KERNFORSCHUNGSANLAGE JÜLICH GmbH
Programmgruppe Technik und Gesellschaft

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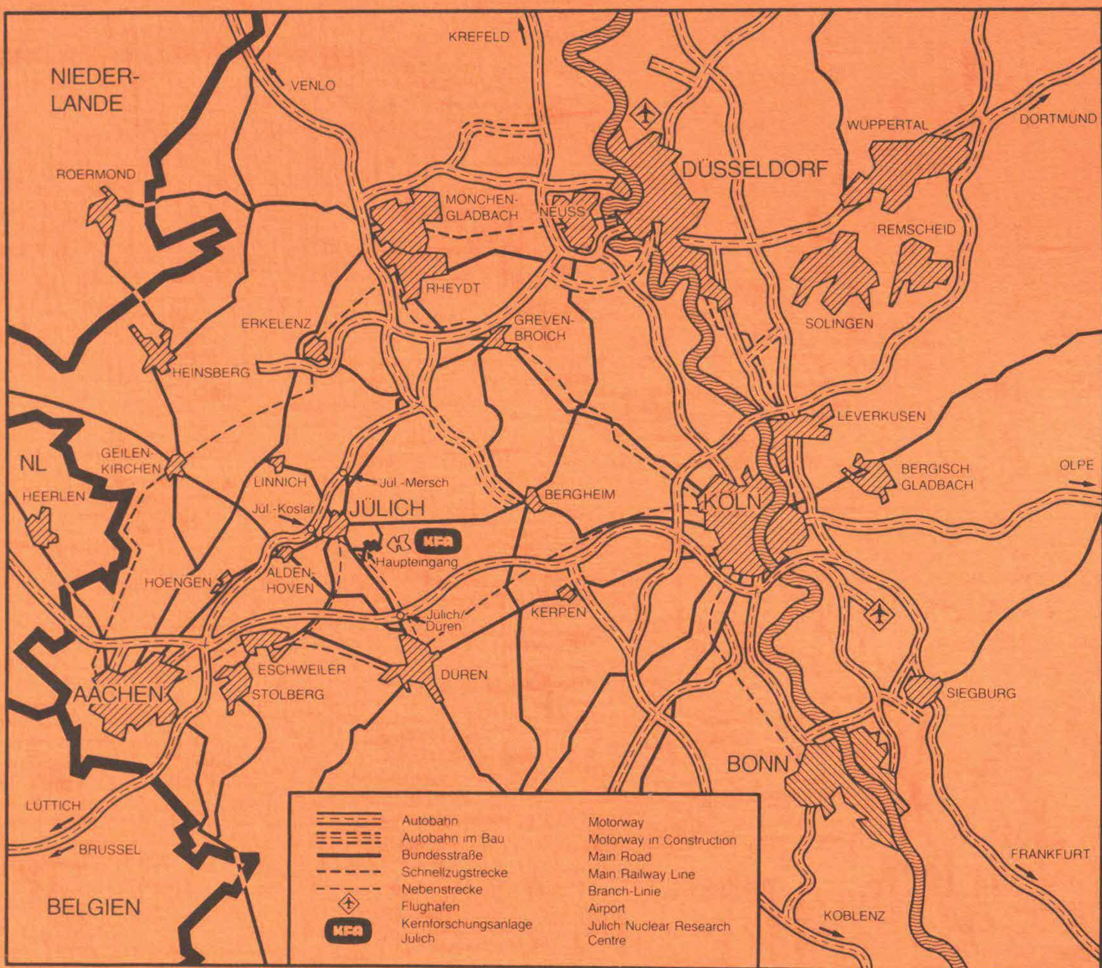
Jül - Spez - 238 /
Translation
February 1984
ISSN 0343-7639



Als Manuskript gedruckt

Spezielle Berichte der Kernforschungsanlage Jülich – Nr. 238/Translation

Programmgruppe Technik und Gesellschaft Jül – Spez – 238/Translation

Zu beziehen durch: ZENTRALBIBLIOTHEK der Kernforschungsanlage Jülich GmbH

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The study reflects the authors opinions and represents the status in June 1983. The contributions dealing with the situation in the U.S.A. are based upon work by Doub and Muntzing, Chartered, Washington D.C.

Contents

1. INTRODUCTION

As recent developments in the international energy situation have shown, the necessity of utilizing all available sources of energy all over the world has become inevitable. This also necessitates increased application of nuclear energy in the industrialized countries and similarly to an increasing extent in the developing countries. However, the many and varied problems of ecology, economy and public acceptance associated with the peaceful uses of nuclear energy require intensive support and close cooperation in the transfer of nuclear technology from industrialized to developing countries.

In addition to cooperation in the R + D sector, the major priority in nuclear transfer between the developing countries and the industrialized countries was to be found in the past in supplying enriched fuel and reactors. The problem of the management of spent fuel from nuclear power stations and its practical solution will in future also increasingly arise in the developing countries with the growing amounts of spent fuel elements. It therefore appears meaningful to include the issue of managing the back end of the fuel cycle in negotiating the boundary conditions of a nuclear transfer from the supplier states to the recipient states, possibly directly connected e.g. with the export of nuclear power stations.

A significant view point which in the past has determined the institutional framework and the contractual structure of international cooperation in nuclear trade was the non-proliferation aspect. The Non-Proliferation Treaty of 1968 intended on the one hand to achieve a fixed status quo in the atomic weapons sector and on the other hand to enable the peaceful uses of nuclear energy to be as unrestricted as possible. The efforts of various countries to obtain de facto possession of nuclear weapons via so-called peaceful explosive devices led to a tightening of the contractual boundary conditions in the international nuclear sector and, particularly in the United States, even culminated in the demand that sensitive activities in the nuclear fuel cycle, such as enrichment or reprocessing, should be completely dispensed with.

Suggestions for adjusting this disturbed balance in the nuclear trade were discussed on various international committees and led to the foundation of the International Nuclear Fuel Cycle Evaluation Conference (INFCE), in which 60 countries and various international organizations participated. A central event in this important conference was that the proliferation question should not be regarded in isolation as a technological problem but rather that political parameters and solutions should also be increasingly included as boundary conditions in international nuclear trade.

So-called institutional solutions seemed to indicate possibilities which could satisfy such boundary conditions. According to the definition in INFCE, this type of institution includes a wide range of possibilities in the field of multinational cooperation such as intergovernmental agreements, technological support for research programmes, as well as international and multinational institutions.

The first considerations in the INFCE were aimed at employing these institutional solutions in mutual interaction both in order to reduce the proliferation risk as well to increase supply assurance. Detailed analyses carried out later at the Nuclear Research Centre Jülich (KFA) showed that further criteria such as cost effectiveness, political independence, transfer of sensitive technology etc., should also be considered in discussing these models. A further result of these studies at the KFA Jülich was that in considering the large number of institutional models, multinationalization or internationalization of plants or materials in the nuclear fuel cycle represents a worthwhile subject for further more detailed investigations. However, these studies also indicated that institutional models with extraterritorial rights or international organizations as operators of nuclear plants were excluded from the outset due to the considerable loss of sovereignty for the host countries of such facilities.

After suitable multinational models with respect to the front end of the fuel cycle had been analyzed in detail in the first subsequent study, this present study intends to concentrate on the problems of the back end of the nuclear fuel cycle. The following stages will be dealt with more closely:

- intermediate storage of spent fuel elements
- reprocessing of spent fuel elements
- MOX fabrication
- direct final storage of spent fuel elements
- final HAW storage.

Multinational models, or cooperation models, which could possibly be applied in the scope of these steps in the fuel cycle range from the financial participation of several countries in one plant up to the operation of subsidiaries in the participating countries. A phased model which intensifies bilateral cooperation step by step and which accompanies a corresponding transfer of technology between the supplier and recipient state can indicate ways of relieving the management of spent fuel elements for countries with fairly small or nascent nuclear programs; the idea of compulsory management of spent fuel for countries exporting nuclear reactors is also included in the discussions.

Such models can also be of interest for the Federal Republic of Germany, which plays an important part in international nuclear trade and in the transfer of nuclear technology to developing countries. In addition to siting problems for these multinational plants there are also political and economic aspects, issues of proliferation as well as of supply assurance for nuclear material, facilities and also technologies which must be solved before suitable models can be implemented to the satisfaction of all the partners.

The study is structured by questions concerning the selection of meaningful models, the necessity of their implementation and the period of their possible application. To this end, the future worldwide development of nuclear energy is first depicted, paying particular attention to the aspect of nuclear transfer to developing countries and problems of spent fuel management. Chapter Three deals with the role of international safeguards as essential measures for preventing proliferation and the potential for possible improvements, as well as other, mainly political solutions for reinforcing the non-proliferation network which are already currently in operation. Chapter Four shows the status of international discussions of institutional models and in Chapter Five the individual stages of the back end are analysed in detail with respect to possible advantages and disadvantages in applying such models; the main emphasis being on a phased model to improve technology transfer with a simultaneous solution of spent fuel management problems. Special requirements for sufficient intermediate storage capacity for spent fuel elements is thus included. In the final Chapter an attempt is made to answer the question of the extent to which acceptance of such models can be ensured.

2. PERSPECTIVES OF WORLDWIDE NUCLEAR ENERGY DEVELOPMENT

The necessity of a further extension of nuclear energy and its application in a growing number of countries results from the uneven distribution of primary energy resources throughout the globe, from the heterogeneity of the world balance of power and interests as well as from the subsequent instability in the currents of world energy trade. These reasons force the individual countries to undertake an independent, i.e. national, solution of their energy problems with respect to long-term assurance of the energy supply within their possibilities. The objectives of national energy policies are therefore intended to decrease both quantitative and qualitative dependence on imports, to diversify the sources of primary energy to be used and applying energy in such a way as to conserve resources. Since energy imports can only be completely dispensed with in a few cases, the remaining import quota must be aimed at world currents of energy trade, their capacity development and the expected international energy demand profile. In this context, nuclear energy offers all technologically highly developed countries a decisive large-scale technological alternative to fossil energy carriers on the basis of the high energy density of its primary energy bases, uranium and thorium, as well as its large potential for application in the heating and electricity supply sector. Before the application potential of this primary energy source can be utilized the step must be taken from thermal to highly converting and breeder reactor systems, i.e. the transition from the prevailing light-water reactor to the high-temperature reactor and fast breeder, which can be realized in the medium term. In this way not only the quantitative but also the qualitative dependence on imports in the uranium supply is minimized and thus the import quota as a whole via the substitution effect; with the breeder system nuclear energy thus becomes more or less a domestic source of energy. The decisive aspect is that in the long run the whole nuclear fuel cycle can be installed in each country and with sufficiently long lead times with thermal reactors, breeder reactors can be fed from this system's "waste" for decades without new natural uranium having to be imported.

In addition to purely technological requirements, nuclear energy utilization in a country should also be correlated with the size of the power station pool as well as the infrastructural and administrative circumstances in order to be able to present evidence for the point at which utilization of nuclear energy should begin and establishment of the nuclear fuel cycle should be decided. These specification factors are by no means to be quantified in the same way as the ratio of domestic primary energy production to domestic primary energy consumption, or domestic primary energy reserves to domestic primary energy consumption, nevertheless they are of at least the same quality as the expected electricity growth rates over the next 50 years which have a decisive influence on the extension rate of nuclear power stations in the electricity sector of a country.

If these uncertainties are included, then the criteria assumed for nuclear energy perspectives in the next 50 years (initiation of nuclear energy utilization in a country with a minimum electricity demand of 20 TWh/a; closing the fuel cycle and breeder utilization at an installed nuclear capacity of approx. 20 GW) can only be seen as reference values especially since socio-political problems of nuclear energy application can only be included in the calculations in a qualitative form (continuity of extension rates).

A global nuclear energy strategy based on these criteria can lead to the worldwide extension of nuclear energy shown in Fig. 2.1 which could achieve an installed nuclear power station capacity of almost 4,000 GW in 2030 (in comparison to this the installed nuclear power at the end of 1982 was 173.1 GW) which would be operated in 74 countries of the world (see Fig. 2.2). However, this requires that the acceptance problems be rapidly overcome and superseded by a continuous further development of nuclear energy application and the timely realization of a spent fuel management strategy which can only consist of reprocessing and recycling the useful substances in the reactor from the aspects of fuel economy and environmental conservation. At the same time as fulfilling these prerequisites, it appears that if the model assumptions are considered (especially the 20 GW rule) the fuel cycle will be closed in 23 countries by 2030 and the step by step transition from the light-water reactor to the fast breeder will have begun. Breeder capacity in operation by 2030 is almost 1000 GW or 25 % of total global nuclear power in that year. This breeder application reduces the worldwide demand for natural uranium to about two thirds of that without breeder utilization.

In addition to this rather perspective outlook into a possible nuclear future, the path by which it is reached is also of interest, i.e. short- to medium-term development in the next 10 to 20 years. This period is characterized by decisions pending in the spent fuel management sector and overcoming acceptance problems.

Excellent operating experience with the world's approximately 300 working nuclear power plants have shifted the emphasis of negative attitudes to nuclear energy towards spent fuel management. Experience with commercial facilities is available, but spent fuel volumes have not previously required large plant units /2.1/. Closing the nuclear fuel cycle assumes a key position today in the train of an extended application of nuclear energy and with respect to acceptance of nuclear energy now associated with spent fuel management. The countries exporting nuclear power stations are therefore especially concerned to close any gaps in the nuclear fuel cycle still present in their own country in order to thus obtain competitive advantages. However, this is not to say that the countries exporting nuclear power stations will automatically take on supply and spent fuel management of the exported nuclear power stations; they only have the chance of additionally offering this in case of emergency.

A glance at Tab. 2.1 shows a survey of the fuel cycle activities of the most important nuclear exporters. In addition to current capacities (in each case the first line) plans for extensions within the next few years are also compiled. The Soviet Union, which largely provides supplies and spent fuel management for the Eastern Bloc, is not represented since there are no reliable data about its capacities. On the other hand, Japan has been included although it has not yet received any export contracts because its entry into the export market can be expected on the basis of its available know-how.

The advantages of the USA and France are clearly visible since, if Barnwell receives operating permission, they will have closed fuel cycles on a commercial basis at their disposal. The United Kingdom, Germany and Japan will admittedly be able to close gaps in their reprocessing sector, but nevertheless in the supply sector they will always be dependent on supplies of natural uranium or natural uranium deposits in the recipient country.

These five countries will at least determine nuclear transfer in the western world in the next two decades and will thus be responsible for the extent to which fissionable materials and nuclear technologies are exploited conscientiously and peacefully. This means that they must develop appropriate modalities and rules for nuclear transfer, and especially for spent fuel management, which must be valid over and above the national sphere. The more so, the less they are interested in undertaking spent fuel management of their exported nuclear power stations on their own territories. For example, the "20 GW rule" must be discussed again to the end that closing the fuel cycle may possibly already appear meaningful at an earlier point in the recipient country.

The criteria which could be decisive for this are discussed in detail in the following Chapters. The objective is by no means to capture export trade for the Federal Republic of Germany but rather to provide access to the peaceful uses of nuclear energy under non-proliferation conditions for all countries interested in nuclear energy and also to counteract in the long term any possible abuse which could be encouraged by refusing transfer of nuclear technology.

		USA	Canada	France	United Kingdom	Germany (F.R.)	Japan
Output of natural uranium	1981	17 100	8 400	3 700	-	-	-
(in t U/a)	~1990	14 100	14 100	3 200	-	-	-
Enrichment	1981	26 400	-	8 000	500	-	-
(in t SWU/a)	~1990	26 900	-	10 800	3 500	5 500	800
Conversion	1981	21 800	4 500	13 000	9 500	-	-
(in t U/a)	~1990	21 800	13 500	15 000	9 500	-	200
Fuel element fabrication	1981	3 280		800	100	870	
(in t/a)	~1990						
Nuclear power stations export	1981	20 937	2 429	5 541	-	7 511	-
(in MW (net))							
Reprocessing UO_2	1981	-	-	400	-	16	210
(in t HM/a)	~1990	1 500 (Barnwell?)	-	1 600	1 200	350	1 410

Tab. 2-1: Fuel cycle activities of the most important nuclear trading partners in the western world

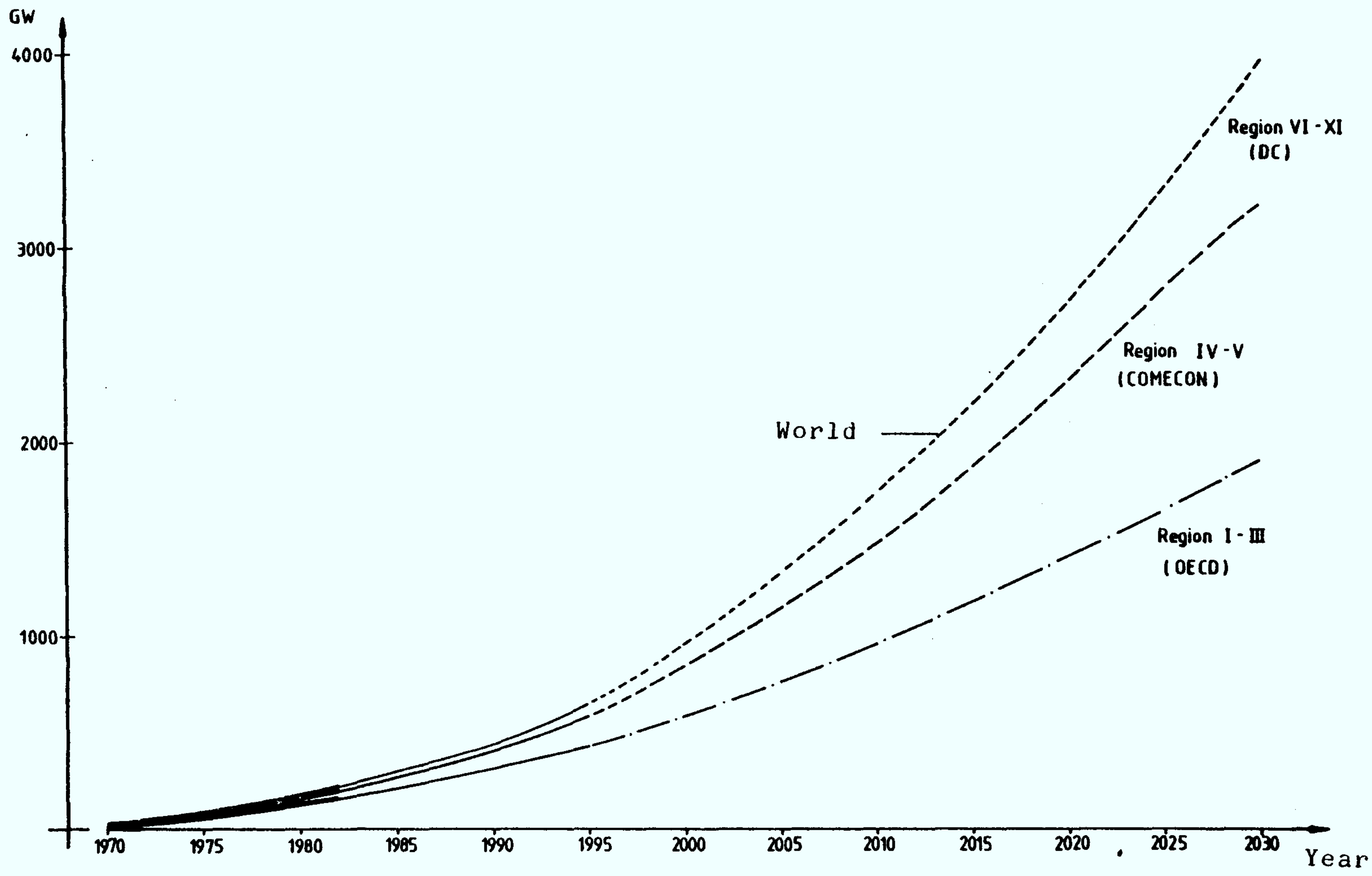
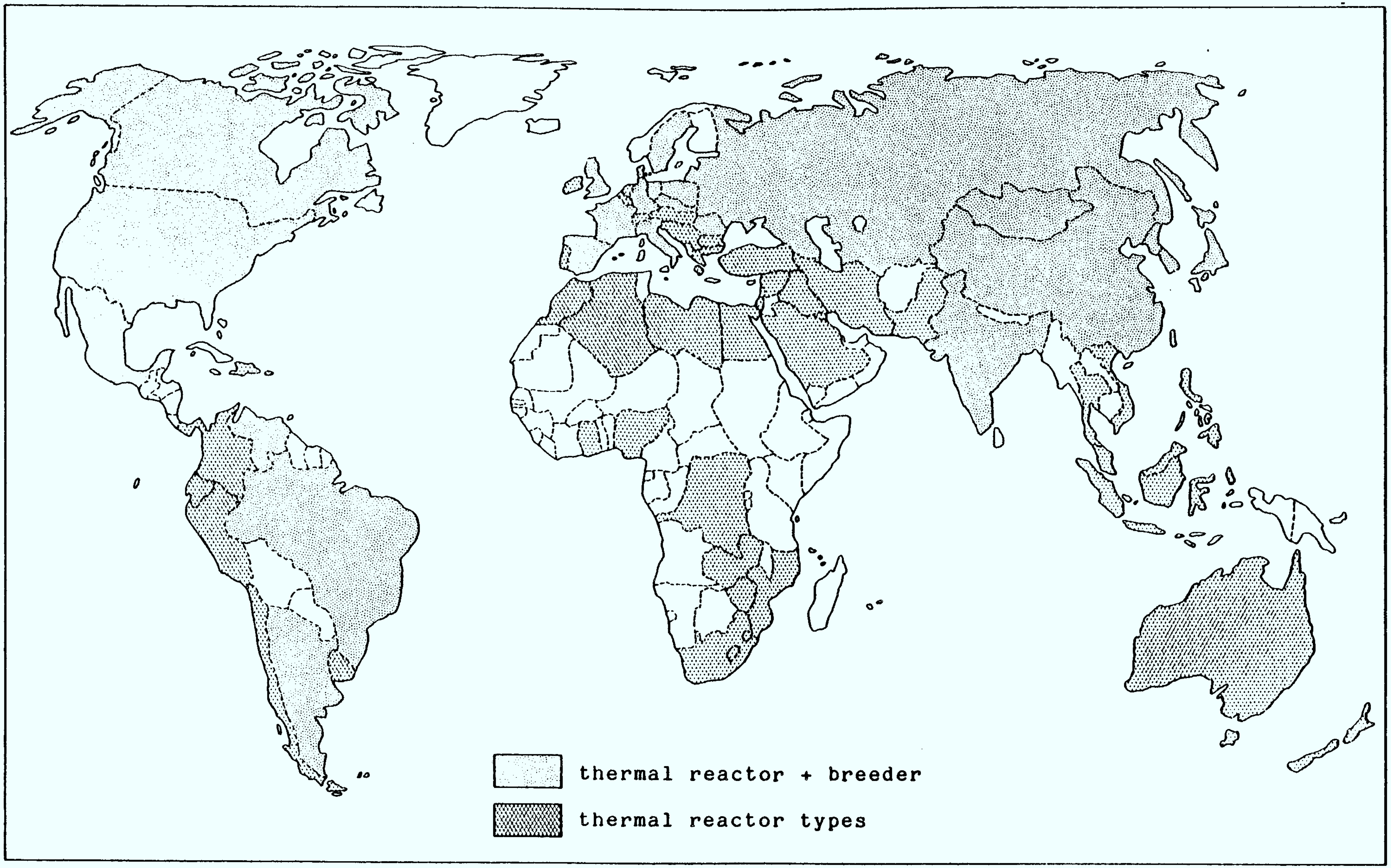


Fig. 2-1: Possible worldwide development of installed nuclear power station capacity within the next 50 years



. 2-2: Possible worldwide distribution of nuclear power stations in 2030

3. POLITICAL AND LEGAL BOUNDARY CONDITIONS (Existing International Mechanisms)

3.1 Introduction

The perspectives for the future global development of nuclear energy indicated above lead one to expect that the connection between peaceful and military uses can in future represent an important aspect of discussions about an appropriate world nuclear regulation. The more countries increasingly develop their own nuclear programs, the more urgently does the question arise about the possibilities of preventing horizontal proliferation. From this point of view it can be expected that in the coming years heated disputes will arise about whether and to what extent new international instruments will have to be created to contain the danger of new nuclear weapons states. The planners of future peaceful uses of nuclear energy have to account for these controversies to be expected. If this is neglected then the military aspect of nuclear energy could become the Achilles' heel of peaceful uses which could one day raise extremely difficult fundamental problems of further developing peaceful uses. On the one hand, the case of an actual increase in the number of nuclear weapons states must be considered and the possible resulting reactions of the international community. On the other hand, it must also be taken into account that the sensitization of the public to the problems of modern technology could be so extraordinarily advanced in future that even minimal aspects of the risks of such technologies could be pushed further and further into the limelight. From this point of view, the connection between peaceful and military uses also requires far-sighted planning.

Discussions in the past decade have adequately demonstrated how difficult and intricate the evaluation of this connection to the former is. Future considerations will have to be based on the practical results of these discussions. It thus also appears particularly significant for the subject of this study to represent recent developments in this problem area in context and to point out existing tendencies.

3.2 The Significance of Art. IV of the Non-Proliferation Treaty

It is to be assumed that the Non-Proliferation Treaty will also in future remain the central instrument of the international community in preventing the horizontal spread of nuclear weapons. More than 114 countries have signed the Treaty up to now; the most recent signatory is Egypt. In surveying the development in international relations in the postwar period, it can be established that the Non-Proliferation Treaty appears to be the global convention (apart from relinquishment of the use of force in the UN Charter) in which states have accepted the most far-reaching losses of national sovereignty; this is true both of the relinquishment of weapons acquisition as well as of the acceptance of the safeguards system agreed upon in the Treaty. This development seems all the more remarkable since these losses naturally do not affect all countries but only those who have not yet detonated any nuclear weapons. The Treaty has not yet been violated by any state. Admittedly the fact remains that a number of states, whose accession would seem particularly urgent from an international point of view because of their status as nuclear threshold countries, have not signed the Treaty. How problematic the boundary conditions agreed upon in the Non-Proliferation Treaty appear in retrospect can be seen from the fact that at the second review conference in 1980 the member states were unable to reach any joint communiqué with a factual content; the most important points of contention at the conference were the tardy progress of the nuclear weapons states' efforts at disarmament mentioned in Art. VI of the Treaty, as well as the insufficient transfer of nuclear energy to the developing countries.

The role of the peaceful uses of nuclear energy within the regime of the Non-Proliferation Treaty is regulated in Art. IV of the Treaty. This regulation requires closer elucidation since the connection between military and peaceful uses of nuclear energy is continually made in international discussions and in this respect Art. IV contains the pertinent regulation.

Art. IV shares in the binding nature of the Treaty as a whole under international law. An analysis of the wording and history of its origins does not reveal any arguments to the contrary. The Federal Republic of Germany in particular emphasized the binding nature of Art. IV even before it came into effect.

As far as the content of the contractual obligations in accordance with Art. IV are concerned then considerable difficulties appear in their interpretation. The wording is chosen in such a way that a clear definition of the contractual obligations hardly seems possible. It can on the one hand certainly be determined that Art. IV cannot be interpreted in such a way that by Art. IV countries are entitled to free access to nuclear technology existing in the states under obligation. However, on the other hand it can also be safely said that it would be contrary to the terms of the Treaty if a state under obligation were to absolutely refuse all cooperation with third countries in the field of nuclear technology (or an essential section thereof). There are also especially good reasons in favour of an interpretation according to which a state under obligation is forbidden by Art. IV to arrange international cooperation under exclusively commercial aspects. Only such an approach assigns the independent obligation to cooperation to Art. IV which was to be contained in this regulation according to its wording and intention. In practice, the NPT signatories have only abided by this rule to a limited extent so far. However, it cannot be assumed that the contractual obligations have changed in view of this practice.

In evaluating the Non-Proliferation Treaty from a German point of view particular attention must be drawn to the fact that Art. IV of the Treaty does not only oblige the nuclear weapons states but also all contracting parties who "are in a position" to undertake the cooperation mentioned in Art. IV. This therefore also includes those non-weapon states who already have a developed peaceful nuclear program at their disposal.

3.3 Possible Further Developments in the Safeguards System

3.3.1 Introduction

The central position of safeguards as measures for preventing proliferation has been featured again and again in various international discussions, such as for example the INFCE Conference. Nevertheless, attention has also constantly been drawn to the limitation of the technical possibilities of IAEA international safeguards. According to the various model agreements, IAEA safeguards are not designed to physically prevent a diversion or misuse of nuclear material but rather only to detect a diversion and thus to give a political mechanism consisting of suitable sanctions the opportunity to intervene. Particular significance is attributed to the aspect of deterrence which is provided by the risk of discovery.

The IAEA has always been able to refute in detail any accusations about its effectiveness /3.1/. Thus no anomalies have been stated in the annual IAEA Safeguards Implementation Reports up to now /3.2/. Recent problems arising in safeguarding a Pakistani facility are based on the inadequacy of older safeguards agreements and not on the limited technical possibilities of safeguards themselves. For example, camera systems as required by the IAEA to be established in the Pakistani facility have already been applied for a considerable time e.g. for monitoring German nuclear reactors /3.3/.

Two sets of problems from recent safeguards discussions are to be analysed in this Chapter. Firstly, the demand is made in connection with the Iraq affair that the monitoring range of safeguards should be extended /3.4/. Namely, in addition to current inspection models, in particular the processing of undeclared nuclear material in clandestine facilities should be made discoverable by suitable detection systems. The inherent problems of these general demands for implementing the model agreements will be discussed in detail. In the second section the potential of technical improvements in the nuclear material accountancy (NRTA) and extended containment & surveillance sectors will be dealt with.

Real-time-accountancy systems make use of process data in order to achieve short-term statements about the flow and distribution of nuclear material in a facility. So-called extended containment and surveillance systems monitor whole sections of the facility by means of electronic sensors such as motion detectors or camera systems. The objective of these recent improved measures is in particular reduction of inspection effort in large sensitive process facilities for enrichment and reprocessing.

3.3.2 Credibility and Technical Solutions

The question of whether international safeguards can ensure a credible deterrent against proliferation on the basis of the peaceful uses of nuclear energy has been present throughout their existence. However, this problem has dramatically stepped into the centre of political and public interest with the events in Iraq. Within the framework of discussions on increasing the effectiveness of present safeguards a series of suggestions have been put forward which are particularly intended to improve the technical elements of safeguards.

These comprise:

1. Further development of measuring, monitoring and control instrumentation and their demonstration to the IAEA.

2. Quantification of safeguards goals: The concept of significant quantities of nuclear material and the timely detection of a diversion is converted into numerical values and should serve as the basis for the conception, implementation and evaluation of safeguards systems.

3. Development of an evaluation method: Systematic approaches shall be compiled towards an objective evaluation for the comparison of safeguards systems.

4. Quantification of effectiveness: As a part of Point 3 the detection probability for all possible diversion

scenarios shall be analysed and evaluated on a plant-specific basis.

5. Development of future safeguards approaches for sensitive facilities: The established safeguards measures of material accountancy and containment & surveillance are to be both extended and intensified in order to be able to cover the quantified safeguards goals for facilities with a large throughput.

6. Extension of the scope of safeguards: The technical task of NPT Safeguards consists of verifying the presence of nuclear material subject to safeguards. This is essentially laid down in Para. 29 of INFCIRC/153 where nuclear material accountancy is taken as the safeguards measure of fundamental importance. Considerations concerning the introduction of new measures, such as monitoring pipelines at the perimeter of the process area, monitoring operating parameters not directly related to the flow of nuclear material (process monitoring), as well as rapid process inventory taking, indicate the beginning of a tendency going beyond pure nuclear material safeguards into the plant monitoring sector.

7. Considerations with respect to undeclared nuclear material: Demands for including undeclared nuclear material in the diversion scenarios is closely connected to the problem of misusing facilities.

So-called near-real-time-accountancy can be mentioned as an example of a purely technical solution. In process facilities with a large throughput of sensitive material (reprocessing plants, MOX fabrication plants etc.) there are doubts about sufficient sensitivity with respect to the timeliness of detecting the diversion of a significant quantity of nuclear material by annual inventories alone. Intensive studies are currently being undertaken to establish the extent to which this situation can be improved by process inventories repeated at brief intervals. The boundary condition is that plant operation must not be impaired in any way (principle of non-intrusiveness). This generally presupposes additional process instrumentation as well as closer cooperation between operator and inspector in order to guarantee the credibility of the data provided by the operator.

Previous model studies show that such methods could ensure improved safeguards effectiveness with respect to detecting abrupt diversions of significant quantities and that they would also be in a position to provide valuable indications about protracted, systematic material losses. This latter characteristic is also of particular interest from the aspect of operational process monitoring (criticality control etc.) /3.5/.

A second example is given by the increased application of c/s measures as closed systems for monitoring large process areas. These so-called penetration monitoring systems should be designed in such a way that all relevant diversion paths leading from a defined facility sector are covered by suitable instrumentation. However, there are currently problems in the practical availability of reliable c/s instruments tested and accepted by the IAEA. There are moreover some conceptual problems, as for example the logical impossibility of recognizing all diversion paths as such and monitoring them. The present tendency is to proceed with the development and application of new, improved c/s equipment, but to continue to consider their application as supporting the fundamental measure of material accountancy. No other method is possible since in the case of a c/s alarm, accounting procedures may, under certain circumstances, become necessary again.

3.3.3 Disadvantages of Purely Technical Solutions

All approaches for improving and further developing international safeguards must be oriented towards the political boundary conditions before introducing technical solutions. Problems of a legal and conceptional nature which could jeopardize the whole safeguards system and its objective must always be included in detail when determining new criteria.

One of these problems has already been implied; namely the approach of changing nuclear material safeguards towards plant control. Other suggestions mentioned above also require critical commentary.

From the point of view of systems analysis, it is extremely important to have available quantified safeguards goals, i.e. significant quantities and timeliness criteria. Inspection frequencies, measurement accuracies required for the accountancy system, statistical sampling plans for verification etc. can be planned and determined on the basis of these types of quantity. However, if these quantified goals are used as an absolute yard stick which has to be achieved as part of a safeguards system then the credibility of safeguards can also be questioned in future if, for example, tightened safeguards goals are applied to a whole state and not to a single facility. Assuming this it is therefore understandable that a safeguards system will be neither credible nor feasible today or in future. Similar conditions result for large reprocessing plants with a high annual throughput of nuclear material where the inaccuracy involved in drawing up a balance far exceeds the goal quantity. To conclude from this that such facilities represent a proliferation risk and therefore should not be constructed or operated is a conclusion which has already been drawn in the past by various parties and which has been refuted in detail within the INFCE Study /3.6/.

Methodologies for evaluating and quantifying safeguards effectiveness could be especially advantageous if various safeguards concepts are to be compared with respect to their inspection and instrumentation effort. However, the limitations of such methodologies must also be clearly defined here. Thus for example in large process facilities in the nuclear fuel cycle an open end to diversion strategies arises with continually growing technical complexity. Quantification of the probability of detecting anomalies which are connected with such abuse strategies, as well as the effectiveness of corresponding countermeasures to expose these strategies is an extremely difficult systems analysis problem since a large number of subjective elements also have to be included. In conclusion it can be said that although progress has been made in the nuclear material accountancy sector in quantifying the goals, c/s measures are still in their initial stages /3.7/.

If one summarizes considerations on evaluating effectiveness then it becomes apparent that if a state is sufficiently motivated and has the appropriate capabilities available then it can acquire strategic nuclear material. It is therefore doubtful whether a rigorous and systematic documentation of all conceivable diversion strategies, as demanded for all sensitive facilities under IAEA safeguards, is meaningful and whether the general non-proliferation framework would not thus be exceeded for the IAEA. Safeguards can be regarded here as an applied science which is in a situation similar to that sometimes occurring in other fields of science, namely that theoretical considerations obscure practical experimental facts. Thus for example international IAEA working groups of experts are discussing possible detection of diversions through containment boundaries instrumented with the most varied conceivable monitoring instruments, but which ignore the fact that current containment-surveillance systems available to the IAEA are limited to simple cap-and-wire seals and film cameras.

Proliferation scenarios based on undeclared nuclear material in safeguarded facilities must consider two aspects. On the one hand, it can be convincingly stated that the credibility of safeguards can be increased if one takes the possible misuse of a commercial facility with undeclared nuclear material into consideration. On the other hand, however, the imputation of these scenarios can cast doubt upon both the general objectives of safeguards as well as the technical basis with which safeguards goals can be achieved. The introduction of undeclared nuclear material into a safeguarded facility is of minor significance if one considers that it would be much simpler for a state to produce weapon-grade nuclear material in a clandestine facility. If undeclared nuclear material is to be considered in a safeguards system for an NPT signatory state then Para. 29 of INFCIRC/153 which designates nuclear material accountancy as a safeguards measure of fundamental importance seems to be completely meaningless. Material accountancy can only be employed for declared nuclear material, concealed sources of undeclared material channelled into a facility cannot in principle be detected by accountancy measures. Nevertheless, containment/surveillance measures, already employed to simplify accountancy, permit a solution of these problems under certain circumstances.

A similar problem, connected with that of undeclared nuclear material, is so-called borrowing of nuclear material. Such nuclear material is "borrowed" from a safeguarded facility, converted into a weapon-grade form in a safeguarded process facility and subsequently used for military purposes. The demand for inclusion of so-called borrowed nuclear material in diversion scenarios, particularly associated with reprocessing and enrichment facilities, would lead to the design of a double safeguards system for this type of nuclear material. Firstly in the facility from which it was originally diverted, and secondly in the facility where it was reprocessed for military purposes.

Non-proliferation transparency can be increased by additional information obtained throughout the whole fuel cycle. A closed fuel cycle with corresponding reprocessing would thus have advantages. International relations within the framework of multinational cooperation could also have a part to play here by taking the safeguards credit of such models into closer consideration. The problem is, however, the extent to which considerations of this kind can actually be included in the legal framework of INFCIRC/153 or e.g. in negotiations on facility attachments.

The safeguards agreement INFCIRC/153, which forms the basis of all bilateral agreements concluded by NPT signatory states, defines the tasks of safeguards as follows:

".. The timely detection of diversion of significant quantities of nuclear material from peaçeful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown and deterrence of such diversion by the risk of early detection."

It becomes apparent that this goes beyond the purely technical task of detecting a diversion by also including deterrence due to the risk of detection for a potential divertor.

The risk of detection could be simply defined as the product of the probability of detection and the consequence of detection. The second factor in this definition has not yet been quantified and therefore the IAEA only allocated a value to the first factor, namely probability of detection, in its provisional quantifications of safeguards goals. 90 - 95 % is currently assumed. The consequences of detecting an NPT violation for a highly developed non-nuclear weapon-state with a multiplicity of international obligations in the economic and trade sector must be regarded as very serious. The risk of detection for such a state must therefore also be regarded as high even if detection probabilities are low, regarded in absolute terms.

It therefore appears that technical improvements and systems analyses in the safeguards sector are feasible, necessary and meaningful. However, it must be remembered that the safeguards system should be exclusively limited to the verification of declared material and information. If this assumption is not made and this safeguards limit is exceeded then suggestions of improvements which were originally intended to increase the credibility of safeguards could have the opposite effect; namely, safeguards objectives and the technical instrumentation available can no longer be brought in line.

By way of summary, it can thus be established that:

1. Every member state of INFCIRC/153 is obliged in principle to declare all sensitive material; exceptions are only valid if this is envisaged in INFCIRC/153.

2. Only materials entered in the inventory list - compiled in accordance with § 41 INFCIRC/153 are subject to safeguards by the IAEA; INFCIRC/153 envisages a special procedure in § 73 for the case that a state does not declare material subject to safeguards.

3. Within the framework of routine inspections, the inspectors only have right of access to those strategic points which have been expressly agreed upon between the IAEA and the member state. Within these strategic points the inspector's inspection right also refers to commercially sensitive points.

4. It is the IAEA's task to detect diversion of nuclear material. Physical prevention of diversion by the IAEA is not envisaged, neither is it feasible. The IAEA has fulfilled this task in an excellent fashion.

3.3.4 Object and Extent of IAEA Safeguards Rights in Accordance with INFCIRC/153

A legally watertight analysis of the questions mentioned in certain documents /3.8/ about the extent of IAEA rights in accordance with INFCIRC/153 must separate three problems from each other. The documents mentioned above mix up these questions to some extent which in part considerably impairs the clarity of the statements.

1. Must a signatory state declare all special fissionable material to the IAEA in the sense of § 112 INFCIRC/153 or Art. XX of the IAEA Statute?

2. Which materials are subject to the IAEA's safeguards authority?

3. In what manner is the IAEA authorized to fulfill its safeguards obligation?
   In particular
   a) Can the IAEA also operate in those areas of a facility subject to safeguards where, according to specifications from the contracting state, there is no declared material?

   b) Can the IAEA also operate in those areas of a safeguarded facility in which, according to the specifications of the contracting state, there is indeed declared material but safeguards are not necessary in these areas in order to exercise control functions?

   c) Can the IAEA also operate in those areas of a facility subject to safeguards in which there is declared material but which, in the view of the contracting state, should not be accessible to the IAEA inspectors for reasons of protecting commercial know how?

There is no unambiguous statement about material to be declared in INFCIRC/153. § 1 determines that "all source or special fissionable material in all peaceful nuclear activities within (the state's) territory, under its jurisdiction or carried out under its control anywhere" should be subject to IAEA safeguards; the formula "in accordance with the terms of the Agreement" is appended. § 1 concerns, according to its title, the "Basic Undertaking" of the signatory state; § 2 ("Application of Safeguards") similarly determines the material subject to safeguards. § 7 makes use of the clause "all nuclear material subject to safeguards under the agreement".

§ 40 ("Subsidiary Arrangements") determines that the control activities of the IAEA should refer to "the nuclear material listed in the inventory provided for in § 41"; however, § 41 itself only picks up the formula "all nuclear material in the State subject to safeguards under the Agreement" again. Finally, a regulation also of significance in the present context is to be found in § 51, according to which the state must also inform the IAEA about any material outside the facilities. This material is also subject in principle to safeguards according to § 51.

Provisions concerning material not subject to any safeguards are to be found in § 36 ff. Four categories are formed:

(a) Material which is applied in certain instruments,
(b) material which, in a permissible fashion according to § 13, is applied for non-peaceful uses,
(c) plutonium at a certain concentration and
(d) slight quantities of material more closely defined in § 37.

Furthermore it must be remembered that in accordance with § 2 the purpose of safeguards is to establish that the monitored material is not employed for the construction of nuclear weapons or explosive devices. If one regards the pertinent standards depicted here as a whole then there are good reasons for saying that all sensitive material must be declared. This is particularly indicated by the fact that INFCIRC/153 intends in principle to subject all material to safeguards and that exemptions are separately listed. This technique of rule and exception generally indicates that exceptions to the rule are only considered where this is expressly envisaged. This is especially to be assumed where the exemptions are enumerated. The consequent assumption of an obligation to make a complete declaration is finally also supported by the purpose of IAEA safeguards expressly mentioned in INFCIRC/153.

3.3.5 Which Materials are Subject to the IAEA's Safeguards Obligation

According to § 40 INFCIRC/153 already mentioned, all materials listed in the inventory provided for in § 41 are subject to safeguards. This inventory is to be compiled by the IAEA in the initial phase and afterwards to be adjusted to the current situation. All "nuclear material subject to safeguards under the Agreement" (§ 41) is to be listed.

The term "nuclear material" is defined in § 112. This regulation refers to Art. XX of the IAEA Statute which precisely defines the concepts "special fissionable material" and "source material". In this context it must also be noted that § 107 also contains its own definition of the term "inventory change" which assists in determining the extent of the member state's obligation to report to the IAEA in accordance with § 62 ff. It thus appears that the categories of material mentioned in § 107 must be included in determining the extent of the obligation to provide reports; the concept of "nuclear material" in the sense of Art. XX of the Statute becomes particularly concrete in § 107.

In interpreting § 41 the question arises of the treatment of those materials which are subject to safeguards according to the agreement between the IAEA and the signatory state, but which nevertheless are not included in the inventory compiled in accordance with § 41. The wording of § 40 indicates that only those materials actually included in the inventory are subject to IAEA safeguards. It could be objected in the sense of a teleological interpretation that all materials in the sense of § 112 (with the exemptions mentioned) are to be included in the inventory and consequently thus also subject to safeguards. This argumentation does not, however, appear to be compelling. In order to clearly delimit IAEA safeguards authority, the formulation of INFCIRC/153 has apparently been selected in such a way that the object of safeguards is beyond doubt. This consideration also offers an explanation for the fact that precisely in § 40 the object of safeguards is not described by the formulation "all nuclear material subject to safeguards" otherwise used in many passages in INFCIRC/153.

According to this interpretation, the source of cooperation between the IAEA and the signatory state should be that this cooperation is based on the contracting partners' mutual confidence and thus there is no reason to assume that the signatory state should not declare material subject to safeguards. An approach of this type may seem legally and politically doubtful from the perspective which allocates an absolute control function to the IAEA and views information from the signatory state mistrustfully from the very beginning. On the other hand, the fact must not be ignored that every member state voluntarily subjects itself to IAEA safeguards and therefore this can and must presume a certain trust in its readiness to cooperate.

Whether the solution found in § 40 of INFCIRC/153 in the sense of the above interpretation presents the proper mean between confidence and distrust from an international standpoint is a question of political appraisal. The authors of INFCIRC/153 apparently replied in the affirmative. Furthermore, the fact must not be ignored that §§ 18-22 are exclusively concerned with cases of settling disputes and possible treaty violations. Moreover, in the case of behaviour contrary to the Treaty the member states are entitled to impose permissible sanctions - in accordance with general international law.

In this context attention must also be drawn to the "special inspections" envisaged in § 73 in case a state apparently does not fulfill its contractual obligations by not making the necessary information available to the IAEA. If material subject to safeguards were not declared then this would also represent a case of information deficit for the IAEA. Procedure in such a case is especially laid down in § 77. This pattern of regulation supports the interpretation of § 40 as given above.

3.3.6 How is the IAEA Authorized to Exercise its Safeguards Responsibilities

The objective of safeguards is described in § 71 ff. This serves to revise the original report and changes occurring later. Apart from the objective of safeguards, INFCIRC/153 expressly regulates the extent of safeguards in § 74 and 75 and in § 76 the question of IAEA inspectors' right of access. § 76 envisages various regulations:

(a) for controls in connection with the export of material subject to safeguards,
(b) for controls before concluding so-called Subsidiary Arrangements and
(c) for routine controls, which are primarily discussed here.

In accordance with § 76 (c), the inspectors' right of access during routine inspections is limited to the so-called strategi points and to the records to be kept by the signatory state. The strategic points are abstractly defined in § 116 as those points in a facility whose monitoring "under normal conditions" ensures the information necessary for implementing safeguards. It must be noted here that the purpose of safeguards is to verify the presence of nuclear material. According to the regulation system of INFCIRC/153, the definition of concepts in § 116 is, however, not directly applicable to safeguarding of a specific facility. The strategic points are rather determined by the IAEA in every individual case for each facility on the basis of facility-specific data (design information) specified in the so-called Subsidiary Arrangements. The IAEA decides in detail on the location of the strategic points at due discretion after consultation with the safeguarded state.

The special feature of the regulation of access rights in INFCIRC/153 results from the fact that inspectors are limited to the locations of the strategic points as laid down in the relevant "Subsidiary Arrangement". This legal regulation is basically quite clear: it undoubtly results from the fact that § 76 (c) expressly determines that the inspectors only have access to these points.

Neither can it therefore be assumed that INFCIRC/153 has a loophole in its regulation system. The special rule in § 73 for "special inspections" draws particular attention with respect to the area of access for inspectors that such "special" inspections can also include areas outside the sections of the facility accessible for routine inspections. The prerequisites for "special inspections" are also clearly determined in this respect in § 77.

The significance of the existence of commercially sensitive areas in a safeguarded facility for the inspectors' right of access must be discussed here. The starting point for this discussion must be the fact that regulations on inspections do not indicate any restrictions for commercially sensitive areas. A compromise between the IAEA's safeguards responsibility on the one hand and the commercial interests of the safeguarded facility on the other can, in accordance with § 46, be achieved by an agreement between the IAEA and the safeguarded facility, before beginning safeguards activities, about certain areas to be exempted from safeguards due to commercial sensitivity. It must be noted that § 46 (IV) says that such areas "may be established". It can be seen from this wording that the safeguarded state has no right to insist that the IAEA exempt certain areas from safeguards. It can rather be presumed that it rests upon the due discretion of the IAEA to create and designate exempted areas.

It is doubtful whether the previous competences and structures of the IAEA are appropriate to undertake in future all essential international tasks in the sphere of nuclear cooperation. If the peaceful uses of nuclear energy continue to develop then the associated transfer of technology to non-weapon states will have to lead to new efforts in the safeguards field. Even if the IAEA were to have more resources available in future to employ in fulfilling its tasks, nevertheless it cannot be expected that the IAEA will thus be in a position to deal globally with all the problems of storing sensitive materials associated with the back end, or even the supply of fissionable material. The IAEA will also have to encourage international cooperation in future; this would by no means justify designating increased efforts at international cooperation in the back-end sector as unnecessary or superfluous.

3.4 Prior Consent in Present International Nuclear Policy

Apart from negotiations about an IPS, the reorientation in international nuclear policy since 1977 has largely been embodied in the uranium supplier countries' demands for a contractual guarantee of so-called prior consent regulations. EURATOM has concluded contracts with prior consent agreements with two main suppliers to date, Canada and Australia, the agreement with Canada /3.9/ dates from 18th December, 1981, the agreement with Australia /3.10/ was concluded on 21st September, 1982. There is not yet any relevant agreement between EURATOM and the USA, although demanded in the NNPA.

It must also be noted that agreements of the prior consent type have not only been made in the past few years. Even in previous decades corresponding clauses were found in international treaties. Nevertheless, it must be stated that the particular design and interpretation of these agreements have changed quite considerably in the past few years. Whereas in earlier contractual practice prior consent in effect only demanded the applicability of already existing, precisely formulated agreements to subsequent utilization after the initial use, the special feature of more recent prior consent regulations is to be found in the fact that the supplier country examines in each individual case the conditions for granting authorizations for the reprocessing in question in the sense of its national legislation or at least makes agreement to further utilization dependent on the continuation of a certain situation in energy policy.

The main point of the demand for prior consent is the effort of the supplier countries to ensure the peaceful uses of material sold by them. Admittedly, the countries concerned regard these efforts as intensified by accedence of the recipient state to the NPT, however, they wish to receive further bilateral assurances from the recipient state about utilization of the material supplied over and above obligations resulting from the NPT. It can thus be concluded that the basis for these prior consent demands is to be regarded as a certain distrust of the comprehensive efficiency of the NPT in implementing NP policy. The pertinent demands of the supplier states refer in detail to (a) preconditions for enrichment of uranium in the recipient state, (b) preconditions for reprocessing nuclear material in the recipient state and (c) transfer to a third country by the recipient state of material supplied.

The recent practice of prior consent in effect involves considerable practical consequences for trade; particularly the uranium trade. For a number of economic and political reasons, the recipient states have recently been attempting to diversify their sources of supply. Due to the variety of supply conditions and licensing stipulations according to prior consent this means in practice that the recipient states have to separately treat and label the uranium supplied depending on origin and supply conditions. This has administrative and financial disadvantages for the recipient. Particular complications arise if supply conditions from two or even more countries are applied to one and the same material. This is in practice by all means possible if, for example, uranium is taken from the country of origin to a different country and enriched there, and both countries contractually implement prior consent regulations with respect to the recipient state.

The agreement with Australia subjects all transfer of material to third states to an approval proviso on the part of Australia (Art. IX), the same is true of relations with Canada /3.11/.

With respect to the enrichment of uranium supplied, both agreements differentiate between enrichment to above or below 20 %. Enrichment to more than 20 % requires the approval of the supplier country /3.12/. It is agreed in both contracts that particular arrangements will be made about conditions under which such enrichment can take place. Publications with respect to this have apparently not yet appeared.

In both agreements reprocessing is similarly subject to obligatory approval /3.13/. Canada authorized reprocessing after the EEC had disclosed its current and planned nuclear energy programme to Canada in accordance with Item 2E. This includes the detailed description of political, legal and statutory elements concerning reprocessing and plutonium storage and utilization. The EEC must in future inform Canada of modifications to all data contained in this description; Canada will reexamine its authorization with each change. The agreement does not specify in detail those modified conditions under which authorization can be withdrawn.

In this connection it is remarkable that in Item 4 of the Canadian agreement the EEC is even contractually committed to "special measures necessary for separation, storage, transport and utilization of plutonium"; among these is also an "effective and internationally accepted international system of plutonium storage".

In the Australian agreement, requirements on the admissibility of reprocessing are laid down in Appendix C. Art. 1 Item. a determines reprocessing for the purpose of utilizing the energy content or management. Such reprocessing is conditional upon a certain nuclear fuel cycle programme. This is apparently described in an executive order unpublished to date.

In this respect the agreement follows the Canadian pattern; admissibility of reprocessing is coupled to the fuel cycle in question, authorization being granted for the current cycle.

Art. 1b of the Appendix envisages storage of the separated plutonium under IAEA safeguards. Finally, Art. 1c determines that special authorization becomes necessary for reprocessing if this is to serve purposes other than those mentioned in Item a.

The agreement with Australia also records (admittedly only in the preamble) the desire of the parties to demand an "effective and generally acceptable international system of plutonium storage".

The 1963 agreement between EURATOM and the United States of America, the revision of which is demanded by the NNPA, still currently remains unchanged in the field under discussion here. Admittedly, it cannot be ruled out that a new understanding on the future nature of the agreement will be achieved before long. In this context it is of significance that the US State Department made known in a statement of 9th June, 1982 /3.14/ that nuclear cooperation will in future not be completely excluded even for those states which reprocess spent materials. The statement says: "... the President has decided that in certain cases, the United States will offer to work out predictable, programmatic arrangements for reprocessing and plutonium use for civilian power and research needs, in the context of seeking near or amended agreements as required by law". The statement said that thus under certain NP requirements, it was possible to cooperate with states with "advanced nuclear power programs". Finally, it is also expressly emphasized that the USA no longer requires its consent in each individual case for every uranium shipment, but rather that approval can now be generally given for "specific, carefully defined programs". As a result it can therefore be expected that in its future contractual practice the USA will seek settlements similar in pattern to the EURATOM agreements with Canada and Australia.

If one puts the two agreements and the currently emerging position of the USA in the context of recent international discussions of international nuclear policy then it immediately becomes apparent that they have the nature of a compromise. The international prohibition of reprocessing and enrichment, which had been discussed for a time on the part of the supplier countries, could not be contractually implemented. On the other hand one must not fail to realize that quite considerable further development in international contractual practice can be seen in these agreements. There is a clearly visible tendency in both agreements for the supplier state to make the admissibility of reprocessing conditional upon the current state of the nuclear energy programme and details of the fuel cycle programme. Viewed globally, this pattern of regulation enables supplier countries to differentiate with respect to the admissibility of reprocessing depending on the requirements of the recipient country in question. This approach implies a rejection of the attitude that all recipient states have to be subjected to the same criteria with the same result for reasons of non-discrimination, irrespective of their energy requirements and their special situation.

It can currently be assumed that the supplier states concerned will retain their authorization stipulations in the near future; namely, this prior consent represents in many respects the basic principle of national regulations concerning the export of sensitive materials and facilities. There is much evidence that the practice described above will only change if common approaches are internationally developed which could make the implementation of the one-sided national conceptions of the supplier countries partially or completely irrelevant.

3.5 International Nuclear Policy Through National Legislation: A Brief Evaluation of the NNPA

From its very beginning the nuclear policy of the United

States of America can be characterized by the "parallelism and competition" of multilateral agreements and unilateral, national measures established in it.

The USA's Atoms for Peace initiative was supplemented by the establishment of the International Atomic Energy Agency (IAEA) instigated by the USA. Its competence has, however, been limited by national American legislation. Moreover, security agreements between the USA and its allies competed with the NP treaty.

This procedural parallelism became a problem for the international credibility of the USA when the USA comprehensively determined its internal and external nuclear policy by national legislation (NNPA) and at the same time demanded international negotiations on an international system inhibiting proliferation (INFCE).

This parallel approach can be evaluated as an expression of the fact that the United States is aware of its opportunities for exercising global influence, but that it does not want to recognize the dependence of its nuclear policy on changes and shifts in emphasis on the international nuclear scenario. Wolf Häfele formulated it as follows: "It must be acknowledged that the USA, consciously or unconsciously, continuously reverted to the position on which the conception of the IAEA was originally based: pursuit of the peaceful uses of nuclear energy under the primacy and control of the USA" /3.15/.

America's constant attempt to restrictively determine the international nuclear system single-handedly culminated in the NNPA (one of its main instruments, prior consent, is dealt with in 3.4 above).

Even if the Reagan Administration handles the tools of the NNPA more pragmatically and flexibly in its programme, nevertheless the legal apparatus still remains and could at any time offer a new administration a means for more literal application.

3.6 Threshold Countries and Non-Proliferation System

Political and economic considerations of reducing their energy dependence and placing their energy economy on a broader basis are in the forefront for the threshold countries of the Third World in deciding on utilizing nuclear energy. In the same way as most of the industrialized states, the threshold countries have not achieved this objective to the envisaged extent.

Within the framework of the international non-proliferation discussion, the threshold countries of the Third World are of the opinion that nuclear export policy since the mid-seventies in the form of unilateral conditions going beyond the NPT has placed the supplier countries in a position to exert influence on national energy programmes. This view is put forward both by countries who are signatories to the NPT as well as those who are not.

It has become apparent that some nuclear threshold countries in the Third World are technically and economically in a position to develop and realize their own nuclear programmes in the long term. Their desire to curtail the construction phase with the aid of western industrialized states does not, however, by any means reflect a willingness to accept unlimited NP restrictions again.

All threshold countries demand the unhampered development of national programmes for the peaceful uses of nuclear energy. This is considered as an important, almost symbolic, indicator of the state of their technological and economic development for these countries, and as an expression of national sovereignty.

Whereas a number of threshold countries are prepared to accept the NPT regulations as boundary conditions for their own nuclear policy, those threshold powers in the Third World who already currently have an advanced nuclear programme at their disposal reject their inclusion in this Treaty system.

Some of these states are prepared to subject their nuclear facilities to international safeguards in order to thus document the exclusively peaceful uses of their facilities. These international safeguards are not acceptable to other threshold countries. They thus cast doubt upon the development of an international non-proliferation system. With the conclusion of INFCE, a new concept was introduced into the international nuclear discussion with "Institutional Models". According to their definition, they comprise a large number of possibilities for cooperation - for example intergovernmental agreements, technical research and support programmes, international, regional and multinational institutions.

The objective of the technology-holding states in CAS and PUNE will have to be to offer the threshold countries solutions which increase proliferation barriers by deterrent or preventative measures, but which on the other hand improve and ensure the assurance of supply with nuclear materials, facilities and technologies to the same extent.

3.7 Committee on Assurance of Supply (CAS)

The Committee on Assurance of Supply was convened as a working committee by the Board of Governors of the IAEA after the conclusion of INFCE in 1980. All members of the IAEA can participate.

The CAS mandate assumes that supply assurance and non-proliferation cannot be considered and treated separately. The task of the CAS is therefore to work out clear, long-range terms of trade for supply assurance.

Nearly 50 states take part in the CAS proceedings. They represent almost all supplier and recipient states involved in trade with nuclear materials. This fact alone makes the CAS a qualified forum for an international exchange of views on the connection between the supply assurance and non-proliferation. Due to the broad spectrum of the CAS (supplier and recipient states, members and non-members of NPT, industrialized and developing countries) rapid progress and results cannot be expected. A positive aspect is that the CAS has been relatively free of north-south conflicts and has not been drawn in to the violent disputes of the past few IAEA general conferences either.

The following list summarizes statements on institutional measures as formulated by the states represented in the CAS in the opening session.

The left side of the Table assigns the participant states to military alliances, economic federations and non-proliferation arrangements.

On the right side are the institutional measures supported by the individual states (for IPS (1), for back-up arrangements (2), for a fuel bank (3), for regional or multinational fuel cycle facilities (4)), attitudes to safeguards and supply assurance (supply assurance complementary to NP conditions (5), safeguards only in the case of supply assurance (6), criticism of the suppliers' policy according to the London Guidelines (7)), to guaranteed access to technology (8) and to the application of full-scope safeguards. Columns (10) and (11) list the developing countries with advanced nuclear technologies and those just beginning to apply nuclear technologies.

3.8 International Conference for the Promotion of International Cooperation in the Peaceful Uses of Nuclear Energy (PUNE)

Within the framework of the United Nations, this Conference for the Promotion of International Cooperation in the Peaceful Uses of Nuclear Energy was demanded especially by the threshold and developing countries, but also by the non-aligned states.

PUNE will not take place as envisaged in Geneva the late summer of 1983, but rather only in 1984. The objective of

Tab. 3-1

Categories of Country

London Group	NATO	WP	EEC	Comecon	OAS	NPT	EURATOM		Institutional Measures 1	2	3	4	Safeguards Supply assurance 5	6	7	8	Nuclear activities in developing countries 9	10	11
					x			Argentina						x	x	x		x	
x						x		Australia		x			x						
x	x		x			x	x	Belgium					x						
					x			Brazil							x			x	
x	x					x		Canada					x				x		
x		x		x		x		Czechoslovakia								x			
	x		x			x	x	Denmark					x						
						x		Egypt		x	x	x	x			x			x
x						x		Finland					x				x		
x			x				x	France											
x		x		x		x		GDR				x	x			x	x		
x	x		x			x	x	FRG	x	x			x						
								India						x	x			x	
x	x		x			x	x	Italy	x				x				x		
x						x		Japan		x			x						
						x		Korea, Rep.				x						x	
					x	x		Mexico							x	x		x	
x	x		x			x	x	Netherlands	x	x	x	x	x				x		
								Pakistan						x	x	x		x	
					x	x		Peru											x
						x		Philippines		x	x		x						x
x		x		x		x		Poland					x						
		x		x		x		Romania					x			x			
								Spain		x									
x						x		Sweden					x						
x						x		Switzerland		x			x						
								Tunesia					x			x			x
	x					x		Turkey					x			x			x
x		x		x		x		USSR	x		x	x	x						
x	x		x			x	x	UK		x			x				x		
x	x				x	x		USA	x	x			x						
						x		Yugoslavia	x				x			x			
						x		Zaire											x

the Conference is to analyse the status and future of nuclear technology in all spheres of application. The main priority will be on problems of cooperation and support for the developing countries from the industrialized nations. In the committee preparing for the Conference various parties requested the peaceful applications of nuclear energy to be treated in all possible areas of application, beginning with energy generation, applications in agriculture and biology, up to medical uses.

It is to be expected that PUNE (like most UN conferences) will be strongly characterized by north-south problems. The developing countries will probably place the emphasis on whether the industrialized nations have complied with their demands in transferring sufficient know-how on nuclear technology, nuclear material and equipment.

The course and results of PUNE will undoubtedly be of significance as a halfway house before the next conference reviewing the NP Treaty.

Due to the wide spectrum of problems, it is also to be expected that aspects will be mentioned previously treated within the IAEA framework, especially in the Committee on Assurance of Supply.

Various delegations have therefore expressed the desire during preparatory sessions for PUNE that the IAEA should contribute to the programme both in the preparations as well as at the conference. The fact that on the fringe of CAS sessions the PUNE programme has been regularly mentioned in conversations between the threshold countries and industrialized nations would seem to favour such a procedure.

3.9 Interim Results

The course of the preceding deliberations has resulted in a complex picture with respect to the stability of international mechanisms for preventing horizontal proliferation. The starting point is the realization that the international community has so far undertaken - particularly within the framework of the NPT and the IAEA Statute - considerable, in many respects even unique, efforts in this field. The special feature of the current situation is that previous results continue to be very differently evaluated in the global context by important protagonists. Whereas the industrialized nations supplying uranium, under the aegis of the USA, are pressing for an intensification of previously created mechanisms, countries in the Third World particularly significant from an NP point of view consider the previous mechanisms too rigorous and thus unreasonable. This stage of development makes it obvious that the search for novel forms of international cooperation will have to be intensified in future. The objective of these efforts will have to be the inclusion in new concepts on the one hand of different demands for effective NP measures and on the other hand of supply assurance. Primarily from this perspective has the idea of "Institutional Models" been considered and recommended in the INFCE. The definition of these models as well as their possible practical form has not yet been conclusively discussed, but in view of present tensions in international nuclear regulations they will require closer consideration in future.

4. STATUS OF DISCUSSION FOR INSTITUTIONAL MODELS

4.1 Introduction

The subsequent activities in connection with the INFCE negotiations, especially in the Federal Republic of Germany and the USA, resulted in various suggestions in the field of international nuclear cooperation as measures for hindering proliferation, complementary to international safeguards. It was presumed that the danger of proliferation emanated in the first place from activities in the reprocessing and enrichment sectors, which the important industrialized states did not want to dispense with, in spite of the vote of the then US Government, with a view to assuring their energy supply.

However, it has in the meantime appeared that particularly in the back-end sector two sets of problems need to be treated on a priority basis. These are the interim storage of spent fuel elements and the storage of separated plutonium.

Two basic papers on international cooperation models are introduced in the following, an American and a German study, insofar as they are relevant for the further institutional developments to be discussed in Chapter 5. After this considerable attention is paid to the description and evaluation of the present status of discussions on the International Plutonium Storage System (IPS). The present Chapter closes with a brief description of the state of discussions on the international management of spent fuel elements from nuclear power stations (ISFM).

4.2 The CUSTODY Model

On the part of the USA, an approach for international nuclear cooperation was investigated in a study /4.1/ which at first sight seems to have great similarities with the objectives of the European Atomic Energy Community (EURATOM). In the following this cooperation model is compared with EURATOM.

In evaluating the study and the "custody authority" suggested in it, it is of essential significance that the operating state should only be able to remove sensitive material from the plants with the approval of the authority. Preconditions for this approval are to be previously determined. The authority should therefore also verify that after granting approval the material is used in accordance with the specifications given to the authority by the operating state.

The study avoids delineating the release criteria in detail. It is merely said that this will involve "one-time release based on end use". Moreover, the study explicitly leaves the question unanswered of whether particular types of application for sensitive material (such as reutilization of plutonium in light-water reactors) should generally be excluded from the envisaged model.

Correspondence of the Custody Model with the EURATOM Structures

1. Regionalization of NP Efforts

   A basic concept of the custody model is the attempt to regionalize efforts at non-proliferation of atomic weapons. This concept of effectively assuring international agreements by intensified cooperation within a homogeneous group of states is actually realized by EURATOM.

2. Complementary Safeguards by IAEA and Regional Organization

   A further important parallel between the custody model and EURATOM results in that both systems envisage safeguards measures by the regional organization. These safeguards are conceived of as complementary to those of the IAEA and are not mutually exclusive.

3. Proprietary Rights of the Regional Organization to Sensitive Material

In the custody model it is admittedly not regarded as necessary, but nevertheless as desirable, that ownership of sensitive material should not be allocated to the national operator, but rather to the international custody authority still to be created. Art. 86 of the treaty establishing the European Atomic Energy Community (EURATOM Treaty) allocates ownership of special fissionable materials to the European Atomic Energy Community; the plant operators only have unrestricted rights of utilization and consumption (Art. 87 EURATOM Treaty).

4. Objectives of the Regional Organization

A difference between the two models can be seen in the differently formulated objectives. The custody model is concerned with an effective non-proliferation policy. The aim of EURATOM is a common market in the nuclear energy sector; non-proliferation aspects forming an important component, but not being the only major priority. The activities of EURATOM (at least in its present legal form) thus refer to all phases of the fuel cycle, including for example contractual relations in acquiring nuclear material. However, this difference alone would not be decisive if the question were merely whether EURATOM fulfilled the conditions of the custody model in the field of NP structures.

5. Permanent Safeguards on Sensitive Material

The custody model requires permanent safeguards on sensitive material. Such far-reaching safeguards are not mandatory in the EURATOM Treaty, neither are they currently realized.

Pursuant to Art. 81 of the EURATOM Treaty, the Commission dispatches inspectors to the member states. The inspectors examine whether the materials are being used in accordance with the states' declarations and pertinent responsibilities under international law. The inspectors have "access at any time to all locations, documents and persons who for reasons of their profession are involved with substances, items of equipment or facilities subject (pursuant to the EURATOM Treaty) to safeguards". This is implemented if "necessary for safeguarding ores, source materials and special fissionable materials, and to determine whether the provisions of Art. 77 are being observed". If these regulations are not observed by a member state then the Community can apply compulsory measures (Art. 83). For example, source materials or fissionable materials can be completely or partially withdrawn from the state.

The EURATOM safeguards are based in detail upon the fact that the operator, pursuant to Art. 78 of the EURATOM Treaty, must supply the Commission with basic technical features of the plant (design information), insofar as they are of significance for the Commission's safeguards function. Furthermore, pursuant to Art. 79, lists must be compiled and presented for sensitive materials accountancy; this also refers to the transport of sensitive materials. These responsibilities are determined in detail by an executive order of 28 May, 1959 /4.2/. In this connection attention must also be drawn to the fact that pursuant to Art. 80 of the EURATOM Treaty, the Commission can demand that "all excess special fissionable materials recovered or produced as byproducts and not actually used or made available for use must be deposited at the European Supply Agency or in other stores subject or accessible to Commission safeguards". A consistent realization of this standard could in practice lead to the member states only being in possession of "non-excess" material, i.e. that the subject of the actual safeguards would only be those materials immediately required for operating the present plants. If one also considers that the access rights of the EURATOM inspectors are very broadly formulated in Art. 81 of the EURATOM Treaty, then admittedly this is still not a permanent safeguards model in the sense of the custody suggestion, but nevertheless, the differences no longer appear basic. The inspection effort is determined relatively flexibly in Art. 81 of the EURATOM Treaty; "insofar as this is required for safeguards". Without necessarily modifying the Treaty this formulation would permit an increase in inspection activity which would in effect approach permanent safeguards.

6. Release Criteria

There is a difference between the two models with respect to compiling so-called release criteria, which are to determine conditions for the release of sensitive material from the international authority to the operator. The custody model presumes that certain forms of utilization for sensitive material are not to be permitted. The safeguards approach in EURATOM is different; pursuant to Art. 77a of the EURATOM Treaty the object of safeguards is "that the ores, the source materials and special fissionable materials shall not be used for purposes other than those specified by their users". Moreover, pursuant to Art. 77b, EURATOM safeguards the responsibilities which the Community has undertaken with a third state or an intergovernmental institution. The EURATOM Treaty itself does not therefore in effect place any limitation on the use of fissionable materials. These limitations result from decisions made by the member states themselves and from external treaties.

Nevertheless, a general evaluation of the existence of EURATOM must also include the actual situation. The non-nuclear-weapons states in EURATOM do not possess any uranium reserves of their own. They are therefore dependent on supplies of uranium from third states and have thus in the past few decades also been dependent on the peaceful uses of nuclear energy, as agreed in the supply contracts. Particularly with respect to the Federal Republic of Germany, it must be noted that the latter is restricted to peaceful uses since it bindingly committed itself to this under international law in 1954.

Regarded as a whole, the EURATOM Treaty creates a dynamic system which guarantees the conversion of valid international responsibilities by means of EURATOM safeguards. Release criteria have apparently not yet been agreed in supply contracts, for this reason no corresponding safeguards yet take place within the EURATOM framework. If this aspect of the situation under international law should change in future then EURATOM safeguards could be, and indeed would have to be, adjusted to this new situation.

In conclusion, it can be established here that the custody model currently goes beyond EURATOM safeguards in this respect, by including additional elements from an IPS in the model. Nothing stands in the way of a future change in EURATOM structure in the sense of the custody model. Furthermore, Art. 80 of the EURATOM Treaty must also be mentioned here for the potential development of EURATOM, according to which the Community has the right to keep excess fissionable materials in its own stores. Implementation of this regulation in practice would require a definition of "excess". At the same time this would institutionally question the way in which separation of excess and non-excess material could be ensured. In this context the question would also have to be answered of the concrete circumstances under which material stored as "excess" by EURATOM could be released.

4.3 The KFA Approach

The approach suggested on the part of the Federal Republic /4.3/ for nuclear cooperation models aimed at hindering proliferation differentiates between national* and international forms of cooperation. Various forms of organization of a national character were defined according to the increase in commitments under international law:

- The initial model only envisages membership of the NP Treaty with the resulting cooperation with and controls on the part of the IAEA as the single international component. The nuclear plant is operated on a purely national basis.

- As an additional commitment under international law, membership of the operator state in EURATOM is stipulated for the second model. Unrestricted utilization rights to nuclear material thus exist, but not proprietary rights. EURATOM carries out safeguards in the same way as the IAEA. Member states are bound to EURATOM for an indefinite period and their membership is in principle not terminable.

- Operation of a national plant takes place with financial participation as well as service rights of a third state, which for its part would not operate any plants.

- A national plant is, pursuant to approval under international law, permanently operated by a multinational operating staff.

- A national plant has a permanent multinational management (with purely national operating staff).

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* Allocation to a national legal system

- In the case of multinational enterprises, the rights to the plants are distributed between several private or national legal entities, which for their part have been founded according to and belong to various national legal systems. The essential aspect is whether the goal and structure of the enterprise can be changed in substance by a revision in the private law of the host country, or whether it is established in a treaty under international law between the states concerned.

- The national cooperation model with the highest degree of internationalization consists of a multinational concern renouncing under international law the exercise of certain sovereign rights in the local area of the plant, as well as the obligation only to amend the pertinent laws with the consent of the signatory partners. The operating state could then no longer nationalize the plant without violating international law.

With respect to constructing models with international organization, studies have led to the following results:

The law applicable to an international organization is characterized by an independent memorandum of association under international law, in which legal relations are determined between the international organization and the host state. The associated heightened legal independence of international organization diminishes the danger of the legislative organs of the operating state changing the pertinent law to the disadvantage of third-party states. The purpose, essential objectives, organs, duration, periods of notice and procedural regulations can be determined in the memorandum of association.

The following can be considered as possible variants of the law applicable for international organizations:

- international organization without any renouncement of sovereign rights on the part of the host state,

- international organization with renouncement of sovereign rights on the part of a host state,
- international organization on extraterritorial soil.

In the case of an international organization founded for the purposes of reprocessing or enriching nuclear material, the following must be specifically established:

- budget
- objectives of the organization in the research and development sector
- issues of technology transfer
- responsibilities of the member states, especially in relation to third states.

The enormous costs to be raised for the plant operated by the international organization force the member states to dispense with flexibility and commit themselves to a guaranteed long-term plan of several decades. In effect, this means that a member state must commit itself for budgetary reasons to an energy policy, at least in the medium term.

In order to prevent further proliferation and development of sensitive technology in the member states, as well as to improve efficient operation of the plants, the international organization must compile its own comprehensive development programme for the whole range of the technologically required plants. Far-reaching consequences thus result for the private sector which can lead to a general prohibition of certain types of research, or at least to considerable restrictions.

Moreover, renouncement of every type of reprocessing and enrichment would have to be among the obligations of the member states. The exclusive operation of sensitive plants by the international organization raises problems with respect to existing plants and the legal status of nuclear weapons states. The economic, scientific and political consequences of an unequal treatment of weapons and non-weapons states in this field must be considered.

It has become apparent that international organizations raise problems of realization and implementation for sensitive plants in the nuclear fuel cycle - enrichment, reprocessing, MOX refabrication plants - which are difficult to solve for a number of reasons and thus should stand down in practical discussions. For national models, the model of a multinational concern on the basis of international law with a renouncement of certain sovereign rights seems best to correspond to the various criteria with a certain priority for hindering proliferation. Due to its basic structures, this model permits such flexibility in balancing the interests involved that it can be regarded in principle both as realistic and conforming to the fact in its approach for further discussions. However, it also became apparent that a national plant involved in themultiple contractual network of the NP Treaty and EURATOM and the associated safeguards and contractual conditions displays considerable advantages with respect to preventing proliferation in comparison to the model described above.

4.4 International Plutonium Storage (IPS) /4.4/

4.4.1 Introduction

The International Plutonium Storage System is an institutional measure in the sense of a further development of international nuclear material safeguards by the IAEA. The goal of the system is a reduction in the danger of proliferation which could result from the accumulation of plutonium under national control. The IPS system envisages a deposit of excess plutonium with the IAEA. It should be noted in this context that EURATOM has contractually bound itself towards Australia and Canada to support efforts at establishing an IPS (cf. comments on prior consent). The legal basis to this is Art. XII A.5, IAEA Statute.

Approaches to the formation and implementation of an IPS system were worked out in a working group "IPS and Safeguards", in which 33 countries were involved, as well as the IAEA and

EURATOM. Since the majority of participating states favoured Alternative A, this alternative will be described and evaluated in order to study international cooperation models. Alternatives B and C are described in a collection of material appended to this study as a separate volume.

4.4.2 Description of Alternative A

(1) Registration

All separated plutonium which is the property of a state and subject to IAEA safeguards is registered. Initial inventories are established at the point of accession to IPS. Information about inventories are brought up to date by inventory change reports. Conditions of ownership must be stated in detail.

This procedure would enable the state to make use of plutonium immediately after separation and registration. To this end, the state must make a "statement of use" to the IAEA either before or after separation or in connection with registration (see Fig. 4-1, Flows 1 and 2). For plutonium not immediately used (Flow 3) the following steps are applicable.

(2) Depositing and

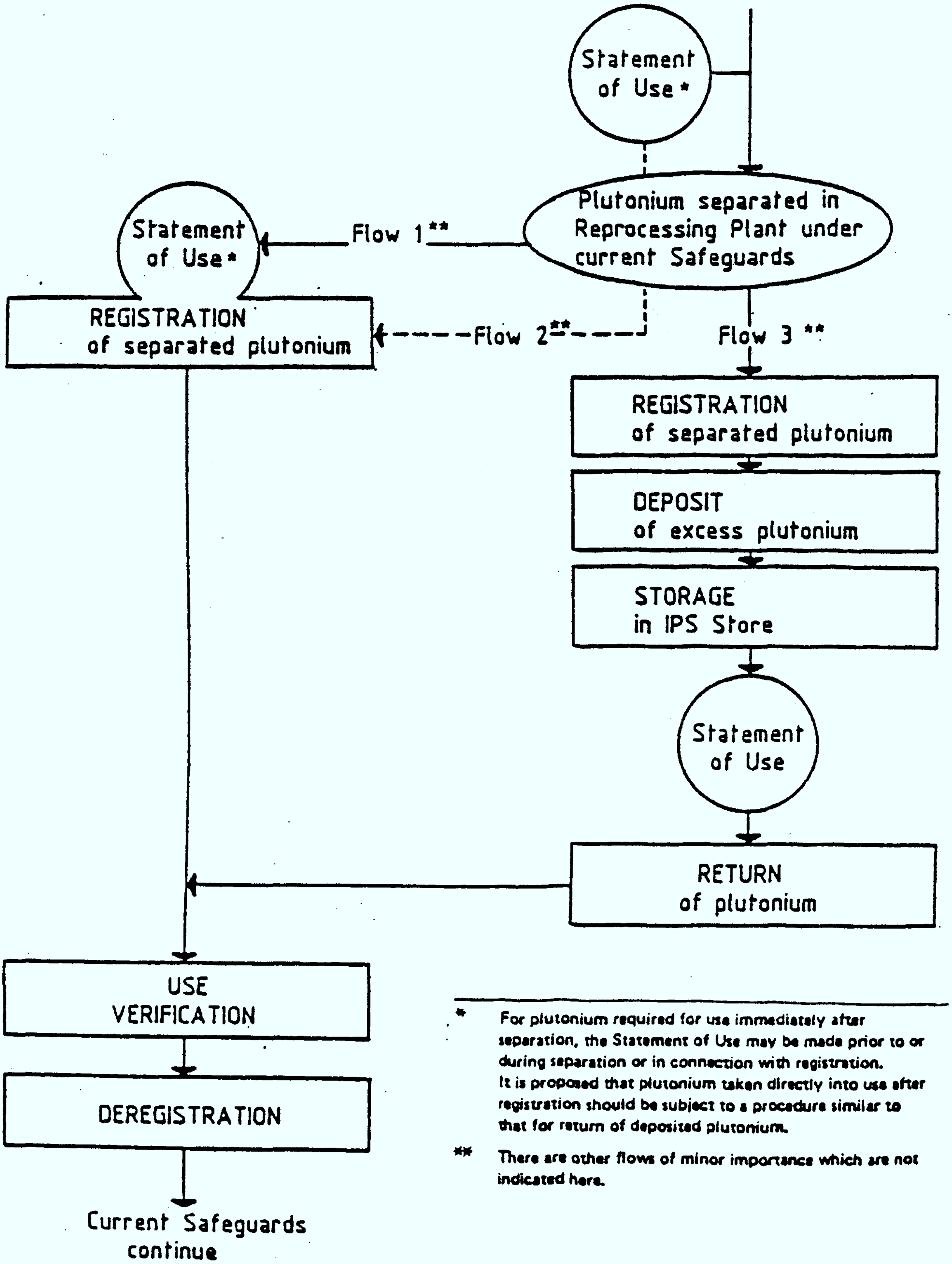
(3) Storage in an IPS store

(4) Return
Stored plutonium is promptly returned at the request of the owner state. This presumes a statement of use.

(5) Use verification
It is verified that the plutonium is used in accordance with the statement of use up to its deregistration. Use verification is applied whether the plutonium is used immediately after registration or whether this first ensues upon return after depositing and storage in an IPS store.

Fig. 4-1

ALTERNATIVE A - PROPOSED PROCEDURES



* For plutonium required for use immediately after separation, the Statement of Use may be made prior to or during separation or in connection with registration. It is proposed that plutonium taken directly into use after registration should be subject to a procedure similar to that for return of deposited plutonium.

** There are other flows of minor importance which are not indicated here.

(6) Deregistration
Deregistration takes place as soon as plutonium is loaded into a reactor as fuel, or as soon as safeguards are terminated in accordance with the valid safeguards agreement.

(7) The valid safeguards measures are to be applied to the steps described.

4.4.3 Status of IPS Discussions

The IAEA expert group on IPS has examined the technical and operational possibilities. But the objective of making completely formulated approaches to the implementation of Art. XII A.5 has not yet been achieved. The following steps still have to be taken:

1) Agreement must be achieved about basic conceptional issues.
2) After this, elements for concluding implementing agreements between the member states and the IAEA have to be drawn up.
3) Elements for concluding agreements between member states and the IAEA on the designation and operation of IPS stores have to be drawn up.
4) The application of procedures for implementing the agreements mentioned above - e.g. in subsidiary arrangements - must also be considered.

4.4.4 Evaluation of Alternative A

A set of basic procedures for implementing Art. XII A.5 of the IAEA Statute, are suggested in the IPS alternative A. Some of the envisaged regulations which are still disputed will be commented in the following. However, a commentary on some of the uncontested points will also be given.

Declaration of Plutonium

In this problem area the disputed issue is whether a member state must declare all the separated plutonium of which it is the owner. That is to say also plutonium which is not within its sovereign territory and thus subject to the jurisdiction and control of a third state. For example, this other state may not be a member of either the IPS or the NPT, and not all its nuclear plants need be subject to IAEA safeguards.

A declaration of separated plutonium on different sovereign territory can only be of significance for the IAEA if it can also verify this inventory. On the other hand, this separated plutonium does not contribute to an accumulation of material in the IPS member state obliged to make declarations. The latter then has the possibility of establishing a source of supply for separated plutonium independent of the IPS system, if that is what it wants.

In effect, it can be said that regulation of the declaration obligation with respect to separated plutonium in a third state should be abandoned for practical reasons of non-verifiability.

Specification of Isotope Composition

The possibility of a state also giving information about isotope composition in specifying its separated plutonium is not universally accepted since this information could influence return of the material to the state.
In this connection, there is a contradiction to Art. XII A.5, IAEA Statute, according to which deposited material must be immediately returned on application for (peaceful) utilization according to specification. The immediate return of the deposited separated plutonium can therefore not be refused on the grounds of the isotope composition.

"Principle of Territorial Responsibility"

Advocates of Alternative A have also concerned themselves with the question of which state is responsible for depositing excess plutonium: (1) the state on whose territory the material is (although this state need not be the owner of the material), or (2) the state which is the owner of the excess plutonium. All advocates of Alternative A, except one, tend towards the second opinion. The first view is discussed under the term "principle of territorial responsibility". The question is the extent to which this principle can be derived from Art. XII A.5, IAEA Statute, and which consequences result for the owner of the material.

As far as the first question is concerned, it must be said that Art. XII A.5 does not specify which state is responsible for depositing excess material. The wording of the article merely indicates that the IAEA has the right to demand deposition from all states who have requested implementation of IAEA safeguards.

If the state on whose territory the plutonium is present is not the owner of the material then the following aspects result: The material is included in the account of the state on whose territory it is. If the agreed buffer quantities are exceeded then plutonium must be deposited. If the principle of territorial responsibility is valid then the state can deposit foreign plutonium in order to retain its own material as a buffer. The owner state would then have to make an application for return to the IAEA in order to obtain its plutonium again. On the other hand, there is also admittedly the possibility that the state on whose territory the excess is located could send foreign material back to the owners in order to keep its own excess amounts small. It is assumed that the owner of the plutonium in principle wants to have his material at his own disposal. The principle of territorial responsibility would therefore amount to an unacceptable disenfranchisement of the owner state.

Determination of Excess Amounts

An essential point of the IPS system concerns the issue of determining excess amounts which are exempted from depositing. This is due to the problem that a process plant cannot be operated normally without a certain material reserve. For this reason an acceptable IPS system must exempt excess plutonium for such purposes from depositing obligations. The disputed issue is whether this amount of material should be determined relative to the whole state or the individual plant.

It is uncontested that the exempted amount must be oriented towards the detection goals of IAEA safeguards*. From the point of view of the safeguards authority there is undoubtedly a great deal in favour of the opinion that the exempted quantity should be related to the whole state. Presuming a state supporting a nuclear energy programme with closure of the fuel cycle (20 GW criterion), then it has an indispensable necessity and right to operate its plants without hindrance. For this reason the exempted amount must also be related to the plant capacity. This certainly requires determination of an exempted amount of a size which, depending on the development of the fuel cycle, far exceeds the threshold quantity. Determination according to the first alternative (reference of the exempted quantity to the whole state) seems to be hardly practicable after the preceding reference to the IAEA detection goals.

On the other hand, the second alternative which envisages referring the exempted quantity to the individual plant tends rather to conform to current safeguards practice. Namely for technical reasons, the IAEA must actually refer its detection goals to the individual material balance areas until further provision is made. The determination of a permitted excess amount per plant would thus both fit in with current safeguards practice and also enable the operator to operate the plant largely unhindered since he can always retain sufficient working material.

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* The current threshold quantity for Pu is 8 kg.

In addition there is the controversial suggestion that in connection with the second alternative the total excess plutonium in a plant should be deposited as soon as the agreed exemption quantity is exceeded. This type of regulation would inevitably lead to operational obstructions. In any case, the administrative efforts of the IAEA on the one hand and the operator on the other hand would be increased. An operator who was forced to deposit all his reserves of excess plutonium would have to simultaneously cope with the depositing formalities as well as the return formalities for that part of the material exempted from depositing according to the agreement. Unjustified additional burdens would thus result especially for the IAEA. If the material is physically transported to and fro then there are also unjustified burdens in the fields of operational safety and physical protection.

The real problems of an IPS system, which has the goal of preventing an accumulation of plutonium in a single state, are in principle to be found in determining the exempted amounts. Orientation towards the threshold quantity of 8 kg is here in conflict with the right to unhindered plant operation. On a commercial scale of the fuel cycle, buffer quantities are required which just do not seem reconcilable with the goal of depositing proliferation-relevant amounts of Pu with the IAEA.

State Responsibility

If one assumes that a state has its own and foreign plutonium to be declared on its sovereign territory, then the following situation could result with respect to depositing. An excess of plutonium is formed on the state's territory. Insofar as foreign plutonium is also involved, the state must call in the foreign owner(s). The latter, if they were unable to make a statement of use, would have to release the material for depositing. If a statement of use is made then the material concerned would have to be transferred to the owner state.

These regulations enable the owner of the plutonium to exercise complete responsibility for his material.

Time Frame

The time limits within which the IAEA must reply to an application for return, and possibly to clarify further enquiries must be seen in relation to the question of buffer-stock limits. In general it can be said that the size of the buffer-stock limits must be proportional to the period of time to which the IAEA is entitled for dealing with return formalities. A period of one to two months must be assumed. The time elapsing after the application for return has been made before the material is actually returned is approximately identical to the period estimated for processing the application.

Verification of Pu Use

The significance of determining IAEA's effort at achieving the IPS goal (verification that no stockpiling is taking place) is not clear. The assertion that this goal could be achieved by applying valid safeguards practice or with very slight additional efforts in the safeguards authority are very difficult to verify in advance anyway. Nevertheless, the authors are of the opinion that certain additional efforts in the safeguards authority will have to be expected over and above current safeguards practice.

4.4.5 Compatability of an IPS System with the Obligation of State Safe-Keeping Pursuant to the Atomic Energy Act (AtG); Storage of Material from Third States

From the point of view of the law in the Federal Republic of Germany, establishment of an IPS in Germany would raise legal problems especially with respect to the implementation of § 5 AtG; in Par. 1 sentence 1 of this regulation it is stipulated that nuclear fuels are to be "deposited with the state".

The organizational solution envisaged in Alternative A could not be regarded as "state safe-keeping". This type of depositing can only be established if governmental organs of the Federal Republic of Germany are exclusively responsible for safe-keeping.

It would therefore depend on whether exemption could be granted pursuant to § 6 AtG for the establishment of an IPS. The first prerequisite for this pursuant to § 6 would be whether there were any "need" for the establishment of an IPS in the sense of the regulation. It has not been necessary up to now to definitively clarify the conditions under which such "need" could be assumed. A case mentioned in the establishment of the AtG (preamble to the draft of an AtG, sentence 22) concerns storage in the vicinity of a reactor in order to ensure continuous operation and to reduce transport problems. Whether accession of the Federal Republic to an IPS system could also create a "need" does not seem quite clear. This could be opposed by stating that governmental safe-keeping should be the rule pursuant to the AtG and exemptions - in accordance with a general interpretation - should only be granted under restricted conditions. On the other hand, it must be pointed out that in the determination of the objectives of the AtG it is said in § 1 that the peaceful uses of nuclear energy are to be furthered, that the protective purpose of the law is to be regarded as internal and external security and that the AtG also serves to fulfill international obligations. If such a situation were then to result in which, according to widespread opinion, establishment of an IPS system could be regarded as a means for ensuring the peaceful uses of nuclear energy, then the view could be put forward that a "need" in the sense of § 6 AtG would arise. Attention could also be drawn to the fact that Art. XII A 5 of the IAEA Statute represents in principle an obligation of the Federal Republic of Germany in the sense of § 1 AtG. In effect, good reasons could thus be put forward for the existence of a "need" in the sense of § 6 AtG in establishing an IPS. Admittedly, such a statement cannot yet be made in view of the current development of the law.

If one presumes the existence of a "need" in the sense of § 6 AtG, then the further prerequisites for granting an exemption would have to be examined. The Federal Republic, pursuant to Par. 2 Sub-par. 1, would have to examine whether those persons entrusted with implementing the IPS could be considered "reliable" and in possession of the necessary specialized knowledge. Furthermore, it would have to be established whether the IPS regulation concerning "necessary precautions against damage according to the state of science and technology" would be applicable (§ 6 Par. 2 Sub-par. 2). Moreover, it would be of particular significance that the IAEA would take on obligations concerning liability: Par. 2 Sub-par. 3 only permits granting of approval if provision has been made for the implementation of legal obligations concerning compensation for damages (cf. § 13 AtG). Finally, the IAEA would have to ensure protection against disturbances from third parties (Par. 2 Sub-par. 4).

The required prerequisites could only be fulfilled as a whole if the Federal Republic were to conclude a treaty with the IAEA which would contractually determine in detail the points mentioned in the sense of § 6 AtG. However, it would have to be examined whether the IAEA has the necessary competence to conclude such an agreement on the basis of its current statute.

Finally, it would have to be noted that the establishment of an IPS on the Federal Republic's territory would have to consider its obligations under the EURATOM Treaty. It must be particularly noted that the Commission can demand pursuant to Art. 80 of the EURATOM Treaty that all excess special fissionable materials recovered or produced as byproducts and not actually used or made available for use be deposited with the EURATOM supply agency or in other stores. For this reason, an IPS agreement would require consent from the responsible EURATOM organs. It is interesting to note that EURATOM rights only refer to materials produced in the member states; material from third countries is accordingly not affected by these rights.

4.5 International Spent Fuel Management (ISFM) /4.6/

At the initiative of the IAEA General Director, a group of experts from 24 countries and three international organizations first met in 1979. The objective of the group was to analyse the potential for international cooperation in the management of spent fuel elements with the goal of supporting the IAEA in solving this problem connected with the growing stockpiling of spent fuel elements. To this end, a series of techniques was identified by the group on the basis of which national, regional or multinational storage facilities should be possible. Several of these techniques are already established, others are still under development.

The group came to the conclusion that arrangements for multinational spent fuel element stores could indeed be of interest for some countries, but that national stores for fuel elements from exclusively domestic nuclear energy utilization represent the most probable solution for the near future. There are, however, a number of measures for national stores which could alleviate the management of spent fuel elements. These measures could be of assistance both for countries with national programmes as well as those involved in multinational cooperation. Among these are for example appropriate improvements in guidelines and standards, technical support as well as technical information in the field of spent fuel element management. Both the IAEA and the NEA-OECD can play an important part in this sector. It can moreover be presumed that those countries with a genuine interest in applying international arrangements will enter into direct contact with each other. The IAEA and the NEA-OECD could provide support as a forum in negotiating international agreements.

The ISFM Group recommends a step by step introduction of multinational arrangements as a meaningful approach. A possible initial step could be the availability of possibilities for back-up arrangements in emergency situations. A second step could be the establishment of new plants in which storage services for foreign partners could be undertaken.

5. INSTITUTIONAL MODELS FOR THE BACK END OF THE NUCLEAR FUEL CYCLE

5.1 Introduction

Taking the perspectives drawn up in Chapter 2 for the world-wide application of nuclear engineering in supplying energy, certain problems are to be expected with respect to a suitable transfer of this sensitive technology. From this resulted on the one hand the motivation to make the nuclear fuel cycle technically more resistant to proliferation, and on the other hand to counteract aims of acquiring nuclear weapons with the aid of different forms of international cooperation in the field of nuclear energy. As a basis for this, four discussion approaches were examined in the preceding Chapter. These approaches should now be elaborated. It will become apparent that these approaches are not to be considered as alternatives, but rather contain a number of elements to be developed which will be considered in one way or another in the following.

The following assumptions must be made:

In this respect international cooperation can supplement international nuclear material safeguards (e.g. in the sense of § 81 (d), INFCIRC/153); it can indeed even limit their extent and intensity. Proliferation is a political problem which is to be combated in this way by a combination of technical measures, for example in connection with accession to the Non-Proliferation Treaty or the Tlatelolco Treaty, and obligations based on cooperation agreements.

However, the non-proliferation aspect cannot play the priority role which was originally assumed in the first considerations of institutional solutions. This problem will be dealt with in detail later.

Nuclear cooperation does not appear equally attractive for every state. Besides nuclear material safeguards, a nuclear weapons state is primarily concerned with safeguarding the flow of know-how and thus the possibility of influencing a non-nuclear-weapons state on a bilateral level. In this sense, a non-nuclear-weapons state which is already a technology holder cannot be influenced, except via the supply of nuclear material. It can thus already be seen that cooperation is most likely to arise if mutual dependence exists from the outset. In this way, a coupling of non-proliferation and supply guarantees results. Nevertheless, over and above these two basic aspects further criteria are also of significance in evaluating international cooperation. The contrary tendency is characteristic in the sense that, for example, national autarky is not of any value in hindering proliferation.

The foreseeable world political situation is on the one hand characterized by the necessity of utilizing all available mechanisms for supplying energy, but on the other hand also indicates socially unstable and thus externally offensive states which endeavour to implement their goals by military means. The objective must be to develop forms of nuclear cooperation which are attractive for all states operating nuclear facilities on the basis of equal treatment of the partners. However, a certain degree of discrimination still remains since the exporting countries have already combined in the London Club of Suppliers and observe certain agreements with respect to technology transfer and export. From the point of view of proliferation, the decisive condition on the part of the exporting countries is that the importing countries must subject themselves to international nuclear material safeguards, at least for the imported plants and technologies. All nuclear cooperation will thus simultaneously involve NP regulations.

The present Chapter deals especially with forms of cooperation for states at different stages of economic and technological development. The evaluation criteria used will be presented immediately after this Introduction. Whereas previous cooperation between technology holders and recipient countries on the international nuclear market has largely been limited to the front end of the fuel cycle for practical considerations, it is becoming more and more obvious that compulsions to solve the issue of the back end of the nuclear fuel cycle require that the back end be included in worldwide nuclear cooperation. Since the Federal Republic of Germany has an important part to play as a technology exporting country, the boundary conditions resulting from the German Atomic Energy Act will first be analysed. A reconception of international cooperation in the field of nuclear energy ought also to include this aspect.

As significant stages in the back end of the nuclear fuel cycle, the reprocessing of spent fuel elements, refabrication of fuel elements, direct final disposal of spent fuel elements as well as the final disposal of highly active waste from reprocessing are included in models for international cooperation.

5.2 Criteria for Evaluating Models of Nuclear Cooperation

A criteria catalogue comprising eleven criteria has been compiled as part of the KFA Jülich's basic work on "Institutional Aspects of the Nuclear Fuel Cycle" /5.1/. A characteristic of these criteria is that they are in part correlated with each other. Those criteria which stand alone are of a basic character. This is largely true of the criteria supply assurance and environmental protection. Political independence is, for example, based on supply assurance. Political acceptance refers to the latter, whereas social acceptance is largely determined by the guarantee of environmental protection. Hinderance of proliferation, as already mentioned, is thus a function of political independence. In this connection, it must be established that a state which desists from acquiring nuclear weapons is in a position of considerable political dependence with respect to the nuclear weapons states which, in the last analysis, can implement all their strategic and political ideas. In this respect, both NATO and the Warsaw Pact hinder proliferation by assigning defensive dependences. A loss of sovereignty on the part of the non-nuclear-weapons states within these alliances is compensated by a gain in power for the USA and the USSR. France and the United Kingdom are roughly in the middle. On the other hand, it must be assumed that even the suspicion of military nuclear activities on the part of one of the non-nuclear-weapons partners would trigger off immediate preventative measures from the opposing superpower.

Supply assurance refers to the availability of raw materials, technologies, knowledge and services. To this extent it includes the criterion of planning assurance, which itself refers to assuring the future of the whole economy. This is then joined by the criterion of profitability. With respect to technologies and plants, the distribution of burdens and risks as well as economic operation at a certain size of plant plays a decisive role. Closely connected with this is, moreover, technology transfer which itself raises various aspects. For reasons of proliferation, certain technological know-how should not be disseminated. The protection of commercial knowledge is aimed in the same direction. Conversely, technological development through technology transfer is the major issue for those states which are not yet technology holders. In general it can be said that knowledge gained in the field of nuclear technology can also partly be applied in other fields. Domestic promotion of technology also exists to this end. The criterion of vulnerability to sanctions depends on supply assurance. It can be said that a state is more vulnerable to sanctions, the more it depends on other states for its supply. In this respect there is once again a connection with hindering proliferation.

In conclusion, an aspect is picked up again which has already been mentioned at the beginning: institutional models are closely connected with international nuclear material safeguards. The question of the safeguardability of nuclear plants thus arises. If problems should arise in this respect at certain plants, then this would inevitably have corresponding consequences in decisions about the management. The more heavily a plant can be safeguarded by the controlling authorities, the more urgent would an international operating organization be for reasons of proliferation. The criterion of safeguardability is therefore also included in order to permit a more comprehensive evaluation of proliferation hindrance.

5.3 New Concepts of International Cooperation

These considerations take as a starting point the fact that according to the current philosophy in the western countries, front-end services are also essentially ensured when exporting nuclear power stations. In the long term, this behaviour on the part of the exporters cannot be regarded as sufficiently responsible towards the recipient countries. Cooperation on a basis of trust between exporting and importing countries can rather be based both on an assured front end (supply of fuel) as well as assured management of spent fuel (storage of spent fuel elements, their reprocessing, plutonium recycling within an appropriate IPS system and possibly safe waste disposal). The complex technical problems, as well as the urgency with which the individual back-end steps have to be fulfilled in the various countries, only permit solutions which proceed in stages, staggered in time. Possible models for cooperation between countries importing and exporting nuclear plants must be adapted to this approach, by means of which technology transfer to the importing country is compacted in stages and, in the long term, leads to an independent back-end solution there. The export of nuclear power stations with front-end and back-end services in the field of storing fuel elements can thus be regarded as the first stage in a phased plan which will be presented in this study. It is obvious that the phased plan philosophy requires identical behaviour on the part of all supplier countries.

In realizing a phased plan by the Federal Republic it must be stated that a back-end service by means of reprocessing is neither possible nor necessary yet. However, this plan requires medium-term planning, according to which it is estimated that this service capacity will possibly be desirable in about the year 2005.

The technology transfer to be expected in future raises quite generally the question of whether a supplier state is fulfilling the complete extent of its political responsibility as a carrier and beneficiary of transfer if it exclusively limits cooperation with the recipient state to the initial delivery of plants and materials. The current international situation draws attention to the fact that the behaviour of the supplier countries will have to be reconsidered in future. This is particularly true if the specific interests of the recipient country are considered in more detail. From this point of view it is obvious that the recipient state in general rightly expects that the supplier state will include cooperation in the whole field of the fuel cycle. A recipient country which admittedly obtains a plant, but which does not receive any guarantee of the effective utilization of the plant within the whole cycle can, in certain circumstances, end up in a precarious situation. International nuclear transfer will thus have to pay increased attention in future to the idea of the necessity of comprehensive cooperation between the supplier and recipient state.

Moreover, this point of view is not only valid from the perspective of the recipient state. In view of the international objectives involved of necessity in increased technology transfer, it is also obvious from the perspective of the international community that the supplier country must assume specific responsibility for solving these new problems. This is equally true of the supply assurance sector, as well as of problems of averting dangers for the recipient state and of the issue of the non-proliferation of nuclear weapons. The question thus arises of whether an international causation principle cannot be defined here, which would impose obligations on the supplier state, especially in the back-end sector, of supporting the recipient country in solving these sensitive problems. Suggestions of how these cooperation obligations could be determined within such a causation principle could be compiled in a code of conduct (see supplementary volume).

5.4 Regulation of the Management of Spent Fuel in the Atomic Energy Act

Before discussing details of the phased plan, the legal boundary conditions of the national legislation should first be indicated which could be of significance for the individual elements of the phased plan.

Together with the passing of the German Atomic Energy Act in 1959, the Federal legislators were empowered pursuant to Art. 74 no. 11a of the Basic Law, to issue a regulation for the disposal of radioactive waste. Seventeen years passed before this regulation was enacted. The pertinent standard in § 9a of the Atomic Energy Act has envisaged since 1976:

§ 9a Utilization of Residual Radioactive Substances and Disposal of Radioactive Waste

(1) Whoever constructs, operates, is otherwise in possession of, significantly modifies, shuts down or removes facilities handling nuclear fuels, handles radioactive substances outside of such facilities or operates facilities for the generation of ionizating radiation, must make due provision that residual radioactive substances arising as well as dismantled or dismounted radioactive facility components
   1. are utilized without damage according to the purposes designated in § 1 nos. 2 to 4 or,
   2. if this is not possible according to the present state of science and technology, not economically viable or incompatible with the purposes designated in § 1 nos. 2 to 4, shall be disposed of in an orderly manner as radioactive waste.

(2) Whoever is in possession of radioactive waste shall surrender this to a plant pursuant to Par. 3. This does not apply insofar as other provision is made on the basis of a legal regulation issued on the basis of this Act, or directed or approved on the basis of this Act or such a legal regulation.

(3) The Laender are to establish collecting points for the interim storage of radioactive waste occurring in their territory, and the Federal Government is to establish facilities for safe management and final disposal of radioactive waste. They may make use of third parties to fulfill their obligations.

The problems in interpreting this regulation which have resulted in the past few years come from viewing it together with the regulation determining the preconditions for licensing plants. § 7 (2) Subpar. 3 determines that a licence can only be granted if "necessary precautions against damage by the establishment and operation of the plant are made according to the current state of science and technology".

After the enactment of § 9a, the legal position with respect to the management of spent fuel is clouded by a series of difficult interpretation problems which have not yet been unambiguously clarified by the courts.

(a) The Federal Government's Obligations to Establish Plants for the safe management and final disposal of radioactive waste

§ 9a Par. 3 is not constructed as a standard of competence but rather as a standard of obligation: "... the Federal Government must establish plants". The Federal Government's obligation to set up such facilities within a certain period cannot be taken from the wording of the regulation. Nevertheless, it still remains unclear whether the regulation should not be interpreted in a manner ensuring in effect that the Federal Government acts within a limited period of time. This period of time could possibly be fixed in such a way that the further utilization of nuclear energy, upon which the Atomic Energy Act is based, would not be jeopardized. The criteria according to which such a period of time should be determined in legal proceedings would require careful consideration. The priority issue, however, concerning the legal implementation of the Federal Government's fulfillment of its obligations, would in any case be the question of which persons would be entitled to initiate proceedings with such a goal. The catalogue of problems thus involved has not yet been conclusively established in any way.

(b) Obligations of the Laender to establish facilities for interim storage of radioactive waste.

Questions similar to those discussed immediately above also arise in interpreting § 9a.

(c) The effect of § 9a on the licensing of nuclear plants.

The significance of § 9a for the licensing procedure pursuant to § 7 of the Atomic Energy Act is the subject of a series of - not always unanimous - opinions in the literature and has also already led to different decisions in legal proceedings. The difficulty in discussions on this topic is mainly to be found in the fact that, on the one hand, the legislators have consciously avoided including the regulation for management of spent fuel prescribed in § 9a in substance in § 7 concerning regulations for the licensing of plants. This form of the regulation indicates that the legislators did not want to change the preconditions contained in § 7 by introducing § 9a. On the other hand, it is quite unmistakable from the wording of § 9a that it is also to be understood as a concretization of the protective goal of the Act contained in § 1 Par. 2, i.e. "of protecting life, health and material goods from the dangers of nuclear energy and the damaging effect of ionizing radiation". This protective goal is also unquestionably to be regarded as the guiding principle in interpreting § 7.

The question thus arises of whether § 9a is to be regarded as an independent standard only applicable with respect to specific back-end problems, or whether its effect also refers to the problem of licensing an individual plant in the sense emanating from § 1. In this respect, the first question arising from the wording of § 7 is whether the regulation of the management of spent fuel concerns the field of "establishing and operating" a plant discussed in § 7 at all. A form of argumentation would be conceivable according to which the question of the management of spent fuel is a general problem in the development of the peaceful uses of nuclear energy, not therefore concerning the "establishment and operation" of a specific plant at all, and therefore cannot be considered within the licensing procedure pursuant to § 7 of the Atomic Energy Act. Although such a point of view has occasional proponents in the literature, the majority of authors rightly do not espouse such an interpretation. The replacement of spent fuel elements and the immediately associated measures for disposing of the radioactive substances are also part of "operating" a plant. Since according to the wording of § 7, management of spent fuel is thus included in the operations to be considered in the licensing procedure, the more general question of the effects of the revised regulation in § 9a on the licensing procedure is raised. Three answers are in principle conceivable. On the one hand, the opinion can be justified that according to the introduction of § 9a, a licensing of new plants ("expansion") may no longer be granted as long as the plans for the management of spent fuel required in § 9a have not been bindingly presented. The opposite position to this would be to regard § 7 and § 9a as strictly separated areas of regulation whose contents do not mutually affect each other. A conciliatory approach might take the form that the courts are not to ascribe any decisive importance to the problem of spent fuel management in licensing procedures, however they are obliged pursuant to the decision of the legislators concerning § 9a of the Atomic Energy Act to attribute more significance to management of spent fuel than in the earlier legal regulation. The latter interpretation would be conceivable since licensing of an atomic plant is anyway at the discretion of the licensing authority according to the formulation of § 7 Atomic Energy Act.

The higher administrative court (OVG) at Lüneburg supported the first alternative mentioned above (plan for management of spent fuel as a precondition for expansion) /5.2/. The court argues that § 9a presumed a definite concept for spent fuel management and therefore an expansion of nuclear energy would only be permissible if no insurmountable legal obstacles were present to the realization of this concept in a preliminary general evaluation. "Compact storage" is not to be equated with the manner of spent fuel management stipulated in § 9a. For this reason the regulation of § 9a must already be observed in licensing. It can also be seen from the court's ruling that in the view of the court higher demands are also to be made on the realization of the concept for spent fuel management standardized in § 9a with progress in establishing new plants.

Whereas the higher administrative court (VGH) of Baden-Württemberg /5.3/ evaluated the significance of § 9a differently from the OVG at Lüneburg. This court viewed § 9a as an independent duty to act which does not have any direct effect on the licensing procedure. The court takes the view that the question of the management of spent fuel does not come within the terms of "establishment and operation" in the sense of § 7. The lack of a realization of the spent fuel management concept pursuant to § 9a does not necessarily result in an endangerment to third parties; interim storage would therefore also satisfy the legal demands. From these principles, the court concludes with respect to an appeal against a construction licence that there is currently no more closely defined group of persons who would have the right to lodge such an appeal. In the court's opinion this may well change when the spatial and technical modalities of spent fuel management pursuant to § 9a are established. In effect the court therefore concludes that § 9a does indeed impose duties to act upon the Federal Government, the Laender and the operators, but that this does not have any effect on the licensing procedure. Admittedly, neither can it be seen from the ruling of the VGH at Mannheim that the problem of spent fuel management should be completely ignored in the granting of licences for constructing new plants. As part of its discretion, the licensing authority can include the question of spent fuel management in its considerations on granting a licence. However, this discretionary decision can only be examined by the courts to a limited extent; discretionary decisions are only examined by courts to discover whether they appear arbitrary. It can at present hardly be said whether and when it would be conceivable in future that courts would overrule the decision of licensing authority because lack of consideration for issues of spent fuel management seemed arbitrary.

§ 9a (1) regulates the manner of spent fuel management. The wording of the regulation makes it clear that the legislators had not decided in favour of a certain form of spent fuel management to be mandatory under all circumstances. Sub-par. 1 says that the residual materials must be "safely utilized". However, under certain circumstances pursuant to Sub-par. 2 "orderly disposal" is regarded as a legitimate form of spent fuel management. This is valid (a) if a utilization pursuant to Sub-par. 1 is not possible "according to the state of science and technology", (b) if utilization pursuant to Sub-par. 1 is not economically viable, or (c) the purposes described in § 1 nos. 2 to 4 cannot be achieved. This structure of Art. 9a (1) therefore makes it clear that the law gives priority to "safe utilization" and intends "orderly disposal" to be a permissible form of spent fuel management of lower priority.

As far as terminology is concerned it must be established that "safe utilization" at the present state of technology can only mean utilization by reprocessing in a reprocessing plant. It can therefore also be presumed that the legislators assumed a reprocessing plant on German soil; admittedly this assumption is not expressed in the text.

If one then considers whether this legal position indicates that the establishment and operation of a reprocessing plant on German territory is mandatory then one comes up against difficulties because there is no explicit directive concerning the construction of a reprocessing plant. The legislators apparently presumed that such a plant would be constructed even without a legal directive. If this assumption should not be valid then a series of reasons could be decisive. The question of finance will undoubtedly also play a role in the decision-making process. If the refusal were on the basis of economic efficiency then such a decision would undoubtedly be legally unobjectionable in view of the formulation of § 9a (1). The position could be different if reasons other than those listed in § 9a (1) Sub-par. 2 were decisive. If the manner of spent fuel management should in general develop differently from the overall concept envisaged in § 9a, then it could be argued with good reason that the legislative intent was no longer being observed. Different conclusions could once again be derived from this. On the one hand, the view could be put forward that non-observation of the legislative intent could make further operation of the existing plants unlawful and thus the executive would have to order closure of the plants; the other justifiable opinion would be that under these circumstances the legislator would be obliged to issue an amended regulation removing existing uncertainties.

For some time legal developments have in a certain sense been approaching the situation described above, in that on the one hand it cannot be assumed that the reasons envisaged in § 9a (1) Sub-par. 2 for the "disposal" solution are not present, but on the other hand there is no concrete sign of any realization of safe utilization envisaged as a priority in § 9a (1) Sub-par. 1. Whereas the spent fuel management principles of 6 May, 1977, still maintained establishment of a reprocessing plant as a priority, this principle is no longer clearly contained in the guidelines of 20 February, 1980. It can no longer be seen from the "parallel approach" that the reprocessing decision should have priority. It could be conceivable to regard present principles for the management of spent fuel as part of a "phased concept of spent fuel management" and to consider construction of a reprocessing plant as a component of the overall concept to be carried out later. Admittedly, this perspective is in a certain contrast to current principles of spent fuel management which do not display any plans whatsoever for the further medium-term implementation of the overall concept.

In conclusion it must be seen that the present legal situation does not permit any clear statement of whether construction of a reprocessing plant is legally stipulated or not; the wording of § 9a of the AtG must therefore be described as inadequate from the present point of view. The reassessment of the principles of spent fuel management in 1980 clouded the legal position even further by formulating this in a manner that was very difficult to reconcile with the legislative intention expressed in § 9a.

With respect to the question of whether direct final disposal represents a form of spent fuel management which fulfills the demands of the Atomic Energy Act (AtG), then the legal position is quite clear. Namely, only in cases where utilization (a) is not possible according to the state of science and technology, (b) it is not economically viable, or (c) it does not permit the protection of life, health and material goods from the dangers of nuclear energy does the Atomic Energy Act permit final disposal. The issue currently unclear is the circumstances under which compact storage or interim storage is compatible with the Atomic Energy Act. Individual courts have recently put forward the opinion that such forms of storage are permissible for a maximum duration of two years /5.4/. This is justified by regarding § 9a of the AtG as representing a conclusive regulation of all possible forms of spent fuel management. This is opposed from the other position by maintaining that the regulation for spent fuel management in § 9a is only valid for the future legal position, but not for the present situation /5.5/.

Such an answer to this question does not seem possible at the moment. The wording of the Act does not provide any clear basis for an interpretation which would exclude the applicability of § 9a to the current situation. On the other hand, it could however be argued that a corresponding legislative intent resulted from the materials as well as from the essence and purpose of the Act. In effect, under these circumstances one will have to speak of a legal uncertainty in this standards area before a decision is made by the supreme court.

There is no indication in the Atomic Energy Act that the reprocessing of foreign material would be unlawful in a German plant. This is also valid for the objectives of the Act in § 1. The same regulations are thus applicable to the recycling of foreign material as to the corresponding treatment of material previously used in Germany.

The question of whether spent fuel management pursuant to § 9a of the AtG could also be carried out by the German operator being involved in a foreign reprocessing plant (e.g. Barnwell) and undertaking recycling there is not expressly regulated in the AtG. § 9a says that the operator "must make provision for" safe utilization. No basic prohibition of utilization abroad can be taken from this wording; nevertheless, special legal questions will undoubtedly arise.

It would be natural to assume that utilization abroad would only then correspond to the demands of § 9a of the AtG if this were to take place within a framework which ensured the continuous fulfillment of the duty established in § 9a. In this sense, it would have to be required that cooperation with the foreign partner could only be terminated at the end of a period which would be long enough to permit alternative solutions in the sense of § 9a of the AtG ("transitional period"). For example with respect to Barnwell, it can thus be established that a participation without simultaneous efforts at domestic reprocessing would only fulfill the demands of § 9a of the AtG if the legal framework for cooperation were designed in such a way that termination would not have to be expected before expiry of the "transitional period" mentioned above. The duration of this period will in the last analysis probably depend on the time in which construction of a plant in Germany could be completed; the minimum would seem to be a decade.

The question is therefore how cooperation would have to be designed in order to fulfill the requisite preconditions. A plant in Barnwell would be subject to American legislation. The NNPA does not conflict with the participation of a foreign concern (cf. the study by Doub and Muntzing, see Chap. 5.6.2).

However, there would have to be reservations with respect to the aspect that the NNPA can be modified by the American legislation at any time; these circumstances would hardly permit one to speak of the assured expectation of continuous cooperation. A different answer could admittedly result if cooperation between the USA and Germany were to be agreed upon in a treaty under international law in such a way that termination of cooperation within the "transitional period" would be legally impossible on the part of the USA. Only cooperation on the basis of international law would make it possible for cooperation with Barnwell to be regarded as fulfilling the duty pursuant to § 9a of the AtG.

5.5 Phased Plan for Institutional Aspects in Spent Fuel Management

Before details of cooperation models are depicted by means of which the supplier countries can possibly support the recipient countries with nuclear plants and materials, an analysis is required of the paths of spent fuel management basically possible in the recipient country itself as well as the corresponding coupling to the supplier country. Fig. 5.1 shows various possibilities of spent fuel management as an interaction between recipient country and supplier country. In considering spent fuel management, the reprocessing and reutilization of separated plutonium for MOX fabrication or for the fabrication of breeder fuel elements has also been included. Interim storage of spent fuel elements, their reprocessing, the possibility of direct final disposal of spent fuel elements as well as the final disposal of radioactive waste are technical stages of relevance here for spent fuel management. IPS, MOX fabrication and fabrication of breeder fuel elements are technical stages which can be of importance in the further processing of the plutonium produced.

Instead of discussing in detail all conceivable possibilities of interactions in spent fuel management between the recipient and exporting country we shall restrict ourselves to the analysis of the, in our opinion, most probable paths for spent fuel management (broad arrows). The spent fuel elements would accordingly first remain in the recipient country itself for interim storage. Such interim storage could be maintained for a relatively long period of time. If one assumes that after interim storage in the recipient country of about 10 years there were still no domestic reprocessing available, then transfer of the spent fuel elements with interim storage and subsequent reprocessing in the supplier country could be offered. The plutonium resulting from this reprocessing would first be stored in an IPS and subsequently converted into fuel elements by MOX fabrication in the supplier country. These fuel elements could then be returned for further utilization in the recipient country's reactor. In any case, the radioactive waste from reprocessing would have to be placed in a final repository in the recipient country at a later point in time. For reasons of acceptance, it seems impossible for the supplier country to take over radioactive waste. The plutonium obtained from reprocessing could also be used as MOX fuel in a reactor or as breeder fuel in a breeder in the supplier country after an appropriate credit had been negotiated.

A further possibility of supporting spent fuel management could be that fuel elements from the recipient country would be directly accepted for interim storage and further utilization in the supplier country (narrow arrows).

If the recipient country has its own reprocessing capacity available then the same spent fuel management and further utilization paths for plutonium as described above can be implemented (medium arrows).

The realization of direct final disposal of fuel elements seems unlikely both in the recipient and supplier country as well for both economic and ecological reasons.

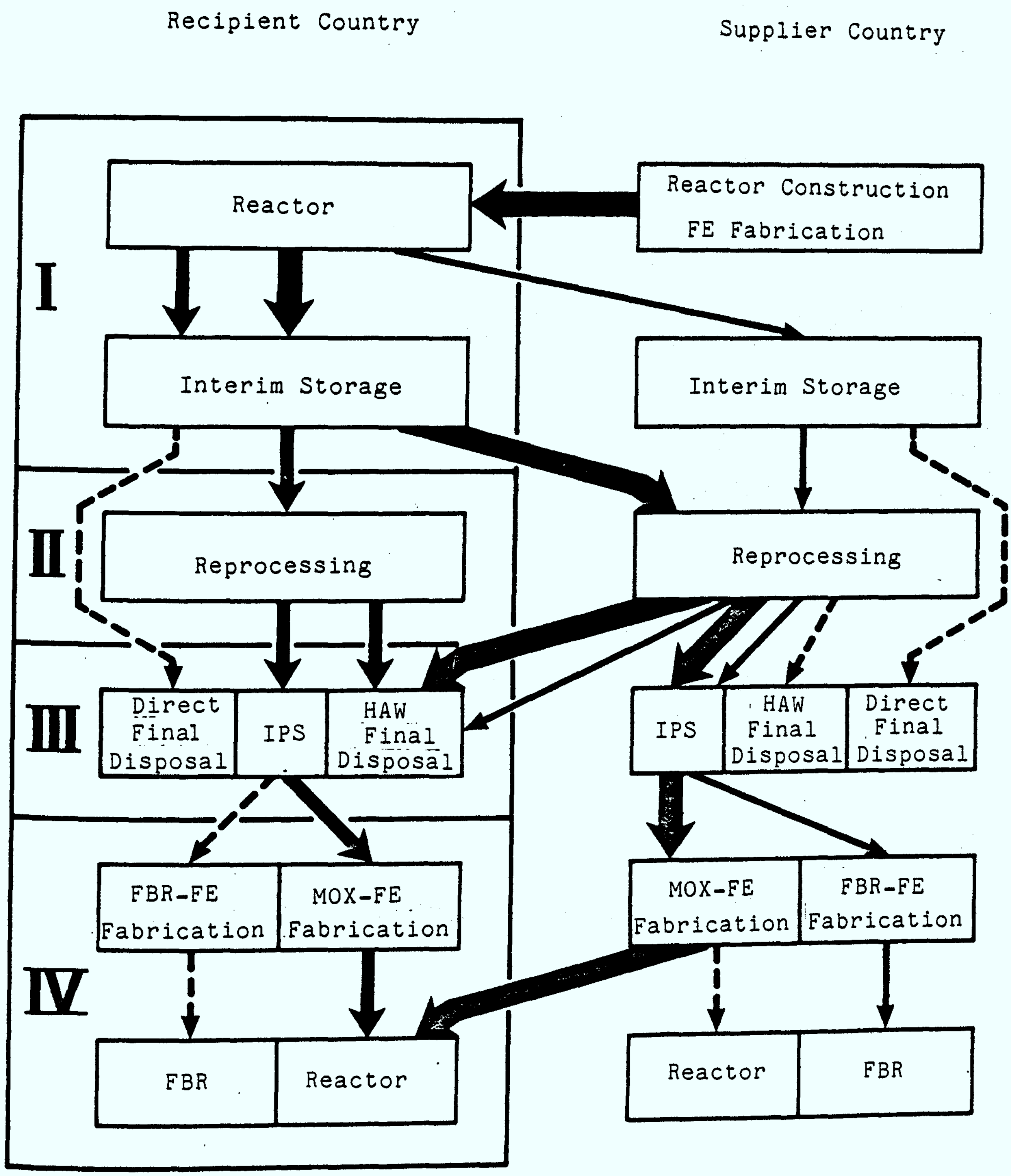

Fig. 5-1 Possibilities of Spent Fuel Management as Interaction between Recipient and Supplier Country

What technical and institutional possibilities are there then in order to implement support for the recipient countries from the supplier countries according to the models sketched above? In order to answer this question it is meaningful to first identify three technical steps: interim storage of fuel elements, fuel element reprocessing, and the treatment and final disposal of radioactive waste. The first and most important spent fuel priority in the country receiving reactors is to guarantee the safe interim storage of spent fuel elements. Since such an interim storage of spent fuel elements has proved to be possible for 10 - 20 years, command of this step in spent fuel management means a medium-term solution to the whole problem of spent fuel management. If this medium-term step in spent fuel management is selected in the recipient country then the supplier country should provide appropriate support in plant design and the construction of interim stores. In addition to supporting the design and management of such a store, storage canisters (e.g. CASTOR) could also be made available for longer-term storage. Storage of spent fuel elements themselves can be implemented in compact stores at the reactor or else in larger central interim stores.

If there is sufficient storage capacity available for spent fuel elements in the supplier country itself, then spent fuel elements from the recipient country could also be accepted here. This could be of special significance if fairly small nuclear energy programmes are planned in the recipient countries.

If one considers long-term scenarios for spent fuel management in countries receiving nuclear plants then the possibility of reprocessing spent fuel elements cannot be ruled out. Support for the recipient country from the supplier country thus suggests itself within the framework of appropriate cooperation; the growing programme size in the recipient country determining the rhythm of this cooperation. A phased plan is conceivable envisaging a growing intensification in the economic, financial and technological sector with respect to the reprocessing of spent fuel elements. It begins with the offer of reprocessing services by the supplier country and finishes with a domestic plant in the recipient country.

The individual phases can be described as follows:

- reprocessing service by the supplier country
- financial participation in reprocessing by the recipient country in the supplier country itself
- management participation by the recipient country in reprocessing in the supplier country
- operational participation (operating personnel) by the recipient country in the reprocessing plant in the supplier country
- multinational plant as a branch operation in the recipient country.

This phased model can be basically regarded as a possible guideline in the field of international cooperation in reprocessing. The rhythm in which the individual phases are to be established can be adapted to the individual circumstances of the recipient and supplier country. For this reason no fixed size of installed nuclear power station capacity can be allocated to the individual phases either. The state of domestic technology, economic efficiency, and the desire for independence play an important role. If the technical, economic and also political boundary conditions are favourable in the country in question, then individual steps can be skipped or a domestic reprocessing plant can even be directly constructed in the recipient country.

The third technical step in spent fuel management refers to the treatment and final disposal of radioactive waste. Support in planning and constructing facilities for treating and conditioning waste from nuclear plants can once again be offered by the supplier country. The problems of the final disposal of radioactive waste can, however, only be dealt with if highly active waste from reprocessing plants is present; that is to say they must be considered on a long-term basis. In this connection, the supplier country should offer support in studying suitable geological formations for a final repository and guarantee support in the planning and construction of such final repositories for radioactive waste. In principle, it must be assumed that radioactive waste from nuclear plants in the recipient country will also be suitably conditioned and stored there. Acceptance of such waste by the supplier country seems problematic even in the long term.

If one considers the time frame for the necessity of introducing the individual technical steps in waste fuel management, then it appears that after solving the interim storage of fuel elements (as well as treatment of radioactive waste) a medium-term solution to spent fuel management has already been found. All further steps can be approached on a long-term basis in suitable cooperation phases with the supplier country. As already mentioned above, tying programme sizes to the individual spent fuel management steps is difficult. However, if one assumes that, according to current perspectives, reprocessing plants of the order of 700 t annual heavy metal throughput represent an economic size then the establishment of such a plant in the recipient country could indicate a rough fixing of the nuclear energy programmes. A financial commitment of the recipient country by participation in a plant in the supplier country will only take place if this spent fuel management step is also to be realized in the long term in its own territory. A programme size of approximately 10 GW seems to be realistic here. However, such figures can only be rough reference values which can differ depending on conditions specific to the country.

Tab. 5-1 Phased Plan for Support from Supplier Countries for Recipient Countries in Spent Fuel Management

Technical Steps in Spent Fuel Management	Institutional Steps in Spent Fuel Management
Interim storage of FE	. Storage in recipient country Support in plant design and construction, supply of equipment, e.g. CASTOR canisters . Storage in supplier country Acceptance of spent FE by supplier country
FE reprocessing	. Reprocessing service by the supplier country . Financial participation in reprocessing plant by the recipient country in the supplier country . Management participation of the recipient country in reprocessing plant in the supplier country . Operating participation (operating personnel) by the recipient country in reprocessing plant in the supplier country . Multinational plant as a branch operation in the recipient country
Treatment and final disposal of radioactive waste	. Support in the planning and construction of plants for treating and conditioning waste . Support in the exploration of geological formations for final repositories . Support in the planning and construction of final repositories for radioactive waste

Tab. 5-2 Applicability of the Phased Plan

Spent Fuel Management Steps	Programme Size	Time Frame
Interim storage of FE	• unlimited • smaller programmes planned	at once - 20 years 3-year interim storage at the reactor
FE reprocessing	• • 10 GW • • • 20 GW	long-term
Treatment and final disposal of radioactive waste	• • 10 GW • 20 GW	at once coupled to reprocessing plant in the long term "

5.6 The Reprocessing Plant

5.6.1 Introduction

Two essential reasons can be stated for the reprocessing of spent fuel elements from nuclear power stations:

1. The recovery of non-consumed uranium as well as bred plutonium in order to conserve reserves of raw materials.

2. The isolation and conditioning of radioactive fission products and actinides with the goal of final disposal and environmental protection.

However, the relevance of reprocessing to proliferation is to be found in plutonium separation. For this reason, the International Atomic Energy Agency is working intensively on control concepts with those states who are about to commercialize reprocessing in the foreseeable future. Precisely the non-nuclear-weapons states Japan and Germany believe that they must carry out reprocessing of nuclear fuel due to their lack of domestic uranium reserves in order to guarantee their energy supply against external influences in the long term. Furthermore, the Federal Republic also has a legal regulation requiring evidence of spent fuel management before nuclear power stations can be put into operation. In addition to the interim storage of spent fuel elements, reprocessing currently forms an accepted possibility for spent fuel management. Furthermore, direct final disposal of spent fuel elements is also being studied, but this raises not inconsiderable problems of nuclear material safeguards.

Further important aspects result for the Federal Republic since it is also among the countries exporting nuclear technology. Recipient countries with fairly small nuclear energy programmes could, for example, ensure their spent fuel management by returning spent fuel elements to a reliable supplier country such as the Federal Republic. This would at the same time have the advantage that such recipient countries would enjoy higher credibility with respect to their own non-proliferation policy. Conversely, the Federal Republic undoubtedly also has a vital interest in continuing to be regarded as a non-nuclear-weapons state in the eyes of the international public.

The essential components of a reprocessing plant are mentioned in the supplementary volume. A discussion of safeguards for such plants is also included there. In the present Chapter, on the other hand, a phased plan is presented and then evaluated as an innovation for international cooperation in reprocessing spent fuel elements from nuclear power stations.

5.6.2 Institutional Models

The discussion of international cooperation in connection with the operation of reprocessing plants should, apart from the problems in possible cooperation models between the supplier and recipient state already mentioned, first consider the concrete situation in Germany, making two different assumptions:

1. the plant is sited in Germany,
2. the plant is sited abroad.

Once again, several approaches are possible with respect to the legal structure and international composition of the operator in question. Before special assumptions are made in this connection, the consequences resulting from the two preconditions mentioned above should be discussed in detail. It should merely be assumed that the plant is subject to a national legal system.

As far as a possible danger of proliferation emanating from the Federal Republic is concerned, a commercial plant abroad would offer greater advantages from the perspective of the international community since the Federal Government would not have any direct influence on the plant. Great political dependence would result from the fact that the Federal Republic would always have to display good political conduct towards the host state in order to obtain uninterrupted assurance of the necessary services and materials. Supply of services and materials, as well as the associated planning in the energy sector, would not be ensured under all circumstances. Moreover, in such a case the Federal Republic would have to refrain from its own development and utilization of modern technology, so that at least in some sectors it would fall behind the modern industrialized states.

If one assumes that an operator also offers reprocessing services to other states, then this would favour an economic plant size and a lower price would be possible. The technological know-how remains in the state constructing and operating the plant. Technology transfer could thus be ruled out. A further important aspect is environmental protection. As far as the Federal Republic is concerned, a plant abroad would have advantages. Finally'an aspect must be mentioned closely connected with supply assurance. The Federal Republic would be exposed to the possibility of sanctions with respect to reprocessing services if there were a reason to assume proliferation activity in the Federal Republic on the part of the host state.

Under the special assumption that the Federal Republic could participate, in some form, in a foreign plant then this could result in the first place in certain improvements in the sector of economic efficiency, since the operator could no longer demand arbitrary prices for his services. Furthermore, limited possibilities in the technology transfer sector as well as supply and planning assurance would be conceivable.

Operation of a reprocessing plant in Germany, in which material used abroad would also be recycled, would at the current state of development also have to consider the existence of prior consent regulations. States supplying Germany's cooperation partner could obstruct cooperation of the type

envisaged here by prohibiting the transfer of material coming from their country to Germany by means of the prior consent agreement. In order to prevent such a disturbance of cooperation it would be expedient to receive a contractual assurance from the supplier state to the effect that the latter would not obstract cooperation between the recipient state and Germany. In this respect, the contractual partners of the supplier state could be either the recipient state, the Federal Republic or both states.
The contract would have to determine in detail the conditions under which the supplier state would approve cooperation between Germany and recipient state.

From another point of view the question would thus arise of the extent to which a cooperation model of the type mentioned could give the supplier state grounds to generally dispense with prior consent demands on the recipient state. If one considers the content of previous prior consent agreements (cf. Chap. 3.4) then it appears that problems of transferring supplied material to third countries on the one hand, as well as enrichment on the other hand, would still be relevant from the perspective of the supplier state by cooperation in the reprocessing sector. It could thus at most be assumed that prior consent regulations could be simplified for the reprocessing sector by the forms of cooperation discussed here.

The analysis of German participation in an American reprocessing plant is of interest. The US position with respect to international cooperation in the reprocessing sector can be summarized as follows /5.6/, /5.7/.

1. General

In mid-1982 the US Government envisaged two basic changes to their export policy in the nuclear energy sector.

- Foreseeable, programmatic arrangements for reprocessing and the use of plutonium from American source material will be offered to the EEC countries and Japan.

- The USA will consider the export of sensitive reprocessing technology and items of equipment to Japan and the EEC states, insofar as the overall NP interests of the USA are not infringed by this. This is to be reexamined from case to case.

This new policy will not automatically take effect. It is rather a negotiating position. The US Government wants to attempt to persuade Japan and EURATOM to renegotiate their cooperation agreements with the USA with the aim of a revised version or modified agreement on cooperation. The US Government must be prepared to find that not all elements of their policy can be implemented and thus only a less comprehensive agreement with respect to international NP measures can be achieved. Finally, this new policy is to serve the goal of reestablishing the leading international role of the USA in the nuclear energy sector.

2. Possible DWK* Participation in Barnwell

The US Government desire that in principle responsibility for commercial reprocessing in the USA is in the hands of private industry.

The possibility of foreign participation, especially by the DWK, in Barnwell is not ruled out on the part of the Department of Energy (DOE). However, the Atomic Energy Act of 1954 (amended) prohibits foreign ownership, control or domination of plants on American territory. Foreign participation may not exceed 50 %. Foreign participation in the Barnwell plant could essentially take on three versions:

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* Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen mbH (German Company for Reprocessing Nuclear Fuel)

(1) The DWK enters into a partnership or limited partnership with American corporations for the sole purpose of operating a plant.

(2) The DWK forms a corporation with American concerns so that the liability from reprocessing activities remains limited to investment in the plant.

(3) The status of ownership in Barnwell could be a mixture of public and private agencies.
A corporation would be required for this which would be the property of the US Government and private contracting partners. The latter would also be the operator.

Finally, there would also be the possibility of the US Government owning the plant, which would exclude financial participation from the private sector.

3. Reutilization of Separated Plutonium

German participation in Barnwell would have two essential motives; furnishing proof of spent fuel management and energy assurance by returning separated plutonium to the Federal Republic. The conditions must therefore be established under which plutonium recovered from American source material could be returned from the USA. First of all, it is clear that in principle there already is a licence for exporting fissionable material to the EEC. The export volume for plutonium is limited to 1500 kg within cooperation between the USA and EEC. However, this limitation exclusively refers to Pu transfer on the part of the US Government and not for Pu transfer carried out on a private basis.

In conclusion it must be established that if a foreign concern is involved in Barnwell and the US Government participates even to a very slight extent, then the essential question could arise of whether Pu transfer would actually be on the basis of private law. Even if this Pu transfer could be organized and implemented on a formally private basis, the question would nevertheless arise in law of whether the Pu transfer were not implemented in substance by the US Government after all.

This question has not yet been answered.

It can thus be said by way of conclusion that for German conditions participation in a foreign plant cannot be desirable as the exclusive solution to spent fuel management. National solutions, offering the highest supply assurance, have absolute priority for the German situation with a large nuclear programme and scarcity of resources.

These remarks indicate the essential basic problems of international cooperation. However, cooperation models in the field of nuclear energy should be oriented towards the principles of the IAEA Statute whose major goal it is "to accelerate and increase the contribution of nuclear energy to peace, health and prosperity in the whole world". This goal involves corresponding objectives on the part of the IAEA and especially on the part of those member states who already have nuclear know-how available. These states consequently bear the moral responsibility for cooperating with and supporting those countries who also wish to utilize nuclear energy.
Finally, this process leads to assuring coverage of energy requirements and to establishing mutual confidence between the nations and thus to stabilizing world peace. There is also the concomitant obligation to the non-proliferation of nuclear weapons.

In order to do justice to these principles the following phased model for international cooperation in the reprocessing sector would be conceivable;

- national plant with front- and back-end service,
- national plant with financial participation,
- national plant with multinational management,
- national plant with multinational operating personnel,
- branch operation as a multinational plant.

In the stages "financial participation", "multinational management" and "multinational operating personnel" this phased plan also does justice to the growing technological needs of the developing countries and culminates in a domestic plant as a branch operation when the nuclear programme has achieved a corresponding size.

5.6.3 Evaluation

Evaluation is carried out according to criteria already familiar. It is assumed that there is no danger of proliferation from the Federal Republic itself. The Federal Republic is rather very much aware of the responsibility which it accepts with respect to the non-proliferation of nuclear weapons by cooperating in the nuclear energy sector.

5.6.3.1 Hindering Proliferation

The development of a phased plan for international cooperation in the field of reprocessing especially serves to support countries with fairly small nuclear energy programmes. The possible consequences arising for international safeguards will now be examined in more detail. The central problem is whether Art. 81d of INFCIRC/153 can be fulfilled in a more qualified manner by applying such models and whether a safeguards credit can even result with respect to a reduction of inspection effort in such multinational plants.

Multinational models can in principle involve three advantages for the non-proliferation of nuclear weapons:

- reduction in the number of sensitive plants,
- contractual barriers against abuse,
- internal safeguards by multinational cooperation.

The last area is certainly of special significance for the possible implications of safeguards. This is to be more closely examined on the basis of the following considerations of diversion problems.

A diversion of fissionable material refers to nuclear plants in which the nuclear material is subject to international safeguards. Diversion, just as the measures for its detection as well, presumes that all necessary information about the nuclear material present is available.

Among this is

- description of the material according to quantity, physical type and chemical composition,
- description of the paths taken by the material through the plant,
- description of the measuring methods used by the operator to trace and document the material in his plant, as well as
- description of the process steps to which the material is subject.

In the final analysis, diversion attempts involve information to which the safeguards authority is contractually entitled being withheld from it. Some examples of possibilities for falsification can be mentioned:

- data are not made available,
- interference with IAEA measurements,
- falsification of the shipper/receiver inventory change reports for the same transaction,
- falsification of reports and records,
- drawing up incomplete, inprecise and inconsistent records,
- subsequent falsification of the accounts,
- use of dummy fuel elements,
- falsification of identification features.

In Table 5-3 the forms of cooperation listed in the phased plan are examined with respect to the opportunities they present for detecting diversion:

Tab. 5-3: Possibilities of Detecting an Anomaly in Different Cooperation Models

Plant	Possibilities of detecting an anomaly
only for internal requirements	- IAEA safeguards
with front- and back-end service	- IAEA safeguards
with financial participation	- IAEA safeguards - further information on plant operation
with multinational management	- IAEA safeguards - the objective of the plant can only be modified by the whole management
with multinational operating personnel	- IAEA safeguards - the actual operation of the plant is conducted and safeguarded by multinational personnel down to the last detail
branch operation	- IAEA safeguards - further possibilities of detection depending on the employment of multinational management or operating personnel

If one considers the Table then in general intensified possibilities of detecting anomalies can be seen with increasing graduation of the models. This results from detailed knowledge and information associated with cooperation concerning

- plant operation and planning,
- nuclear material management,
- financing and budgeting, as well as
- possible anomalies in the plant.

More detailed, quantifiable statements can only be obtained here after the contractual elements of the various multinational models have been determined. The type and number of states involved would also have to be considered as further criteria. The model with multinational operating personnel as well as the branch operation model could offer the greatest possibility for detecting anomalies /5.8/.

5.6.3.2 Political Independence

Political independence depends on the extent to which supply of the necessary services and materials is guaranteed. This is undoubtedly guaranteed for the operator or host state of a reprocessing plant. The following picture emerges for a recipient country: there is basically great political dependence since the plant is subject to national law. This situation only changes in the last stage of cooperation if a branch operation is to be constructed and operated in the recipient country. This dependence is continually alleviated throughout the phases with financial participation, management participation and employment of multinational operating personnel, but the existing legal situation is not changed by this.

5.6.3.3 Supply and Planning Assurance

On the basis of current social conditions, recipient countries could presume the strict fulfillment of contractual obligations for the case of the Federal Republic. Supply and planning assurance in these countries would thus not be a question of imponderabilities in the Federal Republic, but would depend on their own internal conditions.

5.6.3.4 Profitability

It is to be assumed that economic plant sizes will be implemented in the envisaged cooperation. The problem of multinational management and operating personnel and their influence on economic operation is to be regarded on a long-term basis. In the case of cooperation developing slowly and continuously, the negative influence of different nationalities and social origins should be small.

5.6.3.5 Technology Transfer

The transfer of sensitive and commercial know-how can be controlled in the envisaged cooperation. Only in later stages of cooperation, especially where multinational management or operating personnel are envisaged, does the question of technology transfer arise and will then have to be settled contractually. The construction of a branch operation in a recipient country presumes technology transfer.

5.6.3.6 Environmental Protection

The reprocessing plant makes the highest demands as far as environmental protection is concerned since the radioactive inventory of spent fuel elements from several nuclear reactors has to be chemically and physically controlled here. The problem of plant size therefore plays an especially important role in public discussion. Associated with this is the question of the quantity of spent fuel elements from foreign nuclear reactors to be reprocessed.

5.6.3.7 Acceptance

Acceptance by the national public depends in the first place on solution of environmental protection and in the second place on assurance of the energy supply. To this extent problems could arise in realizing the phased plan if it cannot be clearly proven that environmental protection is guaranteed in all phases. Difficulties could particularly arise by taking in foreign fuel elements since the radioactive inventory in the Federal Republic would thus be considerably increased. The problem of disposing both of domestic and also foreign waste would undoubtedly have to be solved in this connection. In later phases there would also be the problem of operating safety with the employment of foreign operating personnel. In contrast, a branch operation abroad would probably not raise acceptance problems of this type. In this case, the problem of proliferation would be of significance for international acceptance.

5.6.3.8 Vulnerability to Sanctions

Vulnerability to sanctions refers to the foreign partners without their own plant who could be hit by the non-performance of reprocessing services in the case of demonstrable proliferation. However, the precondition is that the state aiming at obtaining nuclear weapons does not obtain reprocessing services elsewhere.

5.6.4 Summary

With respect to nuclear material safeguards, commercial reprocessing technology still requires some development work in the field of computer-assisted real time accountancy in order to comply with the IAEA's demands. A phased plan for international cooperation, particularly with threshold countries, is suggested which, on the one hand, is oriented to the goals of the IAEA in furthering the peaceful uses of nuclear energy, but which on the other hand also contains decisive factors for hindering proliferation. The phased plan envisages cooperation between countries supplying and receiving reactors, where in the first phase the countries importing nuclear technology are cffered services for reprocessing spent fuel elements. In the second phase recipient countries can participate financially in reprocessing in order to thus consolidate their legal claims to services. The next cooperation stages envisage foreign participation in management and then assignment of foreign operating personnel. In the final phase, branch operations subject to national law in the recipient country are constructed and operated there. In this way the development and implementation of sensitive technologies in threshold countries could be delayed until such a time as greater social stability had been established there which could possibly be promoted by serious cooperation with industrialized countries to encourage confidence. In the long term, proliferation cannot be prevented by simply attempting to withhold technology from a country. Proliferation can only be hindered in the long term by reliable cooperation and supply guarantees.

5.7 Fuel Element Refabrication Plant

5.7.1 Introduction

Countries with fairly large nuclear energy programmes deciding to introduce the reprocessing of spent fuel elements from nuclear reactors cannot dispense with fuel element refabrication. Obtaining fissionable material from spent fuel elements for the purpose of conserving raw materials (on the one hand and environmental protection by waste conditioning on the other hand) requires at the same time the re-employment and thus the fabrication of fuel elements containing plutonium.

A situation comparable to the problems of reprocessing can thus be seen in fuel element refabrication. Handling separated plutonium makes the ownership and operation of a refabrication plant more proliferation-relevant than that of a facility in which exclusively low enriched uranium is processed into fuel elements /5.9/. However, in comparison with a reprocessing facility there is an advantage from the point of view of international nuclear material safeguards in that the nuclear material (plutonium and uranium) can be much better verified from the outset in a refabrication plant. The incoming material comes from a reprocessing plant and/or from a uranium enrichment plant and has already been accounted for and verified. At the head end of the reprocessing plant, in contrast, only computational information is available about the nuclear material content in the spent fuel elements. Verification of the head end accountancy, especially in the fuel element dissolver of the reprocessing plant, therefore assumes very much more significance.

5.7.2 Institutional Models

However, in dealing with fuel element refabrication emphasis should be solely placed on the fact of processing separated plutonium. For this reason, it is suggested that the same forms of cooperation should be considered for refabrication plants as were previously discussed in dealing with reprocessing. A separate discussion therefore becomes superfluous.

5.8 Repository for Spent Fuel Elements from Nuclear Power Stations

5.8.1 Boundary Conditions

It is to be presumed that a state has decided in favour of utilizing nuclear energy. Accordingly, after some time, a considerable fraction of its energy supply would be based on utilizing nuclear energy. The state under consideration has made the operation of nuclear power stations conditional upon providing proof of spent fuel management. There is no reprocessing of spent fuel elements or recycling of the fissionable material. Waste management is to consist of direct final disposal of the spent fuel elements from nuclear power stations. Operation of a direct repository (D.R.) would thus be indispensable for ensuring the energy supply.

Spent fuel elements are accordingly regarded as waste to be removed from the biosphere. The primary purpose of a D.R. consists of isolating the spent fuel elements from the human habitat in such a way that neither the fuel elements nor parts of them can be brought back either by natural processes or human activities.

A D.R. is to be designed, planned, constructed and operated in accordance with this condition. The licence for constructing and operating a D.R. will, however, not only have to consider the phase of storing spent fuel elements but also the post-operational phase. The latter basically comprises a period of time resulting from the radiotoxicity and going far beyond the state of human experience for historical periods of time. In other words, licensing a D.R. also has to assume a post-operational phase in which the nuclear waste must be isolated from the biosphere for many thousands of years. In addition to assuring the energy supply, environmental protection is thus the second cornerstone supporting the D.R..

With respect to long-term safeguards, there is a parallel between the conditions resulting from environmental protection, physical protection and nuclear material safeguards. Whereas it is conceivable that a D.R. could be equipped with inherent safety as far as environmental protection is concerned so that it could be left to its own devices, it must be presumed for reasons of safeguards that a government intends to recover the nuclear material for military purposes. It is certainly safe to assume that in future it will be technologically easier to recover nuclear material from a D.R.. On the other hand, even the operational phase of a D.R. would seem to be problematical from the safeguards aspect.

The safeguards authority must assume that a diversion could already be undertaken during the operational phase. On the one hand, the problem of reverifying inventories would arise if anomalies indicating a diversion were detected. On the other hand, hindering a diversion would be a desirable goal but not envisaged in NPT safeguards. The safeguards system would therefore have to raise an immediate alarm in order to ensure timely detection. A further basic problem is the question of terminating safeguards. In other words: under what circumstances would the safeguards authority be prepared to release fissionable material from spent fuel elements in a repository from nuclear material safeguards? This final aspect assumes a special role with respect to the passive phase of the repository, that is to say for the period beginning when after 50 years' operation the pit is shut down, filled in and sealed.

5.8.2 Which Institutional Models can be Considered?

From the point of view of a state wishing to assure its energy supply by operating a D.R., a purely national solution seems desirable. However, from the aspect of proliferation the problems of safeguardability are highlighted in the first instance. Diversion of nuclear material can certainly be carried out most easily during the active phase of the D.R.. Since a reverification of the nuclear material inventory would raise great problems, the D.R. must be operated in such a way that either a diversion is prevented from the very beginning or else at least clearly detectable without a renewed inventory. This requirement makes the highest possible degree of internationalization in plant management seem desirable, which is associated with an unavoidable loss of sovereign rights.

On the other hand institutional models under international law would be very difficult to realize for reasons of acceptance.

It therefore seems more realistic to consider institutional models under national legal systems. Nevertheless, the possibility must also be considered for the European region of the Commission of the European Communities being involved in a suitable manner in the operation of a D.R.. It is of significance in this connection that the EURATOM member states only have an (unlimited) utilization right to nuclear material anyway, but no proprietary rights. It would therefore be appropriate for EURATOM, as the owner of the nuclear material, to receive spent fuel elements from the member states for reasons of nuclear material safeguards. In this way the credibility of the individual EURATOM member states would also be increased from an international perspective.

In order to evaluate applicable institutional models, a D.R. should be considered on the one hand which is also the property of the state independently operating it. On the other hand, there is a D.R. at least operated by a multinational enterprise.

The reader is referred in particular to Chapter 7, Jül-Spez-69 for legal details.

5.8.3 Evaluation

Evaluation of the possibilities of an institutional solution is carried out on the basis of a series of criteria already presented in Chapter 5.2.

5.8.3.1 Safeguardability

Assuming that a reverification of fuel elements in a repository would raise very great problems, airtight safeguarding of the D.R. must be ensured. Each C/S alarm must involve a direct action by the inspector. Only by basically safeguarding all movements in the D.R. at all times can it be verified whether diversion has taken place or not. A diversion could thus also be detected without a renewed inventory of fuel elements already in the repository.

In the passive phase of the D.R. when the pit had also been filled in and above ground plants shut down, no permanent inspector presence is expected to be necessary. It should be sufficient to safeguard the site with instruments together with regular inspections.

In these considerations it is assumed that the D.R. is national property under purely national operational management. Every diversion will therefore be detected immediately in good time by the uninterrupted inspector presence. A diversion can admittedly be detected in good time in this institutional model, but it cannot be prevented.

Conditions would be quite different if the D.R. were operated multinationally, if for example EURATOM were to operate such a D.R.. In this connection it is to be assumed that the host state of a multinational enterprise would renounce the exercise of certain sovereign rights in the locality of the D.R. in accordance with an international agreement through the national legislation and would at the same time undertake only to amend the relevant laws with the consent of the contractual partners. In the case of EURATOM it would only be legally possible to withdraw material from the repository with the consent of the remaining member states. In this case, diversion in the active phase of the D.R. could only be forced after launching a massive action by the host state. Under these circumstances, diversion would be preceded by a violent conflict. These problems would only be defused if the fissionable material contained in the spent fuel elements were conditioned and placed in the repository in such a way that the safeguards authorities would accept this as proof of non-recoverability and could agree to a termination of safeguards.

5.8.3.2 Hindering Proliferation

Hindering proliferation should be understood here in the sense that proliferation is to be prevented as far as possible. Of the models under consideration here, this is only possible in the variant "multinational enterprise renouncing certain sovereign rights under international law". In the case of purely national operation of a D.R. with a permanent inspector presence without any renunciation of sovereignty, the major factor of prevention is to be found exclusively in deterring diversion by immediate detection. National enterprises with the financial participation and service rights of third-party states do not have any additional relevance for increased hindrance of proliferation. Models with international operating personnel or management are also of significance in the first instance for detecting but not for preventing diversion, since the host state could expel the foreign employees from its territory.

5.8.3.3 Political Independence

Political independence would only be completely ensured in a purely national model (ownership, operation), since only in this case would there be sufficient supply and planning assurance with respect to the management of spent fuel from nuclear power stations. On the other hand, the EURATOM states have already waived their proprietary rights to nuclear material. It would therefore be conceivable for EURATOM to operate a D.R. on a multinational basis.

5.8.3.4 Supply and Planning Assurance

As an extention of the comments on political independence, it should also be considered that in multinational enterprises a rationing of the storage capacities would possibly be necessary insofar as the partner states were to insist on a contractually regulated reservation of repository capacity for their spent fuel elements. The flexibility of the host state in expanding its nuclear energy programme could be limited by this.

5.8.3.5 Profitability

The question of profitability undoubtedly only plays a minor role. However, if profitability increases with the capacity of the D.R. then the following two aspects could be of significance:

1. The D.R. could be designed for spent fuel elements from several countries.
2. Apart from spent fuel elements, the D.R. could also receive other dangerous waste, e.g. heavy metal residues,

the disposal of which has not yet been considered in any thing like as much detail as that of nuclear waste.

5.8.3.6 Technology Transfer

A certain technological know-how must admittedly be available in the final disposal of spent fuel elements from nuclear power stations. However, this cannot be regarded as sensitive from the point of view of proliferation. Therefore no particular significance is ascribed to technology transfer.

5.8.3.7 Environmental Protection

This criterion is of paramount importance since the real goal of a D.R. is to reliably isolate radioactivity from the biosphere. For reasons of social acceptance, the question of the extent to which spent fuel elements from other countries should also be received is of significance here. The endangerment potential of the D.R. increases in principle by expanding capacity. It is decisive for political and social acceptance that the valid environmental protection laws of the host state are complied with. A host state will not be able to dispense with this. In this respect, the question of the organizational form is irrelevant for a D.R. operator.

5.8.3.8 Acceptance and Vulnerability to Sanctions

Political and social acceptance are orientated to assuring the supply of nuclear energy by waste management as well as guaranteeing functional environmental protection. The first criterion in particular is promoted by institutional models in which the host state is both owner and operator of the D.R.. At the same time such models have an especially low degree of vulnerability to sanctions. This latter is highest for the model of a multinational D.R. where certain sovereign rights have been renounced. Vulnerability to sanctions means hindering proliferation.

5.8.4 Summary

With respect to environmental protection, it is irrelevant whether a D.R. is operated by a national or multinational enterprise since the host state has the possibility of insisting on observation of its valid environmental protection law.

As far as proliferation hindrance is concerned, the difference is tc be found in that in a multinationally operated D.R. an essentially larger degree of prevention can be realized whereas in a purely national repository solely immediate detection can be guaranteed. Prevention is conditioned by the multinational personnel as well as the relinquishment of certain sovereign rights in the locality of the D.R..

Political independence by assuring waste management is promoted by national enterprises in which no international personnel is involved.

However, participation by EURATOM in the operation of a D.R. would mean the consistent continuation of the proprietary right to nuclear material for the scope of the European Community. By renouncing their right to own nuclear material, the member states have already emphasized their confidence in the multinational organization. In this respect there does not seem to be any objection to a waste management concept with considerable EURATOM participation.

5.8.5 Other Countries' Possibilities

In the following the technological possibilities and geological preconditions are described for the construction and operation of repositories (for spent FE/highly active waste) in other countries.

5.8.5.1 Introduction

The application of institutional models in the field of final disposal, particularly the direct final disposal of spent fuel elements from LWR nuclear power stations, must on the one hand be oriented towards the actually existing worldwide nuclear energy programmes and on the other hand towards geological conditions. With respect to the nuclear energy programmes the references /5.10/, /5.11/ and /5.15/ were evaluated, with respect to purely geological aspects references /5.12/, /5.13/ and /5.14/ as well as several geological maps of various European regions. For reasons of time, the evaluation of the literature had to be restricted to salt formations. In the following the countries already operating nuclear energy programmes are listed. After that states are discussed who have already made known their plans concerning the utilization of nuclear energy.

In evaluating geological conditions for the final disposal of highly active waste, it must however be considered that no statements can be made about the suitability of geological formations for the purpose in hand solely on the basis of data from the literature insofar as no corresponding programme of geological investigations has already been carried out in the country in question and the results published. The suitability of a geological formation depends inter alia essentially on its size and geometry as well as on the rate of run-off, fissuring, interstratifications and geological mobility.

5.8.5.2 Countries with Nuclear Energy Programmes

The following Table provides a summary of information on the geology and nuclear energy programmes of the individual countries already utilizing nuclear energy /5.16/.

Tab. 5-4

Region/Country	Geology	Nuclear Energy Programme
EEC		
Belgium	- clay (L'Argile de Boom à Mol) - slate (Ardennes)	The possibilities are being investigated of final disposal in clay under the Mol research centre.
Netherlands	- dissected salt beds (pillow structure) in the Almelo/Hengelo district, thickness 30-100 m depth 300-400 m - rock salt (pillow structure) in the Central Netherlands, thickness up to 200 m	The possibilities are being studied of final disposal in salt.
Federal Republic of Germany	- rock salt - iron ore	The possibilities are being studied of final disposal in rock salt (Asse) and iron ore (Konrad); drilling programme in the Gorleben salt dome with respect to a first, commercial repository for radioactive waste, including suitability for highly active waste.
France	- saline rock (pillow structure) in the Paris basin - salt pillows and domes in the Pyrenean foot hills - potash deposits in Alsace - granite* in the Massif Central and at La Hague	The possibilities are being investigated of final disposal in crystalline formations, especially in salt. Drillings have been undertaken in granite at La Hague.

Tab. 5-4 (cont.)

Italy	-loam/clay (South Italy) -granite* (Sardinia) geologically very mobile** region	Possibilities are being studied of final disposal in loam/clay beneath the Trisaia Center in South Italy
United Kingdom of Great Britain and Northern Ireland (GB)	-rock salt, potash salts (Yorkshire, Durham), slight thickness limited formation -rock salt, gypsum (Isle of Man) -granite* (Scotland, Northern Ireland) stable platform areas -loam, clay	Possibilities are being studied of final disposal in crystalline formations (granite). The first repository should be operational in about the year 2000.
Western Europe		
Switzerland	-anhydrite -granite* (in the heart of the Alps, e.g. Gotthard) geologically mobile** region	Anhydrite formations are being studied for the purpose of final disposal in the Jura and in the Alps.
Sweden	-granite* stable platform region as part of the Baltic Shield	See Ref. /5.11/: Site studies resulted in suitable granite formations for repositories in the order Karlshamm, Finnsjö and Kråkemåla. It is envisaged that galleries with vertical bore holes will be constructed at great depth.

Tab. 5-4 (cont.)

Finland	-granite* stable platform region as part of the Baltic Shield	Possibilities are being investigated of the final disposal of spent fuel elements and HAW in crystalline formations on domestic territory (granite).
Spain	-salt -loam/clay -anhydrite -crystalline formations (granite)	Possibilities are being studied of final disposal in salt, loam/clay, anhydrite and crystalline formations.
Eastern Europe		
USSR	-all formations available	There are plans for studying possibilities of final disposal in the geological formations on domestic territory.
German Democratic Republic	-rock salt	see USSR
Czechoslovakia	-granite (no reliable information)	Plans for final disposal of HAW in crystalline formations are at the stage of basic design.
Bulgaria	-mobile regions	

Tab. 5-4 (cont.)

North America Canada	-granite (crystalline igneous pluton) -salt	There is a Plutonic Rock Programme for the Ontario section of the Canadian Shield with the aim of constructing a repository to be operational in about the 2000.
USA	-deep-seated salt formations -anhydrite -granite -slate -basalt -tuff -unsaturated rock -loam/clay	Possibilities are being studied of final disposal in various geological formations.
South America Argentina		
Asia Japan		
India		There are plans for studying possibilities of final disposal in geological formations on domestic territory.
Pakistan South Korea Taiwan		

* Granite formations have, inter alia, a very great vertical thickness; granite is one of the plutonites (= deep-seated magmatic rock)

** seismic, geothermal, volcanically active

5.8.5.3 Countries with Plans for a Nuclear Energy Programme

The following Table is a summary of information on the geology and nuclear energy programmes of individual states who have made known that they wish to utilize nuclear energy.

Table 5-5

Region/Country	Geology	Nuclear Energy Programme
EEC		
Luxemburg	iron ore	
Denmark	salt domes (Southern Denmark)	There are plans for studying possibilities of final disposal in geological formations on domestic territory. Two energy utilities have suggested final disposal of HAW in the deep bore hole of the Mors salt dome.
Republic of Ireland		
Greece	mobile region	
Western Europe		
Portugal	granite	
Austria	granite (Waldviertel), Alps geologically mobile region	There are plans for studying the possibilities of final disposal in geological formations on domestic territory.

Tab. 5-5 (cont.)

Eastern Europe		
Poland	salt	
Hungary		
Romania	salt domes (Carpathians, Carpathian Foothills)	
Yugoslavia	mobile zone	
Central and South America		
Mexico		
Brazil		
Peru		
Australia		
New Zealand		
Asia		
Turkey	granite (small deposits) rock salt (Central Anatolia) thickness about 400 m, little explored mobile zone	
Iraq	no deposits	
Iran	salt domes (Southern Persia) granite complexes mobile zone	
North Korea		
Indonesia		
People's Republic of China		
Israel	salt in alternate stratifications with sand stone and slate (below the Dead Sea), mobile rift valley zone	

Tab. 5-5 (cont.)

Africa	belt of rock salt extending from Algeria to Lybia, encircling Tunesia	
Egypt	granite (southern Sinai) gypsum with rock salt interstratifications	
Tunesia	gypsum	
Zaire		
South Africa		

5.8.5.4 Concluding Remarks

Information is still lacking concerning particularly India, Pakistan, Taiwan, South Africa, Argentina and Brazil with respect to geological conditions. A more intensive study of the literature could be of assistance here.

5.9 Final Disposal of Highly Active Waste from Reprocessing

The problem of applying institutional models for the final disposal of highly active waste from the reprocessing of spent fuel elements is essentially influenced by the criteria of proliferation hindrance and safeguardability. The decisive factor is the extent to which the concentration, volume and homogeneity of residual fissionable material in the waste can be reduced so that the safeguards authority can consent to release it from nuclear material safeguards. If this should be the case then evaluation could largely refer to the aspects of supply and planning assurance as well as environmental protection.

On the other hand, if one presumes that a state is to base its energy supply on the operation of nuclear power stations and makes this dependent on safe waste management, then the highest degree of supply and planning assurance is given with a national repository. With respect to environmental protection, no significant disadvantages are to be perceived if one presumes that construction and operation would in every case be subject to the most stringent conditions.

As far as social acceptance is concerned, disadvantages can be seen if for example spent fuel elements from third states are to be reprocessed and their radioactive waste deposited in the repository. The question of the repository's capacity in connection with deposits of foreign waste could lead to this type of repository concept meeting with acceptance problems on the part of the population of the host country. For this reason an international repository is not given any great chances of being realized. The disadvantages with respect to political acceptance and independence are thus added to disadvantages concerning supply and planning assurance.

With respect to profitability, it could on the other hand also be argued that even a purely national waste repository could be designed in such a way that other highly dangerous, long-lived waste - such as heavy metal waste - could also be deposited there. In view of the serious problems in this connection, especially in the industrialized countries, acceptance could even be increased by this, if the effectiveness of environmental protection measures were convincingly demonstrated.

6. ACCEPTANCE OF INSTITUTIONAL APPROACHES

The discussion concerning the expansion of nuclear energy has been virulent in the Federal Republic of Germany for many years. This controversy has still not yet been settled although in the meantime more than 20 % of the public electricity supply is generated on the basis of nuclear power stations. However, whereas the aversion to the operation of nuclear power stations has abated somewhat, and a rejection of front-end plants in the nuclear fuel cycle, e.g. enrichment, never became apparent at all, resistance has been become concentrated on the waste management facilities in the fuel cycle, on reprocessing and final disposal.

This took place on the one hand for tactical reasons since as the "bottle neck" in nuclear energy utilization, waste management plays a key role in the obstruction strategy of the opponents of nuclear energy. On the other hand, the opponents of nuclear energy have succeeded in arousing certain reservations in the public at large against this technology and waste management plants. Reasons for this could be found in the extremely small number of commercial reprocessing plants worldwide, in the apparently high susceptability to failure of some plants, in the political overemphasis on reprocessing, especially on the part of the USA, as well as in the "damnation" of the fissionable material plutonium which is isolated from the spent fuel elements during reprocessing and thus paves the way to the "dangerous plutonium economy" - a frequently heard but not precisely defined slogan. Finally, the proliferation-related aspects of reprocessing and plutonium utilization by technical recycling or in the fast breeder reactor have considerably reinforced acceptance deficits in the population at large.

Reservations about the final disposal of highly active waste originate in the subliminal apprehension concerning disposal of waste in general, upon which recent negative experience in handling dangerous waste from industry and technology has had a reinforcing effect. Even the natural lack of experimental trials for the centuries of final storage is taken as a confirmation of the reservations, in the same way as the protracted development phase of the planned repository in Gorleben, which can easily arouse doubts about the quality of this solution, especially in non-specialist observers.

The approach discussed in the present study of obliging countries supplying nuclear power stations to provide front-end and especially spent fuel management services in the interests of minimizing the number of sensitive plants in the back-end of the nuclear fuel cycle, precisely this approach enters into this critical area for the acceptance of nuclear energy, namely spent fuel management. A strategy of this type would result in not only spent fuel elements from domestic nuclear power stations being reprocessed and highly active waste being stored, but moreover fuel elements from states to which nuclear power stations had been exported. The reprocessing capacity would thus be increased, and also the quantity of highly active waste to be disposed of. Even if this additional capacity and storage quantity were only to be in the range of a few percent of domestic requirements, the slogan "World's Nuclear Rubbish Dump" would achieve a considerable negative emphasis in evaluating the acceptance of this process.

In answer to this type of acceptance reservation, it can be said that the actual quantity of additional materials for spent fuel management is extremely small and merely corresponds to the exported fraction of nuclear power station production. On the other hand, in future chances of exporting nuclear power stations will be considerably increased by an associated offer of nuclear front-end and back-end services, or even actually made possible by this. This assessment of the situation is confirmed by the fact that some other states exporting nuclear power are already technologically in a position to provide services of this type since the necessary plants already exist on their territory. From this point of view, support of this type can indeed be ncessary for possibilities of exporting nuclear facilities, which are undoubtedly among the top technological products and are export objects characteristic of a highly developed country. This can lead to an improvement in the balance of payments and also to the maintenance of highly qualified jobs at home and thus can also be mentioned as an acceptance argument in favour of reprocessing.

Moreover, the theory is put forward on the part of the Germans that the utilization of geological formations, especially rock salt, represents the most favourable solution for final disposal. A sufficient number of salt domes of this type are available in the North German Lowlands so that in principle this type of "optimum" solution for the final disposal of highly active fissionable products would also have to be available to those countries without such deposits or other similar possibilities.

In addition to economic, ecological and proliferation arguments, this leads to a further export-oriented argument in favour of constructing a reprocessing plant of an appropriate size on the territory of the Federal Republic of Germany, without which it would not be possible for the Germans to offer the spent fuel management services discussed above.

Over and above hindering proliferation, which has already been discussed in detail above, further positive arguments could be put forward such as improving acceptance by creating better conditions on the already tight world markets, and reasons of practicability for final disposal in salt domes.

Proliferation arguments opposed to reprocessing and breeder utilization recently put forward extensively in the nuclear energy controversy could be neutralized by the proliferation-hindering aspects of accepting supply and especially spent fuel management services for other countries, whether this be by reducing sensitive facilities, as has been propagandized by the United States for years, or by invalidating the argument of countries with small nuclear energy programmes that the lack of a complete nuclear fuel cycle would prevent nuclear "emancipation" or at least make it considerably more difficult.

Up to now, possibilities of returning spent fuel elements are only available for the COMECON countries which send their spent fuel elements back to the USSR which also constructed the reactors. Other countries in the world have not had this possibility up to now so that the procedure suggested in this study could introduce a new concept of peaceful nuclear planning in some countries.

The objective must therefore be to provide the population with more information, to invalidate acceptance difficulties due to an increase in the amount of waste by factual arguments and at the same time to use the resulting advantages for improving the acceptance of reprocessing and final disposal in the Federal Republic. In the long term, the behaviour of the remaining countries supplying nuclear technology will move in this direction anyway and therefore the acceptance of such a procedure will be necessary in our country if the Federal Republic wishes to continue playing a leading role in nuclear exports.

ACKNOWLEDGEMENT

The authors express their appreciation to DR.W.SCHLIMM, Geological State Office of Northrhine-Westphalia, for his assistance in collecting and evaluating data relevant to other states' geological prerequisites to establish final repositories for spent fuel elements or highly radioactive waste.

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ABBREVIATIONS

AtG	Atomgesetz (German Atomic Energy Act)
atw	atomwirtschaft/atomtechnik
BGBl.	Bundesgesetzblatt (Federal Gazette)
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Hannover) (Federal Institute for Earth Sciences and Raw Materials - Hannover)
CAS	Committee for Assurance of Supply
CEC	Commission of the European Communities
COMECON	Council for Mutual Economic Assistance
C/S	containment/surveillance
DC	developing country
D.R.	direct repository
DWK	Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen m.b.H. (German Company for Reprocessing Nuclear Fuel)
EAGV	Treaty Establishing the European Atomic Energy Community
EEC	European Economic Community
ESARDA	European Safeguards Research and Development Association

ET	Energie-Technologie
EURATOM	European Atomic Energy Community
FE	fuel element
GW	gigawatt, giga = 10^9
HAW	highly active waste
HM	heavy metal
IAEA	International Atomic Energy Agency
INFCE	International Nuclear Fuel Cycle Evaluation (international conference Oct. 1977 - Feb. 1980)
INFCIRC/	Information Circular (IAEA)
IPS	International Plutonium Storage System
ISFM	International Spent Fuel Management
KBS	Kärn-Bränsle-Säkerhet (Swedish safety report)
KFA	Kernforschungsanlage Jülich GmbH (Jülich Nuclear Research Centre)
KfK	Kernforschungszentrum Karlsruhe GmbH (Karlsruhe Nuclear Research Centre)
LWR	light-water reactor
MUF	material unaccounted for
MW	megawatt, mega = million

MWd/t	megawatt-days per tonne heavy metal
NATO	North Atlantic Treaty Organization
NEA	Nuclear Energy Agency (OECD)
MOX	mixed oxide, usually uranium-plutonium mixed oxide
NDA	non-destructive analysis
NNPA	Nuclear Non-Proliferation Act of 1978 (USA)
NPT	Nuclear Non-Proliferation Treaty
NRTA	near real-time materials accountancy
NSG	Nuclear Suppliers Group (Club of London)
OAS	Organization of American States
OECD	Organization for Economic Cooperation and Development / NEA
ORNL	Oak Ridge National Laboratory, USA
OVG	Oberverwaltungsgericht (Higher Administrative Court)
Pu	plutonium
PUNE	UN Conference for the Promotion of International Cooperation in the Peaceful Uses of Nuclear Energy
RP	reprocessing plant
t SWU/a	tonnes of separative work units/a
t U/a	tonnes of uranium per year

TWh/a	terawatt hours per year, tera = 10^{12}
U	uranium
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
VG	Verwaltungsgericht (Administrative Court)
WG	working group
WP	Warsaw Pact