

NRC committee in December that a 10^6 improvement in NIF's repetition rate and a 10^5 increase in NIF's fusion energy per shot will be needed to make a fusion power plant economically viable.

Bureaucratic issues

A multitude of other engineering issues will remain for IFE should ignition be attained. Materials for lining the target chamber must be developed that can withstand both the constant bombardment of neutrons and the flying debris that will be generated as targets explode several times per second. In an IFE plant, the neutrons produced during fusion would breed the tritium needed to make new fuel from lithium that lines the inside wall of the target chamber.

Researchers will have to develop a system for extracting tritium from the reactor, and they will need a high-

volume process for manufacturing fuel pellets. A scheme for repetitively and accurately positioning targets in the path of the driver's beam is also required. While Koonin doesn't see any showstoppers, he expects that target fabrication could prove to be the most daunting challenge. But Dean says that DOE contractor General Atomics has a conceptual design for fabricating targets at 16 cents a copy.

If NIF succeeds, a more immediate question will be where the IFE effort should be housed within DOE. Koonin thinks it should be with the Office of Science, but that organization has its hands full with magnetic fusion and ITER and has no funding to spare. Having NNSA run IFE is problematic, since energy is not part of NNSA's weapons-related mission. On the other hand, the weapons program did administer an IFE program for 10 years. Carried out

by the NRL, the high-average-power lasers program worked toward developing an integrated IFE system based on a krypton fluoride direct-drive process. The program fell between the cracks in the congressional appropriations process two years ago and hasn't been revived.

If the NIF schedule holds, IFE will be about 10 years ahead of the timetable for ITER's ignition experiments. Assuming the successful development of the required materials and the meeting of fuel fabrication needs, a decision on an IFE demonstration plant could come in 10 years, Koonin says. But choosing between magnetic and inertial confinement is much further off, he feels. "We are engaged in an obvious next stage on the magnetic side," he says, referring to ITER. "We are at the very beginning of IFE."

David Kramer

Obama calls for increased spending for electric vehicles and solar energy

Advanced batteries, high-risk energy research, and development of clean electricity would benefit from the plan outlined in the State of the Union address. The president sends Vice President Biden and other top officials out to sell that plan.

Looking to maximize the adoption of cleaner energy sources and create new US jobs, President Obama is proposing a major increase in federal funding for renewable energy R&D, including creation of three new multidisciplinary research centers and a big increase for a three-year-old Department of Energy program that awards grants for long-shot research into potentially transformative energy sources. In a State of the Union speech that included a proposed five-year freeze on domestic discretionary spending, the president said the increases could be offset by ending subsidies now enjoyed by fossil-fuel producers.

In remarks a day after the State of the Union address, Energy Secretary Steven Chu predicted that batteries capable of powering an electric car up to 400 miles on one charge will be commercially available in as few as "half a dozen years." Currently available all-electric vehicles have a maximum range of 100 miles per charge, insufficient to overcome the "range anxiety" that deters many would-be buyers. That same day, Vice President Biden told workers at Ener1, an Indiana manufacturer of advanced batteries, that their factory owed its existence to a \$118 million DOE grant funded through the American Recovery and Reinvestment Act.

Obama, in his 25 January address, said, "Two years ago, I said that we

JOHN MARTIN FOR GENERAL MOTORS



The lithium-ion battery that powers the Chevrolet Volt (left) is based on technology that was developed at Argonne National Laboratory. In his State of the Union speech, President Obama called for major spending increases for R&D on advanced batteries and other technologies in support of his goal of having one million electric vehicles on US roads by 2015.

needed to reach a level of research and development we haven't seen since the height of the space race. We'll invest in biomedical research, information technology, and especially in clean-energy technology—an investment that will strengthen our security, protect our planet, and create countless new jobs for our people."

Although the details of his new clean-energy push didn't become public until the mid-February release of the fiscal year 2012 budget request (after PHYSICS TODAY went to press), pieces of it emerged as Biden, Chu, and other

high-ranking administration officials fanned out in the days following Obama's speech to sell it to the public. The White House said it will ask Congress to increase current spending for clean-energy technology by one-third, to around \$8 billion. Specific new items are to include establishment of three "energy innovation hubs"—interdisciplinary R&D centers housed at universities or federal labs that bring scientists and engineers together to tackle a particularly tough energy technology challenge. The Bell-tablets, as Chu sometimes refers to the hubs, are meant to address their topic from the basic research end of the R&D spectrum to the pre-commercial-development stage. Obama had sought to create eight hubs in FY 2010, but lawmakers provided money for only three. The president's request for FY 2011 included a fourth hub. But Congress has failed to approve any of the annual appropriations

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bills, and spending has been frozen at FY 2010 levels.

Climate change isn't mentioned

To pay for the increases he wants for energy R&D, Obama has called for eliminating \$4 billion in annual federal subsidies that now flow to oil, gas, and coal producers. "Instead of subsidizing yesterday's energy, let's invest in tomorrow's," he challenged Congress. Pitching his new energy spending proposals in economic terms, Obama said that the increases will help US companies compete in a burgeoning global market for renewable energy that is just around the corner. Though he never mentioned the politically divisive term "climate change," the president proclaimed an overarching goal for the nation to generate 80% of its electricity from "clean" sources by 2035. That is the magnitude of change climate scientists believe will be required to avert the worst effects of climate change.

Obama created some confusion, however, over the definition of clean energy. "Some folks want wind and solar. Others want nuclear, clean coal, and natural gas," he observed in the address. "To meet this goal we will need them all."

In a conference call with reporters on 28 January, Chu said that by the president's definition, about 40% of the nation's electricity is already provided from clean sources. But that includes natural gas, which emits CO₂, albeit only about half as much as coal combustion. Chu noted that many of the nation's oldest and worst-polluting coal plants will be converted to gas-burning plants in the coming years. Although Obama didn't specify whether natural gas generation, like coal, would count

as clean only if the CO₂ is captured and sequestered, Chu indicated that would be the goal. Excluding natural gas, he said, the US now gets 30% of its electricity from carbon-free sources that include nuclear, hydroelectric, wind, and solar. Increasing that to 80% will be "ambitious," he admitted, "but is it over the top? No."

Industries, environmentalists react

Advocates for renewable energy were especially upset with Obama's inclusion of coal in his clean-energy calculus. "Excuse me, but how is coal clean?" asks Scott Sklar, chair of the steering group of the Sustainable Energy Coalition. "Even if you could sequester carbon, it emits mercury [and] carcinogens, requires much water, emits other greenhouse gases, leaves us with coal-ash waste piles, and drives the blowing-up of our mountain tops, ruining waterways and farmland."

Antinuclear forces fault Obama's embrace of nuclear energy. Thousands of new nuclear reactors will be needed to accommodate rapidly growing global energy demand, producing enough plutonium in spent fuel each year to fuel between 50 000 and 100 000 nuclear weapons, says Arjun Makhijani, president of the Institute for Energy and Environmental Research. And there still is no acceptable solution for disposing of the spent fuel. "Making plutonium in the course of boiling water is not a clean way to boil water," Makhijani says.

The major energy producers reacted along predictable lines. The American Gas Association not only commended Obama for recognizing it as clean, but suggested that gas should be added to the alternatives to oil for transportation.

The American Petroleum Institute complained that Obama had failed to recognize that new jobs would be created with increased oil development. The petroleum industry pays taxes at higher effective rates than other industries, said API president Jack Gerard, and it gets no subsidies for exploration. The tax deductions that the industry gets, such as depletion allowances and credits for enhanced oil recovery and for production from marginal oil wells, "are similar to those enjoyed by other industries to encourage energy production and new jobs," Gerard said. Nuclear Energy Institute executive vice president Alex Flint extolled Obama's plan, saying his commitment to nuclear energy reinforced bipartisan support for increased domestic nuclear generation and for exportation of the technology.

The additional R&D spending will help lower the cost of solar electricity generation to make it competitive with fossil-generated power. Chu said he hopes the new solar push, which he calls a "sun shot," will lower the cost of US-produced photovoltaics by a factor of four before 2020. That could restore the US to world leadership in PVs, a position it has ceded to Japanese, European, and, increasingly, Chinese manufacturers, he said. US companies would then be situated to reap many of the benefits of what he anticipates will soon become an enormous world market for solar energy.

"We have had our Sputnik moment," Chu said, borrowing a line from Obama's speech. "We have watched China say that everything in the energy efficiency and energy generation sector is a key industry and we want to develop it for ourselves, but we also want to export it." **David Kramer**

For underrepresented minorities, bridge programs ease transition to PhD studies

Existing models for increasing the minuscule number of minority physics PhDs in the US include funding research experiences, forging university partnerships, and fostering a support network.

Initiatives to recruit, prepare, or retain underrepresented minorities for PhD degrees in physics are on the rise. Some focus on providing research experience between undergraduate and graduate school; others offer professional and social support to students once they get into graduate school. One of these so-called bridge programs for African Americans, Hispanic Americans, and Native Americans is credited with putting Vanderbilt University in Nashville, Tennessee, on pace to become a top pro-

ducer of underrepresented minority PhD physicists and astronomers.

Vanderbilt owes that success to a partnership that began six years ago between its physics department and the one at Fisk University, a neighboring HBCU (historically black college and university) institution. "The Fisk-Vanderbilt master's-to-PhD bridge program uses the master's degree from Fisk as a way to fast-track students into Vanderbilt's PhD program," says the program's codirector, Vanderbilt as-

tronomy professor Keivan Stassun. It has also doubled the enrollment of Fisk's physics master's program and is drawing an increasing number of Hispanic Americans to both schools.

The Fisk-Vanderbilt program is endorsed by the American Physical Society, which has launched its own bridge program "to measurably increase" the number of physics PhDs granted to underrepresented minorities over the next 10 years. The APS program will assist physics departments interested in