LETTERS

Nuclear Waste Storage

In public discussion of nuclear power and public safety, much concern is expressed about the need for storing the radioactive waste for centuries. While such long-term storage is an essential part of nuclear power development, the projected public safety issue involved is minimal, compared with other environmental problems. A completely adequate waste storage system is trivial in terms of scope and cost, although we depend upon its being there and functioning properly and would suffer hazard and expense if it were not. Because of the long radioactive lifetime of nuclear waste, we are of necessity handing on to future generations a problem that we have "wrapped up" in one form or another. There is some ambiguity about what this form should be, derived mainly from a lack of clear distinction between the concepts of "waste disposal" and "waste management." We believe that perpetual, flexible management is essential so that future generations can have the option of choosing new solutions as new conditions and new technologies appear. Such perpetual care is neither difficult nor costly, chiefly because the inherent volume of nuclear waste is so small.

Each citizen of the United States consumes about 7000 kilowatt-hours of electricity per year, on the average; this amount of power is obtained from the fissioning of about 1 gram of nuclear fuel, equal to the weight of three aspirin tablets, but with a volume less than that of one aspirin. Thus if the source of the electric power is nuclear, about 1 gram of fission products to be stored per year per person is created. The waste concentration process is carefully arranged so that valuable plutonium is removed for fuel purposes, but there the removal of certain other inert material is too much trouble. The safest way to handle the final mixture is to drip it in liquid form into a small pot, heated by electric coils, where it boils dry and then melts to form a glasslike ceramic clinker that is insoluble in water. This is done in a sealed chamber behind heavy walls and watched and controlled with telescopes. After firing and cooling is completed, the clinker, pot and all, is sealed up inside a tight can, and then in still another. It then can be safely moved in a thick-walled shipping cask to a final place. In clinker form the 1 gram of fission products and the accompanying inert material (representing about 1 man-year of electricity use) will occupy about 1/10 of an ounce, volume measure, and the total cost of processing, transport, and permanent storage will amount to about 14 cents (*1*). The heat emitted is 1/40 of a watt, or about 1/10 the energy of a penlight flashlight. In a lifetime of 70 years, each person served by nuclear power could account for a maximum nuclear waste accumulation of less than half a pint in volume. The value of the electric power consumed in his life, at 2 cents per kilowatt-hour, would be, at most, $10,000, and the cost of the nuclear waste storage would be $10 of this.

Thus, the volume to be stored is trivial, and the cost of storage is a fraction of a percent of the value of the power, but the wastes last a long time, must be kept behind thick walls, and must get rid of a certain amount of heat. Nuclear wastes accumulated for 1 year emit 10 watts of heat for each megawatt of heat emitted while in the reactor. If wastes from the same power source are continuously added to the storage vault, a steady-state heat output is reached of 550 watts per megawatt, since the older residues are decaying (*2*).

Where would we store such wastes? How can we contemplate a continuity of protection and integrity of containment that will extend over hundreds of generations? Has anyone ever made such commitments before? The answer is yes—in Egypt, and with rather remarkable success. Wooden chests and sarcophagi removed from the Egyptian pyramids are perfectly preserved and look like new after 5000 years in the desert. Metal, ceramic, and glass objects are also unchanged. Can we not do as well?

The stone of the great pyramid of Cheops, which is about 230 meters square at the base, could be arranged to form a series of smaller vaults that would house all the nuclear wastes that could be generated by the United States, at its present rate of electric power consumption, for over 5000 years. The heat dissipation of 275 megawatts is a small load for such a "dry cooling tower." During these thousands of years, some spent waste could be removed for simple burial to make room for new, so that in fact a perpetual capacity would exist for our present rate of electricity use. New pyramids would be needed as electrical loads increased, perhaps one every decade or so.

We recognize that an engineered storage facility with appropriate handling and cooling facilities would require additional volume, and might look more like the Pentagon than a pyramid. The point of this example is to give perspective to the quantities of waste to be managed, which are indeed tractable and feasible to handle. We are not seriously suggesting that pyramids in the desert are the best way to store nuclear wastes. Other places, such as salt mines, are perhaps better. But if all else fails, they would work, they could be safe and attractive, and they would not be forgotten (*3*). The key objective is to give our successors the freedom to manage the radioactive waste and to change the storage plan if they find a better one, or if surrounding conditions change.

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References and Notes

1. W. G. Belter, *Nucl. Safety* **8**, 174 (1966).
2. A. M. Weinberg and R. P. Hammond, "Global Effects of Increased Use of Energy" (paper presented at the Fourth International Conference on Peaceful Use of Atomic Energy, Geneva, 1971), table III.
3. Since the above was written, the Atomic Energy Commission has announced plans for vault storage, while continuing research on other modes.

Herbicide Study

As one accustomed to hearing scientists charge that reporters will sometimes distort reality through selective reporting, I feel obliged to report evidence that at least some journalists and some scientists share a common humanity. Vide the statement from Arthur Galston in his book review (14 Apr., p. 154) of *Harvest of Death* (*1*) that "in the meantime, the National Academy of Sciences has picked up the ball, and under a grant from the Department of Defense(!) is conducting an additional survey" [of the effects of herbicides in Vietnam].

That the financial instrument is a contract rather than a grant is not terribly important; what is more important is that the contract between the Department of Defense and the National Academy of Sciences was not made at the initiative of the department but at the behest of the Congress, specifically in the Military Procurement Act of 1970.

Two corrections are therefore in order. It is the Congress that deserves credit for "picking up the ball," and the implication should be hastily removed that the National Academy of Sciences turned to the Department of Defense to support the described study. Galston's exclamation point is herewith returned, for more appropriate use elsewhere(!).

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Reference

1. J. B. Neilands, G. H. Orians, E. W. Pfeiffer, A. Vennema, A. H. Westing, *Harvest of Death* (Free Press, New York, 1972).

I am willing to change "grant" to "contract" and "picked up the ball" to "accept the ball." In both instances, I was aware of the situation Lewis describes and do not feel that the changes are substantial.

I must, however, insist on restoring the returned exclamation point to its original location in my review. It is somewhat surprising that the Department of Defense (DOD), which was responsible for spreading massive quantities of herbicides over Vietnam without adequate knowledge concerning the consequences of such an action, should now be in the position of supporting, after the fact, a National Academy of Sciences (NAS) investigation into the extent of the partly irreversible ecological damage it has caused. At the very least, DOD sponsorship has led several able anthropologists to refuse to participate in the study. I suspect there have been other disadvantages as well.

It has been reported that previous investigating teams, including the Herbicide Assessment Commission of the AAAS, received less than complete cooperation from the military once they got to Vietnam. I presume that the NAS was able to ensure a more favorable ambience for its investigations. But whatever the concessions made by the DOD to the NAS investigating group, many scientists would have been happier with alternative financial sponsorship. Perhaps the NAS should have sensed this and acted accordingly.

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