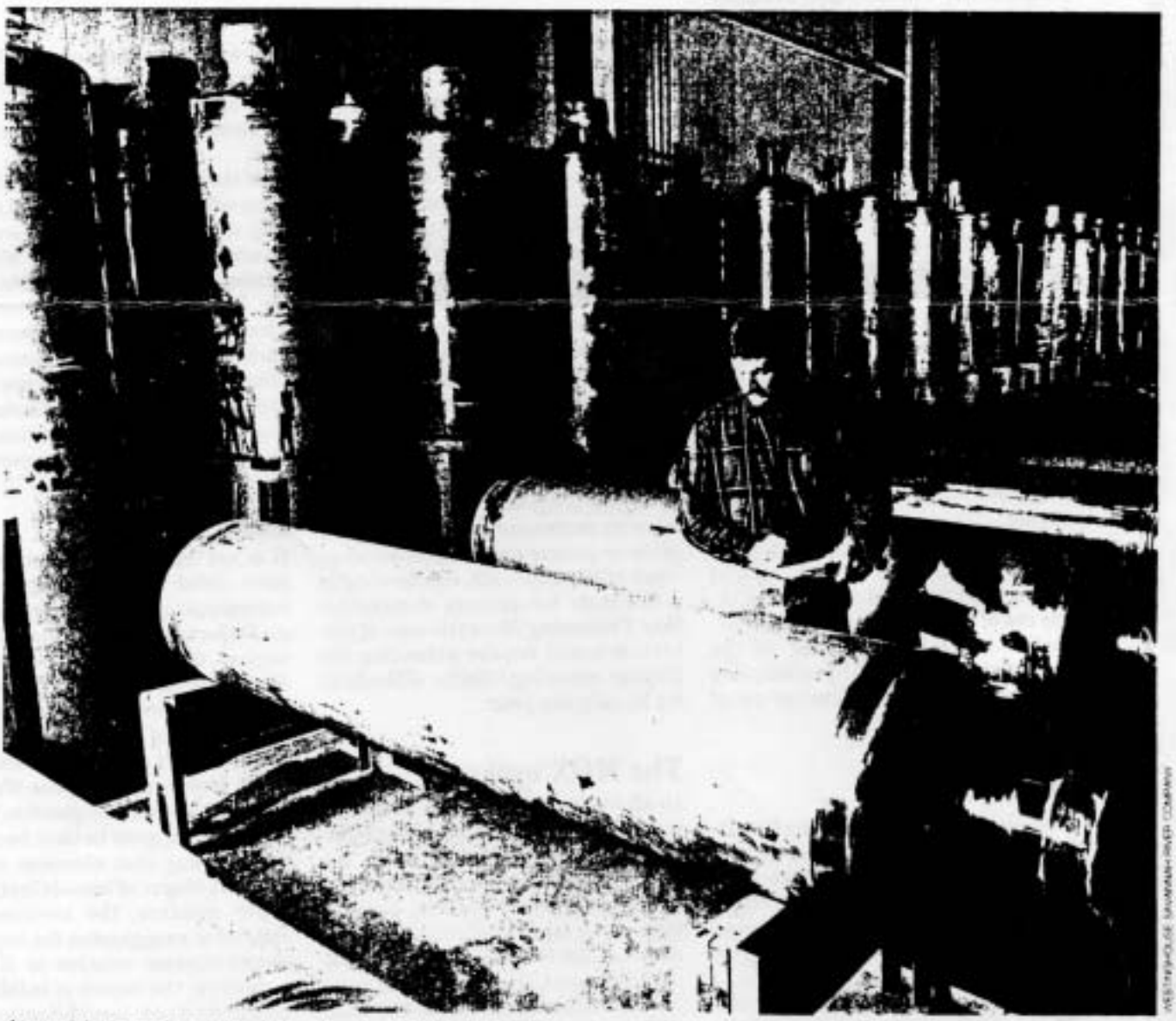
WEAPONS PLUTONIUM:
Just can it

By EDWIN S. LYMAN



A promising experimental technique for "immobilizing" surplus weapons plutonium: At the Savannah River waste facility, small cans of plutonium are inserted into larger canisters that are then filled with vitrified high-level nuclear waste.

Of all the dilemmas plaguing the U.S. Energy Department as it tries to deal with the aftermath of 50 years of manufacturing nuclear weapons, choosing a way to dispose of surplus warhead plutonium should be one of the simplest to resolve.

The Clinton administration pledged in March 1995 to dispose of approximately 200 metric tons of highly enriched uranium and plutonium. It was later disclosed that this included 38.2 tons of plutonium, of which 21.3 will be drawn from the Defense Department inventory.

The Energy Department anticipates that eventually about 50 metric tons of plutonium, half from weapons components, will be made available for disposition. This implies that virtually all U.S. separated plutonium not in pit form, as well as about 35–40 percent of existing pits, will be considered surplus.

Two disposition methods are under consideration. The first is "immobilization"—converting the plutonium into a stable and proliferation-resistant form. The other is converting it to mixed-oxide (MOX) reactor fuel, which would be burned in existing power reactors.

The "MOX option" appears to have a great deal of support, but any fair comparison of the two disposal options will show that the immobilization process is less costly, could be started and completed more rapidly, would have a smaller environmental impact, and would require less intensive security and safeguards. In addition, immobilization carries none of the negative political baggage of MOX, the use of which would likely be interpreted as an abandonment of the long-standing U.S. anti-proliferation policy opposing the commercial use of plutonium.

Immobilization

Immobilization involves incorporating plutonium into a glass- or ceramic-based matrix suitable for geologic disposal. A primary goal is to render the warhead plutonium as inaccessible as the plutonium found in highly radioactive spent commercial fuel. To meet this "spent fuel standard," the plutonium would be combined and buried with a gamma radiation source such as high-level radioactive waste.[1]

Some have proposed building a new facility where plutonium and high-level waste could be uniformly mixed together in the same form. But there is a quicker and less costly alternative.

"Can-in-canister" immobilization could use existing facilities, especially the recently completed vitrification plant at the Savannah River Site, which is now immobilizing highly radioactive waste in large glass cylinders. Although this facility experienced some problems at startup, these have been resolved and it is now operating according to schedule.

If this facility were used, the plutonium could first be immobilized in small cans without a gamma source, an operation that could be conducted in a glovebox. The cans would then be placed in the waste facility's canisters before they are filled with vitrified waste. Recent cold testing of this process suggests that it would have minimal impact on Savannah River's vitrification program. The initial tests were so successful that Energy now plans to pursue accelerated development of the approach, culminating in a full-scale hot-process demonstration. Processing 50 metric tons of plutonium would require extending the 25-year operating lifetime of the facility by only one year.

There is a lower-cost, faster, and safer way to dispose of weapons plutonium—and it uses an existing facility.

The MOX option

In all likelihood, MOX disposition of plutonium would not be as straightforward as its promoters claim. Before any excess plutonium could be burned in a power reactor, it would have to be fabricated into MOX fuel and then distributed to U.S. or Canadian reactors. There are no facilities for fabricating MOX fuel in the United States, so either a new plant would have to be built or an existing facility would have to be modified. This would introduce a significant delay.

Alternatively, the Energy Department is considering contracting with European MOX fuel-fabrication plants for the first few fuel cores, which would mean shipping at least a few metric tons of weapons-grade plutonium to Europe. The political sensitivity of this option may disqualify it.

Energy's optimistic timetable is likely to slip. It calls for five pressurized-water reactors to be loaded with full cores of MOX, even though industrial operating experience is limited to cores that contain 50 percent or less.

Of the 50 metric tons of U.S. plutonium expected to be declared surplus, only about 33 tons are pure enough to be used directly as feed for MOX fuel fabrication. Immobilization is clearly the best option for the remainder. Thus the real choice the Energy Department faces is not between immobilization and MOX, but between the exclusive or partial use of immobilization. Only the immobilization option could dispose of the entire surplus.

Stacking the deck?

It is not easy to tease out the good news about immobilization from the voluminous stack of paper the Energy Department has produced on the subject of disposition, including its *Draft Programmatic Environmental Impact Statement on the Storage and Disposition of Weapons-Usable Fissile Materials* and its *Technical Summary Report For Surplus Weapons-Usable Plutonium Disposition*.[2] These documents appear to have been written in a way that obscures many of the advantages of immobilization.

For instance, the environmental statement exaggerates the impacts of immobilization relative to MOX by comparing the impact of building and operating a new immobilization facility to that of using MOX fuel in existing reactors. It is more appropriate to

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compare the effects of can-in-canister immobilization, which uses existing facilities, with the existing reactor plan. The technical report's summary statement is written in a way that can mislead the casual reader (as it has most of the trade press) into thinking that whichever method is chosen, disposal could start at about the same time. In fact, as the full document shows, immobilization could begin three to seven years before Energy would have MOX fuel ready to use. The technical report's economic analysis of the options is even more misleading.

Just a decade ago, the Energy Department was cranking the plutonium production machine as fast as it could. Now it is charged with plutonium disposal. Many in the department still hold plutonium in high regard, and dismiss immobilization as a wasteful, "throw-away" option. In contrast, the MOX option offers them the illusion that excess plutonium retains some value. Although senior officials tried to insure that a balanced assessment was conducted, the pro-MOX slant of both the environmental statement and the technical report reflect a subconscious preference, if not a deliberate bias.

There is little reason to believe that immobilization will get a fairer hearing outside the department. The public debate has been dominated by the international nuclear industry, which has frenetically supported the MOX option—and has the resources to make its views known.

A concerted lobbying effort has been led by the European MOX fabricators—British Nuclear Fuels, Cogema, and Belgonucléaire. These companies hungrily eye both the U.S. and Russian plutonium stockpiles, not only because they see the conversion of weapons plutonium into MOX as a lucrative opportunity, but also because they think that the process might bestow the imprimatur of nuclear disarmament upon their operations, which have often been criticized for their proliferation potential.

U.S. companies are not as enthusiastic about the MOX option as they were when they believed it might lead to government financing for new power reactors, but they still believe plutonium disposal as MOX could give their declining industry an important boost.

In the background of the U.S. debate stands the Russian nuclear agency, MinAtom, which has so far displayed contempt for the idea of mixing Russian plutonium with waste. There is no reason why the United States and Russia should adopt the same approach, but MOX proponents have attempted to use MinAtom's position to discredit immobilization of U.S. plutonium by arguing that Russia does not believe it is a serious disposition option.

Given that MinAtom has repeatedly stalled negotiations to implement rudimentary bilateral monitoring procedures for plutonium storage and has said that it will not accept international safeguards on MOX fabrication facilities built in Russia, the notion that the United States must reject immobilization to earn MinAtom's trust is bizarre.

Using plutonium as reactor fuel appeals mainly to utilities in search of government subsidies.

Even in the arms control community, many advocates of prompt plutonium disposition give immobilization only lukewarm support. This stems in part from their belief that the MOX option is more pragmatic because it would engage the interests of private industry and benefit from private-sector efficiencies. They regard immobilization as an idealistic dream that will be opposed by the plutonium-loving bureaucrats who will have final say in the matter.

Given the uncertain economic future of nuclear power in the United States, however, it is unlikely that the private sector has much to offer. Indeed, the MOX option appeals mainly to financially troubled electric utilities in search of government subsidies to soften the blow they will take when the electricity market is fully deregulated, which is expected to occur by 2005. These subsidies—incentives for using MOX—could run to as much as several billion dollars, making the MOX option prohibitively expensive.

On the other hand, by virtue of the simplicity of the process and its relatively straightforward financing, it is hard to imagine immobilization incurring cost overruns of the same magnitude. Immobilization is the more practical option. This point should not be lost amid the irrational prejudices of ex-Cold Warriors or the self-serving propaganda of commercial interests.

The true cost of MOX

In the technical report, released in July, the Energy Department attempted to compare the estimated costs of the plutonium disposition options. According to the report, the net life-cycle costs of both can-in-canister immobilization and the least expensive existing reactor option were nearly identical, about $1.8 billion in undiscounted 1996 dollars. The $1.8 billion estimate for the MOX option, however, covered only the incremental cost of operating an existing reactor with a full core of MOX instead of low-enriched uranium fuel. Although the report does not discuss in detail how this figure was derived, it probably reflects the cost of modifications to the core control systems, more stringent security and safeguards, and the difference in price between low-enriched uranium fuel and the more expensive MOX.

A few years ago, the Energy Department asserted that it would realize generous revenues from MOX fuel. But last year the National Academy of Sciences (NAS), in a definitive two-volume study, *Management and Disposition of Excess Weapons Plutonium*, skewered Energy's rosy projections.[3] The NAS study concluded that both immobilization and the MOX option would cost between $0.5 and $2 billion. The more recent estimates found in the technical report are in basic agreement with the NAS conclusion—it is a sign of progress that the Energy Department now agrees that MOX disposition of plutonium would not be a bonanza for the Treasury.

But neither Energy nor NAS has allowed for the cost of incentives. The technical report assumed that the utilities would reimburse the government for MOX at the price they would otherwise pay for less expen-

sive fuel, and that they would not expect to receive an additional fee for using MOX.

Nothing could be further from the truth. The report's authors ignored recent public statements by utility executives, who have made it clear that patriotism alone will not motivate them to participate in the program. As Jack Bailey, vice president for nuclear engineering at Arizona's Palo Verde nuclear power station (one of the leading candidates for burning MOX) has said: "The benefits [to ratepayers and shareholders] must be substantial. If not, the entire proposition is a non-starter. . . . Any agreement involving Palo Verde would require more than the incremental costs associated with using MOX fuel instead of uranium. That kind of payment would be insufficient."[4]

According to a recent industry report, many utility officials who have expressed interest in MOX expect, at a minimum, to receive the fuel at a discount or free of charge. That would be the equivalent of paying an average subsidy of as much as 0.6 cents per kilowatt-hour, and it would wipe out the $1.4 billion "fuel displacement credit" that the Energy Department assumed it would receive for the MOX. In short, it would nearly double MOX's life-cycle cost.[5]

Free fuel may not be enough to satisfy some financially troubled utilities. Some industry officials see the MOX program as a source of funds to help them recover their so-called "stranded" costs.[6] Stranded costs are those investments that will be unrecoverable after the industry is deregulated, at which point U.S. and Canadian nuclear power plants will be forced to compete with lower-cost suppliers. A survey by the General Electric Corporation found that utilities would expect to receive an incentive for burning MOX "approximately equal to the difference between the current total generation cost of the selected facility and the cost of alternative energy supplies, thus making the facility competitive."[7]

How large would incentives have to be? It is difficult to predict. There is still a great deal of uncertainty surrounding the transition to deregulation, including what fraction of potentially stranded costs state utility commissions would allow the industry to recover through accelerated depreciation.

But in a fully deregulated market, nuclear plants would have to compete with new combined-cycle gas turbine plants, which can generate electricity at a total cost (including capital costs) of 4 cents per kilowatt-hour. Very few existing nuclear plants could match this price today without taking a loss. U.S. nuclear plants' average cost to produce electricity was 2.2 cents per kilowatt-hour in 1995, and the average capital charge was more than 4 cents per kilowatt-hour. Many nuclear plants would need a subsidy of at least 1 to 2 cents per kilowatt-hour to compete with gas-turbine plants.

The Energy Department does not expect full-scale MOX burning to begin before 2010. However, the more heavily nuclear utilities, which are experiencing competitive pressures today, would need to be subsidized as early as 2000, if they were going to commit themselves to the program. By that time industry restructuring should be well under way.

If the Energy Department has to provide a subsidy of 1 cent per kilowatt-hour beginning in 2000 to the operators of the five pressurized-water reactors that are selected for the program, it will have paid billions in subsidies before the first full core of MOX is loaded.

Expecting incentives of this magnitude may seem like wishful thinking on the part of utility owners, but such payments may be unavoidable if the Energy Department chooses the MOX option. It will simply not be in the interest of utility shareholders to participate in a MOX program unless it can benefit them by effectively providing a guaranteed rate of return for investments that are now very shaky.

The Energy Department would also be forced to absorb significant additional costs if a reactor selected to burn MOX became uncompetitive (on a marginal-cost basis), either because of a rise in operating and maintenance costs or a need to make major capital improvements. In this case, it would be in the utility's best interest to shut the plant down prematurely, unless some means were found to offset the liability before the loading of MOX fuel began. The Energy Department would have to subsidize the price of electricity generated by the plant, pay for capital improvements up front, or buy the plant outright.

Fixer-upper plants

The prospect that the plutonium disposition program could be saddled with huge stranded costs would be less worrisome if the utilities chosen to participate were in good financial shape, had well-run reactors, and were in a strong position to compete against low-cost fossil-fuel generation. But the better off a utility is, the less likely it is to accept the additional risks associated with the MOX program, which is likely to entail delays, and which may reverse the recent trend toward lower operating and maintenance costs and higher fuel burnups.

A glance at the list of utilities that responded to the Energy Department's January 1996 request for "Expressions of Interest" in a MOX program confirms the point and deepens the concern that weaker utilities view the program as a means of securing a government bailout of their stranded-cost burden. Nine of the 12 investor-owned utilities on the list were described in 1995 by Moody's Investor Service as having "potentially large" stranded nuclear investments.[8]

They include Centerior Energy (with an estimated $5.5 billion in stranded cost), PECO (with $4.6–7 billion), and Niagara Mohawk, which is on the verge of bankruptcy. Only three of the utilities on the list appear to be able to generate nuclear electricity at an approximate total cost at or below 4 cents per kilowatt-hour.[9] Several of the utilities operate reactors that generate electricity so expensively that they will not be competitive even after their total capital costs are retired.

In addition, some of the plants on the list need major capital improvements. For instance, Wisconsin Public Service Company's Kewaunee plant appears to be a competitive generator of electricity because it is older than the other plants (and has further depreciated). Nevertheless, its owners have chosen not to replace its failing steam generators because they fear that the $100 million it would cost to replace them will be stranded—this at a plant where so

many steam generator tubes have been taken out of service that the plant cannot operate at full power.

The plant's operators do not believe the plant can continue to operate throughout its license period, which ends in 2013, unless they are replaced.[10] In the case of Kewaunee, its owners' interest in the MOX program has all the earmarks of a search for government financing.

A similar situation applies to the Bruce A power station owned by the Canadian utility, Ontario Hydro. Hydro has been vigorously campaigning for its Canadian-government-approved MOX proposal, which would use the Bruce A CANDU power station to dispose of both U.S. and Russian warhead plutonium.

Hydro's official press statements describe the proposal as a "significant and meaningful contribution to international peace and security," but the company's financial statements tell a less flattering story. The Bruce A reactors are uncompetitive and are in need of extensive repairs, including the replacement of pressure tubes.

One reactor, Bruce 2, which has damaged steam generators, was mothballed in 1995 because the utility was unwilling to invest in the necessary upgrades. Although Hydro said in its proposal that it was planning to have the work done, it is now clear that it had no intention of paying the nearly $1 billion cost and was hoping to charge it to the plutonium disposition program. After the technical report gave Hydro's proposal an unfavorable review, the company deferred its decision on retubing until at least 2000.[11]

Cost cutting and safety

Another disturbing aspect of the Energy Department's MOX plan is that the same utilities that are attracted to it are the ones now undertaking vigorous cost-cutting measures, including layoffs, that may adversely affect the safe operation of their plants.

This is a dangerous combination, because the consequences of a catastrophic accident involving a reactor fueled with MOX could be significantly greater than one at a reactor fueled only with uranium.[12] Several of the plants are historically poor performers with troubled safety records, including the Washington Public Power Supply System's WNP-2 plant, which in 1993 logged more Nuclear Regulatory Commission inspection hours than any other.

Another example is Commonwealth Edison in Illinois, which owns some of the best- and worst-run plants in the country. ComEd has offered only high-end plants for plutonium disposition (perhaps in the hope of subsidizing the operation of its low-end ones), but its nuclear division overall has suffered from mismanagement. Nuclear Regulatory Commissioner Kenneth Rogers said recently that he was "disgusted" with the utility.[13]

ComEd has been trying to postpone steam generator replacements by seeking a regulatory change to permit its reactors to operate with circumferential cracks in their steam generator tubes. This corner-cutting attitude is not appropriate for a utility that wants to take on the additional safety challenges of MOX fuel.

Security at existing nuclear power plants would be of even greater importance if MOX fuel were to be used. Recent incidents of apparent sabotage at a reactor that was recently withdrawn from the MOX list, Florida Power & Light's St. Lucie plant, should raise some eyebrows. Three safety switches were found glued shut in a secured area of the plant, and news reports suggested that the incident may be linked to employee frustration about the erosion of safety at the plant due to cost-cutting measures.[14] Is this the type of environment into which the Energy Department should be shipping truckloads of MOX?

A decision to dispose of warhead plutonium by burning MOX in existing U.S. power reactors links the success of a critical disarmament measure to the fortunes of a failing industry. If participating utilities are able to secure the most favorable terms—and they may very well be able to, given the abundance of cheap reactor fuel and the small number of viable candidates—the disposition program would essentially be forced to write a blank check to underwrite past investments and subsidize inefficient, costly, and dangerous electricity generation.

The sooner the Energy Department abandons the MOX path, the less money it will have wasted on this boondoggle. Can-in-canister immobilization is a much better bet and deserves support. ■

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14. United Press International, "Possible Sabotage at Nuclear Plant," Aug. 15, 1996.