure:	**+17,070**
The increase from $950,000 to $18,020,000 provides funds to initiate replacement of the Entrance Control Facility at the Materials and Fuels Complex to provide adequate space and flow to perform personnel inspections consistent with operational tempos.	
Information Security:	**+732**
The increase from $5,016,000 to $5,784,000 supports Controlled Unclassified Information (CUI) program implementation.	
Personnel Security:	**+360**
No significant change.	
Material Control & Accountability:	**+700**
The increase from $5,825,000 to $6,525,000 funds nuclear material tracking activities consistent with operational tempos.	
Program Management:	
No significant change.	**+100**
Cybersecurity:	**+3,696**
The increase from $23,916,000 to $27,612,000 funds computer network tools and associated staff to protect laboratory systems against dynamic cyber security threats and activities to implement Executive Order 14028, *Improving the Nation's Cybersecurity.*	
Total, Idaho Sitewide Safeguards and Security	**+27,733**

Idaho Sitewide Safeguards and Security

Description

The Idaho Sitewide Safeguards and Security (S&S) program funds Office of Nuclear Energy (NE) base physical and cybersecurity activities for the Idaho National Laboratory (INL), providing protection of the Department of Energy's (DOE) nuclear materials, classified and unclassified matter, government property, personnel, and other vital assets from theft, diversion, sabotage, espionage, unauthorized access, compromise, and other hostile acts that may cause adverse impacts on our national security; program continuity; or the health and safety of employees, the public, or the environment.

Protective Forces

Protective Forces provides security police officers and other specialized personnel, equipment, training, and management needed during normal and security emergency conditions for the adequate protection of site assets consistent with site security plans. Protective force personnel are deployed 24 hours a day, 7 days a week, across 890 square miles to deter, detect, delay, and respond to adversarial threats.

Security Systems

Physical Security Systems provides preventive and corrective maintenance, performance testing, and replacement of intrusion detection and assessment systems, entry and search control equipment, barriers, secure storage, lighting, sensors, entry/access control devices, locks, explosives detection, and tamper-safe monitoring.

Security Infrastructure

Security Infrastructure provides upgrades, refurbishments, and/or replacements of security facilities, including associated planning and construction activities.

Information Security

Information Security provides for the protection and control of classified and sensitive matter that is generated, received, transmitted, used, stored, reproduced, and/or destroyed. Information Security subprogram also includes the Technical Security Countermeasures and Controlled Unclassified Information programs.

Personnel Security

Personnel Security provides access to classified and sensitive information and assignment of personnel in sensitive positions through the clearance program, adjudication, security awareness and education, U.S. citizen and foreign visitor control, Human Reliability Program, psychological/medical assessments, and administrative review costs.

Material Control and Accountability

Material Control & Accountability (MC&A) provides the personnel, equipment, and services required to account for and control special nuclear materials (SNM) from diversion.

Program Management

Program Management includes policy oversight, development, and update of site security plans, vulnerability assessments, performance testing, investigations into incidents of security concern, and issuance of security infractions. Program management also ensures activities are conducted to analyze and identify the impacts of changes to Departmental policies and requirements on the site-wide safeguards and security program.

Cybersecurity

Cybersecurity maintains the staffing, computing infrastructure, and network security configuration necessary to support classified and unclassified information and electronic operations. Cybersecurity uses a graduated risk approach based on data sensitivity and impact of loss/compromise to ensure that electronic or computer information systems are protected in a manner consistent with upholding key priorities, including importance to national security, support of DOE missions and programs, vulnerability to threats, and the magnitude of harm that would result from an information system and industrial control systems compromise.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Protective Forces $88,497,000	**$92,922,000**	**+$4,425,000**
• Maintained protective force staff levels, including planned hires for Phase IIB Implementation Plan protective force staffing requirements. • Purchased Protective Force equipment, including ammunition, weapons, protective gear, and maintained security vehicles.	• Maintains protective force staffing levels, consistent with the Site Security Plan and approved site labor wage agreements. • Procures specialized Protective Force equipment such as simulation devices, ammunition, weapons, protective gear, and maintains security vehicles.	• The increase funds training, equipping, and maintaining Protective Force staffing levels consistent with Departmental security requirements.
Security Systems $12,203,000	**$12,853,000**	**+$650,000**
• Planned and conducted preventive and corrective maintenance on physical security systems across multiple Idaho National Laboratory (INL) security areas. • Operated and maintained the INL central alarm stations, including life-cycle replacement of security alarm systems.	• Maintains preventive and corrective maintenance programs for physical security systems across INL multiple security areas. • Operates and maintains INL central alarm stations, including life-cycle replacement of security alarm systems. • Provides funds for security systems to enhance detection capabilities at INL security areas.	• The increase funds planned maintenance and end-of-life replacement of security systems and components.
Security Infrastructure $950,000	**$18,020,000**	**+$17,070,000**
• Initiated preconceptual planning for the Materials and Fuels Complex (MFC) Entry Control Facility Replacement project.	• Initiates design and construction of the MFC Entry Control Facility Replacement project. This project will meet the increased personnel throughput needs due to the expanding mission at MFC while providing modern inspection capabilities.	• The increase provides funds for design and construction activities consistent with Departmental requirements.
Information Security $5,016,000	**$5,748,000**	**+$732,000**
• Operated information security activities to protect classified and sensitive unclassified matter including Classified Matter Protection and Control, Technical Surveillance Countermeasures, Classification/Declassification, and Operations Security programs. • Initiated efforts to establish a Controlled Unclassified Information (CUI) program for INL.	• Conducts information security activities to protect classified and sensitive unclassified matter including Classified Matter Protection and Control, Technical Surveillance Countermeasures, Classification/Declassification, and Operations Security programs. • Continues implementation of CUI program for INL, consistent with EO 13556 and other applicable rules and requirements.	• The increase support CUI implementation activities.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Personnel Security $5,593,000	**$5,953,000**	**+$360,000**
• Conducted federal contractor personnel security programs to process clearances; operated Idaho National Laboratory (INL) badging office; processed foreign visits and assignments; and managed human reliability program activities.	• Conducts federal and contractor personnel security programs to process clearances; operating INL badging office; coordinating foreign visits and assignments; and managing human reliability program activities.	• No significant change.
Material Control & Accountability (MC&A) $5,825,000	**$6,525,000**	**+$700,000**
• Maintained INL's nuclear material database and tracking systems, coordinated on-and off-site material movements, and conducted accountable special nuclear material inventories.	• Maintains INL's special nuclear material database and tracking systems, manages on-and off-site material movements, and conducts accountable special nuclear material inventories. • Procures and installs equipment to ensure accountability of special nuclear materials.	• The increase funds required nuclear material tracking activities consistent with research and development operational schedules.
Program Management $8,000,000	**$8,100,000**	**+$100**
• Updated INL security plans to meet Design Basis Threat and Departmental security requirement changes.	• Develops and maintains site security documentation, including vulnerability and risk assessments, to ensure alignment to Departmental requirements.	• No significant change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Cybersecurity $23,916,000	**$27,612,000**	**+$3,696,000**
• Provided 24/7 intrusion detection and prevention monitoring to ensure incidents and breaches are discovered and remediated. • Implemented cybersecurity vulnerability management tools to monitor Idaho National Laboratory (INL) network systems. • Completed life-cycle replacement of network boundary protection firewalls.	• Provides 24/7 intrusion detection and prevention monitoring to ensure incidents and breaches are discovered and remediated. • Implements Executive Order (EO) 14028 requirements moving towards Zero Trust principles. • Apply INL's cybersecurity capabilities toward multitude of Industrial Control Systems (ICS), which will enable the ability to identify protect, detect, and respond to malicious cyber-attacks on an array of scientific instruments/capabilities. • Procure a data classification and data loss prevention capabilities to improve protection of data in accordance with the requirements documented in Zero Trust Architecture.	• The increase funds computer network tools and associated staff to protect laboratory systems against dynamic cyber security threats and activities to implement Executive Order 14028, *Improving the Nation's Cybersecurity Activities.*

Idaho Sitewide Safeguards and Security

Capital Summary ($K)

	Total	Prior Years	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Minor Construction Projects							
Materials and Fuels Complex Protective Forces Building	15,600	15,600	0	0	0	0	+0%
Consolidated Training Facility at the Central Facilities Area	12,000	12,000	0	0	0	0	+0%
Materials and Fuels Complex Entrance Control Facility	25,000	0	0	950	18,020	+17,070	+1,797%
Total, Minor Construction Projects	**52,600**	**27,600**	**3,518**	**950**	**18,020**	**+17,070**	**+1,797%**
Total, Capital Summary	**52,600**	**27,600**	**3,518**	**950**	**18,020**	**+17,070**	**+1,797%**

Idaho Sitewide Safeguard and Security Reimbursable Costs

The FY 2024 Budget Request provides direct funding for the NE's S&S base program. Strategic Partnership Projects (SPP) will continue to fund an allocable share of the S&S base program through full cost recovery. Extraordinary security requirements, such as dedicated security for non-NE infrastructure, special projects or exercises, will be a direct charge to SPP customers. Other DOE programs at the Idaho Site are responsible for directly funding their S&S costs. Information regarding SPP full cost recovery estimates are provided in the table below.

(Dollars in thousands)

	FY 2022 Actual	FY2023 Enacted	FY2024 Request	FY2024 Request vs. FY2023 Enacted ($)	FY2024 Request vs. FY2023 Enacted (%)
Idaho National Laboratory	9,048	9,000	10,700	+1,700	+18.8%

International Nuclear Energy Cooperation

Overview

The International Nuclear Energy Cooperation (INEC) program leads the Department of Energy's international engagement on civil nuclear energy, including the development, coordination, and implementation of U.S. civil nuclear energy policy integrated with the Office of Nuclear Energy's (NE) technical programs. INEC works with the international community through both bilateral and multilateral fora to ensure U.S. government and industry equities are represented, while advancing nuclear energy as a key part of climate change and energy security strategies. INEC is leading collaborative bilateral and multilateral supply chain mapping efforts to support diversification within the nuclear supply chain. INEC is leveraging technical expertise from DOE's network of national laboratories to assist countries planning for nuclear infrastructure and workforce development, developing creative proposals for financing for nuclear builds, supporting nuclear safety frameworks and regional capacity building, and identifying opportunities for international collaboration to offset gaps in national capabilities. In conducting many of these activities, INEC works to promote U.S. influence in the International Atomic Energy Agency, including its International Project on Innovative Nuclear Reactors and Fuel Cycles, as well as the Organization for Economic Cooperation and Development's Nuclear Energy Agency, and leverages its leadership roles in the International Framework for Nuclear Energy Cooperation, the Nuclear Innovation: Clean Energy (NICE) Future Initiative under the Clean Energy Ministerial, and the Partnership for Transatlantic Energy and Climate Cooperation.

INEC has played a key role in developing strategic partnerships to serve as the foundation for commercial opportunities for U.S. companies. INEC has continually assessed and defined market opportunities and partnered with U.S. industry associations to verify market prioritizations, which help to guide engagement efforts. INEC has created opportunities for U.S. companies to engage with decision makers in central and eastern Europe, Asia, and Africa to promote U.S. technologies. INEC has led U.S. Government engagement on the Romania nuclear power project and provided key advice on the Poland nuclear power project.

In FY 2024, INEC will continue to coordinate its international activities with its partners within the Department and the U.S. interagency, as well as the U.S. nuclear industry to identify opportunities for U.S. nuclear exports, including advanced reactors, to provide solutions to countries seeking to meet economic development, energy security, and climate change goals. In FY 2024, INEC will contribute to Front End Engineering and Design (FEED) studies supporting potential U.S. nuclear builds in partner countries.

INEC will continue to work with partner countries' Clean Energy Training Centers (CETC) to familiarize local academic, government, industry and professional communities with U.S. nuclear technology and nuclear power's role in hybrid energy systems. INEC provides training within each CETC curated to the needs of the region and could offer simulator-assisted training on U.S. reactor designs, online and in-person curricula, and other activities necessary to develop the expert workforce required for a sustainable nuclear energy program. Currently CETCs exist in Poland and Ghana. FY 2024 funding will support the addition of two more CETC partnerships.

In FY 2024, INEC will also continue to support nuclear safety activities in Armenia and Ukraine. INEC will continue its support of Armenia's training pipeline for graduate students and professionals to join the skilled workforce needed to meet Armenia's current and future staffing requirements for its nuclear program. In Ukraine, INEC has amid ongoing hostilities continued to provide training for Ukrainian graduate students and professionals and is also seeking opportunities to procure the materials and supplies necessary for the continued safe operation of Ukraine's nuclear power plants.

Highlights of the FY 2024 Budget Request

The FY 2024 Request for INEC includes support for the following: Deployment of two additional CETCs to increase awareness of U.S. nuclear technology and best practices; contributing to FEED studies supporting potential U.S. nuclear builds in partner countries; and providing U.S. nuclear expertise to partners in eastern and central Europe, the Baltic States, Southeast Asia, and the Americas to support cooperation in nuclear workforce capacity building, academic and professional training, joint technical studies, and regional technical events. INEC will continue to support nuclear safety activities in Armenia and Ukraine.

International Nuclear Energy Cooperation
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	$3,000	$0	$13,000
Total, International Nuclear Energy Cooperation	**$3,000**	**$0**[1]	**$13,000**

[1] In FY 2023, INEC was funded at $3 million within the NE Program Direction budget.

International Nuclear Energy Cooperation
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
• $3,000 of the FY 2024 budget funds INEC's continued bilateral and multilateral engagement on the sustainable use of nuclear energy, including cooperative R&D with advanced nuclear programs and broad training for programs in development; establishment of two regional CETCs in priority regions; and continued training for the Armenian nuclear workforce and operator training plus emergency supplies procurement for Ukraine.	**+3,000**
• The increase of $10,000 will fund FEED studies for new U.S. advanced reactor builds in partner states, describing reactor and plant design and associated engineering required for the construction and operation of the completed reactors.	**+10,000**
Total, International Nuclear Energy Cooperation	**+13,000**

International Nuclear Energy Cooperation

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
International Nuclear Energy Cooperation **$0**	**$13,000,000**	**+$13,000,000**
• In FY 2023, INEC was funded at $3 million within the NE Program Direction account. Funded activities included the following: • Provides for NE's international engagement activities • Continue support for nuclear safety in Armenia and Ukraine, including emergency support due to the ongoing hostilities in Ukraine. • Continue deployment of CETCs to inform small and emerging nuclear states of U.S. nuclear technology within clean energy systems. • Increase U.S. technical presence through bilateral nuclear cooperation particularly in Eastern Europe, the Baltic States, Southeast Asia, and the Americas, including workforce capacity building, academic and professional training, joint studies, and regional technical events. • Organize a nuclear energy management school. • Continue Fukushima Forensics activities that support improved operation and safety of U.S. domestic nuclear power plants. • Leverage U.S. sponsorship of subject matter experts in international organizations to advance U.S. nuclear equities. • Continue bilateral engagement to build U.S. nuclear cooperation in Baltics, Eastern Europe, Africa and Asia.	• Contribute to FEED studies supporting potential U.S. nuclear builds in partner countries. • Continue support for nuclear safety in Armenia and Ukraine, including emergency support due to the ongoing hostilities in Ukraine. • Continue deployment of CETCs to inform small and emerging nuclear states of U.S. nuclear technology within clean energy systems. • Increase U.S. technical presence through bilateral nuclear cooperation particularly in Eastern Europe, the Baltic States, Southeast Asia, and the Americas, including workforce capacity building, academic and professional training, joint studies, and regional technical events. • Co-sponsor and host an IAEA nuclear energy management school. • Continue Fukushima Forensics activities that support improved operation and safety of U.S. domestic nuclear power plants. • Leverage U.S. sponsorship of subject matter experts in international organizations to advance U.S. nuclear equities. • Continue bilateral engagement to build U.S. nuclear cooperation in Baltics, Eastern Europe, Africa and Asia.	• Contribute to FEED studies supporting potential U.S. nuclear builds in partner countries.

Program Direction

Overview

Program Direction provides the federal staffing resources and associated costs required to support the overall direction and execution of the Office of Nuclear Energy (NE) programs. NE has staff strategically located in multiple locations: Washington, D.C. Headquarters, Nevada Field Office, and the Idaho Operations Office. Activities within the site offices support inherently federal functions that facilitate the efficient execution of Department of Energy (DOE) programs or directly execute DOE mandated safety, security, business functions, and public outreach. In addition to NE federal personnel, Program Direction supports select federal staff and support for the Office of Human Capital Service Center.

The Support Services subprogram allows the Department to cost-effectively hire the best available industry experts to support federal staff in managing the nuclear programs and complex activities. The ability to acquire expertise quickly and on an "as needed basis" provides flexibility in team composition as the needs of NE evolve. Program Direction also includes the Other Related Expenses subprogram, which provides NE's directed funding contribution to the Department's Working Capital Fund (WCF). The WCF supports specific Departmental services and activities that are shared across DOE including: employee health and testing services, and consolidated training and recruitment initiatives; all established in previous fiscal years and supported in FY 2024.

In addition to appropriated funds, NE also manages approximately $200 million annually from other activities including: Strategic Partnerships Program and reimbursable funding from the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD).

The FY 2024 Request will allow the Office of Nuclear Energy to support its increasing mission and address succession planning for critical technical positions and add diversity. NE has successfully utilized the Department's direct hire authority, outreach through job fairs and social media, and the Oak Ridge Institute for Science and Education (ORISE) fellowships and scholars. The ORISE Fellowships and Scholars are focused on developing the environmental justice and equity strategies to include integrating Energy Justice into program areas, participating in key research and development, as well as collaborating with communities, tribes, and other outside stakeholders. In addition, NE is also utilizing more hiring incentives, such as recruitment bonuses, Advanced-in Hire, creditable leave accrual, student loan repayments, and remote work opportunities for all employees.

Highlights of the FY 2024 Budget Request

The FY 2024 Program Direction Budget Request includes a transfer of the INEC program within the NE Program Direction Budget Request to a program level activity within the overall NE Congressional Budget Request. NE has been working to rebuild its workforce levels necessary to execute the robust Research and Development, and Infrastructure activities that NE is responsible for overseeing. NE plans on meeting, and then sustaining that level in the FY 2024 Request and beyond.

Program Direction
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted($)	FY 2024 Request vs FY 2023 Enacted(%)
Program Direction					
Salaries and Benefits	53,011	55,002	57,302	2,300	4%
Travel	1,000	1,400	1,600	200	14%
Support Services	12,159	12,758	13,259	501	4%
Other Related Expenses	13,830	12,840	13,339	499	4%
International Nuclear Energy Cooperation	0	3,000	0	-3,000	-100%
Total, Program Direction	**80,000**	**85,000**	**85,500**	**500**	**1%**

Nuclear Energy FTEs

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request
Nuclear Energy FTEs			
Program Direction	265	294	320
Inflation Reduction Act - HALEU	0	6	9
Inflation Reduction Act - Infrastructure	0	1	2
Total, Nuclear Energy FTEs	**265**	**301**	**331**

Program Direction
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Salaries and Benefits: The increase from $55,002 to $57,302 reflects the funds necessary to achieve and maintain a consistent level of staffing to support Headquarters and Idaho Operations Offices in FY 2024.	**2,300**
Travel: The increase from $1,200 to $1,600 reflects a return to normal travel spending levels post COVID-19 restrictions as well as funding to support the travel of NE's increasing workforce.	**200**
Support Services: The increase from $12,758 to $13,259 reflects additional funding allocated for contractual support as needed to aid and support the increased federal workforce responsible for executing NE's requirements.	**501**
Other Related Expenses: The increase from $12,840 to $13,339 reflects funding to support other expenses related to the increase of NE's workforce that occurred in FY 2023 and will be sustained in FY 2024.	**499**
International Nuclear Energy Cooperation: The decrease from $3,000 to $0 reflects the International Nuclear Energy Cooperation's transfer from NE Program Direction to a program level activity within the FY 2024 NE Congressional Budget Request.	**-3,000**
Total, Program Direction	**500**

Program Direction
Funding ($K)

	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Program Direction Summary			
Washington Headquarters			
Salaries and Benefits	27,753	29,195	1,442
Travel	1,200	1,300	100
Support Services	8,053	8,289	236
Other Related Expenses	7,010	7,109	99
Total, Washington Headquarters	**44,016**	**45,893**	**1,877**
Nevada Field Office			
Salaries and Benefits	1,784	1,784	0
Travel	0	0	0
Support Services	0	0	0
Other Related Expenses	115	115	0
Total, Nevada Field Office	**1,899**	**1,899**	**0**
Idaho Operations Office			
Salaries and Benefits	25,465	26,323	858
Travel	200	300	100
Support Services	4,705	4,970	265
Other Related Expenses	5,715	6,115	400
Total, Idaho Operations Office	**36,085**	**37,709**	**1,623**
Total Program Direction			
Salaries and Benefits	55,002	57,302	2,300
Travel	1,400	1,600	200
Support Services	12,758	13,259	501
Other Related Expenses	12,840	13,339	499
International Nuclear Energy Cooperation	3,000	0	-3,000
Total, Program Direction	**85,000**	**85,500**	**500**
Federal FTEs	**305**	**320**	**15**

	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Support Services			
Technical Support			
Mission Related	830	930	100
Advisory and Assistance	2,102	2,358	256
Total, Technical Support	2,931	3,287	356
Management Support			
Administrative	2,918	3,015	97
IT	6,909	6,957	48
Total Management Support	9,827	9,972	145
Total, Support Services	**12,758**	**13,259**	**501**
Other Related Expenses			
Working Capital Fund	5,250	5,499	249
Training	100	150	50
Miscellaneous	5,453	5,653	200
Rents and Utilities	2,037	2,037	0
Total, Other Related Expenses	**12,840**	**13,339**	**499**

Program Direction
Funding

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Program Direction $85,000,000	**$85,500,000**	**$500,000**
Salaries and Benefits $55,001,745	**$57,301,745**	**$2,300,000**
• Provides salaries and benefits for 305 FTEs.	• Provides salaries and benefits for 320 FTEs.	• The increase reflects funding for salaries and benefits of an additional 15 FTE positions.
Travel $1,400,000	**$1,600,000**	**$200,000**
• Provides for travel of the federal staff including any necessary permanent change of duty status costs.	• Provides for travel of the federal staff including any necessary permanent change of duty status costs.	• The increase reflects funding to support travel related expenses due to the increase of NE's workforce.
Support Services $12,758,255	**$13,259,270**	**$501,015**
• Provides for technical and administrative support services for the Nuclear Energy (NE) federal staff.	• Provides for technical and administrative support services for the NE federal staff.	• The increase reflects additional funding allocated for contractual support as needed to aid and support the increased federal workforce responsible for executing NE's requirements.
Other Related Expenses $12,840,000	**$13,338,985**	**$498,985**
• Provides for NE's share of goods and services procured through the Department's Working Capital Fund (WCF); rents and utilities associated with the Idaho Operations Office; federal training expenses; and other miscellaneous expenses.	• Provides for NE's share of goods and services procured through the Department's WCF; rents and utilities associated with the Idaho Operations Office; federal training expenses; and other miscellaneous expenses.	• The increase reflects funding to support other expenses related to the increase of NE's workforce.
International Nuclear Energy Cooperation $3,000,000	**$0**	**-$3,000,000**
• Provides for NE's international engagement activities • Continue support for nuclear safety in Armenia and Ukraine, including emergency support due to the ongoing hostilities in Ukraine. • Continue deployment of CERTCs to inform small and emerging nuclear states of U.S. nuclear technology within clean energy systems.	• This activity will be requested as it's own program within the FY 2024 Congressional Budget Request.	• The decrease reflects INEC's transfer from NE Program Direction to a program level activity within the FY 2024 NE Congressional Budget Request.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
• Increase U.S. technical presence through bilateral nuclear cooperation particularly in Eastern Europe, the Baltic States, Southeast Asia, and the Americas, including workforce capacity building, academic and professional training, joint studies, and regional technical events. • Organize a nuclear energy management school. • Continue Fukushima Forensics activities that support improved operation and safety of U.S. domestic nuclear power plants. • Leverage U.S. sponsorship of subject matter experts in international organizations to advance U.S. nuclear equities. • Continue bilateral engagement to build U.S. nuclear cooperation in Baltics, Eastern Europe, Africa and Asia.		

Nuclear Energy
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request
NEUP SBIR/STTR and TCF			
SBIR	24,997	23,385	21,314
STTR	3,515	3,288	2,997
Total, SBIR	**24,997**	**23,385**	**21,314**
Total, STTR	**3,515**	**3,288**	**2,997**
Total, SBIR/STTR	**28,512**	**26,673**	**24,311**

Nuclear Energy
Research and Development ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request
Basic	0	0	0
Applied	965,099	1,001,402	962,535
Development	309,492	336,816	327,065
Subtotal, R&D	**1,274,591**	**1,338,218**	**1,289,600**
Equipment	0	0	0
Construction	41,850	7,300	0
Total, R&D	**1,316,441**	**1,345,518**	**1,289,600**

Nuclear Energy
Safeguards and Security($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request
Idaho Sitewide Safeguards and Security			
Protective Forces	85,356	88,497	92,922
Security Systems	11,575	12,203	12,853
Security Infrastructure	3,518	950	18,020
Information Security	6,174	5,016	5,748
Personnel Security	4,714	5,593	5,953
Material Control & Accountability	6,376	5,825	6,525
Program Management	10,175	8,000	8,100
Cybersecurity	21,912	23,916	27,612
Total, Idaho Sitewide Safeguards and Security	**149,800**	**150,000**	**177,733**

Nuclear Energy
Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by this budget and displayed below are intended to halt asset condition degradation. This excludes maintenance of excess facilities (including high-risk excess facilities) necessary to minimize the risk posed by those facilities prior to disposition.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2022 Actual Cost	FY 2022 Planned Cost	FY 2023 Planned Cost	FY 2024 Planned Cost
Idaho National Laboratory	59,820	32,583	33,503	34,450
Total, Direct-Funded Maintenance and Repair	59,820	32,583	33,503	34,450

Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2022 Actual Cost	FY 2022 Planned Cost	FY 2023 Planned Cost	FY 2024 Planned Cost
Idaho National Laboratory	29,139	22,358	22,797	23,372
Total, Indirect-Funded Maintenance and Repair	29,139	22,358	22,797	23,372

Report on FY 2022 Expenditures for Maintenance and Repair

This report responds to legislative language set forth in Conference Report (H.R. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2022 to the amount planned for FY 2022, including congressionally directed changes.

Nuclear Energy
Total Costs for Maintenance and Repair ($K)

	FY 2022 Actual Cost	FY 2022 Planned Cost
Idaho National Laboratory	88,959	54,941
Total, Maintenance and Repair	**88,959**	**54,941**

Each year, the "Planned Cost" for maintenance and repair is a minimum target amount. The Nuclear Energy (NE) program met its planned minimum target in FY 2022. The NE program exceeded the minimum target amount due to strategic investments at the Advanced Test Reactor and Materials and Fuels Complex at the Idaho National Laboratory.

Nuclear Energy
Excess Facilities

Costs for Direct-Funded Excess Facilities ($K)

	FY 2022 Actual Cost	FY 2022 Planned Cost	FY 2023 Planned Cost	FY 2024 Planned Cost
Idaho National Laboratory	0	0	0	0
Total, Direct-Funded Excess Facilities	0	0	0	0

Costs for Indirect-Funded Excess Facilities ($K)

	FY 2022 Actual Cost	FY 2022 Planned Cost	FY 2023 Planned Cost	FY 2024 Planned Cost
Idaho National Laboratory	86	153	65	470
Total, Indirect-Funded Excess Facilities	86	153	65	470

In FY 2022, INL:

- Removed the CF-1704 15,000-gallon underground diesel fuel tank.

In FY 2023, INL plans to:

- Remove the CF-1705 15,000-gallon underground diesel fuel tank; and
- Continue legacy underground storage tank (UST) removals and abandoned well closures.

In FY 2024, INL plans to:

- Demolish the CF-638 Dosimetry Lab; and
- Continue legacy UST removals and abandoned well closures.

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Ames Laboratory			
Crosscutting Technology Development	18	0	0
Nuclear Energy Enabling Technologies	18	0	0
Total Ames Laboratory	**18**	**0**	**0**
Argonne National Laboratory			
NEUP, SBIR/STTR, and TCF	700	0	0
LWR Sustainability	0	11	0
Advanced Reactor Technologies	5,400	4,300	5,500
Reactor Concepts RD&D	5,400	4,311	5,500
Materials Recovery and Waste Form Development	1,445	1,625	1,625
Accident Tolerant Fuels	30	131	131
TRISO and Graphite Qualification	450	155	155
Fuel Cycle Core R&D	2,986	3,525	3,525
Used Nuclear Fuel Disposition R&D	1,300	1,000	2,500
Integrated Waste Management System	200	510	1,900
Fuel Cycle Research & Development	6,411	6,946	9,836
Crosscutting Technology Development	2,111	3,285	3,500
Joint Modeling and Simulation Program	5,180	6,400	6,400
National Scientific User Facility	0	11	10
Transformational Challenge Reactor	500	0	0
Nuclear Energy Enabling Technologies	7,791	9,696	9,910
Demonstration 2 (Natrium)	2,939	0	0
Regulatory Development	5,440	4,610	4,700
Advanced Reactor Safeguards	690	500	500
Advanced Reactors Demonstration Program	9,069	5,110	5,200
International Nuclear Energy Cooperation	779	0	380
Total Argonne National Laboratory	**30,150**	**26,063**	**30,826**
Argonne Site Office			
National Reactor Innovation Center	2,385	3,520	3,000
Advanced Reactors Demonstration Program	2,385	3,520	3,000
Total Argonne Site Office	**2,385**	**3,520**	**3,000**
Brookhaven National Laboratory			
NEUP, SBIR/STTR, and TCF	90	0	0
Accident Tolerant Fuels	295	715	715
Fuel Cycle Core R&D	1,066	433	433
Fuel Cycle Research & Development	1,361	1,148	1,148
Crosscutting Technology Development	23	0	0
Nuclear Energy Enabling Technologies	23	0	0
Advanced Reactor Safeguards	190	300	400
Advanced Reactors Demonstration Program	190	300	400
Total Brookhaven National Laboratory	**1,664**	**1,448**	**1,548**
Chicago Operations Office			
National Scientific User Facility	1	1	0
Nuclear Energy Enabling Technologies	1	1	0
Total Chicago Operations Office	**1**	**1**	**0**
Idaho National Laboratory			
University Fuel Services	0	0	20,172
NEUP, SBIR/STTR, and TCF	5,820	21,154	3,900

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Advanced SMR R&D	1,789	80	100
LWR Sustainability	17,248	18,219	13,869
Advanced Reactor Technologies	20,658	21,781	25,500
Reactor Concepts RD&D	39,695	40,080	39,469
Materials Recovery and Waste Form Development	24,825	31,900	28,400
Accident Tolerant Fuels	29,079	24,070	24,070
TRISO and Graphite Qualification	29,000	24,369	19,004
Fuel Cycle Core R&D	9,825	11,557	11,557
Advanced Nuclear Fuel Availability	0	7,281	7,281
Used Nuclear Fuel Disposition R&D	3,200	5,000	3,000
Integrated Waste Management System	1,000	7,500	3,000
Fuel Cycle Research & Development	96,929	111,677	96,312
Crosscutting Technology Development	16,223	13,894	15,000
Joint Modeling and Simulation Program	10,525	10,070	10,000
National Scientific User Facility	29,141	33,819	33,000
Transformational Challenge Reactor	2,423	0	0
Nuclear Energy Enabling Technologies	58,312	57,783	58,000
National Reactor Innovation Center	50,689	62,330	30,230
Demonstration 1 (X-Energy)	200	0	0
Demonstration 2 (Natrium)	8,948	0	0
Risk Reduction for Future Demonstrations	0	3,725	20,000
Regulatory Development	3,583	2,995	3,200
Advanced Reactor Safeguards	298	75	100
23-E-200 LOTUS Project	0	20,000	32,000
Advanced Reactors Demonstration Program	63,718	89,125	85,530
INL Facilities Operations and Maintenance	291,035	313,852	313,852
Research Reactor Infrastructure	14,923	0	0
16-E-200 Sample Preparation Laboratory	41,850	7,300	0
Infrastructure	347,808	321,152	313,852
Idaho Sitewide Safeguards & Security (050)	148,054	148,600	175,733
International Nuclear Energy Cooperation	212	0	225
Program Direction - Nuclear Energy	3,955	4,250	4,250
Total Idaho National Laboratory	**764,503**	**793,821**	**797,443**
Idaho Operations Office			
University Nuclear Leadership Program	0	0	6,130
University Fuel Services	0	0	50
NEUP, SBIR/STTR, and TCF	53,628	6,550	550
Integrated University Program	5,989	0	0
Advanced SMR R&D	146,614	162,720	18,900
LWR Sustainability	4,730	10,220	10,000
Advanced Reactor Technologies	380	220	220
Reactor Concepts RD&D	151,724	173,160	29,120
Materials Recovery and Waste Form Development	0	5,140	5,140
Accident Tolerant Fuels	68,439	61,323	61,323
TRISO and Graphite Qualification	2,550	2,220	1,563
Fuel Cycle Core R&D	0	2,456	2,456
Advanced Nuclear Fuel Availability	1,629	49,810	60,810
Used Nuclear Fuel Disposition R&D	6,000	5,000	5,000
Integrated Waste Management System	2,000	20,000	12,000
Fuel Cycle Research & Development	80,618	145,949	148,292
Crosscutting Technology Development	220	220	220
Joint Modeling and Simulation Program	220	69	70
National Scientific User Facility	220	220	220
Transformational Challenge Reactor	220	0	0

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Nuclear Energy Enabling Technologies	880	509	510
National Reactor Innovation Center	216	220	220
Demonstration 1 (X-Energy)	29,408	0	0
Demonstration 2 (Natrium)	17,157	0	0
Risk Reduction for Future Demonstrations	12,500	60,000	80,000
Regulatory Development	0	220	220
Advanced Reactor Safeguards	50	0	0
Advanced Reactors Demonstration Program	59,331	60,440	80,440
INL Facilities Operations and Maintenance	3,334	3,401	3,401
Research Reactor Infrastructure	50	0	0
Infrastructure	3,384	3,401	3,401
Idaho Sitewide Safeguards & Security (050)	1,400	1,400	2,000
International Nuclear Energy Cooperation	331	0	1,165
Program Direction - Nuclear Energy	31,351	32,835	33,459
Total Idaho Operations Office	**388,636**	**424,244**	**305,117**
Lawrence Berkeley National Laboratory			
NEUP, SBIR/STTR, and TCF	280	0	0
Materials Recovery and Waste Form Development	0	51	51
Used Nuclear Fuel Disposition R&D	4,000	3,500	3,500
Fuel Cycle Research & Development	4,000	3,551	3,551
Crosscutting Technology Development	52	0	0
Joint Modeling and Simulation Program	150	150	150
Nuclear Energy Enabling Technologies	202	150	150
Total Lawrence Berkeley National Laboratory	**4,482**	**3,701**	**3,701**
Lawrence Livermore National Laboratory			
Accident Tolerant Fuels	0	376	376
Used Nuclear Fuel Disposition R&D	372	351	351
Fuel Cycle Research & Development	372	727	727
Crosscutting Technology Development	250	0	0
Nuclear Energy Enabling Technologies	250	0	0
Total Lawrence Livermore National Laboratory	**622**	**727**	**727**
Livermore Site Office			
Advanced Reactor Technologies	25	0	0
Reactor Concepts RD&D	25	0	0
Total Livermore Site Office	**25**	**0**	**0**
Los Alamos National Laboratory			
NEUP, SBIR/STTR, and TCF	765	0	0
Advanced Reactor Technologies	3,276	1,800	2,500
Reactor Concepts RD&D	3,276	1,800	2,500
Materials Recovery and Waste Form Development	385	0	0
Accident Tolerant Fuels	5,603	4,606	4,606
Fuel Cycle Core R&D	1,926	2,889	2,889
Advanced Nuclear Fuel Availability	0	5,745	5,745
Used Nuclear Fuel Disposition R&D	2,700	3,200	3,200
Fuel Cycle Research & Development	10,614	16,440	16,440
Crosscutting Technology Development	750	550	600
Joint Modeling and Simulation Program	4,360	3,915	4,000
Nuclear Energy Enabling Technologies	5,110	4,465	4,600
Advanced Reactor Safeguards	300	300	300
Advanced Reactors Demonstration Program	300	300	300

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Total Los Alamos National Laboratory	**20,065**	**23,005**	**23,840**
National Energy Technology Lab			
LWR Sustainability	83	0	0
Reactor Concepts RD&D	83	0	0
Crosscutting Technology Development	74	149	150
Nuclear Energy Enabling Technologies	74	149	150
Total National Energy Technology Lab	**157**	**149**	**150**
National Renewable Energy Laboratory			
NEUP, SBIR/STTR, and TCF	25	0	0
Crosscutting Technology Development	119	0	0
Nuclear Energy Enabling Technologies	119	0	0
International Nuclear Energy Cooperation	180	0	0
Total National Renewable Energy Laboratory	**324**	**0**	**0**
Nevada Field Office			
Program Direction - Nuclear Energy	1,899	1,999	1,989
Total Nevada Field Office	**1,899**	**1,999**	**1,989**
Oak Ridge Institute for Science & Education			
University Nuclear Leadership Program	0	0	500
NEUP, SBIR/STTR, and TCF	0	500	0
Joint Modeling and Simulation Program	100	0	0
Nuclear Energy Enabling Technologies	100	0	0
Idaho Sitewide Safeguards & Security (050)	100	0	0
Program Direction - Nuclear Energy	45	200	352
Total Oak Ridge Institute for Science & Education	**245**	**700**	**852**
Oak Ridge National Laboratory			
NEUP, SBIR/STTR, and TCF	480	0	0
LWR Sustainability	4,856	4,960	3,776
Advanced Reactor Technologies	2,886	1,294	4,000
Reactor Concepts RD&D	7,742	6,254	7,776
Materials Recovery and Waste Form Development	1,900	1,442	1,442
Accident Tolerant Fuels	9,250	7,304	7,304
TRISO and Graphite Qualification	3,000	3,776	2,950
Fuel Cycle Core R&D	4,652	2,167	2,167
Advanced Nuclear Fuel Availability	0	5,745	5,745
Used Nuclear Fuel Disposition R&D	3,700	3,300	3,300
Integrated Waste Management System	4,000	5,990	6,000
Fuel Cycle Research & Development	26,502	29,724	28,908
Crosscutting Technology Development	1,376	1,817	1,800
Joint Modeling and Simulation Program	5,177	4,305	5,200
National Scientific User Facility	0	0	1,170
Transformational Challenge Reactor	21,500	0	0
Nuclear Energy Enabling Technologies	28,053	6,122	8,170
National Reactor Innovation Center	100	100	50
Demonstration 1 (X-Energy)	392	0	0
Demonstration 2 (Natrium)	371	0	0
Risk Reduction for Future Demonstrations	0	11,900	10,000
Regulatory Development	3,400	1,905	2,080
Advanced Reactor Safeguards	673	550	800
Advanced Reactors Demonstration Program	4,936	14,455	12,930

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
ORNL Nuclear Facilities O&M	19,754	20,000	0
Infrastructure	19,754	20,000	0
International Nuclear Energy Cooperation	1,170	0	1,025
Total Oak Ridge National Laboratory	**88,637**	**76,555**	**58,809**
Oak Ridge Office			
Advanced Nuclear Fuel Availability	199	0	0
Fuel Cycle Research & Development	199	0	0
Total Oak Ridge Office	**199**	**0**	**0**
Pacific Northwest National Laboratory			
NEUP, SBIR/STTR, and TCF	700	0	0
Advanced Reactor Technologies	3,390	1,555	4,000
Reactor Concepts RD&D	3,390	1,555	4,000
Materials Recovery and Waste Form Development	1,390	889	889
Accident Tolerant Fuels	75	93	93
Fuel Cycle Core R&D	1,772	1,445	1,445
Advanced Nuclear Fuel Availability	0	5,745	5,745
Used Nuclear Fuel Disposition R&D	9,050	6,800	6,800
Integrated Waste Management System	3,500	13,000	16,000
Fuel Cycle Research & Development	15,787	27,972	30,972
Crosscutting Technology Development	1,256	1,540	1,600
Transformational Challenge Reactor	300	0	0
Nuclear Energy Enabling Technologies	1,556	1,540	1,600
National Reactor Innovation Center	90	50	0
Demonstration 2 (Natrium)	585	0	0
Regulatory Development	568	150	300
Advanced Reactor Safeguards	350	450	450
Advanced Reactors Demonstration Program	1,593	650	750
International Nuclear Energy Cooperation	70	0	180
Total Pacific Northwest National Laboratory	**23,096**	**31,717**	**37,502**
Sandia National Laboratories			
NEUP, SBIR/STTR, and TCF	160	0	0
LWR Sustainability	3,576	3,750	2,855
Advanced Reactor Technologies	4,850	4,900	0
Reactor Concepts RD&D	8,426	8,650	2,855
Accident Tolerant Fuels	60	149	149
Used Nuclear Fuel Disposition R&D	19,134	17,674	17,000
Integrated Waste Management System	4,000	1,500	1,500
Fuel Cycle Research & Development	23,194	19,323	18,649
Crosscutting Technology Development	1,783	2,436	2,400
Joint Modeling and Simulation Program	0	250	250
Nuclear Energy Enabling Technologies	1,783	2,686	2,650
Regulatory Development	433	300	400
Advanced Reactor Safeguards	2,429	1,890	2,740
Advanced Reactors Demonstration Program	2,862	2,190	3,140
International Nuclear Energy Cooperation	12	0	0
Total Sandia National Laboratories	**36,437**	**32,849**	**27,294**
Sandia Site Office			
Fuel Cycle Core R&D	673	1,156	1,156
Fuel Cycle Research & Development	673	1,156	1,156
Total Sandia Site Office	**673**	**1,156**	**1,156**

DEPARTMENT OF ENERGY
Funding by Site
TAS_0319 - Nuclear Energy - FY 2024
(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Savannah River Operations Office			
Fuel Cycle Core R&D	250	0	0
Used Nuclear Fuel Disposition R&D	300	175	300
Integrated Waste Management System	500	2,000	800
Fuel Cycle Research & Development	1,050	2,175	1,100
Total Savannah River Operations Office	**1,050**	**2,175**	**1,100**
Savannah River Site			
Advanced Nuclear Fuel Availability	0	22,400	22,400
Fuel Cycle Research & Development	0	22,400	22,400
Total Savannah River Site	**0**	**22,400**	**22,400**
SLAC National Accelerator Laboratory			
Crosscutting Technology Development	23	0	0
Nuclear Energy Enabling Technologies	23	0	0
Total SLAC National Accelerator Laboratory	**23**	**0**	**0**
Washington Headquarters			
Integrated University Program	11	0	0
Advanced SMR R&D	1,597	2,200	1,000
LWR Sustainability	17,507	7,840	4,500
Advanced Reactor Technologies	18,135	13,150	1,480
Reactor Concepts RD&D	37,239	23,190	6,980
Mining, Conversion, and Transportation	2,000	2,000	0
Materials Recovery and Waste Form Development	55	3,953	1,453
Accident Tolerant Fuels	2,169	15,233	10,133
TRISO and Graphite Qualification	2,000	1,480	1,328
Fuel Cycle Core R&D	0	3,372	3,372
Advanced Nuclear Fuel Availability	43,172	3,274	12,274
Used Nuclear Fuel Disposition R&D	244	1,000	1,924
Integrated Waste Management System	2,800	2,500	11,800
Fuel Cycle Research & Development	52,440	32,812	42,284
Crosscutting Technology Development	4,722	8,109	7,508
Joint Modeling and Simulation Program	4,288	3,341	2,430
National Scientific User Facility	3,638	949	600
Transformational Challenge Reactor	57	0	0
Nuclear Energy Enabling Technologies	12,705	12,399	10,538
National Reactor Innovation Center	1,520	3,780	500
Risk Reduction for Future Demonstrations	102,500	44,375	10,000
Regulatory Development	1,576	70	100
Advanced Reactor Safeguards	20	685	710
Advanced Reactors Demonstration Program	105,616	48,910	11,310
INL Facilities Operations and Maintenance	631	1,671	1,671
ORNL Nuclear Facilities O&M	246	0	0
Research Reactor Infrastructure	27	0	0
Infrastructure	904	1,671	1,671
Idaho Sitewide Safeguards & Security (050)	246	0	0
International Nuclear Energy Cooperation	246	0	10,025
Program Direction - Nuclear Energy	42,750	45,716	45,450
Total Washington Headquarters	**252,157**	**164,698**	**128,258**
Undesignated LPI			
NEUP, SBIR/STTR, and TCF	37,352	102,072	115,408

DEPARTMENT OF ENERGY

Funding by Site

TAS_0319 - Nuclear Energy - FY 2024

(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Mining, Conversion, and Transportation	0	0	1,500
Fuel Cycle Research & Development	0	0	1,500
Advanced Reactor Demonstration Program (ARDP)	0	60,000	0
Advanced Reactors Demonstration Program	0	60,000	0
Total Undesignated LPI	**37,352**	**162,072**	**116,908**
Total Funding by Site for TAS_0319 - Nuclear Energy	**1,654,800**	**1,773,000**	**1,562,620**

Nuclear Waste Disposal

Nuclear Waste Disposal

Nuclear Waste Disposal
Appropriation Language

For Department of Energy expenses necessary for activities to carry out the purposes of the Nuclear Waste Policy Act of 1982, Public Law 97–425, as amended, *$12,040,000,* to remain available until expended, which shall be derived from the Nuclear Waste Fund.

Nuclear Waste Fund Oversight

Overview

Under the Nuclear Waste Policy Act of 1982 (NWPA), the Department of Energy (DOE) is responsible for legal services and other support for nuclear waste disposal activities, including managing the Nuclear Waste Fund (NWF), administering the Standard Contract, providing legal services for nuclear waste disposal, and maintaining the security of the Yucca Mountain site.

Highlights of the FY 2024 OMB Budget Request

The Nuclear Waste Fund Oversight program's FY 2024 Budget Request supports activities that include the following:

- Implementation of an appropriate investment strategy and prudent management of the NWF investment portfolio;
- Administration of the Standard Contract for the disposal of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) between contract holders and the government;
- Provision of legal services for activities related to nuclear waste disposal, including but not limited to interim storage;
- Management of the physical security requirements for the Yucca Mountain site under DOE Order 473.3A as well as site maintenance and fulfillment of environmental requirements;
- Execution of the annual agency financial report and audit; and
- Operation and maintenance costs for Yucca Mountain legacy licensing and data management system.

These funds are inclusive of program direction activities and management and technical costs necessary to carry out the mission.

Nuclear Waste Fund Oversight
Funding ($K)

($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted	
				$	%
Nuclear Waste Fund Oversight					
Nuclear Waste Fund Oversight	7,500	10,205	12,040	+1,835	+18.0%
Interim Storage[1]	20,000	0	0	0	0%
Total	**27,500**	**10,205**	**12,040**	**+1,835**	**+18.0%**

Future Year Energy Program($K)					
	2024 Request	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**
Nuclear Waste Disposal	12,040	12,000	13,000	13,000	13,000

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2025 - FY 2028. The outyear funding levels use the growth rates from and match the outyear account totals published in the FY 2024 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

Outyear funding for the Nuclear Waste Fund Oversight program will continue support for the implementation of an appropriate investment strategy and prudent management of the NWF investment portfolio, the administration of the Standard Contract, the management of physical security requirements for the Yucca Mountain site, legal services for activities related to nuclear waste disposal, the annual agency financial report and audit, operation and maintenance costs for Yucca Mountain legacy licensing and data management system, and associated federal staff.

[1] The Interim Storage program's FY 2024 Budget Request is included in the Integrated Waste Management System subprogram within Fuel Cycle Research and Development.

Explanation of Major Changes

Funding ($K)

	FY 2024 Request vs FY 2023 Enacted
Nuclear Waste Fund Oversight:	
The increase from $10,205,000 to $12,040,000 reflects funding for the operation and maintenance costs for the Yucca Mountain legacy licensing and data management system being requested within the Nuclear Waste Fund Oversight program (Nuclear Waste Disposal account).	**+$1,835**

Nuclear Waste Fund Oversight

Description

The United States (U.S.) utilizes nuclear technology for national defense, research and development, and electric power generation. These activities produce and create quantities of spent nuclear fuel (SNF) and high-level waste (HLW) that require safe storage and eventual disposal. Commercial electricity generation, the largest generator of SNF, has to date generated approximately 90,000 metric tons of uranium (MTU) of SNF. The current nuclear power reactor fleet has the potential to generate an additional 50,000 MTU, for a total of approximately 140,000 MTU by 2060[1]. Nearly all existing commercial SNF is stored at the reactor site where it was produced. Of the over 70 commercial power reactor sites storing SNF, approximately a quarter of these sites no longer have an operating reactor. The U.S. inventory of HLW includes HLW produced from commercial activities stored in one state and HLW produced from defense activities stored in three states.

Under the NWPA, the Federal government, specifically DOE, is responsible for the disposal of SNF and HLW. The Nuclear Waste Fund Oversight program is responsible for providing legal and other support for nuclear waste disposal activities associated with carrying out the purposes of the NWPA. The program will ensure the prudent management of the NWF investment portfolio and the administration of the Standard Contract. The program will also support legal services related to nuclear waste disposal activities, including but not limited to the NWF and the Standard Contract. Lastly, the program will continue to support requirements for the management and operation of physical security at the Yucca Mountain site under the Protection Program Operations Directive (DOE Order 473.3A).

[1] Peters, S., J. Carter, and K. Banerjee. Spent Nuclear Fuel and Reprocessing Waste Inventory, FCRD-NFST-2013-000263, Rev. 9, PNNL-33938, November 2022.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Interim Storage and Nuclear Waste Fund Oversight **$10,205,000**	**Nuclear Waste Fund Oversight** **$12,040,000**	**+$1,835,000**
• Implemented an appropriate investment strategy for the NWF investment portfolio and prudently manage the NWF portfolio. • Administered the Standard Contract between contract holders and the government. • Maintained physical security requirements for the Yucca Mountain site under DOE Order 473.3A as well as provide site maintenance and fulfill environmental requirements. • Provided legal services for nuclear waste disposal activities. • Supported the agency financial report and audit. • Supported associated Federal staff and support.	• Implement an appropriate investment strategy for the NWF investment portfolio and prudently manage the NWF portfolio. • Administer the Standard Contract between contract holders and the government. • Maintain physical security requirements for the Yucca Mountain site under DOE Order 473.3A as well as provide site maintenance and fulfill environmental requirements. • Provide legal services for nuclear waste disposal activities. • Support the agency financial report and audit. • Support associated Federal staff and support. • Operation and maintenance costs for Yucca Mountain legacy licensing and data management system.	• The increase from $10,205,000 to $12,040,000 reflects funding for the operation and maintenance costs for the Yucca Mountain legacy licensing and data management system being requested within the Nuclear Waste Fund Oversight program (Nuclear Waste Disposal account).

DEPARTMENT OF ENERGY

Funding by Site

TAS_5227 - Nuclear Waste Disposal Fund - FY 2024

(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Argonne National Laboratory			
Interim Storage	625	0	0
Total Argonne National Laboratory	**625**	**0**	**0**
Idaho National Laboratory			
Interim Storage	400	0	0
Total Idaho National Laboratory	**400**	**0**	**0**
Idaho Operations Office			
Interim Storage	100	0	0
Total Idaho Operations Office	**100**	**0**	**0**
Lawrence Berkeley National Laboratory			
Interim Storage	100	0	0
Total Lawrence Berkeley National Laboratory	**100**	**0**	**0**
Los Alamos National Laboratory			
Interim Storage	100	0	0
Total Los Alamos National Laboratory	**100**	**0**	**0**
Oak Ridge National Laboratory Site Office			
Interim Storage	475	0	0
Total Oak Ridge National Laboratory Site Office	**475**	**0**	**0**
Pacific Northwest National Laboratory			
Oversight Activities Nuclear Waste Disposal	530	700	700
Interim Storage	4,559	0	0
Total Pacific Northwest National Laboratory	**5,089**	**700**	**700**
Sandia National Laboratories			
Oversight Activities Nuclear Waste Disposal	0	0	1,800
Interim Storage	1,646	0	0
Total Sandia National Laboratories	**1,646**	**0**	**1,800**
Savannah River National Laboratory			
Interim Storage	300	0	0
Total Savannah River National Laboratory	**300**	**0**	**0**
Washington Headquarters			
Oversight Activities Nuclear Waste Disposal	6,970	9,505	9,540
Interim Storage	11,695	0	0
Total Washington Headquarters	**18,665**	**9,505**	**9,540**
Total Funding by Site for TAS_5227 - Nuclear Waste Disposal Fund	**27,500**	**10,205**	**12,040**

Fossil Energy and Carbon Management

Fossil Energy and Carbon Management

Fossil Energy and Carbon Management (FECM)
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
825,000	890,000	905,475	+$15,475	+1.7%

Overview

The Office of Fossil Energy and Carbon Management (FECM) conducts research and development (R&D) that focuses on technologies to reduce carbon emissions and other environmental impacts from fossil fuel production and use and from key industrial processes, particularly the hardest-to-decarbonize applications in the electricity and industrial sectors. Furthermore, the program advances technologies that convert and store carbon dioxide (CO_2) into value-added products and technologies on carbon dioxide removal (CDR) to remove atmospheric and legacy emissions of CO_2.

To meet these challenges, the Budget focuses funding on technology priority areas of point-source carbon capture, carbon transport and storage, carbon conversion, hydrogen (H_2) with carbon management, methane emissions reduction, critical mineral production, and CDR. FECM recognizes that broad decarbonization is essential to meeting climate goals – 100 percent carbon pollution free electricity by 2035 and net-zero greenhouse gas (GHG) emissions economy-wide by 2050 – and works to engage with international colleagues to leverage expertise in these areas. FECM is also committed to improving the economic and environmental conditions of Energy Communities[1], retaining and creating good-paying jobs and supporting domestic energy and industrial production and manufacturing across our nation.

FECM prioritizes the meaningful engagement and participation of communities, with special focus on disadvantaged communities and emphasis on improving the economic and environmental conditions of those communities, retaining and creating good-paying jobs and supporting domestic energy and industrial production and manufacturing across our nation. These priorities are at the center of funding decisions and partnership development.

The FY 2024 Budget Request for FECM will extend the impact of the Department of Energy's (DOE) R&D activities by leveraging creative funding mechanisms—such as prizes, competitions, technical assistance, and programs targeted to small businesses. The goal is to enable the commercialization of climate and clean energy innovations that will reduce costs, accelerate deployment, and spur job creation and do so across a more geographically diverse and impactful research, development, demonstration and deployment (RDD&D) portfolio. This request also includes funding for the basic operating costs of FECM and investment at the National Energy Technology Laboratory (NETL).

FECM's FY 2024 priorities follow:

- **Facilitate the Future Deployment of Point Source Carbon Capture:** R&D for point-source carbon capture and storage (CCS) in the power and industrial sectors to enable wider, strategic commercial deployment to meet net-zero emissions goals by 2050.
- **Reduce Methane Emissions:** Develop technologies and regional initiatives to quantify, monitor and reduce methane emissions from fossil fuel infrastructure including coal, oil, and gas.
- **Advance CDR and Carbon Dioxide Conversion:** Advance direct air capture (DAC), biomass with carbon removal and storage, and mineral carbonation technologies and develop novel approaches to recycle captured carbon emissions.
- **Advance Critical Minerals (CM), Rare Earth Elements (REE), and Mine Remediation:** Improve REE separation/recovery technologies to manufacture products from CO_2 and carbon ores and to address current market and process economics. Advancing R&D to address abandoned mines.
- **Increase Efficient Use of Big Data and Artificial Intelligence (AI):** Use AI, machine learning, and data analysis to create learning algorithms within large dataset to help discover new materials, optimize processes, and run autonomous systems.

[1] https://energycommunities.gov/

- **Accelerate Carbon-Neutral Hydrogen:** Develop technologies that leverage the natural gas infrastructure for hydrogen production, transport, storage, and use, coupled to carbon management.
- **Invest in Thoughtful Transition Strategies:** Invest in technologies and approaches and deploy regional initiatives that provide economic and environmental benefits to affected communities and invest in American workers as we transition to a net-zero carbon economy.

Highlights and Major Changes in the FY 2024 Budget Request
Recognizing recent developments in the United States (U.S.) and global energy landscape, the FY 2024 FECM Budget Request is adjusted relative to the FY 2023 Enacted Level:

- Next-generation decarbonized technologies can achieve a net-zero carbon economy. This requires a strategic investment and prioritization of carbon management activities, including point-source carbon capture, DAC, carbon conversion, and CO_2 storage.
- Recent analyses[2] are converging on the importance of zero-carbon and carbon-neutral hydrogen to achieve net-zero emissions, economy wide, by 2050. In partnership with the Office of Energy Efficiency and Renewable Energy's Hydrogen and Fuel Cell Technologies Office, DOE is investing in a wide array of hydrogen technologies to expedite the hydrogen energy economy.
- Methane is one of the most potent GHGs. It is critical that we reduce unabated methane emissions. To that end, FECM will invest in approaches to identify and mitigate methane emissions from the oil, gas (e.g., fugitive methane and flaring), and coal (methane emissions from active and abandoned mines) industries toward the production of useful chemicals such as hydrogen and ammonia.
- The U.S. must increase domestic production and processing capacity to build CM and REE supply chains here at home. FECM will focus on the characterization of CM and REE as well as the sustainable production and processing of CM using unconventional resources such as coal waste and byproducts from the industry. This work will help support communities and regions of the U.S. that are heavily dependent on this industry today.

For comparability, all discussions of funding changes that follow assume the FY 2024 proposed budget structure. Funding crosswalks in the Budget Structure Crosswalks chapter of this narrative provide details of the proposed changes.

Office of Carbon Management Technologies ($464M)
The Office of Carbon Management (OCM) supports RDD&D aimed at achieving a net-zero carbon economy by focusing on the entire carbon management value chain of capture, removal, conversion, transport and geologic storage. OCM addresses emissions associated with the power and industrial sectors, as well as the accumulated emissions in the atmosphere, and seeks to permanently store CO_2 in geologic formations and/or convert CO_2 to reduce negative climate impacts.

Descriptions of major funding and programmatic changes and highlights within the Carbon Management Technologies (CMT) program for the FY 2024 Budget Request are as follows:

- **Hydrogen with Carbon Management ($85M)**
  The Hydrogen with Carbon Management (HCM) subprogram invests in research, development and demonstration (RD&D) to evaluate carbon-based clean hydrogen (i.e., coupled to CCS) as a fuel and support development of technologies to use hydrogen from any source. The subprogram's efforts are an integral part of DOE's recently launched Hydrogen Shot™, with a goal of reducing clean H_2 costs by 80 percent to $1 per 1 kilogram within 1 decade (1-1-1) while expanding employment of the U.S. energy workforce. Seeking a cost-competitive decarbonized alternative to unabated fossil fuels, the subprogram has an R&D portfolio consisting of a new generation of carbon neutral or net-negative GHG emissions technologies. Gasification, reversible solid oxide fuel cells (R-SOFCs), technologies in H_2 turbines, and advanced materials, sensors and controls all support this goal.

  The FY 2024 Budget Request for HCM of $85 million for these activities will provide research with a platform for developing the advanced systems of the future, while reducing emissions. In FY 2024, the subprogram will not fund RDD&D specific to traditional fossil power generation, but rather, will narrow the focus to work on hydrogen-fueled

[2] https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf

turbines, fuel cells, CCS-relevant technologies, and production of clean hydrogen through gasification. Improvements to these technologies are also applicable to other energy systems. These improvements to new and existing plants will also make them less carbon intensive and allow these assets to provide continued low-cost baseload power and resilient flexible grid services. This subprogram aligns with the Administration's priority to reduce the environmental impact of the power sectors, especially regarding disadvantaged communities. As such, the subprogram is working to address local air quality issues associated with nitrogen oxide emissions that could be produced as a byproduct of hydrogen combustion – and working to ensure that impacts to disadvantaged communities are robustly considered when siting new hydrogen infrastructure.

- **Carbon Transport and Storage ($110M)**
  The Carbon Transport and Storage (CTS) subprogram is uniquely positioned to support the U.S. as it helps the carbon transport and storage industry achieve the scale necessary to decarbonize the economy while considering associated economic, environmental and social benefits and impacts. This subprogram is making key investments in advanced technology R&D, and large-scale transport scenario analysis will facilitate the deployment of commercial-scale storage facilities, and regional transport and storage hubs that achieve economies of scale reducing costs and enabling deeper emissions reductions. Critical components that will help catalyze deployment at-scale include, but are not limited to, strategies to develop the infrastructure for carbon storage, R&D to improve technology performance and reduce costs, educational partnerships to grow the workforce, technology transfer, and technical assistance to stakeholders.

  The FY 2024 Budget Request provides $110 million for the CTS subprogram activities that address the performance challenges of operating and monitoring commercial scale CO_2 storage sites. The activities supported by the CTS subprogram will aim to improve storage and operational efficiency, improve understanding of overall costs, and advance de-risking strategies to reduce those costs. Achieving each of these elements through site characterization and developing advanced monitoring and modeling tools is critical for enabling a CCS industry that is safe, economically viable, and environmentally benign.

- **Carbon Dioxide Removal ($70M) and Carbon Dioxide Conversion ($50M)**
  The Carbon Dioxide Removal subprogram advances a diverse set of technology pathways in service of facilitating gigatonne-scale removal by mid-century. It emphasizes rigorous analysis of life cycle impacts and consideration of project design to ensure clear benefits to affected communities. The subprogram invests in R&D of CDR technologies, such as DAC and direct ocean capture (DOC) with permanent storage; biomass with carbon removal and storage; and mineralization to remove accumulated emissions from the atmosphere to counterbalance emissions from hard-to-abate sectors in order to achieve net-zero GHG emissions by mid-century.

  The Carbon Dioxide Conversion subprogram invests in R&D to advance technologies that recycle CO_2 into value-added products, such as building materials, fuels, and chemicals, through mineralization, catalytic conversion, and biological approaches. Through these investments, the Carbon Dioxide Conversion subprogram can help the U.S. achieve the goals of a net-zero carbon economy by 2050, while simultaneously developing technologies that help traditional industries build new business models for the future, while creating high-wage jobs and reducing GHG and other emissions in communities dependent on and impacted by energy and industrial production.

  In FY 2024, the Budget Request provides $70 million for CDR and $50 million in the Carbon Dioxide Conversion subprograms. CDR funding will support continued activities to advance novel DAC and DOC materials and processes to help optimize and reduce the cost, front-end engineering and design (FEED) studies for biomass with carbon removal and storage, and novel approaches that can leverage industrial waste minerals and naturally occurring minerals to capture atmospheric CO_2.

  Technologies for the Carbon Dioxide Conversion subprogram have the potential to develop additional markets for carbon-based products. Areas of research include, but are not limited to, new projects focused on the catalytic conversion of carbon waste streams to higher value products such as fuels, chemicals, polymers, and nutraceuticals; mineralization to building products; generation of solid carbon products; and algal systems designed to integrate captured CO_2. Specific focus on catalysts made from low-cost materials and improved reactor designs will be pursued to lower the energy penalty and capital cost of the conversion process.

- **Point-Source Carbon Capture ($144M)**
  The Point-Source Carbon Capture RDD&D subprogram focuses on committed emissions associated with infrastructure that are expected to persist through mid-century. Natural gas power generation and carbon dioxide-emitting industrial sectors, such as cement, steel, pulp and paper, and hydrogen production are particular priorities. The FY 2024 Budget Request provides $144 million in the Point-Source Carbon Capture subprogram for pre- and post-combustion capture R&D on transformational gas separation technologies that can help achieve decarbonization goals. This includes technologies such as non-aqueous solvents, sorbents, membranes, and cryogenic processes. R&D activities will investigate approaches that can be flexible in operation and result in higher rates of CO_2 capture. Additionally, the Point-Source Carbon Capture subprogram will leverage its extensive experience on carbon capture technology development for power sector applications to increase focus on hard to decarbonize industrial applications, specifically, cement, steel, pulp and paper, and hydrogen production. In FY 2024, R&D will focus on optimization of technologies for these applications to reduce cost and improve performance. Funding will also maintain progress on R&D to decarbonize power generation.

- **Carbon Management – Policy, Analysis, and Engagement ($5M)**
  The Office of Carbon Management conducts systems, economic, and environmental analysis that is primarily focused on: cost and performance for carbon management technologies; the role of carbon management in energy markets; life cycle analysis; energy markets assessments; integration of carbon management technologies with the U.S. power grid; and effects of carbon management deployment in local communities.

  A variety of analysis methodologies are used in combination to provide a robust understanding of the cost, performance, and barriers to the deployment of carbon management technologies. Through a system of coordinated efforts and thoughtful engagement with stakeholders, realistic scenarios can be crafted using market and technology-based information. This subprogram has three activities that it funds: 1) Carbon Management – Policy and Analysis, 2) Carbon Management – Engagement, and 3) Carbon Management – Federal Partnerships. The Budget Request provides $5 million to support activities in this subprogram.

  The FY 2024 Request supports R&D of CMT through engagement with key partners within the U.S. and globally. Funding will support domestic engagement efforts as well as international collaboration with various partners through bilateral and multilateral agreements. FECM will focus on building capacity and working with interagency partners to ensure safe, effective, and efficient implementation of its programs. FECM will work with various stakeholders to build a foundation for expeditiously administering several new investments, leveraging existing programs and developing new relationships with stakeholder networks and communities.

Office of Resource Sustainability ($179M)

The Resource Sustainability Office addresses critical issues associated with reducing the environmental impacts of fossil energy production and use. This includes conducting R&D that reduces environmental impact from the extraction, development, transportation, distribution, and storage of fossil fuels and reducing emissions throughout the supply chain. Descriptions of major programmatic changes and highlights within the Resource Sustainability program for the FY 2024 Budget Request, which totals $179 million, are as follows:

- **Advanced Remediation Technologies ($13M)**
  The Advanced Remediation Technologies program will conduct R&D of novel technologies and approaches to address wellbore integrity, induced seismicity, produced water treatment, and offshore safety and spill prevention. A redesigned field program will focus on conducting research to minimize the environmental impacts associated with unconventional oil and gas production, and exploration of pathways that would result in a positive impact on climate, such as coupling production with carbon dioxide storage.

- **Methane Mitigation Technologies ($100M)**
  The Methane Mitigation Technologies program will conduct R&D to advance methane sensor technologies to detect and quantify methane emissions from production fields, pipelines, infrastructure equipment, storage facilities, and abandoned wells; pipeline materials, pipeline sensors, and pipeline data management and computational tools; and

advanced modular natural gas conversion technologies for the purpose of beneficially utilizing otherwise flared or stranded natural gas. The program will collect, analyze, and distribute methane emissions data, information, and knowledge to inform efforts on methane mitigation technology development and support the Environmental Protection Agency's (EPA) Greenhouse Gas Inventory. The program will expand field research on methane measurement technologies and analysis methods for quantifying emissions at basin-level assessments. The program will implement a strategy to reconcile methane emissions estimates from surface-based measurements (bottom-up) and atmospheric measurements (top-down) that will minimize and resolve the difference between these two segments on a large-scale.

- **Natural Gas Decarbonization and Hydrogen Technologies ($20M)**
  The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) subprogram will support R&D to advance clean hydrogen production and infrastructure for natural gas decarbonization; hydrogen production from produced water; technologies for enabling safe and efficient transportation within the U.S. natural gas pipeline system; and fundamental research to enable subsurface hydrogen storage. Programmatic activities will be conducted in support and coordination with the Hydrogen and Carbon Management Division within FECM and with the Hydrogen and the Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

- **Mineral Sustainability ($45M)**
  The Mineral Sustainability Program will advance technologies to support domestic supply chain networks required for the economically, environmentally, and geopolitically sustainable production and processing of critical minerals. This mission will be accomplished by prioritizing the use of unconventional resources such as coal waste and by-products from industry feedstocks for domestic critical minerals, rare earth elements and carbon ore-to-products production. The program will also focus on utilizing materials to be recovered from currently mined and previously mined resources outside of traditional thermal and metallurgical markets that can support high-wage employment and value-added production in communities and regions dependent on traditional mining.

- **Resource Sustainability – Analysis and Engagement ($1M)**
  Analysis and Engagement will focus on analysis and studies that support the environmentally prudent production, transport, storage and use of domestic fossil fuels with an understanding of their role as a strategic asset for the U.S. and its allies for global energy security and provides evidence-based, portfolio-wide analysis for decision-makers. This includes economic and environmental analysis, modeling, market analysis, analysis of markets during volatility, studies that provide support to the overall Resource Sustainability Program, and data driven assessments of the impacts of different tools and levers that can be used to provide reliable and affordable fossil energy supplies to the domestic market. The program will inform research priorities, engagement with domestic and international governments and organizations, and provide market and industry analysis to inform the Department on fossil energy resources.

Other FECM Program Activities

Energy Asset Transformation ($6M)

The Energy Asset Transformation program will help leverage and transform decommissioned and retiring energy assets, including coal power plants, coal mines, and abandoned oil and gas wells, by repurposing them for clean energy and manufacturing. This is one of the best ways to unite industry, environmental and community interests in places where employment and opportunity is on the decline. Many existing energy assets offer private sector actors a skilled workforce with knowledge of industrial operations; community relationships; access to rail lines, ports, and waterways; highway transportation, transmission, and distribution infrastructure; electrical interconnect equipment and direct grid connections; industrial land, facilities; and potentially even site and permitting licenses among, other benefits. As innovative clean energy and manufacturing companies fan out across the country, it increasingly makes sense for them to choose to locate in energy communities to leverage existing infrastructure. In some instances, repurposing can ensure that historic energy communities have a path forward and can benefit from both short-term and permanent employment, opportunities for worker retraining programs, access to local work that does not require relocation, and opportunities to work in cutting-edge technology sectors. Importantly, repurposing allows communities to become active participants in crafting their own economic future.

The FY 2024 Budget Request of $6 million will support energy asset transformation efforts across the U.S., through both direct assistance and paper case studies. It will also continue to support place-based interagency efforts related to energy

transition and energy asset transformation, including by contributing to DOE's funding of the Rapid Response Teams associated with the Interagency Working Group on Coal and Power Plant Communities. The program will fund concept development through prizes or a competitive solicitation to repurpose the existing energy assets, with the intent of supporting transformation efforts in seeking additional support for FEED studies and other work. The program will support research and case studies focused on safety and reliability challenges for assets reaching end of life in the near and medium term, particularly given dynamic operational constraints.

University Training and Research ($19M)
The request of $19 million provides funding for University Training and Research (UTR), which comprises funding for University Carbon Research (UCR), Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI).

The Transformational Coal Pilots, STEP, and Unconventional FE Technologies programs are at the end of their scheduled programming and will not require additional funding in FY 2024.

National Energy Technology Laboratory (NETL)

	($K)		
	FY 2022 Enacted	**FY 2023 Enacted**	**FY 2024 Request**
NETL Program Direction	29,400	29,900	31,550
NETL Infrastructure	75,000	55,000	55,000
NETL Research and Operation	83,000	87,000	89,000
Interagency Working Group	0	3,000	0
Subtotal, NETL	**187,400**	**174,900**	**175,550**
Special Recruitment	1,001	1,000	1,000
HQ Program Direction (includes Import/Export)	37,400	40,100	60,925
Subtotal, Remaining Programs	**38,401**	**41,100**	**61,925**

FECM is committed to supporting NETL's capabilities and competitiveness. NETL, whose primary funding source is FECM, is the only Government-Owned, Government-Operated (GOGO) Laboratory in the DOE National Laboratory system. The FY 2024 Budget Request for NETL is $175.55 million and an additional $61.45 million for HQ Program Direction and Special Recruitment – see table above for funding breakdown.

- **NETL and Headquarters (HQ) Program Direction and Special Recruitment Programs:** The Request of $92.5 million for NETL/HQ program direction and $1 million for Special Recruitment provides for the FECM organization's headquarters federal workforce and contractor support including salaries and benefits, support service contracts, travel, training, the working capital fund, and other employee costs. These staff are responsible for the oversight and administration of the FECM programs and natural gas regulatory activities. In addition, funding for NETL federal technical staff and contractor support that provide Acquisition, Finance and Legal functions is supported.
- **NETL Infrastructure:** The FY 2024 Budget Request of $55 million supports the fixed costs of maintaining NETL's lab footprint in three geographic locations: Morgantown, WV; Pittsburgh, PA; and Albany, OR. The footprint of these sites is approximately 240 acres, including 165 research laboratories. The Request provides funding for general plant projects to maintain research capabilities and combat deferred maintenance, the lease of NETL's next generation high performance computer, support for AI infrastructure to accelerate innovation, and for information technology (IT) development, modernization, and enhancement.
- **NETL Research and Operations:** The Request of $89 million supports the salaries, benefits, travel, and other employee costs for the NETL staff of scientists, engineers and technical professionals who conduct onsite research and project management activities for FECM programs. The Request also funds partnership, technology transfer, and other collaborative research activities and supports the variable operating costs of NETL's research sites.
- **Interagency Working Group:** The Interagency Working Group will be managed by the Office of State and Community Energy Programs, instead of FECM. Thus, FECM is not requesting FY 2024 funding.

Fossil Energy and Carbon Management
Funding by Congressional Control ($K)
(Comparable)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Carbon Management Technologies					
Hydrogen with Carbon Management	101,000	95,000	85,000	(10,000)	-10.5%
Carbon Transport and Storage	97,000	110,000	110,000	0	0%
Carbon Dioxide Removal	49,000	70,000	70,000	0	0%
Carbon Dioxide Conversion	29,000	50,000	50,000	0	0%
Point-Source Carbon Capture	99,000	135,000	144,000	9,000	6.7%
Carbon Management – Policy, Analysis, and Engagement	2,400	0	5,000	5,000	N/A
Supercritical Transformational Electric Power (STEP)	15,000	0	0	0	0
Subtotal, Carbon Management Technologies	**393,400**	**460,000**	**464,000**	**4,000**	**0.9%**
Resource Sustainability					
Advanced Remediation Technologies	55,600	55,000	13,000	(42,000)	-76.4%
Methane Mitigation Technologies	39,000	60,000	100,000	40,000	66.7%
Natural Gas Decarbonization and Hydrogen Technologies	20,000	26,000	20,000	(6,000)	-23.1%
Mineral Sustainability	53,000	54,000	45,000	(9,000)	-16.7%
Resource Sustainability – Analysis and Engagement	0	0	1,000	1,000	N/A
Subtotal, Resource Sustainability	**167,600**	**195,000**	**179,000**	**(16,000)**	**-8.2%**
Energy Asset Transformation	**5,000**	**6,000**	**6,000**	**0**	**0%**
University Training and Research	**13,000**	**13,000**	**19,000**	**6,000**	**46.2%**
Special Recruitment	**1,001**	**1,000**	**1,000**	**0**	**0%**
Program Direction	**66,800**	**70,000**	**92,475**	**22,475**	**32.1%**
NETL Infrastructure	**75,000**	**55,000**	**55,000**	**0**	**0%**
NETL Research and Operations	**83,000**	**87,000**	**89,000**	**2,000**	**2.3%**
Interagency Working Group	**0**	**3,000**	**0**	**0**	**-100%**
Congressionally Directed Projects	**20,199**	**0**	**0**	**0**	**N/A**
Total, Fossil Energy and Carbon Management	**825,000**	**890,000**	**905,475**	**+15,475**	**1.7%**
Federal FTEs	**709**	**719**	**733**	**+14**	**+1.9%**

SBIR/STTR:

- FY 2022 Enacted: SBIR $13,959; STTR: $1,963
- FY 2023 Enacted: SBIR $17,966; STTR: $2,527
- FY 2024 Request: SBIR $16,626; STTR: $2,338

Bipartisan Infrastructure Law (BIL) Investments

FECM was appropriated funds through the Bipartisan Infrastructure Law (BIL) (P.L. 117-58). Not all BIL activities will be managed by the organization to which funds were appropriated. Activities that FECM will manage that are appropriated to other organizations are discussed below.

($K)

Fossil Energy and Carbon Management	FY 2022 BIL Funding	FY 2023 BIL Funding	FY 2024 BIL Funding	Managing Organization
Regional Direct Air Capture Hubs	700,000	700,000	700,000	OCED
Carbon Storage Validation and Testing	500,000	500,000	500,000	FECM
Carbon Dioxide Transportation Infrastructure Finance and Innovation (CIFIA)	3,000	2,097,000	0	LPO
Critical Material Innovation, Efficiency, and Alternatives Activities	230,000	100,000	135,000	FECM
Critical Material Supply Chain Research Facility	40,000	35,000	0	FECM
Rare Earth Elements Demonstration Facility	140,000	0	0	MESC
Rare Earth Mineral Security Activities	23,000	24,200	25,400	FECM
Carbon Capture Technology Program	20,000	20,000	20,000	FECM
Carbon Utilization Program	41,000	65,250	66,563	FECM
Commercial Direct Air Capture Technology Prize Competitions	100,000	0	0	FECM
Precommercial Direct Air Capture Technology Prize Competitions	15,000	0	0	FECM
Orphaned, Abandoned, or Idled Wells on Federal Land Activities	30,000	0	0	FECM
Total, Fossil Energy and Carbon Management	**1,842,000**	**3,541,450**	**1,446,963**	

- **In consultation with other offices:**
  - **Regional Direct Air Capture Hubs (with the Office of Clean Energy Demonstrations (OCED)) –** The goal of this investment is to establish a program under which the Secretary shall provide funding for eligible projects that contribute to the development of 4 regional DAC hubs.
  - **Carbon Dioxide Transportation Infrastructure Finance and Innovation (CIFIA) (with the Loan Programs Office)** – The goal of this investment is to provide flexible, low-interest loans for carbon dioxide transport infrastructure projects and grants for initial excess capacity on new infrastructure to facilitate future growth. Modeled after the existing Transportation Infrastructure Finance and Innovation Act (TIFIA) and Water Infrastructure Finance and Innovation Act (WIFIA) programs for highway and water infrastructure, CIFIA will help facilitate private sector investment in infrastructure critical for reaching net-zero emissions.
  - **Rare Earth Elements Demonstration Facility (with the Office of Manufacturing and Energy Supply Chains)** – The goal of this investment is to demonstrate the feasibility of a full-scale integrated REE extraction and separation facility and refinery. The facility established shall – (A) provide environmental benefits through use of feedstock derived from acid mine drainage, mine waste, or other deleterious material; (B) separate mixed rare earth oxides into pure oxides of each rare earth element; (C) refine rare earth oxides into rare earth metals; and (D) provide for separation of rare earth oxides and refining into rare earth metals at a single site. OCED will manage FECM's REE demonstration facility.

- **Managed by FECM:**
  - **Carbon Storage Validation and Testing –** The goal of this investment is to establish a program of research, development, and demonstration for carbon storage. Specifically, the activity will focus on development of new or expanded commercial large-scale carbon sequestration projects and associated carbon dioxide transport infrastructure, including funding for the feasibility, site characterization, permitting, and construction stages of project development.
  - **Critical Material Innovation, Efficiency, and Alternatives Activities** – The goal of this investment is to conduct a program of research, development, demonstration, and commercialization to develop alternatives to critical

materials, to promote their efficient production and use, and ensure a long-term secure and sustainable supply of them.

- **Critical Material Supply Chain Research Facility** – The goal of this investment is to support construction of a critical materials supply chain research facility.
- **Rare Earth Mineral Security Activities** – The goal of this investment is to conduct a program of R&D to improve security of supply for REEs.
- **Carbon Capture Technology Program** – The goal of this investment is to expand DOE's Carbon Capture Technology program to include a program for carbon dioxide transport infrastructure necessary to deploy carbon capture, conversion and geologic storage.
- **Carbon Utilization Program** – The goal of this investment is to establish a grant program for state and local governments to procure and use products derived from captured carbon oxides.
- **Commercial Direct Air Capture Technology Prize Competitions** – The goal of this investment is to support large-scale DAC pilot and demonstration projects. Prizes will be awarded to projects that demonstrate the technical and commercial viability of technologies to reduce CO_2 emissions from the atmosphere. Projects will also include rigorous life cycle and techno-economic analyses to confirm net removal of CO_2.
- **Precommercial Direct Air Capture Technology Prize Competitions** – The goal of this investment is to advance research, development, demonstration, and commercial application of direct air capture technologies. Prizes will be awarded to projects that achieve breakthrough innovation in DAC technologies.
- **Orphaned, Abandoned, or Idled Wells on Federal Land Activities** – The goal of this investment is to administer a program for plugging wells on Federal land, and for issuing grants to States and Tribes on State, private, and Tribal land.

Inflation Reduction Act (IRA) Investments

FECM was appropriated funds through the Inflation Reduction Act of 2022 (IRA).

Fossil Energy and Carbon Management	FY 2022 IRA Funding ($K)	Managing Organization
National Laboratory Infrastructure	150,000	FECM
Total, Fossil Energy and Carbon Management	**150,000**	

- **National Laboratory Infrastructure:** The goal of this investment is to fund Infrastructure and General Plant Projects at the National Energy Technology Laboratory (NETL).

Carbon Management Technologies (CMT)
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
393,400	460,000	464,000	+4,000	+0.9%

Overview

The Carbon Management Technologies program invests in transformational technologies that will help achieve the Administration's goals to decarbonize the electricity sector by 2035 and the economy by 2050. The program focuses its efforts on hydrogen with carbon management; carbon transport and storage; carbon dioxide removal; carbon dioxide conversion; point-source carbon capture, and carbon management as it relates to policy, analysis, and engagement activities. There is a long history of investment in federal research, development, demonstration, and deployment (RDD&D) of technologies to reduce emissions from power plants and industrial sources.

The Carbon Management Technologies activities are focused on the following key priorities:

- **Facilitate the Future Deployment of Point Source Carbon Capture:** R&D for point-source carbon capture and storage (CCS) in the power and industrial sectors to enable wider, strategic commercial deployment to meet net-zero emissions goals by 2050.
- **Advance Carbon Dioxide Removal (CDR) and Carbon Dioxide Conversion:** Advance direct air capture, biomass with carbon removal and storage, and mineral carbonation technologies and develop novel approaches to recycle captured carbon emissions.
- **Increase Efficient Use of Big Data and Artificial Intelligence (AI):** Use AI, machine learning, and data analysis to create learning algorithms within large dataset to help discover new materials, optimize processes, and run autonomous systems.
- **Accelerate Carbon-Neutral Hydrogen:** Develop technologies that leverage the natural gas infrastructure for hydrogen production, transport, storage, and use, coupled to carbon management.
- **Invest in Thoughtful Transition Strategies:** Invest in technologies and approaches and deploy regional initiatives that provide economic and environmental benefits to affected communities and invest in American workers as we transition to a net-zero carbon economy.

Highlights of the FY 2024 Budget Request

The Carbon Management Technologies program will pursue the following major activities in FY 2024:

Hydrogen with Carbon Management

The FY 2024 Budget Request for the Hydrogen with Carbon Management program is $85 million. The program comprises six activities: (1) Gasification Systems, (2) Advanced Turbines, (3) Reversible Solid Oxide Fuel Cells, (4) Advanced Energy Materials, (5) Sensors, Controls, and Other Novel Concepts, and (6) Simulation-Based Engineering. In FY 2024, these activities will provide a research platform for developing the advanced systems of the future capable of net-zero emissions operations. In FY 2024, the primary focus is on thermal and electrochemical power systems and hydrogen production, and improvements to these technologies are also applicable to other energy systems such as concentrated solar, nuclear, and the chemical industry. Improvements to new and existing plants will also support their efforts to be carbon neutral and allow these assets to provide low-cost baseload power and resilient flexible grid services. These activities align with the Administration's priority of reducing environmental impacts from the power sector, especially in disadvantaged communities.

Carbon Transport and Storage

The Budget Request provides $110 million for the Carbon Transport and Storage subprogram to accelerate innovation in CCS and storage-based CDR (e.g., direct air capture or biomass with carbon removal) technologies that will contribute to decarbonizing industry and developing a carbon removal industry. These activities include: (1) strategies to develop the infrastructure for carbon transport and storage; (2) R&D to improve performance and reduce costs of site characterization and active/post-injection and transport operations; (3) technology transfer; (4) technical assistance to stakeholders for project development; and (5) community engagement.

Carbon Dioxide Removal

Many climate modeling scenarios project that carbon dioxide removal will be required in the future to achieve economy-wide decarbonization. Carbon dioxide removal refers to activities that remove carbon dioxide from the atmosphere and store it in geologic formations, products, terrestrial sinks, or in the ocean. The FY 2024 Budget Request for Carbon dioxide removal is $70 million and includes: direct air capture (DAC), direct ocean capture, biomass with carbon removal and storage and mineralization, terrestrial carbon removal and sequestration (e.g., agricultural land management, afforestation, reforestation), and coastal blue carbon (e.g., carbon dioxide storage in wetlands).

Carbon Dioxide Conversion

In FY 2024, the Budget Request provides $50 million for the carbon dioxide conversion subprogram for lab- and bench-scale projects to advance carbon conversion technologies that have the potential to develop environmentally and socially-beneficial low and zero-emission products facilitated by building markets for carbon dioxide and carbon monoxide as a feedstock. Areas of research include, but are not limited to, new technologies focused on catalytic conversion to higher value products such as fuels, chemicals, and polymers; mineralization to building materials; generation of synthetic aggregates; and algal systems with high carbon dioxide utilization efficiency in conversion to various bioproducts. Additional efforts will include developing guidance on benchmarking catalytical conversion technologies and techno-economic analysis. Funding will support the development of at least one fully-integrated field-test-continuous system, as well as continued support for carbon conversion test facilities such as the National Carbon Capture Center (NCCC).

Point-Source Carbon Capture

The Point-Source Carbon Capture subprogram has completed its efforts in 1st generation technology through successful demonstration projects. FY 2024 activities represent a focus on next-generation capture technologies to enable clean hydrogen and allow for the integration of advanced carbon capture technologies with both power and diverse industrial emission sources. Specifically, the FY 2024 Budget Request provides $144 million to the point-source carbon capture activities for R&D on advanced gas separation technologies capable of deep decarbonization (at least 95% of CO_2 at high purity suitable for compression and transport). These investments can improve energy efficiency, reduce capital costs, and achieve high capture rates.

Carbon Management – Policy, Analysis, and Engagement

The Carbon Management – Policy, Analysis, and Engagement subprogram has a Budget Request of $5 million and has three activities that it funds: 1) Carbon Management – Policy and Analysis, 2) Carbon Management – Engagement, and 3) Carbon Management – Federal Partnerships. It supports high-impact, crosscutting, analysis, and engagement activities through close coordination within the Office of Fossil Energy and Carbon Management (FECM) technology programs and with other DOE offices, federal agencies, and global partners. This subprogram provides portfolio-wide analysis for decision-makers and extensive data, tools, and technical assistance to relevant stakeholders as the Nation embarks on an unprecedented build-out of carbon management projects and infrastructure in support of the Administration's goals. Policy, analysis, and engagement efforts will help FECM maximize the impact of its research dollars, track the impacts of FECM investments, and help ensure benefits for all Americans. This subprogram also supports strategic planning by identifying major challenges and opportunities to improve efficiency, cost, and socioenvironmental performance within all the subprograms of the Carbon Management Technologies program.

Carbon Management Technologies
Funding by Congressional Control ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Carbon Management Technologies					
Hydrogen with Carbon Management					
Gasification Systems	44,000	28,000	30,000	2,000	7.1%
Advanced Turbines	30,000	30,000	30,000	0	0%
Reversible Solid Oxide Fuel Cells	5,000	10,000	5,000	-5,000	-50.0%
Advanced Energy Materials	15,000	16,000	9,000	-7,000	-43.8%
Sensors, Controls and Other Novel Concepts	3,000	5,000	5,000	0	0%
Simulation-Based Engineering	4,000	6,000	6,000	0	0%
Subtotal Hydrogen with Carbon Management	**101,000**	**95,000**	**85,000**	**-10,000**	**-10.5%**
Carbon Transport and Storage					
Storage Infrastructure	75,000	90,000	85,000	(5,000)	-5.6%
Advanced Storage RDD&D	22,000	20,000	25,000	5,000	25.0%
Subtotal Carbon Transport and Storage	**97,000**	**110,000**	**110,000**	**0**	**0%**
Carbon Dioxide Removal	**49,000**	**70,000**	**70,000**	**0**	**0%**
Carbon Dioxide Conversion	**29,000**	**50,000**	**50,000**	**0**	**0%**
Point-Source Carbon Capture	**99,000**	**135,000**	**144,000**	**9,000**	**6.7%**
Carbon Management – Policy, Analysis, and Engagement					
Carbon Management – Policy and Analysis	2,400	0	3,500	3,500	N/A
Carbon Management – Engagement	1,000	0	1,000	1,000	N/A
Carbon Management – Federal Partnerships	0	0	500	500	N/A
Subtotal Carbon Management – Policy, Analysis, and Engagement	**3,400**	**0**	**5,000**	**5,000**	**N/A**
Supercritical Transformational Electric Power (STEP)	**15,000**	**0**	**0**	**0**	**0%**
Total, Carbon Management Technologies	**393,400**	**460,000**	**464,000**	**4,000**	**0.9%**

SBIR/STTR:

- FY 2022 Enacted: SBIR $11,187; STTR: $1,573
- FY 2023 Request: SBIR $12,451; STTR: $1,751
- FY 2024 Request: SBIR $12,035; STTR: $1,692

	FY 2024 Request vs FY 2023 Enacted
Hydrogen with Carbon Management: Funding will accelerate development of co-gasification systems for flexible waste feedstocks such as legacy coal waste, plastics, and sustainably-sourced biomass, with CCS to reach negative emissions. The funding will be utilized for funding opportunity announcements addressing topic areas in 100% hydrogen turbines.	**-$10,000**
Carbon Transport and Storage: Funding level ensures the launch of CarbonBASE and the selection of additional CarbonSAFE Phase II and CarbonSTORE projects that will have broad and immediate applicability to CCS and storage-based CDR activities. Funding also continues the DOE Regional Initiative to provide technical assistance to project developers and facilitate community and stakeholder engagement to help ensure appropriately designed CCS and storage-based CDR deployment and project success. The request prioritizes R&D to enable technologies and approaches for optimizing performance of commercial-scale transport and storage operations. Funding level maintains priority R&D on improving site/hub characterization tools and techniques critical for assessing practical CO_2 storage resources and resource management, including CO_2 mineralization.	**$0**
Carbon Dioxide Removal: The funding continues efforts on mineralization and enhanced weathering concepts.	**$0**
Carbon Dioxide Conversion: Funding allows for continued scale up and higher-technology readiness level field testing of promising conversion technologies, such as at the National Carbon Capture Center.	**$0**
Point-Source Carbon Capture: The funding request complements the $3.5 billion in BIL funding for CCS demonstrations and pilot projects and reflects prioritization of key areas of advanced technologies for achieving higher capture rates, pilot-scale tests, and FEED studies for industrial and natural gas-derived sources of CO_2.	**+$9,000**

	FY 2024 Request vs FY 2023 Enacted
Carbon Management – Policy, Analysis, and Engagement: The increase in funding will expand the capabilities of the analysis division, allowing work on hydrogen technologies and infrastructure, carbon capture, transport and storage, and general systems-based energy and carbon management modeling. This includes integration of advanced enhancements to the FECM version of the National Energy Modeling System to analyze potential future deep decarbonization scenarios and carbon management technologies' contribution to reliability and resilience. The funding increase will also enable integrated analysis of market driven opportunities in the industrial and power sector for carbon management technologies. This will enable further inventory and systems analyses to highlight lower cost opportunities for achieving carbon reductions. Additional funding will support expanded domestic engagement of communities, key stakeholder and state and local officials in regions where project deployment is expected to occur to help ensure communities and key stakeholders see tangible economic, environmental and jobs benefits from the deployment of projects and infrastructure to help ensure project success, as well as engagement with key countries and international partners working to advance carbon management globally. The increased request will support FECM's activities to support domestic interagency cooperation and to provide technical and other information on regulatory and permitting issues to industry, states, and other interested parties to advance FECM's mission.	**+$5,000**
Supercritical Transformational Electric Power: No funding is requested for FY 2024.	**$0**
Total, Carbon Management Technologies	**+$4,000**

Carbon Management Technologies
Hydrogen with Carbon Management

Overview

The Hydrogen with Carbon Management subprogram invests in research to evaluate carbon-neutral hydrogen (i.e., coupled to carbon capture and storage, or CCS) as a fuel and supports development of technologies to use carbon-neutral hydrogen from any source. The subprogram's efforts are an integral part of the Department of Energy's (DOE) launched Hydrogen Shot, with a goal of reducing clean hydrogen costs by 80% to $1 per 1 kilogram (kg) within 1 decade (1-1-1), while expanding employment of the U.S. energy workforce. Seeking a cost-competitive decarbonized alternative to traditional unabated fossil fuels, the subprogram has a research and development portfolio consisting of a new generation of carbon neutral or net-negative greenhouse gas (GHG) emissions technologies. The subprogram comprises of six RDD&D activities: (1) Gasification Systems, (2) Advanced Turbines, (3) Reversible Solid Oxide Fuel Cells (R-SOFCs), (4) Advanced Energy Materials, (5) Sensors, Controls, and Other Novel Concepts, and (6) Simulation-Based Engineering.

This subprogram provides a platform for developing the advanced systems of the future capable of net-zero emissions operations. These efforts are complementary to the Infrastructure Investment and Jobs Act (IIJA) Hydrogen Hubs, as many of the technology advancements being developed in Gasification Systems, Advanced Turbines and R-SOFCs will be deployed at Hydrogen Hubs over the next five to ten years. While the primary focus is on thermal and electrochemical power systems and hydrogen production, improvements to these technologies are also applicable to other energy systems such as concentrated solar, nuclear, and the chemical industry. Improvements to new and existing plants will also support their efforts to be carbon neutral and allow these assets to provide low-cost baseload power and resilient flexible grid services. These activities align with the Administration's priority of reducing environmental impacts from the power sectors, especially in disadvantaged communities.

A description of each Hydrogen with Carbon Management activity is presented below:

Gasification Systems

Gasification technologies can potentially turn any carbonaceous feedstock into syngas and other chemical building blocks such as clean hydrogen, liquid fuels, chemicals (e.g., ammonia), and carbon products. Furthermore, feedstock blends that consist of legacy coal waste, municipal solid waste, waste plastics, and biomass (including biomass wastes) may afford a carbon neutral (or even a carbon negative) emissions profile when used in combination with CCS. Gasification technology with integrated pre-combustion carbon capture is an efficient pathway to quickly roll out clean hydrogen to meet the ambitious cost and schedule goals articulated in the Hydrogen Shot initiative. An additional motivation for advancing flexible feedstock gasification technology is in its potential to reduce environmental impacts on affected communities by consuming, and therefore eliminating, various liability [carbon-based] waste materials, a unique attribute that gasification may accomplish that other hydrogen production technologies cannot address. Strategic siting of new clean hydrogen production near waste landfills and similar waste storage stockpiles can improve economic conditions of marginalized communities by removing sources of contamination and obstacles to economic development, thus attracting commercial investment, and bringing steady, well-paying jobs to economically depressed regions.

The FY 2024 Budget Request provides $30 million for R&D with industry, universities, and DOE National Laboratories to develop technologies that could overcome the constraints that have been inhibiting the deployment of conventional gasification-based plants. The Request will enable technology development in the following areas:

- **Clean Hydrogen production**: This sub-activity aims to advance and mature novel technologies capable of producing clean hydrogen with net-negative emissions, from co-gasification of blended biomass and wastes, including municipal solid waste, legacy coal waste, and nonrecyclable plastics, to enable remediation and reduction of legacy pollution.

- **Scale-up of moderate-technology readiness level advanced oxygen production technologies**: The sub-activity aims to advance the Technology Readiness Level of emerging oxygen production technologies from air separation. Scale-up will allow for maturation of novel, highly efficient, and lower cost oxygen production technologies from DOE's national labs into commercially-relevant prominence, thus facilitating interest from the commercial sector and attracting technology transfer partner(s). Lower cost oxygen is crucial to enable gasification to leverage pre-combustion carbon capture and produce clean hydrogen at a low enough cost to meet the Hydrogen Shot initiative's goal. This technological maturation activity will improve the viability and economics of net-zero carbon gasification systems.
- **Using novel microwaves for enhanced gasification robustness and quality**: This sub-activity aims to advance waste cleanup/gasification technology by developing microwave enhancements that produce valuable hydrogen from organic impurities in syngas that might survive the primary gasification process. Addressing the concerns of condensable organic species in raw syngas increases the likelihood of commercial sector adoption of flexible and variable waste-feedstocks to clean hydrogen production. Incorporating microwave technology at a gasifier's exit offers the promise of destroying any remaining complex molecules into simple molecules like hydrogen, which will improve the systems reliability, availability, and maintainability, all of which allows greater impact on generating clean electricity with net-zero carbon emissions.
- **Enhanced blended gasification feedstock pretreatment processes**: This sub-activity aims to develop, investigate, and advance the TRL of various novel pretreatment techniques for blended feedstocks (biomass, mixed wastes, MSW, unrecyclable plastics, etc.). Blended feedstocks that include biomass are important for future gasification systems for production of power, hydrogen, and ammonia with net-zero emissions. However, blended feedstock-based systems are severely limited in scope due to two key issues: reliably feeding blended materials with different characteristics into the gasification process, and accessing, shipping, and storing the feedstock materials in a low- or zero-carbon intensity method. Development of these technologies focuses on addressing these two key issues.
- **Clean hydrogen production systems integration & optimization:** This sub-activity aims to improve integration of components within systems, hybridization of processes, and improving process reliability, to optimize hydrogen production efficiency and cost reductions given scale of the system, feedstock availability, and market factors.

Advanced Turbines

The FY 2024 Budget Request provides $30 million in funding to develop gas turbine combustion systems to accommodate hydrogen, ammonia and hydrogen-natural gas fuel blends while minimizing nitrogen oxide (NOx) emissions and maintaining machine efficiency. R&D investments will also support efficiency goals of 67% (lower heating value, or LHV natural gas) and 50% (LHV natural gas) for combined cycle and simple cycle machines, respectively. The program will also invest in a long-term goal of a 70% efficient combined cycle machine (LHV natural gas).

Investments will be made in the application of advanced manufacturing and machine learning/artificial intelligence (AI) to attain efficiency goals. The activity will be executed in cost-shared collaboration with capital equipment manufacturers, the secondary market supporting turbine technology, U.S. universities, and the DOE National Labs. The Advanced Turbines activity supports four key technologies that will advance clean, low-cost power production while providing options for CO_2 mitigation. These key technologies include: (1) Advanced Combustion Turbines, (2) Pressure Gain Combustion, (3) Modular Turbine-Based Hybrid Heat Engines, and (4) Supporting the University Turbine Systems Research program. DOE's R&D in advanced turbines technology develops and facilitates low-cost advanced energy options for energy ecosystems. Sub-elements of this program include:

- **Advanced Combustion Turbines:** The Request will support a significant investment in the development of hydrogen combustion systems for hydrogen and hydrogen carriers like ammonia for retrofit applications and new gas turbines. The Request will also support new designs for gas turbine components, advanced cooling techniques, aerodynamics, sealing, combustion systems and materials.

- **Pressure Gain Combustion:** Pressure gain combustion has the potential to significantly improve gas turbine performance by realizing a pressure increase versus a pressure loss through the combustor of the turbine. Hydrogen is a particularly attractive fuel for pressure gain combustion and is being explored in this program.
- **Modular Turbine-based Hybrid Heat Engine:** Projects seek to develop modular turbine-based hybrid heat engines that integrate with modular gasifiers, promote the clean use of stranded fuels, support energy storage cycles, make hydrogen generation more affordable, improve the efficiency and environmental performance of natural gas compression stations, and provide an affordable cost of electricity.
- **University Turbine Systems Research:** The Request also supports the University Turbine Systems Research sub-activity within the Advanced Turbines activity, which supports hydrogen turbine research at U.S. universities. This cost shared activity, with industry endorsement, supports fundamental and applied R&D projects that improve the efficiencies of turbines and related turbine technologies. Additionally, this program helps train the workforce of combustion turbine scientists, engineers, and technicians.

Reversible Solid Oxide Fuel Cells

Reversible Solid Oxide Fuel Cells (R-SOFCs) use natural gas and up to 100% hydrogen to produce electricity, water and CO_2 when operating in a fuel cell mode. R-SOFCs can be configured to operate in reverse as an electrolyzer using power and water as inputs to produce hydrogen, with oxygen as a byproduct. This electrolyzer mode turns the R-SOFC into a Solid Oxide Electrolyzer Cell (SOEC). SOECs essentially function as a SOFC in reverse and optimize the use of these system to reduce overall costs. The carbon dioxide produced from the process with natural gas as a fuel in a fuel cell mode can then be sequestered for storage or use in other applications.

R-SOFCs can both store and produce energy with a single system and can contribute to clean energy generation/storage when paired with a renewable fuel such as hydrogen (in fuel cell mode) or renewable electricity (in electrolysis mode). Hydrogen created from R-SOFCs is a promising fuel source and can be stored for future use when renewable energy sources are not available. When the grid demands power, the R-SOFC consumes the stored hydrogen to produce electricity. R-SOFCs allow for a continuous stream of clean energy into the grid.

The focus areas for Reversible Solid Oxide Fuel Cells Program include:

- Clean hydrogen production from SOEC systems;
- Developing and validating the materials proposed for improving the cost, performance, and reliability of R-SOFC systems; and
- R&D for degradation at start-up of SOEC operation and enabling technologies for dynamic operation of SOEC/SOFC Systems.

The Request provides $5 million to conduct additional R&D to advance R-SOFC technologies, including operating as SOECs. This activity will identify advanced R-SOFC configuration concepts that enable the generation of ultra-efficient, low-cost electricity for the near-term deployment of distributed generation/modular power systems.

Advanced Energy Materials

The Advanced Energy Materials activity focuses primarily on material discovery and development that will lower the cost and improve flexibility and reliability while enabling high efficiency, low-carbon performance. Materials of interest are those that enable components and equipment to perform in the high temperature, high pressure, corrosive environments of an advanced energy system with specific emphasis on durability, availability, and cost. The activity also seeks to enhance the nation's supply chain for high-temperature materials to support a competitive U.S. industry base and create a skilled workforce.

The activity has four main themes:

- **Advanced Materials Development**: This sub-activity creates cost-effective structural and functional materials for advanced fossil energy power generation technologies, and reduces the cost and time needed to develop and commercialize new materials for applications in extreme operating environments.

Development focuses on advanced manufacturing methods for high-performance materials and computational materials modeling as enabling technologies. The National Energy Technology Lab (NETL) leads a national laboratory consortium, Extreme Environment Materials (eXtremeMAT or XMAT), dedicated to changing how materials are conceived and developed. In addition, this sub-activity will evaluate the impact of hydrogen on materials to develop models critical to understanding hydrogen-related impacts to establish a new domestic supply chain of hydrogen resistant materials.

- **Supply Chain Development**: The Advanced Ultra-Supercritical consortium developed high temperature materials and manufacturing technologies that are now being exploited in applications such as natural gas combined cycles, concentrated solar, and high efficiency plants. The recently completed supply chain development effort includes R&D, large-scale component manufacturing trials, American Society of Mechanical Engineers (ASME) code cases, and techno-economic analyses (TEA) that readied the domestic supply chain to support construction of advanced power generation technology power plants.
- **Work Force Development:** This sub-activity supports the education and training of advanced technical workers who are trained in skills necessary to manufacture and repair components suitable for applications and industries that will be necessary for a decarbonized electricity sector by 2035 and economy by 2050. This sub-activity provides funding to eligible applicants proposing to provide training in target skills while addressing the employment and training needs of the local and regional workforce. These training programs are created in collaboration with community partners and in coordination with existing economic development strategies to support worker training for coal and power plant communities.
- **High-Performance Computing for Materials (HPC4Mat)**: This sub-activity aims to utilize the high-performance computing (HPC) resources of DOE's National Laboratories to help industry develop new or improved materials and resolve materials challenges for their applications.

The FY 2024 Request of $9 million will provide funding for supply chain R&D to develop ceramic matrix composite (CMC) materials for turbine applications (thermal barrier coatings or turbine blade materials) and carbon management advanced manufacturing methods to reduce fabrication costs and improve cyclic durability. The Request supports the NETL-led XMAT National Lab Consortium to incorporate material-hydrogen interactions in materials models, develop prediction methods for component lifetimes, and accelerate the design of new materials.

Sensors, Controls, and Other Novel Concepts

This activity provides $5 million to fund early-stage R&D on low-cost, reliable wired and wireless technologies to measure process temperature, pressure, and concentration of gas species. With additional investment by industry, these technologies could be capable of providing real-time information critical to the operation, reliability, and efficiency of next generation power systems. This is needed as a part of greater efforts to achieve a carbon pollution-free power sector by 2035.

Technological advances will enable industry to shift from time-based preventive maintenance schedules to predictive condition-based maintenance to improve reliability and overall plant economics. Advanced sensors and controls can also be used to monitor, identify, and mitigate transients associated with a cyber-attack, providing increased asset security, safety, and grid stability. Novel instrumentation that can withstand harsh process environments can replace inferred process conditions with actual measurements. This facilitates optimized performance, improved component health monitoring, and faster/safer response times during flexible operations.

R&D will focus on advanced data analytics and controls development for power plants and industrial facilities of the future. This activity builds off lessons learned from testing at existing power plants, emphasizing integration of materials lifetime modeling and control algorithms. By advancing research and development, technology prototypes are designed, packaged, ruggedized, and readied for plant integration. Other novel/emerging technologies will be developed to support future energy applications essential for energy security and efficiency.

Technologies developed by this program could also be applied to hydrogen production and utilization; CCS; flexible-fuel boiler systems; and energy storage.
Focus areas include:

- **Real Time Monitoring & Diagnostics:** Early-stage R&D on low-cost and reliable multi-sensing wired and wireless technologies to conduct process monitoring and component health by measuring critical process parameters that, with additional investment by industry, could be capable of providing real-time information critical to the operation, reliability, and efficiency of next-generation power systems.
- **Advanced Controls:** Advanced control algorithm development is critical in the optimization of systems with highly coupled, nonlinear interactions. Dynamic controls and integration will enable flexible operation of energy systems, including load following, demand response, and hybrid energy integration, while enhancing safety and grid stability.
- **Condition-Based Maintenance:** Advances in sensor R&D will enable industry to shift from time-based preventive maintenance to predictive condition-based maintenance with improved reliability and overall plant economics. This could save millions of dollars in maintenance costs across all power cycles.
- **Cyber Security:** Project areas focus on the protection of assets from cyber threats. This focus area conducts gap analyses to develop automated awareness technologies, data integration tools, and blockchain technologies to harden potential targets. Some sub-areas are:
    - **Machine Learning (ML):** Develops technologies that monitor power plant networks to identify abnormal behaviors because of operational issues or a malicious cybersecurity event.
    - **Blockchain and Distributed Ledger Technology**: Blockchain can facilitate detection of manipulated data. Its ability to secure data in a distributed and decentralized manner gives utilities protection against unauthorized access. Testing programs are needed to properly evaluate blockchain-based concepts.

Simulation-Based Engineering

The Simulation-Based Engineering activity includes computational software development, high performance computing, advanced optimization, TEA, and AI and ML. Simulations generate information beyond the reach of experiments alone, rapidly, and inexpensively. They enable the discovery of new materials, optimization and troubleshooting of novel devices, and the design and optimization of complex process systems. This activity also comprises modeling, simulation, and TEA to resolve challenges and optimize power plants as they integrate with a dynamic, evolving electricity grid. Key objectives include improving the reliability, flexibility, and economics of the next generation fleet and the industrial and manufacturing sectors.

In FY 2024, the Budget Request for Simulation-Based Engineering provides $6 million to continue funding for DOE National Laboratory R&D, including existing modeling and analysis projects funded under the Grid Modernization Initiative (GMI); and the NETL-led Institute for the Design of Advanced Energy Systems (IDAES) in collaboration with Sandia National Laboratory (SNL) and Lawrence Berkeley National Laboratory (LBNL), which develops process systems engineering tools and optimized approaches in the conceptual design and process intensification of innovative systems. The Multiphase Flow with Interphase exchanges (MFiX) element, led by NETL, will also support computational efforts, including ML, in collaboration with industry, to gain deep insight into plant operation to improve performance outcomes and reduce unexpected, forced outages. In addition, the funding will allow the upkeep of capabilities associated with the Computational Fluid Dynamics (CFD) for Advanced Reactor Design (CARD) and IDAES activities. The CARD activities include the development of models that allow the production of hydrogen from biomass and plastics. The physics-based model will allow for proper scale-up when the technology is ready for commercialization. IDAES activities will focus on continuing support for the stakeholder communities and developing new features and capabilities to address the challenges associated with the design and operation of integrated energy systems to enable deep decarbonization of the energy and industrial sectors.

The Hydrogen with Carbon Management subprogram closely coordinates its RDD&D activities with the Office of Energy Efficiency and Renewable Energy (EERE) Hydrogen and Fuel Cell Technology Office (HFTO) to work collaboratively where appropriate and to ensure no duplication of effort. Intra-agency coordination includes the

following DOE Offices: EERE, FECM, Office of Science (SC), Office of Nuclear Energy (NE), Advanced Research Projects Agency (ARPA-E) and the Office of Electricity (OE). The Science and Energy Technology Team will strengthen collaboration with all DOE offices, including the crosscutting offices (such as the Office of Technology Transitions (OTT) and the Loans Program Office (LPO)) involved with various hydrogen initiatives.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Hydrogen with Carbon Management: **$95,000,000**	**$85,000,000**	**-$10,000,000**
Gasification Systems $28,000,000	**$30,000,000**	**+$2,000,000**
• Develop robust, fuel-flexible, load-following modular gasification systems, specifically for community-scale gasification of legacy coal waste and opportunity feedstocks. • Develop process technology that integrates oxygen separation from air and uses advanced techniques for gasification of waste feedstocks. • Develop small-scale, modular microwave reactor technologies that expand the capability to use low value and waste feedstocks (including waste plastics and legacy coal waste and biomass).	• Scale-up and maturation of novel, highly efficient and lower cost oxygen production technologies. • Support advancement of clean hydrogen production from co-gasification of blended waste and biomass to accomplish remediation and reduction of legacy pollution. • Support integration of components, hybridization of processes, and improving process reliability, to optimize hydrogen production efficiency from gasification and cost reductions given scale of the system, feedstock availability, and market factors.	• Additional funding will accelerate development of co-gasification systems for flexible waste feedstocks such as legacy coal waste, plastics, and waste biomass, with CCS to reach negative emissions.
Advanced Turbines $30,000,000	**$30,000,000**	**$0**
• Support new turbine component designs for hydrogen, ammonia, and gas with carbon capture, advanced cooling techniques, aerodynamics, sealing, combustion systems and materials. • Supports University Turbine Systems Research.	• Support experimental development and technology demonstration of retrofit combustor systems for hydrogen, ammonia, and hydrogen and natural gas blends. • Issue biannual University Turbine Systems Research funding opportunity announcement. • The funding will be utilized for FOAs addressing topic areas in 100% hydrogen turbines.	• Continue at current levels.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Reversible Solid Oxide Fuel Cells $10,000,000	**$5,000,000**	**-$5,000,000**
• Investigate reversible SOFC/SOEC operation and system studies to integrate heat required for SOEC operation from other processes (e.g., nuclear). • Mature SOFC technologies and advance R&D on SOECs. • Focus on carbon neutral hydrogen production from SOECs.	• Develop the materials for improving the cost, performance, and durability of R-SOFC systems. • Focus on clean hydrogen production from SOECs.	• Conduct basic R&D to advance R-SOFC technologies, including operating as SOECs.
Advanced Energy Materials $16,000,000	**$9,000,000**	**-$7,000,000**
• Funding is shifted to focus on areas that will have a significantly greater impact on achieving a net-zero carbon economy by mid-century. • Evaluate the impacts of hydrogen on materials to develop models critical to understanding hydrogen-related impacts to establish a new domestic supply chain of hydrogen resistant materials.	• Extend models developed under XMAT to include the effects of hydrogen on materials and component life. • Continue development of models critical to understanding hydrogen-related materials impacts to establish a new domestic supply chain of hydrogen resistant materials.	• Develop alloy compositions and manufacturing techniques to improve resistance to hydrogen embrittlement.
Sensors and Controls and other Novel Concepts $5,000,000	**$5,000,000**	**$0**
• R&D on low-cost and reliable multi-sensing wired and wireless technologies, focusing on hydrogen and CCS activities. • Develop technologies that monitor power plant networks to identify abnormal behaviors because of operational issues or a malicious cybersecurity event.	• Continue R&D on advanced monitoring, controls, and integration techniques for optimized performance and reliability of hydrogen and carbon management systems. • Supports the investigation of novel concepts/ disruptive, emerging technologies that may be impactful for future FECM-relevant systems, such as quantum sensing, blockchain and distributed ledger technologies. • Cultivate a robust technology development pipeline, focused on maturation of concepts through meaningful testing and demonstration, and technology transfer to industry.	• Continue at current levels.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Simulation Based Engineering $6,000,000	**$6,000,000**	**$0**
• Supports the development of interactive visualization technology and data communication optimization methods to improve the design and operation of advanced power systems with CCS to meet decarbonization goals. • Provides first principle and physics-based modeling of phenomenon for complex energy conversion and carbon capture processes. • Continue the development, validation, application, and support of the multiphase flow with Interphase eXchanges (MFiX) computational fluid dynamics (CFD) software suite. • Continue working on the design, scale-up, and optimization of pyrolysis and gasification reactors for hydrogen production from biomass and plastics.	• Continue the development, validation and application of flagship, open-source software codes, including Multiphase Flow with Interphase Exchanges (MFIX) and the Institute for the Design of Advanced Energy Systems (IDAES). • Leverage models and simulations to accelerate the design, optimization, and/or scale-up of complex, integrated technologies and systems, including (but not limited to hydrogen production; carbon capture and conversion technologies and advanced scenarios for decarbonization). • Exploration of novel methodologies to increase computational speeds, including advanced computing architectures (e.g., graphics processing unit-accelerated systems for high-performance computing, quantum computing, etc.) and deployment of novel AI/ML techniques.	• Continue at current levels.

Carbon capture, use, and storage (CCUS) and carbon dioxide removal (CDR) are critical components of the Administration's broad and aggressive efforts to meet decarbonization targets leading to a net-zero carbon economy by 2050. Through the Bipartisan Infrastructure Law (BIL), the Inflation Reduction Act (IRA), and the Create Helpful Incentives to Produce Semiconductors (CHIPS) And Science Act Of 2022, Congress has committed resources and established policies that will spur the growth of carbon management industries, including CCUS, CDR and support for basic science research.

Critical components that will help catalyze the growth of the requisite subsurface and transport resources necessary for storing CO_2 captured from industrial facilities and power plants and removed from the atmosphere include, but are not limited to, strategies to develop the infrastructure for carbon transport and storage; research and development (R&D) to improve performance and reduce costs of site characterization and active/post-injection and transport operations; technology transfer; and technical assistance to stakeholders for project development and community engagement.

CCUS projects supported by DOE and other organizations around the world have demonstrated safe transport and secure geologic storage of CO_2 in a variety of different geologic formations and depositional environments. Since 2016, FECM has been focused on deploying carbon storage at scale in the U.S. with the launch of the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative. Since passage of the BIL, the number of first-mover, large-scale commercial storage projects have substantially expanded, largely through policy changes that have incentivized CCUS and CDR and the construction of commercial carbon storage facilities funded by BIL Section 40305. FECM expects this increase in storage projects will likewise increase the confidence among operators, regulators, insurers, financial institutions, environmental groups, local communities, and community leaders that geologic storage of captured CO_2 is secure.

In FY 2024, the Carbon Transport and Storage (CTS) subprogram will continue to play an important role in accelerating CCUS infrastructure buildout and storage-based CDR by advancing next generation, cutting edge technologies intended to lower the cost of CO_2 storage facility development and to improve operational performance.

The Budget Request provides $110 million for the Carbon Transport and Storage subprogram for technology R&D that will accelerate CCS and storage-based CDR (e.g., direct air capture, or DAC) as clean energy innovations that will contribute toward decarbonizing industry and developing a carbon removal industry. These activities include:

- Continuing the competitive solicitation and selection of CarbonSAFE Phase II projects to increase eligibility for later-phase CarbonSAFE projects funded under BIL Section 40305;
- Launching the Carbon Basin-scale Assessment and Storage Evaluation (CarbonBASE) Initiative to collect necessary data, develop models, and apply decision tools to optimize secure CO_2 storage across geologic basins;
- Selecting additional Carbon Storage Technology and Operational Research (CarbonSTORE) facilities and supporting new research at these facilities;
- Continuing feasibility studies on various CO_2 transport modes and performing network optimization scenarios;
- Continuing support for the DOE Regional Initiative, which supports technical assistance for project developers and states to leverage the national network of experts on geologic storage, permitting, and community engagement; and
- Advancing early-stage, cutting edge technologies that fill priority technology gaps and near-term industry needs, including AI-enabling/supporting technologies.

These initiatives and other activities are targeted to advance storage security, performance, and infrastructure buildout and are driving the CTS subprogram forward to accelerate commercial CCUS and storage-based CDR deployment. In FY 2024, CTS program efforts will also be aligned with the technology development goals of the DOE Subsurface Energy Innovations Crosscut (in progress), which target cross-cutting innovations in characterization, monitoring, drilling, and engineering across DOE's subsurface programs with consideration to basic science gaps.

Storage Infrastructure

The CTS budget request includes $85 million for Storage Infrastructure activities that will leverage active field projects supported by prior year funding and continue support for the competitive selection of CarbonSAFE Phase II projects. These projects perform feasibility studies of potential on- and offshore storage sites that could support the deployment of CCUS for the power sector, hydrogen production facilities, hard-to-decarbonize industries (e.g., steel, cement), and storage-based CDR (e.g., DAC with CO_2 storage). The Storage Infrastructure activities will also kickoff the CarbonBASE Initiative that will focus on drilling deep characterization wells in dedicated saline and mafic/serpentine rock storage formations to collect data in the most promising geologic formations that are likely to host multiple large-scale storage projects throughout the country. Coupled with collaborative efforts with multiple stakeholders (Federal and State leasing agencies, National labs, regulatory agencies, academia, industry), CarbonBASE projects will develop basin-scale models and decision support tools to support the management of multiple commercial projects to include active reservoir management, pore space utilization optimization, interference assessments of pressure and plumes, management of basin-scale seismicity, and accounting procedures. A key outcome of CarbonBASE will be tools and approaches for resource managers to define and utilize pore and pressure space efficiently and safely. This activity will also include collaboration with other DOE programs to assess potential crosscutting benefits from the production of brine (as a pressure management strategy) such as opportunities for geothermal energy and critical minerals extraction from the produced brine.

FY 2024 Storage Infrastructure request will also support the development and implementation of a technical assistance strategy that leverages existing data and the national network of expertise on carbon storage. Funding will support DOE Regional Initiative projects to provide technical assistance on carbon management hub development, basin scale management, regional geologic characterization, and technical assistance to stakeholders in state governments that may be responsible for regulating or overseeing carbon transport and storage efforts. Technical assistance activities will include strong community engagement to ensure social equity and to communicate community benefits.

In an effort to make further improvements in the cost and performance of applied monitoring technologies, the Storage Infrastructure activity will also seek to competitively award additional CarbonSTORE projects integrated with later-Phase CarbonSAFE projects or other commercial storage facilities. CarbonSTORE facilities serve as field laboratories for testing new technologies, monitoring storage performance, and providing data for program-wide efforts. Any new CarbonSTORE projects selected this fiscal year would target priority areas and research opportunities not covered by CarbonSTORE projects selected in the prior year.

FY 2024 activities will also leverage the experience and findings of on-going and new field efforts to improve understanding of national infrastructure and transport needs, onshore/offshore deployment, leveraging existing oil and gas infrastructure and natural CO_2 deposits to convert these systems for CO_2 transport or dedicated CO_2 storage. Analyses will include evaluations of financial incentives to deployment, and storage hub resource assessments and efficiencies. Research will also be conducted through national laboratories in support of new field projects and to complete on-going field studies that were initiated with prior year appropriations. Systems modeling of a transportation system to support the wide-scale transport and storage of CO_2 will also be supported to determine opportunities for multi-modal and inter-modal transport systems. Overall, the sub-activities within the Storage Infrastructure activity will be designed to support and align with congressional direction on CCS and storage-based CDR as outlined in relevant sections of the BIL.

Advanced Storage

The CTS Budget Request includes $25 million for Advanced Storage R&D that will continue high-priority activities to advance technologies specific to CO_2 geologic storage targeting enhanced plume imaging/tracking, high-temporal and high-spatial resolution monitoring, improved geomechanical stress/strain characterization, high fidelity sensing, and automation and intelligent systems including AI-enabling/supporting technologies. FY 2024 funds will also support individual site and hub screening and characterization tools and techniques for improved storage capacity assessments and pore/pressure space optimization. FY 2024 funds will support testing and validation and system performance at CarbonSTORE facilities. Targeted research by national laboratories and other research institutions includes advancing fault/fracture networks characterization and associated stress state, fluid/pressure migration management, basin-scale modeling for evaluating storage resource management strategies, legacy wellbore characterization, repurposing of oil, gas, and CO_2 production infrastructure, intelligent monitoring systems, and developing approaches/methods for adaptive reservoir management.

The program will also support R&D on the repurposing of transport infrastructure that are used for other gases/fluids, as well as research on material performance and new materials. FY 2024 funds will also continue to support the curation of data from CTS supported projects into the DOE National Energy Technology Laboratory (NETL) Energy Data Exchange (EDX), which has been serving as the portal for public access to CTS data products.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Carbon Transport and Storage: $110,000,000	**$110,000,000**	**$0**
Storage Infrastructure: $90,000,000	$85,000,000	-$5,000,000
• Supports competitive selection of additional Phase II CarbonSAFE projects to characterize, evaluate, and analyze the feasibility of onshore and offshore storage sites and hubs for dedicated storage in saline formations, depleted oil and gas assets, CO_2 domes, and deposits for mineralization. • Supports competitive selection of CarbonSTORE projects to serve as field laboratories at commercial CO_2 storage sites for dedicated storage, which will be critical for testing new and potentially lower-cost storage monitoring technologies and systems and providing real-world data for program-wide RDD&D efforts. • Supports Regional Initiative as regional technical assistance to CCUS stakeholders and project developers. • Supports capabilities development in support of national transport network planning and cost analyses. • Supports economic and market analysis for commercial-scale onshore and offshore geologic storage of CO_2.	• Supports competitive selection of CarbonBASE projects to collect data in the most promising geologic formations for the development of storage resource assessment tools and analyses. • Supports competitive selection of additional Phase II CarbonSAFE projects to characterize, evaluate, and analyze the feasibility of onshore and offshore storage sites and hubs for CO_2 transport and dedicated storage in saline formations, depleted oil and gas assets, CO_2 domes, and deposits for mineralization. • Supports competitive selection of additional CarbonSTORE projects to serve as field laboratories at commercial CO_2 storage sites for transport and dedicated storage. • Supports the DOE Regional Initiative to provide technical assistance to regional CCUS and storage-based CDR project developers and stakeholders, including strong community engagement. • Supports capabilities development for national and multi-modal CO_2 transport network planning and cost analyses. • Supports economic and market analysis for commercial-scale onshore and offshore transport and geologic storage of CO_2.	• Funding ensures launch of CarbonBASE and the selection of additional CarbonSAFE Phase II and CarbonSTORE projects that will have broad and immediate applicability to BIL funded CCS and storage-based CDR activities. • Funding also continues the DOE Regional Initiative to provide technical assistance to project developers and help facilitate socially equitable CCS and storage-based CDR deployment.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Advanced Storage: RDD&D: $20,000,000	$25,000,000	+$5,000,000
• Supports competitive selection of R&D projects on high priority topics including legacy well assessment, above-zone monitoring methods and tools, existing well and pipeline repurposing for CO_2 transport and storage. • Supports R&D on advance tools, sensors and monitoring systems that create data and data streams compatible with Science-informed Machine learning to Accelerate Real-Time (SMART) machine learning (ML) algorithms and capabilities. Topics of interest include advanced fiber optic sensing, wireless power systems, data integration/inversion methods, low-cost continuous monitoring systems. • Support R&D on the characterization and analysis of mineralization of CO_2 in geologic deposits with reactive materials, such as serpentines. • Continued support for Energy Data Exchange (EDX) data curation and platform maintenance.	• Supports competitive selection of R&D projects on high priority topics including legacy well characterization, above-zone monitoring methods and tools, feasibility studies for various CO_2 transport modes, existing well and pipeline repurposing for CO_2 transport and storage. • Supports R&D on advanced tools, sensors and monitoring systems that create data, and processing data streams that enable intelligent monitoring systems and AI-based technologies. Topics of interest include advanced fiber optic sensing, wireless power systems, data integration/inversion methods, low-cost continuous monitoring systems, edge computing. • Support R&D on the characterization and analysis of mineralization of CO_2 in geologic deposits with reactive materials, such as serpentines. • Continued support for Energy Data Exchange (EDX) data curation and platform maintenance.	• Funding is prioritized to enable technologies and approaches for optimizing performance of commercial-scale transport and storage operations. Funding level maintains priority R&D on improving site/hub characterization tools and techniques critical for assessing practical CO_2 storage resources and resource management, including CO_2 mineralization.

Carbon Management Technologies
Carbon Dioxide Removal

Overview

Many climate modeling scenarios project that carbon dioxide (CO_2) removal (CDR) will be required in the future to achieve economy-wide decarbonization. CDR refers to activities that remove CO_2 from the atmosphere and store it in geologic formations, products, terrestrial sinks, or in the ocean. CDR activities include direct air capture, direct ocean capture, biomass with carbon removal and storage, mineralization, and terrestrial carbon removal and sequestration (e.g., agricultural land management, afforestation, reforestation, and CO_2 storage in wetlands).

The U.S. Department of Energy's (DOE) Office of Fossil Energy and Carbon Management (FECM) supported a 2019 study by the National Academies of Sciences, Engineering, and Medicine (NASEM) on CDR. Two key findings of the report are:

- Negative emissions technologies (NETs) or CDR, are best viewed as part of a decarbonization portfolio that first achieves maximum emissions reductions from existing sources.
- NETs/CDR need to play a large role on the order of gigaton removal in order to meet the Administration's goal of net-zero greenhouse gas emissions by midcentury.

FECM has been working on carbon capture and storage projects for almost 20 years and has invested heavily in the development of technologies to capture relatively higher concentrations of CO_2 from industrial facilities and power plants. More recently, the Department has been applying this technology development to various NETs, including biomass with carbon removal and storage and direct air capture, which requires capture of extremely low concentration CO_2 from the atmosphere.

An objective of DOE's CDR work is to advance technologies to make significant progress towards reaching the Carbon Negative Shot target of less than $100/net metric ton CO_2 equivalent for both capture and permanent storage. Investments in various CDR approaches can help reduce cost and optimize performance. Through these investments, DOE will help advance promising technologies in partnership with industry, academia, and national laboratories, while ensuring future deployment occurs in a manner that provides demonstrable economic and environmental benefits to communities and workers.

The CDR portfolio builds on FECM's work on mineralization, co-firing of biomass, and capture technology development to support achieving net zero emissions economywide by 2050. The FY 2024 Budget Request is focused on scaling CDR technologies pathways of DAC, DOC, BiCRS, and mineralization, as well as necessary system analysis tools such as monitoring, reporting, verification, technoeconomic analysis and life cycle analysis.

Activities to develop and commercialize direct air capture systems largely follow known chemical-based separations processes (e.g., solvents and solid sorbents). Due to the low concentration of CO_2 in the air, the volume of gas flow per ton of CO_2 captured is much larger for direct air capture systems compared to point sources. Subsequently, the power requirements to overcome the pressure drop in packed configurations contributes to high operating costs while the requirement to process more inert gas (e.g., nitrogen in air) with CO_2 in low purity (e.g., 417 ppm in air based on National Oceanic and Atmospheric Administration (NOAA) estimates) correlates to increased contactor areas and high capital costs.

Concerted research and development(R&D) can reduce costs and the energy penalty, and improve scalability, siting, and operations. Efforts will focus on conducting materials and components R&D, including preliminary work on CDR pilots such as front-end engineering and design (FEED) studies, and pre-FEEDs. Both the pilot-scale testing and the FEED studies can complement the Bipartisan Infrastructure Law Regional Direct Air Capture Hubs program. It should be noted that first generation technologies will also continue to improve, and R&D conducted for transformational technologies may also improve the processes and components of first-generation technologies. FECM will also continue to analyze the economic circumstances for commercial deployment.

Direct Ocean Capture (DOC) activities will focus on areas of FECM expertise, such as separations processes, ocean alkalinity enhancement and engineered designs. For example, FECM has applied electrochemical separations and conversion

systems as part of its point-source capture, direct air capture, and carbon conversion programs, which can be applied to direct ocean capture. In FY 2023, FECM is working to establish a coordinated funding opportunity with NOAA. This partnership and shared learning will help direct FECM's expertise and investment into DOC into FY 2024.

Biomass with carbon removal and storage offers an opportunity for near-term deployment of CDR technologies. Biomass can be used to produce various products—power, fuels, chemicals—like other carbon-based feedstocks such as coal, oil, and natural gas. During its growing phase, biomass consumes CO_2 from the atmosphere through photosynthesis and releases this CO_2 when it is subsequently processed and consumed (i.e., power generation, fermentation, etc.). However, if this CO_2 is captured and permanently stored, the CO_2 is ultimately removed from the atmosphere, rather than returned.

The carbon capture technologies that currently exist and are being developed for power generation and industrial sources through the Point-Source Carbon Capture subprogram can be applied to biomass conversion facilities. Technology improvements in capital and operating costs, reducing the energy penalty, and systems integration are directly applicable in the case of power generation and gasification processes, which are areas where FECM has historical knowledge and capabilities. FECM will also leverage its activities on carbon storage to ensure biomass with carbon removal and storage approaches leverage resources through that sub-program.

The NASEM report characterizes carbon mineralization as occurring at the surface as well as subsurface. Carbon mineralization has the potential to use alkaline-containing rocks and minerals, including materials such as mine tailings and wastes, to react with CO_2 and permanently store it as a solid material.

Mineralization is part of the Carbon Transport and Storage subprogram's activities where there has been an extensive R&D program on geologic carbon storage over the past two decades. This work has included studies and field tests on injection of CO_2 into subsurface formations such as basalts. FECM previously conducted various studies and experimental work on surface carbon mineralization. A more recent analysis by the United States Geological Survey (USGS),[1] provides a summary of the potential for ex-situ and in-situ carbon mineralization opportunities in the U.S. The study suggests that the use of mine tailing and alkaline industrial wastes already at the surface can be a competitive option for CO_2 removal.

For all the CDR approaches, life cycle analyses (LCA) are critical to confirm that a given technology is removing more CO_2 from the atmosphere than is generated by the process over its life cycle. While LCA is a common tool and approach in many industries and for many processes, it is currently evolving in the CDR arena. Many technologies are relatively new, and the energy inputs required can significantly impact the LCA. R&D can provide the fundamental scientific and technical basis for LCA tools and methodologies applied to CDR applications. Coupling together R&D, LCAs and techno-economic analyses (TEAs) will ensure assessments can be made on the best available information, which will also inform global assessment models and decarbonization scenario analyses.

As the range of CDR technologies under development expands, FECM must also ensure that appropriate monitoring, reporting and verification (MRV) is being conducted on projects in which it invests. FECM will continue to fund tailored MRV approaches for the specific types of projects in our portfolio.

[1] Blondes, M.S., Merrill, M.D., Anderson, S.T., and DeVera, C.A., 2019, Carbon dioxide mineralization feasibility in the United States: U.S. Geological Survey Scientific Investigations Report 2018–5079, 29 p., https://doi.org/10.3133/sir20185079

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Carbon Dioxide Removal: $70,000,000	**$70,000,000**	**+$0**
• Continue development of transformational materials and components, and feasibility studies of current direct air capture systems. • Continue R&D on mineralization and enhanced weathering applications. • Evaluate biomass with carbon removal and storage applications at existing facilities.	• Continue development of transformational materials and components, and feasibility studies of current direct air capture systems. • Continue R&D on mineralization and enhanced weathering applications. • Evaluate biomass with carbon removal and storage applications at existing facilities. • Continue development of direct ocean capture.	• No change to current funding levels.

Carbon Management Technologies
Carbon Dioxide Conversion

Overview

The Carbon Dioxide Conversion subprogram develops technologies to convert carbon oxides (carbon monoxide, or CO, and carbon dioxide, or CO_2) into economically valuable products manufactured in a commercially viable and environmentally and socially beneficial manner. Research and development (R&D) activities within the subprogram address the challenges and potential opportunities associated with maturing conversion technologies, scaling systems to commercial deployment, and integrating systems with various emission point sources or carbon capture systems.

Federal government sponsored R&D in this area can validate the emissions reductions from carbon-based products, support achievement of economic viability, and facilitate the broader ecosystem for technology deployment. This is an area of national research interest since it has long-term economic and environmental benefits for the U.S. and industry. Beyond R&D, realizing these benefits may be further supported by financial incentives to utilize or convert carbon oxides into products, such as the recently expanded Federal Section 45Q tax credit, the California Low Carbon Fuel Standard, and regional procurement policies for lower-carbon or sustainably produced materials.

Further advancements in carbon conversion technology will help ensure that industry has verifiable information to assess economically and accurately the greenhouse gas (GHG) life cycle of carbon-based products. In addition, carbon conversion technologies can use excess low-carbon electricity, industrial waste heat, and components in byproduct streams such as wastewater and flue gas to create valuable products.

There are many opportunities to improve carbon conversion systems performance and to reduce costs. For example, R&D can enhance product yields by improving catalyst selectivity and energy efficiency, integrate carbon-neutral hydrogen production, and advance process engineering and design. Other challenges include the energy-intensive preparation of reactants to achieve feasible conversion or required additives that must be regenerated and recycled, which results in an energy penalty for the conversion process. Other hurdles include higher cost for novel processes, conservative risk attitudes in established product markets such as the building sector, and limited field trials and demonstrations to prove viability and diminish risk.

Carbon Dioxide Conversion

The Carbon Dioxide Conversion subprogram focuses on novel approaches to recycle carbon oxide emissions, into value-added products. Potential feedstocks include flue gas from power generation, industrial point sources, captured/concentrated CO_2, aqueous sources, mixed gas streams, or CO_2 captured from the atmosphere. These carbon sources are then converted through a bio-mediated, catalytic, mineralization, or hybrid pathway. Some processes are already commercially available while others are in the very early stages of R&D. This subprogram engages in a variety of collaboratives efforts and analysis across science and applied energy programs at DOE.

Each conversion technology comes with challenges and opportunities. A critical challenge across conversion technology pathways (mineralization, catalytic conversion, and bio-mediated) is the cost-effective, energy-efficient, and selective upgrading of CO_2. CO_2 is a stable, non-reactive molecule that typically requires heat or electricity, and other reactants to be converted into products. This subprogram will work to address the need for enabling technologies, including using carbon-neutral hydrogen as a reactant in the synthesis of fuels and chemicals and maintaining an alkalinity source for mineralization. The efficiency of reaction conversion, the amount of CO_2 stored in a product and energy use of these utilization processes also represent critical challenges that the Office of Fossil Energy and Carbon Management (FECM) is uniquely positioned to assess and invest in the development of these technologies.

The FY 2024 Budget Request provides $50 million for this subprogram and supports lab- and bench-scale carbon conversion technologies that have the potential to develop carbon-based products that promise GHG and environmental benefits over incumbent products. Areas of research include, but are not limited to, new projects focused on the catalytic conversion to higher value products such as fuels, chemicals, and polymers; mineralization to building materials; generation of synthetic aggregates; and algal systems with high CO_2 utilization efficiency of conversion to various bioproducts. The subprogram aims to continue investment activities from FY 2023, such as reactive capture and conversion, and progress first generation

conversion technologies to field-scale testing. Additional efforts will include guidance on benchmarking prototypical catalytical conversion, such as electrochemical reduction, for carbon conversion, as well as developing techno-economic analysis (TEA) guidance for screening various technology pathways or product markets. Funding will support the development of at least one fully integrated, field-test continuous system and continue support for carbon conversion test facilities at the National Carbon Capture Center.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Carbon Dioxide Conversion: $50,000,000	**$50,000,000**	**$0**
• Lab- and bench-scale technologies to convert CO_2 into valuable products such as chemicals, fuels, bioproducts and building materials. • Increased field-scale testing of technologies to pilot scale. • Standardized benchmarking for catalytic conversion systems.	• Lab- and bench-scale technologies to convert carbon oxides into valuable products such as chemicals, fuels, bioproducts and building materials. • Continued development of at least two carbon conversion integrated systems. • Standardized benchmarking for catalytic conversion systems.	• Continued scale up and higher-technology readiness level field testing of promising conversion technologies, such as at the National Carbon Capture Center.

Carbon Management Technologies
Point-Source Carbon Capture

Overview

Advancements in carbon capture technologies can support U.S. efforts to decarbonize industry and power generation. Transformational carbon capture technologies will advance U.S. leadership in low-emission generation, clean hydrogen innovation, and decarbonization of a range of industries, thus supporting efforts to achieve a decarbonized power sector by 2035 and a decarbonized economy by 2050. Carbon capture technologies can be applied to a wide variety of industries, such as electric power, ethanol, fertilizer, cement, steel, chemicals, refining, pulp and paper, natural gas processing and liquefaction, and others. Research and development (R&D) is focused on adapting technologies to under-investigated applications like heavy industry and natural gas power generation to make them robust enough to capture greater than 95 percent of the CO_2 emissions from a wide variety of sources. R&D can address materials and systems configuration challenges such as differences in pollution control systems, oxygen content, CO_2 concentrations, and unique integration issues associated with industrial applications.

R&D can improve economies of scale and address the technical challenges posed by increased capture efficiency, such as improved thermodynamics (reduced energetic requirements, lower pressure drops, lower temperature, process optimization), and kinetics (faster, more selective chemical/physical separation pathways). Process intensification and advanced manufacturing can reduce capital and operating costs. Scalability, durability, and flexibility are challenges that must be met to ensure long-term performance and the ability to work with variable power and capture rates.

The Department of Energy's (DOE) Office of Fossil Energy and Carbon Management's (FECM) Point-Source Carbon Capture subprogram is focused on R&D of carbon capture technologies that play a key role in decarbonizing committed emissions associated with hard-to-decarbonize industries and the power sector. The Point-Source Carbon Capture subprogram is developing capture technologies that are flexible to complement the ever-changing power grid, while simultaneously capable of achieving deep decarbonization of emission sources.

The subprogram has completed its efforts in 1st generation technology through successful demonstration projects. FY 2024 activities represent a focus on next-generation capture technologies to enable clean hydrogen and allow for the integration of advanced carbon capture technologies with both power and diverse industrial emission sources. Specifically, the FY 2024 Budget Request provides $144 million to capture R&D on transformational gas separation technologies capable of deep decarbonization (at least 95% of CO_2 at high purity suitable for compression and transport). The subprogram participates in the Industrial Decarbonization Science and Energy Technology Team and the Hydrogen Energy Earthshot groups and provides funding and analysis to support their goals. These investments can improve energy efficiency, reduce capital costs, and achieve high capture rates.

These advanced technologies will be designed to adapt to the operational demands of current and future power systems including the increasing need for thermal power plants to, at times, be load-following/demand-responsive electricity generators. The activity will investigate approaches to optimize the capture process for all point sources such as natural gas-based power systems including both natural gas combined cycle systems and simple cycle operations. Additionally, the subprogram will leverage its prior and current R&D experience on carbon capture technology development for application to industrial applications. R&D will focus on optimization of technologies for these applications to reduce cost and improve performance.

Key RDD&D challenges include:

- Improving Scalability – providing economic viability at all relevant process scales across all types of CO_2 emissions sources in the power and industrial sectors.
- Improving Thermodynamics – reducing energetic requirements through better regeneration energy, lower pressure drops, lower required temperatures, and process optimization.
- Improving Kinetics – improving equipment through faster, more selective chemical/physical separation pathways.
- Reducing Capital Cost – reducing equipment size and costs through advanced manufacturing, process intensification, integration, and optimization.
- Improving Durability – providing rugged long-term performance with slow degradation rates.
- Improving Flexibility – improving process dynamics by improving turn down and operation at variable capture rates.

- Minimizing Environmental Impact – providing technologies that minimize air pollution release and minimizing waste generation.

The Point-Source Carbon Capture subprogram will focus on carbon capture front-end engineering design (FEED) studies for power plants and industrial sources. FEED studies are a critical step in the process for eventual technology deployment. They help define the design of the system and provide valuable technical input for eventual investment decisions. FEED studies also help identify potential areas for R&D and information to validate techno-economic studies and lifecycle analyses. FEED studies for industrial sources allows decisions regarding both the aggregation of numerous emission points and the possible integration of the capture system with the industrial facility. One FEED study of interest is emissions sources co-located with the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) projects, which is funded by the Carbon Transport and Storage subprogram. Pilot projects at industrial facilities will also be a focus of the Point-Source Carbon Capture sub-program.

Although FEEDs and pilots will be a central focus, activities in FY 2024 will continue to some extent on R&D for CO_2 capture technologies such as non-aqueous solvents, membranes, advanced sorbents, and cryogenic processes that may lead to significantly decreased energy needs. This will be achieved using advanced computational tools for rational material discovery, design of advanced capture systems components, use of advanced manufacturing, and synthesis of these materials with characterization of their physical properties. Initial work on reactive capture and conversion projects was started in FY 2021 and follow-on work from those successful projects can be initiated in FY 2024. Funding will continue to support the National Carbon Capture Center (NCCC) to provide testing on actual flue gas.

The FY 2024 request also includes separation of CO_2 from synthesis gas streams derived from gasification (or other high-pressure streams) prior to its combustion for power production, or the separation of CO_2 to produce hydrogen or other products.[1] Specifically, hydrogen from natural gas can be generated from various technological approaches such as steam methane reformers, autothermal reformers, and partial oxidation. Steam methane reformers remain the most economical and widespread way to produce hydrogen and currently account for over 90% of the hydrogen produced globally. New autothermal reformer construction is becoming increasingly more common as the process concentrates CO_2 and allows for deeper decarbonization using pre-combustion technologies at lower cost than steam methane reformers. Partial oxidation is another method for hydrogen production that has potential for commercialization. Following the passage of the Inflation Reduction Act and the enhancements for clean hydrogen production, many projects are anticipated.

The Point-source Carbon Capture sub-program is also focusing on reducing the costs and emissions of non-CO_2 pollutants associated with the use and combustion of carbon-containing fuels. This effort includes systems analyses and technical assessments to identify and address issues associated with non-CO_2 emissions from power plants and industrial applications (e.g., trace and heavy metal emissions in solid, liquid, and gaseous effluents that are potential areas of concern). This will also include evaluation of possible emissions and waste streams from carbon capture technologies to ensure these systems are environmentally robust. Additional broad research objectives include technologies to reduce and analyze environmental legacy issues related to ash storage facilities. Where applicable, the impacts of and the correlation between feedstocks, their content of basic and trace elements, and geochemical interactions in-situ, and the correlation of geology on ash composition are topics of consideration.

[1] Syngas is primarily hydrogen (H_2) and carbon monoxide (CO) but can include other gaseous constituents. After the syngas is produced, it is further processed in a Water Gas Shift (WGS) reactor to prepare it for pre-combustion capture. WGS converts CO and water to additional H_2 and CO_2.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Point-Source Carbon Capture $135,000,000	**$144,000,000**	**+$9,000,000**
• Continue support for several transformational bench scale carbon capture tests on actual flue gases from coal and natural gas, focused on capture rates >95% and determination of co-benefits of capture. • Support transformational R&D and pilot-scale carbon capture projects for industrial sources of CO_2. • NCCC: Fund and operate the NCCC post-combustion carbon capture test facility for transformational technology development. • Support up to 10 carbon capture FEED studies for industrial and natural gas sources of CO_2. • Conduct transformational carbon capture R&D for hydrogen production from gasification-based systems using fossil fuels, biomass, and waste plastics. • Conduct transformational carbon capture development that supports hydrogen production and other industrial applications. • Conduct R&D, systems analyses and technical/economic assessments to identify and address non-CO_2 emissions from power plants and industrial sources (e.g., trace metals emissions in solid, liquid, and gaseous effluents that are potential areas of concern) as well as legacy storage facilities such as ash impoundments and landfills.	• Support transformational pilot-scale carbon capture projects for industrial sources of CO_2. • NCCC: Fund and operate the NCCC post-combustion carbon capture test facility for transformational technology development. • Support up to 12 carbon capture FEED studies for industrial and natural gas sources of CO_2. • Fund follow-on promising reactive capture and conversion projects. • Funding supports evaluation of emissions sources from carbon capture technologies and corresponding mitigation solutions. • Conduct R&D, systems analyses and technical/economic assessments to identify and address non-CO_2 emissions from power plants and industrial sources (e.g., trace metals emissions in solid, liquid, and gaseous effluents that are potential areas of concern) as well as legacy storage facilities such as ash impoundments and landfills.	• The funding request complements the $3.5 billion in Bipartisan Infrastructure Law funding for CCUS demonstrations and pilot projects and reflects prioritization on key areas of transformational technologies for higher capture rates, pilot-scale tests, and FEED studies for industrial and natural gas-derived sources of CO_2.

Carbon Management Technologies
Carbon Management – Policy, Analysis, and Engagement

Description

Carbon Management – Policy, Analysis, and Engagement supports high-impact, crosscutting, integrative analysis, and engagement activities through close coordination within the Office of Fossil Energy and Carbon Management (FECM) technology programs, other DOE offices, other federal agencies, and other global partners. It has three activities that it funds: 1) Carbon Management – Policy and Analysis, 2) Carbon Management – Engagement, and 3) Carbon Management – Federal Partnerships. The Budget Request provides $5 million to support activities in this subprogram.

This subprogram provides portfolio-wide analysis for decision-makers and extensive data, tools, and technical assistance to relevant stakeholders as the Nation embarks on an unprecedented build-out of carbon management research, development, demonstration, and deployment (RDD&D) efforts in support of the Administration's goals. Policy, analysis, and engagement efforts will help FECM maximize the impact of its research dollars, track the impacts of FECM investments, and help ensure benefits for all Americans. This subprogram also supports strategic planning by identifying major challenges and opportunities to improve efficiency, cost, and socioenvironmental performance within all the subprograms of the Carbon Management Technologies program.

Carbon Management – Policy and Analysis

The Carbon Management – Policy and Analysis activity evaluates potential economic, employment, and socioenvironmental benefits from the deployment of carbon management technologies. It also creates and disseminates tools and information used by other external users to better understand the role of carbon management technologies in an ever-evolving energy economy. The Budget Request of $3.5 million for this activity:

- Allows FECM to perform economic and environmental benefit assessments for the Office of Carbon Management's RDD&D portfolio using advanced modeling methodologies. Advanced modeling methodologies include the use of modified versions of the Energy Information Administration's (EIA's) National Energy Modeling System (NEMS), big data analytics on key energy and industrial market metrics, and use of production cost modeling to understand electricity market dynamics.
- Informs Carbon Management's RDD&D strategic planning and decision-making by studying current and potential future market conditions which might influence future technology marketability. These studies seek to identify potential market-driven opportunities which might aid in the deployment of carbon management technologies. It also seeks to identify potential market needs which can be addressed by RDD&D activities.
- Disseminates best practices and approaches for carbon management technologies in economic and market models. Entities like the Environmental Protection Agency (EPA), EIA, and others depend on FECM systems analysis to characterize and represent future decarbonization opportunities.
- Analyzes crosscutting issues which have the potential to affect the deployment of carbon management technologies like electric power grid integration, infrastructure deployment, and competitiveness implications of changing energy and industrial markets as they seek to reduce their GHG emissions.

Carbon Management - Engagement

The Carbon Management – Engagement activity supports RDD&D of carbon management technologies through engagement with key partners within the U.S. and globally. Funding will support domestic and international engagement efforts. Scaling up technologies within the carbon management RDD&D program portfolio is a global challenge that requires effective international engagement. FECM accomplishes this work through strategic partnerships with other governments, research organizations, bilateral and multilateral stakeholder efforts and through technical support and capacity building assistance provided to other countries. FECM will work with various stakeholders to build a foundation for expeditiously administering several new investments, leveraging existing programs and developing new relationships with stakeholder networks and communities. The $1 million Budget Request for this activity:

- Accelerates the advancement and responsible deployment of technologies within the carbon management RDD&D program portfolio globally, through both policy and technical expertise, along with forward-looking RDD&D, and capacity building.

- Works with international partners committed to carbon management as a long-term climate strategy and to prioritizing decarbonization by 2050 through concerted global actions.
- Makes targeted investments in international carbon management efforts with select countries that can accelerate technological development for climate mitigation and prime major global markets for American technologies and services.
- Works with stakeholders and communities to build a foundation for effectively administering new and augmented federal investments in carbon capture and storage (CCS), carbon dioxide removal (CDR), and other carbon management technologies and infrastructure.
- Facilitates and regularly engages in exchanges of information and insights with partners and stakeholders on RDD&D progress and needs, as well as policy tools and public-private partnerships in the U.S.
- Conducts proactive, place-based community engagement and planning processes that include consideration of CCS and CDR development, in the context of broader decarbonization options, to ensure that carbon management projects benefit communities.

Carbon Management – Federal Partnerships

The Carbon Management – Federal Partnerships activity is focused on policy, regulatory, and interagency engagement needed to successfully execute DOE's carbon management RDD&D programs, including the Office of Carbon Management's interactions with other government agencies on environmental, legislative, and regulatory matters related to carbon management technologies within the RDD&D portfolio. Support will be for interagency engagement for the Office and facilitating dialogue on regulatory and permitting issues among industry, states, and other interested parties to advance the Office of Carbon Management's mission. The Budget Request of $0.5 million for this activity:

- Leads government-wide efforts to enhance interagency collaboration and coordination on carbon management with a particular focus on sharing information about DOE R&D programs and leveraging technical expertise within the Department to support government-wide efforts associated with carbon management technologies and approaches.
- Conducts outreach and engagement with a wide range of federal and state regulators to build awareness and technical capacity to develop and implement new regulations, update existing best practices, issue permits, develop monitoring technologies and protocols, and evaluate any other regulatory or policy barriers for the DOE projects.
- Supports Congressional, Administration, and DOE priorities associated with deployment of carbon management technologies and approaches which are policy or regulatory in nature and require significant interagency collaboration such as IRS tax credit policy development/execution, federal advisory committees, and reports to Congress. This includes implementation of specific Congressional mandates or Executive Orders.
- Serves as a key focal point across the U.S. Government for interagency collaboration on technical, policy, and regulatory issues related to CCS and CDR.
- Serves as a central point of contact for stakeholders to ensure timely resolution of technical concerns and enable efficient, orderly, and responsible development of carbon management technologies at increased scale.
- Works with other agencies to develop and improve accounting frameworks and tools to accurately measure carbon removal and storage methods and technologies. Per the Energy Act of 2020, the Secretary of Energy "shall collaborate with the Administrator of the EPA and the heads of other relevant Federal agencies to develop and improve accounting frameworks and tools to accurately measure carbon removal and sequestration methods and technologies." (Title IV—Carbon Management and Title V— Carbon Removal, Section 5001, Energy Act of 2020, Division Z of P.L. 116-260).

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Carbon Management - Policy, Analysis, Engagement: $0	**$5,000,000**	**+$5,000,000**
Carbon Management – Policy and Analysis: $0	**$3,500,000**	**+$3,500,000**
• Evaluate potential economic, jobs, and environmental benefits and impacts from the deployment of carbon management and fossil technologies.	• Perform economic and environmental benefits assessments for the Office of Carbon Management's RDD&D portfolio using advanced modeling methodologies, study current and potential future market conditions which might change future technology viability, analyze crosscutting issues which have the potential to affect the deployment of Carbon Management technologies, and provide technical support as part of intergovernmental activities in areas of expertise (e.g., EPA, Internal Revenue Service (IRS) Section 45Q and 45V, LCA Guidelines).	• The increase in funding will expand the capabilities of the analysis division, allowing work on hydrogen technologies and infrastructure, carbon capture and storage, and general systems-based energy and carbon management modeling. This includes integration of advanced enhancements to the National Energy Modeling System to analyze potential future deep decarbonization scenarios and carbon management technologies contribution to reliability and resilience. • Funding increase will also enable integrated analysis of market driven opportunities in the industrial and power sector for carbon management technologies. This will enable further inventory and systems analyses to highlight lower cost opportunities for achieving carbon reductions.
Carbon Management – Engagement: $0	**$1,000,000**	**+$1,000,000**
• Support domestic and international engagement activities and agreements.	• Support domestic and international engagement activities and agreements, including key global partnerships to advance DOE's RDD&D programs.	• Additional funding will support expanded domestic engagement as well as new international agreements supporting the administration's decarbonization priorities.
Carbon Management – Federal Partnerships: $0	**$500,000**	**+$500,000**
• This is a new activity in the FY 2024 Request.	• Conduct policy, regulatory, and interagency engagement needed to successfully execute DOE's carbon management RDD&D programs, including working with federal partners on permitting.	•Additional funding will support interagency engagement and facilitating dialogue on regulatory and permitting issues among industry, states, and other interested parties to advance the Office of Carbon Management's mission.

Carbon Management Technologies
Supercritical Transformational Electric Power (STEP)

Description

The Supercritical Transformational Electric Power (STEP) activity line was created within the Carbon Capture, Utilization and Storage (CCUS) and Power Systems Program by Public Law 113-235 Consolidated and Further Continuing Appropriations Act, 2015).

The STEP program focuses on research, development, demonstration, and deployment (RDD&D) to advance higher efficiency, lower cost technologies that use supercritical CO_2 (sCO_2) for power cycles. In FY 2024, the program will continue to work toward design, construction, start-up, shakedown, and operation of the 10 MWe pilot facility and support initial testing to establish operability and performance of a simple sCO_2 cycle. This effort includes the design, development, and fabrication of major components in the cycle (i.e., turbomachinery, recuperators, heat source integration, etc.).

No funding is requested for the STEP 10 MWe pilot in the FY 2024 Budget Request. Currently, the project is fully funded for Phase 2 of the original scope of work (SOW) and will complete the existing SOW in FY 2024-Q1.

The FY 2024 Budget Request does not provide additional funds for this activity.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Supercritical Transformational Electric Power (STEP)		
$0	**$0**	**$0**
• No funding was enacted in FY 2023.	• No funding is requested in FY 2024.	• No funding requested in FY 2024.

Resource Sustainability
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
167,600	195,000	179,000	-16,000	-8.2%

Overview

Methane is a potent greenhouse gas (GHG) and is the second most abundant anthropogenic source of GHG emissions after carbon dioxide (CO_2). Reducing the impacts associated with the production, transportation, and storage of oil, natural gas, and coal is critical to achieving net-zero GHG emissions. Looking ahead, innovative technologies will provide alternative solutions, such as conversion of flared or vented methane to high-value products and cleaning water produced from hydraulic fracturing operations for agriculture use.

The U.S. has the most extensive natural gas production, gathering, processing, storage, and delivery infrastructure systems in the world. The natural gas pipeline network includes more than 300,000 miles of interstate and intrastate pipelines, and this infrastructure is facing operational challenges including the leaking of methane emissions into the atmosphere, risks of delivery disruptions, and public safety. It is critical to safely monitor and repair pipeline infrastructure and develop new technologies and solutions for reducing the risks of future leaks and delivery disruptions as the infrastructure system grows and pipelines age.

The Resource Sustainability Program addresses the critical environmental and safety issues associated with the U.S.' historical and continued production and use of fossil fuels. Specifically, the Program's mission is to conduct research, development, demonstration, and deployment (RDD&D) that reduces environmental impacts from the development, extraction, transportation, distribution, and storage of fossil fuels. The program comprises five subprograms: Advanced Remediation Technologies, Methane Mitigation Technologies, Natural Gas Decarbonization and Hydrogen Technologies, Mineral Sustainability, and Resource Sustainability – Analysis and Engagement.

The Advanced Remediation Technologies program focuses on developing solutions that address the environmental and social impacts of oil and natural gas exploration and production. Oil and gas development results in large volumes of produced water which could be cleaned and used to benefit local communities or safely disposed of without causing induced seismic events. Offshore oil development carries the risk of oil spills and contamination to important ecological environments. Many communities that rely on oil and natural gas development for jobs and economic activity are also the same communities affected by poor air quality, water contamination, oil spills, and induced seismicity.

The Methane Mitigation Technologies program supports activities focused on innovative sensors, compressors, infrastructure components, and analytical technologies that enable the detection, quantification, and mitigation of emissions and improve the reliability of natural gas transmission, distribution, and storage facilities. Given the Nation's reliance on natural gas, it is critical to ensure the safety and reliability of related infrastructure. This program will develop advanced technologies to detect, locate, and measure emissions that will inform research, analytics, and remediation efforts. Finding and measuring emissions from natural gas production fields, transportation and storage systems, and legacy infrastructure, including abandoned and orphaned wells, is critical to reducing emissions and addressing negative impacts to air quality and ground water that impact communities. The program will also develop innovative technologies to reduce flaring and venting of natural gas through conversion of the flared and vented natural gas to high-value, readily transportable products.

The Natural Gas Decarbonization and Hydrogen Technologies program supports the development of hydrogen technologies that help contribute to a carbon-pollution-free economy. The fastest and most reliable path to advance a hydrogen economy is to build on low-cost, readily available natural gas and existing natural gas infrastructure. The Natural Gas Decarbonization and Hydrogen Technologies program will focus on advancing technologies for the carbon-neutral production, transportation, and storage of hydrogen sourced from natural gas. The program will also leverage the Office of Fossil Energy and Carbon Management's (FECM's) extensive experience with underground storage of natural gas to develop technologies for underground storage of hydrogen.

The Resource Sustainability - Analysis and Engagement program provides analytical capability to prioritize efforts across the Resource Sustainability research program, informs research decisions, conducts natural gas economic and environmental life cycle analysis, and analysis of fossil energy markets and industry to better inform the Department on fossil energy resources. The program also engages with domestic and international stakeholders on activities associated with technologies and approaches related to fossil energy.

Highlights of the FY 2024 Budget Request

The Resource Sustainability Program will pursue the following major activities in FY 2024:

Advanced Remediation Technologies

The Advanced Remediation Technologies program will conduct R&D to address wellbore integrity, induced seismicity, produced water treatment, and offshore safety and spill prevention. A redesigned field program will focus on conducting research to minimize the environmental impacts associated with unconventional oil and gas production, and exploration of pathways that would result in a positive impact on climate, such as coupling production with CO_2 storage.

Methane Mitigation Technologies

The Methane Mitigation Technologies program will conduct R&D to advance methane sensor technologies to detect and quantify methane emissions from production fields, pipelines, infrastructure equipment, storage facilities, and abandoned wells; pipeline materials, pipeline sensors, and pipeline data management and computational tools; and advanced modular natural gas conversion technologies for the purpose of beneficially utilizing otherwise flared or stranded natural gas. In addition, the program will collect, analyze, and distribute methane emissions data, information, and knowledge to inform efforts on methane mitigation technology development and support the Environmental Protection Agency's (EPA) Greenhouse Gas Inventory; expand field research on methane measurement technologies and analysis methods for quantifying emissions at basin-level assessments; and implement a strategy to reconcile methane emissions estimates from surface-based measurements (bottom-up) and atmospheric measurements (top-down) that will minimize and resolve the difference between these two segments on a large-scale.

Natural Gas Decarbonization and Hydrogen Technologies (NGDHT)

The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) Program will support R&D to advance clean hydrogen production and infrastructure for natural gas decarbonization; Hydrogen production from produced water; technologies for enabling safe and efficient transportation within the U.S. natural gas pipeline system; and fundamental research to enable subsurface hydrogen storage. Programmatic activities will be conducted in support of and coordination with the Hydrogen and Carbon Management Division within FECM and with the Hydrogen and the Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

Mineral Sustainability

The Mineral Sustainability Program will advance technologies to support development of the domestic supply chain networks required for the economically, environmentally, and geopolitically sustainable production and processing of critical minerals (CM). This mission will be accomplished by prioritizing the use of unconventional resources such as coal waste and by-products from industry feedstocks for domestic CM, rare earth elements (REE) and carbon ore to products production. The program will also focus on utilizing materials to be recycled from currently mined and previously mined resources outside of traditional thermal and metallurgical markets that can support high-wage employment and value-added production in communities and regions dependent on traditional mining.

Resource Sustainability - Analysis and Engagement

Analysis and Engagement will focus on analysis and studies that support environmentally prudent production, transport, storage, and use of domestic fossil fuels with an understanding of their role as a strategic asset for the U.S. and its allies for global energy security and provides evidence-based, portfolio-wide analysis for decision-makers. This includes economic and environmental analysis, modeling, market analysis, analysis of markets during volatility, studies that provide support to the overall Resource Sustainability Program, and data driven assessments of the impacts of different tools and levers that can be used to provide reliable and affordable fossil energy supplies to the domestic market. The program will inform research priorities, engagement with domestic and international governments and organizations, and provide market and industry analysis to inform the Department on fossil energy resources.

Resource Sustainability
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
RESOURCE SUSTAINABILITY					
Advanced Remediation Technologies					
Environmentally Prudent Stewardship	41,000	25,000	13,000	-12,000	+48.00%
Gas Hydrates	10,000	20,000	0	-20,000	-100.00%
Water Management Technologies	4,600	10,000	0	-10,000	-100.00%
Subtotal Advanced Remediation Technologies	**55,600**	**55,000**	**13,000**	**-42,000**	**-76.4%**
Methane Mitigation Technologies	**39,000**	**60,000**	**100,000**	**+40,000**	**+66.7%**
Natural Gas Decarbonization and Hydrogen Technologies	**20,000**	**26,000**	**20,000**	**-6,000**	**-23.1**
Mineral Sustainability					
Critical Minerals	44,000	44,000	12,000	-32,000	-72.73%
Carbon Ore Processing	9,000	10,000	4,000	-6,000	-60.00%
Resource Characterization Technologies	0	0	29,000	+29,000	N/A
Subtotal Mineral Sustainability	**53,000**	**54,000**	**45,000**	**-9,000**	**-16.7%**
Resource Sustainability – Analysis and Engagement	**0**	**0**	**1,000**	**+1,000**	**N/A**
TOTAL, RESOURCE SUSTAINABILITY	**167,600**	**195,000**	**179,000**	**-16,000**	**-8.21%**

SBIR/STTR:

- FY 2022 Enacted: SBIR $2,772: STTR: $390
- FY 2023 Enacted: SBIR $5,348: STTR: $752
- FY 2024 Request: SBIR $4,037: STTR: $568

Resource Sustainability
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Resource Sustainability	
Advanced Remediation Technologies: This decrease reflects the completion of gas hydrates field work in the Gulf of Mexico and the completion of the Alaska production test. No funding is requested for the treatment of effluent waters from coal wastes. The program will focus on research to develop solutions that address the environmental impacts of oil and natural gas development in FY 2024.	**-42,000**
Methane Mitigation Technologies: Funding increase reflects a focus on the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, maintainable, and low-cost integrated methane monitoring platform that will enable early detection and, ultimately, quantification of emissions along the natural gas supply chain. This integrated methane monitoring platform will incorporate surface level sensors, autonomous, low-cost optical methane sensors and imagers on unmanned aerial systems, integration of methane emissions data acquired from geospatial satellites, and new multidimensional data modeling and predictive capabilities using machine learning tools. In addition, the funding increase will enable the scale-up and field validation of advanced pipeline materials, methane sensor technologies, compressor and engine leak mitigation components, and computational technologies for emissions reduction in oil and gas infrastructure; conversion technologies for stranded and vented gas; and advanced remote detection technologies.	**+40,000**
Natural Gas Decarbonization and Hydrogen Technologies: Decrease reflects a lower level of effort in research on hydrogen storage for FY 2024 and strategic focus on conversion, blending, and transportation.	**-6,000**
Mineral Sustainability: Funding decrease reflects reduced funding for coal-based building materials composed of carbon ore, while maintains partial funding for supporting large-scale pilot development through FEED studies to produce large quantities of high purity, commercial-grade REE and other CMs, and maturation of transformational processing from unconventional resources.	**-9,000**
Resource Sustainability - Analysis and Engagement: Funding increase will support the technical, economic, and socio-economic studies to support the Department and other agencies regarding methane emissions, critical minerals, hydrogen storage, and other crosscutting efforts. Funding will provide economic, market, and industry analysis on oil, gas, coal, and petrochemical resources. It will also support the international and domestic engagements with governments, states, industry, and other stakeholders to reduce methane emissions related to fossil fuel use, and to pursue the development of critical materials from domestic fossil resources.	**+1,000**
Total, Resource Sustainability	**-16,000**

Resource Sustainability
Advanced Remediation Technologies

Overview

Fossil fuels have contributed to America's economy and have provided fuel for vehicles, heat for homes, industrial goods, plastics, and other important products. These many benefits from oil, natural gas, and coal also come with impacts to climate and the environment. The Advanced Remediation Technologies Program addresses these critical issues. The Program conducts research and development(R&D) that reduces the climate and environmental impacts from the development, transportation, distribution, and storage of fossil energy resources.

The Environmentally Prudent Stewardship subprogram will focus on developing solutions that address the environmental, climate, and social impacts of fossil fuel development. Hydraulic fracturing requires the use of large amounts of water and chemicals, which need to be cleaned and safely disposed of without causing induced seismic events. Offshore oil development carries the risk of oil spills and contamination to important ecosystems. Many communities that rely on oil, natural gas, and coal development for jobs and economic activity are also the same communities affected by poor air quality, water contamination, oil spills and/or induced seismicity.

There is no funding requested for the Water Remediation subprogram in FY 2024.

There is no funding requested for the Gas Hydrates subprogram in FY 2024.

Highlights of the FY 2024 Budget Request

The Environmentally Prudent Stewardship subprogram will conduct R&D technologies to address wellbore integrity, induced seismicity, produced water treatment, water management for coal related wastes, and offshore safety and spill prevention.

Resource Sustainability
Advanced Remediations Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Advanced Remediations Technologies					
Environmentally Prudent Stewardship	41,000	25,000	13,000	-12,000	-48.00%
Gas Hydrates	10,000	20,000	0	-20,000	-100.00%
Water Remediation Technologies	4,600	10,000	0	-10,000	-100.00%
Total, Advanced Remediations Technologies	**55,600**	**55,000**	**13,000**	**-42,000**	**-76.4%**

Resource Sustainability
Advanced Remediation Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Advanced Remediation Technologies	
Environmentally Prudent Stewardship: This decrease reflects continued research to develop solutions that address the environmental impacts of oil and natural gas development.	**-12,000**
Gas Hydrates: No funding requested in FY 2024 due to the completion of field work in the Gulf of Mexico and the Alaska production test.	**-20,000**
Water Management Technologies: No funding requested in FY 2024.	**-10,000**
Total, Advanced Remediation Technologies	**-42,000**

Overview

Environmentally Prudent Stewardship

The Environmentally Prudent Stewardship subprogram will focus on addressing the environmental impacts from oil and natural gas development, including unconventional development and offshore safety and spill prevention. The program will build on previous research conducted and data collected from the Department of Energy's (DOE) 17 Field Laboratory projects to inform future research. These field projects conducted research on multiple facets of the production process in unique geological basins, including capturing environmental data before, during, and after hydraulic fracturing operations. Research included mapping and visualization of the subsurface, wellbore integrity, produced water research, groundwater contamination, air quality, and data analytics.

The Field Laboratory program focused on conducting research to minimize the environmental impacts associated with unconventional oil and gas production. There has been a substantial body of knowledge gained about the geochemistry, geomechanics, and geophysics of oil and gas reservoirs from this program. Artificial Intelligence/Machine Learning (AI/ML) efforts are being applied to leverage this knowledge and data to the storage of CO_2 in depleted conventional and unconventional oil and gas reservoirs. Research will continue to focus on minimizing the environmental impacts associated with unconventional oil and gas production, as well as exploration of pathways that will result in a positive impact on climate, such as coupling production with CO_2 storage.

DOE's offshore safety and spill prevention research will focus on identifying and mitigating risks from ocean currents and seafloor hazards, such as landslides; reducing risks associated with infrastructure used to deliver chemicals to the well and to bring produced fluids to the platform; and assessing, predicting, and mitigating the risks associated with an aging offshore infrastructure. DOE is working with the Department of the Interior (DOI), under a Memorandum of Collaboration, to pursue collaborative offshore research to increase safety and reduce environmental risk.

Water Remediation Technologies

There is no funding requested for the Water Remediation Technologies subprogram in FY 2024.

Gas Hydrates

There is no funding requested for the Gas Hydrates subprogram in FY 2024.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Advanced Remediation Technologies **$55,600,000**	**$13,000,000**	**-$42,000,000**
Environmentally Prudent Stewardship **$25,000,000**	**$13,000,000**	**-$12,000,000**
• Research on reducing the environmental footprint of unconventional oil and gas development. • Funding Opportunity Announcement (FOA), on an environmentally focused field test sites program. • FOA on produced water treatment research.	• Funding will support research that addresses the environmental impacts of fossil fuel development. These topics include wellbore integrity, produced water remediation, and oil spill prevention.	• This request represents a continuation of research that addresses the environmental impacts of fossil fuel development at an appropriate level of effort. These topics include wellbore integrity and oil spill prevention.
Gas Hydrates $20,000,000	**$0**	**$-20,000,000**
• No funding was requested within the Advanced Remediation Technologies Budget Request in FY 2023.	• No funding is requested within the Advanced Remediation Technologies Budget Request.	• No funding is requested within the Advanced Remediation Technologies Request due to the completion of field work in the Gulf of Mexico and the Alaska production test.
Water Management Technologies $10,000,000	**$0**	**$-10,000,000**
• No funding was requested for Water Management Technologies in FY 2023.	• No funding is requested within the Advanced Remediation Technologies Budget Request.	• No funding is requested within the Advanced Remediation Technologies Budget Request. Research related to water management is requested within the Environmentally Prudent Stewardship subprogram focused on produced water from unconventional oil and gas production.

Resource Sustainability
Methane Mitigation Technologies

Overview

The Methane Mitigation Technologies Program addresses methane emissions associated with the production, processing, transportation, and storage of domestic oil and natural gas. Methane is the second highest anthropogenic greenhouse gas (GHG) and is more potent than carbon dioxide. The Program's mission is to conduct research and development, (R&D) of technologies and solutions that detect, quantify, reduce, and mitigate methane emissions throughout the oil and natural gas value-chain.

The program supports R&D focused on advanced materials, innovative sensors, natural gas compressors and engines, infrastructure components, and analytical technologies that enable the detection and mitigation of leaks, and improve the reliability of natural gas transmission, distribution, and storage facilities. The program will address natural gas flaring and venting through the development of modular technologies that can be deployed to the field and capture and convert natural as into high-value, readily transportable products. The program develops and demonstrates technologies for detecting and quantifying methane emissions from oil and natural gas production areas, processing facilities, transportation networks, storage systems, and legacy infrastructure (e.g., abandoned wells). Efforts will also be focused on accelerating the application of real-time emissions monitoring capabilities across broad areas (basin-wide) and on resolving current differences between surface-based ("bottom-up") and remote sensing ("top-down") emissions detection and measurement approaches through the development of integrated monitoring platforms.

Highlights of the FY 2024 Budget Request

The Methane Mitigation Technologies Program will pursue the following major activities in FY 2024:

- Developing technologies in advanced pipeline materials, pipeline sensors and systems, pipeline data management and computational tools, in-pipe inspection and repair technologies, and compressor and engine methane slip mitigation technologies.
- Developing advanced modular natural gas conversion technologies, capable of being deployed near wellheads, natural gas processing facilities, and transportation infrastructure, for the purpose of beneficially utilizing otherwise flared or stranded natural gas.
- Developing advanced methane sensor technologies to detect and quantify methane emissions from production fields, pipelines, infrastructure equipment, storage facilities, and abandoned wells.
- Developing and validating methane emissions detection and measuring technologies to accelerate adoption of the most accurate and cost-effective methods, including superior and even transformational technologies that have yet to gain a significant market share.
- Collecting, analyzing, and distributing methane emissions data, information, and knowledge to inform methane mitigation technology development and the Environmental Protection Agency's (EPA) Greenhouse Gas Inventory.
- The program will expand field research on methane measurement technologies and analysis methods for quantifying methane emissions and expanding to basin-level assessments. The program will implement a strategy to achieve a convergence of methane emissions estimates from the surface-based natural gas and oil emission estimates (bottom-up) and the atmospheric emission measurements (top-down)—to minimize and transparently resolve the difference between these two segments on a large-scale.

Resource Sustainability
Methane Mitigation Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Methane Mitigation Technologies	39,000	60,000	100,000	+$40,000	+66.7%
Total, Methane Mitigation Technologies	**39,000**	**60,000**	**100,000**	**+$40,000**	**+66.7%**

Resource Sustainability
Methane Mitigation Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Methane Mitigation Technologies: Funding increase reflects a focus on the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, maintainable, and low-cost integrated methane monitoring platform that will enable early detection and, ultimately, quantification of emissions along the natural gas supply chain. This integrated methane monitoring platform will incorporate surface level sensors, autonomous, low-cost optical methane sensors and imagers on unmanned aerial systems, integration of methane emissions data acquired from geospatial satellites, and new multidimensional data modeling and predictive capabilities using machine learning tools. In addition, the funding increase will enable the scale-up and field validation of advanced pipeline materials, methane sensor technologies, compressor and engine leak mitigation components, and computational technologies for emissions reduction in oil and gas infrastructure; conversion technologies for stranded and vented gas; and advanced remote detection technologies.	**+$40,000**
Total, Methane Mitigation Technologies	**+$40,000**

Resource Sustainability
Methane Mitigation Technologies

Description
The Methane Mitigation Technologies program is committed to developing advanced, cost-effective technologies to reduce emissions from fossil energy infrastructure. Priority areas for the program include research on technologies to detect, measure, and mitigate emissions. This includes remote sensors, advanced materials for pipeline integrity, data management and systems, tools that employ artificial intelligence, and more efficient and flexible compressors to adapt to varying pipeline conditions and additional fluids.

The program will accelerate advances in remote sensor technologies that can detect and locate emissions from pipelines, natural gas storage, and legacy infrastructure. The program will conduct research on materials and remediation technologies that can be deployed by states, industry, or other government agencies to aid in the remediation of legacy emitters.

The program will advance technologies for the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, maintainable, and low-cost integrated methane monitoring platform. This integrated methane monitoring platform will incorporate surface level sensors, autonomous, low-cost optical methane sensors and imagers on unmanned aerial systems, integration of methane emissions data acquired from geospatial satellites, and new multidimensional data modeling and predictive capabilities using Artificial Intelligence/Machine Learning (AI/ML) tools.

The program will accelerate advances in materials science that can enhance pipe integrity, reduce leaks, and improve the efficiency of infrastructure operations. Research will support the development of low cost, low maintenance sensor technologies that can provide predictive analytics on pipeline corrosion rates via detection and monitoring of temperature, pressure, chemical composition of materials, vibration, and strain.

The program will develop advanced modular technologies capable of being deployed near wellheads and natural gas processing and transportation infrastructure for the purpose of beneficially utilizing otherwise flared, vented, or stranded natural gas. The program envisions an R&D effort focused on developing and field testing new and disruptive technologies aimed at converting the otherwise wasted resource, consisting primarily of methane and ethane into electricity or value-added, easily transportable products.

The program will focus on developing advanced technologies to detect, locate, and measure emissions. This will include the development and validation of measurement and sensor technologies for the collection, dissemination, and analysis of emissions data, and will provide support to EPA's Greenhouse Gas Inventory. These activities will also inform future research efforts and priorities; improve analytics and modeling; and inform mitigation and remediation efforts for oil and natural gas production and processing sites, natural gas pipelines, storage facilities, and legacy infrastructure.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Methane Mitigation Technologies $60,000,000	**$100,000,000**	**+$40,000,000**
• Research on materials, coatings, and sensors to improve the reliability, safety, and reduce emissions from natural gas supply and delivery infrastructure. • New and innovative technologies aimed at converting flared and vented methane into value-added products. • Advanced methane detection and measurement technology validation. • Conduct basin-level methane emissions measurements.	• Funding for advanced remote detection technologies for natural gas infrastructure. • Funding to develop technologies in advanced materials, data management tools, in-pipe inspection and repair technologies, and dynamic compressor research and development. • Funding to develop advanced modular conversion technologies for stranded and flared natural gas. • Funding for the development of modular remediation materials and solutions. • Funding to support the development of integrated direct and remote measurement sensor technologies for the collection, dissemination, and analysis of emissions data. • Research, data collection, and analytics that support EPA's Greenhouse Gas Inventory.	• Funding increase reflects a focus on the need to support the monitoring, measurement, and mitigation of methane emissions within a low cost, efficient, implementable, maintainable, and low-cost integrated methane monitoring platform that will enable early detection and, ultimately, quantification of emissions along the natural gas supply chain. • Scale-up and field validation of advanced pipeline materials, methane sensor technologies, compressor and engine leak mitigation components, and computational technologies (Artificial Intelligence/Machine Learning) to enhance pipeline integrity. • Scale-up and pilot-scale field testing of technologies to eliminate natural gas flaring and venting.

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Overview

The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) program will focus on technologies for carbon-neutral 1) production of clean hydrogen; 2) transportation of hydrogen and fluid hydrogen carriers; and 3) geologic storage technologies that leverage existing natural gas resources and infrastructure. Technology development and maturation will focus on decarbonizing natural gas production infrastructure; ensuring safe and effective hydrogen blending within existing natural gas pipeline transportation; and characterizing, demonstrating, and supporting the deployment of bulk subsurface storage infrastructure. The program will also develop analytical tools and models that are able to evaluate potential advanced technologies, technology performance metrics, technoeconomic and lifecycle analyses, and resource evaluations.

Highlights of the FY 2024 Budget Request

The NGDHT Program will focus on extramural R&D related to: 1) Clean Hydrogen Production and Infrastructure for Natural Gas Decarbonization; 2) Hydrogen Production from Produced Water; 3) Technologies for Enabling the Safe and Efficient Transportation of Clean Hydrogen within the U.S. Natural Gas Pipeline System: and 4) Fundamental Research to Enable High-Volume Subsurface Hydrogen Storage. Programmatic activities will be conducted in support of and coordination with the Hydrogen and Carbon Management Division within FECM and with the Hydrogen and the Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Natural Gas Decarbonization and Hydrogen Technologies	20,000	26,000	20,000	-6,000	-23.1%
Total, Natural Gas Decarbonization and Hydrogen Technologies	**20,000**	**26,000**	**20,000**	**-6,000**	**-23.1%**

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Natural Gas Decarbonization and Hydrogen Technologies: Decrease reflects a lower level of effort in research on hydrogen storage for FY 2024 and strategic focus on conversion, blending, and transportation.	**-$6,000**
Total, Natural Gas Decarbonization and Hydrogen Technologies	**-$6,000**

Resource Sustainability
Natural Gas Decarbonization and Hydrogen Technologies

Description

The Natural Gas Decarbonization and Hydrogen Technologies (NGDHT) program was formally initiated in the FY 2022 Omnibus. The program coordinates with other DOE offices to support the transition towards a clean hydrogen-enabled economy through the decarbonization of natural gas conversion, transportation, and storage. The NGDHT program addresses specific methane utilization challenges including 1) hydrogen production research that focuses on technology maturation for next-generation production pathways to convert natural gas into hydrogen or application-specific co-products; 2) enabling more effective pipeline transport of hydrogen and natural gas blends by advancing the viability of related materials and technologies that emphasize sensors and sensing capabilities that can detect low concentrations of hydrogen and quantify emissions during transport within natural gas infrastructure; and 3) progress toward the development and demonstration of subsurface storage technologies to reliably inject and withdraw hydrogen and natural gas blends within characterized geologic systems, including depleted oil and natural gas reservoirs, salt caverns, hard rock caverns, and saline aquifers. The NGDHT program can leverage DOE assets and expertise to engage industry to accelerate technology demonstration and deployment opportunities across a decarbonized natural gas value chain in support of Administration goals.

Highlights of the FY 2024 Budget Request

The NGDHT will support the development of hydrogen technologies that help contribute to a carbon-pollution-free economy. The NGDHT program's mission is supported by analytical tools and models, which can provide better insight on utilizing natural gas to enable a more decarbonized hydrogen economy. The fastest and most reliable path to advance a hydrogen economy is to build on low-cost, readily available natural gas and existing natural gas infrastructure. The NGDHT program will focus on advancing technologies to adapt existing natural gas infrastructure for the transportation and storage of hydrogen, and to convert flared natural gas into hydrogen.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Natural Gas Decarbonization and Hydrogen Technologies $26,000,000	**$20,000,000**	**-$6,000,000**
• Research on production of carbon-neutral hydrogen from methane, including novel conversion technologies. • Develop blending and separation technologies for natural gas with hydrogen and materials and components for dual use of infrastructure. • Research on utilizing natural gas storage for hydrogen.	• Research on production of hydrogen from methane and produced water. • Develop sensing and sensor technologies to ensure safe and effective transport while mitigating leaks and emissions. • Research on utilizing natural gas storage for hydrogen and pilot-scale technology demonstration.	• Decrease reflects a lower level of effort in research on utilizing natural gas storage for hydrogen and pilot-scale technology demonstration.

Overview

Building our clean energy and industrial economy to meet our energy security and climate goals will require ever larger quantities of minerals and metals than are currently being consumed. Unfortunately, the U.S.'s import dependency on many of the minerals and metals needed for these technologies has continued to increase dramatically over the past 30 years.

The Mineral Sustainability program activities in the DOE Office of Fossil Energy and Carbon Management (FECM), along with complementary investments in the Office of Energy Efficiency and Renewable Energy (EERE), and the Manufacturing and Energy Supply Chains (MESC) Office are reversing this trend and providing the U.S. a path to reestablish itself as a leader in developing extraction and processing technologies to support a domestic supply chain for clean energy and national defense within the next decade, especially through the Critical Minerals and Materials (CMM) Science and Energy Technology Team (SETT).

Developing more sustainable domestic CMM resources for meeting current and future demand has become a national priority. New mining projects often take more than a decade to get permitted and begin operations, so it is critical to diversify supply by enabling sustainable mining operations, and by bringing unconventional and secondary sources to market. Development of sustainable and resilient CMM supply chains has the potential to address environmental concerns traditionally associated with mining, revitalize domestic manufacturing capabilities, and create good paying jobs. Production of waste from coal and industrial sectors has the potential to create a mineral processing workforce in local disadvantaged coal and power plant communities by building co-production of CM and carbon products. Moreover, unconventional co-production provides our country with the added advantage of removing environmentally adverse materials that might disproportionately harm residents of those disadvantaged communities as we transition to a clean energy and industrial economy. Finally, unconventional and secondary resources provide an alternative source of CMM to support and in some cases replace newly mined minerals.

The Mineral Sustainability program will support resilient domestic supply chains required for the economically, environmentally, and geopolitically sustainable production of critical minerals (CM). This mission will be accomplished by prioritizing the use of unconventional and secondary resources such as coal, coal waste and by-products from industry feedstocks for domestic CM, rare earth elements (REE) and carbon ore to products production.

These unconventional and secondary resources are defined as coal, coal waste, and industrial by-products. This includes coal refuse, clay/sandstone materials, ash, aqueous effluents such as acid mine drainage (AMD), and associated solids and precipitates resulting from AMD treatment. In addition, critical mineral extraction associated with produced water from the fossil fuel industry, industrial byproducts associated with steel, cement, and refining industries, phosphate sludge and other waste materials, and byproducts from hard rock mining and mine tailings will also be considered.

Critical Minerals Processing (formerly part of Critical Minerals)

The development of a domestic, economically competitive supply chain for CMs is needed to help fuel our nation's economic growth; transition to clean energy and industrial technologies; secure our energy independence by reducing our reliance on foreign CM and REE sources; and increase our national security. The Critical Minerals Processing subprogram focuses on the sustainable processing of all CM, including REE throughout the midstream and downstream supply chain by prioritizing the use of unconventional resources as an environmentally beneficial primary feedstock resource for domestic production and one that builds on longstanding FECM program areas and expertise.

The Critical Minerals subprogram activities will continue to develop advanced technologies throughout the supply chain, improve the economics of future projects through the evaluation of co-production of other valuable products (both critical and noncritical), and enable large-scale processing, separation, and metallization pilot-projects.

Other activities within the Critical Mineral subprogram leverages the success of the former, fully integrated "Feasibility of Recovery of Rare Earth Element" RDD&D that developed separation and recovery technologies and the capability to assess and characterize feedstocks, but also demonstrated the technical feasibility of recovering CMs from a diversity of carbon ore feedstocks. Building on this success, this activity will continue to enable future commercial technologies while minimizing land disturbance and maximizing environmental stewardship. This will be accomplished through technology development and validation—including machine learning and artificial intelligence, small- and large-scale pilot projects—including public-private partnerships, and existing regional partnerships developed through Carbon Ore Rare Earth-Critical Mineral Initiative (CORE-CM).

Since 2014, R&D has provided successful results for Pilot-Scale REE-CM Separation facilities at the University of North Dakota, University of Kentucky, West Virginia University and at Physical Sciences Inc. in Massachusetts and Winner Water Services in Pennsylvania, which have demonstrated the technical feasibility of extracting and producing CMs and REEs from carbon ore and related waste materials in small quantities. These facilities were the first-of-a-kind projects to demonstrate the capability to extract CMs/REEs from coal, coal refuse, coal ash, and AMD. These small-scale projects were the foundation for the development of future the large-scale demonstration projects. Pre-front end engineering and design (FEED) studies have been completed and will be a pre-cursor to new FEED studies for the development of demonstration-scale facilities that will produce 1-3 tonnes/day mixed REEs and other CMs, and one such demonstration facility will be funded through the Infrastructure Investment and Jobs Act (IIJA).

There are two key focus areas in which R&D will be conducted:

- **Sustainable Resource Extraction and Separation Technology Development** – Novel technology development and validation for conventional and unconventional extraction to enable the recovery of CMs/REEs from sources that are not currently being recovered or that could be recoverable with more sustainable practices. This includes the extraction of CMs from unconventional feedstocks such as abandoned mining or other industrial process residuals while maximizing environmental controls.
- **Extractive Metallurgy, Reduction, and Alloying Technology Development**– Advanced technology development for concentration and processing of CMs and REEs. This area also includes technology development of individual high-purity elements and metallization. High purity elements will be critical to future metallization technology development and eventual use in manufactured products. This work is coordinated with ongoing work in EERE.

Highlights of the FY 2024 Budget Request

- Further advance facilities to produce large quantities of high purity, commercial grade REEs and other CMs, through FEED studies and large-scale pilots, which is the next stage of development to broadly enable extraction of REEs and other CMs from unconventional feedstocks (such as coal refuse and acid mine drainage) towards a commercial industry.
- Further support the regional basin projects (the CORE-CM Initiative), covering larger portions of the country by regions, and the development of transformational technologies for individually separated highly purified, individual CMs/REEs, including individual separation, reduction to metals, and alloying. This work is coordinated with ongoing work in EERE.
- Support the maturation of transformational separation and extraction technologies, potentially through laboratory and/or bench-scale innovative process concept development, as well as modeling and validation of models for optimization and efficiency improvements that would improve process economics.

Carbon Ore Processing

The Carbon Ore Processing activity (formerly Advanced Coal Processing) is focused on utilizing materials from currently and previously mined resources beyond the traditional thermal and metallurgical markets that can support high-wage employment and value-added production in communities and regions dependent on traditional mining. This activity is focused on developing transformational technologies to enable domestic manufacturing of strategic materials and superior building products from carbon ore at competitive market prices, while ensuring worker safety and environmental responsibility. These transformational technologies have minimal emissions, superior product performance, and better lifecycle for new and existing products in the market.

R&D in the Carbon Ore Processing activity will further efforts for the development of existing and new technologies and identify projected markets for everyday and high value stream carbon products generated from coal and coal waste and refuse; and identify the potential markets for carbon products if production costs are reduced to make it more competitive with the current state of the art. Transformational technology development and validation will be conducted to enable future commercial industries in three areas:

- High-value carbon products, especially those needed for the clean energy and industrial economy, such as synthetic graphite, battery anodes, and supercapacitor materials from carbon ore, as well as graphene, quantum dots, activated carbon, and conductive inks;
- Universal infrastructure components, such as components for mass transit, sewers and tunnels, roads and bridges; and
- Continuous industrial processes to reduce capital and operating costs for future carbon products.

The FY 2024 Budget Request of $4 million for Carbon Ore Processing combines basic chemistry and combustion/pyrolysis science along with basic and fundamental research on physical properties, materials interactions, and heat transfer to improve how carbon ore from coal and coal waste is processed and utilized to expand market opportunities. This work is coordinated with other DOE Offices and DOE's CMM SETT. The funding will be used to:

- Develop new technologies for creating products such as synthetic graphite.
- Support techno-economic characterization, life cycle analyses, and health and safety studies to assess the environmental impacts for coal and coal waste-derived carbon products.

Resource Characterization Technologies (formerly part of Critical Minerals)

The development of a domestic, economically competitive supply of CMs are needed to help fuel our nation's economic growth; transition to clean energy technologies; secure our energy independence by reducing our reliance on foreign CM and REE sources; and increase our national security. The Resources Characterization Technologies Subprogram focuses on the sustainable recovery of all CM, including REE and carbon ore, by prioritizing the use of unconventional and secondary resources as an environmentally sustainable feedstocks for domestic production.

The Resource Characterization Subprogram leverages the success of the former R&D, including the technologies and the capability to assess and characterize unconventional and secondary feedstocks, but also demonstrates the technical feasibility of recovering CMs from a diversity of carbon ore-based feedstocks in small quantities. Building on this success, this activity will continue to enable future commercial technologies while minimizing land disturbance and maximizing environmental stewardship. This will be accomplished through technology development and validation—including machine learning and artificial intelligence, and existing basin partnerships developed through Carbon Ore Rare Earth-Critical Mineral Initiative (CORE-CM), including public-private partnerships. This includes mineral characterization and analysis that has been conducted on thousands of samples from 14 coal-producing states. Initial geologic characterization research activities have shown positive indicators for finding materials (in Appalachia and other basins) associated with carbon ore beds that exceed the ore grades of some REE mining projects under development worldwide. This work has found the presence of materials from which REEs can be recovered using an ion-exchange solution, a technique that accounts for about 30% of Chinese REE production. Minerals of this type have been previously unknown to exist in the U.S., and thus

offers an opportunity for REE production with less intensive processing steps required to produce REEs from conventional ores.

The two primary focus areas for RDD&D will be:

- **Resource Characterization and Technology Development** – Technology development and validation for environmentally sustainable exploration and production from various sources. This includes regional opportunities and assessments, the economic recovery of CMs through identification (including physical and chemical properties), mineral assays, prediction and assessment of resources and volumes of CMs/REEs from various feedstocks. It also includes development of new technologies for assessment of recoverable resources (drones, real time sensing and analytics, and micro drilling technologies). This work is coordinated with the U.S. Geological Survey (USGS) in the Department of Interior and the Environmental Protection Agency.
- **International Engagements, Standards, Supply Chain Development, and Characterization Technology Development** – Prioritize leadership among international allies to address sustainable practices throughout the world, across the supply chain, from exploration through manufacturing.

Highlights of the FY 2024 Budget Request

- Initiate Phase II of the regional basin projects (the CORE-CM Initiative), covering larger portions of the country by regions, including the development of assessment methodology and technology for many unconventional and secondary feedstocks, including machine learning, and optimization modeling for characterization of CMs/REEs.
- Work with the USGS to improve exploration and characterization technologies to reduce time, cost, and environmental impact, thereby enabling more rapid new upstream CMM projects to proceed.

Resource Sustainability
Mineral Sustainability
Explanation of Major Changes ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Mineral Sustainability					
Critical Minerals Processing	44,000	44,000	12,000	-32,000	-72.73%
Carbon Ore Processing	9,000	10,000	4,000	-6,000	-60.00%
Resource Characterization Technologies	0	0	29,000	+29,000	N/A
Total, Advanced Remediations Technologies	**53,000**	**54,000**	**45,000**	**-9,000**	**-16.67%**

Resource Sustainability
Mineral Sustainability
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Mineral Sustainability	
Critical Minerals Processing: This decrease represents the breakout of the Resource Characterization as a separate subprogram as shown below. Research in this area will continue into the development of existing and new technologies and identify projected markets for everyday and high value stream carbon products generated predominantly from coal and coal waste and refuse; and identify the potential markets for carbon products if production costs are reduced to make it more competitive with current state of the art.	**$-32,000**
Carbon Ore Processing: This decrease in funding represents a shift in focus to the Resource Characterization efforts mentioned below. Research will continue into the utilization of materials to be recycled from currently and previously mined resources outside of traditional thermal and metallurgical markets that can contribute to the U.S. gross domestic product.	**$-6,000**
Resource Characterization: This increase represents the breakout of this new subprogram, formerly part of Critical Minerals, that will initiate Phase II of the regional basin projects (the CORE-CM Initiative), covering larger portions of the country by regions.	**+$29,000**
Total, Mineral Sustainability: This decrease reflects a greater emphais on the CORE-CM initiative under the new Resource Characterization subprogram.	**-$9,000**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Mineral Sustainability $54,000,000	**$45,000,000**	**-$9,000,000**
Critical Minerals $44,000,000	**$12,000,000**	**-$32,000,000**
• R&D to support FEED studies for technology development of CM including REE from unconventional feedstocks to produce large quantities of high purity, commercial grade REE and other CMs. • Further development of regional basin projects (the CORE -CM Initiative), and the development of transformational technologies for individually separated highly purified, individual CMs/REEs, including individual separation, reduction to metals, and alloying. • Support the maturation of transformational separation and extraction technologies, characterization of CMs/REEs, machine learning and optimization modeling.	• R&D to support FEED studies for technology development of CM including REE from unconventional feedstocks to produce large quantities of high purity, commercial grade REE and other CMs. • Support the maturation of transformational separation and extraction technologies, characterization of CMs/REEs, machine learning and optimization modeling. • Supporting the CORE-CM initiative, which will be moving to the Resources Characterization Technologies Subprogram.	• This decrease represents the breakout of the Resource Characterization as a separate subprogram. Research in this area will continue into the development of existing and new technologies and identify projected markets for everyday and high value stream carbon products generated predominantly from coal and coal waste and refuse; and identify the potential markets for carbon products if production costs are reduced to make it more competitive with current state of the art.
Carbon Ore Processing $10,000,000	**$4,000,000**	**$-6,000,000**
• Develop existing and new technologies to turn coal and coal waste and refuse into synthetic graphite and graphene. • R&D on carbon fiber production at Oak Ridge National Laboratory's (ORNL) Carbon Fiber Technology Facility (CFTF). • Support the development of next generation carbon-based building materials and infrastructure products with superior mechanical properties.	• Support safe and environmentally sustainable coal and coal waste to products work. • Continue to support additive manufacturing of products via 3D printing using coal and coal refuse to reclaim abandoned coal mining land. • Continue to support R&D of high value carbon-based products such as quantum dots and memristor computer chips, using novel technologies.	• This decrease in funding represents a shift in focus to the Resource Characterization efforts mentioned below. Research will continue into the utilization of materials to be recycled from currently and previously mined resources outside of traditional thermal and metallurgical markets that can support communities and economies in regions traditionally reliant on mining.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Resource Characterization Technologies $0	**$29,000,000**	**+$29,000,000**
• No funding requested in FY 2023	• Further development of regional basin projects (the CORE-CM Initiative), and the development of transformational technologies for individually separated highly purified, individual CMs/REEs, including individual separation, reduction to metals, and alloying. • Improve exploration and characterization technologies to reduce time, cost, and environmental impact, especially for unconventional and secondary resources.	• This increase represents the creation of a new subprogram to continue and to expand the former CORE-CM Initiative.

Resource Sustainability
Resource Sustainability –Analysis and Engagement

Overview

The United States continues to produce and use fossil energy, specifically oil and natural gas, at historically high rates. Fossil energy will continue to provide for a portion of domestic energy consumption as the U.S. transitions to a net zero economy. As that transition occurs, the Office of Fossil Energy and Carbon Management is engaging with domestic and international stakeholders, advancing research and technologies, and bringing together critical programs and funding to reduce the environmental and climate impacts of our fossil energy production and use.

The United States and our global partners have an opportunity to decarbonize our energy use. This requires a robust analytical capability to prioritize and support the Resource Sustainability research portfolio, analyze shifting market conditions, and provide data driven analysis, studies, and reports to Department leadership and government policy makers.

The Resource Sustainability - Analysis and Engagement Program will focus on economic and environmental analysis, modeling, market analysis, and studies that provide support to the overall Resource Sustainability Program, including informing research priorities, engagement with domestic and international governments and organizations, and provides market and industry analysis to inform the Department on Fossil Energy resources.

The Resource Sustainability –Analysis and Engagement Program conducts analysis and studies that support the environmentally prudent production, transport, storage, and use of domestic fossil fuels with an understanding of their role as a strategic asset for the U.S. and its allies for global energy security. This includes analysis of markets during volatility, providing data driven assessments of the impacts of different tools and levers that can be used to provide reliable and affordable fossil energy supplies to the domestic market. Strategic Analysis provides evidence-based, portfolio-wide analysis for decision-makers.

The program also engages with domestic and international stakeholders on activities associated with technologies and approaches that will reduce the environmental impacts of our historical and continued dependence on coal, oil, and natural gas. This includes support for activities to inform key FECM audiences and stakeholders about FECM's work to foster a clean energy and industrial economy and to address climate change, as well as support for communities that host fossil energy production and assets.

Funding will support domestic engagement efforts and international collaboration with various partners through bilateral and multilateral agreements regarding technologies and approaches that serve to decarbonize the production, transport, and end uses of fossil fuels. Activities under this area include technical exchanges, studies, and reports. The program will work with various stakeholders to build a foundation for expeditiously administering several new approaches to recognizing and detecting fossil fuel greenhouse gas emissions and impacts, leveraging existing programs and developing new relationships with stakeholder networks and communities.

Highlights of the FY 2024 Budget Request

The Resource Sustainability – Analysis and Engagement Program will pursue the following major activities in FY 2024:

- Perform analysis on various pathways to achieve domestic and global climate goals, including lifecycle analysis.
- Assesses market conditions to determine impacts to energy markets and technology development.
- Leverage experience in working successfully with global governments, organizations, and stakeholders through a variety of bilateral and multilateral mechanisms to accelerate the advancement and responsible deployment of methane mitigation technologies through both policy and technical expertise, along with forward-looking R&D, and capacity building.
- Work with international partners committed to reducing methane emissions as a long-term climate strategy and partnerships that prioritize a decarbonized economy by 2050 through concerted global actions. These partners are willing and able to work with FECM to move their countries and regions toward net-zero goals, and where FECM expertise can provide leverage, develop long-term projects and relationships for technical exchange and joint R&D with these partners.

- Serve as a key focal point and provide analysis and data across the U.S. Government for interagency collaboration on technical and policy issues related to methane mitigation technologies.
- Work with other agencies to develop and improve accounting frameworks and tools to accurately measure and reduce greenhouse gases and other impacts from fossil fuel production and use.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Resource Sustainability – Analysis and Engagement: $0	**$1,000,000**	**+$1,000,000**
Policy & Analysis $0	$1,000,000	+$1,000,000
• No funding requested in FY 2023	• This activity will provide funding for technical, economic, and socio-economic studies as well as technical expertise and analysis needed to support EPA and other agencies regarding methane emissions, critical minerals, hydrogen storage, and other crosscutting efforts. • Provide economic, market, and industry analysis and studies on oil, gas, coal, and petrochemical resources. • Support international and domestic engagements with industry, governments, and non-governmental organizations to reduce methane emissions related to fossil fuel use, and to pursue the development of sources critical minerals and materials from domestic fossil resources such as coal waste.	• Increase in funding will provide funding for technical, economic, and socio-economic studies as well as technical expertise and analysis needed to support EPA and other agencies regarding methane emissions, critical minerals, hydrogen storage, and other crosscutting efforts. • Increase in funding will provide economic, market, and industry analysis and studies on oil, gas, coal, and petrochemical resources. • Increase in funding will support international and domestic engagements with industry, governments, and non-governmental organizations to reduce methane emissions related to fossil fuel use, and to pursue the development of critical minerals and materials from domestic fossil resources such as coal waste.

NETL Infrastructure
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
75,000	**55,000**	**55,000**	**+$0**	**0%**

Overview

The National Energy Technology Laboratory (NETL) Infrastructure Program supports the fixed costs of NETL's laboratory footprint in three geographic locations: Morgantown, WV; Pittsburgh, PA; and Albany, OR. Table 1 provides information on the size of each site.

The NETL Infrastructure Program comprises the following subprograms:

(1) **High-Performance Computer (Super Computer)** provides funding for the lease of Joule, NETL's high-performance computer (HPC) at Morgantown, WV. The FY 2024 Budget Request includes $6.0 million for a new 4-year lease.

(2) **Laboratory and Sitewide Facilities** includes repairs to existing laboratory facilities, general-purpose buildings, and sitewide infrastructure and the continued management of deferred maintenance balances. Priorities for funding are established to ensure compliance with life safety standards, ensure critical laboratory research facilities and infrastructure, and comply with High Performance Sustainable Building (HPSB) goals. Funding also includes information technology (IT) development, modernization, and enhancement (DME) investment as well as AI infrastructure support.

(3) **Safeguards and Security** provides funds to ensure protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the Office of Fossil Energy and Carbon Management (FECM) research, development, demonstration, and deployment (RDD&D) mission.

(4) **Environmental Restoration** supports NETL's obligations to the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) across all NETL sites and one off-site location in Wyoming.

Table 1[1]: Comparison of Physical Footprint, Workforce, and Value of Assets by Campus and in Total, National Energy Technology Laboratory as of January 31, 2023.

	Morgantown	Pittsburgh	Albany	Total NETL
Buildings	43	31	37	**111**
Sq. Ft. of Building Space (000s)	445	433	253	**1,131**
Acres	136.0	57.4	43.9	**237.3**
NETL Federal Workforce	167	192	45	**497[2]**
NETL Contractor Workforce (FTEs)	348	420	81	**893[3]**
Assets Replacement Value	$292.9 million	$243.9 million	$180.9 million	**$717.7 million**

Table 2: Reconciliation of FECM RDD&D Federal Employees (FTEs).

	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
NETL Program Direction	138	140*	+2
NETL Research & Operations	440	460	+20
TOTAL, NETL	**578**	**600**	**+22**

[1] Table 1 reflects on board employees as of January 31, 2023 and Table 2 reflects authorized and requested FTEs.

[2] Total NETL includes two employees located in Houston, TX and ninety-one with a remote duty station. Total NETL excludes forty-five employees funded through the Infrastructure Investment and Job Act.

[3] Total NETL includes five contractors located in Houston, TX and thirty-nine located offsite.

FECM-HQ Program Direction	141	168	+27
TOTAL, FECM RDD&D	**719**	**768**	**+49**

*The FY 2024 Request includes 127 FTE funded through the FECM appropriations and 13 FTE funded with Program Direction from other Program Offices (EERE, OE, CESER).

Highlights of the FY 2024 Budget Request

The FY 2024 Budget Request for NETL Infrastructure is $55 million. This request includes $20 million for General Plant Projects (GPP), prioritizing research laboratory upgrades in key FECM areas such as Artificial Intelligence, Materials Characterization, and Geological Environmental Sciences. Additional GPP investments include deferred maintenance management projects and investments in reducing NETL's carbon footprint. An additional $6 million is requested for NETL's high performance computer lease. High performance computing is an essential element in more than 50% of NETL's research projects. The balance of the request is for investments in information technology (IT) development, modernization, enhancements, and fixed operational costs such as utilities, IT licenses and agreements, safeguards and security, environmental compliance and remediation, and routine building maintenance, along with support for a Net Zero Lab Initiative.

Funding will support the administration's cybersecurity priorities established by OMB and DOE, including implementing zero trust architectures, improving incident detection and response capabilities, addressing supply chain risks, and increasing automation across IT infrastructure operation/maintenance, portfolio management, cybersecurity risk management.

NETL Infrastructure
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
NETL Infrastructure					
Super Computer	6,000	6,000	6,000	0	0%
Laboratory- & Site-Wide Facilities	59,500	39,000	39,000	0	0%
Safeguards and Security	7,500	8,000	8,000	0	0%
Environmental Restoration	2,000	2,000	2,000	0	0%
Total, NETL Infrastructure	**75,000**	**55,000**	**55,000**	**0**	**0%**

NETL Infrastructure
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
NETL Infrastructure: No Change.	**0**
Total, NETL Infrastructure	**0**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
NETL Infrastructure $55,000,000	**$55,000,000**	**+$0**
High Performance Computer (Super Computer) $6,000,000	**$6,000,000**	**$0**
• Funding is for the 4-year lease of Joule, National Energy Technology Laboratory's (NETL) high performance computer (HPC) at Morgantown, WV.	• Funding is for the 4-year lease of Joule, NETL's HPC at Morgantown, WV.	• No change.
Laboratory and Site wide Facilities $39,000,000	**$39,000,000**	**$0**
• Funding includes repairs to existing laboratory facilities and general-purpose buildings and site-wide infrastructure. Priorities for funding are established to ensure compliance with life safety standards, ensure critical laboratory research facilities and infrastructure and comply with High Performance Sustainable Building (HPSB) goals.	• Funding includes repairs to existing laboratory facilities and general-purpose buildings and site-wide infrastructure, including AI. Priorities for funding are established to ensure compliance with life safety standards, ensure critical laboratory research facilities and infrastructure and comply with HPSB goals.	• No change.
Safeguard and Securities $8,000,000	**$8,000,000**	**$0**
• Funding is to ensure protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the FECM RDD&D mission.	• Funding is to ensure protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the FECM RDD&D mission.	• No change.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Environmental Restoration $2,000,000	**$2,000,000**	**$0**
• Continue active operation and maintenance of the air sparge ground water remediation systems at Rock Springs, Wyoming, Sites 4, 6, 7, 9, and 12 under the guidance of the Wyoming Department of Environmental Quality (DEQ). • Continue all NETL on-site Resource Conservation and Recovery Act (RCRA) hazardous waste compliance and management activities. • Continue all NETL Albany ground water investigation and compliance activities.	• Continue active operation and maintenance of the air sparge ground water remediation systems at Rock Springs, Wyoming, Sites 4, 6, 7, 9, and 12 under the guidance of the Wyoming DEQ. • Continue all NETL on-site RCRA hazardous waste compliance and management activities. • Continue all NETL Albany ground water investigation and compliance activities.	• No change.

Plant and Capital Equipment
Capital Summary ($K)

	Total	Prior Years	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Capital Operating Expenses Summary (including Major Items of Equipment (MIE))						
Capital Equipment >$500,000 (including MIE)	n/a	0	0	0	0	0
Minor Construction Project (>$5 million)	25,000	0	25,000	0	0	0
Total, Capital Operating Expenses	**25,000**	**0**	**25,000**	**0**	**0**	**0**
Capital Equipment > $500,000 (including MIE)						
Total Non-MIE Capital Equipment	n/a	0	0	0	0	0
Total, Capital Equipment (including MIE)	**n/a**	**0**	**0**	**0**	**0**	**0**
Minor Construction Projects (>$5 million)						
Direct Air Capture Center	25,000	0	25,000	0	0	0
Total, Minor Construction Projects	**25,000**	**0**	**25,000**	**0**	**0**	**0**
Total, Capital Summary	**25,000**	**0**	**25,000**	**0**	**0**	**0**

NETL Research and Operations
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
83,000	87,000	89,000	+$2,000	2.3%

Overview

The National Energy Technology Laboratory (NETL) is an integral part of the U.S. Department of Energy (DOE) national laboratory system. There are 17 National Laboratories in the DOE laboratory system; NETL is unique in that it is the only government-owned, government-operated laboratory. NETL supports the DOE mission by addressing energy and environmental challenges through transformative science and technology solutions. NETL is recognized for its capabilities in applied material science, computation science, chemical and systems engineering, subsurface science, decision science, as well as its expertise in government contract and project management.

The NETL Research and Operations Program comprises three subprograms:

(1) **Research, Development, Demonstration, and Deployment** (RDD&D) funding supports Federal researcher salaries and benefits, travel, personal protective equipment, and other employee costs for the NETL staff of scientists and engineers who conduct in-house research activities for Fossil Energy and Carbon Management (FECM) RDD&D programs. This subprogram also funds the salaries, benefits, travel, and other employee costs for the NETL staff of engineers and technical professionals who conduct project management for FECM RDD&D programs. This subprogram also funds partnership, technology transfer, and other collaborative research activities with universities, other National Laboratories, state and local governments, and industry, as well as strategic energy analysis and research data management.

(2) **Site Operations** includes funding for: (a) building operations and maintenance such as non-capital repairs, routine upkeep, and pandemic protocols; and (b) grounds maintenance including parking lot repair, lighting, groundskeeping, snow removal, etc.

(3) **Program Oversight** includes funding for Federal employees and contractors performing research-enabling functions such as managing financial assistance and providing legal and finance oversight of research grants and awards.

Highlights of the FY 2024 Budget Request

The NETL Research and Operations Request is $89.0 million. The request includes $78.5 million to fully fund federal salaries and benefits at the requested FTE level. An additional $7.0 million is for contractor support in the areas of information technology operations, technology transfer and business outreach, research data management, and strategic energy analysis. The balance of the request funds travel, training, material, supplies, and other employee costs for the federal staff and NETL's Laboratory-Directed Research and Development (LDRD) contribution.

	Funding ($K)				
	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
NETL Research and Operations					
Research, Development, Demonstration, and Deployment	51,000	55,000	57,000	+2,000	+3.6%
Site Operations	21,000	21,000	21,000	0	0%
Program Oversight	11,000	11,000	11,000	0	0%
TOTAL, NETL Research and Operations	**83,000**	**87,000**	**89,000**	**+2,000**	**2.3%**
Federal FTEs	**430**	**440**	**460**	**+20**	**+4.5%**

Federal FTEs shown above include technical project managers and procurement and finance personnel providing support to DOE's Office of Energy Efficiency and Renewable Energy (EERE), Office of Cybersecurity, Energy Security, and Emergency Response (CESER), and Office of Electricity (OE). These NETL personnel are funded by those non-FECM RDD&D offices to the extent that their time is spent supporting those offices.

NETL Research and Operations
Explanation of Major Changes
($K)

	FY 2024 Request vs FY 2023 Enacted
NETL Research and Operations:	**+$2,000**
• Increase reflects fully funding authorized federal headcount at projected FY 2024 average salary and benefits. Contractor support in key research areas is being scaled back as NETL strengthens the depth of our federal workforce.	
Total, NETL Research and Operations	**+$2,000**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
NETL Research and Operations $87,000,000	**$89,000,000**	**+$2,000,000**
Research, Development, Demonstration, and Deployment $55,000,000	**$57,000,000**	**+2,000,000**
• Research, Development, Demonstration, and Deployment (RDD&D) funding supports salaries and benefits, travel, personal protective equipment, and other employee costs for the NETL staff of scientists and engineers who conduct in-house research activities for the Office of Fossil Energy and Carbon Management (FECM) RDD&D programs. Funding also supports NETL's Research & Innovation Center strategic efforts such as the FECM Roadmap and NETL Science & Technology competency assessments. • RDD&D funding also provides for collaborative research, development, demonstration, and deployment activities, including Federal salaries/benefits, travel and employee costs for engineers, and technical project managers associated with the FECM programs. • Funding provides for costs targeted toward collaboration, strategic energy analysis and research data management areas. Funding also provides for ongoing operation and maintenance of project management information systems.	• RDD&D funding supports salaries and benefits, travel, personal protective equipment, and other employee costs for the NETL staff of scientists and engineers who conduct in-house research activities for FECM RDD&D programs. Funding also supports NETL's Research & Innovation Center strategic efforts such as the FECM Roadmap and NETL Science & Technology competency assessments. • RDD&D funding also provides for collaborative research, development, demonstration, and deployment activities, including Federal salaries/benefits, travel and employee costs for engineers, and technical project managers associated with the FECM programs. • Funding provides for costs targeted toward collaboration, strategic energy analysis and research data management areas. Funding also provides for ongoing operation and maintenance of project management information systems.	• Increase reflects fully funding authorized federal headcount at projected FY 2024 average salary and benefits. Contractor support in key research areas is being scaled back as NETL strengthens the depth of our federal workforce
Site Operations $21,000,000	**$21,000,000**	**$0**
• Site Operations funding supports variable costs of operating NETL's laboratories and research sites. Funding provides for operations personnel	• Site Operations funding supports variable costs of operating NETL's laboratories and research sites. Funding provides for operations personnel	• No change

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
along with support contractors for building operations, grounds maintenance, etc.	along with support contractors for building operations, grounds maintenance, etc.	
Program Oversight $11,000,000	**$11,000,000**	**+$0**
• Program Oversight funding at NETL supports salaries/benefits for federal employees performing research-enabling support functions necessary for the performance of NETL's research activities.	• Program Oversight funding at NETL supports salaries/benefits for federal employees performing research-enabling support functions necessary for the performance of NETL's research activities.	• No change.

Interagency Working Group
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2022 Request vs FY 2023 Enacted (%)
0	3,000	0	-$3,000	-100%

Overview

On January 27, 2021, President Biden signed Executive Order (EO) 14008, "*Tackling the Climate Crisis at Home and Abroad.*" EO 14008, Section 218, established an Interagency Work Group (IWG) on Coal and Power Plant Communities and Economic Revitalization; co-chaired by the Director of the National Economic Council and the National Climate Advisor, and is administered the Secretary of Energy. In April 2021, the IWG prepared an Initial Report to the President on Empowering Workers through Revitalizing Energy Communities and identifies 25 communities across the country hard-hit by coal mine and power plant closures. The IWG will promote investments that support economic revitalization and job creation in these and other energy communities and will also proactively promote investments in communities likely to be impacted by these closures in the near-term. These communities include workers directly employed in coal mining and power generation, those in related jobs in logistics and services, and residents who are dependent on coal and power plant-related tax revenue to fund schools, public services, and infrastructure as well as fenceline communities and other communities impacted by the environmental and health effects of fossil energy generation.

Highlights of the FY 2024 Budget Request

The Interagency Working Group will be managed by SCEP, instead of FECM. Thus, FECM is not requesting FY 2024 funding.

Interagency Working Group
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Interagency Working Group:	**-$3,000**
• The Interagency Working Group will be managed by SCEP, instead of FECM. Thus, FECM is not requesting FY 2024 funding.	
Total, Interagency Working Group	**-$3,000**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Interagency Working Group $3,000,000	**$0**	**-$3,000,000**
• Continue targeted, place-based interventions using an interagency approach that leverages existing federal and technical assistance resources to assist energy communities, including displaced energy workers. • Establish a concierge function to provide direct technical assistance to energy communities on how to access Federal resources. • Streamline the process for applying Federal funding. Create a pilot that uses a common application for two or more agencies. • Maintain the clearinghouse on Federal funding opportunities available to energy communities.	• The Interagency Working Group will be managed by SCEP, instead of FECM. Thus, FECM is not requesting FY 2024 funding.	• The Interagency Working Group will be managed by SCEP, instead of FECM. Thus, FECM is not requesting FY 2024 funding.

Special Recruitment Programs
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
1,001	1,000	1,000	0	N/A

Overview

The Office of Fossil Energy and Carbon Management (FECM) emphasizes educational programs to support an increase in the number of women and under-represented minorities entering science (including social science), technology, engineering, and mathematics (STEM) career fields within the U.S. workforce. FECM programs, including the Mickey Leland Energy Fellowship (MLEF) and other educational programs, offer undergraduate, graduate, and post-graduate students majoring in STEM disciplines opportunities to learn about programs, policies, and research, development, demonstration, and deployment (RDD&D) initiatives within FECM and the challenges in providing clean, affordable energy for future generations. FECM also utilizes Departmental programs such as the Minority Educational Institution Student Partnership Program (MEISPP), the Department of Energy (DOE) Scholars Program, and the DOE Science, Technology and Policy (STP) Program to provide students the opportunity to gain work experience and learn about the FECM and DOE missions to support preparation for careers with DOE and in the STEM workforce. The Special Recruitment Programs aligns with the Administration's Justice40 Initiative and equity priorities.

Highlights of the FY 2024 Budget Request

In FY 2024, FECM will recruit and select a diverse group of undergraduate, graduate, and post-graduate students in STEM majors to participate in FECM and DOE educational programs such as the MLEF, MEISPP, DOE Scholars, STP, and other student programs. Recruitment emphasis will be on Historically Black Colleges and Universities (HBCUs) and other Minority Serving Institutions (MSIs). All participants in the MLEF, MEISPP, DOE Scholars, STP, and other FECM and DOE educational programs will complete challenging assignments supporting the FECM mission through hands-on R&D projects under the mentorship of an FECM scientist, researcher, or program official.

Special Recruitment Programs
Funding ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Special Recruitment Programs	1,001	1,000	1,000	0	N/A
Total, Special Recruitment Programs	**1,001**	**1,000**	**1,000**	**0**	**N/A**

Special Recruitment Programs
Explanation of Major Changes ($K)

	FY 2024 Request vs FY 2023 Enacted
Special Recruitment Programs:	**+$0**
• The FY 2024 Budget Request level supports administration of the MLEF, MEISPP, DOE Scholars, STP, or other educational programs.	
Total, Special Recruitment Programs	**+$0**

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Special Recruitment Programs $1,000,000	**$1,000,000**	**+$0**
• A diverse group of undergraduate, graduate, and post-graduate students in STEM majors will be recruited and selected to participate in the MLEF, MEISPP, DOE Scholars, DOE STP, or other educational programs. Provides students opportunity to gain hands-on research and work experience and learn more about the DOE and the FECM missions.	• A diverse group of undergraduate, graduate, and post-graduate students in STEM majors will be recruited and selected to participate in the MLEF, MEISPP, DOE Scholars, DOE STP, or other educational programs. Provides students opportunities to gain hands-on research and work experience and learn more about the DOE and FECM missions.	• No change.

Program Direction
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
66,800	70,000	92,475	+$22,475	+32.1%

Overview

Program Direction provides for the Headquarters (HQ) workforce responsible for the oversight and administration of the Office of Fossil Energy and Carbon Management (FECM). It also supports technical staff at the National Energy Technology Laboratory (NETL) who perform procurement, finance and legal functions, as well as Federal workforce and contractor support for communications. It does not include NETL scientific researchers or project managers who are funded through the NETL Research and Development control point.

Funding also support continued IT modernization and the administration's cybersecurity priorities established by OMB and DOE, including implementing zero trust architectures, improving incident detection and response capabilities, addressing supply chain risks, and increasing automation across IT infrastructure operation/maintenance, portfolio management, and cybersecurity risk management.

Program Direction also includes funding for the operations of the Import/Export Authorization Office, which is managed by the Division of Natural Gas Regulation within the Office of Resource Sustainability. The program has responsibility for regulating natural gas and liquefied natural gas (LNG) imports and exports under the Natural Gas Act of 1938, section 3, using both Federal staff and contractor support.

Each of these elements also fund the Department of Energy's (DOE) Oak Ridge Human Resources Shared Service Center and the FECM program office contribution to the DOE Working Capital Fund.

Highlights of the FY 2024 Budget Request

The FY 2024 Program Direction Budget Request is $92.475 million. The Request includes $58 million to fully fund federal salaries and benefits at the requested FTE level. Increase reflects fully funding authorized federal headcount at projected FY 2024 average salary and benefits. An increased federal staffing level is required to maintain appropriate program oversight and administration of FECM programs, including support efforts at NETL to oversee, award, manage, and closeout RDD&D programs and projects. These efforts increase the effectiveness of government sponsored RDD&D and reduce the risk of noncompliance. This funding level also supports the Department's efforts to evaluate ways to improve operational efficiency.

Program Direction
Funding ($K)

Program Direction Summary	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Washington Headquarters					
Salaries and Benefits	25,860	25,732	34,624	+8,892	+34.6%
Travel	400	400	1,508	+1,108	+277.0%
Support Services	550	2,620	4,124	+1,504	+57.4%
Other Related Expenses	7,710	8,418	13,709	+5,291	+62.9%
Total, Washington Headquarters	**34,520**	**37,170**	**53,965**	**+16,795**	**+45.2%**
National Energy Technology Laboratory					
Salaries and Benefits	19,300	19,300	21,500	+2,200	+11.4%
Travel	400	400	400	0	0.0%
Support Services	6,600	7,100	6,150	-950	-13.4%
Other Related Expenses	3,100	3,100	3,500	+400	+12.9%
Total, National Energy Technology Laboratory	**29,400**	**29,900**	**31,550**	**+1,650**	**+5.5%**
Import/Export Authorization					
Salaries and Benefits	1,845	1,930	1,845	-85	-4.4%
Travel	20	20	207	+187	+935.0%
Support Services	485	450	3,205	+2,755	+612.2%
Other Related Expenses	530	530	1,703	+1,173	+221.3%
Total, Import/Export Authorization	**2,880**	**2,930**	**6,960**	**+4,030**	**+137.5%**
Total Program Direction					
Salaries and Benefits	47,005	46,962	57,969	+11,007	+23.4%
Travel	820	820	2,115	+1,295	+157.9%
Support Services	7,635	10,170	13,479	+3,309	+32.5%
Other Related Expenses	11,340	12,048	18,912	+6,864	+57.0%
Total Program Direction	**66,800**	**70,000**	**92,475**	**+22,475**	**+32.1%**
Federal FTEs – HQ	**141**	**141**	**168**	**+27**	**+19.1%**

Program Direction Summary	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Federal FTEs – NETL[1]	**138**	**138**	**140**	**+2**	**+1.4%**
Federal FTEs – Total	**279**	**279**	**308**	**+29**	**+10.4%**
Support Services					
Technical Support					
Headquarters	550	2,620	4,124	+1,504	+57.4%
NETL	0	0	0	0	0.0%
Import/Export Authorization	485	450	3,205	+2,755	+612.2%
Total, Technical Support	**1,035**	**3,070**	**7,329**	**+4,259**	**+138.7%**
Management Support					
Headquarters	0	0	0	0	0.0%
NETL	6,600	7,100	6,150	-950	-13.4%
Import/Export Authorization	0	0	0	0	0.0%
Total Management Support	**6,600**	**7,100**	**6,150**	**-950**	**-13.4%**
Total, Support Services	**7,635**	**10,170**	**13,479**	**+3,309**	**+32.5%**
Other Related Expenses					
Headquarters	7,710	8,418	13,709	+5,291	+62.9%
NETL	3,100	3,100	3,500	+400	+12.9%
Import / Export Authorization	530	530	1,703	+1,173	+221.3%
Total, Other Related Expenses	**11,340**	**12,048**	**18,912**	**+6,864**	**+57.0%**

[1] Additional NETL FTEs are funded within the NETL Research and Operations budget line.

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Program Direction $70,000,000	**$92,475,000**	**+$22,475,000**
Salaries and Benefits $46,962,000	**$57,969,000**	**+$11,007,000**
• The funding supports Headquarters (HQ) Federal staff who provide monitoring (oversight and audit) activities for the Office of Fossil Energy and Carbon Management (FECM) research, development, demonstration, and deployment (RDD&D) portfolio. • The funding supports the technical Federal staff at the National Energy Technology Laboratory (NETL). The staff covered in this area provide for management of the Lab, communications, legal, acquisition and finance activities.	• The funding supports HQ Federal staff who provide monitoring (oversight and audit) activities for the FECM RDD&D portfolio. • The funding supports the technical Federal staff at NETL. The staff covered in this area provide for management of the Lab, communications, legal, acquisition and finance activities.	• The HQ increase reflects the additions to full-time equivalents (FTE) to support FECM's mission as well as a 5.2% pay raise for federal staff in 2024, the Federal Employees Retirement System (FERS) increase, and awards pool funding increase in FY 2024.
Travel $820,000	**$2,115,000**	**+$1,295,000**
• Travel includes funding for management meetings, training, etc.	• Travel includes funding for management meetings, training, etc.	• Travel increase is due to the return to a normal travel schedule with COVID restrictions being lifted.
Support Services $10,170,000	**$13,479,000**	**+$3,309,000**
• Support Services at HQ includes technical support, information technology (IT) support, site operations support, administrative support. • Support services at NETL include management and communications support, as well as finance and acquisition technicians.	• Support Services at HQ includes technical support, IT support, site operations support, administrative support. • Support services at NETL include management and communications support, as well as finance and acquisition technicians.	• The $3.3M increase over FY 2023 Enacted Budget for Import/Export Program Direction support services is to cover anticipated studies and environmental reviews, Fossil Energy Regulatory Gas Activity System (FERGAS), and 5.2% adjustment for cost-of-living increase. • As FTEs increase, cost categories such as WCF, training, supplies, rent (outside of WCF), equipment, and IT expenses increase as well. • NETL Support Services projected obligations are flat.

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Other Related Expenses $12,048,000	**$18,912,000**	**+$6,864,000**
• The activities supported by this line item include E-Government initiatives, Working Capital Fund (WCF), computer systems and support, contractual services for HQ and environmental, security, safety, and health requirements at HQ and Human Resources shared service center payments.	• The activities supported by this line item include E-Government initiatives, WCF computer systems and support, contractual services for HQ and environmental, security, safety, and health requirements at HQ and Human Resources shared service center payments.	• Request reflects an increase due to the anticipated increase in FTEs.

Energy Asset Transformation
($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
5,000	6,000	6,000	0	N/A

Overview

Over the next few decades, the U.S. and the world will need to dramatically reduce greenhouse gas (GHG) emissions to halt ongoing contributions to climate change. This imperative implies an unprecedented transition in the energy and industrial system away from unabated GHG-emitting fuels (coal, oil, and natural gas) and toward clean energy sources. This transition will be challenging for a variety of technical, political, and socio-economic reasons.

In the U.S., fossil resources (coal/natural gas/oil) play a major role in meeting energy needs. Coal generation has declined over the past decade, leading to challenges in host communities. In parts of Appalachia, coal-related employment has declined for decades due to increased automation and reduced demand. In the Powder River Basin, the largest source of U.S. coal, production began declining in 2008 and has fallen more sharply in recent years.

Fossil asset retirements can mean that transmission and distribution infrastructure, electrical interconnection equipment, site and permitting licenses, and other infrastructure become available for alternative uses. As the Nation reduces its carbon footprint and deploys new technology and infrastructure, productively repurposing energy assets allows communities and regions to participate actively in building a clean energy and industrial economy and to maximize economic, social, and environmental opportunities that come with productively leveraging existing assets for new uses. This can help retain the local skilled workforce, keep former plant sites economically active, maximize the value of infrastructure, and provide grid stability benefits.

The Energy Asset Transformation program will support leveraging and transforming decommissioned and retiring energy assets, including coal power plants, coal mines, and abandoned oil and gas wells, through repurposing them for clean energy and manufacturing, including through technical assistance, financial assistance, and developing publicly available tools and resources. The program will also conduct stakeholder outreach and fund studies on how existing energy assets can safely and reliably support energy service provision as decarbonization proceeds. Many fossil energy asset sites host a skilled workforce with knowledge of industrial operations, livelihoods, community relationships, access to rail lines, ports, and waterways, highway transportation, transmission and distribution infrastructure, electrical interconnect equipment and direct grid connections, industrial land, facilities, and potentially even site and permitting licenses among other assets.

The FY 2024 Budget Request of $6M will support energy asset transformation efforts across the U.S., through both direct assistance (e.g., funding an ongoing project in a community hosting an asset undergoing transition, through mechanisms like prizes, competitive solicitations, and Partnership Intermediary Agreements (PIAs)) and paper case studies (e.g., through supporting work at headquarters, the National Labs, or contractor funding). It will also continue to support place-based interagency efforts related to energy transition and energy asset transformation, including by contributing to DOE's funding of the Rapid Response Teams associated with the Interagency Working Group on Coal and Power Plant Communities. The program will fund concept development through prizes or a competitive solicitation to repurpose the existing asset, with the intent of supporting transformation efforts in seeking additional support for FEED studies and other work. The program will also support research and case studies focused on safety and reliability challenges for assets reaching end of life in the near and medium term, particularly given dynamic operational constraints. Success will be measured by number of applications (an indicator of need) and number of projects funded (an indicator of project quality). Where appropriate, success will also be measured by projects' impacts on their host communities (e.g., through indicators like those developed under Justice40) and contribution to further funding applications (e.g., for FEED or demonstration funding, or loan support).

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
Energy Asset Transformation $6,000,000	**$6,000,000**	**+$0**
• Funding supports both direct assistance to energy asset host communities (through mechanisms like prizes, Partnership Intermediary Agreements, and Technical Assistance) and financial support for project development (through mechanisms like competitive solicitations and prizes), in addition to analysis and outreach efforts at headquarters. Funding also supports DOE engagement in Rapid Response Teams and other place-based initiatives focused on energy transitions.	• Funding will continue to support engagement by the Rapid Response Teams • Funding will be used for direct assistance to energy asset host communities, including through prizes, technical assistance, and PIAs. • Funding will be used to support transformation activities and develop early-stage concepts through prizes, competitive solicitation, and technical assistance, potentially leading to some pre-front end engineering design (FEED) for asset repurposing and adaptive use given new and challenging operational constraints.	• The program is not seeking additional funding for FY 2024 versus FY 2023.

Fossil Energy and Carbon Management Workforce Development
University Training and Research

($K)

FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
13,000	13,000	19,000	+6,000	+46.2%

Overview

The Department of Energy's (DOE) FY 2024 Budget Request proposes historic increases in funding for foundational research and development (R&D) to train the next generation of students at Historically Black Colleges and Universities (HBCU) and Minority-Serving Institutions (MSI) majoring in science (including social science), technology, engineering, and mathematics (STEM), and humanities disciplines to strengthen the workforce. The University Training and Research (UTR) subprogram focuses on introducing students to the diversity of research topics pursued in support of the Fossil Energy and Carbon Management mission and goals. The FY 2024 Budget funds a new competitive funding opportunity announcements (FOA) for U.S. academic institutions of higher learning to support fundamental research that cuts across the Office of Fossil Energy and Carbon Management's (FECM) research focus areas, including exploration and education of the integration of cultural sensitivities, design and esthetics, and other community issues, into the development and deployment of new technology. The funding aims to sustain a national university program of research in energy, environmental, science, social science, engineering, and humanities that focuses on innovative and fundamental investigations pertinent to advancing the Administration's research, development, demonstration, and deployment (RDD&D) and equity goals.

The UTR subprogram comprises of two areas, which are competitively funded on an annual basis to encourage broad participation:

- **University Carbon Research (UCR) $5 million:** This sub-activity provides funding to colleges and universities to support early-stage research and education into societal and human impacts of new technology development and deployment consistent with the program's goals including Advancing Carbon Dioxide Removal, Accelerating Clean Hydrogen, Demonstrating and Deploying Point-Source Carbon Capture, and Advancing Critical Minerals (CM), Rare Earth Elements (REEs), Coal and Coal Waste to Products, and Mine Remediation. This sub-activity provides a threefold benefit: (1) conducting directed energy research in an innovative environment; (2) expanding the research capabilities and education of students in STEM and humanities disciplines; and (3) developing research-based solutions to support Administration RDD&D and equity goals.
- **Historically Black Colleges and Universities (HBCU) and other Minority Serving Institutions (MSI) $14 million**: This sub-activity also supports early-stage mission-focused research and investigations and education into the societal and human impacts of new technology deployment related to the FECM mission. Grants awarded under this program are intended to maintain and upgrade the educational, training, and research capabilities of HBCUs/MSIs in the fields of STEM and humanities with project results being used to further DOE and the Administration's commitment to equity and to advancing carbon management, critical minerals, and environmental remediation priorities.

Fossil Energy and Carbon Management Workforce Development
University Training and Research

Activities and Explanation of Changes

FY 2023 Enacted	FY 2024 Request	Explanation of Changes FY 2024 Request vs FY 2023 Enacted
University Training and Research $13,000,000	**$19,000,000**	**+$6,000,000**
University Carbon Research $5,000,000	**$5,000,000**	**+$0**
• Released competitive funding opportunity announcements (FOA) for U.S. academic institutions of higher learning to support fundamental research that cuts across the Office of Fossil Energy and Carbon Management's (FECM) research focus areas.	• Funding through a FOA(s) to the national university program for research in energy, environmental, science, social science, engineering, and humanities that focus on innovative and fundamental investigations pertinent to advancing the goals of the program.	• Support curriculum design, research on successful recruitment and retention methods, development of outreach or mentorship programs, fellowships, and building science, engineering research, and education capacity.
HBCU, MSI, Education, and Training $8,000,000	**$14,000,000**	**+$6,000,000**
• Released competitive FOAs for U.S. academic institutions of higher learning to support fundamental research that cuts across FECM's research focus areas.	• Funding increase through a FOA(s) to the national university program for research in energy, environmental, science, social science, engineering, and humanities that focus on innovative and fundamental investigations pertinent to advancing the goals of the program.	• The request level significantly increases historical funding levels, in part, to accommodate the Administration's Justice40 Initiative. • Support curriculum design, research on successful recruitment and retention methods, development of outreach or mentorship programs, fellowships, and building science, engineering research, and education capacity.

Fossil Energy and Carbon Management
Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. Facilities Maintenance and Repair activities funded by this budget are displayed below.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2021 Actual Cost	FY 2021 Planned Cost	FY 2022 Planned Cost	FY 2023 Planned Cost
National Energy Technology Laboratory	19,282	10,915	19,780	19,780
Total, Direct-Funded Maintenance and Repair	**19,282**	**10,915**	**19,780**	**19,780**

Report on FY 2021 Expenditures for Maintenance and Repair

This report responds to legislative language set forth in Conference Report (H.R. Conf. Rep. No. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2021 to the amount planned for FY 2021, including Congressionally directed changes.

Total Costs for Maintenance and Repair ($K)

	FY 2021 Actual Cost	FY 2021 Planned Cost
National Energy Technology Laboratory	19,282	10,915
Total, Direct-Funded Maintenance and Repair	**19,282**	**10,915**

In review of the planned vs actual costs for FY 2021, the primary reason for higher than planned costs is pandemic-related delays in project execution. Certain costs originally planned for FY 2019 and FY 2020 were not incurred until FY 2021. Larger dollar projects that were delayed included NETL's sensitive compartmented information facility and water line replacement at the Pittsburgh site. A fire at the Albany site also contributed to higher actual FY 2021 maintenance and repair costs.

Excess Facilities

Excess Facilities are facilities no longer required to support the Department's needs, present or future missions or functions, or the discharge of its responsibilities. In this table, report the funding to deactivate and dispose of excess infrastructure, including stabilization and risk reduction activities at high-risk excess facilities, resulting in surveillance and maintenance cost avoidance and reduced risk to workers, the public, the environment, and programs. This includes maintenance of excess facilities (including high-risk excess facilities) necessary to minimize the risk posed by those facilities prior to disposition.

Fossil Energy and Carbon Management
Excess Facilities

Costs for Direct-Funded Excess Facilities ($K)

	FY 2021 Actual Cost	FY 2021 Planned Cost	FY 2022 Planned Cost	FY 2023 Planned Cost
National Energy Technology Laboratory (All)	54	45	40	40
NA	0	0	0	0
Total, Direct-Funded Excess Facilities	54	45	40	40

Fossil Energy and Carbon Management
Capital Summary ($K)

	Total	Prior Years	FY 2022 Enacted	FY 2022 Actuals	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted
Capital Operating Expenses Summary (including Major Items of Equipment (MIE))							
Capital Equipment >$500,000 (including MIE)	n/a	0	0	0	0	0	0
Minor Construction Project (>$5 million)	32,000	0	32,000	32,000	0	0	0
Total, Capital Operating Expenses	**32,000**	**0**	**32,000**	**32,000**	**0**	**0**	**0**
Capital Equipment > $500,000 (including MIE)							
Total Non-MIE Capital Equipment	n/a	0	0	0	0	0	0
Total, Capital Equipment (including MIE)	**n/a**	**0**	**0**	**0**	**0**	**0**	**0**
Minor Construction Projects (>$5 million)							
Computational Science & Engineering Center	12,000	0	12,000	12,000	0	0	0
Direct Air Capture Center	20,000	0	20,000	20,000	0	0	0
Total, Minor Construction Projects	**32,000**	**0**	**32,000**	**32,000**	**0**	**0**	**0**
Total, Capital Summary	**32,000**	**0**	**32,000**	**32,000**	**0**	**0**	**0**

Fossil Energy and Carbon Management
Safeguards and Security ($K)

	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Protective Forces	3,164	3,164	4,325	+1,161	36.7%
Physical Security Systems	171	171	150	-21	-12.3%
Information Security	156	163	3,239	+3,076	1,887.1%
Cybersecurity*	4,416	4,416	7,398	+2,982	67.5%
Personnel Security	346	358	383	+25	7.0%
Material Control and Accountability	0	0	0	0	N/A
Research, Development, Demonstration, and Deployment (RDD&D)	0	0	0	0	N/A
Program Management	316	320	337	+17	5.3%
Security Investigations	0	0	0	0	N/A
Transportation Security	0	0	0	0	N/A
Construction	0	0	0	0	N/A
Total, Safeguards and Security	**8,569**	**8,592**	15,832	+7,240	**84.3%**

*Does not include Fossil Energy and Carbon Management (FECM) RDD&D-funded HQ cybersecurity (FY 2022, $1.3 million; FY 2023, $1.8 million; FY 2024, $2.3 million)

National Energy Technology Laboratory (NETL) - Funding will support continued IT modernization and the administration's cybersecurity priorities established by OMB and DOE, including implementing zero trust architectures, improving incident detection and response capabilities, addressing supply chain risks, and increasing automation across IT infrastructure operation/maintenance, portfolio management, cybersecurity risk management. For FECM RDD&D, this includes operation and enhancement of the FECM RDD&D cybersecurity policy and program as it relates to the enterprise computing environment at field locations. Key activities include cybersecurity policy implementation, governance and oversight activities, incident detection and response through continuous monitoring and diagnostics, and meeting Departmental requirements for the Identity Control and Access Management initiative.

Protective Forces and Physical Security Systems funding reflects the physical security costs (contractor and federal oversight) of maintaining round-the-clock physical security at NETL's three research campuses.

DEPARTMENT OF ENERGY

Funding by Site

TAS_0213 - Fossil Energy and Carbon Management - FY 2024

(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Ames Laboratory			
Hydrogen with Carbon Management	0	595	683
Carbon Management Technologies	0	595	683
Advanced Energy Systems	730	0	0
Cross Cutting Research	806	0	0
FECM_PreBY23	1,536	0	0
Total Ames Laboratory	**1,536**	**595**	**683**
Argonne National Laboratory			
Hydrogen with Carbon Management	0	829	952
Carbon Dioxide Conversion	0	1,376	1,376
Carbon Management Technologies	0	2,205	2,328
Unconventional Fossil Energy from Petroleum - Oil Technologies	150	0	0
Total Argonne National Laboratory	**150**	**2,205**	**2,328**
Chicago Operations Office			
Hydrogen with Carbon Management	0	1	1
Carbon Management Technologies	0	1	1
Total Chicago Operations Office	**0**	**1**	**1**
Idaho National Laboratory			
Hydrogen with Carbon Management	0	665	764
Carbon Dioxide Conversion	0	1,089	1,089
Point-Source Carbon Capture	0	387	342
Carbon Management Technologies	0	2,141	2,195
Natural Gas Decarbonization and Hydrogen Technologies	0	452	348
Resource Sustainability	0	452	348
Carbon Capture	110	0	0
Advanced Energy Systems	1,603	0	0
Cross Cutting Research	641	0	0
FECM_PreBY23	2,354	0	0
Total Idaho National Laboratory	**2,354**	**2,593**	**2,543**
Lawrence Berkeley National Laboratory			
Hydrogen with Carbon Management	0	557	640
Carbon Transport and Storage	0	3,129	2,821
Point-Source Carbon Capture	0	574	507
Carbon Management Technologies	0	4,260	3,968
Advanced Remediation Technologies	0	354	355
Natural Gas Decarbonization and Hydrogen Technologies	0	452	348
Resource Sustainability	0	806	703
Unconventional Fossil Energy from Petroleum - Oil Technologies	1,672	0	0
NETL Research and Operations - Fossil Energy	0	661	709
Carbon Capture	465	0	0
Carbon Storage	2,115	0	0
Cross Cutting Research	1,734	0	0
FECM_PreBY23	4,314	0	0
Total Lawrence Berkeley National Laboratory	**5,986**	**5,727**	**5,380**
Lawrence Livermore National Laboratory			
Hydrogen with Carbon Management	0	190	218
Carbon Transport and Storage	0	2,788	2,514
Carbon Dioxide Removal	0	6,533	7,036
Point-Source Carbon Capture	0	2,889	2,554

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Carbon Management Technologies	0	12,400	12,322
Methane Mitigation Technologies	0	3,506	3,506
Natural Gas Decarbonization and Hydrogen Technologies	0	9,048	6,960
Resource Sustainability	0	12,554	10,466
Unconventional Fossil Energy from Petroleum - Oil Technologies	1,000	0	0
Carbon Capture	720	0	0
Carbon Storage	2,000	0	0
Cross Cutting Research	306	0	0
Natural Gas Technologies Research	500	0	0
FECM_PreBY23	3,526	0	0
Total Lawrence Livermore National Laboratory	**4,526**	**24,954**	**22,788**
Los Alamos National Laboratory			
Hydrogen with Carbon Management	0	1,333	1,531
Carbon Transport and Storage	0	6,851	6,177
Carbon Dioxide Conversion	0	389	389
Point-Source Carbon Capture	0	901	796
Carbon Management Technologies	0	9,474	8,893
Methane Mitigation Technologies	0	374	374
Resource Sustainability	0	374	374
Unconventional Fossil Energy from Petroleum - Oil Technologies	1,279	0	0
Carbon Capture	1,264	0	0
Carbon Storage	2,794	0	0
Advanced Energy Systems	128	0	0
Cross Cutting Research	306	0	0
FECM_PreBY23	4,492	0	0
Total Los Alamos National Laboratory	**5,771**	**9,848**	**9,267**
National Energy Technology Lab			
Hydrogen with Carbon Management	0	63,615	73,073
Carbon Transport and Storage	0	100,668	90,766
Carbon Dioxide Removal	1,000	54,184	58,352
Carbon Dioxide Conversion	0	31,574	31,574
Point-Source Carbon Capture	0	149,916	132,520
Supercritical Transformational Electric Power (STEP)	14,500	0	0
Transformational Coal Pilots	10,000	0	0
Carbon Management Technologies	25,500	399,957	386,285
Advanced Remediation Technologies	0	12,470	12,505
Methane Mitigation Technologies	0	79,834	79,834
Natural Gas Decarbonization and Hydrogen Technologies	0	214	164
Mineral Sustainability	7,357	40,839	41,767
Resource Sustainability	7,357	133,357	134,270
Unconventional Fossil Energy from Petroleum - Oil Technologies	38,489	0	0
Program Direction - Fossil Energy	27,780	69,699	91,696
NETL Infrastructure - Fossil Energy	55,000	54,987	54,987
NETL Research and Operations - Fossil Energy	83,000	82,339	88,291
Carbon Capture	8,562	0	0
Carbon Utilization	4,365	0	0
Carbon Storage	15,509	0	0
Advanced Energy Systems	20,994	0	0
Cross Cutting Research	18,731	0	0
Natural Gas Technologies Research	25,000	0	0
FECM_PreBY23	93,161	0	0
Total National Energy Technology Lab	**330,287**	**740,339**	**755,529**
National Renewable Energy Laboratory			

DEPARTMENT OF ENERGY

Funding by Site

TAS_0213 - Fossil Energy and Carbon Management - FY 2024

(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Hydrogen with Carbon Management	0	84	96
Carbon Transport and Storage	0	2,327	2,098
Carbon Dioxide Removal	0	2,360	2,541
Carbon Dioxide Conversion	0	10,585	10,585
Point-Source Carbon Capture	0	1,326	1,172
Carbon Management Technologies	0	16,682	16,492
Mineral Sustainability	0	1,704	1,743
Resource Sustainability	0	1,704	1,743
Carbon Utilization	2,250	0	0
Cross Cutting Research	306	0	0
FECM_PreBY23	2,556	0	0
Total National Renewable Energy Laboratory	**2,556**	**18,386**	**18,235**
Nevada National Security Site			
NETL Infrastructure - Fossil Energy	0	13	13
Total Nevada National Security Site	**0**	**13**	**13**
Oak Ridge Institute for Science & Education			
Hydrogen with Carbon Management	0	1,189	1,366
Carbon Dioxide Removal	0	1,923	2,071
Carbon Dioxide Conversion	0	597	597
Point-Source Carbon Capture	0	218	192
Carbon Management Technologies	0	3,927	4,226
Advanced Remediation Technologies	0	44	44
Methane Mitigation Technologies	0	1,210	1,210
Mineral Sustainability	0	1,457	1,490
Resource Sustainability	0	2,711	2,744
Program Direction - Fossil Energy	0	592	779
Total Oak Ridge Institute for Science & Education	**0**	**7,230**	**7,749**
Oak Ridge National Laboratory			
Hydrogen with Carbon Management	0	2,226	2,557
Carbon Dioxide Removal	900	0	0
Carbon Dioxide Conversion	0	3,072	3,072
Point-Source Carbon Capture	0	2,416	2,136
Carbon Management Technologies	900	7,714	7,765
Methane Mitigation Technologies	0	1,169	1,169
Mineral Sustainability	10,325	0	0
Resource Sustainability	10,325	1,169	1,169
Carbon Capture	1,380	0	0
Carbon Storage	450	0	0
Advanced Energy Systems	878	0	0
Cross Cutting Research	786	0	0
Natural Gas Technologies Research	250	0	0
FECM_PreBY23	3,744	0	0
Total Oak Ridge National Laboratory	**14,969**	**8,883**	**8,934**
Pacific Northwest National Laboratory			
Hydrogen with Carbon Management	0	2,085	2,394
Carbon Transport and Storage	0	5,586	5,037
Carbon Dioxide Conversion	0	1,318	1,318
Point-Source Carbon Capture	0	4,098	3,622
Carbon Management Technologies	0	13,087	12,371
Advanced Remediation Technologies	0	96	96
Methane Mitigation Technologies	0	8,765	8,765
Natural Gas Decarbonization and Hydrogen Technologies	0	9,048	6,960

DEPARTMENT OF ENERGY

Funding by Site

TAS_0213 - Fossil Energy and Carbon Management - FY 2024

(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Resource Sustainability	0	17,909	15,821
Unconventional Fossil Energy from Petroleum - Oil Technologies	500	0	0
Carbon Capture	2,636	0	0
Carbon Storage	1,901	0	0
Advanced Energy Systems	256	0	0
Cross Cutting Research	456	0	0
Natural Gas Technologies Research	1,000	0	0
FECM_PreBY23	6,249	0	0
Total Pacific Northwest National Laboratory	**6,749**	**30,996**	**28,192**
Sandia National Laboratories			
Hydrogen with Carbon Management	0	631	725
Carbon Transport and Storage	0	651	587
Carbon Management Technologies	0	1,282	1,312
Methane Mitigation Technologies	0	5,142	5,142
Natural Gas Decarbonization and Hydrogen Technologies	0	6,786	5,220
Resource Sustainability	0	11,928	10,362
Unconventional Fossil Energy from Petroleum - Oil Technologies	1,800	0	0
Total Sandia National Laboratories	**1,800**	**13,210**	**11,674**
Sandia Site Office			
Carbon Storage	798	0	0
Cross Cutting Research	1,206	0	0
FECM_PreBY23	2,004	0	0
Total Sandia Site Office	**2,004**	**0**	**0**
Savannah River National Laboratory			
Point-Source Carbon Capture	0	180	159
Carbon Management Technologies	0	180	159
Total Savannah River National Laboratory	**0**	**180**	**159**
SLAC National Accelerator Laboratory			
Unconventional Fossil Energy from Petroleum - Oil Technologies	252	0	0
Total SLAC National Accelerator Laboratory	**252**	**0**	**0**
Washington Headquarters			
Carbon Dioxide Removal	38,100	0	0
Carbon Management Technologies	38,100	0	0
Mineral Sustainability	35,318	0	0
Resource Sustainability	35,318	0	0
Unconventional Fossil Energy from Petroleum - Oil Technologies	858	0	0
Special Recruitment Programs	700	1,000	1,000
Program Direction - Fossil Energy	31,353	0	0
Carbon Capture	71,163	0	0
Carbon Utilization	16,385	0	0
Carbon Storage	53,433	0	0
Advanced Energy Systems	67,411	0	0
Cross Cutting Research	23,722	0	0
Import Export Authorization	2,367	0	0
Natural Gas Technologies Research	30,250	0	0
FECM_PreBY23	264,731	0	0
Total Washington Headquarters	**371,060**	**1,000**	**1,000**
Undesignated LPI			
NETL Interagency Working Group	0	3,000	0

DEPARTMENT OF ENERGY

Funding by Site

TAS_0213 - Fossil Energy and Carbon Management - FY 2024

(Dollars in Thousands)

	Request Detail		
	Requested Total		
	FY 2022	FY 2023	FY 2024
Total Undesignated LPI	**0**	**3,000**	**0**
Total Funding by Site for TAS_0213 - Fossil Energy and Carbon Management	**750,000**	**869,160**	**874,475**

GENERAL PROVISIONS—DEPARTMENT OF ENERGY

SEC. 301.

(a) No appropriation, funds, or authority made available by this title for the Department of Energy shall be used to initiate or resume any program, project, or activity or to prepare or initiate Requests For Proposals or similar arrangements (including Requests for Quotations, Requests for Information, and Funding Opportunity Announcements) for a program, project, or activity if the program, project, or activity has not been funded by Congress.

(b)

(1) Unless the Secretary of Energy notifies the Committees on Appropriations of both Houses of Congress at least 3 full business days in advance, none of the funds made available in this title may be used to—

(A) make a grant allocation or discretionary grant award totaling $1,000,000 or more;

(B) make a discretionary contract award or Other Transaction Agreement totaling $1,000,000 or more, including a contract covered by the Federal Acquisition Regulation;

(C) issue a letter of intent to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B); or

(D) announce publicly the intention to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B).

(2) The Secretary of Energy shall submit to the Committees on Appropriations of both Houses of Congress within 15 days of the conclusion of each quarter a report detailing each grant allocation or discretionary grant award totaling less than $1,000,000 provided during the previous quarter.

(3) The notification required by paragraph (1) and the report required by paragraph (2) shall include the recipient of the award, the amount of the award, the fiscal year for which the funds for the award were appropriated, the account and program, project, or activity from which the funds are being drawn, the title of the award, and a brief description of the activity for which the award is made.

(c) The Department of Energy may not, with respect to any program, project, or activity that uses budget authority made available in this title under the heading "Department of Energy—Energy Programs", enter into a multiyear contract, award a multiyear grant, or enter into a multiyear cooperative agreement unless—

(1) the contract, grant, or cooperative agreement is funded for the full period of performance as anticipated at the time of award; or

(2) the contract, grant, or cooperative agreement includes a clause conditioning the Federal Government's obligation on the availability of future year budget authority and the Secretary notifies the Committees on Appropriations of both Houses of Congress at least 3 days in advance.

(d) Except as provided in subsections (e), (f), and (g), the amounts made available by this title shall be expended as authorized by law for the programs, projects, and activities specified in the "Final Bill" column in the "Department of Energy" table included under the heading "Title III—Department of Energy" in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act).

(e) The amounts made available by this title may be reprogrammed for any program, project, or activity, and the Department shall notify the Committees on Appropriations of both Houses of Congress at least 30 days prior to the use of any proposed reprogramming that would cause any program, project, or activity funding level to increase or decrease by more than $5,000,000 or 10 percent, whichever is less, during the time period covered by this Act.

(f) None of the funds provided in this title shall be available for obligation or expenditure through a reprogramming of funds that—

(1) creates, initiates, or eliminates a program, project, or activity;

(2) increases funds or personnel for any program, project, or activity for which funds are denied or restricted by this Act; or

(3) reduces funds that are directed to be used for a specific program, project, or activity by this Act.

(g)

(1) The Secretary of Energy may waive any requirement or restriction in this section that applies to the use of funds made available for the Department of Energy if compliance with such requirement or restriction would pose a substantial

risk to human health, the environment, welfare, or national security.

(2) The Secretary of Energy shall notify the Committees on Appropriations of both Houses of Congress of any waiver under paragraph (1) as soon as practicable, but not later than 3 days after the date of the activity to which a requirement or restriction would otherwise have applied. Such notice shall include an explanation of the substantial risk under paragraph (1) that permitted such waiver.

(h) The unexpended balances of prior appropriations provided for activities in this Act may be available to the same appropriation accounts for such activities established pursuant to this title. Available balances may be merged with funds in the applicable established accounts and thereafter may be accounted for as one fund for the same time period as originally enacted.

SEC. 302. Funds appropriated by this or any other Act, or made available by the transfer of funds in this Act, for intelligence activities are deemed to be specifically authorized by the Congress for purposes of section 504 of the National Security Act of 1947 (50 U.S.C. 3094) during fiscal year *2024* until the enactment of the Intelligence Authorization Act for fiscal year 2023.

SEC. 303. None of the funds made available in this title shall be used for the construction of facilities classified as high-hazard nuclear facilities under 10 CFR Part 830 unless independent oversight is conducted by the Office of Enterprise Assessments to ensure the project is in compliance with nuclear safety requirements.

SEC. 304. None of the funds made available in this title may be used to approve critical decision–2 or critical decision–3 under Department of Energy Order 413.3B, or any successive departmental guidance, for construction projects where the total project cost exceeds $100,000,000, until a separate independent cost estimate has been developed for the project for that critical decision.

SEC. 305. Notwithstanding section 161 of the Energy Policy and Conservation Act (42 U.S.C. 6241), upon a determination by the President in this fiscal year that a regional supply shortage of refined petroleum product of significant scope and duration exists, that a severe increase in the price of refined petroleum product will likely result from such shortage, and that a draw down and sale of refined petroleum product would assist directly and significantly in reducing the adverse impact of such shortage, the Secretary of Energy may draw down and sell refined petroleum product from the Strategic Petroleum Reserve. Proceeds from a sale under this section shall be deposited into the SPR Petroleum Account established in section 167 of the Energy Policy and Conservation Act (42 U.S.C. 6247), and such amounts shall be available for obligation, without fiscal year limitation, consistent with that section.

SEC. 306. No funds shall be transferred directly from "Department of Energy—Power Marketing Administration—Colorado River Basins Power Marketing Fund, Western Area Power Administration" to the general fund of the Treasury in the current fiscal year.

SEC. 307. None of the funds made available in this title may be used to support a grant allocation award, discretionary grant award, or cooperative agreement that exceeds $100,000,000 in Federal funding unless the project is carried out through internal independent project management procedures.

TITLE V—GENERAL PROVISIONS

SEC. 501. None of the funds appropriated by this Act may be used in any way, directly or indirectly, to influence congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. 1913.

SEC. 502. None of the funds made available by this Act may be used in contravention of Executive Order No. 12898 of February 11, 1994 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations).

SEC. 503. (a) None of the funds made available in this Act may be used to maintain or establish a computer network unless such network blocks the viewing, downloading, and exchanging of pornography. (b) Nothing in subsection (a) shall limit the use of funds necessary for any Federal, State, Tribal, or local law enforcement agency or any other entity carrying out criminal investigations, prosecution, or adjudication activities.