

Assessing the Damage at TMI

The inventory includes a hot reactor, a nearly bankrupt utility, and a skittish financial market

Investigations into the accident at Three Mile Island are sprouting like toadstools after a spring rain, and one of the first questions they seek to answer is, Just how extensive was the damage?

One of the few industries that will benefit from the reactor's breakdown is the investigative business. On 11 April, the President created his own 11-member commission of inquiry, chaired by John Kemeny, the president of Dartmouth College. The group has been given a budget of \$1.3 million, and instructed to come up with a report in 6 months that explains what happened and makes general recommendations for the future regulation of nuclear power. The Edison Electric Institute has sponsored a nine-point program to improve safeguards at nuclear reactors. Chief among these was the decision to have the Electric Power Research Institute (EPRI) conduct a massive technical review of Three Mile Island, costing as much as \$6 million, according to one official estimate. The Nuclear Regulatory Commission (NRC) has at least two major investigations under way, one in the licensing and one in the regulatory division. The Senate Subcommittee on Nuclear Regulation, chaired by Senator Gary Hart (D-Colo.), and the House Subcommittee on Energy and the Environment, chaired by Morris Udall (D-Ariz.), have announced that they will look into the accident.

An aide to Udall, explaining that the subcommittee has the primary jurisdiction for nuclear power in the House, said that this investigation will be "a big deal . . . we're going to look into the whole spectrum of major nuclear issues." He said other congressmen would want questions answered, and Representatives John Dingell (D-Mich.) and Toby Moffett (D-Conn.), both of whom chair subcommittees that consider energy policy, have expressed an interest in Three Mile Island. Senator Edward Kennedy (D-Mass.) has conducted hearings on the subject; Senator John Glenn (D-Ohio) intends to begin some in May; and Senator Howard Metzenbaum (D-Ohio) nearly held some in his home state until an offended mayor vetoed the plan. The General Accounting Office, a creature of

Congress, has been asked by Dingell to make a 6-month study of the accident and by Senator Richard Schweiker (D-Pa.) to review all nuclear plant training programs. In addition, the Department of Health, Education, and Welfare, Pennsylvania state officials, and Metropolitan Edison—the owner of the reactor—have begun their own specialized investigations. The press is active, as always.

Carl Walske, president of the Atomic Industrial Forum (AIF), told Senator Hart in hearings on 23 April that the accident was "the most serious in 25 years of commercial reactor operation. This is particularly true in terms of apparent damage to fuel elements and accidental release of radioactive materials." Herman Dieckamp, president of the General Public Utilities Corporation (GPU), parent of Metropolitan Edison, said the same day, "the reality of this accident has had a far greater impact than we could ever have projected." He guessed it would take at least 2 to 3 years to clean up and rehabilitate the billion-dollar

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plant, which had been officially on-line for only 3 months before the accident. The company is now on the verge of bankruptcy, not because of the \$140-million cost of the cleanup (which is insured), but because the local utility commission decided that the company cannot charge customers for the uninsured "consequential costs" of the accident. Both GPU and Metropolitan Edison are paying \$24 million a month to buy electricity from other producers in order to make up for lost generating power. Utility company executives are trying to put

together an insurance pool that would rescue other companies should any find themselves in such a bind in the future.

One question will not be answered properly until workers reenter the Three Mile Island containment building, but has already produced a lot of expert speculation. This is, How close did the accident come to causing a disaster? Industry spokesmen were annoyed by the emphasis the press put on the chances that the reactor core might melt or explode. The fact that no uranium has been found in the coolant solution indicates that the fuel never melted or even began to melt. Carl Goldstein of AIF also discounted stories suggesting that the hydrogen bubble might have exploded, saying there was no oxygen in the reactor core, where the bubble was lodged, to combine with the hydrogen in an explosion. However, oxygen was present in the containment building, which houses the core. Whether or not a major explosion in this area might have caused a leak he could not say.

There appears to be no question now about the source of the hydrogen bubble: It was produced when the zirconium metal cladding that holds the fuel assembly together combined with water in the coolant system at temperatures of 2700°F or higher. Metropolitan Edison believes that, as a result of this reaction, about 15 percent of the structure that holds the fuel in place has been eaten away. The NRC estimates this figure to be closer to 30 percent. Theodore Taylor, a nuclear physicist who formerly worked on the weapons program at Los Alamos and now sits on the President's commission of inquiry, discussed this question before his appointment. His figures agree with those of the NRC, suggesting, he said, that one-third of the uranium oxide fuel pellets (30 tons) have fallen out of place, and that many have dropped to the bottom of the pressure vessel that holds the reactor core. There is thought to be no danger of their reheating. At least one of the fuel assemblies was so badly damaged during the accident that cooling water cannot circulate through it freely, thus creating a hot spot (320°F) in the core. This has necessitated

some complicated plumbing changes to cool the system without releasing radioactive steam. It is not known for certain whether the reactor will reach "cold shutdown" by mid-May, as is hoped.

These clues, and some of the unofficial chronologies of the accident, suggest that the reactor was seriously out of control for some time but not on the brink of a meltdown or an explosion, as some news reports suggested over the weekend of the bubble crisis. The fuel core was subjected to repeated shocks and, according to Metropolitan Edison, was not brought to a stable condition until 16 hours after the accident began. During this initial period, the core may have been exposed to steam three different times, once for as long as an hour. "One of the few bright spots in all this" a spokesman for the AIF said, "might be that the core did not melt." Although it sounds callous, the utility company spokesmen make a valid point when they say that no one was killed in the most serious accident at a commercial nuclear plant in 25 years. The accidents that taught the industry how to run fossil-fuel plants safely were paid for with much grimmer statistics than those coming from Three Mile Island.

Nevertheless, this silver lining must stretch around what looks like a very large and dark cloud. The nuclear accident investigators say it is too early to decide whether human error or mechanical failure played the greater role in causing the accident, but it is clear that many changes will be made in the training of operators, in the administrative and financial emphasis put on safety, in the design of plants, and in the attention given to critics and worriers. All of it will cost money, making nuclear power less competitive in the marketplace than it has been.

Responding to consumers' anger, the Pennsylvania commission that sets rates for Metropolitan Edison has told the utility—in what seems a rushed decision—that it cannot count the broken reactor or its problems as part of its cost of operation. There is no reason to doubt the company's claim that this will drive it to bankruptcy. What will be the result? The parent company, GPU, already has decided to delay construction of two new plants, a nuclear-powered one in New Jersey and a coal-fired one in Pennsylvania. The value of GPU's stock has fallen sharply, as has Wall Street's estimate of the value of its bonds. Other utilities, such as Commonwealth Edison of Chicago and Consolidated Edison of New York, are losing their preeminence in the bond market. This means that money

will be harder to obtain, and that lenders will charge higher rates for its use. The cost of financing electric plants will increase, according to one estimate cited at Senator Hart's hearings, by as much as \$2 billion nationwide. Construction

will slow down and electricity rates will escalate. If the trend continues, it could necessitate crash conservation programs or mandatory rationing (blackouts).

The NRC decided on 27 April to bring about a "voluntary" closing of plants

The President's Investigation

President Carter created the Commission on the Accident at Three Mile Island by executive order on 11 April, asking it to analyze the technical causes of the accident, to evaluate the performance of regulatory and emergency preparedness agencies, review the handling of public information, and make broad recommendations for improving the safety of nuclear plants. Carter said that it was essential that we "make sure that the safety of our citizens is never again endangered in this way."

At the first meeting of the commission, the chairman, John Kemeny, said he took this to mean that the group should "learn everything there is to know" about Three Mile Island and then, after reaching a consensus, make recommendations that should "enable us to prevent any future nuclear accident." It is an awesome responsibility, Kemeny said, particularly since the final report is due on 25 October. The commission is authorized to include 12 members, but at this point only the following 11 have been named:

John G. Kemeny, chairman, has been president of Dartmouth College since 1970. A native of Hungary, he became a naturalized U.S. citizen in 1945, worked as a researcher on the Manhattan Project at Los Alamos, New Mexico, taught mathematics and philosophy at Princeton University, and spent 2 years as an assistant to Albert Einstein. He later became chairman of the mathematics department at Dartmouth and was a co-inventor of the computer language known as BASIC.

Bruce E. Babbitt was elected governor of Arizona in 1978 after having served as state attorney general. He has a masters degree in geophysics.

Patrick E. Haggerty retired as chairman of the board and president of Texas Instruments in 1976. He is chairman of the board of Rockefeller University and a trustee of the University of Dallas.

Paul A. Marks, a physician and biochemist, is vice president for health sciences of Columbia University. He has been a member of the President's Cancer Panel and a founding member of the Radiation Effects Research Foundation of Japan.

Cora B. Marrett, an associate professor of sociology at the University of Wisconsin in Madison, has concentrated her research on organizational structure, communication, and opportunities for the advancement of women and minorities in science and engineering.

Lloyd McBride is president of the United Steelworkers of America.

Harry C. McPherson, a Washington, D.C., attorney, served as a special counsel to President Lyndon Johnson. He has been deputy undersecretary of the Army and an assistant secretary of state.

Russell Peterson, who recently resigned as director of the Office of Technology Assessment, is president of the National Audubon Society. He has served as governor of Delaware and as chairman of the President's Council on Environmental Quality.

Thomas Pigford is chairman of the department of nuclear engineering at the University of California at Berkeley. He has taught at the Massachusetts Institute of Technology and served on the American Physical Society's study group on nuclear fuel cycles and waste management.

Theodore B. Taylor is a part-time professor of aerospace and mechanical science at Princeton University and a consultant to the Rockefeller and Ford foundations. He has worked for the Los Alamos nuclear weapons laboratory and was deputy director of the Defense Atomic Support Agency.

Ann Trunk, a mother of six children, lives in Middletown, Pennsylvania, a few miles from Three Mile Island. A civic activist, she was chosen as a nonexpert representative of the public.

which, like the one at Three Mile Island, were designed by Babcock & Wilcox (B & W) and could experience similar accidents. This has done the nuclear industry's reputation in the financial markets no good. The industry has been shaken only slightly by the immediate cost of the accident; it is more worried about the long-term prospects for federal intervention in the business, more frequent shutdowns, and longer licensing delays. These are anathema to nuclear people, just as miners' strikes are to coal operators.

According to the Edison Electric Institute, the inflationary trends last year were moving in a direction that favored nuclear power. The cost of generating a kilowatt-hour of electricity in 1977 was 1.5¢ with nuclear power, 1.8¢ with coal, and 3.7¢ with oil. In 1978, the corresponding figures were 1.5¢, 2¢, and 4¢. Goldstein of the AIF said that "unless we change the Clean Air Act," the cost of burning coal will escalate faster than the cost of nuclear power. "The public should know," an AIF handout says, "that even after we conserve to the utmost, we have only three real options when it comes to future electric power supplies: coal, nuclear energy, and shortages." William Lee, president of the Duke Power Company, which owns three of the B & W reactors being shut down this spring, used stronger language when trying to persuade the NRC to keep his plants open. He predicted there would be "rotating blackouts" this summer in the eastern United States if his company were forced to close its nuclear plants.

Lee changed this dire forecast after the NRC backed away from the original plan, which would have required an indefinite shutdown for mechanical changes. Instead, the NRC agreed to a compromise requiring that two of Duke Power's reactors be closed for only one weekend each. The third will be closed longer because the company already had scheduled it for an extended period of refueling. "We are going home with a very reasonable solution," Lee said. The apocalypse is no longer on the horizon.

Nevertheless, the NRC's willingness to compel plant shutdowns for the second time in a few months (the earlier case also involved B & W machinery, as reported in *Science*, 30 March) suggests that nuclear power is losing its special claim to efficiency. It is no longer the dependable, nuisance-free resource it once seemed. If it becomes as costly as coal, as it could well do in a few years, it will have lost much of its appeal.

—ELIOT MARSHALL

Senior Scholars Unite

A couple of over-65-year-olds were shaking their heads together a while back over society's habit of shoving people out to pasture when they are still at the height of their creative powers. The tendency is particularly egregious in academia. So the two enterprising oldsters, economists Kenneth Boulding and Lawrence Senesh of the University of Colorado, decided to do something about it. They wrote to about 60 of their brightest and busiest friends to see how many would be interested in setting up an institution that would encourage and make use of the work of retired scholars, scientists, and thinkers.

The response was enthusiastic; a conference was held last January, and the result is a plan for a national Academy of Independent Scholars.

The board of trustees,* including the two originators, has just completed a proposal seeking \$300,000 to lay the groundwork for the academy over the next 3 years. Plans are still preliminary, but the basic scheme is to establish regional academies around the country and a national one to coordinate their activities and serve as a liaison with other groups. (Headquarters location has not been decided, but Colorado is not ruled out.)

The purpose of the academy will be threefold. First, it will act as "facilitator"—that is, it will supply support systems to some retired scholars to permit them to continue their work and help others find outside sources of support. Second, it will have a "brokerage" function, bringing together creative people from all sectors with mutual or complementary interests, and, for example, finding retired professors to act as replacements for professors on leave from their institutions. Finally, there is the "programmatic" function. This will embrace task forces, public hearings, symposia, and surveys related to public policy issues and to subjects close to the academy's heart, such as retirement policies and the relationship between creativity and aging. There are plans to publish a journal called *New*

*Kenneth Boulding and Lawrence Senesh, University of Colorado; Robert A. Aldrich, University of Colorado Medical School; David Easton, University of Chicago; Arthur Goldschmidt, United Nations; Henry Koffler, University of Minnesota; and Berta Scharrer, Albert Einstein College of Medicine.

Ideas, to tie the network together.

Qualifications for academy membership have not been determined and the board is divided over how exclusive it should be, although everyone agrees membership should not be honorific but should be based on current achievements. "Boulding wants to avoid a mutual admiration society," says Senesh. "This is not for brownie points earned in the past." Most members will be senior thinkers, but the academy will be open to younger people "whose creative interests cut across the lines of conventional institutional arrangements," according to Senesh.

The academy founders want to encourage projects that involve cooperation between younger and older scholars—"intergenerational dyads," as their report puts it. "There is little communication between older and younger generations in academia," Senesh observes.

The academy basically wants to do things that are not done very well at institutions of higher education: promote integrative and interdisciplinary approaches to topics of interest; facilitate the transfer of "frontier" knowledge to the community at large; and pull in people of intellectual accomplishment from outside the world of scholardom.

The response to the academy idea, which Senesh describes as "utterly overwhelming," has brought into stark perspective not only the appalling waste of elderly talent but also the repression of creativity many academics feel at their institutions. "Some people in academia can hardly wait for retirement so they can do creative work," says Senesh, but many find themselves relegated to tending their vegetable gardens instead.

The planning conference, held at Wingspread in Racine, Wisconsin, was subsidized by the University of Colorado, the Exxon Foundation, and the Johnson Foundation. The source of future support no one knows for sure, but the bandwagon is rolling. Sixty persons have been invited to become charter members, and acceptances are rolling in—from Nobel laureate Glenn Seaborg and author and critic Alfred Kazin, to name two. And already, a group of faculty members from a large state university have written to ask for advice in setting up a regional academy.