Disposal of High-Level Nuclear Waste: Is It Possible?

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DISPOSING OF HIGH-LEVEL RADIOACTIVE WASTE HAS BEcome a problem of first magnitude, if dollars and time spent on efforts to solve it are an appropriate measure. For more than 30 years the problem has been recognized as serious, yet this most dangerous kind of nuclear waste still remains without a generally accepted means of disposal. What has gone wrong?

High-level waste (HLW) is a product of the operation of nuclear reactors. It is distinguishable from low-level waste (also a problem, but a less intractable one) by its high concentration of radioactive elements and by the length of time—up to a few million years—that some of them will remain dangerous if released to the biosphere. In the United States, material regarded as HLW has two forms: the spent fuel rods discarded from a reactor after several months of operation and the liquid waste produced when fuel rods are dissolved in acid for the production of plutonium for military purposes. The fuel rods at present are kept in large basins of cold circulating water at reactor sites, and the liquid reprocessing waste is stored in steel tanks sunk just below the ground surface at the two places where plutonium has been produced in large quantity, Hanford in southern Washington and the Savannah River plant in South Carolina. In some other countries the fuel rods are not considered waste, because plutonium obtained from them can be used as a commercial energy source as well as for making weapons. Both in this country and abroad efforts are under way to convert at least some of the liquid waste into a more easily handled solid material, most commonly a kind of glass.

High-level waste in any of its forms continually generates high-energy ionizing radiation which is extremely destructive to living cells with which it may come in contact. The radiation can be absorbed and rendered harmless by a variety of materials, for example, the water and metal of the fuel-rod basins and the concrete and earth around the tanks holding the reprocessing waste. Thus the waste at present poses no threat to its surroundings but could do great harm if any appreciable quantity should escape.

Escape is unlikely as long as surveillance of the waste is maintained, that is, as long as someone is present to check for leaks or corrosion or malfunctioning of equipment and to take action if any of these occur. Can we expect such surveillance to continue for the long time during which the waste will remain dangerous? This hardly seems likely; it would imply a continuity of social order for more than ten millennia, which on the basis of past history seems a dubious assumption. Such thinking has led producers of HLW the world over to the conclusion that a better means of disposal must be developed, that somehow a place must be found to put the waste where it will stay out of human environments for the necessary long times without the need of caretakers.

How can this be accomplished? Many clever schemes have been suggested, but there is now general agreement, here and abroad, that the best method is disposal underground. HLW must be buried deeply enough so that it cannot affect the present living world and in a geologic situation stable enough to prevent any appreciable amount from reaching the surface for at least a hundred centuries. Seemingly this should not be difficult. Let a geologist find an area that is tectonically stable and where the rock a few hundred meters down is strong, dry, and chemically unreactive. Let an engineer sink a shaft and drive tunnels from its base as if he were developing a mine, then enclose the waste in metal containers and put the containers in holes drilled into walls or floors of the tunnels. These are all standard procedures, well within the capability of current technical know-how. A waste repository of this sort could be constructed immediately, and the problem of HLW disposal would be solved.

But of course it is not this simple. A major difficulty is ground water: Rock at depths of a few hundred meters is nearly everywhere saturated with water and the water is slowly moving. The tunnels in a few decades will fill with water, the metal containers will eventually corrode, and water will come in contact with waste. Some of the radioactive elements may dissolve and be carried by the water to points on the surface where it emerges in springs and seepages. All this will take a long time. Are the rates of the different processes—ground-water movement, metal corrosion, waste dissolution—slow enough to keep hazardous amounts of radioactive material from appearing at the surface during the next 10,000 years? If not, can the design of the repository be changed, or can its walls be coated, or can it be filled with sorbent material, to make the rates sufficiently slow?

Questions like these are troublesome for both geologists and engineers because they demand the unaccustomed exercise of attempting predictions for a long future. Many years of research in many laboratories have gone into developing the background for such predictions: research on solubilities of different forms of waste, on rates of metal corrosion, on reactions of the different radioactive elements with the rock through which they would move, and on the different kinds of rock and different kinds of tectonic situation in which a repository might be located. For most in the technical community the predictions give adequate assurance that geologic sites can be found and repositories can be constructed so that any escape of radioactive elements will be minor, well within limits prescribed by current regulations.

But inevitably such predictions have uncertainties, and some scientists are hesitant to accept the majority view until additional research is done. A few reject the majority opinion altogether. In a situation like this—general agreement among supposed experts that repositories will be safe but some lingering doubts and a few loud

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objections—should repository construction be authorized? Or should it be delayed pending results of further research? These are not technical questions, but questions for the man in the street and his elected representatives. On their shoulders must rest the ultimate decision as to whether and when waste disposal should begin. But the lack of unanimity among experts makes the decision particularly difficult.

A dilemma of this sort is not unique to waste disposal. Differences of technical opinion about details can arise for any large construction project, say the building of a bridge, the excavation of a mine, the siting of a power plant. If voters are called on for approval, they may well have worries about the differences, but normally the worries do not prevent construction from going ahead. By contrast, with regard to HLW disposal the concern about technical disagreement has been sufficient to stop even the preliminary steps of repository construction, both here and in other countries.

To break the impasse, some sort of government action seems called for. The U.S. government has indeed responded to the need, but the result of its attempted guidance has been only a long series of frustrations. Congress tried valiantly to do its part by passing the Nuclear Waste Policy Act of 1982, which set out a detailed schedule of activities by the Department of Energy (DOE) and the Nuclear Regulatory Commission that would lead to the start of HLW disposal into a mined repository not later than 1998. The record of compromises that have pushed this starting date ever further into the future is testimony to the difficulty of HLW disposal and to the apparent inability of government to deal effectively with the problem.

The carefully crafted program spelled out in the act quickly ran afoul of objections from state governments and local groups. Despite generous provisions for consultations with the states, even for financial aid to any state selected as a repository host, all states with any prospect of being selected proved hostile. No state wanted a repository within its borders. After several years of fruitless attempts by DOE to make the detailed studies of sites in a number of states that the act called for, Congress in 1987 felt obliged to amend its legislation by designating a single site, Yucca Mountain, Nevada, as the most promising one for a repository and therefore the one on which exploratory research should be concentrated. At about the same time DOE moved its projected date for opening the first repository to 2003, and in 1989 the date was further postponed to 2010. Meeting even this deadline now seems highly improbable.

Limiting intensive study to a single site in Nevada has brought little progress. The DOE has indeed marshaled its forces for the long investigation. But the state is implacably opposed and has voiced its displeasure by publicizing every possible technical objection to the Yucca Mountain site and by refusing to grant permits even for preliminary surface clearing and drilling. The controversy is now headed for the courts: Nevada claims that it vetoed selection of the site, as permitted by the 1982 legislation, and is suing DOE to stop its activity; DOE is suing the state for its obstructionist tactics. The only moral to be drawn from this story is its demonstration of the inadequacy of government action to assure that repository construction will be accomplished—or will even be started.

The failure of government is understandable. People are afraid of radioactivity and want no installation with even the slightest chance of radioactive release near their homes. Waste should be disposed of, everyone will agree, and as quickly as possible—but always in some other state and someone else's backyard. One can point out, as DOE's scientists have done repeatedly, that the risk from a well-sited and well-constructed repository is less than other risks that citizens accept as a matter of course in ordinary life. But the risk is not zero: no scientist or engineer can give an absolute guarantee that radioactive waste will not someday leak in dangerous quantities from even the best of repositories. And without such a guarantee people are swayed by their fears, especially when they know that a few of the technical experts are less certain than the majority about the long-term performance of a repository. In the United States this means that ways can always be found to block construction indefinitely, either by state governments defying the federal interlopers or by individuals who, honestly or not, feel that their estimates of future radioactive release are better than those accepted by most of their colleagues.

Faced with this seemingly hopeless situation, one is tempted to ask: Why is building a repository so urgent? As long as the waste is not harming its surroundings, why not for a time just leave it where it is? In answer to this query, efforts to dispose of HLW in a hurry are commonly justified on three grounds. First, waste kept in containers near the earth's surface is always subject to massive release by acts of nature—violent storms or earthquakes—or by sabotage, or by carelessness on the part of those supposedly watching over it. Second, if a method of disposal cannot be demonstrated soon the nuclear energy industry is in deep trouble: opponents can claim that waste is an insoluble problem, hence that production of more should be stopped at once. And third, in a more philosophical vein, the waste that we do not dispose of now will remain as an unjustified burden for our children and grandchildren to cope with. These arguments have seemed convincing to the U.S. public but less so abroad. The drive to get repository construction under way soon is stronger in the United States than in most other countries.

The other side of the question, putting off disposal to an indefinite future, can be defended with arguments that seem equally good. For one thing, waste becomes easier to handle on standing because its radioactivity steadily decreases. Also, with the rapid progress of technology, we can expect that a half-century hence we will know more about the optimum design of repositories and about finding the best geologic locations. And finally, leaving waste in storage near the surface keeps it readily accessible, an advantage if sometime later a use is found for some of its constituents. Considerations of this sort have led most European countries to adopt a deliberate policy of postponing final disposal of HLW for at least several decades.

In the United States it looks increasingly as if a choice between these alternatives will be made for us automatically. At present schedules no HLW will be put underground until 2010 and most likely not until much later. By the time actual burial begins, much of the waste will be more than 50 years old, as old as the waste that is planned for later disposal in Europe. Despite pushes by Congress to speed up the program and well-meant efforts by DOE and other federal agencies to play their assigned roles, a combination of public dread of all things radioactive, of technical disagreements about the safety of long-term burial, and of disputes among the many federal and state agencies involved has made it impossible to accomplish waste disposal quickly.

Perhaps this is not to be deplored. If indefinite postponement is accepted as a necessary evil, the pace of the disposal program can be made less frantic, and its continued delays will seem less frustrating. The long and expensive effort to find a suitable site and to ensure compliance with accepted standards of radioactive release, discouragingly unproductive as it now appears, will not have been in vain. The years of research have taught us a great deal about repository construction and about the behavior of radioactive elements in natural environments, perhaps even about handling federal-state opposition. When a decision is finally reached for us or our children to get disposal started, this background of knowledge and experience should make it possible to complete the job in short order.