MILLENNIUM

Journal of International Studies

London School of Economics

Vol. 6 No. 2 Autumn 1977

£1·25

Millennium: Journal of International Studies, Vol. 6, No. 2.

The Myth of the Peaceful Atom

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Although it is only in recent years that the risks of nuclear proliferation have become a source of acute diplomatic tension and uncertainty, international concern over this issue has, in fact, a long history dating back to the period immediately following the Second World War. Demonstration of the enormously destructive power of atomic weapons in 1945 prompted several governments, particularly the United States, to consider means of limiting such destructive potential. Acting on the recommendation of the great powers, the United Nations adopted in January 1946 a resolution establishing the U.N. Atomic Energy Commission to which was entrusted the task of devising controls for the peaceful use of atomic energy, including effective safeguards, by way of inspection and other means, to protect complying states against the hazards of violations and evasions. Five months later the United States presented to the United Nations a comprehensive scheme prepared by the " Acheson-Lilienthal Committee " which had concluded on the basis of its investigations that " the development of atomic energy for peaceful purposes and the development of atomic energy for bombs are in much of their course interchangeable and interdependent."[1]

The U.S. proposal, known as the Baruch Plan, provided for international ownership or control of the " intrinsically dangerous " aspects of the nuclear fuel cycle, from the processing of ore at a uranium mine to its end uses. The plan foundered largely on the inability of the two superpowers to agree on whether the establishment of a control system should follow or precede the abolition of nuclear weapons. The failure to create the proposed international atomic authority made the U.S. Congress all the more determined to preserve the secrets of nuclear technology, at least until satisfactory controls were instituted. The 1946 Atomic Energy Act prohibited U.S. nuclear exports or even exchanges of information until Congress found by joint resolution that " effective and enforceable safeguards against the uses of atomic energy for destructive purposes " were in operation. No such resolution was ever passed.[2]

In spite of this early but clear perception of the dangers implicit in nuclear proliferation, members of the energy bureaucracy and scientific community continued to nurture the hope that the civilian and military facets of nuclear power could somehow be disentangled.[3] At first, extravagant claims were made suggesting that plutonium-239, the basic

substance for the manufacture of atomic weapons, could be " denatured " by the generation of a large proportion of higher isotopes of plutonium, thereby drastically reducing the probability of producing an effective explosive device. Although these claims were seriously questioned, the natural impulse to put this enormous source of energy to economic advantage encouraged the facile assumption that the civilian potential of nuclear power was a substitute for its military application.

In a dramatic but not altogether unexpected reversal of previously stated policy, President Eisenhower announced in December 1953 in his " Atoms for Peace " address to the U.N. General Assembly that the peaceful use of atomic energy was a start towards diminishing " the potential destructive power of the world's atomic stockpiles." Stocks of nuclear material were to be contributed by the weapon states, together with appropriate technical assistance, to a new International Atomic Energy Agency. The ingenuity of scientists, it was argued, would provide the necessary safeguards " under which such a bank of fissionable material can be made essentially immune from surprise attack." Beginning in 1955 the United States gave expression to this new policy through " Cooperation Agreements " with several countries for the transfer of nuclear materials and technology, on the understanding that these would be used only for peaceful purposes. The United States also reserved the right to verify these uses through periodic inspections arranged on a bilateral basis.[4]

Gradually, with the creation of the International Atomic Energy Agency (IAEA) in 1957 and the mushrooming growth of commercial nuclear power, the United States phased out application of its bilateral safeguards programme. The safeguarding function of the IAEA and other regional organisations, notably EURATOM, encouraged the United States to concentrate more on the promotional function of nuclear transfers than on their control provisions. However, the IAEA itself, by the very terms of its constitution, was intended to: " accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world . . . " [5] Indeed, it can be argued that the initial safety requirements of the IAEA were acceptable to its members only because of its primary role in facilitating wider access to nuclear fuels, equipment and facilities, greater exchange and training of scientific personnel, and much more rapid transfer of scientific and technical information,

Before the Treaty for the Non-Proliferation of Nuclear Weapons (NPT) came into force in March 1970, IAEA safeguards consisted of voluntary agreements by member states based on the guidelines of IAEA document INFCIRC/ 66, and applied mainly to nuclear materials imported from nuclear states for the supply of research facilities and prototype plants. IAEA safeguards were subsequently revised to incorporate additional provisions relating to reprocessing plants and nuclear material in conversion and fuel fabrication plants, but it was not till the adoption of the NPT that the entire civil nuclear power programmes

of all non-nuclear-weapon signatories were placed under IAEA safeguards. The other main innovation of the NPT regime, whose safeguard standards were now set out in IAEA document INFCIRC/ 153, was its requirement that non-nuclear-weapon signatories abstain form manufacturing or otherwise acquiring nuclear weapons or devices, including peaceful nuclear explosives.

Although the only existing barrier to nuclear proliferation, the present NPT safeguards system remains a weak and ultimately self-contradictory instrument of inspection and control. Apart from the fact that it has not received universal adherence, the NPT-IAEA arrangements are still wedded to the notion of the peaceful atom, and are therefore designed to interfere as little as possible with the free flow of nuclear know-how and materials.[6]

Proliferation of Nuclear Technology

Two decades of " atoms for peace " have strengthened the commitment of governments and industry as well as regional and international organisations to the nuclear option and inevitably weakened the effectiveness of existing safeguards, to the point that it is now doubtful whether the NPT system provides anything more than an illusion of security. The Indian nuclear explosion of May 1974 has aptly demonstrated the growing link between nuclear weaponry and the peaceful use of atomic energy. Unlike the established nuclear-weapon countries which developed their civilian nuclear industries directly from their military capability, it would seem that future members of the nuclear club will rely far more than in the past on fissionable material derived from ostensibly peaceful nuclear programmes. In this context, it is worth noting that the nuclear device detonated by India was made with plutonium manufactured in a research reactor provided by Canada and using heavy water supplied by the United States.

The increasing risk of nuclear proliferation stems then directly from the vastly enhanced role envisaged for nuclear technology, particularly the use of nuclear power reactors for the generation of electricity. The Federal Republic of Germany was the first country to embark on a purely civilian nuclear power programme, its first nuclear power reactor going into operation in 1960. By the end of 1975, 19 countries — Argentina, Belgium, Bulgaria, Canada, Czechoslovakia, France, the German Democratic Republic, the Federal Republic of Germany, India, Italy, Japan, the Netherlands, Pakistan, Spain, Sweden, Switzerland, the United Kingdom, the United States and the U.S.S.R. — had installed 157 reactors, each of output greater than 30 million watts of electricity (MWe), producing a total output of 71,900 MWe.[7] China had one or two nuclear power reactors feeding its uranium enrichment plant, as part of its military programme. Another 13 countries—Australia, Brazil, Finland; Hungary, Iran, Luxembourg, Mexico, the Philippines, Poland, Romania, South Korea, Taiwan and Yugoslavia—had nuclear power

reactors under construction or on order. Several other countries, including Egypt, Indonesia, Israel, South Africa, Thailand and Turkey, had also announced their intention to harness nuclear power. According to some current projections, by 1985 total nuclear generating capacity in the world will have risen to more than 400,000 MWe, approximately six times that of 1975, and by the year 2000 it will have increased another fivefold.[8]

The military potential of this vast nuclear energy programme derives from the large amounts of plutonium produced by nuclear power reactors. A typical power reactor of about 500 MWe produces about 120 kg of plutonium annually, which would in theory be sufficient to produce 12 nuclear devices with yields similar to the bomb dropped on Nagasaki, which had an explosive power of 20,000 tons of TNT. Admittedly nuclear reactors geared to the generation of cheap electricity do not produce the type of plutonium that is ideally suited to the construction of the most efficient nuclear weapons. Nevertheless the plutonium obtained from these reactors could still be used to manufacture effective nuclear devices. Even if the device is detonated prematurely—before the fissile material has reached the desired degree of supercriticality—because of the presence of a higher fraction of plutonium-240, the yield for 10 kg of plutonium is likely to be the equivalent of several thousand tons of TNT. Even if its efficiency was as low as 0·1 per cent., it is estimated that a device using 12 kg of plutonium would produce an explosion equivalent to 200 tons of chemical explosive, sufficient to shatter the centre of a city.[9] According to one estimate, by 1980, the world's nuclear reactors will be capable of producing about 45,000 kg of plutonium annually, 40 per cent. of which is likely to be located in the non-nuclear-weapon states, sufficient for them to develop some 2,000 nuclear weapons.[10]

It is not difficult to understand, then, the widespread anxiety which has recently emerged as a result of the projected expansion of the nuclear industry in the Third World. A market survey prepared by the IAEA in 1973-74 purported to demonstrate that a substantial market existed in underdeveloped countries for small and medium-sized reactors in the 150-400 MWe range, It was estimated that some 140 such units would be required for the period 1981-89, representing a total installed capacity of 38,000 MWe or 18 per cent. of the anticipated world market.[11] These inflated calculations could not of course withstand careful scrutiny since, as is generally recognised, nuclear power has an extremely limited contribution to make to the energy needs of the Third World. Even a relatively rapid increase in the demand for electricity would not neces-sarily imply extensive grid systems capable of supporting large power generating units. Moreover, where nuclear electricity grids exist, they are more likely to supply the needs for the already a anent urban minority rather than the deprived rural masses. Although subsequent IAEA projections of nuclear capacity in underdeveloped countries were revised down-wards, a noticeable upswell of international concern had taken place

with respect to the environmental impact of Third World nuclear power programmes.

The international proliferation of nuclear technology and the resulting international *traffic* in plutonium and enriched uranium could prove especially destabilising in view of the intense rivalries that exist among many of the small countries aspiring to nuclear status. Acquisition of a nuclear weapons capability by one or more of these states would almost certainly increase the likelihood of nuclear threats and might even lead to a direct nuclear exchange. The violent upheavals—coups, revolutions or civil wars—which have characterised the recent history of much of the Third World could suddenly take on international significance if nuclear weapons were involved. Given much less sophisticated systems of technical control than those likely to operate in advanced industrial societies, such weapons *could* even pass out of government control, ending perhaps in the hands of criminal groups which could ultimately threaten distant nations. Moreover, the nuclear arsenals of small countries would tend to be highly vulnerable to surprise attack and might there-fore invite a pre-emptive strike, thereby threatening to turn almost every local or regional crisis into an international conflict. In such circumstances, the great powers could find themselves entangled on opposite sides of the dispute, with unforeseeable consequences for the already precarious balance of terror.[12]

For a long time assessment of the potential of Nth-nuclear countries tended to concentrate on their stage of economic development, on the assumption that a reasonably high degree of industrialisation and technical sophistication was a prerequisite for the development of a nuclear-weapons capability. It is now increasingly recognised that political will may be a more decisive factor than technological competence in deter-mining a government's nuclear policy.[13] Moreover, economic considerations are unlikely to pose a serious obstacle to nuclear aspirations, so long as the objective is the acquisition of a few fission bombs rather than elaborate delivery systems designed to provide a first strike capability. The nuclear device which India exploded in May 1974 was entirely a by-product of India's "peaceful" nuclear programme and is estimated to have cost no more than $400,000 including the cost of the plutonium and the preparation of the test site.[14]

Even the most cursory analysis of the prospects of nuclear proliferation tends to show that the countries most likely to join the nuclear club are not the advanced industrial nations of Europe, Canada or Australia, but those Third World countries whose internal and/or external situation is characterised by conflict and instability. It is not without significance that apart from the two nuclear-weapon powers, France and China, other countries that have so far refused to ratify the NPT include Argentina, Brazil, India, Indonesia, Israel, Pakistan and South Africa.[15] India, by virtue of its nuclear explosion, is already classified by some as a member of the nuclear club. India's first reprocessing facility cost some $7·5 million and its second and much larger one is estimated at

$20 million. The Indian government claims that its capacity to reprocess spent fuel is based on general chemical and machining skills and "published technical literature," which Indian scientists and engineers have utilised without any foreign collaboration.[16]

Of the other countries not party to the NPT, Israel, Pakistan, and South Africa are the most obvious candidates to join the second rank of nuclear powers. Most experts believe that Israel has already manufactured or is on the point of manufacturing an atomic bomb. The French-supplied reactor at Dimona, which is not subject to IAEA safeguards, has since 1964 had the capacity to produce enough plutonium to build one bomb a year. Israel probably has several untested nuclear weapons which it might use or threaten to use in certain extreme situations in which it considered its survival to be at risk. Pakistan, for its part, has not signed either the 1963 Partial Test-Ban Treaty or the NPT and therefore need have no legal inhibitions about testing in the atmosphere. Although it has only one small nuclear power station, Pakistan has contracted to purchase a reprocessing plant from France for the recovery of plutonium. South Africa has several nuclear research reactors, large uranium reserves, has ordered two nuclear power stations from France, and claims to have developed a new secret process for enriching uranium. South Africa undoubtedly has the ability to make a bomb and is possibly more advanced in nuclear technology than India. Of perhaps even greater concern, in the light of regional tensions, is Brazil's decision to obtain from West Germany a complete atom-fuel cycle, involving eight reactors, an enrichment plant and a reprocessing plant. Although Japan, South Korea and Taiwan have all ratified the NPT, their access to all kinds of nuclear equipment could, at the appropriate moment, be converted to a nuclear capability, with obvious but far-reaching implications for the delicate strategic and diplomatic equilibrium which currently prevails in the Far East.[17]

Over the next few years one or more of the governments of these near-nuclear countries may be tempted to divert nuclear materials or facilities from civilian to military purposes. In the first place, such diversion may help to reduce the time lag between the initial decision to acquire a nuclear capability and the actual deployment of nuclear weapons. A secondary but nonetheless important consideration may be the need to conserve resources by avoiding duplication of facilities. If the government in question embarks on a large military programme, it will eventually have to construct military production facilities, but may still prefer for political and other reasons to depend in the early stages of its nuclear development on the shield provided by the civilian pro-gramme. The various phases associated with the acquisition of nuclear armaments prior to actual manufacture—initial planning, warhead design, and non-nuclear testing — are comparatively easy to conceal in the absence of military reactors or special enrichment plants. If the initial requirements of weapons-grade nuclear materials can be obtained from civilian installations, then it is no longer necessary to

start early on the construction of highly visible military facilities which the government may regard as inexpedient because of domestic political opposition or adverse international reaction.

But quite apart from these political incentives, the proliferation of nuclear technology in the Third World has been greatly assisted by the export policies of the major nuclear powers. Because of several economic, political and technical difficulties encountered by the nuclear industry in the last few years, notably environmental opposition, scarcity of capital and reduced energy demand, governments and electricity utilities in the United States, Japan and Western Europe have had to lower their projected commitment to nuclear power. Faced with the real danger of economic collapse, the nuclear industry in these countries has sought to complement its dwindling domestic market with a vigorous export policy, supported by a variety of financial enticements, including loan guarantees, low interest loans and deferred payments.[18] The fact that many of the recipient countries (e.g. India, Pakistan, Israel, Brazil, Argentina) are not party to the NPT has inevitably heightened concern about the possible misuse of civilian nuclear technology.

United States Policy

Given that the United States has roughly half the world's nuclear business and that it enjoys a near monopoly on the supply of enriched uranium in the Western world—not to mention the preponderant role of two American multinational enterprises, Westinghouse Electric Corporation and General Electric Corporation, in the worldwide supply of nuclear equipment—it is hardly surprising that the policies of the United States should be regarded as critical to the future of the nuclear industry. As already indicated, commercial incentives and mistaken assumptions about the risks of proliferation combined after the mid-1950s to produce a gradual loosening of controls over dangerous materials exported by the United States. Dr. Victor Gilinsky of the U.S. Nuclear Regulatory Commission has clearly described the consequences of this policy:

> Plutonium controls . . . went from a completely unambiguous veto over reprocessing in our earliest arrangements, to a second stage in which the U.S. retained discretion over reprocessing based on the acceptability of facilities in which it was to be carried out, to the present situation in which permission to reprocess U.S. fuel is conditioned in some cases on the "safeguardability" of the separation facilities. . . In following this course we have finally arrived at a situation in which a country can come arbitrarily close to going nuclear with our materials without violating any agreements.[19]

The Indian nuclear explosion in 1974, the failure of the NPT Review Conference in May 1975 to launch a more effective safeguards system,[20] and the mounting dangers associated with the prospective plutonium

economy, all contributed to a profound re-examination of United States policy, even within the inner circles of the nuclear technocracy which had for so Iong dedicated itself to the worldwide expansion of nuclear energy. Undoubtedly the new and most disturbing element in the situation was the possible extraction of weapons-grade plutonium from the blanket elements of the proposed breeder reactor. To the extent that the preferred fuel for future generations of breeders might well be weapons-grade plutonium, the problem already created by thermal reactors would be vastly magnified. The commercial development of the fast breeder coupled with the protracted and inconclusive nature of international certainly ensure that at least a small fraction of the much increased volume of fissionable material in international transit found its way into the hands of persons intent on nuclear theft, sabotage or blackmail.

The possible list of malefactors includes foreign governments and their agents, sub-units of foreign governments acting with or without official approval, individuals or groups engaged in domestic subversive activity, criminals, psycopaths, mercenaries, opportunists and disgruntled employees.[21] Whatever the specific motive for nuclear theft, there can be little doubt of its feasibility. A safeguards report, prepared for the U.S. Atomic Energy Commission (AEC) and submitted to the U.S. Senate in April 1974, acknowledged that the AEC's present system of safe-guarding explosive uranium and plutonium in the nuclear power industry was "entirely inadequate" to meet the threat of theft by terrorist groups.[22] In a separate report submitted to the U.S. Congress Joint Committee on Atomic Energy, details were given of investigations carried out in September–October 1972 into the safeguards relating to large shipments of nuclear material. In each case they were found to be grossly deficient.[23]

The Congress, disturbed by these reports and by the proliferation hazards implicit in the internationalisation of sophisticated nuclear technology,[24] began to take a much closer look at United States policy.[25] In a series of speeches, resolutions, bills and amendments to bills, members of Congress drew attention to the inherent dangers of plutonium stockpiling, to the ambiguities about explosives in nuclear agreements with several countries, and to the deficiencies of existing safeguards. Though the 1976 presidential election and powerful pressures from the pro-nuclear lobby stifled attempts at congressional legislation, there had now emerged in the American political process a much more acute awareness of the international dangers of the nuclear fuel cycle. The Ford administration, for its part, sought to apply pressure on other governments regarding the export of sensitive technologies—especially uranium enrichment, spent fuel reprocessing and heavy water production —both bilaterally and through the Nuclear Suppliers Group brought together at the initiative of the United States.[26] Although successfully opposing French sales of reprocessing plants to South Korea and Taiwan American resistance failed to prevent the French and German agreements with Pakistan and Brazil respectively, which would provide both

countries, neither of which was a signatory to the NPT, with an undeniable nuclear weapons option.

By the time the presidential election campaign got under way, President Ford was readily admitting that the expansion of the nuclear industry threatened to get out of control. Having urged a careful assessment of the alternatives, he took the position that reprocessing should not proceed unless it were shown that the associated risks of proliferation could be effectively overcome. However, neither the Ford policy statement nor legislative activity in Congress, much less the licensing disputes within the Nuclear Regulatory Commission, had yet fully come to terms with the myth of the peaceful atom.

Growing public awareness of the dangers of nuclear proliferation coupled with the protracted and inconclusive nature of international negotiations led the new Carter administration to set in motion a series of unilateral initiatives. In announcing the new U.S. policy on nuclear power, President Carter admitted that " serious consequences " could follow from laxity in the handling of nuclear materials and the spread' of their use by other countries. In an effort to curb the trend towards proliferation he outlined, in April 1977, a seven-point plan :

1. to defer indefinitely the commercial reprocessing and recycling of the plutonium in the U.S. nuclear power programmes;
2. to restructure the U.S. breeder programme to give greater priority to alternative designs of the breeder and to defer the date when breeder reactors would be put into commercial use;
3. To redirect funds for U.S. nuclear research and development programmes to accelerate research into alternative nuclear fuel cycles which do not involve direct access to materials usable in nuclear weapons;
4. to increase U.S. production capacity for enriched uranium to pro-vide adequate and timely supply of nuclear fuel for domestic and foreign needs;
5. to pass the necessary laws permitting guaranteed fuel supplies to foreign countries;
6. to continue to embargo the export of equipment or technology that would permit uranium enrichment and chemical reprocessing;
7. to continue discussions with supplying and recipient countries to try and reconcile energy needs and anti-proliferation measures.[27]

The various aspects of the new policy were presented by the Carter administration as part of an anti-proliferation package intended to prevent the misuse of plutonium by proscribing the recycling of spent nuclear fuel. To try and encourage other nations to follow suit and abandon the commercial introduction of fast breeders, the U.S. President was willing not only to expand U.S. capacity for supplying the world with enriched uranium but to buy back spent nuclear fuel for storage in the United States. Whatever the personal motivation of those directly involved in the decision-making process, one may safely assume that

several economic and political considerations other than the anti-proliferation objective were inextricably intertwined in the formulation of the new policy. In energy matters as in all other sensitive issues, where the stakes are high and political decisions depend on a complex web of interacting and often conflicting pressures, it is reasonable to suppose that the President's inclinations had somehow to be reconciled with the interests and demands of industry, Congress and the bureaucracy.

Significantly, the announcement of the Carter energy programme coincided with the release of several semi-official reports on world energy supplies, all emphasising the end of the era of growth in oil production, and all recommending in varying degrees increasing reliance on nuclear power.[28] President Carter's approach to proliferation should therefore be interpreted against the background of the much publicised " energy gap." The proposed physical restraints, it should be noted, on the international flow of nuclear technology specifically excluded the light water reactor on the grounds that it did not pose any proliferation hazard. Indeed, the White House informed Congress that in order to speed up the licensing process nuclear plants would henceforth be based on a standard design which would no longer require extensive individual licensing.[29] Clearly, the proliferation controls were so designed as not to prejudice the interests of the nuclear industry.

While rejecting " the premature entry into a plutonium economy," the American President went to considerable lengths to show that he was not opposed to the development of nuclear power at home or abroad. The Carter energy policy actually envisaged a substantial increase in U.S. nuclear generating capacity as well as continuing research into alternative breeder programmes. Estimates of the number of reactors required to fill the alleged gap varied from a cautious " minimum of 400 " 1000 MWe reactors ventured by the Atomic Industrial Forum to " about 600 " suggested by Congressman Mike McCormack.[30]

It is arguable that, in shelving some of the more sophisticated but as yet unnecessary and economically unviable nuclear technologies, one of the main objectives of the Carter policy was to achieve favour with the anti-nuclear lobby and thus take the heat off the conventional nuclear programme. The Report of the Workshop on Alternative Energy Strategies identified three states of choice in nuclear energy policy:

stage one—thermal reactor operation involving a single use of the uranium fuel
stage two—reprocessing of spent fuel to extract and recycle uranium and plutonium
stage three—use of fast breeder reactors to make more efficient use of the recycled plutonium and uranium.

Rather than hold up stage one projects because of unresolved problems about the other two stages, the Carter administration decided to consolidate the position of the light water reactor, and leave to a later date the battle for reprocessing and recycling.

The decision to restrict the breeder programme becomes even clearer when it is viewed in the context of the poor performance and enormous capital costs of existing prototypes.[31] It is worth noting here that, in its attempt to close the fuel cycle, the United States had probably fallen behind Western Europe and the Soviet Union, and may therefore have lost some of its earlier enthusiasm for these technologies. There is little doubt that the U.S. nuclear industry would greatly benefit from the continued dependence of other countries on the purchase of American nuclear fuels and technology. It is precisely in order to break from such dependence that Britain, France, Germany and Japan have devoted so many resources to the acquisition of a reprocessing and recycling capability. Moreover, by securing lifelong contracts for the return of nuclear fuel from overseas reactors the United States is likely to acquire at relatively little cost a large stockpile of plutonium which, in the event of future policy changes, could ensure its dominance in the world plutonium economy.

In the light of their vastly different geopolitical situation, it is hardly surprising that Japan and the main Western European countries should have reacted to the Carter nuclear policy with a good measure of scepticism. Apart from the United States, the only major nuclear powers to have found commercially significant sources of uranium are France and the Soviet Union. The fast breeder is therefore regarded by many of these countries as a powerful insurance against rising world uranium prices and against adverse collective action by the main uranium producing nations. Moreover, for such countries as Britain, France and West Germany reprocessing represents a major nuclear export prospect.[32] Given that in many of these countries the future of the nuclear industry has come to depend on a vigorous export policy, it is unlikely that overseas markets will be readily jeopardised for the sake of pleasing the United States.

Admittedly, since it agreed to supply Pakistan with a reprocessing facility, the French government has established a new policy against any other such sales. More recently, a decision was taken to withhold delivery to Pakistan of critical components of the nuclear reprocessing plant.[33] However, it would be premature to interpret these developments as evidence of the success of the Carter policy. So far no major nuclear power other than the United States has agreed to proscribe the reprocessing and recycling of plutonium. The West German and Brazilian governments remain adamant that their agreement providing for the transfer of a complete atom-fuel cycle will go ahead as planned. The announcement by Chancellor Helmut Schmidt's government that it would not permit exportation of nuclear reprocessing technology "for the time being" was made with the proviso that the prohibition would not affect existing contracts and in. the knowledge that no other customer for enrichment or reprocessing was currently available.[34] As for the Japanese government, there was little sign that its determination to begin operation of the Tokai-Mura reprocessing plant, built with French assistance,

would be deflected by American demands for stringent anti-proliferation safeguards.

Britain, for its part, while supporting in general terms President Carter's anti-proliferation objective, was critical of the strategy he had adopted. In a carefully phrased speech, the British Foreign Secretary stressed that a large commercial reprocessing plant was not essential for the construction of an atomic bomb which, it was argued, could be made from highly enriched uranium as easily, if not more easily, than from plutonium.[35] The Carter strategy was also criticised by the Soviet Union, which reprocesses spent nuclear fuel for all the Eastern bloc nations. In the Soviet view, the stocks of fissile materials such as plutonium and highly enriched uranium accumulated at the research centres of non-nuclear-weapon states represent an important proliferation risk which has yet to be considered. Another area of major concern for the Soviet Union is the absence of effective sanctions which can be applied against nations violating existing safeguards.

The sharp differences separating the American approach to proliferation from that of most other governments obviously make universal acceptance of the Carter strategy an unlikely prospect. Both European and Third World delegations at the 1977 IAEA Conference on the Nuclear Fuel Cycle were generally unsympathetic to the American position, which they tended to regard as motivated more by economic self-interest than by concern for proliferation. Nor has criticism of President Carter's programme been confined to foreign governments. Elements of the pro-nuclear lobby in the United States who do not accept the budgetary cuts in the reprocessing and breeder projects are obviously hoping to use all the leverage at their disposal to breathe new life into them. The vote of the House Science and Technology Committee, restoring $150 million to the energy research budget to enable work to continue on the Clinch River breeder project, is a clear indication of the way that the nuclear industry and its political allies intend to exploit to their own advantage the inconsistencies and ambiguities of President Carter's nuclear policy.

Limitations of U.S. Anti-Proliferation Strategy

The most obvious weakness of current official American thinking on proliferation is that it cannot achieve the objective it has set itself. Even if all countries were to abstain from the commercial reprocessing and recycling of plutonium, reactor-grade plutonium could nevertheless be used to make crude but convincing bombs of unpredictable yield but sufficient to wipe out a government or breach the containment of a nuclear facility.[36] On the other hand, nearly pure plutonium-239 can be produced in power reactors without violating any agreements by limiting the burn-up of the uranium fuel, that is, by removing and replacing fuel rods before significant quantities of higher isotopes have built up. Although this technique would increase the cost of electricity from the

reactor, it would greatly improve the plutonium's quality as bomb material, and the latter is likely to be the decisive consideration for any government wishing to produce nuclear weapons.[37]

As it happens, Third World countries like India and Pakistan with small electricity grids and poor maintenance have had to operate their reactors at a much more irregular rate than the theoretical 80 per cent. norm, which even advanced industrial countries have often had difficulty in achieving.[38] Moreover, though the NPT explicitly forbids the manufacture of nuclear weapons, it is possible for a state to come very close to manufacture without actually violating the treaty, and in the process to lay the groundwork for a nuclear weapons programme. Neither the economics of nuclear power nor the legalities of international safe-guards can therefore be said to present a daunting obstacle to any government intent on acquiring a nuclear weapons capability.

The rapid increase in the production and dissemination of reactor-grade plutonium will invariably make the task of inspection and control progressively more difficult. Even in the most strictly supervised plants there is the MUF factor—Material Unaccounted For—of nearly one per cent., which does not necessarily reflect an actual loss of plutonium but a degree of statistical uncertainty as to its exact location. In spite of continuing improvements in accounting procedures, it is estimated that by the year 2000 the world MUF factor may be the equivalent of 5 tons of plutonium annually, enough for 500 or more bombs.[39] These accounting deficiencies, whatever their specific explanation, are a potential cloak for diversion of small amounts of plutonium, which over a period of time could form the basis of a secret nuclear stockpile.

Once a country has a civilian nuclear programme, then a weapons capability can be acquired at little or no additional cost. A suitable small-scale reprocessing plant, not designed to be commercially viable, clean or safe, could be built in a year or two at an estimated cost of between one and three million dollars and at a scale sufficient to yield several bombs per year. Apart from the major nuclear powers, which have built or are contemplating large commercial reprocessing plants, India, Italy, Spain, Yugoslavia, Argentina and Taiwan are operating or building experimental or pilot scale reprocessing plants. Brazil and Pakistan are now also expected to acquire such facilities. Clearly, President Carter's initiatives can do little to deny the reprocessing capability desired by these countries, many of them with obvious nuclear aspirations.

Plutonium, however, is not the only avenue for making bombs. The first enrichment plants were constructed to produce very highly enriched (about 90 per cent.) uranium for bombs, and even today commercial enrichment capacity consists largely of plants originally designed for military purposes. Uranium highly enriched in uranium-235 is currently produced by the gas diffusion process, but the technology, capital costs and energy requirements place it beyond the reach of nearly all potential Nth countries at this time, with the exception of Japan and West

Germany. However, the collective pooling of resources may bring the technology within the reach of many more countries. France, Belgium, Iran, Italy and Spain are collaborating through the EURODIF project in the construction of a gas diffusion plant which is scheduled to come into operation in the late 1970s and is to have an annual capacity of nearly 11,000 tonnes.

Apart from the well-known case of South Africa, which may have developed, partly with the aid of U.S.-supplied nuclear fuel, its own uranium enrichment programme, several other countries are known to be developing new technologies, including lasers and the centrifuge process, in order to reduce the cost and increase the efficiency of enriched uranium. Once the laser design reaches a higher stage of development, it may be possible to separate almost completely the uranium isotypes, thereby offering a short cut to a weapons option. Soon it may also be possible to construct a set of crude centrifuges which does not require unusual skills but which can slowly produce bomb material. Although not efficient or commercially competitive, such a technology may nevertheless enable a clever technician to make a bomb from several tons of natural uranium.

While the present U.S. administration has recognised the military potential of enriched uranium, it has so far offered no solution to its possible misuse. The large amounts of enriched uranium already exported from the United States may have been quantitatively and qualitatively sufficient to give as many as half a dozen non-nuclear-weapon countries a significant weapons capability. Nor has the pattern of supply been significantly altered by President Carter's new policy. A few days prior to the London Economic Summit in May 1977, the U.S. President personally authorised eight shipments of highly enriched uranium, about 1,153 pounds, to West Germany, France, Canada, Japan and other countries, ending a delay that had apparently caused tensions between the United States and several of its customers.[40] A few weeks later it was announced that the United States would resume shipments of enriched uranium to India to fuel the reactor at Tarapur, even though India had already achieved an explosive capability as a result of its underground nuclear blast in May 1974.

The American decision to remain the principal supplier of strategic nuclear fuels has been justified on the grounds that such transfers will be permitted only on the basis of the most stringent safeguards. It is arguable, however, that existing and proposed safegards will not ensure timely detection. Dramatic evidence of the unreliability of bilateral and international controls came recently with the revelation that in November 1968, a ship carrying 200 tons of natural uranium from Belgium to Italy simply disappeared. Several weeks after its disapearance the ship reappeared with a new name, new registry, new captain, and new crew, but no uranium. The 448,000 pounds of uranium have never been located although several intelligence agencies, including the CIA, investigated the disappearance. However, the general consensus among informed

observers is that the uranium found its way to Israel. Then, one of the few nations in the world capable of using natural uranium, Israel was being embargoed by France, its principle supplier of nuclear fuel.[41] A few days after this revelation, the General Accounting Office admitted to the U.S. Congress that commercial nuclear facilities in the United States were not able to account for thousands of pounds of highly enriched uranium and plutonium.[42]

By deferring the reprocessing and recycling of plutonium, yet at the same time giving his blessing to the present generation of thermal reactors, President Carter has refused to take his rejection of the plutonium economy to its logical conclusion. On the other hand, his attempt to justify continued reliance on the light water reactor by refer-ence to optimistic but unsubstantiated estimates of future uranium sup-plies [43] is unlikely to convince those within or outside the United States who have firmly committed themselves to a nuclear future. In this sense, President Carter is only the latest in a long line of American policy-makers, who have understood that the peaceful and military atoms are essentially identical, yet have paradoxically tried to promote the one and ban the other. In the end, even the attempt to outlaw the military atom has suffered from conceptual confusion and political inertia. For there can be no long-term solution to the problem of horizontal proliferation until some progress has been made in curbing the vertical arms race. So long as the serious imbalance in obligations and responsibilities between the nuclear-weapon states and the non-nuclear-weapon states persists, so long as no effective restraints are imposed on the increasing sophistication and destructive potential of existing nuclear forces, no safeguards system is likely to prove feasible, much less universally acceptable.

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