Natural Resources Defense Council, Inc.

1710 N Street, N.W.
Washington, D.C. 20036
202 783-5710

New York Office
15 WEST 44th STREET
NEW YORK, N.Y. 10036
212 869-0150

Palo Alto Office
664 HAMILTON AVENUE
PALO ALTO, CALIF. 94301
415 327-1080

The Plutonium Decision

A Report on the Risks of Plutonium Recycle

By

J. Gustave Speth
Arthur R. Tamplin
Thomas B. Cochran

September, 1974

"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."

James D. Watson
Nobel Laureate,
Medicine

I. Introduction

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"[1] 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.[2] The final version of the impact statement, which is expected to confirm the decision to authorize plutonium recycle, is due in six to nine months.

Plutonium is not native to Earth: 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 (there are 28 grams in an ounce) has been shown capable of producing cancer in animals. 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.

Thus, former AEC physicist Donald Geesaman observes that "plutonium is a fuel that is toxic beyond human experience." Its use, he states, "will inextricably involve our society in the large-scale commercial production of a substance that is a suitable nuclear explosive."[3] The successful theft of this material, as Mason Willrich and Theodore Taylor note, "could enable a small group to threaten the lives of many people, the social order within a nation, and the security of the international community of nations."[4]

It is the burden of this report 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. And those who have asked what changes in our institutions will be necessary to accomodate plutonium have come away from that enquiry profoundly concerned.[5]

The AEC's impact statement assessment of plutonium recycle reinforces, and does not allay, these concerns. It 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 beneficience of the technology it has fostered or from a callous promotion of the bureaucratic and industrial interests of the nuclear power complex, the AEC decision cannot be justified in light of what we know and, just as important, what we do not know.

II. Dimensions of a Commercial Plutonium Industry

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

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 200-250 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 this plutonium produced in LWR's, process it and recycle it as fuel back into LWR's.

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. The spent fuel contains

---

*/ Only with extremely sophisticated technology not available to the public, notably gaseous diffusion plants, can uranium be enriched to weapons grade.

**/ LWR's capable of producing 1000 megawatts (1 million kilowatts) of power are being built today. The plutonium is produced when the uranium-238 in the LWR fuel captures neutrons.

plutonium, uranium and extremely toxic fission products or "high-level wastes" (strontium-90, cesium-137, etc.). The function of the reprocessing plant is to separate these three constituents and prepare them for their next destinations. For example, reprocessing plants are supposed to solidify the 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 agency know whether the technology and social institutions for isolating high-level wastes for geologic periods can be made available.

The principal purpose of a reprocessing plant, however, is to recover plutonium, to convert it to oxide form, and to ship it 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 what is called "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.

The only privately owned fuel reprocessing plant which has operated in the United States is the Nuclear Fuel Services (NFS) plant at West Valley, New York. Until recently the AEC purchased the plutonium output of this facility for weapons and research purposes. Recently, however, the AEC stopped purchasing recovered plutonium, and in June, 1972, the NFS plant closed for renovation and enlargement. Since mid-1972, then, all spent fuel from LWR's has been simply stored and not reprocessed, a favorable development in terms of nuclear theft since the penetrating radiation of the high-level wastes virtually insures that plutonium will not be stolen as long as it is still mixed with these wastes in the spent fuel rods.

Two additional fuel reprocessing plants are now being constructed, a General Electric plant at Morris, Illinois, and an Allied-Gulf plant at Barnwell, South Carolina. GE recently announced, however, that its Morris plant might never operate and that most of its investment would be lost due to faulty design and construction.[6] Operating license proceedings are scheduled to begin shortly for the Barnwell plant.

There are at present no major commercial plutonium fuel fabricating plants operating or under construction.* The first such plant is planned by Westinghouse for Anderson, South Carolina. Nor has there yet been any non-experimental use of plutonium as fuel in light-water reactors, although the AEC attempted such a recycle until stopped by a lawsuit.[7]

In sum, plutonium recycle has not yet begun, and there is no major industrial commitment of resources to it at this point. The reprocessing plants that have been built do not represent a substantial investment in national terms, and reprocessing plants may be needed in any case to prepare spent fuel for long-term storage.

On the other hand, if the plans of the AEC and the nuclear industry are permitted, a major plutonium industry will develop quickly. Some 140 tons of plutonium could be recovered from commercial reactors by 1985 and some 1700 tons by the year 2000.[8] This figure for the year 2000 includes the plutonium that will be

---

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

produced in the fast breeder reactor, which the AEC plans to introduce in the mid-1980's. This is a new type of reactor designed to produce more plutonium than it consumes. A plutonium industry by the turn of the century could involve hundreds of LWR's 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.

III. The Toxicity of Plutonium

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. Its insolubility and long half-life make the continuing resuspension of particulate contamination another unresolved concern of serious proportions."[9]

To determine whether the AEC's radiation protection standards for plutonium are inadequate, as Geesaman suggests, Arthur Tamplin and Thomas Cochran undertook a major review of the biological evidence for the Natural Resources Defense Council. Their conclusions, found in their report "Radiation Standards for Hot Particles," are 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.[10] 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 the Tamplin-Cochran report, NRDC formally petitioned the AEC and the Environmental Protection Agency to reduce the present maximum permissible exposure levels by 100,000. Neither AEC nor EPA have responded finally to the NRDC petition, but the petition is now being considered by the National Commission on Radiation Protection, the National Academy of Sciences, the Biophysical Society and several of the AEC national laboratories. Moreover, EPA will 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 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."[11]

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 draft environmental impact statement for plutonium recycle does neither.

It should be remembered that there is clear experimental evidence that plutonium is one of the most carcinogenic substances known regardless of one's views about the hot particle risk: one millionth of a gram has caused cancer in experimental animals. Thus, the more basic question 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. Aside from the worldwide plutonium contamination associated with the fallout from atmospheric weapons tests, there is significant ground contamination at the Nevada Test Site and the Bikini and Eniwetok Atolls. The AEC's plutonium weapons plant at Rocky Flats, 10 miles west of Denver, Colorado, was the site of one of the most costly industrial fires in history. The leakage of plutonium from contaminated oil at this site led to an uncontrolled source of plutonium which was some orders of magnitude larger than the integrated effluent loss during the 17 years of plant operation. As a result of this source, tens to hundreds of grams of plutonium went off site, 10 miles upwind from Denver. The loss was internally unnoticed, the ultimate deposition is now speculative, as is its human significance.[12]

One can derive little comfort in the current operation of the small commercial plutonium fuel fabrication facilities. The Nuclear Materials and Equipment Corporation (NUMEC) of Apollo, Pennsylvania was recently fined $13,720 for a sixteen count violation of AEC regulations ranging from failure to follow radiation monitoring procedures to failure to comply with certain safeguards requirements.[13] Production workers from the Nuclear Fuel Services facility in Erwin, Tennessee 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.

IV. Nuclear Theft and Safeguards

A. The Problem Defined

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 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."[14]

In our troubled world, terrorist activity and other forms of anti-social violence is an almost daily occurrence. A recent AEC study identified more than 400 incidents of <u>international</u> terrorism carried out by small groups during the past six years.[15] 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 recently 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."[16]

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, for if the plutonium has not been "detoxified" by separating it from the high-level wastes in the spent fuel, it is very effectively protected from theft, at least for hundreds of years. Willrich and Taylor explain these important 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 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.
>
> "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." (Emphasis added.)[17]

In sum, plutonium recycle will bring with it all the risks associated with nuclear theft that numerous authors have described.[18] Reasonable prudence dictates, therefore, that we have adequate answers to the problem of nuclear theft well in hand before we begin plutonium recycle.

B. Safeguards and the Impact Statement

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 are woefully inadequate. The AEC's own 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 pro-

> fessional 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."[19]

It is not that the AEC has not implemented the necessary safeguards programs; rather it has not even developed an adequate program on paper.

On the subject of safeguards, the AEC's draft impact statement for 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 Pu by current safeguards measures."[20] Steps which might be taken to correct current inadequacies are 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."[21]

Despite the facts (1) that these proposals are preliminary and their content not well-defined, (2) that they are still being studied, some for the first time, (3) that several would require Congressional action, (4) that several would necessitate substantial changes in the structure of the U.S. utility industry, and (5) that a sophisticated safeguards program would pose a major threat to civil liberties and personal privacy, 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 Pu recycle."[22] The Commission's faith, unfortunately, is hardly reassuring.

The issues of a federal plutonium police force and personnel security and surveillance measures will be discussed in the following section,[23] for they are the entering wedge of what promises to be more pervasive and continuing undermining of our civil rights. Two other potential safeguards should be mentioned here, however, in order to highlight the degree to which the issues remain unresolved. First, the draft statement refers to the possible use of "spiked" plutonium, i.e. plutonium combined with radioactive material emitting high levels of penetrating radiation. The type of radiation emitted by plutonium -- an alpha particle -- while extremely carcinogenic in soft tissue, is not very penetrating and can be shielded against without heavy concrete or lead structures. The spiking of plutonium with more penetrating radiation would substantially increase the hazards of handling it and thus decrease the theft incentive. This step would appear to be an essential part of any safeguards program, yet it could substantially increase the costs of plutonium recycle, making it much less attractive to the industry.

Second, the AEC's lead safeguards suggestion -- the Integrated Fuel Cycle Facility concept -- 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.[24] 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.

C. Are Adequate Safeguards Possible?

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.[25] This is true for several reasons.

First, the problem is immense. The illegal diversion of weapons material is only one type of anti-social 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.[26] Moreover, a safeguards system would have to exist on a vast, worldwide basis. Some 1000 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.[27] 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. Some indication of the degree to which the industry is sensitive to the diversion hazards, and the degree with which the industry is likely to be an effective partner in the enforcement and implementation of safeguards programs can be gleaned from published accounts of the industry's response to the modest strengthening of the AEC safeguards rules which were first published in the February 1, 1973, Federal Register.

Some of the comments received on these proposed regulations were:

> ". . . it is clear that the severity of the proposed [physical security] procedures greatly exceeds any reasonable relationship to the public need intended to be served. We are unaware, and we believe the industry as a whole is unaware, of occurrences of industrial sabotage which would tend to justify the imposition of requirements as strict as those proposed. The Commission has not demonstrated the need . . . or offered any justification or explanation . . . . Certainly the public interest will not be served by adoption of burdensome requirements disproportionate to the end sought."
>
> ---from comment of Kerr-McGee;

and,

> ". . . a move backward to the types of security practices in the Manhattan District era."
>
> ---from comment of Westinghouse;

and,

> "One principal objection is to the emphasis placed on the use of armed personnel . . . and the seeming reliance on such personnel to protect against threats to the common defense and security . . . . To the extent that the proposed regulations . . . require an armed confrontation between a licensee's security force and potential divertors, the proposed regulations should be amended. The surest and most proper method of protection . . . is prompt detection and reporting . . . ."
>
> ---from comment of United Nuclear.

Third, experience with present safeguards is hardly reassuring. The NUMEC, over several years of operation, was unable to account for six percent (100 kilograms) of the weapons grade material that it handled, and as noted previously was recently fined by the AEC, in part because of safeguards violations. At a recent 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."[28] 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 Bulletin of the Atomic Scientists have noted that the frequent "misrouting" of nuclear shipments highlights a key safeguards problem -- hijacking. They cite instances where theft of weapons grade materials would have been relatively easy: a shipment bound for Missouri ended up in Boston; another shipment between two California cities was eventually located in Tijuana, Mexico.[29] Finally, 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. In contrast, the AEC's inspectors were giving the same facilities good marks on virtually every security category.[30]

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 which might 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 acceptible? 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."[31] 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.

V. The 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 an ultimately 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 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. We believe that enabling legislation such as this is necessary to the further improvement of personnel selection practices."[32]

The keeping of police dossiers will not be limited to nuclear industry personnel. The <u>New York Times</u> reported August 11 that Texas state police maintain files on nuclear power plant opponents.[33] The police stated that they had information that some nuclear opponents might attempt to sabotage transmission lines, though they declined to disclose their information or its source. 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."[34]

But what standards should govern and restrain the operations of such a force? The AEC has already issued shoot-to-kill orders once to personnel directing the production, shipment and storage of atomic weapons, at the height of the Yom Kippur War.[35] 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.[36] 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 towards 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 or 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.

Dr. Alvin Weinberg, former Director of the Oak Ridge National Laboratory, 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. Dr. Weinberg's views on this subject merit close attention.

Weinberg's basic premise is stated in his article "Social Institutions and Nuclear Energy" which appeared in the July 7, 1972, issue of <u>Science</u>:

> "We nuclear people have made a Faustian bargain with society. On the one hand, we offer - in the catalytic nuclear burner - an inexhaustible source of energy . . . .
>
> "But the price that we demand of society for this magical energy source is both a vigilance and a longevity of our social institutions that we are quite unaccustomed to . . . . In a sense, we have established a military priesthood which guards against inadvertent use of nuclear weapons, which maintains what a priori seems to be a precarious balance between readiness to go to war and vigilance against human errors that would precipitate war. Moreover, this is not something that will go away, at least not soon. The discovery of the bomb has imposed an additional demand on our social institutions. It has called forth this military priesthood upon which in a way we all depend for our survival.
>
> "It seems to me (and in this I repeat some views expressed very well by Atomic Energy Commissioner Wilfrid Johnson) that peaceful nuclear energy probably will make demands of the same sort on our society, and possibly of even longer duration."[37]

Here Dr. Weinberg observes that nuclear power will place unprecedented strains on our institutions. He correctly states that the nuclear power industry will pose problems for society that eclipse those posed by nuclear weapons.

In an unpublished paper circulated prior to a conference at the Woodrow Wilson International Center for Scholars in Washington, D.C., on June 18, 1973, Dr. Weinberg elaborated his views on the type of institutions required to cope with the plutonium economy:

> "One suggestion (proposed by Sidney Siegal) 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 1000 years: only the Catholic Church has survived more or less continuously for 2000 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 Dr. 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.

VI. The 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.

Dr. 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 guerilla activity, and no revolution of 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."[38]

In his article in Science, Dr. Weinberg similarly stresses the need, ". . . of creating a continuing tradition of meticulous attention to detail." It is important to recognize that such a tradition would have to be "created." There are no historical precedents to suggest that this is possible on the scale demanded by the nuclear industry. Dr. Weinberg has also observed 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, prevent diversion. Moreover, in this ultimate world, nuclear reactors will be in Uganda as well as the U.S.A., in Ethiopia as well as England. And one must ensure the same high degree of expertise in the underdeveloped country as in the developed country."[39]

We quote Dr. Weinberg because he is one, if not the only, proponent of nuclear power who has given serious thought to its requirements. But 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. What are the qualifications of these people? How does the AEC and the nuclear industry plan to attract and continuously motivate them? We suggest that it is beyond human capability to develop a cadre of sufficient size with expertise of "very" high order that can be counted upon to understand nuclear technology, to control it, to prevent accidents and diversion over many generations, or even over the present generation.

There is considerable evidence at the present time to suggest that the fledgling nuclear industry is already unmanageable. For example, in testimony presented to the Congressional Joint Committee on Atomic Energy, Ralph Nader and the Union of Concerned Scientists on January 29, 1974, made public a heretofore secret report by an AEC Task Force dated October, 1973. That report stated the following:

"Review of the operating history associated with 30 operating nuclear reactors indicated that during the period 1/1/72 - 5/30/73 approximately 850 abnormal occurrences were reported to the AEC. Many of the occurrences were significant and of a generic nature requiring followup investigations at other plants. Forty percent of the occurrences were traceable to some extent to design and/or fabrication related deficiencies. The remaining incidents were caused by operator error, improper maintenance, inadequate erection control, administrative deficiencies, random failure and combinations thereof."

Regarding these incidents, on page 16, the Task Force stated:

"The large number of reactor incidents, 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."

In addition to these 850 abnormal occurrences, 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 over a period of 51 days while no one monitored the tank. Consider that the radioactive releases from the famed Shippingport reactor were higher than recorded. Consider that the executives of the Consumers Power Corporation failed to notify the AEC that their radioactive gas holdup system was not functioning. Consider that two reactors were half completed before the AEC was informed that they were being constructed over an earthquake fault. Consider that the GAO found the 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.

VII. Options: Alternatives to Plutonium Recycle

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.

First, we could phase out nuclear power reactors. There is mounting apprehension within the scientific community concerning the human and societal hazards of fission reactors which would only be compounded by plutonium recycle. As evidence of this apprehension among scientists, a statement of concern over the environment and world peace (The Menton Statement) which was signed by 2,200 scientists, included a call for an end to the proliferation of nuclear reactors. It was presented to U.N. Secretary U. Thant, and published in the U.N. Courier, July, 1971. Similarly, scientists from all nations at the 23rd Pugwash Conference on Science and World Affairs in September, 1973, 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.

Second, 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 is 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.

Third -- and we believe that this is an option that must command general support -- a decision regarding plutonium recycle, and of course plutonium recycle itself, could be deferred several years 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. 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.

The basic question which must be answered is whether the public is 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.

Footnotes

1. "The Plutonium Economy of the Future," Speech by AEC Chairman Glenn T. Seaborg, AEC Release No. S-33-70, dated October 5, 1970.

2. AEC, Draft Generic Environmental Statement On The Use Of Mixed Oxide Fuel, WASH-1327, July, 1974 [hereinafter cited as WASH-1327].

3. Donald P. Geesaman, "Plutonium and the Energy Decision," in The Energy Crisis, (ed. R.S. Lewis and B.I. Spinrad, 1972), pages 58-59.

4. Mason Willrich and Theodore B. Taylor, Nuclear Theft: Risks and Safeguards (1974), page 1.

5. See the discussion at pages 17-23, infra.

6. "GE Fuel Recovery Plant Inoperable," Weekly Energy Report, Vol. II, July 15, 1974, page 1.

7. West Michigan Environmental Action Council v. AEC (W. D. Mich. Dkt. No. G-58-73).

8. AEC, Nuclear Power Growth: 1974-2000, WASH-1139 (1974), page 34 (Case D projection).

9. Geesaman, op. cit., pages 58-59.

10. Arthur Tamplin and Thomas Cochran, Radiation Standards for Hot Particles, February 14, 1974. Copies of this report are available from NRDC for $3.00 per copy.

11. WASH-1327, Chapt. IV, Section J, page 7.

12. Geesaman, op. cit., page 59.

13. AEC News Releases, Vol. V, August 14, 1974, page 4.

14. Willrich and Taylor, op. cit., pages 107-108.

15. Paper by W.C. Bartels and S.C.T. McDowell of the AEC's Division of Safeguards and Security, reprinted in Nuclear News, Vol. 17, (Aug., 1974), page 46.

16. "Nuclear Materials Safeguards: A Joint Industry-Government Mission," Speech by AEC Commissioner Clarence E. Larson, published in Proceedings of AEC Symposium on Safeguards Research and Development, October 27-29, 1969. See also Deborah Shapley, "Plutonium: Reactor Proliferation Threatens a Nuclear Black Market," Science, 9 April 1971, page 143.

17. Willrich and Taylor, op. cit., page 168.

18. See, e.g., Bernard T. Feld, "The Menace of a Fission Power Economy," Bulletin of the Atomic Scientists, April, 1974, pages 32-34; Lawrence Scheinman, "Safeguarding Nuclear Materials," Bulletin of the Atomic Scientists, April, 1974, pages 34-36; David T. Rose, "Nuclear Electric Power," Science, 19 April 1974, pages 351-359. See also Robert L. Heilbroner, An Inquiry Into The Human Prospect (1974), pages 40-43.

19. See, e.g., "A Special Safeguards Study," a report to the AEC on the Adequacy of Current Safeguards (the "Rosenbaum Report"), reprinted at 120 Cong. Rec. S6623 (April 30, 1974); U.S. General Accounting Office, Improvements Needed in the Program for the Protection of Special Nuclear Material, (GPO: November 7, 1973), reviewed by Robert Gillette in Science, December 14, 1973, pages 1112-1114.

20. WASH-1327, page S-6.

21. WASH-1327, page S-7.

22. WASH-1327, page S-7.

23. See pages 18-24 , infra.

24. See Dean E. Abrahamson, "Energy: Nuclear Theft and Nuclear Parks," Environment, July/August, 1974, page 5.

25. 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." Op. cit., page 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% assurance against theft." Op. cit., page 123. They never say what level of nuclear theft, or what size plutonium black market or how many unauthorized nuclear explosions is in fact acceptable.

26. See L. Douglas DeNike, "Radioactive Malevolence," Bulletin of the Atomic Scientists, February, 1974, page 16.

27. See text accompanying note 8, supra.

28. Quoted in Geesaman, op. cit., page 59.

29. The Energy Crisis, op. cit., page 59.

30. GAO, Improvements Needed in the Program for the Protection of Special Nuclear Materials, op. cit.

31. Alvin Weinberg, "Social Institutions and Nuclear Energy," Science, 7 July 1972, pages 33-34.

32. WASH-1327, Chapter V, page 42.

33. New York Times, "News of the Week in Review," August 11, 1974, ("Texas Police Have A List For Dissenters").

34. WASH-1327, Chapter V, page 42.

35. The Washington Post, October 12, 1973, page A-3.

36. DeNike, op. cit.

37. Weinberg, op. cit., pages 33-34.

38. Hannes Alfven, "Energy and Environment," Bulletin of the Atomic Scientists, May, 1972.

39. Weinberg, op. cit.

The Authors

Arthur R. Tamplin has been a biophysicist at the Lawrence Radiation Laboratory in Livermore, California since 1963. During the period June, 1967 to January, 1969 he was a member of the AEC's Division of Biology and Medicine Committee on Space Nuclear Systems Radiological Safety. The primary interest of this committee was the hazard of plutonium. Dr. Tamplin holds a Ph.D. degree in Biophysics from the University of California at Berkeley. He has published and lectured extensively on the problems of nuclear power. His books include Poisoned Power: The Case Against Nuclear Power Plants (with Gofman). For the past year he has been working on the staff of NRDC while on a one-year leave of absence from the Laboratory.

J. Gustave Speth has been an attorney on the staff of NRDC since 1970, specializing on nuclear power problems. He was the attorney for the Scientists' Institute for Public Information in Scientists' Institute v. AEC, 481 F.2d (D.C. Cir. 1973), which required the AEC to prepare an environmental impact statement for its fast breeder reactor development program. He is a former Rhodes Scholar and law clerk to Supreme Court Justice Hugo L. Black and is the author of "The Federal Role in Technology Assessment" in Federal Environmental Law (Environmental Law Institute: 1974).

Thomas B. Cochran is a nuclear physicist on the staff of NRDC. Before joining NRDC, Dr. Cochran was a Senior Research Associate at Resources for the Future. He is the author of The Liquid Metal Fast Breeder Reactor: An Environmental and Economic Critique (1974), which was published by Resources for the Future. He is a member of the Federal Power Commission's Task Force on Energy Conversion Research and Development, part of the National Power Survey. Dr. Cochran holds a Ph.D. degree in physics from Vanderbilt University and is a former AEC Health Physics Fellow.