Nuclear waste: Don't bury it, recycle it

Other countries have successfully implemented a full nuclear reprocessing program, using "wastes" for fuel. Why not the United States? Marjorie Mazel Hecht reports.

The recent scare stories in the press about the planned burial of high-level radioactive waste neglect to tell readers the basic point about nuclear power: Of the so-called waste produced by nuclear reactors, more than 96% can be reprocessed, to be reused as uranium or plutonium fuel. Only about 4% is actually high-level radioactive waste that requires disposal.

In fact, this remaining 4% of high-level waste could also be turned into a resource: Advanced isotope separation technologies can separate and concentrate it into its constituent isotopes—including costly and scarce strategic metals like rhodium, ruthenium, and palladium.

By treating as "waste" all of the spent fuel produced by a single 1,000-megawatt nuclear plant over its 40-year lifetime, we throw away the equivalent of 130 million barrels of oil or 37 million tons of coal. This does not even take into account the value of the strategic metals and other isotopes that could be "mined" from the high-level waste.

During the Atoms for Peace years, beginning during the Eisenhower administration, one of the selling points for nuclear power was its closed fuel cycle, because it was clear that this would cheapen the use of nuclear power and ensure a steady supply of fuel, no matter what became of the natural uranium supply. The other nations that went nuclear—Canada, France, England, Japan, and the Soviet Union, for example—completed the nuclear cycle and are reprocessing their fuel. Most recently, India has initiated reprocessing. Yet the United States, which led the world in developing reprocessing technology, has not. What happened?

The answer has little to do with the technology involved; it is a political question. From the beginning of the nuclear age, scientists were convinced that the disposal of high-level nuclear waste was technologically feasible and safe.

Thirty years ago, in 1957, the National Academy of Sciences recommended that high-level waste could best be disposed of by burial in geological salt formations. In a report to the Atomic Energy Commission, the NAS committee stated that it was convinced that "radioactive waste can be disposed of safely in a variety of ways and at a large number of sites in the United States." They advised the immediate investigation of a "large number of potential future sites as well as the complementary laboratory investigations of disposal methods" so that the nation would be prepared to handle the waste expected from an increasing number of civilian reactors.

This was then accepted as U.S. policy, with the general assumption that the United States would develop commercial reprocessing facilities and that only the high-level waste remaining after reprocessing would require permanent disposal. The Oak Ridge National Laboratory in Tennessee conducted further studies, and by 1969, Oak Ridge had developed a design for a repository for high-level waste in deep salt deposits.

A site was selected in Lyons, Kansas, to test the suitability of salt burial in 1971, after an advisory committee appointed by the President concluded that "the establishment and burial of high-level waste can be carried out safely." The Lyons site was abandoned in 1972 as inappropriate, however, when the AEC discovered that salt mining was still going on a few miles away. The Atomic Energy Commission then began to develop an interim plan for a Retrievable Surface Storage Facility, which it expected to begin receiving waste for storage in 1980.

This concept was overturned in 1975, however, when the successor agency to the Atomic Energy Commission, the Energy Research and Development Agency (ERDA), decided once again to pursue a site for a salt repository and investigate other geological possibilities for repositories. ERDA's aim was to have an operational salt repository by 1985.

ERDA abandoned the idea of interim repositories, not because of any technical difficulties, but under pressure from the environmentalists and the Environmental Protection Agency, which charged that the repositories would become "permanent dumping grounds."

Then came Jimmy Carter

President Jimmy Carter then officially *banned* the reprocessing of spent fuel in 1977, on the basis of the political goal of "nonproliferation"; reprocessing facilities, the administration said, would make plutonium accessible to terrorists who could then convert it to a weapons-grade fuel.

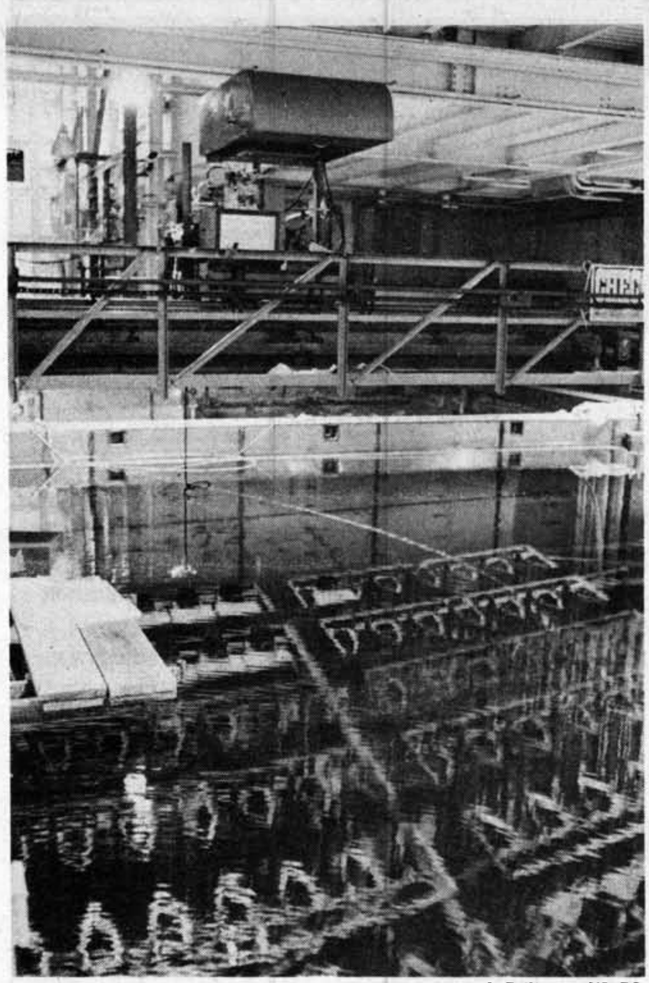
Carter guaranteed that the waste issue would remain a political football. By then the antinuclear movement was off and running, with the President on their side. In looking at what Carter did, it is hard to avoid the conclusion that his administration hoped the antinuclear movement would be able to use the waste issue to bury civilian nuclear power in the United States.

At the same time that Carter chose to make burial of nuclear waste the only option for the United States by eliminating reprocessing, he also bogged down the plans to build a repository for high-level waste by creating a new interagency bureaucracy (the Interagency Review Group on Nuclear Waste Management).

The political battle today over where the waste repositories should be located, is the legacy of that bureaucracy. The Nuclear Waste Policy Act of 1984 has tentatively named three sites (narrowed down from nine) for the nation's first repository and is awaiting a final environmental assessment from the National Academy of Sciences on these sites (Hanford, Washington; Yucca Mountain, Nevada, and Deaf Smith County, Texas). After further evaluation, the President will select the final site in 1991.

The schedule is then to have the Nuclear Regulatory Commission issue a construction permit in 1993, and to have spent fuel and high-level waste begin to come into the first repository by 1998.

A second repository is also mandated, this one to be located in the eastern United States. Twelve potential sites were recently announced, which set off the environmentalist howls. This list is expected to be narrowed down to five by 1989, and then three sites will be presented to the President in 1993 for him to choose. A final decision is scheduled for 1999, with the construction permit obtained in 2002.



J. E. Westcott, USAEC

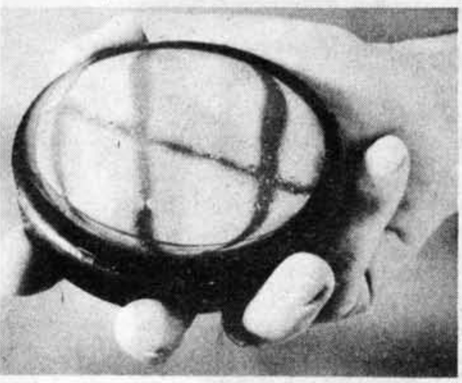
General Electric's Midwest Fuel Recovery Plant at Morris, Illinois. The plant, built to process spent fuel from nuclear reactors, was scheduled to begin reprocessing in 1974, but never opened, because of a design flaw that necessitated changes in the plant that the company deemed too expensive to make. Shown here are the water-cooled basins to store fuel pending reprocessing.

All of these sites are being extensively researched by the national laboratories and other contractors for the Department of Energy for geological considerations. In addition, there has been ongoing research on the most efficient way to prepare and store such waste.

The recommended budget for both depositories is $769,349,000.

Fear of technological optimism

The only way to understand why a project for burying nuclear waste, that was deemed both feasible and safe in



This photo shows a modern technique of glassified waste storage. If all the electricity used by one man in his lifetime were generated by nuclear power, it would result in this total amount of waste.

What is 'high-level nuclear waste'?

The spent fuel from a nuclear plant is removed after about three years in the fuel assembly, when the concentration of the fissile uranium-235 in the fuel is less than about 1% and the chain reaction is impeded. A 1,000-megawatt nuclear plant would replace about 60 of its fuel assemblies per year.

The spent fuel includes uranium and plutonium, all the fission products that have built up in three years or so of operation, and very small amounts of some transuranic elements (those heavier than uranium)—neptunium, americium, and curium, among others—which have very long decay times. (Of course if the spent fuel is reprocessed, the uranium and plutonium are removed.)

Initially, the spent fuel is very hot, generating about 221 megacuries of radioactivity and 2.2 megawatts of thermal heat per metric ton. The spent fuel is stored in water pools to cool it and to provide radiation shielding. After one year in the water, both the radioactivity and the heat output decline by factors of 88 and 216, respectively. In other words, after a year or so, the total radioactivity level is about 12% of what it was when it first came out of the reactor, and after five years, it is down to just 5%.

How long do these most hazardous isotopes live? Unlike other poisons like lead or arsenic, radioactive isotopes become harmless with time. This decay process is measured in terms of "half-life," which refers to the amount of time that it takes for half of the mass to decay. While a few radioisotopes have half-lives on the order of thousands of years, the hazardous components of nuclear waste rapidly decay to a radioactive toxicity level lower than that of natural uranium ore. To take the example given by the Electric Power Research Institute, the strontium in waste becomes less toxic than natural uranium ore in 450 years. The total waste, including plutonium, becomes less toxic in 500-1,000 years, depending on the fuel history. . . ."

Note that if the waste is not reprocessed, it takes 10,000 years for the toxicity to fall below that of natural uranium.

1957, is still on the drawing boards in 1987, is to look at the decline of cultural optimism in the United States and the parallel growth of the environmentalist movement.

The opponents of nuclear power and the industrial growth that it symbolizes, understood very well that their enemy was "technological optimism." The Office of Technology Assessment's consultant on the waste management issue, Daniel Metlay, wrote the following about the Atomic Energy Commission in the March 1985 OTA report on waste:

> An illusion of certainty was created where, in reality, none existed. Over the years, the sense of technological optimism embedded itself in the attitudes and thoughts of important agency policymakers. It became, in a sense, an official doctrine at AEC. There is no evidence that its validity was ever seriously questioned until the mid-1970s.

The reprocessing story

In the early days of the nuclear age, the cultural optimists took it for granted that there would be a commercial reprocessing industry. Thus, the permanent burial of waste was not seen as urgent, and the research proceeded to test geological formations over a period of years.

But commercial reprocessing—a 40-year-old technology—was aborted in the United States, despite its advantages both in reducing the amount of waste that has to be disposed of and in rendering the high-level waste in a less soluable, hence safer, form.

Although France began commercial reprocessing in 1958, the first U.S. commercial reprocessing facility did not open until the late 1960s. The West Valley, New York plant, operated by Nuclear Fuel Services, was reprocessing commercial spent fuel from 1966 to 1972. The plant was in the process of modernizing and expanding to handle a larger volume of waste, when the environmentalists intervened to delay the Nuclear Regulatory Commission's licensing of the expansion. Finally, in 1976, the private owner gave up entirely, because it had become too costly to maintain an unused plant.

Another reprocessing facility in Morris, Illinois, built by General Electric in the early 1970s, never opened because an unanticipated design flaw necessitated changes in the plant that GE deemed too costly to make.

A third facility at Barnwell, North Carolina, operated by Allied General Nuclear Services, is the one that President Carter stopped in 1977—when it was 75% completed—with his ban on reprocessing. At the same time, Carter's actions halted the plans of the Exxon Nuclear Co. to build a commercial reprocessing plant in Oak Ridge, Tennessee, which was planned to be larger than the other three plants.

The Reagan administration could have rescued the Barnwell plant in 1981, but, as with the Clinch River breeder reactor, Reagan chose to abandon this technology to a "private enterprise" economy so sunk in the depression that it could not pick up on these major infrastructure development projects. Reagan also reversed Carter's policy of providing federal facilities for utilities to store spent fuel, and again made this the responsibility of individual utilities.

How much waste?

The closed West Valley reprocessing plant has about 234 metric tons of high-level waste from its reprocessing of spent fuel, and both the Morris and Barnwell facilities have storage pools for spent fuel. Other spent fuel is stored, at the nuclear plants where it was generated, in water-filled basins to dissipate the heat and allow the decay of the short-lived fission products. By the end of 1983, there was an estimated 4,600 cubic meters of spent fuel being stored at plant sites, with about 620 cubic meters additionally expected each year.

There is no problem in continuing to store spent fuel in these pools for 30 to 35 years, but according to Department of Energy estimates, the interim storage room available at plant sites will be full by the end of the 1980s.

In addition to the commercial spent fuel, there is also a much larger volume of high-level waste from the defense program, 324,000 cubic meters. This waste is stored at government facilities in Hanford, Washington, Savannah River in South Carolina, and in Idaho. The defense waste has all been reprocessed at the two government-operated reprocessing facilities.

Although the commercial spent fuel is approximately only 1% of the volume of defense waste, it has a higher level of radioactivity and heat output, because the defense waste is diluted. The Department of Energy estimate is that defense waste has a radioactivity of 1,370 megacuries, while the commercial waste has a radioactivity of 35,700 megacuries. (One curie is the quantity of radioactive isotope that decays at the same rate as 1 gram of radium, 3.7×10^{10} disintegrations per second.)

To get an idea of the relatively small physical dimensions of the problem: All the high-level waste from U.S. commer-

Radioisotopes: a resource for medicine and industry

Separating out some of the nearly 500 radioactive isotopes from high-level nuclear waste not only creates a valuable new resource for medicine and industry; it also vastly lessens the toxicity of the remaining waste. In effect, removing the radioactive isotopes from high-level nuclear waste is like "aging" the waste—the radioactivity is decreased. For example, if cesium-137 and strontium-90 are removed, the effect will be that of aging the waste hundreds of years. If the platinum group metals are also removed—neptunium, americium, and technetium, for example—this has the effect of aging the waste thousands more years.

Many of these radioisotopes are already in use. There are now between 80 and 100 million medical procedures yearly, for example, that use nuclear isotopes. In addition, the Department of Energy has an extensive plan for recovering and using these nuclear by-products for defense as well as civilian purposes.

- Plutonium-238 is now used to power heart pacemakers, as well as small reactors in space.
- Cesium-137 is used as the radiation source in food irradiation plants and is experimentally being used to process sludge—turning sewage into a pure and usable fertilizer product.
- Strontium-90-powered radioisotope-fueled thermoelectric generators (RTGs) have been used to provide electric power for remote weather stations as well as remote surveillance stations, navigational aids, and defense communications systems. A strontium-90 thermomechanical generator is now being developed for use with low-power radar systems and remote emergency power sources.
- Krypton-85, tritium, and promethium-147 are used in self-powered lights. When the first spacecraft docked, it was promethium-147-powered lights that guided the final maneuvering. These lights use beta-emitting radioisotopes to activate phosphors, and are particularly appropriate for remote or tactical applications. The promethium-147 is especially promising because it requires considerably less shielding than the krypton-85.

Nonradioactive krypton is also used in fluorescent and incandescent lights, where it is superior to nitrogen or argon. Since natural krypton gas is scarce, it could be profitably "mined" from the fission product krypton.

- The platinum group metals—including platinum, palladium, rhodium, iridium, ruthenium, and osmium—are costly imports for the United States, which uses about 35% of the yearly world production and imports nearly 90% of this. (South Africa produces 46% and the Soviet Union 48% of the world supply.) Advanced isotope separation processes will be necessary to develop these resources to maximum advantage.

These metals have a high melting point, chemical inertness, catalytic properties, and refractoriness, according to the Department of Energy plan for nuclear by-product use. They are now used in industry as catalysts and inhibitors of corrosion, in electronics, and in medical applications. As the National Research Council noted, the platinum metals are "generally either the only material that can be used or the most cost effective of the available options, and therefore, replacement seems unlikely to be significant. Indeed, the usage trend seems likely to accelerate more rapidly over the forecast period than at any other time in history."

cial nuclear plants would fit into one 1.5 mile underground repository.

There is no mystery to the permanent burial of nuclear waste. The basic method used today in France was actually developed in the 1950s in the United States, by Brookhaven National Laboratory, and there have been continuous improvements in the technology to make the waste more stable.

The liquid waste is mixed with glass frit, and then poured into a 1-inch thick stainless steel canister that is 10 feet high and ½ to 2 feet in diameter. The canister is heated until the glass melts and then it is cooled, which fixes each atom of the waste solidly in the borosilicate glass. The canister is then packed in a another barrier of molded steel, and the entire assembly is surrounded with a metal or ceramic corrosion barrier. Finally, the assembly is buried in a specially designed vault in a geological formation in salt, volcanic rock, or granite, which forms an additional barrier. The United States has been testing various geological formations to see which are the most stable for long term storage.

The general principle is to set up a system of multiple barriers, to ensure that no radioactivity is released.

The tests that the French have done on this vitrified waste indicate that after 900 years of storage, the glass will still be a satisfactory storage medium. According to the International Atomic Energy Agency, such glass is so stable that even if placed in flowing warm water, "it would take 100 years to dissolve away about 1 millimeter of the surface of such a glass."

There have also been advances in the preparation and transportation of fuel. For example, the casks for transporting waste are probably the best designed containers ever made. They became famous in films made by the Sandia National Laboratories, showing trucks with waste casks colliding full speed with a locomotive or crashing into a wooden structure. In all these dramatic tests, the cask emerged unscathed.

Alternative methods of waste disposal have been developed that are also ready now. For example, fluidized bed calcining, developed at the Idaho Chemical Processing Plant near Idaho Falls, solidifies the waste and stores it dry. The defense waste at the Idaho facility has been stored in this manner.

The future

The pioneers of the atomic age saw the Atoms for Peace program as a way to lift mankind out of poverty worldwide and into an age of plenty. Their technological optimism is as well-founded today as it was in the 1950s. We should be mass-producing nuclear plants for domestic use and export, and we should overturn the present "throwaway" nuclear fuel cycle and implement a reprocessing program. If we immediately gear up to reprocess nuclear waste and turn 96% of it—and probably all of it—into new resources, there will be no problem of nuclear waste burial.

Fighting lasers with

by Charles B. Stevens

In an apparent turnabout, Dr. Thomas Karas, project director of the Congressional Office of Technology Assessment, has called on the U.S. government to respond immediately to the imminent threat of a Soviet breakout from the ABM Treaty. The OTA has been a bastion of opposition to President Reagan's Strategic Defense Initiative (SDI).

Testifying before the Research and Development Subcommittee of the House Armed Services Committee on March 11, Dr. Karas sounded the alarm that, "at least in the near term, the Soviet Union is better prepared than the U.S. to deploy a nationwide, if only modestly effective, BMD [ballistic missile defense] system."

Karas's warning is opportune, but the solution he offers is a disaster. The OTA is demanding that the SDI missile defense program be focused on *near-term deployment systems,* like the obsolete anti-missile missile defenses ("High Frontier") championed by Lt.-Gen. (ret.) Danny Graham, to the detriment of research and development on the more advanced directed energy laser and particle beam systems, such as the x-ray laser, which actually hold the key to the future of antiballistic missile defense.

Already, under pressures of the Gramm-Rudman budget-cutters and the OTA, over 50% of the SDI budget is being diverted to High Frontier-type kinetic energy weapon and anti-missile missile defenses, and away from more advanced beam-weapon approaches.

Soviet force improvements

The Air Force has presented Congress with updated reports on the "determined, steady increase" in Soviet strategic nuclear weapons programs, emphasizing that the "momentum of these improvements is a clear and growing sign of Soviet intentions; they serve as a danger signal to Western security." The latest developments summarized by the Air Force include:

• **ICBMs:** The Soviets currently have 1,373 intercontinental ballistic missile launchers carrying nearly 6,500 warheads, with a payload (throwweight) about three times that of the U.S. ICBM force. The 300 SS-18s, alone, have a hard-target throwweight capability in excess of that of the entire U.S. strategic missile force—both submarine and ICBM. In violation of the SALT II Treaty, the Soviets are deploying,