APPENDIX IX-F

MULTINATIONAL AND INTERNATIONAL FUEL CYCLE FACILITIES

by

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Any nuclear power reactor produces as a necessary by-product of its operation fissile material that could be separated from the spent fuel by chemical means and used in the fabrication of nuclear explosive devices. For all reactor types now commercially available or expected to be available during the next decade, the relevant fissile by-product of power production is plutonium.* One of the most important proliferation-related issues that emerges out of the gradual international diffusion of nuclear power technology, therefore, is how the spent fuel and particularly its plutonium contents will be handled.

Basically two options are available. States may choose to reprocess spent fuel to separate the plutonium and uranium from each other and from the highly radioactive fission products and other actinide elements that are produced as the fuel burns or they may choose not to do so. The benefits of reprocessing are the recovery of uranium and plutonium for reuse in power reactors, and the reduction in volume of high level nuclear waste that must be isolated from the environment for tens to hundreds of thousands of years. Whether states will prefer to reprocess or store spent fuel depends on the relative economics (which are currently very uncertain[2]) of reprocessing and recycle versus the so-called throw-away option; their preferred method for handling nuclear wastes; and the extent to which they see non-economic incentives to recycle recovered uranium and plutonium. Such incentives might derive from a

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*One high temperature gas reactor, operating on a thorium-uranium-233 fuel cycle is now in operation in the United States. Despite German and some continuing American interest in this technology, however, such reactors do not now appear likely to contribute significantly to nuclear power programs over the next decade. A thorium-uranium fuel cycle could be used in today's light- and heavy-water reactors and proposals to do so have been made.[1] Nonetheless, this again seems unlikely to play a significant role over the next decade.

desire to reduce dependence on imported uranium or the purchase of uranium enrichment services or to gain experience with plutonium fuel in anticipation of ultimate reliance on plutonium breeder reactors.[3]

In anticipation of the possibility that a number of non-nuclear countries will, for one reason or another, choose to reprocess their spent fuel, considerable attention has focused on possible mechanisms to reduce the likelihood that widespread reprocessing and the use of plutonium in reactor fuel will contribute to the proliferation of nuclear weapons. One possibility is for the United States and other states with advanced nuclear industries to use exhortation, example, provision of alternatives through the market, or some combination of these to persuade other states not to reprocess. Another is to encourage states not to build their own reprocessing facilities. A ban on the international transfer of reprocessing facilities or technology is widely thought in the United States to be reinforcing of both objectives.* Reliance on spent fuel storage facilities or sufficient reprocessing capacity under national control in nuclear or low-risk non-nuclear countries to provide storage or reprocessing services to other states is also frequently suggested as a means of dissuading states from building their own reprocessing plants. Finally, the creation of such facilities under multinational control has also been proposed to serve the same purpose. One multinational reprocessing facility, the Eurochemic plant in Mel, Belgium, has already been built but is no longer operating.

The fuel for most power reactors now in use and expected to be available at least through the end of the century requires uranium that has been partially enriched in the U-235 isotope. Although such low-enriched uranium cannot be used for explosives, any enrichment facility can (with an economic penalty dependent on the technology used) be employed to produce high-enriched, weapons grade uranium. Substantial concern also applies to the spread of enrichment technology, therefore,

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*For the role of the nuclear suppliers' conference in regulating the international diffusion of this technology, see the submission entitled "The Suppliers Conference."

although in this case the fact that the material produced in normal operations would not be weapons grade somewhat reduces the risks compared to the reprocessing case. Multinational facilities (MNFs) have again been proposed as a means of preventing the diffusion of enrichment technology and facilities to non-nuclear states. In fact two multinational organizations, Urenco /Centec and Eurodif already exist for the purpose of providing enrichment services.

A few commentators on the subject of nuclear proliferation and the nuclear industry have suggested going beyond the creation of multinational facilities to truly internationalizing these components of the industry.[4] Unlike a multinational arrangement which would involve a limited number of participating states with each or at most a few facilities under the control of any given multinational organization, the international approach would have one organization, perhaps the IAEA, which has open and perhaps close to universal membership own or control all (or at least most) such facilities in the world.

Advantages and Disadvantages

There are several possible advantages of MNFs that might persuade states to rely on them rather than build their own reprocessing or enrichment plants. First, they would serve as mechanisms for mobilizing the technical personnel and know-how of advanced industrial states to provide a service for which smaller, less advanced states might otherwise have to become dependent on the industrialized states. Second, by serving a larger market than would national plants in countries with small nuclear industries, economics of scale are possible and the cost of services could be reduced. Third, if spent fuel were stored at an MNF or if high level wastes separated by reprocessing were not returned to the country of origin, the MNF would solve the waste management problem which for many states is very difficult. Fourth, participation in an MNF might serve as a mechanism for a state to acquire sufficient technical expertise to build its own facilities at a later date. From a non-proliferation. perspective the safeguarding and physical protection of a single, large MNF might be easier and more certain than of many smaller, national facilities. Compared to relying on services purchased from nuclear supplier nations, MNFs might provide the further

advantages of greater security of supply and at least partial satisfaction of symbolic or nationalistic objectives that might prompt some developing states to acquire indigenous facilities as a demonstration of their ability to create and manage complex technological enterprises.

Proponents of the international approach claim that it would have all of these same advantages. Their major additional asset would be their ability to mollify more successfully the "sense of inequality, resentment against what is perceived as discrimination, and a desire for equivalent rights and status"[5] on the part of developing states.

Disadvantages of MNFs are of three kinds: those common to any facility, those pertaining to both enrichment and reprocessing facilities, and those pertaining only to facilities that provide reprocessing. Participation in any MNF would to some extent reduce the freedom of individual action of participating states in organizing and managing their domestic industries. In addition, the problems of designing the institutional and legal structure and of successfully initiating, constructing, and operating any MNF would be very severe, perhaps so severe that failure, unacceptable delays or insecurities in the supply of services would be anticipated or realized. The possibility of technology transfer cited above as a potentially attractive feature of an MNF for small nuclear states can also be seen as a serious disadvantage from a non-proliferation perspective when reprocessing or enrichment were involved.

Support for a MNF that included reprocessing would weaken the case that reprocessing itself should be foregone or delayed. If significantly subsidized by nuclear states in an effort to encourage participation, an MNF would obscure or undermine the natural market forces that might otherwise tend to discourage reprocessing. In any case, the argument against reprocessing would be more difficult to sustain in the face of a major multinational effort to create a reprocessing facility.

More serious, once plutonium were separated at an MNF it must be prevented from finding its way into national explosive programs. Reprocessing in a MNF and shipping the recovered plutonium back to the state of origin, even if under safeguards, would be no better than having

each state with its own safeguarded reprocessing plant and plutonium storage area. Mechanisms must be found, therefore, if a MNF with reprocessing is to be useful from a rim-proliferation perspective, to prevent such automatic return of plutonium. Several possibilities are available. In order to persuade states not to use plutonium fuel at all, they could be offered an equivalent amount of uranium fuel in exchange for their plutonium. Such an arrangement would require the cooperation of at least some suppliers of enrichment services and perhaps also some uranium producers. Alternatively, states could be shipped their plutonium, but only under strict safeguards and in quantities required for fairly immediate use in their reactors. To implement this procedure the MNF would have to include a plutonium storage facility and almost certainly a mixed-oxide fuel fabrication capability.

A MNF that provided only spent fuel storage services would not experience these difficulties associated with reprocessing. It would in addition have many fewer technical and administrative demands made of it and probably be easier and quicker to create than a larger and more complex facility that included a reprocessing plant and other back-end facilities. While not a substitute for national reprocessing for states determined to recycle plutonium, a multinational spent fuel storage facility would be quite sufficient for those states whose only interest is dealing with nuclear wastes.

The disadvantages of international control of fuel cycle facilities are again the same as those for multinational control, except significantly stronger. Particularly the problems of institutional design, distribution of power and efficient operation would appear to be very serious in the international case, even if the IAEA were used as the relevant organizational entity.

Analyses of MNFs

Beyond the internal analyses of international or multinational control of fuel cycle facilities that have been conducted within the U.S. and perhaps other governments, two significant studies have been undertaken. The first is the Regional Nuclear Fuel Cycle Center (RFCC) Study of the IAEA, initiated in 1975 following a preliminary study the

previous year. The second was the 26th Pugwash Symposium, International Arrangements for Nuclear Fuel Reprocessing, held in May 1976 under the joint sponsorship of the Canadian and American Pugwash Groups. Both have focused on the back end of the fuel cycle and on multinational arrangements only. Much, but not all, of the analysis carries over directly, however, to the enrichment case and international arrangements.

1. IAEA Region Nuclear Fuel Cycle Center Study

The IAEA study was initiated in response to the interest of member states in the MNF concept. It is intended "to assist the Member States in evaluating the relative merits of the RFCC approach to establishing fuel cycle facilities."[6] As described by the Study's director its specific objectives are:

1. "To develop the methodology for assessment of alternative strategies for establishment of integrated regional nuclear fuel cycle centres, so as to evaluate their advantages and disadvantages vis-a-vis dispersed fuel cycle facilities.
2. "To prepare a report on this methodology, including illustrative examples on approaches and advantages to Member States, for the use of those organizations interested in the implementation of nuclear fuel cycle activities.
3. "To provide a mechanism for the establishment of a forum where Member States and other interested parties can work out alternative strategies with regard to nuclear fuel cycle activities as well as evolve appropriate frameworks to cover institutional, legal and other aspects related to the establishment of such multinational fuel cycle centers."[7]

A small internal staff at the IAEA is relying heavily on consultants from member countries to provide technical, financial and other relevant input data. The technologies to be considered cover the entire back end of the fuel cycle: spent fuel transport, spent fuel storage, reprocessing, mixed oxide fuel fabrication, and waste management. The study also includes the possibility that spent fuel would be stored for a long period prior to reprocessing. Besides an analysis of economics and materials flow for which computer simulation and optimization models

have been constructed, the study will examine institutional and legal aspects; organization and administrative aspects; financial considerations; health, safety and environmental aspects, safeguards, physical security and process controls; and public acceptance considerations.[8] A report on Institutional - Legal Framework Aspects was issued in July 1976.[9] A summary report with illustrative analyses of alternative fuel cycle strategies is expected to be presented to the Conference on Nuclear Power and its Fuel Cycle to be held by the IAEA is Salzburg in May 1977.

Several significant results have already emerged from the IAEA study. First, despite the emphasis on the regional nature of MNFs in the study's name and original conception, this notion has now largely been abandoned because of the recognition that transportation costs are small enough to preclude significant economies arising out of geographical proximity.[10] Second, at least one participant in a MNF would have to bring to the project rather extensive technical know-how and industrial support and to provide or arrange for a major part of the financing. Thus, a MNF cannot be a consortium only of states with immature nuclear industries. The assistance and support of at least one of the major nuclear supplier countries is thought to be necessary.[11] Third, there appears to be important financial benefit to be derived from states joining forces to build multinational facilities rather than building their own national ones. This financial incentive is thought to be a major incentive for states to participate.

Fourth, great flexibility and variation is possible for the institutional and legal structure that would underlie an MNF. Indeed substantial variation already exists among the three current MNFs, Eurochemic, Eurodif and Urenco/Centec.* Existing multinational enterprises that can serve as useful models for a MNF include not only these three but also Intelsat, Scandinavian Airlines System, Central American Air Navigation Service Corporation and European Company for the Financing of Railways.[13]

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*United Reprocessors, while a multinational enterprise does not own plants or provide services. It is therefore not a useful model for a MNF.[12]

2. Pugwash Symposium on International Arrangements for Nuclear Fuel Reprocessing[14]

The Pugwash Symposium examined the possible motivations for reprocessing in general and for reprocessing in MNFs in particular. It compared reprocessing at national facilities and MNF along the dimensions of economics, safeguards, health and safety, waste management, and physical security. It concluded

> "with reasonable clarity that multinational operation need not necessarily entail a penalty on any of these dimensions. Indeed, in some respects the multinational approach holds out the possibility of substantial gains."[15]

The major potential gains were found to be in economics of scale compared to many small plants, and in facilitating safeguards and physical security.

The Symposium recognized the concern of all participant states for security of supply and the special sensitivities of developing country participants concerning their being provided a full and equal share in the enterprise. It also recognized the problems of ultimate disposal of plutonium and of technology transfer. Dealing adequately and simultaneously with all of these concerns was seen to be a very demanding task. As stated in the Symposium paper on institutional arrangements, "The overarching tension or trade-off is that between the commercial and political aspects of the enterprise."[16]

The institutional analysis stressed both the variety of mechanisms available and the difficulty of creating a MNF. It stressed the need for a high degree of governmental involvement and of increasing size, functional complexity and membership from a modest beginning. Spent fuel storage was seen as an appropriate function with which to begin,

Institutional and Political Issues

Some of the institutional and political issues that must be addressed in considering multinational or international facilities have already been mentioned. The most important ones revolve around membership, distribution of power, the political-commercial tension, access to technology, and the role of the IAEA. It is the existence of such issues

that constitutes the important distinction between these institutional arrangements and national facilities. The extent to which they can be adequately resolved will determine both the feasibility and value of multinational or international facilities. Answers to detailed questions about the instrumentality by which the enterprise would be launched and given legal status, (whether it be an intergovernment treaty or the creation of a traditional shareholding company for example), and whether new or existing entities would be charged with management and operations would flow directly from the manner in which these more fundamental issues are resolved.

Membership in a MNF could be determined on the basis of geography, historical ties between governments or commercial enterprises within participating states, or shared common interests and plans for nuclear development. There appears to be agreement that at least one technically advanced state must participate in a multinational venture, but whether as a regular member or not is not definite. For a MNF membership would. presumably be closed to the initial interested parties or to other states acceptable to them. An international arrangement would, by definition, be open to participation by any state. One special case of an MNF is of particular interest. This is a bilateral arrangement for joint control of a reprocessing or enrichment facility between a nuclear supplier state and its customer. Such an arrangement might significantly reduce the risk of diversion from transferred sensitive facilities.

Distribution of power within the venture will be an important issue. If states are to forego their option to build domestic reprocessing or enrichment plants and are to feel secure in their dependence on a multinational or international facility, they must be assured through an appropriate distribution of power over policy and operations that their interests will be protected. That is, the structure of the organization must be politically acceptable to participating governments. This may be assured by careful drafting of an enabling treaty instrument, by a requirement for consensus on important decisions, by appropriate

distribution of voting rights and specifying different majority requirements for different issues, by division of responsibility among a number of decision making bodies following different procedures or by some combination of these.

There will be a tension within any multinational or international facility between the desire to operate efficiently on a commercial basis and the need to be responsive to a variety of (sometimes contradictory) political objectives. While governments will inevitably be directly involved in oversight and plotting policy directions, day to day management and supply of services should be protected as much as possible from political interference. Whether this means creating a multinational commercial enterprise to manage the facility or contracting with a single private concern to do so is a matter of choice.

If a facility that includes reprocessing or enrichment is not to serve as a mechanism by which participating states can increase their own technological base for the purpose of eventually initiating national plants, limitations must be imposed on the transfer of technology or on the purposes to which acquired technology may be put. Competing with this will be the desire of developing states to use their participation in the arrangement to increase their level of technological sophistication. This is a fundamental issue that will be difficult to resolve.

The role of the IAEA can certainly be to provide technical assistance and a facilitating mechanism for the creation of a multinational or international facility. It would also no doubt be called on to provide safeguards. Article 1X.1.1 of the IAEA Statute authorizes the Agency to "establish or acquire . . . . plant, equipment, and facilities for the receipt, storage, and issue"[17] of nuclear materials. It therefore presumably already has authority to establish an international spent fuel storage facility under its control. The Agency cannot of course act to do so without authorization from the Board of Governors or perhaps the General Conference. Whether or not its mandate under Article III, Functions, could be interpreted broadly enough to permit its direct operation of a reprocessing or enrichment plant or whether its mandate should be appropriately extended are matters that must be decided by the Governing Board and Member States.

Evaluation

In assessing its utility from a non-proliferation perspective, any multinational or international fuel cycle facility must be compared to the alternatives of facilities under national control in non-nuclear states and relying on other mechanisms to dissuade states from reprocessing or relying on their own sensitive facilities. The primary alternative mechanisms of dissuasion would be, in the case of reprocessing, assuring states of sufficient supplies of enriched uranium to obviate their desire to recycle plutonium and move rapidly to breeders and, for enrichment and reprocessing providing sufficient capacity in nuclear or low-risk non-nuclear states that others would be content to rely on for delivery of services.

The obstacles to establishing a truly international mechanism for owning and operating fuel cycle facilities seem greatly to outweigh the anticipated benefits compared to other alternatives. It does not, therefore, appear to be a fruitful avenue for study or for policy initiatives. The relative lack of attention given this option, seems completely appropriate.

Despite the widespread concern of only a few years ago that the coming decade would see a shortage of enrichment capacity or at least a very tight market for enrichment services, this no longer appears to be the case. Over the next ten to fifteen years there is in fact a high likelihood that excess enrichment capacity will exist in the world and that the major policy question for supplier countries, particularly the United States, is whether or not to build enriched uranium stockpiles. In addition, the number of commercial suppliers of enrichment services is diversifying compared to the past when the United States was the only one. No urgency currently exists, therefore, for the international community to stimulate the expansion of enrichment capacity at MNFs or otherwise. Two of the new enrichment suppliers have in fact been established as MNFs in order to share both the financial cost and enter-preneurial risks. Urenco/Centec involves companies and the governments of Britain, Holland and West Germany in the provision of enrichment services using centrifuge technology. Eurodif is a commercial venture

with participation from government agencies or private entities in France, Belgium, Italy, Spain and Iran. Except for Iran there is no participation in these MNFs from developing countries towards whom the multinational concept is primarily directed. Nonetheless, given the anticipated excess and diversity of supply, there appears to be little incentive at present to stimulate the creation of a new MNF with broader developing country participation.

The primary interest in MNFs, therefore, is for the back end of the fuel cycle. Except for the small number of states with reprocessing plants operating or close to completion, no long term spent fuel storage, uranium-oxide fuel reprocessing or nuclear waste management capability exists. There is however a growing demand for such services in every country with a current or anticipated nuclear industry. The focus *to* date on MNFs for reprocessing and spent fuel storage is, therefore, totally appropriate. The concept does appear in this case to have some potential net benefit as a mechanism for reducing the likelihood that the diffusion of nuclear power technology will contribute to nuclear weapons proliferation.

The strongest case can be made for a MNF that would take and store spent fuel. Offering such a solution to the waste management problem of states not now particularly interested in recycling plutonium would reduce their incentives to reprocess either domestically or abroad. Of course a national enterprise that offered such services on a commercial basis would be equally useful, but seems unlikely to come into existence because of the universal reluctance on the part of countries to serve as a nuclear dumping ground. This same reluctance might preclude the establishment of a MNF for that purpose, since it must be actually sited within some country's boundaries. There is some chance, however, that the multinational nature of the facility and its important role in aiding the cause of non-proliferation would mitigate the opposition.

An assessment of the utility of MNFs for reprocessing depends on expectations concerning states' decision to reprocess and the growth of the commercial reprocessing industry as now constituted. If expectations are high that most states with emerging nuclear industries can be persuaded not to reprocess, no action should be taken now to initiate a MNF with

reprocessing. If, to the contrary, many such states are expected to seek mechanisms to reprocess their spent fuel, the question becomes how to persuade them not to build their own national facilities. Unlike the enrichment case, reliance on existing or anticipated excess reprocessing capacity in advanced industrialized states does not appear viable. Great uncertainty exists concerning the reprocessing industry in the United States. Japan is unlikely to have excess capacity in the foreseeable future. The only sure suppliers of services are the European partners of United Reprocessors. But even here, the West Germans face serious difficulties of public acceptance of their planned 1500 tonne per year plant and expansion of capacity by Britain and France is not assured. Even if significant capacity could be made available by United Reprocessors countries to the international market, many states might well be reluctant to rely on a single foreign supplying entity and to pay the high prices that United Reprocessors is demanding. In this case, therefore, the creation of one or more MNF might well be desirable.

Little can be done until the report of the IAEA Study is delivered and studied in depth. If, as is likely, the Study finds MNFs feasible and economically advantageous, action could then be taken by the United States, by other suppliers or through the suppliers' conference to stimulate interest in a specific MNF project. Stimulation is all that will be possible, however. The major interest and initiative must come from the states that would be the primary users of the facility. As pointed out by those analyzing institutional arrangements for the Pugwash symposium,

> "any effort to cajole - not to say coerce - participation in a multinational fuel cycle enterprise would be wholly misplaced. A reluctant partner would have available an infinitude of points and issues to create plausible, irritating, and ultimately defeating delay and complication in the negotiating process. Only assent freely given in the perception that the enterprise really serves the interests-of the countries involved will be able to surmount the many institutional problems that will inevitably arise."[18]

Furthermore, while an MNF for reprocessing might well provide economic and security of supply advantages to its participating states, it will contribute to the objectives on non-proliferation only if provisions are built in to protect against states ultimately building national plants with technology acquired from the MNF and if an alternative is found to shipping large quantities of plutonium, even under safeguards, back to the participating states.

Given the apparent agreement of those who have studied the MNF concept that modest beginnings stand the greatest chance of success, economics of reprocessing, there may be considerable advantage in proceeding in stages. Starting with a spent fuel storage facility would avoid an early commitment to reprocessing, assist immediately with the waste management problem and provide a period of modest demands for the MNF to prove its ability to function and gain the confidence of participating states. If initially chartered with a mandate to expand into reprocessing and mixed oxide fuel fabrication and if sited appropriately, a MNF that initially provides only spent fuel storage services could be expanded later. This is an approach very worth considering.

1. See Harold A. Fieveson and Theodore Taylor, 'Alternative Strategies for International Control of Nuclear Power', in Ted Greenwood, Harold Fieveson and Theodore Taylor, Nuclear Proliferation: Motivations, Capabilities and Strategies for Control (New York: McGraw-Hill, 1977), and S. Banerjee, E. Critoph and R.G. Hart, "Thorium as a Nuclear Fuel for CANDU Reactors", The Canadian Journal of Chemical Engineering, 53 (June 1975), pp. 291-296.
2. See Mark Sharefkin, "The Simple, Uncertain Economics of Multinational Reprocessing Centers", in Abram Chayes and W. Bennett Lewis (editors), International Arrangements for Nuclear Fuel Reprocessing, (Cambridge, Mass.: Ballinger Publishing co., 1977), pp. 47-64; and Ted Greenwood, George W. Rathjens, and Jack Ruina, "Nuclear power and Weapons Proliferation", Adelphi paper 130, (London: International Institute for Strategic Studies, 1977), pp. 18-20.
3. For a full discussion on motivations for reprocessing, see Ted Greenwood, "Why Reprocess?" in Chayes and Lewis, pp. 17-29.
4. See Lincoln P. Bloomfield, "Nuclear Spread and World Order", Foreign Affairs, Vol. S3, (July 1975), pp. 743-755; and David E. Lilienthal, "If This Continues, the Cockroach Will Inherit the Earth", The New York Times, (June 20, 1975), p. 33.
5. Bloomfield, p. 746.
6. International Atomic Energy Agency, "IAEA Study Project on Regional Nuclear Fuel Cycle Centers, Status Report", (September 1976), IAEA-RFCC/3, p. 1.
7. Vinay Meckoni, "Regional Nuclear Fuel Cycle Centers", IAEA Bulletin, Vol. 18, No. 1, p. 5.
8. IAEA-RFCC/3, p. 8-9.
9. International Atomic Energy Agency, 'Regional Nuclear Fuel Cycle Centre Study: Institutional-Legal Framework Aspects', IAEA-RFCC/2, (July 1976).
10. IAEA-RFCC/3, p. 2.
11. IAEA-RFCC/3, p. 2.

12. For a description of Urenco/Centec and United Reprocessor, see C. Allday, "Some Experiences in Formation and Operation of Multinational Uranium-Enrichment and Fuel-Reprocessing Organizations", in Chayes and Lewis, pp. 177-187. IAEA-RFCC/2 provides a discussion of Eurochemic, EURODIF and URENCO. See pages 8-11.
13. IAEA-RFCC/2 briefly discusses these on p. 12. See also Eugene B. Skolnikoff, "Relevance of Intelsat Experience for Organizational Structure of Multinational Nuclear Fuel Facilities", in Chayes and Lewis, pp. 223-232.
14. The Proceedings of this Symposium are given in Chayes and Lewis.
15. Constance B. Smith and Abram Chayes, "Institutional Arrangements for a Multinational Reprocessing Plant", in Chayes and Lewis, p. 145.
16. Smith and Chayes, p. 148.
17. Statute of the International Atomic Energy Agency Article 1X.1.1.
18. Smith and Chayes, pp. 17S-176.