THE bulletin OF THE ATOMIC SCIENTISTS

# Plutonium Recycle: The Fateful Step

Impending move to reprocess fuel would escalate the risks of nuclear power

*I fear that when the history of this century is written, that the greatest debacle of our nation will be seen not to be our tragic involvement in Southeast Asia but our creation of vast armadas of plutonium, whose safe containment will represent a major precondition for human survival, not for a few decades or hundreds of years, but for thousands of years more than human civilization has so far existed.*

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The Atomic Energy Commission, if unchecked, is about to sow the seeds of a national crisis. The Commission now proposes to authorize the nuclear power industry to proceed to use plutonium as fuel in commercial nuclear reactors around the country. The result of a decision approving this commercial use of plutonium will be the creation of a large civilian plutonium industry and a dramatic escalation in the risks posed by nuclear power.

This decision to launch what the AEC calls the plutonium economy is the conclusion of the AEC's recently released draft environmental impact statement for *plutonium recycle*: the recycling of plutonium as fuel in the present generation of light water reactors [1, 2]. The final version of the impact statement, which is expected to confirm the decision to authorize plutonium recycle, is due in a few months.

Plutonium is virtually unknown in nature; the entire present-day inventory is man-made, produced in nuclear reactors. Plutonium-239, the principal isotope of this element, has a half-life of 24,000 years, hence its radioactivity is undiminished within human time scales. It is perhaps the most toxic substance known. One millionth of a gram has been shown capable of producing cancer in animals [3]. Plutonium is also the material from which nuclear weapons are made. An amount the size of a softball is enough for a nuclear explosive capable of mass destruction. Scientists now widely recognize that the design and manufacture of a crude nuclear explosive is no longer a difficult task technically, the only real obstacle being the availability of the plutonium itself [4].

We believe that the commercialization of plutonium will place an intolerable strain on our society and its institutions. Our unrelenting nuclear technology has presented us with a possible new fuel which we are asked to accept because of its potential commercial value. But our technology has again outstripped our institutions, which are not prepared or suited to deal with plutonium. Those who have asked what changes in our institutions will be necessary to accommodate plutonium have come away from that enquiry profoundly concerned. And the AEC's environmental impact statement does not allay these concerns. It reinforces them.

The AEC concedes that the problems of plutonium toxicity and nuclear theft are far from solved and indicates that they may not be for some years. Yet it concludes, inexplicably, that we should proceed. Whether stemming from blind faith in the technology it has fostered or from callous promotion of the bureaucratic and industrial interests of the nuclear power complex, the AEC's proposal cannot be justified in light of what we know and, just as important, what we do not know.

The fuel now used in present-day reactors, the light water reactors, is uranium which has been enriched; the uranium-235 content is increased from 0.7 percent present in natural uranium to about 3 or 4 percent. Uranium-235 is a fissionable isotope of uranium, the remainder being non-fissile uranium-238. Unlike plutonium, uranium fuel is not extremely toxic, and it is not sufficiently rich in uranium-235 to be fashioned into nuclear weapons. The uranium

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can be enriched to weapons grade material only with extremely sophisticated technology which is not available to the public, notably gaseous diffusion plants.

While present-day reactors are operating, however, they are also producing as a by-product moderate amounts of plutonium, principally plutonium-239. A typical large reactor produces about 200 to 250 kilograms of plutonium each year. Since this plutonium is easily fissioned, it can be used as reactor fuel. Plutonium recycle is the nuclear industry-AEC proposal to recover the plutonium produced in light water reactors, process it and recycle it as fuel back into these reactors.

Several critical steps are involved in recycling this plutonium. First, the used or spent fuel from the reactor must be shipped to a fuel reprocessing plant where the plutonium is recovered from the spent fuel, converted to oxide form and shipped to the next fuel cycle stages—the fuel fabricating and assembly plants. At a fuel fabricating plant the plutonium oxide will be mixed with uranium oxide into mixed oxide fuel. This mixed oxide fuel will be fabricated into fuel pellets, the pellets will be placed in fuel rods, and these rods will be collected into fuel assemblies. These assemblies will then be sent to the reactors for use, thus completing the fuel cycle.

At this point plutonium recycle has not yet begun, and there is no major industrial commitment of resources to it [5]. No major commercial plutonium fuel fabricating plants are operating or under construction.* No commercial reprocessing plants are operating now.** Reprocessing plants, in addition to recovering plutonium and other fission products from the spent fuel, are supposed to solidify high-level wastes and ship them to a permanent AEC repository for perpetual management. As yet, however, the AEC has no such repository. Nor does the AEC know whether the technology and social institutions for isolating these high-level wastes for geologic periods can be made available.

If the plans of the AEC and the nuclear industry are permitted, however, a major plutonium industry will develop quickly. Some 140 tons of plutonium could be recovered from commercial reactors by 1985 and some 1,700 tons by the year 2000 [7]. A plutonium industry by the turn of the century could involve hundreds of light water reactors fueled with plutonium, perhaps a score of fuel reprocessing and fabricating plants, and thousands of interstate and international shipments containing hundreds of tons of plutonium.

### *Plutonium Toxicity*

The most pernicious product of the nuclear industry is plutonium. Microgram quantities in skin wounds cause cancer, and in the body plutonium is a bone seeker where, once deposited, it can cause bone cancer. But plutonium is most dangerous when inhaled. Donald Geesaman explains this hazard:

> Under a number of probable conditions plutonium forms aerosols of micron-sized particulates. When lost into uncontrolled air these particulates can remain suspended for a significant time, and if inhaled they are preferentially deposited in the deep lung tissue, where their long residence time and high alpha activity can result in a locally intense tissue exposure. The lung cancer risk associated with these radiologically unique aerosols is unknown to orders of magnitude. Present plutonium standards are certainly irrelevant and probably not conservative. Even so, the fact that under present standards, the permissible air concentrations are about one part per million billion is a commentary on plutonium's potential as a pollutant [3].

To determine whether the AEC's radiation protection standards for plutonium are inadequate, as Geesaman suggests, two of the authors of this article undertook a review of the biological evidence for the Natural Resources Defense Council (NRDC). Their report, *Radiation Standards for Hot Particles* [9], concludes that plutonium particulates or hot particles are uniquely virulent carcinogens and that the current AEC radiation protection standards governing the amount of plutonium to which members of the public can be exposed are roughly 100,000 times too lax.

The lung cancer risk associated with hot particles of plutonium, as estimated by Tamplin and Cochran, is comparable to the lethal dose of botulin toxin, a biological warfare agent. Certainly one would hope that this nation would give careful consideration and pursue all alternatives before implementing an energy policy based on such toxic materials.

As a result of this study, NRDC formally petitioned the AEC and the Environmental Protection Agency to reduce the present maximum permissible exposure levels by 100,000. Neither the AEC nor the EPA have responded finally to NRDC's petition, but the petition is now being considered by National Council on Radiation Protection and Measurements, National Academy of Sciences, Biophysical Society and several AEC national laboratories. Moreover, EPA will

*There are, however, several small commercial facilities that process plutonium for research and development purposes.

**The first commercial reprocessing plant built in the United States, Nuclear Fuel Services in West Valley, New York, was shut down in 1972 for repairs and enlargement. The Midwest Fuel Recovery Plant under construction near Morris, Illinois, has been declared an almost total loss due to faulty design and construction [6]. The Barnwell Nuclear Fuel Plant in South Carolina is 70 percent complete. Thus, since mid-1972, all spent fuel from light water reactors has been simply stored and not reprocessed.

shortly commence a series of hearings and other initiatives on plutonium-related issues, including the hot particle controversy.

Although the adequacy of the AEC's plutonium standards is thus a matter of considerable doubt and great controversy, the AEC's draft environmental impact statement for plutonium recycle simply assumes that the present standards are adequate. The entire risk analysis of the statement, as well as the ultimate decision to proceed with plutonium recycle, are based upon a premature and unexplained rejection of the hot particle hypothesis. Yet, the AEC is forced to concede that this hypothesis "is being given careful consideration in a separate proceeding" [2, chap. 4, pp. 5-7].

We submit that the AEC has no basis whatever to conclude that plutonium recycle will not cause undue risk to the public health and safety until it has either satisfactorily resolved the hot particle issue or calculated the impacts of plutonium recycle using the assumption that hot particles are uniquely carcinogenic. The AEC's draft environmental impact statement for plutonium recycle does neither. However, the more basic issue is whether we want our energy system based on a material of unprecedented toxicity.

Some plutonium contamination of the environment has already occurred, due principally to the atomic weapons program. The leakage of plutonium from contaminated oil at the AEC's plutonium weapons plant at Rocky Flats, 10 miles west of Denver, Colorado, led to an uncontrolled source of plutonium which was much larger than the integrated effluent loss during the 17 years of plant operation. Tens to hundreds of grams of plutonium went off-site, 10 miles upwind from Denver [3, p. 59].

The Nuclear Materials and Equipment Corporation (NUMEC) of Apollo, Pennsylvania, was recently fined $13,720 for a 16 count violation of AEC regulations ranging from failure to follow radiation monitoring procedures to failure to comply with certain safeguards requirements [9]. Production workers at Nuclear Fuel Services, Inc. in Erwin, Tenn., a fuel processing and fabricating facility, met with AEC inspectors on August 13, 1974 to complain about the absence of even the rudiments of accepted health physics practices at that plant. Occurrences such as these can reasonably be expected to multiply greatly if plutonium is made a major article of commerce.

### *Nuclear Theft*

On May 18 of this year the world was made dramatically aware of the relationship between nuclear power and nuclear weapons when India exploded a nuclear device made from plutonium taken from a peaceful reactor built with Canadian assistance. The magnitude of the threat posed by the availability of plutonium from power reactors is set out by Willrich and Taylor in their book *Nuclear Theft: Risks and Safeguards:*

> As fuel for power reactors, nuclear weapon material will range in commercial value from $3,000 to $15,000 per kilogram—roughly comparable to the value of black market heroin. The same material might be hundreds of times more valuable to some group wanting a powerful means of destruction. Furthermore, the costs to society per kilogram of nuclear material used for destructive purposes would be immense. The dispersal of very small amounts of finely divided plutonium could necessitate evacuation and decontamination operations covering several square kilometers for long periods of time and costing tens or hundreds of millions of dollars. The damage could run to many millions of dollars per gram of plutonium used. A nuclear explosion with a yield of one kiloton could destroy a major industrial installation or several large office buildings costing hundreds of millions to billions of dollars. The hundreds or thousands of people whose health might be severely damaged by dispersal of plutonium, or the tens of thousands of people who might be killed by a low-yield nuclear explosion in a densely populated area represent incalculable but immense costs to society [4, pp. 107-108].

In our troubled world, terrorist activity and other forms of anti-social violence are an almost daily occurrence. A recent AEC study identified more than 400 incidents of *international* terrorism carried out by small groups during the past six years [10]. In an age of bombs and bomb threats, of aircraft hijacking, of the ransom of diplomats and the murder of Olympic athletes, the risks of nuclear theft, blackmail and terrorism are not minimized even by some of the most ardent supporters of nuclear energy. Thus former Atomic Energy Commissioner Clarence Larson has described the evolution of a plutonium black market:

> Once special nuclear material is successfully stolen in small and possibly economically acceptable quantities, a supply-stimulated market for such illicit material is bound to develop. And such a market can surely be expected to grow once the source of supply has been identified. As the market grows, the number and size of thefts can be expected to grow with it, and I fear such growth would be extremely rapid once it begins. . . .Such theft would quickly lead to serious economic burdens to the industry, and a threat to the national security [11].

The critical point here is that these tremendous risks will become real with the advent of plutonium recycle. Unless plutonium is reprocessed and recycled, the possibility that it will be stolen is small. If the plutonium has not been detoxified by separating it from the high-level wastes in the spent fuel at a reprocessing plant, it is very effectively protected from theft, at least for hundreds of years. Willrich and Taylor explain these relationships:

> In the light water reactor (LWR) fuel cycle without plutonium recycle, plutonium which is produced in a power reactor, if reprocessed, might be stolen at the

**Is the American public willing to accept the risks of plutonium in exchange for the promised benefits?**

output end of a reprocessing plant, during transit from the reprocessing plant to any separate storage facility used, and from a long-term plutonium storage facility. *Until irradiated fuel is reprocessed, the theft possibilities in the LWR fuel cycle are minimal.* (Emphasis added.)

In the LWR fuel cycle with plutonium recycle, in addition to possibilities without recycle, plutonium might be stolen during transit from any separate long-term storage facility, and from a fuel fabrication plant. Complete LWR fuel assemblies, each containing a significant quantity of plutonium might also be stolen during transit from a fuel fabrication plant to a power reactor, and at a power plant prior to loading into the reactor, although the weight of each assembly makes this difficult [4, p. 168].

In sum, plutonium recycle will bring with it all the risks associated with nuclear theft that numerous authors have described [12]. Reasonable prudence dictates, therefore, that we have adequate answers to the problem of nuclear theft well in hand before we begin plutonium recycle.

### *Safeguards and the AEC*

In the language of the nuclear industry, the various programs and techniques to prevent nuclear theft and recover stolen nuclear material are called 'safeguards.' There is now widespread agreement—at least among those outside the nuclear industry—that present safeguards against nuclear theft are woefully inadequate [13]. The AEC's Rosenbaum Report concluded:

> In recent years the factors which make safeguards a real, imminent and vital issue have changed rapidly for the worse. Terrorists groups have increased their professional skills, intelligence networks, finances and level of armaments throughout the world. . . .Not only do illicit nuclear weapons present a greater potential public hazard than the radiological dangers associated with power plant accidents, but. . .the relevant regulations are much less stringent [13].

The problem is not simply that the AEC has not implemented the necessary safeguards programs; rather the agency has not even developed an adequate program on paper.

On the subject of safeguards, the AEC's draft impact statement on plutonium recycle is a marvel of clouded reasoning and breezy optimism. The statement concedes that the objective of keeping the risk of nuclear theft small "will not be fully met for the recycle of plutonium by current safeguards measures" [2, pp. 5-6]. Steps which might be taken to correct current inadequacies are then summarized in the statement as follows:

> 1. Minimization or elimination of the transportation of plutonium from reprocessing plants to mixed oxide fuel fabrication facilities which is the operation most vulnerable to an attempted act of theft or sabotage. To the extent that such shipments are minimized or eliminated, the safeguarding of plutonium would be enhanced. This objective can be accomplished by locating mixed oxide fuel fabrication plants in close proximity to or adjacent to reprocessing plants in Integrated Fuel Cycle Facilities. . . .
>
> 2. Further protection of transportation functions by use of massive shipping containers, special escort or convoying measures, vehicle hardening against attack, improved communications and response capabilities.
>
> 3. Additional hardening of facilities through new barrier requirements, new surveillance instrumentation, new delaying capabilities (e.g., incapacitating gases).
>
> 4. Upgrading of operating and guard functions through the use of personnel security clearance procedures, a federally operated nuclear security system, more advanced systems for monitoring and searching of personnel, and closer liaison with law enforcement authorities.
>
> 5. Improving the timeliness and sensitivity of the system of internal control and accountability of plutonium.
>
> 6. Use of 'spiked' plutonium which would be less susceptible to theft and would be more difficult to manufacture into a nuclear explosive because of the required elaborate handling procedures [2, pp. 5-7].

Despite the facts that: (1) these proposals are preliminary and their content not well defined, (2) they are still being studied, some apparently for the first time, (3) some would require Congressional action, (4) some would necessitate substantial changes in the structure of the U.S. utility industry, and (5) a sophisticated safeguards program would pose a major threat to civil liberties and personal privacy—despite all these facts the draft impact statement nevertheless recommends that we proceed now with plutonium recycle because "the Commission has a high degree of confidence that through implementation of some combination of the above concepts the safeguards general objective set forth earlier can be met for plutonium recycle" [2, pp. 5-7]. The Commission's faith, unfortunately, is hardly reassuring.

The AEC's lead safeguards suggestion—the Integrated Fuel Cycle Facility concept—merits special comment. It actually represents a major watering down of a far more significant concept, that of nuclear power parks where reactors as well as fuel reprocessing and fabricating plants are all located at one site [14]. In our judgment, a safeguards system which does not require nuclear parks is not addressing the problem of theft during transportation in a serious and responsible way. Moreover, the nuclear industry's current plans, already well advanced, do not call for the implementation of even the Integrated Fuel Cycle Facilities concept.

### *Adequate Safeguards?*

While it may be possible to devise an adequate safeguard system in theory, there is little reason to believe that such a system would be acceptable in practice [15]. This is true for several reasons.

First, the problem is immense. The illegal diversion of weapons material is only one type of antisocial behavior a safeguards program must protect against. Terrorist acts against the reactors, shipments of radioactive wastes, fuel reprocessing facilities and waste repositories can result in catastrophic releases of radioactivity. Such threats against nuclear facilities have already occurred [16]. Moreover, a safeguards system would have to exist on a vast, worldwide basis. Some 1,000 nuclear reactors are projected for the United States in the year 2000, with hundreds of shipments of radioactive materials daily. Hundreds of tons of plutonium will be in the commercial sector of our economy by that date.

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Abroad, American firms are constructing nuclear reactors in countries that have little political stability and in countries, such as Japan, who have not signed the Non-Proliferation Treaty. Safeguarding nuclear bomb material would ultimately require a restructuring of the socio-political institutions on a worldwide scale. The United Nations unfortunately gives us little reason to believe that this is a practical reality.

Second, safeguards measures are strongly opposed by the nuclear industry. The degree to which the industry is sensitive to the diversion hazards and is likely to be an effective partner in the enforcement and implementation of safeguards programs was apparent in the vociferous industry opposition to the modest strengthening of the AEC safeguards rules which were first published in the February 1, 1973, *Federal Register* [17].

Third, experience with present safeguards is hardly reassuring. Nuclear Materials and Equipment Corporation, over several years of operation, was unable to account for six percent (100 kilograms) of the weapons grade material that it handled. As noted previously, it was also fined by the AEC, in part, because of safeguards violations. At a safeguards symposium the director of the AEC's Office of Safeguards and Materials Management observed that "we have a long way to go to get into that happy land where one can measure scrap effluents, products, inputs and discards to a one percent accuracy" [3, p. 59]. This statement takes on particular significance when it is realized that only one-half of one percent of the plutonium utilized by the commercial sector in the year 2000 is enough to make hundreds of atomic bombs. The editors of the *Bulletin* have noted that the frequent 'misroutings' of shipments of weapons grade materials highlights a key safeguards problem —hijacking [18].

A spot-check by General Accounting Office investigators at three AEC-licensed contractors showed that in some cases access to easily portable quantities of special nuclear material could be gained in less than a minute using the simplest of tools. At two of the three plants checked, GAO found weak physical barriers, ineffective guard patrols, ineffective alarm systems, lack of automatic-detection devices, and the absence of an action plan should material be stolen or diverted. AEC's inspectors, however, were giving the same facilities good marks on virtually every security category [GAO, 13].

Fourth, and perhaps most basically, there is little reason to believe that safeguards will work when little else does. For example, the AEC supports the creation of a federal police force to provide an immediate federal presence whenever the use of force may be needed to protect these incredibly dangerous materials from falling into the hands of would-be saboteurs and blackmailers. But is there anyone who believes that police are effective at a level commensurate with the potential nuclear hazard? The New York City police department was proven incapable of maintaining security over confiscated heroin. Are similar losses of plutonium acceptable?

The general point here is that our safeguards system must be essentially infallible. It must maintain what Alvin Weinberg, former director of the Oak Ridge National Laboratory, has called "unaccustomed vigilance" and "a continuing tradition of meticulous attention to detail" [19]. Yet our human institutions are far from infallible. Our experience indicates that rather than sustaining a high degree of esprit, vigilance and meticulous attention to detail, our governmental bureaucracies instead become careless, rigid, defensive and, less frequently, corrupt. A basic question, then, is whether we want to entrust so demanding and unrelenting a technology as plutonium recycle to institutions which are negligent of their own responsibilities and insensitive to the rights of others and to technical fixes which are untried and unproven.

### *Threat to Civil Liberties*

One principal reason for our believing that an adequate safeguards system would not be acceptable in practice is the tremendous social cost of such a system in terms of human freedom and privacy. Safeguards necessarily involve a large expansion of police powers. Some one million persons have been trained in the handling, moving and operation of nuclear weapons. The projected growth of the nuclear industry will give rise to a parallel and, ultimately, a much larger group of persons, in this case civilians, who will be subjected to security clearance and other security procedures now commonplace in the military weapons program. Indeed, the AEC makes the following disturbing statement in its draft environmental impact assessment of plutonium recycle:

> Security problems are much simplified when it can be established with high probability that the persons who are responsible for the handling of plutonium or implementing of related safeguards programs are trustworthy. Various court rulings in recent years have been favorable to the protection of individual privacy and of individual right-to-work. These rulings have made it difficult to make a personnel background check of an individual in commercial activities to assure with high probability that he is trustworthy and, hence, potentially acceptable as a steward for the protection of plutonium. The AEC has requested legislation which would allow background checks of individuals with access to plutonium and related material accountability records [2, chap. 5, p. 42].

The keeping of police dossiers will not be limited to nuclear industry personnel. The New York Times reported August 11 that Texas state police maintain files on nuclear power plant opponents. How much more government investigation into the private lives of individuals can be tolerated by a free society? Security and surveillance procedures at best infringe upon the privacy of families and their friends. At worst, they are the instruments of repression and reprisal.

A second AEC safeguards proposal is the creation of a federal police force for the protection of plutonium plants and shipments. The draft impact statement for plutonium recycle justifies such a federal force in the following terms:

> A federal security system would be less apt to have the variations in staff and capability that would be encountered in use of private security guards. In addition, it should be noted that the consequences of a successful theft or diversion of plutonium would undoubtedly have nationwide impacts and could best be handled by Federal authorities; certainly, with Federal participation, there is the potential for a larger force, more effective weapons, and better communications [2, chap 5, p. 42].

How large would such a force be? What standards should govern and restrain its operations? The Washington Post reported in October 1973 that the AEC issued shoot-to-kill orders to personnel directing the production, shipment and storage of atomic weapons at the height of the Yom Kippur War.

Once a significant theft of plutonium or other weapons material has occurred, how will it be recovered? To prevent traffic in heroin, police have asked for no-knock search laws. This infringes upon one of our most cherished freedoms. To live with plutonium we may have to abandon this freedom along with others. In the presence of nuclear blackmail threats, the institution of martial law seems inevitable. It has been said that the widespread availability of weapons material and terrorists targets in the nuclear fuel cycle will radically alter the power balance between large and small social units (De Nike [16]). It should be added that the threatened society will undoubtedly attempt to redress that balance through sophisticated and drastic police action.

In sum, to accommodate plutonium we shall have to move toward a more intimidated society with greatly reduced freedoms. In this respect the following passage from the report of the distinguished international group of scientists attending the 23rd Pugwash Conference on Science and World Affairs is instructive:

> The problem of theft of nuclear material by internal groups of individuals intent on sabotage, terrorism or blackmail was agreed to be a very serious one, although there was some sentiment expressed that the possibility of such activity was much smaller in socialist states.

We believe that sentiment to be true. It is also apparent that that is the direction in which we must move to accommodate the nuclear industry. After having spent billions of dollars for our nuclear deterrent, our civilian nuclear industry might well accomplish that which our defense system is trying to prevent.

Alvin Weinberg is one of the few persons closely associated with the nuclear power complex who has looked carefully at the political and regulatory institutions that will be necessary to support a plutonium-based nuclear power economy, and his views on this subject merit close attention [19]. Weinberg's basic premise is that nuclear power will place unprecedented strains on our society. In an unpublished paper circulated prior to a conference in June 1973 at the Woodrow Wilson International Center for Scholars in Washington, D.C., Weinberg set out his views on the type of new institutions required to cope with the plutonium economy:

> One suggestion (proposed by Sidney Siegel) that is relevant to the situation in the United States would be to establish a national corporation patterned after COMSAT to take charge of the *generation* of nuclear electricity. Such an organization would have technical resources that must exceed those available to even a large utility: and a high order of technical expertise in operating reactors and their sub-systems is essential to ensuring the continued integrity of these devices. [Here Dr. Weinberg suggests nationalization of the industry.]
>
> Each country now has its own AEC that sets standards or, in some cases, actually monitors or operates reactors. Perhaps this will be sufficient forever. Yet no government has lasted continuously for 1,000 years: only the Catholic Church has survived more or less continuously for 2,000 years or so. Our commitment to nuclear energy is assumed to last in perpetuity—can we think of a national entity that possesses the resiliency to remain alive for even a single half-life of plutonium-239? A *permanent* cadre of experts that will retain its continuity over immensely long times hardly seems feasible if the cadre is a national body.
>
> It may be that an International Authority, operating as an agent of the United Nations, could become the focus for this cadre of expertise. The experts themselves would remain under national auspices, but they would be part of a worldwide community of experts who are held together, are monitored, and are given long-term stability by the International Authority. The Catholic Church is the best example of what I have in mind: a *central authority* that *proclaims* and to a degree *enforces* doctrine, maintains its own long-term social stability, and has connections to every country's own Catholic Church. (Emphasis added.)

These are far-reaching concepts presented by Weinberg. The basic question they pose is: Will the plutonium economy raise socio-political problems of such magnitude that their resolution will be unacceptable to society? In attempting to do the impossible—live with plutonium—we may create the intolerable.

### *Super-Human Requirements*

The commercialization of plutonium will bring with it a major escalation of the risks and problems already associated with nuclear power. Plutonium will further strain the already weakened regulatory fabric of the nuclear industry.

Hannes Alfven, Nobel laureate in physics, has described the regulatory imperatives applicable to the nuclear industry:

> Fission energy is safe only if a number of critical devices work as they should, if a number of people in key

positions follow all their instructions, if there is no sabotage, no hijacking of the transports, if no reactor fuel processing plant or reprocessing plant or repository anywhere in the world is situated in a region of riots or guerrilla activity, and no revolution or war—even a "conventional one"—takes place in these regions. The enormous quantities of extremely dangerous material must not get into the hands of ignorant people or desperados. No acts of God can be permitted [20].

Weinberg similarly stresses the need ". . . of creating a continuing tradition of meticulous attention to detail" and suggests that "what is required is a cadre that, from now on, can be counted upon to understand nuclear technology, to control it, to prevent accidents, to prevent diversion" [19].

The public and its decisionmakers must seriously question whether it will be possible to attract, train and motivate the personnel required for these functions. These must be highly qualified persons who will maintain a tradition of "meticulous attention to detail" even when the glamorous aspects of a new technology become the commonplace operations of an established industry. We suggest that it is beyond human capabilities to develop a cadre of sufficient size and expertise that can be counted upon to understand nuclear technology, to control it, and to prevent accidents and diversion over many generations.

There is considerable evidence at the present time to suggest that the fledgling nuclear industry is already unmanageable. Consider, for example, that a previously secret AEC study released by Ralph Nader concluded that:

> The large number of reactor incidents [850 abnormal occurrences], coupled with the fact that many of them had real safety significance, were generic in nature, and were not identified during the normal design, fabrication, erection, and preoperational testing phases, raises a serious question regarding the current review and inspection practices both on the part of the nuclear industry and the AEC [21].

In addition, consider the tritium that recently appeared in the drinking water of Broomfield, Colorado. Consider the 115,000 gallons of high-level radioactive wastes that leaked from the tank at Hanford, Washington, over a period of 51 days while no one monitored the tank. Consider that the radioactive releases from the famed Shippingport reactor in Pennsylvania were higher than recorded. Consider that the executives of Consumers Power Corporation in Michigan failed to notify the AEC that their radioactive gas holdup system was not functioning. Consider that two reactors in Virginia were half completed before the AEC was informed that they were being constructed over an earthquake fault. Consider that the GAO found security at plutonium storage areas totally inadequate after the AEC inspectors had certified the facilities.

Considering all this, there is good reason to suggest, because of the meticulous attention to detail that will be required at every stage of plutonium recycle, that a decision to proceed with plutonium recycle will precipitate an already unmanageable situation into a national crisis.

Given that the risks of plutonium recycle are unacceptably high, particularly in light of the present uncertainties, a key question is what are our options? What are the alternatives to the AEC's proposal to proceed now with plutonium recycle? We believe that there are essentially three options, each of which is preferable to the AEC's announced plan.

**Plutonium in cake form. This batch was produced at the AEC's Savannah River Plant near Aiken, S.C.**

### *Alternatives to Plutonium Recycle*

• We could phase out nuclear power reactors. There is mounting apprehension among knowledgeable persons concerning the human and societal hazards of fission reactors which would only be compounded by plutonium recycle. The 23rd Pugwash Conference on Science and World Affairs in September, 1963, concluded:

> 1. Owing to potentially grave and as yet unresolved problems related to waste management, diversion of fissionable material, and major radioactivity releases arising from accidents, natural disasters, sabotage, or acts of war, the wisdom of a commitment to nuclear fission as a principal energy source for mankind must be seriously questioned at the present time.
> 2. Accordingly, research and development on alternative energy sources—particularly solar, geothermal and fusion energy, and cleaner technologies for fossil fuels—should be greatly accelerated.
> 3. Broadly based studies aimed at the assessment of the relation between genuine and sustainable energy needs, as opposed to projected demands, are required.

This third recommendation implies the implementation of energy conservation measures. It is important to recognize that energy conservation can be our major energy source between now and the year 2000. Conservation means using our present energy more efficiently; it need not mean a change in life styles. Coupled with the use of solar and geothermal energy, energy conservation could eliminate the need for new nuclear power stations.

• We could continue with the present generation of light water reactors but strictly prohibit plutonium recycle for the foreseeable future. Such a decision would be premised upon a judgment that plutonium

is too dangerous because of its toxicity and explosive potential to be allowed to become an article of commerce. Of course, we would still have plutonium to cope with because it is produced in present-day reactors. But without plutonium recycle there should be little incentive to reprocess the plutonium out of the spent fuel, so the plutonium could remain in the spent fuel where it is effectively protected from theft and, hopefully, confined and contained.

The benefits of plutonium recycle are small. Plutonium recycle would reduce the annual uranium requirements by about 10 to 15 percent and reduce the light water reactor fuel cycle cost by about the same amount. But the nuclear fuel cycle cost represents less than 20 percent of the total cost of power from nuclear plants, and nuclear plants by 1985 will represent less than 40 percent of the electric, or about 15 percent of the total, domestic energy supplied. In other words, plutonium recycle involves an economic savings of less than one-half of one percent.

Plutonium differs from the high-level wastes in the spent fuel in one critical respect: whereas the radioactivity of high-level wastes will continue for thousands of years, that of plutonium will continue for hundreds of thousands. Thus, while the problem of effectively storing both these materials and preventing their entering the environment are unprecedented in human history, plutonium must be contained for eons longer. For this reason, an argument can be made that, ultimately, the safest thing that can be done with plutonium is to burn or fission it in reactors, thus making it into high-level wastes rather than plutonium. But that is an activity that is best left for decades or even centuries hence—for a society more capable and less violent than today's.

- We could defer for several years the decision regarding plutonium recycle until present uncertainties regarding safeguards and plutonium toxicity are satisfactorily resolved and a basis has been laid for a more intelligent judgment regarding the risks and benefits of the commercialization of plutonium. We believe that this option must command general support. Too many questions, both technical and social, are unanswered today. And until these questions are answered it would be a grave error, we believe, to rush into the AEC's plutonium economy.

Is the American public willing to accept the risks of plutonium in exchange for the promised benefits? The national debate which must occur on this basic question has hardly begun.

## NOTES

1. Glenn T. Seaborg, "The Plutonium Economy of the Future," Release No. S-33-70 (Washington, D.C.: Atomic Energy Commission, October 5, 1970).
2. Atomic Energy Commission, "Draft Generic Environmental Statement on the Use of Mixed Oxide Fuel," WASH-1327 (Washington, D.C.: The Commission, July 1974).
3. Donald P. Geesaman, "Plutonium and the Energy Decision," in *The Energy Crisis*, ed. R.S. Lewis and B.I. Spinrad (Chicago, Ill.: Bulletin of the Atomic Scientists, 1972), pp. 58-59.
4. Mason Willrich and Theodore B. Taylor, *Nuclear Theft: Risks and Safeguards* (Cambridge, Mass.: Ballinger, 1974).
5. The AEC's attempt to recycle plutonium into the Big Rock Point (Mich.) reactor was stopped by a lawsuit. *West Michigan Environmental Action Council v. AEC* (W. D. Mich. Dkt. No. G-58-73).
6. *Weekly Energy Report*, "GE Fuel Recovery Plant 'Inoperable,'" II (July 15, 1974), 1.
7. Atomic Energy Commission, "Nuclear Power Growth: 1974-2000," WASH-1139 (Washington, D.C.: The Commission, 1974), p. 34 (Case D projection). The year 2000 figure includes plutonium produced in liquid metal fast breeder reactors.
8. Arthur Tamplin and Thomas Cochran, *Radiation Standards of Hot Particles* (Washington, D.C.: Natural Resources Defense Council, Feb. 14, 1974). Copies of this report are available from NRDC (1710 N St., N.W., Washington, D.C. 20036) for $3 per copy.
9. Atomic Energy Commission, press release, August 14, 1974.
10. W. C. Bartels and S. C. T. McDowell, quoted in *Nuclear News*, 17 (Aug. 1974), 46.
11. Clarence E. Larson, "Nuclear Materials Safeguards: A Joint Industry-Government Mission," in *Proceedings of AEC Symposium on Safeguards Research and Development*, Oct. 27-29, 1969, WASH 1147 (Washington, D.C.: The Commission, 1969); and Deborah Shapley, "Plutonium: Reactor Proliferation Threatens a Nuclear Black Market," *Science*, 172:3979 (April 9, 1971), 143.
12. See, for example, Bernard T. Feld, "The Menace of a Fission Power Economy," *Bulletin*, 30 (April 1974), 32-34; Lawrence Scheinman, "Safeguarding Nuclear Materials," *Bulletin*, 30 (April 1974), 34-36; David T. Rose, "Nuclear Electric Power," *Science*, 184:4134 (April 19, 1974), 351-359. See also Robert L. Heilbroner, *An Inquiry into the Human Prospect* (New York: W. W. Norton, 1974), pp. 40-43.
13. See, for example, Atomic Energy Commission, "The Threat of Nuclear Theft and Sabotage" (Rosenbaum Report), *Congressional Record*, April 30, 1974, p. S 6621; General Accounting Office, "Protecting Special Nuclear Material in Transit: Improvements Made and Existing Problems," B-164105 (Washington, D.C.: U. S. Government Printing Office, 1973).
14. Dean E. Abrahamson, "Energy: Nuclear Theft and Nuclear Parks," *Environment* (July/August, 1974), 5.
15. Taylor and Willrich believe that "a system of safeguards can be developed that will keep the risks of theft of nuclear weapon materials from the nuclear power industry at very low levels" [4, p. 171]. Yet they also emphasize that "regardless of its effectiveness, a nuclear safeguards system applicable to the nuclear power industry in this country cannot provide complete assurance that unannounced fission explosions will not occur in the United States in the future." They point out that "no future safeguards system that will be practical can offer 100 percent assurance against theft" [4, p. 123]. They never say what level of nuclear theft, or what size plutonium black market or how many unauthorized nuclear explosions are in fact acceptable to them.
16. L. Douglas DeNike, "Radioactive Malevolence," *Bulletin*, 30 (February 1974), 16. See also the story on the bomb threats that have occurred at the Zion nuclear power plant in northern Illinois reported in *Environment*, "Spectrum" (October 1974).
17. *Nuclear Industry*, "Industry Inundated by Proposed New Safeguards Rules" (February 1973), pp. 45-47.
18. R. S. Lewis and B. I. Spinrad, eds., *The Energy Crisis*, (Chicago, Ill.: Bulletin of the Atomic Scientists, 1972), p. 59.
19. Alvin Weinberg, "Social Institutions and Nuclear Energy," *Science*, 177:4043 (July 7, 1972), 32-34.
20. Hannes Alfven, "Energy and Environment," *Bulletin*, 29 (May 1972), 5.
21. AEC Task Force Report, dated October, 1973, page 16, released in testimony presented to the Joint Committee on Atomic Energy by Ralph Nader and the Union of Concerned Scientists, January 29, 1974.