Chapter 7. A history of non-proliferation efforts

I. Early US initiatives

The Baruch–Lilienthal proposal

Among the earliest expressions of concern over the possibility of a future nuclear arms race and a proliferation of nuclear weapons were those of the scientists engaged in the Manhattan atomic bomb project. In the last two war years the eminent Danish physicist Niels Bohr strongly urged negotiations between the United States and the Soviet Union on international control of atomic energy [1]. Also, in 1945, a group of scientists at the University of Chicago Metallurgical Laboratory wrote a report to the US Secretary of War pressing for some form of international control on atomic energy development [2].

Political leaders, in particular Franklin Roosevelt and Winston Churchill, were also aware of the potential significance of atomic energy, not only to the war effort but also to post-war international relations. They understood that the new technology had important implications for both military and industrial development and committed their countries to extensive co-operation in the secret agreements made in 1943 at Quebec. Another part of this agreement was a commitment not to communicate any information to third parties without prior consent. This provision was aimed primarily at preventing as long as possible the acquisition of nuclear 'secrets' by the Soviet Union. After World War II subsequent revelations of spying in the British nuclear programme, and a less co-operative attitude on the part of the Truman Administration and the US Congress, led to severe restrictions on the interchange of scientific and technical information between the two allies. Ultimately, these tensions led to US termination of the atomic co-operation provided for in the Quebec Agreements. However, this did not prevent the USA from later referring to the Agreement when it objected to transfer of nuclear information and possible co-operation between the UK and France on uranium enrichment in the 1950s.

After the actual explosion of two nuclear weapons in Japan at the end of World War II the political leaders of the USA, the UK and Canada explicitly recognized the proliferation risks of an uncontrolled future nuclear development. The source of the troubles, according to their Three-Power Declaration of November 1945, was that "the military exploitation of atomic energy depends, in large part, upon the same methods and processes as would be required for industrial uses" [3a].

In line with these ideas the USA, in 1946, brought to the Atomic Energy Commission of the fledgling United Nations a plan for internationalization of nuclear energy development, the Baruch Plan (see pp. 73–74). However, a crucial provision in the proposal would have allowed the United States to retain its nuclear weapons until full international control of atomic energy had been realized. The implied temporary US monopoly of nuclear weapons was unacceptable to the Soviet Union whose counter-proposal demanded the abolition of all nuclear weapons before establishing international control. This proved unacceptable to the United States.

With the failure of these first attempts at preventing proliferation by internationalization, the USA continued its policy of strict secrecy as prescribed in the Atomic Energy Act of 1946, the so-called McMahon Act. This was a law explicitly designed "to conserve and restrict the use of atomic energy for the national defense, to prohibit its private exploitation, and to preserve the secret and confidential character of information concerning the use and application of atomic energy" [3b].

Accompanying this overt policy of secrecy was a covert attempt by the United States to gain control of all the world's exploitable uranium resources in the belief that this would severely retard other nations' efforts to develop nuclear energy [4]. Although pursued vigorously for several years, this tactic had to be abandoned when it became clear that it was politically unrealistic and that uranium could be found in many more places than were originally known.

A strict secrecy policy

The US secrecy and monopoly policy had no demonstrable effect on the progress of the Soviet nuclear weapons programme. The Soviet Union exploded its first atomic bomb in 1949 using plutonium, and by that time already had an enrichment facility nearing completion. The latter is thought to have started operation sometime around 1950 [5, 6a].

The UK also engaged in both a military and civilian nuclear programme after the war. When the Quebec Agreements were abrogated by the McMahon Act, which excluded the UK along with all other countries from access to restricted information, the British proceeded on their own [6b]. The UK succeeded in constructing and exploding its first atomic bomb in 1952. The fissionable material used was plutonium,

produced in British graphite-moderated reactors, which are fuelled with natural rather than enriched uranium.

British requests for US assistance in constructing an enrichment facility had been denied by the United States and the independent establishment of a domestic gaseous diffusion enrichment plant in the UK made relatively slow progress. The plant for the production of highly enriched uranium at Capenhurst was put into operation between 1954 and 1957. By that time British development of a thermonuclear bomb was already under way. For lack of highly enriched uranium, which at that time was the preferred material for use in the trigger of a thermonuclear bomb, the British attempted to develop an H-bomb with a pure plutonium-based trigger. They succeeded in manufacturing such an H-bomb, and tested it successfully in 1957 [6c].

'Atoms for Peace' selective secrecy

The US policy of strict secrecy not only failed to prevent the Soviet Union and the United Kingdom from developing their own atomic bombs, but it also did not prevent other countries, notably in Europe, from developing indigenous nuclear programmes. In contrast to the British programme, which was until the mid-1950s almost completely military, most of the other programmes were aimed exclusively at civilian applications of nuclear energy. However, given the close connection between the technological bases of civilian and military use of nuclear energy, such nuclear activities would inevitably provide more countries with the technical capabilities and materials for manufacturing nuclear weapons.

This 'anarchistic' development and the desire to score a political gain over the USSR caused the USA to change its non-proliferation policy from one of total secrecy and denial to selective secrecy and control by co-operation. In his famous 'Atoms for Peace' speech of 1953, President Eisenhower offered US co-operation to all countries that were or wanted to be engaged in the development of nuclear energy for peaceful purposes. To this end the Atomic Energy Act of 1946 was replaced by the Atomic Energy Act of 1954, allowing the controlled transfer of nuclear equipment, materials, and scientific and technical know-how. The new policy implicitly recognized that possible acquisition of information by the USSR was no longer a problem, since the Soviets had already demonstrated their capability to develop all aspects of nuclear technology, in particular the manufacture of both fission and thermonuclear weapons [7]. Nevertheless, the changes in US policy did not come without a bitter battle within the United States over the need for continued secrecy.

The resulting agreements for co-operation on atomic energy between the USA and other countries contained provisions that the US supplies were to be used only for peaceful purposes. This was to be ensured by means of a US inspection system ('safeguarding').

However, US policy regarding the release of nuclear information and equipment remained restrictive. Sensitive processes, in particular enrichment technology, were considered to be restricted information and kept secret by the United States and not shared with other countries. This policy was motivated both by the fear that a national enrichment plant could provide a country with direct access to weapon-grade uranium, and by the realization that an indigenous enrichment capability would also make the country independent of the United States in satisfying its needs for enriched uranium. The dependence on the USA for enrichment services, as implied by the agreements of co-operation, was supposed to play a central part in implementing the US safeguarding and control of atomic developments in other countries.

Soviet policy towards the Socialist countries resembled US policy in providing these countries with research reactors, nuclear materials and equipment and technical assistance. The Soviet Union also refrained from providing other countries with sensitive technology, such as uranium enrichment, except for the case of the People's Republic of China, which it assisted in building a gaseous diffusion plant. After the termination of Soviet nuclear assistance in 1959 China succeeded in completing the enrichment plant, and in 1964 it became the first nuclear weapon state since the United States to use highly enriched uranium as the fissionable material for its first atomic bombs.

After this traumatic experience, Soviet non-proliferation policy became much stricter. There have been no further exports of enrichment technology by the Soviet Union.

The US policy of combining co-operation and selective secrecy under Atoms for Peace was not completely effective either. France refused to be manoeuvred into a position of dependence on the United States. In particular, it had its own nuclear programme, which at first had mainly civilian objectives but after 1952 became more militarily oriented, notably towards the production of plutonium [8a]. In November 1956, an explicitly military programme was established, including a new protocol for the French Atomic Energy Commission (CEA), charging it with preparing preliminary studies for a nuclear explosion. The CEA was at the same time charged with the responsibility of preparing studies for the creation of an isotope separation plant [6d, 8b]. The production of highly enriched uranium was considered to be of special importance for manufacturing a thermonuclear explosive [6e].

Because of its lack of technical know-how and the very high development and construction costs of an enrichment facility, France had previously asked for British co-operation. At the end of 1954, negotiations had started between France and the UK on the construction of a gaseous diffusion plant, similar to the one in Capenhurst, the first stages of which had just been put into operation. These negotiations were aborted in the beginning of 1955 because of formal objections by the United States based on the Quebec Agreements (see above) [6f, 8c].

After the British refusal of assistance, France, in its desire for an enriched uranium supply independent of the United States, looked for other possible partners. In the negotiations among the six countries of the European Economic Community on the creation of Euratom, starting in 1955, France pressed for consideration of the establishment of a joint European enrichment plant as a major task of Euratom [6f]. This costly undertaking was discouraged by a US offer of cheap and ample enriched uranium supplies to West European countries, an offer made possible by the overcapacity of the large US gaseous diffusion plants, considerably in excess of US military needs.

With no prospect of a joint Euratom enrichment facility, France continued negotiations in 1957 on a trilateral basis with FR Germany and Italy, resulting in an arrangement for co-operation negotiated by the defence ministers of these countries. According to this agreement the FRG and Italy would provide France with financial and technical support for a joint enrichment plant. However, this agreement was rejected in 1958 when General de Gaulle came into power. He did not want to bring FR Germany closer to nuclear armament [6g, 9a].

Finally, in the absence of any support from European partners in establishing a French or joint European enrichment plant, France decided in 1960 to start the construction of a national enrichment facility. This project was strongly opposed by the United States, which had several times since 1958 hinted at the eventual possibility of France obtaining ^{235}U from the USA for French armaments [6h]. Nevertheless, the French gaseous diffusion plant was built at Pierrelatte and put into operation between 1964 and 1967. It produced the highly enriched uranium that was used in the fission trigger of the first French H-bomb, exploded in 1968. The following French thermonuclear test explosion used only plutonium in the fission trigger [6i].

Also during the second half of the 1950s, research on gas centrifuge technology was going on in the United States, the United Kingdom, FR Germany and the Netherlands. In 1960 the US Atomic Energy Commission (AEC) classified this research because of its proliferation-prone character and asked the other countries to act likewise [10a]. Research and development on the centrifuge eventually resulted in the early 1970s in the first enrichment plants outside the present nuclear weapon states, notably in the Netherlands.

In retrospect it is fair to conclude that the selective secrecy of the Atoms for Peace programme did indeed temporarily delay the spread of uranium enrichment facilities to other countries. However, it did not succeed in stopping this process, nor could it prevent France and China from developing their fission and thermonuclear bombs. Two major objectives of the Atoms for Peace programme were to prevent the proliferation of nuclear weapons while at the same time stimulating the application of nuclear energy for peaceful purposes. It has, however, been argued that a fundamental tension exists between these objectives, and that the increased dissemination of nuclear technology and the spread of

nuclear reactors greatly enhance the danger of the spread of nuclear weapons [3c].

II. The end of monopoly

Early multinational efforts

The above-mentioned attempts by France to form multinational enrichment consortia were symptomatic of a growing realization by a number of countries that the enormous expense and effort required to develop and construct enrichment facilities were too great for most countries to handle on their own. This realization led to a number of other attempts to encourage co-operation among nations, some of which have been successful.

The motivations for earlier multinational efforts had little to do with non-proliferation objectives. They had much more to do with seeking independence of fuel supply and/or economic advantage. Thus in 1956, after the United Kingdom's refusal to assist France in building a gaseous diffusion plant, six West European countries adopted the establishment of a common isotope separation plant as a major task [11a]. A working group was set up for the purpose of deciding on an enrichment process. This group was later transformed into the Research Association for the Construction of a European Plant and extended to include Denmark, Sweden and Switzerland. At the end of 1957 France took the lead in campaigning for the immediate construction of a gaseous diffusion enrichment plant [8d, 11a], but progress in the joint enterprise was discouraged, mainly as a result of the US offer of low-priced enriched uranium to West European countries [8e]. The secret agreement in 1957 between the Ministers of Defence of France, FR Germany and Italy for a joint effort, including the production of parts of nuclear weapons [9b, 12] (FR Germany and Italy would contribute scientific and financial support for nuclear projects on French territory [9c]), also failed to result in co-operation in an enrichment project. After these failures France decided on the independent construction of the separation plant at Pierrelatte.

Although little progress was made in the 1950s towards multinational collaboration on enrichment, the principle of European multinational co-operation on nuclear matters was institutionalized in the formation of Euratom in 1957. This organization was established by the six West European countries that constituted the European Economic Community (EEC) at the time (Belgium, France, FR Germany, Italy, Luxembourg, and the Netherlands).

Euratom was supposed to co-ordinate, promote and control the

development and use of nuclear power in Western Europe and to constitute a framework for obtaining technological support from the United States. The USA supported Euratom as an aspect of its larger interest in European integration and as a potential instrument for implementing US non-proliferation objectives [13a].

On the intergovernmental level the Euratom Treaty of 1957 defines an institutional framework for nuclear developments in the member states. However, it does not prohibit any national activities in the nuclear field. Before the Euratom Treaty was agreed upon much discussion was devoted to the question of whether the Treaty should prohibit the use of nuclear energy in member states for military purposes. At that time France was already engaged in a nuclear programme which would in a few years provide it with a nuclear weapon capability [8f]. Whereas in February 1956 French Premier Mollet stated "We will ask that the member states of Euratom take a solemn engagement to renounce the use of the atom for military purposes" [8g], this position underwent substantial change in the next half year. Under internal pressure from the military and the CEA, among others, Mollet shifted to the position that France's juridical and material capacity to manufacture atomic weapons, if it chose to do so, should not in any way be hindered by French membership in the Euratom community. As a consequence the resulting Euratom Treaty does not forbid member states the use of nuclear energy for military purposes [8h]. The Euratom Treaty does prohibit the diversion of civilian nuclear material for military use, and to this end the Treaty contains provisions for safeguarding nuclear materials and installations used for civil purposes in the member states [14]. Euratom's non-nuclear weapon states are fulfilling their NPT responsibilities by an agreement between Euratom and the IAEA [15]. This agreement was signed in 1973 and entered into force in 1977 after ratification by the member states. It incorporated the essentials of the IAEA's safeguarding provisions of INFCIRC/153 (see chapter 3). Actually, under the agreement Euratom will continue its own inspections, which will be verified by the IAEA [16, 17]. One problem created by this special arrangement is the perception by other nations that it represents what amounts to a self-inspection operation [10b].

The early failures in establishing multinational enrichment facilities did not discourage further attempts in this direction. At the end of 1966 FR Germany and Italy once again brought up the idea of a common European enrichment plant, but neither the UK nor France wanted to allow FR Germany access to their gaseous diffusion techniques. The UK did offer FR Germany a purely commercial share in an eventual enlargement of the Capenhurst plant, but FR Germany was not interested [6j, 11a]. Then, at the end of 1968 the West German, British and Dutch governments announced their decision to co-operate in developing gas centrifuge technology, leading to the first successful multinational enrichment arrangement, Urenco/Centec. This was followed in 1973 by the creation of the second multinational enrichment enterprise, Eurodif.

Urenco/Centec came into being as an *ad hoc* combination of government agencies and public or private industrial firms of the United Kingdom, the Netherlands and FR Germany. It brought together the gas centrifuge isotope separation techniques developed independently in the three countries in an effort to establish a joint enrichment service, independent of the United States. The economic prospects for such an enterprise looked quite favourable in the early 1970s.

Urenco/Centec was established in 1970 under the Treaty of Almelo, a trilateral agreement on the joint development and exploitation of the gas centrifuge process. The corporate structure of the undertaking is rather complex. Centec GmbH is the trilateral society for centrifuge technology, located in FR Germany and established under West German law [18a]. Urenco is the trilateral corporation for management of the enrichment services. A Joint Committee made up of representatives of the three governments deals with 'sensitive political issues', such as safeguards, co-operation with and technology transfer to other countries, location of enrichment plants, and with far-reaching decisions on technological and economic questions. Each of the partners in the Joint Committee has the right of veto [19].

Eurodif was first established by the CEA as a multinational study group to assess the economics of a full-scale gaseous diffusion plant in Europe. The apparent aim was to create an enrichment capacity under French control, primarily to provide the means to satisfy independently its civilian demand for enriched uranium. To sustain this financially risky enterprise, France needed partners both as capital contributors and as assured customers. The economies of scale require commercial gaseous diffusion plants to have large capacities, so both investment and sales must be large to assure profitability.

The original members of the Eurodif study group included private and governmental organizations from Belgium, Italy, Spain, Sweden, FR Germany, the Netherlands and the UK. The latter three countries, after they formed Urenco, withdrew from Eurodif in May 1973 [13b]. In the same year the remaining countries transformed the study group into a private enrichment company, which in 1974 decided to build a large gaseous diffusion plant in France at Tricastin. Sweden subsequently withdrew from the project in 1974 [18b], probably because of the uncertain prospects for future expansion of its nuclear power plant capacity. Sweden's existing enrichment needs were already satisfied by supply contracts with the USA and the USSR. Their 10 per cent share in Eurodif went to Iran in 1975, when the Iranian Atomic Energy Commission and the French company Cogema (a wholly owned subsidiary of the CEA) established the enterprise Sofidif (60 per cent Cogema, 40 per cent Iranian AEO), which acquired a 25 per cent share in Eurodif. Present ownership of Eurodif is divided as follows: France, 50.3 per cent; Italy, 17.5 per cent; Belgium 11.1 per cent; Spain 11.1 per cent; and Iran, 10 per cent (see also p. 215).

Urenco and Eurodif have had mixed success as anti-proliferation measures, but their record has been impressive enough to convince many people of the value of multinational collaborations in the nuclear fuel cycle. Once it was clear that substantial progress was being made in Europe towards independent commercial enrichment enterprises, and once the US monopoly on the supply of enrichment services was broken by a contract for supply of such services by the USSR to France, the USA offered its co-operation in establishing a West European enrichment facility on a multinational base, using US gaseous diffusion techniques. This offer was received with much scepticism in Europe and finally abandoned by the USA as a result of policy conflicts within the US government [11b, 13c, 18a, 20a].

In 1974 the perceived threat of a continuing spread of sensitive techniques to many countries caused the US government (notably Secretary of State Kissinger) to advocate the establishment of multinational or regional fuel centres. The possible transfer of US diffusion and centrifuge techniques was even held out as an incentive [18c, 20b, 21]. The idea of establishing multinational instead of national facilities for sensitive techniques was also endorsed by the London Nuclear Suppliers Club (see below) [22]. However, US enthusiasm cooled as some officials argued that multinational organizations could themselves become vehicles for the further spread of sensitive techniques.

Another endorsement of the multinational concept came in the Final Declaration of the 1975 NPT Review Conference, which took note of the possibility that regional or multinational fuel centres might contribute to non-proliferation goals [23]. The Declaration supported the Regional Nuclear Fuel Cycle Centers Study Project initiated by the International Atomic Energy Agency in 1975 "to determine if multinational fuel cycle centers would have significant advantages for the activities related to the back-end of the nuclear fuel-cycle, in addition to making substantial contributions towards goals of non-proliferation" [24a].[1] The Project report, published in 1977, concluded that implementation of the regional fuel cycle centres was indeed potentially advantageous to serving non-proliferation goals [24b]. Even though this study focused on the back-end of the nuclear fuel cycle, a number of its conclusions are also valid for multinational enrichment arrangements.

Finally, both the US Nuclear Non-Proliferation Act of 1978 [25a] and the International Nuclear Fuel Cycle Evaluation (INFCE) conference (see below) recommended multinational arrangements as important institutional measures for minimizing the proliferation risks of sensitive nuclear techniques. Given this widespread advocacy for multinational fuel cycle collaborations it is important that the existing models (Urenco,

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[1] The 'back-end' refers to those parts of the fuel cycle such as reprocessing, plutonium storage and radioactive waste disposal which follow the irradiation of nuclear fuel in reactors to produce electricity.

Eurodif and Euratom) be examined carefully to determine how well they carry out their non-proliferation function. This analysis is done in chapter 3.

Commercialization and conflict

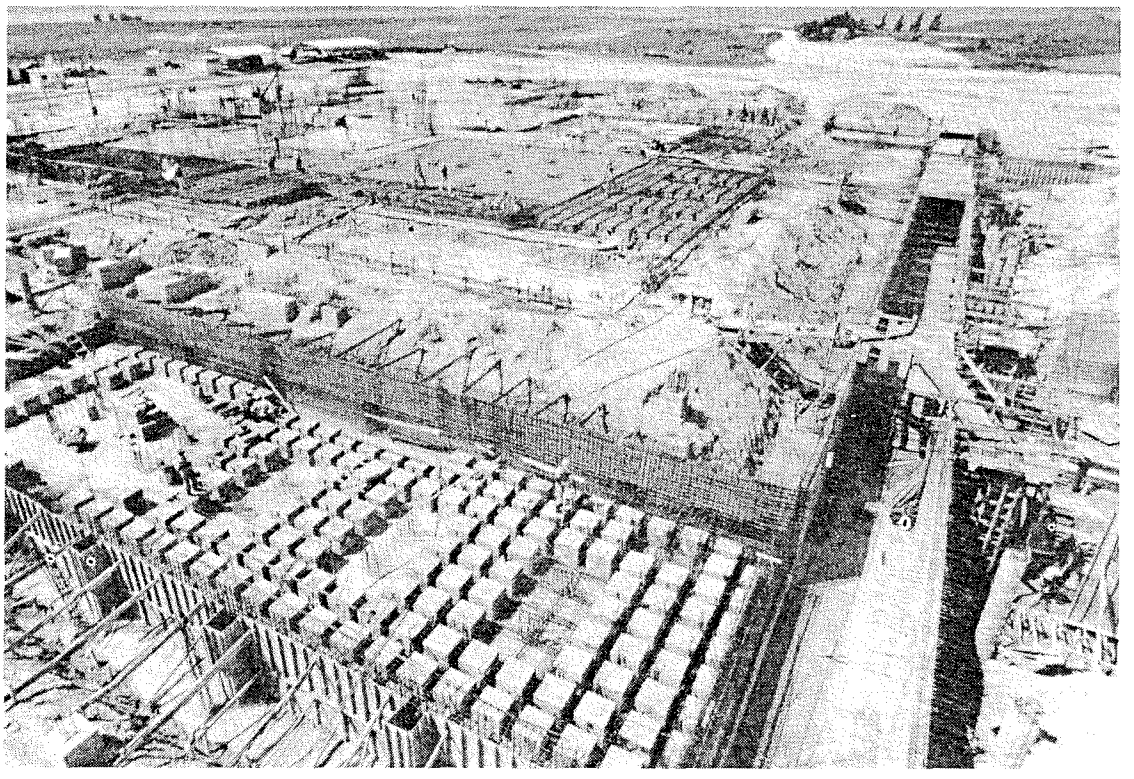
By 1970, when the Non-Proliferation Treaty (NPT) took effect, concern about proliferation had decreased considerably, and much more attention was being paid to the apparently great commercial opportunities presented by the expected growth of the nuclear electric power industry. This was certainly the case for uranium enrichment, where, for example, political pressure in the USA increased for turning enrichment activities over to private industry. While advantageous for industry, this step would have had the effect of diminishing the role of enrichment services in US non-proliferation policy. Despite this the US AEC established two programmes to encourage the private sector to develop the capability to build enrichment facilities [26] and started negotiations with interested companies to this end. However, for two important reasons the objective was never realized. First, private industry lost interest in the financially risky enrichment undertaking because of slow-downs in nuclear energy growth; and second, renewed attention around 1975 to the special role of sensitive technology in nuclear proliferation caused the US government to have second thoughts about the benefits and risks of a private enrichment industry [27a]. The Indian nuclear explosion of 1974 played an important part in this reassessment.

Commercial interest in enrichment also grew rapidly in Western Europe in the early 1970s, as shown by the rapid growth of Urenco and Eurodif. Not only did a competitive market in enrichment services, involving several independent enrichment enterprises, arise, but also the transfer of sensitive techniques (notably reprocessing and enrichment methods) began to be included in nuclear package deals between West European countries (in particular, France and FR Germany) and other countries. In addition, these deals were made not only with countries party to the NPT, but also with non-NPT countries. A nuclear package deal in 1975 between FR Germany and Brazil comprised a nearly complete nuclear fuel cycle, including eight nuclear reactors, a fuel fabrication plant and both an enrichment and a reprocessing plant. France contracted to build a reprocessing plant in South Korea (1975) and in Pakistan (1976) [28], and Taiwan also acquired an option to obtain such a facility from France [29a]. This burgeoning trade in sensitive technology, together with the Indian nuclear explosion in 1974, in which material diverted from an unsafeguarded reactor was used to make the explosive, created deep concern, especially in the USA, with regard to the possible consequences about the proliferation problem. It was clear that these sensitive techniques would open the door to direct access to weapon-usable

materials. The lead time for manufacturing a nuclear bomb by a country possessing modern enrichment or reprocessing capabilities would in general be very short, once a political decision to obtain a bomb had been taken.

In 1975 these developments resulted in further changes in the US position on several proliferation issues. In particular, the safeguarding of sensitive facilities was no longer considered to be a sufficient barrier against diversion of weapon-usable material and a possible spread of nuclear weapons. According to US reasoning, it followed that the spread of sensitive facilities and technology themselves should be limited. Consequently, the USA put pressure on France and FR Germany not to transfer the above-mentioned enrichment and reprocessing facilities. When it encountered strong resistance in the supplier countries, the USA also put pressure on the receiving countries. As a result South Korea and Taiwan, both heavily dependent on the United States for their national security, cancelled their contracts, but Pakistan and Brazil resisted US pressure. A few years later, in 1978, France suggested to Pakistan a modified reprocessing facility in which plutonium and uranium are extracted together from spent fuel. However, Pakistan showed no interest and finally the French assistance in construction stopped. West German deliveries to Brazil have been retarded by the slow-down in the Brazilian nuclear programme, but construction of the first demonstration enrichment cascade is under way (see figure 7.1).

Figure 7.1. The Brazilian enrichment facility at Resende



Source: E.W. Becker, P. Nogueira Batista and H. Völker, *Nuclear Technology*, Vol. 52, 1981, p. 114.

These developments clearly demonstrated the differences in non-proliferation policy between the USA and a number of West European countries. A situation had arisen in which sensitive technology contracts, the scope of safeguards, and other non-proliferation conditions had become part of the competition for nuclear export contracts. This situation, together with the failure to reach agreement with each of the competitors separately, caused the Nixon Administration to invite a number of supplier countries for talks on these matters. The first closed meetings of this group took place in London in 1975. In the beginning seven countries participated (Canada, France, FR Germany, Japan, the UK, the USA and the USSR), but in 1976 this number was enlarged to 15 and included Belgium, Czechoslovakia, German DR, Italy, the Netherlands, Poland, Sweden and Switzerland.

The London Club meetings were an attempt to arrive at stricter and more uniformly applied non-proliferation conditions on nuclear exports by the various supplier countries. They focused on the special proliferation problems created by the spread of sensitive facilities and technology, implicitly recognizing the insufficiency of the NPT regime for these matters. Apparently the United States and the Soviet Union again recognized a common interest in creating a stricter non-proliferation regime. Neither the United States nor the Soviet Union (since its 'enrichment experience' with China) has transferred any sensitive facilities or technology to other countries. In 1976 US President Gerald Ford announced that the United States would continue its refusal to export reprocessing and enrichment facilities and their technology. The battle lines at the London meetings were drawn between the USA and the USSR on one side, and France, FR Germany and Japan on the other. The United States tried once more within the framework of the London Club to get France and FR Germany to cancel the above-mentioned contracts involving the transfer of sensitive equipment and technology, but the effort was again unsuccessful. The only positive result of this effort was that France in 1976 joined the US embargo on export of reprocessing facilities, but only for future sales [29b]. FR Germany followed in 1977, also exempting its export contract with Brazil. In the meantime the US Congress had passed the International Security Assistance Act, directing the Administration to cut off military and economic aid to countries supplying or receiving reprocessing and enrichment plants and technology [25b, 29c].

In 1976 the London Club agreed on a number of nuclear export guidelines which were made public in 1978 [29d, 30a, 31]. These constituted a voluntary 'gentlemen's agreement' and did not amount to a treaty. The special position of sensitive facilities and technology in the proliferation problem is made clear in these guidelines, the relevant parts of which are summarized and analysed in chapter 3.

III. Recent US initiatives

The anti-plutonium decision (1977)

Although it is not directly related to uranium enrichment, the 1977 decision by the Carter Administration to ban all commercial fuel reprocessing serves as an interesting example of an effort to deliberately avoid a potentially useful process just because of the proliferation dangers associated with it. Its implications are worth examining, because suggestions for similar policies have been made with regard to enrichment technology [32].

In 1977 President Carter followed a recommendation in the Ford-MITRE Report which stated that the USA should defer "indefinitely the commercial reprocessing and recycling of the plutonium produced in U.S. nuclear power programs" [27b]. The Carter Administration decided to restructure its breeder programme "to give greater priority to alternative designs of the breeder other than plutonium and to defer the date when breeder reactors would be put into commercial use", asking other countries to join this policy [33].

The Carter anti-plutonium policy met with strong resistance from other countries, notably from France, FR Germany, Japan and the UK, all of whose nuclear policies were strongly oriented towards the future commercial use of plutonium. The USA was accused of trying to keep a dominant position in the nuclear field, because it was precisely in the breeder programme that the United States was lagging behind the West European countries. It was also alleged that because of its large uranium resources, the USA could tolerate the 'luxury' of a nuclear fuel cycle which did not use plutonium. It was argued that this situation did not hold for other countries. Nevertheless, a few years later FR Germany abandoned its plans for building a large reprocessing plant at Gorleben, officially for internal political reasons, such as resistance from citizen movements. However, there were also strong indications that both the USA and the USSR had urged FR Germany to refrain from building the plant.

France and the UK have continued commercial reprocessing and are even expanding these activities. The USSR is also continuing its breeder programme, probably viewing the spread of reprocessing facilities to be a problem caused by the nuclear export policies of Western countries, something which should not have any repercussions on the Soviet breeder programme. The Soviet Union has not exported reprocessing facilities and requires the spent fuel produced in Socialist countries from Soviet-supplied uranium to be returned to the USSR for reprocessing. However, this requirement is not imposed on West European states who buy Soviet enrichment services.

The Carter Administration's decision to abandon commercial reprocessing in order to avoid the circulation of large amounts of separated

plutonium also had a direct impact on its enrichment policy. The anti-plutonium decision included plans to increase the US capacity to produce nuclear fuels, "enriched uranium in particular, to provide adequate and timely supplies of nuclear fuels to countries that need them so that they will not be required or encouraged to reprocess their own materials" [33]. Thus the supply of uranium enrichment services again became an instrument in US non-proliferation policy.

The Nuclear Non-Proliferation Act (1978)

A stricter US non-proliferation policy, which the US Congress had begun to urge under Presidents Nixon and Ford, ultimately won the approval of the Carter Administration. The result in 1978 was the Nuclear Non-Proliferation Act (NNPA) [25c]. The NNPA was in fact the first comprehensive legislative change of nuclear energy policy since the Atomic Energy Act of 1954. The Law gives special attention to the matter of non-proliferation conditions to be included in agreements on nuclear co-operation with other countries and for nuclear exports. These conditions are more or less equivalent to Nuclear Suppliers Group Guidelines. However, in the following provisions the NNPA went even further.

1. Not only were safeguards required on supplied nuclear materials and facilities, but full-scope safeguards were also demanded for non-nuclear weapon states. For exports to nuclear weapon states, safeguards were required on the delivered nuclear items.

2. Prior consent by the USA for retransfer by a recipient country was not only required for 'sensitive' nuclear materials, facilities and technology, but also for all US-supplied nuclear materials, equipment and facilities.

3. Prior consent by the USA was required for reprocessing spent fuel produced from nuclear fuel or with equipment supplied by the USA. In any new agreement for nuclear co-operation the requirement of prior consent by the USA must also be satisfied for further enrichment of US-supplied fuel.

These conditions were supposed to apply not only to future exports, but also to existing agreements. A two-year transition period was provided in the Act to allow renegotiation to bring existing agreements into accordance with the NNPA requirements. If after that period no agreement with the recipient country had been reached on the fulfilment of the export conditions, an export licence could only be issued if specific criteria were met and if failure to approve the export would be "seriously prejudicial to the achievement of United States non-proliferation objectives or otherwise jeopardize the common defense and security" [34a].

According to the NNPA the achievement of US non-proliferation objectives once again rests heavily on assurances of nuclear fuel supply, especially the supply of enrichment services. The Act states that the USA

"will provide a reliable supply of nuclear fuel to those nations and groups of nations which adhere to policies designed to prevent proliferation" [34b]. To this end US uranium enrichment capacity was to be increased, a decision previously announced by President Carter in his 1977 anti-plutonium policy. In addition, the USA decided to pursue a vigorous research and development programme on advanced isotope separation (AIS) methods, in order to maintain its leadership in this field. The AIS programme was aimed at developing separation techniques that would make the enrichment of the tails from present enrichment facilities economically attractive, thus extending existing uranium supplies (see p. 183). Finally, the NNPA advocated the establishment of an international fuel authority (INFA) with responsibility for providing fuel services to ensure supply on reasonable terms. These fuel services should be supplied, however, only under strict non-proliferation conditions, such as full-scope safeguards for recipient non-nuclear weapon states. The services should also be available only to countries which do not establish any new enrichment or reprocessing facilities under national control, and which place any such existing facilities under "effective international auspices and inspection" [34c]. The guarantee of an assured fuel supply by such an authority was to help in minimizing the number of enrichment plants under national control, and therefore in limiting physical access to the means of production of weapon-usable material.

IV. Recent international efforts

INFCE (1978–1980)

The Carter Administration's anti-plutonium decision and the NNPA were both unilateral measures, just as the Nuclear Suppliers Club guidelines were the result of a one-sided effort by a group of technologically advanced countries to impose their non-proliferation objectives on other countries. These 'unilateral' actions drew strong protests from other countries and were only partly successful. Therefore the USA also began to look for ways to arrive at a broader international agreement on a non-proliferation regime, stricter than that of the NPT, but at the same time acceptable to more countries. In particular, ways were sought to influence countries engaged in nuclear activities, but not party to the NPT. With this objective in mind President Carter, in announcing his anti-plutonium decision in 1977, called for an International Nuclear Fuel Cycle Evaluation (INFCE) conference. This would investigate the proliferation dangers of various parts of the nuclear fuel cycle and look for more proliferation-resistant alternatives to reduce these risks.

A total of 46 countries and 5 international organizations participated in the INFCE conference, which lasted from 1978 to 1980. Among these

countries were several relatively advanced nuclear countries not party to the NPT, such as Argentina, Brazil, France and India. INFCE was organized as a technical conference, in which eight working groups investigated various aspects of the nuclear fuel cycle. The aim was to provide thorough technical and economic analyses to support the development of less proliferation-prone nuclear fuel and reactor strategies for the future.

The most important issues discussed at the INFCE conference centred on two main areas. On one side was the availability of nuclear fuel (resources, prices, international trade) and of various nuclear facilities and technology. On the other side considerable attention was paid to spent fuel management, reprocessing, plutonium management and breeder reactors. Emphasis on these issues reflected the differing interests of the various participating countries. For the USA one of the main interests was to emphasize the proliferation risks of a plutonium economy and to show that commercial reprocessing, plutonium recycling and breeder employment were economically unattractive, at least for the coming decades. Along with this the USA tried to show that technical alternatives were available or could be developed, both for spent fuel management without reprocessing and for a more economical utilization of uranium resources. Other countries stressed the need for an assured supply of nuclear fuel, in both the short and long terms, and the timely availability of the technological means to this end, for example, the breeder reactors. Their attitude in making choices on specific reactor and fuel strategies was to emphasize that "the risk of proliferation must be balanced against any economic, environmental, energy strategy and resource utilization advantages these facilities may have", in which "some risk of proliferation might be considered acceptable" [35a].

In its analysis of the proliferation risks inherent in enrichment technology the Enrichment Working Group established three categories: the diversion of nuclear materials, the spread of technology, possibly leading to the construction of an undeclared or unsafeguarded facility, and the misuse of a declared facility devoted to commercial purposes [35b]. To reduce the proliferation risks of enrichment, INFCE considered the use of the following three methods.

1. International safeguards should be applied to materials and facilities through a system of material accountancy reports, on-site inspection and verification, and various containment and surveillance techniques. Safeguards capabilities were evaluated rather positively at INFCE, and suggestions were made for improvement. It was noted, however, that the only practical experience so far gained is that of Euratom in safeguarding Urenco enrichment plants. This also means that experience has been gained only with gas centrifuge technology. None of the gaseous diffusion plants in France, the UK, the USA, or the USSR have ever been open for inspection (see chapter 3).

2. Institutional measures involving either national or multinational

arrangements were favoured for supervision of plants, technology transfer and nuclear materials. Such measures included classification, export control of equipment and enrichment know-how, and the establishment of facilities under multinational auspices. It was concluded that these institutional measures are partly available and "to some extent have been effective in reducing the risks and concerns which would not be covered by international safeguards alone" [35c]. However, these arrangements were not elaborated in much detail by the Working Group.

3. Certain special features of various enrichment techniques were identified as being potentially helpful in making the clandestine production of highly enriched uranium more difficult. However, opinions differed strongly as to the real influence which these specific technical features might have in a country's decision to construct a small clandestine facility [35d].

The Working Group was aware that these measures could at best reduce the proliferation risks of enrichment activities, but not eliminate them; all enrichment activities remain potentially dangerous. Consequently it stressed that "limitation of the number of plants and development of additional enrichment capacity only in response to needs of a competitive market would be desirable from the perspective of non-proliferation" [35e]. It was concluded that the enrichment market should be competitive, with free access to it by the developing countries, in order that there would be "appropriate flexibility in supply arrangements", reducing for these countries the need to establish their own facilities [35f]. It is also concluded that only a few states in the world are actually in a position to develop commercial-size enrichment capabilities on a national level. Such facilities require a large capital investment, a highly developed technology base and an advanced industrial infrastructure. Of those few states capable of developing national facilities, "those having substantial commercial or industrial incentives to do so would include countries having a large domestic nuclear power program or large indigenous natural uranium resources" [35e]. This, of course, avoids the question of whether other countries might build a small dedicated facility for different reasons.

In its Summary Volume INFCE states its consensus on the relative importance of the above-mentioned three measures against proliferation. The conclusion was that "technical measures have a powerful influence on reducing the risk of theft, but only a limited influence on reducing the risk of proliferation. It is judged that safeguards measures are more important than the technical measures. Potentially more important than technical measures are the institutional measures" [35g]. Such institutional arrangements to reduce proliferation risks would include multinational arrangements for the management of sensitive facilities, an international spent fuel and plutonium storage regime, and international fuel supply arrangements. However, just as in the report of the Enrichment Working Group, these institutional arrangements were not described or analysed in any detail. Such an analysis has been attempted in chapter 3 of this book.

IAEA Committee on Assurance of Supply (CAS)

Partly in response to concerns raised by INFCE, the IAEA has set up three expert consultant groups to study specific aspects of the nuclear fuel cycle. One of these groups is studying the possibility of International Plutonium Storage (IPS), and another International Spent Fuel Management (ISFM). The one most relevant to the enrichment industry is the Committee on Assurances of Supply (CAS) which was created in 1980 to discuss and make recommendations on issues relating to international supply of nuclear material and equipment. The motivation for this committee is the assumption that "assurance of supply and assurance of non-proliferation are complementary" [35h]. The hope is that incentives for establishing national enrichment and reprocessing facilities by a country might be reduced if nuclear fuel supply were guaranteed in accordance with its needs.

V. Concluding note

This brief account of the history of non-proliferation efforts has focused on the role played by uranium enrichment. This industry has been seen both as a cause of proliferation and as a potential means for controlling it, and a wide variety of mechanisms have been attempted or proposed to use enrichment for the latter purpose. In chapter 3 these efforts are categorized and analysed on the basis of the degree to which they involved international collaboration. This variable seems to be a critical one in determining the degree of success of non-proliferation measures.