

ic fusion, which the House had marked up earlier for \$280 million—a savage cut from the Bush Administration's request of \$349 million. In the amended bill, the Princeton lab, which had suffered a \$40 million reduction in the earlier version, would get back half of its loss. (In the Senate bill, which passed in late July, the mark for magnetic fusion was \$330.4 million and in the joint House-Senate version the program wound up with somewhat more, \$330.8 million—though the exact amount for the Princeton Lab is not yet known).

The "you support mine and I'll support yours" trade-off gained Roe's support for the SSC. According to several lawmakers, Roe was able to swing many undecided members on the science committee and the public works committee, which he once led. What's more, they add, Roe's impassioned speech at the climax of the SSC debate contributed to the large vote for the project. When Massachusetts Republican Mario Conte, his voice rising and his arms flailing, resorted to some vintage Texas-bashing about greedy state legislators demanding money for the SSC and other projects, Roe became indignant. "Do not pit one section of the country against the other," he told his colleagues. "If I could have this [SSC] built in New Jersey . . . I would be fighting as hard as the people in Texas are."

It wasn't only Texas politicians battling for the SSC. The day before the House vote, Obey got a phone call

from a physicist at the University of Wisconsin urging him not to submit his amendment to strike construction funds. "The SSC is seen as so much pork that will be divvied up everywhere," said Obey. "So many people think they have a piece of the action."

Spreading the money around

Indeed, about three-fourths of the roughly \$205 million appropriated for SSC R&D in the past five years went to three national laboratories—Lawrence Berkeley, Brookhaven and Fermilab. The labs, in turn, have spread the money to university researchers and commercial contractors around the country. DOE, for its part, has awarded direct grants in 18 states.

Some lawmakers thought they would be free of all outside pressures once the site around Waxahachie, Texas, was chosen for the machine. In the past year, for instance, Don Ritter, a Pennsylvania Republican who had been an outspoken opponent of the SSC for years, has lowered his voice. That's not surprising, considering that Westinghouse Electric and Air Products & Chemicals, both headquartered in his state, are competing for contracts to build the \$6 billion machine. On the Senate side, J. Bennett Johnston, chairman of the energy and natural resources committee and powerful on budget and appropriations committees, had been cool to building the SSC in an era of large deficits. But he became one of its ardent proponents when General

Dynamics let him know it would build a plant in Hammond, Louisiana, if it was selected to manufacture the superconducting magnets that will hold the beams in their oval course. Babcock & Wilcox, another company that wants to build SSC magnets and other components, also is located in Johnston's state. Johnston, in fact, effectively led the Senate campaign for the SSC. He met little resistance because Texas's own Lloyd Bentsen and Phil Gramm had already signed up more than 60 senators.

In conference, Johnston, working with Republican senators Pete Domenici of New Mexico, Mark Hatfield of Oregon and Thad Cochran of Mississippi, got House members to agree to add two key points to the SSC section of the Energy and Water Development Appropriations Act: One calls for \$25 million in construction funds "to be available only to initiate the first tunnel sector contract and for no other purpose." The other argues that while foreign participation in the project could significantly reduce its cost to the US, it is likely that such contributions would require sharing in its technological development. Congress wants DOE to report on the advantages and disadvantages of foreign partnerships before any agreement is made. The agreement says, "Using this report, Congress can then make a decision on how much and what type of foreign participation is appropriate."

—IRWIN GOODWIN

WHITE HOUSE GLOBAL CLIMATE PLAN CALLS FOR RESEARCH BY 7 AGENCIES

With the abundance of scientific reports that humans are altering the basic chemistry of the Earth's atmosphere, leaders of the most industrialized nations are latching on to a hot topic. Britain's Margaret Thatcher and the Soviet Union's Mikhail Gorbachev speak forcefully on environmental issues, though cynics argue that their eloquence is shaped by public opinions and actual events like Chernobyl and summer droughts, not by personal principles. In his campaign for the US presidency last year, George Bush promised to clean up America and become the "environmental President."

In his budget manifesto, "Building a Better America," he declared he is "committed to developing a better understanding of the processes that influence global climate." As he saw it, "present understanding of complex

Earth system processes is rudimentary and substantial research will be necessary before we can begin to make reliable predictions of global climate change." Considering the uncertainty, the President is loath to promise to limit or lower the levels of atmospheric gases—notably, CO₂, S₂O, CH₄, N₂O and chlorofluorocarbons such as CFCl₃ and CF₂Cl₂—that seem to trap some of the sun's radiation like the glass in a greenhouse.

'White House effect'

"The problem . . . is international in scope," Bush is quoted in "Building a Better America" as saying. "Unilateral action by the US alone will not solve it. In fact, some say the problem is just too big to be solved. . . . I say they are wrong. Those who think we're powerless to do anything about the greenhouse effect are forgetting

about the 'White House effect.' As President, I intend to do something about it." In fact, Bush's budget, submitted last February along with "Building a Better America," included \$191.5 million for a US Global Change Research Program—a 43% increase over fiscal 1989 research activities, which amounted to \$133.9 million spread through seven agencies—among them, the National Science Foundation, Environmental Protection Agency, the Energy and Agriculture departments and NASA.

Little more was heard about Bush's global climate change program until D. Allan Bromley was asked about it in July by Senator Albert Gore Jr, the Tennessee Democrat. At the Senate science subcommittee's hearing on Bromley's confirmation as the new director of the White House Office of Science and Technology Policy, Gore

said the time has come to find out just what is the White House effect. Not only did Gore want to see the report by the Committee on Earth Sciences of the interagency Federal Coordinating Council on Science, Engineering and Technology, but he wanted to know what Bromley would do to reduce the threat of global warming.

Bromley's answer was ambiguous. "There's every reason not to wait," he said, to pursue certain actions, such as preserving tropical rain forests, practicing energy conservation and planting more trees. But, he added, he had yet to see compelling scientific evidence arguing for reducing or eliminating most of the gases that have been identified so far as culprits in climate change.

The committee report from FCCSET (ironically pronounced "fix-it") came out on 31 August at a news conference called by OSTP. It contains a coordinated plan for a broad government program that will involve geophysicists, Earth scientists, biologists, atmospheric modelers and other specialists. One purpose of this multidisciplinary study is to examine the likelihood of global warming and ozone depletion so that others may be able to better determine their implications for public policies.

The report also carries some statements guaranteed to puzzle and provoke environmentalists. "Many global changes can have tremendous impacts on the welfare of humans," it states at the start. "These events may stem from natural processes that began millions of years ago or from human influence. Responding to these changes without a strong scientific basis could be futile and very costly."

Priorities of study

Accordingly, says the report, research needs to be done on the "interactive physical, geological, chemical, biological and social processes that regulate the total Earth system." To help achieve this end, the report sets priorities for seven broad categories of research to monitor, understand and ultimately predict global climate. Studies will be done, for instance, on ocean circulation and on cloud cover. At the top of the research list is clouds, a major source of uncertainty in models of the greenhouse effect. Clouds act as both a blanket to trap heat near the Earth and as a reflector of the sun's rays to cool the planet. Understanding the balance between these actions is critical in predicting climate change. (See article by Ramanathan and others in *PHYSICS TODAY*, May, page 22). At the bottom of

the list is the heading "solar influences," which includes studies of ultraviolet light and solar radiation.

At the press conference announcing the program, Robert W. Corell, NSF's assistant director of geological science, characterized its purpose as answering questions about "how this magnificent planet works, how it ticks." Corell, a member of the interagency panel, explained that the research categories had been ranked according to questions that committee members believed needed answers to help resolve scientific uncertainties. "This is the 1989 edition of the key scientific questions," he said. He then observed that the questions were apt to change as scientists learned



Dallas Peck: 'Embarrassment of riches'

more about the interactions of humans, the planet and its atmosphere. Once the causes and consequences are understood and evaluated, the government's plan of actions presumably will follow.

The picture of Earth's history that scientists have assembled so far, the report states, shows dramatic changes in global conditions, such as warm and cool epochs, continental shifts, rising and falling sea levels, and movements of deserts, marshes and mountains. While humans have contributed to environmental changes for centuries, it is only since the Industrial Revolution that conditions have been seriously altered. With increased burning of coal and oil to run power plants and transport vehicles, concentrations of CO_2 in the atmosphere has risen by something like 30% in the past 100 years.

Still, evidence for global warming remains largely conjectural, the report observes. True, Earth scientists seem to agree that the world's tem-

perature has risen by about 0.5°C since the beginning of the century and that the six warmest years on record came in the 1980s. But most meteorologists are not sure about the warming to come. Even if the world stopped producing all greenhouse gases today, some warming would still occur. This is because of the Earth's thermal inertia, due largely to the way oceans and vegetation hold heat, and because of the decades it would take greenhouse gases to disperse. The conventional belief is that the global mean temperature may rise by between 1°C and 2°C by 2030 and an additional 0.5°C by mid-century. A 2° rise is hardly a modest change, however, considering that the mean temperature was lower by only 5°C during the ice age, some 18 000 years ago.

The FCCSET committee's report argues that it is essential to understand natural systems so that undesirable climate changes can be avoided before large parts of the US turn into tropics or deserts and before the ocean currents and sea levels make some coastal regions unlivable and some agricultural lands unproductive. In a statement accompanying the report, Bromley observes that global change "may well represent the most significant societal, environmental and economic challenges facing the US and the world."

Congress is likely to back the research program, says Dallas L. Peck, director of the US Geological Survey and chairman of the FCCSET committee. Peck has been with USGS since 1951, when he received his BS degree from Caltech, and served as a geologist with the agency while he earned his MS from Caltech and his PhD from Harvard. Over the years, he has followed Congress's concern with the subject. Peck is so sure the funds will be appropriated for the research that some agency programs may experience "an embarrassment of riches."

Bills before Congress

Indeed, several bills have been introduced in Congress to deal with it—notably, the World Environmental Policy Act (S. 201), introduced by Senator Gore, which calls for regulating and eventually phasing out anthropogenic gases, improving fuel efficiencies for vehicles, preserving the world's biodiversity and developing international controls on greenhouse gases; and the Global Warming Prevention Act (H. R. 1078), by Representative Claudine Schneider, a Rhode Island Republican, which covers the same matters. Schneider's bill, now cosponsored by 150 House members, would give highest priority, in her

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words, "to reinvigorating the nation's energy efficiency and renewable energy R&D programs," which suffered severe budget cuts of 50% and 75%, respectively, in the past decade.

During the Reagan years the White House displayed little or no commitment to such policies. Under Bromley, OSTP is in charge of coordinating the global climate research program, but even sources in the Administration admit they are not convinced that the President or any one agency has the interest and influence to bring it off. "It's not clear how the Administration is going to exercise authority over highly independent,

competitive agencies that are all competing for increasingly limited resources," says a DOE official.

Despite this pessimism, Bush has made some headway. He has taken a stand that the US will not destroy any more wetlands, the habitats of large varieties of wildlife. The White House Domestic Council recently urged Bush to campaign for planting 10 billion trees in the US over the next decade. He is virtually certain to call on government agencies, corporate interests and individuals to do that as an easy preventive action against global climate change.

—IRWIN GOODWIN

NSAC BACKS BROOKHAVEN'S RHIC AND SUGGESTS CLOSINGS TO COME

For the Nuclear Science Advisory Committee, the conclusions reached at Boulder, Colorado, last August evoked a bittersweet taste. Committee members were absolutely overjoyed to recommend as NSAC's top priority that the Department of Energy should build the long-sought Relativistic Heavy Ion Collider, but they were saddened at what the project would mean for other elements of nuclear physics. They know, for instance, that by starting RHIC the department will need to make hard choices about closing older facilities.

This disagreeable prospect was raised in a letter to NSAC on 11 July from Robert O. Hunter Jr, director of DOE's Office of Energy Research, who asked the committee to evaluate the proposed facilities in the field. Hunter's letter pointed out that current "budget balancing activities, competition with other highly regarded scientific projects and other pressing and high-priority concerns within DOE all indicate that even maintaining ongoing levels of expenditures will require substantial justification." Accordingly, the letter went on, while RHIC is a one of the "forefront opportunities" in nuclear physics, NSAC needs to consider whether it should be built in light of its implications for nuclear physics and scientific manpower. Specifically, Hunter wanted to know if the community advocates going ahead with RHIC, knowing that the budget for the field would be virtually constant and that the operation of some existing facilities would be curtailed.

The response to Hunter's letter came on 18 August from NSAC Chairman Peter Paul of the State University of New York at Stony Brook. Paul made it clear that NSAC understood

Hunter's message: that when it comes to the economics of science there is no free lunch. Paul explained that a Long Range Working Group that met for a week before NSAC's discussion had rated "swift construction" of RHIC second only to "timely completion" of the Continuous Electron Beam Accelerator Facility at Newport News, Virginia.

Engine of scientific change

CEBAF and RHIC symbolize the progress in nuclear physics as well as some of the problems that afflict the field. The new instruments are patently engines of change. They drive new physics. This makes experiments on older facilities less interesting.

NSAC's endorsement of RHIC was unambiguous. "After the long delay which this project has already experienced," Paul wrote in his letter, "we urge swift start of construction, even under an approximately constant budget for nuclear science." Still, with a DOE budget of around \$300 million for all nuclear physics in 1990 and a likelihood that it will not go beyond \$315 million in fiscal 1991, RHIC might seem a high price to pay. The machine—a 2.5-mile ring in which two beams of heavy ions will collide with a center-of-mass energy of 200 GeV per nucleon—and its detectors and equipment are now estimated to cost \$328 million on completion. According to knowledgeable sources in the Bush Administration, DOE plans to include the first year of RHIC's construction in its 1991 budget request, to be given to Congress in January. The cost of building RHIC would be spread over five years—from 1991 through 1995.

The committee agonized over how to build RHIC in a period when

nuclear physics is unlikely to get much more funding, Paul recalls. Down deep, NSAC knew that however distasteful the idea of closing facilities was, it had to come to grips with the budget dilemma. Assuming a constant budget in nuclear physics, Paul's letter says, RHIC could still be built—but not without sacrifice: Its construction would need to be stretched out from five to six years. Lawrence Berkeley's aging Bevelac, which is capable of accelerating to 1 GeV per nucleon all ion species up to uranium, would be phased out in the mid-1990s; reductions would be made in some programs no longer considered of great value; and Brookhaven's combination tandem Van de Graaff and Alternating Gradient Synchrotron might be curtailed "at an appropriate time." Of these, only the tandem-AGS gives pause. When it was linked with the tandem Van de Graaff at Brookhaven a few years ago, the AGS was transformed from a purely proton synchrotron to a hybrid that also accelerates heavy ions. The machine is now undergoing another transformation that will enable the AGS to accelerate all the heavy ions the tandem can produce, including those as heavy as gold, up to 15 GeV per nucleon.

As for other machines of high priority, NSAC informed Hunter it favored US participation in the building of KAON, a high-intensity 30-GeV K-meson factory that the Canadian government would like to add to the TRIUMF cyclotron operating near Vancouver, British Columbia (PHYSICS TODAY, June, page 44). The committee finds KAON "a very cost-effective and timely opportunity" to investigate important questions in physics. Still, the committee admits that completing CEBAF and starting RHIC will cause budget pressures requiring DOE to look beyond a constant funding level for money to join up with Canada. Canada has sought a total of \$75 million from the US to build KAON over a five-year period and possibly another \$30 million for detectors and other equipment. The total cost of the project is estimated at \$450 million (in US dollars).

Even though DOE adds a 30% contingency to the cost of building projects, it remains uncertain if existing operations at laboratories and universities can be fully funded in an era of severe budgetary constraints. CEBAF was originally figured to cost \$236 million. But then the start of construction was delayed and the job was stretched by a year. The machine is now calculated to be completed for \$265 million. —IRWIN GOODWIN