tivities. The budget also contains a provision for $45 million in federal funding for cleanup of existing waste sites, in a project yet to be approved by Congress that also calls for industry contributions.

Overall, the agency's budget is slated to rise by 11 percent in operating funds, with specific increases in the areas of:

- drinking water (15 percent), for studies of small water systems, and of the effects of polluted water on reproduction and early human development;
- pesticides (10 percent), for exposure assessments and the disposal of a suspended pesticide, silvex; and
- management and support (28 percent).

Because the agency has traditionally had a poor record in handling toxic substances and pollution from its own installations, it recently hired an expert from the industrial sector who intends to spend 25 percent more on laboratory management.

Basic research at EPA will remain steady with an overall increase of 9 percent. Research will increase on solid waste, radiation, and toxic substances—but at the expense of research on air, water, and pesticides. The agency intends to look into airport noise, as well as the nonauditory health effects of noise, even though the noise program will decline overall; the emphasis in energy research will also shift from modeling of nitrous oxide caused by coal burning to the effects of synthetic fuels.

—R. JEFFREY SMITH

Fusion Energy in Our Time

Congressman McCormack proposes an Apollo-type project to generate electricity with a magnetic fusion reactor before the year 2000

Fusion energy has always been the farthest away of the long-term solutions to the energy scarcity. But commercialization of fusion could come a lot sooner than projected, says Representative Mike McCormack (D-Wash.). In a mid-January press briefing, McCormack announced that he is urging the Administration to make a national commitment to fusion now—somewhat in the spirit of the Apollo project to put a man on the moon. McCormack estimates the cost of the project to be about $20 billion and says we could have electricity from a demonstration magnetic fusion reactor by the turn of the century, at least 15 years ahead of the Department of Energy's current timetable.

The first major step toward accelerated development of magnetic fusion would be to begin immediately to design a $1 billion Engineering Test Facility (ETF), which would be the first fusion project to concentrate on engineering issues instead of basic plasma physics. McCormack is asking President Carter to make the ETF a line item in the fiscal 1981 budget. Although annual expenditures for the entire magnetic fusion program would not increase greatly during the early design phase of the ETF, they would rise to about $1 billion within 2 years, not quite three times the current level.

McCormack has already made the rounds within the Administration, touching bases with the Energy Department, the Office of Management and Budget (OMB), the Office of Science and Technology Policy (OSTP), and the White House Domestic Council. He has not been able to meet with President Carter, however. While McCormack claims to be encouraged because nowhere has anyone responded with a flat "No," what signs there are are not so sanguine. Secretary of Energy Charles Duncan has been quoted as saying that the Administration plans to "turn a deaf ear" to entreaties to build an ETF soon. (The fiscal 1981 budget of $404 million for magnetic fusion contains no new funds for an ETF.) And in an election year with constituents worried about fuel shortages and balanced budgets, says a Senate staffer, it is unlikely that Congress will be making additional large financial commitments to fusion, which will not be able to produce large amounts of power for decades to come. Nonetheless, on 22 January McCormack introduced a bill (H.R. 6260—the Fusion Energy Research, Development, and Demonstration Act of 1980) providing for the fusion program he sees as necessary if the technology is going to be ready to contribute when the short-term energy options run out in the early part of the next century. Thirty-six of the 42 members of the House Science and Technology Committee have agreed to be cosponsors.

The source of McCormack's optimism is a succession of encouraging experiments at the Princeton Plasma Physics Laboratory, the Massachusetts Institute of Technology, the Oak Ridge National Laboratory, and elsewhere. Taken together, says McCormack, the data from these experiments mean "we can now predict with certainty that the conditions required for a successful fusion reaction can be obtained in devices now under construction." Because of this happy situation, he argues, it is time to shift the emphasis in fusion research from basic science to the related technological and engineering problems that must be solved before fusion can be a commercially attractive source of energy.

In magnetic fusion, it is necessary to heat a deuterium-tritium mixture to at least 50 million degrees Kelvin while simultaneously holding the resulting hot ionized gas (plasma) together with a magnetic field. A plasma with a density of about 10^{14} ions per cubic centimeter confined for 1 second or longer would do the trick. Energetic neutrons and helium nuclei are the products of the fusion reactions in the plasma, with the kinetic energy of the neutrons being converted to heat to power an electricity generator or to produce synthetic fuels and the energy of the helium helping to keep the plasma hot.

As recounted by Melvin Gottlieb, director of the Princeton laboratory, 25 years ago fusion researchers were in a sorry situation. Nearly all the experimental results were surprises, and the first test device even fell apart. Now, thanks in part to the larger fusion research budgets that began appearing after the 1973 Arab oil embargo, a temperature higher than that needed to start a fusion reaction has been achieved at Princeton, and a value of a parameter called the density-confinement time product that is higher than required for fusion has been reached at MIT. Cur-

0036-8075/80/0208-0622$00.75/0

rently under construction at Princeton is a $290 million Tokamak Fusion Test Reactor (TFTR), which is widely expected to achieve these conditions simultaneously. Moreover, many researchers believe that the resulting fusion reactions will release more energy than it took to produce and heat the plasma in the first place, thereby demonstrating the scientific feasibility of fusion.

The problem now, says McCormack, is that rather than pushing rapidly ahead with fusion on the basis of the recent experimental successes and the ones expected from the TFTR, the Administration has entered a period of level fusion funding with no start on the next generation fusion device, the ETF, scheduled for several more years. Moreover, to decrease the effects of limited budgets, the energy department has reduced spending on engineering and technology in favor of theory and physics research. McCormack fears that the development of fusion energy will slip too far into the future to help with even the long-term energy problem unless the momentum built up in the last few years in magnetic fusion continues to grow through an expanding program.

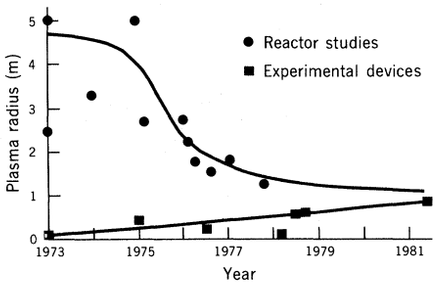
A similar concern has been expressed by Senator Howard Baker (R-Tenn.), who wrote to Energy Secretary Duncan in December, "prudence would dictate that we find the means to build an engineering test facility now, so that we can gather the data to determine whether fusion will be a realistic option for our long-term energy future."

Moreover, several recent fusion studies support the congressmen's ideas:

• An Energy Department fusion power coordinating committee comprising project directors in the department's national laboratories, division directors in the department's Office of Fusion Energy, and outside consultants last April recommended "that the magnetic fusion program proceed immediately with the design leading to construction of a major Engineering Test Facility aimed at producing significant amounts of fusion energy and at testing the major engineering subsystems prototypical of a fusion reactor."

• McCormack last summer assembled a fusion advisory panel made up of 12 senior scientists and executives, which found that "it is none too soon for the Department of Energy to plan a comprehensive strategy for bringing a . . . fusion electric demonstration plant on line by 1995."

• The Atomic Industrial Forum in January released a report of a yearlong study by its Committee on Fusion that urges "that a national goal be established aimed at construction and operation of a fusion energy facility producing net power before the end of the century."



Fusion adherents argue that commercial fusion reactors, not long ago thought to be too large and expensive to be of interest to utilities, are actually comparable in size and cost to fission reactors. This graph shows that the size of reactors considered in engineering studies (upper curve) is converging to the size of experimental Tokamak devices (lower curve). [Source: Department of Energy]

• A study by 400 fusion researchers from the United States, Europe, the U.S.S.R., and Japan, accepted in December by the International Atomic Energy Agency, concluded "that it is scientifically and technologically feasible to undertake the construction of INTOR to operate in the early 1990's provided that the supporting R & D effort is expanded immediately to provide an adequate data base in a few critical areas." (INTOR is a fusion machine similar to ETF that would be built as an international cooperative project.)

Despite this impressive barrage, McCormack's proposal has a tough row to hoe. One obstacle is that magnetic fusion has had to take a backseat to finding solutions to short-term energy problems at the Energy Department. According to one observer, when the department subsumed the old Energy Research and Development Administration a little over 2 years ago, magnetic fusion was then in danger of being cut back. An Ad-Hoc Experts Group on Fusion, chaired by John Foster of TRW, Inc., submitted a report that successfully staved off the budget cutters, but, at the same time, some criticisms were made. The group concluded that the magnetic fusion program was too lopsided in favor of one fusion reactor concept, the Tokamak. (A Tokamak is basically a doughnut-shaped, vacuum-tight vessel through which the plasma circulates. Magnetic fields keep the plasma away from the walls of the vessel and confined tightly enough for fusion to occur.)

In particular, the Foster committee recommended that "commitment to construction of a next generation Tokamak beyond TFTR should not be made until results from TFTR and other related experiments justify it." And "before commitment to a Tokamak-type engineering prototype reactor . . . a convincing case should be made that Tokamaks can be engineered into attractive energy producers." A similar conclusion was reached in a June 1978 study by an OSTP Working Group on Basic Research, which cited the fusion program for "attempts to move ahead too rapidly without adequate theoretical, experimental, and engineering assessment of existing results." Thus, the Energy Department's present policy is to make a decision about the ETF in the mid-1980's, when other reactor concepts have developed to the point where the best one can be chosen. Right now, only the Tokamak is advanced enough to be taken to the ETF stage.

The saving grace of this strategy is that, if it did not reduce the fusion budget, at least it did not increase it. Since the Energy Department's birth, spending on magnetic fusion has not increased in real dollars. Moreover, according to a letter from the Vice President's office made public by Stephen Dean, president of Fusion Power Associates, a new fusion industry lobbying group, the Energy Department submitted a proposed fiscal 1981 magnetic fusion budget of some $393 million. OMB, which is known to have become interested in fusion and has commissioned the National Science Foundation to do a study on whether now is the time to accelerate fusion development, offered to add $24 million to this figure. But, says a recent energy newsletter, the department turned the offer down. Meanwhile, still another committee is being formed by the new director of energy research, Edward Frieman of Princeton University, for the department's own assessment of the appropriate pace for fusion development.

How about the Foster committee's recommendation not to begin the ETF too soon? Although it is following this advice, the Energy Department apparently does not think there is any scientific or technological reason why a faster pace could not be maintained without foreclosing the option of switching to a different reactor concept than the Tokamak, if any of those now under development should turn out to be superior. For example, in response to a request from McCormack to Undersecretary of Energy John Deutch, the department devised three timetables for development of a demonstration fusion reactor, one to be on-line in 2010, one in 2000, and one in 1995. In testimony before McCormack's energy research and production sub-

committee, Edwin Kintner, director of the Office of Fusion Energy, said, "All three of these paces retain the basic internal logic of the [department's] policy for fusion in (1) demonstration of scientific feasibility, (2) development of an engineering data base, (3) maintenance of a strong scientific and technological base, and (4) research into attractive alternate concepts."

Opinion among fusion scientists and engineers seems largely to back up Kintner's testimony. Even in the absence of any experimental data from the TFTR, there seems to be little doubt among physicists that the ETF will work about as it is supposed to (that is, it will maintain a "burning" plasma). Marshall Rosenbluth of the Institute for Advanced Study, who has been called the undisputed dean of Tokamak theory, says that "the science looks good enough that if we decided not to go ahead with the ETF right now, the results of the TFTR experiments would look very favorable, and we would feel unhappy that 5 or 6 years were lost." Somewhat more concern has been expressed for the jump between the ETF and the demonstration reactor. Weston Stacey of the Georgia Institute of Technology, for example, says that there must be at least 10 years (15 years is better) between starting the ETF and starting a demonstration reactor, if use of experimental data from ETF is to be used in the latter's design. A demonstration reactor by the year 2000 is just reachable by this criterion but one by 1995 is not, says the Georgia Tech engineer.

One objection that has been raised in the past to a too-fast development of fusion power is that the best fusion technology may get locked out in the rush to get something running. The biggest danger to fusion, says John Holdren of the University of California at Berkeley, is that by rushing too fast into a crash program, the resulting fusion reactor may be so unattractive that utilities will not buy it, government agencies would not license it, and local groups would protest any attempt to locate it nearby. For example, while not nearly the hazard of radioactive wastes from fission reactors, wastes from fusion reactors will not be radiation free. In addition to the need to handle large amounts of radioactive tritium in a deuterium-tritium reactor, the high-energy neutrons have two effects on stainless steel, the likely structural material in first generation reactors. The first is to cause radiation damage, so that eventually the material must be replaced. The second is to cause neutron activation, so that the replaced stainless steel is radioactive and must be securely stored.

While fusion advocates argue that a demonstration reactor is exactly what is needed to answer such questions, there seems to be enough diversity of opinion and enough more pressing energy concerns that McCormack will have to work hard to convince the Administration and the Congress that now is the time to move ahead with fusion.

—ARTHUR L. ROBINSON

A New Call for Abolishing the NRC

Report from the commission's own Three Mile Island inquiry says an executive branch agency should be set up—the White House disagrees

A new call for abolishing the Nuclear Regulatory Commission (NRC) has been heard from a special Three Mile Island inquiry group even though President Carter and key members of Congress are committed to saving it. This latest recommendation to replace the NRC with an executive agency headed by a single administrator has come from a $3-million inquiry commissioned by the NRC itself.

"We have found the [NRC] an organization that is not so much badly managed as it is not managed at all," said the report from this study, which was directed by Mitchell Rogovin, a Washington attorney, under an NRC contract. According to the report, which was made public 24 January, "A radical reorganization of the commission's structure and management is called for, now."

The President's Three Mile Island commission headed by John G. Kemeny, president of Dartmouth College, arrived at the same conclusion in its report last fall. The congressional reaction to this recommendation was distinctly negative, chiefly because an independent agency headed by several commissioners obviously is more responsive to Congress than an executive agency accountable to the President.

On 7 December, President Carter, acting partly in deference to the powers-that-be on Capitol Hill, announced (*Science*, 21 December) the main outlines of a reorganization plan that would strengthen the authority of the NRC chairman but leave the commission intact as a five-member collegial body. He also announced that a new chairman will be appointed from outside the agency later this year, and that, as an interim arrangement, commissioner John Ahearne was taking over as chairman from Joseph Hendrie.

The Rogovin report, taking note of these White House decisions, observes that the President has urged the commission to bring about "prompt implementation" of needed reforms. It then adds caustically: "Apparently the new chairman from the outside is to arrive to preside over a house already in order."

The report, prepared with the help of a large staff on which several dozen NRC employees served, described the present situation at the NRC in unsparing terms:

> [The commission] can make no decisions and take no action without a majority of the commissioners in agreement. In 1975, the original NRC legislation was amended to make the chairman of the commission the "chief executive officer" with rather vaguely described powers to exercise executive and administrative authority. At the same time, however, the act prescribes that the chairman shall be governed by the policy of the commission and gives the commissioners as a whole approval authority over appointments to the major staff offices and formulation of the agency's budget. There was also some sentiment that the 1975 amendment was procured by the then-chairman behind the backs of the other commissioners, so that subsequent chairmen have been reluctant as a political matter to try to exercise whatever additional authority the law may confer on them.
>
> Below the commission there is no general manager or chief executive officer with singular authority over the staff. The staff is divided into five major offices, three of which are independently chartered by the statute, and each of which is headed by an office director. Between the office directors and the commis-

(Continued on page 626)

0036-8075/80/0208-0624$00.50/0