INTERNATIONAL REGULATION OF NUCLEAR FUEL CYCLES: ISSUES FOR EAST ASIA

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ABSTRACT

This paper provides an overview of initiatives to develop international regulatory regimes for spent fuel and plutonium which go beyond the application of nuclear safeguards. These initiatives have a long history, going back to the Baruch Plan of 1946. The idea of international control over special fissionable materials was embedded in the statute of the IAEA in 1956, and was extensively reviewed during the late 1970s and early 1980s. There has recently been a revival of interest an international regulatory regime covering these materials, especially in East Asia. This interest coincides with a number of other regional developments and international initiatives related to plutonium and spent fuel. The paper reviews of some key issues in East Asia, offers a brief analysis of fuel and plutonium inventories in the world and in Asia, discusses international plutonium and fuel management regimes, and assesses recent proposals for an Asian co-operative framework. The prospects for an Asian scheme are discussed in the concluding section.

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1. Introduction

The international nuclear non-proliferation regime includes formal and informal elements. Formal measures include unilateral declarations, and bilateral, multilateral and regional agreements. Informal elements include the many political assumptions and relationships which underpin the regime. Together this evolving regime of measures has encouraged the development of peaceful uses of energy, while restraining the proliferation of nuclear weapons. The balancing of these two objectives has been achieved within the context of deep political tensions within the international system, and despite strained relations between states in many regions.

The keystone to the regime is the 1968 nuclear Non-Proliferation Treaty (NPT). Its contribution is threefold. The NPT is at the heart of efforts to prevent the proliferation of nuclear weapons to additional countries; provides an essential framework for international co-operation to use the atom for peaceful purposes under international safeguards; and entails the only legally-binding obligation on the nuclear-weapon states (NWS) to pursue negotiations on nuclear disarmament.[1]

Good-faith acceptance of the treaty's safeguards obligations provides a means for countries to demonstrate to their neighbours a commitment not to acquire nuclear weapons. This can build confidence and enhance regional security. The obligations take two forms: a) acceptance of safeguards by non nuclear-weapons states (NNWS) which verify non-diversion of nuclear materials from peaceful uses;[2] and b) an undertaking by suppliers of nuclear materials and technology not to transfer these to other countries, except when they are subject to safeguards. International inspections and monitoring of nuclear facilities are carried out by the International Atomic Energy Agency (IAEA). Over the past five years considerable effort has gone into strengthening the IAEA safeguards system in relation to clandestine nuclear activities (Programme '93+2'), and full-scope or comprehensive safeguards were accepted by all the major nuclear suppliers as a condition of nuclear trade at the 1995 NPT Review and Extension Conference.

A crucial element of the safeguards system is full knowledge and verification of the stocks and flows of special fissionable materials (plutonium and enriched uranium)[3] through the nuclear fuel cycle in each state. Despite the operation of the IAEA safeguards system, supported by regional safeguards systems in the European Union (EURATOM), and in Brazil and Argentina (ABACC)[4], there has been a long-standing concern that further political, and organisational measures are desirable for managing and verifying the peaceful use of fissile materials. Given the threat posed by nuclear weapons proliferation, many states and critics of the non-proliferation regime have felt uneasy with placing too much faith in the IAEA system. For many, these concerns were deepened when the clandestine nuclear programmes in Iraq and the DPRK were uncovered.

This paper provides an overview of initiatives to develop international regulatory regimes for spent fuel and plutonium which go beyond the application of nuclear safeguards. These initiatives have a long history, going back to the Baruch Plan of 1946. The idea of international control over special fissionable materials was embedded in the statute of the IAEA in 1956, and was extensively reviewed during the late 1970s and early 1980s. There has recently been a revival of interest an international regulatory regime covering these materials, especially in East Asia. This interest coincides with a number of other regional developments and international initiatives

related to plutonium and spent fuel. The paper reviews (in section two below) of some key issues in East Asia, followed in section three by a brief analysis of fuel and plutonium inventories in the world and in Asia. Section four discusses international plutonium and fuel management regimes, and this is followed in section five by an assessment of recent proposals for an Asian co-operative framework. The prospects for an Asian scheme are discussed in the concluding section.

2. The East Asian context

East Asia is the only region of the world where steady nuclear expansion is expected. In July 1997 total world nuclear capacity was 348 GWe, of which 60.1 GWe was located in East Asia.[5] East Asian nuclear capacity is expected to grow to about 120 GWe by the year 2010, by when it will account for about one-third of world nuclear capacity.[6] Most of this growth will take place in North-East Asia. The growth of power generating capacity will coincide with the development of nuclear fuel cycle facilities and infrastructures (uranium enrichment, nuclear fuel storage, nuclear fuel reprocessing, plutonium fuel recycling) in some these countries. This will take place in a complex industrial and political context, in which there may be great benefits in co-operation, but where there are also important obstacles.[7]

Differing stages of development: While the nuclear power programmes in Japan, South Korea (Republic of Korea, ROK) and Taiwan can be described as mature, those of all the other countries in the region, including China, are at a much earlier stage of development. At present the prospects for nuclear power in South-East Asia are quite uncertain. The problems faced by the two groups of countries are quite different. For those with mature programmes, the problems are associated with the back-end of the nuclear fuel cycle, in particular the management of spent fuel and radioactive wastes. For those embarking on nuclear programmes, the problems are related to creating robust institutional and regulatory structures to manage reactors and fuel cycle infrastructures.

Lack of a tradition of co-operation: East Asian countries have been dependent on nuclear technology from North America and Europe during the start-up phase of their nuclear programmes. Even the more mature programmes continue to be dependent on Europe and North America for nuclear fuel cycle services and technology. This attitude of 'turning outwards', rather than 'turning inwards' persists today, a striking example being the procurement by China of reactor systems from France, Canada and Russia, but not from Japan. Japan, ROK and China have each developed, or sought to develop a national industrial capability to build nuclear reactors. Japan has also pursued an policy to achieve nuclear fuel cycle autonomy since the 1960s. This is sharp contrast to the internationalisation and consolidation which has taken place in the North American and European nuclear industries.

Divergent nuclear fuel cycle strategies: While Japan and China have pursued reprocessing and plutonium use policies, other countries in the region have not been prevented from following this path. Taiwan, ROK and North Korea (Democratic People's Republic of Korea, DPRK) have all sought to develop indigenous fuel reprocessing capabilities, but been forced by US opposition to halt or abandon these policies. The US rationale has been two-fold. First, storage is a cheaper, more environmentally-sound, and strategically more rational way of managing spent nuclear fuel.

Second, reprocessing and plutonium-based activities carry with them risks of proliferation, and the associated threat to regional stability. This policy is perceived by those states affected to be discriminatory, and has tended to deepen their suspicion of fuel cycle activities in China and Japan.

Political and regional instability: Deeply-rooted bilateral tensions exist between many states across the whole of Asia. DPRK and ROK, Taiwan and China, India and China, India and Pakistan are all examples of these fragile relationships. In addition, mutual mistrust between Japan and victim countries in World War II (especially China and Korea) have not yet been resolved.

Risks of nuclear proliferation: Most countries with civil nuclear programmes either have nuclear weapons, or have nuclear weapons intentions. China is the only regional NWS, although the US has a clearly defined role in securing regional security, and DPRK is suspected of having had a clandestine nuclear weapons programme up to 1994. India and Pakistan are also widely believed to be 'nuclear-capable'. Beyond that Taiwan and ROK are also suspected of having had nuclear weapons ambitions in the past.

Spent fuel and plutonium: inventories and policies

Basic data

Power reactors in 31 countries have discharged spent nuclear fuel.[8] By the end of the year 2000, some 220,000 tonnes of spent fuel will have been discharged from power reactors and a further 100,000 tonnes or so will be added to this total in each of the next two decades (see table 1). The distribution of fuel is extremely wide, stretching at one end from Pakistan whose power reactors are expected to discharge about 300 tonnes of fuel by 2010 and the United States which will have discharged a little over 60,000 tonnes by then.

About 80 percent of discharged fuel will be handled as spent fuel waste, with about 20 percent of the fuel discharged to 2000 is expected to be reprocessed.[9] Assuming the large European reprocessing plants continue operating, a similar proportion of fuel discharged to 2010 will have been reprocessed. Using a crude conversion factor, we may estimate that by 2010 some 260,000 tonnes of spent fuel and about 50,000 m^3 of vitrified HLW will be in storage, awaiting disposal.[10] We estimate that roughly 40,000 tonnes of this fuel, and 10,000 m^3 of vitrified HLW will have accumulated in East Asia.

Table 1: Estimated spent fuel discharges by country: 1960-2010

	1961-70	*1971-80*	*1981-90*	*1991-00*	*2000-10*	*Total*
Argentina	0	361	1006	1917	2044	5328
Armenia	0	14	256	84	0	354
Belgium	0	200	1080	1279	917	3476
Brazil	0	0	33	198	322	553
Bulgaria	0	110	577	572	773	2031
Canada	45	3784	10780	14399	17828	46836
China	0	0	0	403	649	1052
Czech Republic	0	0	178	455	345	978
Finland	0	46	767	729	507	2049
France	371	5548	10610	13347	11615	41490
Germany	20	940	4040	4967	3805	13772
Hungary	0	0	308	652	367	1328
India	0	190	555	1859	4747	7351
Italy	463	644	603	452	0	2162
Japan	200	1260	6230	10964	9082	27736
Lithuania	0	0	439	1876	1291	3607
Mexico	0	0	0	353	254	607
Netherlands	4	94	141	146	83	468
Pakistan	0	45	50	86	121	302
Republic of Korea	0	20	1345	3806	5655	10826
Russia	264	1390	5733	5789	6819	19995
Slovakia	0	0	421	601	753	1775
Slovenia	0	0	115	153	114	382
South Africa	0	0	160	331	338	830
Spain	0	895	1782	2569	1324	6570
Sweden	0	310	1840	2150	2147	6447
Switzerland	0	315	786	951	564	2616
Taiwan	0	71	937	1335	979	3322
Ukraine	0	51	1509	2695	2670	6926
United Kingdom	4195	9716	9013	9810	8119	40854
United States	440	6590	15151	19790	19000	60971
Total	**6002**	**32594**	**76445**	**104720**	**103232**	
Cumulative	**6002**	**38595**	**115040**	**365419**	**322993**	

Source: D Albright, F Berkhout and W Walker, 1997, pp 140-143.

Projections of future plutonium inventories depend on estimates of two quantities: the rate of separation of plutonium in reprocessing; and the rate of consumption of plutonium in power and research reactors. Two major projections have been published recently, both of them showing that the large current world surplus of separated civil plutonium (about 150 tonnes) will continue to grow at least until early next century and probably beyond. The main reason for this is that at a world scale plutonium separation will continue at a faster rate than plutonium re-use or disposition in reactors. This problem of growing stockpiles will be exacerbated as plutonium extracted from dismantled nuclear weapons begins to be moved from military to civilian stockpiles. Figure 1 shows one of these projections showing world civil plutonium stockpiles continuing to grow, reaching about 250 tonnes by 2010. Note that this does not account of possible transfers of plutonium extracted from dismantled nuclear weapons to civilian inventories.

National radioactive waste strategies

The national spent fuel strategies of the 31 countries holding spent fuel and/or HLW are given in table 2. This shows a great variety of approaches and a good deal of uncertainty about future strategy. Of the 31 countries, some 21 have published national strategies for spent fuel management.[11] The main conclusion to be drawn from this assessment is the steady shift away from reprocessing policies and towards spent fuel storage and disposal policies.

Table 2. National spent-fuel management policies, 1960-2000 and beyond

Country	*1960s/1970s*	*1980s*	*1990s*	*Post-2000*
Argentina	S	S	S	S + R(D)?
Armenia	R(D)	R(D)	TB + R(F)	..
Belgium	R(D)	R(F+D)	R(F) + S	S + R(F)?
Brazil	S	S	S	S
Bulgaria	..	TB	TB + S	S + R(F)?
Canada	S	S	S	S
China	..	..	S	S + ?
Czech Republic	..	TB + S	TB + S	S
Finland	..	TB + S	S + TB	S + R(F)?
France	R(D)	R(D)	R(D) + S	R(D) + S
Germany	R(F+D) + TB	R(F+D) + TB	R(F) + S	S + R(F)?
Hungary	..	S + TB	S + TB	S
India	R(D)	R(D) + S	R(D) + S	R(D) + S
Italy	R(F)	R(F)	R(F)	..
Japan	R(F)	R(F+D)	R(F+D)	R(F+D) + S
Kazakhstan	S+ R(D)	R(D)	R(F)	R(F)?
Korea, Republic of	..	S	S	S + R(F)?
Lithuania	..	S	S	S
Mexico	..	..	S	S
Netherlands	R(F)	R(F)	R(F) + S	S
Pakistan	S	S + R(D)	S + R(D)	S + R(D)?
Romania	..	..	S	S
Russia	R(D) + S	R(D) + S	R(D) + S	R(D) + S
Slovak Republic	..	S + TB	S + TB	S?
Slovenia	..	S	S	S
South Africa	..	S	S	S
Spain	TB	R(F) + TB	R(F) + TB + S	S
Sweden	R(F)	S	S	S
Switzerland	R(F)	R(F)	R(F) + S	S
Taiwan	..	S	S	S
Ukraine	..	S + R(D)	S + TB	S + R(F)?
United Kingdom	R(D)	R(D)	R(D) + S	R(D) + S
United States	R(D) + S	S	S	S

Note: S = interim storage (either at reactor or away from reactor); R(D) = reprocessing (domestic); R(F) = reprocessing (foreign); TB = fuel returned to supplier under 'take back' arrangement. For states which were Soviet Republics before 1990, R(D) indicates reprocessing domestic to the Soviet Union, i.e. in Russia.

3. International plutonium and fuel management regimes

International control and international co-operation have been advocated for the management of spent nuclear fuel since the dawn of the nuclear era. In general these concepts have emerged from a concern with the threat of nuclear proliferation amongst powerful states - usually the United States. None of these concepts has been implemented, primarily because other states have felt that the loss of sovereignty over spent fuel policy would not be compensated for by an improvement in regional or international security. In general, these states, including European countries, have argued that international safeguards and national physical security controls were adequate to prevent the proliferation of nuclear weapons on the basis of civil nuclear activities.

Multinational schemes

The Baruch Plan

The first session of the United Nations General Assembly in 1945 adopted a resolution in favour of the international control of nuclear energy and nuclear weapons. The first proposal for a system of international control of nuclear energy came with the Baruch Plan, presented to the UN in June 1946 by the US representative, Bernard Baruch. The plan proposed the creation of an International Atomic Development Authority (IADA) that would be responsible for the ownership and control of uranium mines and plants producing fissile materials. The IADA would have the power to control, inspect and license nuclear facilities as well as engaging in research into nuclear energy and its misuse. Under the Baruch Plan the international control system would be in place before the United States destroyed its own nuclear weapons. The Soviet Union considered the proposal and rejected it, insisting that all nuclear weapons be destroyed first. It also argued that the inspections proposed by Baruch would threaten its national sovereignty.

Atoms for Peace

President Eisenhower's Atoms for Peace proposal to the UN in December 1953 was a renewed attempt by the Americans to develop international controls on the peaceful uses of nuclear energy. A core feature of the Atoms for Peace proposal was the creation of an International Atomic Energy Agency which would receive contributions of uranium and fissionable materials from the stockpiles of all states. These materials would become the responsibility of the agency and would be distributed under safeguards to any state requesting them for peaceful purposes. While the organisation proposed by Eisenhower was formed, its formal rights to custody of nuclear materials were severely constrained, and indeed have never been acted upon.[12] The IAEA's main tasks have been to provide technical assistance and to administer international nuclear safeguards.

Regional Nuclear Fuel Cycle Centres (RFCC)

In 1975 the IAEA launched a study project to examine the economic, safety, safeguards and security aspects of a multinational approach to nuclear fuel cycle facilities. For the purposes of the study, RFCCs were envisaged to include spent fuel storage, fuel reprocessing, plutonium fuel

fabrication and waste disposal. These centres could either be based on existing facilities, or could be new developments

The study group reported in 1977 with very encouraging results, arguing that from many perspectives considerable advantages could be expected from the RFCC concept. First the intergovernmental agreements envisaged for RFCCs would bring non-proliferation advantages. These agreements would lead to enhanced safeguards and physical protection, and improved siting of facilities. In addition, the creation of international centres would reduce the pressure to develop national reprocessing capabilities.[13] Second, the study argued that economic and operational advantages in geological disposal could also be expected, although the report argued that repositories would probably not be co-located with reprocessing and fuel fabrication plants. Third, and most significant, the RFCC concept held out the prospect of cost savings of a factor of 2 to 3 in the provision of the main fuel cycle services - reprocessing, MOX fuel fabrication and waste management - for many countries thought to be embarking on small national fuel cycle programmes.[14]

Although the study was well received by many countries, no concrete steps were ever taken to develop the concept further. This was primarily because within two years many of the basic assumptions about the expansion of reprocessing capability had been proven wrong and because by then British Nuclear Fuels Ltd (BNFL) in the UK and Cogema in France had established a tight grip on the international fuel reprocessing market. The large reprocessing contracts on 1978 and 1979 proved that for a couple of decades at least, nuclear operators the world over could depend on the British and French reprocessing facilities.

The International Nuclear Fuel Cycle Evaluation (INFCE)
Coincident with the development of grand concepts for international fuel cycle centres, and following the Indian nuclear explosion of 1974, a growing unease about the proliferation of nuclear weapons emerged in the United States. This was first articulated by President Ford and later became a primary concern of President Carter's foreign policy. American pressure to curtail civil reprocessing and plutonium use led to the creation of the International Fuel Cycle Evaluation (INFCE) project at the IAEA. Little agreement was reached in most of the discussions, and INFCE did not lead to dramatic changes in the fuel cycle policies of any of the participating countries. For this discussion, the main results of interest were the creation of two expert groups: one on International Plutonium Storage; and a second on International Spent Fuel Management.

International Plutonium Storage (IPS)
The expert group on IPS was set up to develop ideas for how the IAEA could act upon the rights provided for in article XII.A.5 of its statute (see above). Following a preliminary report in 1978, the study was turned over to an expert group open to all IAEA members. This group set out a number of concepts for an IPS. No consensus had been found by the time of the final report in 1982, and no further work was done until a decade later (see below).

The study based itself on the assumption that under an IPS agreement, all separated plutonium in excess of current requirements for safeguarded use in reactors, fuel production and research would be stored under international control. Stored plutonium would be released according to

rules to be agreed. At this stage three problems were encountered:[15] the definition of 'excess' plutonium; the conditions for release; and the location of plutonium stores.

Three different options for the international control of plutonium stocks were reviewed in the 1982 IPS report, ranging at one extreme from a system under which all plutonium stocks would be continuously under IAEA control, to at the other a voluntary system under which states could register 'excess' stocks with the Agency. Under the more comprehensive system, states would be obliged to provide a 'statement of use' for plutonium they wanted to withdraw from the IPS, demonstrating how the material would be used for legitimate peaceful uses. The Agency would also have rights to assess the validity of the statement of use before making plutonium available. Under the voluntary system, plutonium would be returned to states immediately on request. The main point of debate was over whether the IAEA should be given the right to withhold plutonium which a country had registered with an IPS if it was not satisfied that the material would be put to peaceful use.[16]

International Spent Fuel Management

The expert group on international spent fuel management was convened in 1979 and also reported in 1982. Its brief was to investigate options for the international spent fuel storage, either through countries sharing storage capacity, or through technical assistance. The main issue of the report was whether there were economic, logistical or strategic reasons for developing international arrangements for spent fuel storage, and how these arrangements might be set up. The report did not include much discussion about the disposal of fuel in the host country. Under the main scenarios studied, spent fuel would be returned to the customer country after a number of years, either in its original form or following some further conditioning. However, it was argued that international arrangements would be most attractive to customer countries in the future if they included '...an overall solution to their need to close the back-end of the fuel cycle' (including radioactive waste disposal).' This is an echo of the RFCC idea.

The report argued that countries most suitable as a host for an international spent fuel store would be those with a nuclear energy programme with previous experience of handling spent fuel. It presented costs estimates for spent fuel storage which showed that unit costs for spent fuel storage technologies flattened out for facilities with a capacity of about 5000 tonnes. International fuel stores could therefore be expected to deliver savings for those national programmes generating less than 5000 tonnes of fuel. The report also contained some discussion of the key elements of the international agreements which would need to be drawn up for an international spent fuel venture. It concluded that in the short term no demand for international arrangements existed, and that a framework already existed for carrying forward initiatives on spent fuel management.[17]

The OECD/NEA Study

The Radioactive Waste Management Committee (RWMC) of the Nuclear Energy Agency published a preliminary study on possible international approaches to radioactive waste disposal in 1987.[18] The report was not widely publicised, and attracted little attention from national governments. Since the mid-1980s, although the concept of international co-operation has been

raised several times within the RWMC (with the Dutch government especially keen supporters), no further substantive discussion has occurred in the committee.

The report concluded that there were two basic approaches to international waste repositories (IWR): an international project; or the extension of a national project, on a commercial basis, to accept additional material from other countries. It further concluded that there were no apparently insurmountable safety, technical, economic or institutional obstacles to serious consideration of the concept. Nevertheless, because of slow progress in the development of national repositories, the committee did not believe that the time was right to embark on a comprehensive generic study.

The report further concluded that: i) The economic incentives for an IWR (rather than a national repository) would be limited to countries with 'very small nuclear programmes'. No definition of 'very small' was provided; ii) The main logistical problem associated with an IWR would concern the transport of radioactive waste or spent fuel to the repository. This would limit the maximum size of such a repository; iii) The creation of an IWR through the commercial extension of national programmes was a more credible route than the formation of an international project; and iv) A good deal of harmonisation of safety standards between countries had already occurred through the widespread adoption of IAEA and ICRP standards.

Commentary
Although practical experience with multinational schemes in the back-end of the nuclear fuel cycle is limited and generally unsuccessful, the idea of multinational arrangements has remained attractive for policy-makers in international organisations. This is partly because these organisations see a new role for themselves in fostering such schemes.

The schemes which have been proposed in the past have been justified for a variety of reasons. In the immediate post-war phase (mid-1940s-1950s) the main justification for international ownership and control over civil nuclear activities was to prevent the proliferation of nuclear weapons and to spread the benefits of nuclear power evenly. Although radioactive waste disposal was not explicitly discussed, it was assumed that wastes would also be dealt with collaboratively.

After a twenty year gap, the idea of international control of fuel cycle activities emerged again. On the one hand these scheme were driven by a concern that the anticipated rapid growth of nuclear power around the world could be achieved only through intensified international industrial and political co-ordination. Most multinational schemes of the period were therefore concerned with internationalising the whole of the back-end of the fuel cycle, including spent fuel storage, reprocessing and plutonium fuel fabrication, as well as (in some cases) the disposal of radioactive wastes. None were developed beyond conceptual studies, and by the late 1970s interest in these schemes faded for political and commercial reasons.

On the other hand, there was renewed concern (mainly from the United States) about the proliferation of nuclear weapons, but also a belief that by co-operating in the development of fuel cycle capabilities, small countries would benefit economically. Towards the end of this second phase, the concept of international waste disposal had become much less pronounced, primarily

because there were felt to be serious problems of public acceptability. International debate about international options was also stifled by a concern that national repository programmes were a priority, and that these would be undermined by high-profile studies into international alternatives.

4. Current schemes for international approaches to plutonium and radioactive waste management

There has been a revival in interest in the international control of nuclear activities in recent years. In the field of nuclear safety there have, since the Chernobyl accident in 1986, been a number of initiatives to harmonise nuclear safety approaches and to improve international co-operation on safety (the 1996 Convention on Nuclear Safety). A new convention to strengthen international co-operation in spent fuel and radioactive waste management was agreed at the IAEA General Conference in September 1997. This follows the development of international standards and peer review as a means of aiding the process of public acceptance for waste policies.[19] Preliminary discussion are also being held to develop the notion of multinational approaches to the management and disposal of certain classes of radioactive waste.[20] Finally, informal discussions on the international management of plutonium began again in Vienna in 1992, as concerns grew about the control of civil and military stockpiles. This process, while much delayed, is expected to reach a conclusion soon.

The underlying motivation of these developments appears to be a deepening perception that nuclear safety and security are global issues which all nations have a right and responsibility to address. How far this 'globalisation' of nuclear safety and control will lead to firm multinational ventures in the back-end of the fuel cycle in future is still very hard to tell. The first phase of globalisation is already seeing growing international transparency and oversight over nuclear activities, together with greater technical co-operation and technology transfer to countries perceived as having a weak technological base. At an industrial level, stagnation in the nuclear industry has forced restructuring through the formation of multinational consortia and alliances.

In this section we review present discussions over international approaches to plutonium and radioactive waste management. These are a set of unconnected discussions, frequently with rather modest aims, although in some cases there is clearly an ambition to pave the way to a more comprehensive scheme. Rather than being visionary, as in the 1970s, these schemes are mostly an attempt to develop international controls incrementally.

International Plutonium Regime

In September 1993 further international controls on fissile materials were again discussed at the IAEA General Conference. Two new concerns had arisen in the intervening years. First, nuclear weapons disarmament meant that large stockpiles of special fissionable materials - plutonium and HEU - were expected to be recovered from dismantled weapons. A large proportion of these materials would be excess to future military needs. Establishing secure international control over these stocks was seen as a priority and a potential new role for the Agency. Second, stocks of separated civil plutonium were seen to be growing, and certain countries - led by Japan - were concerned that their civil plutonium programmes would come under international suspicion as

these stocks mounted. By seeking additional international controls and transparency, these countries aimed to allay some of the public and international doubts about their programmes.

A group of nine countries have been participating in discussions over an International Plutonium Regime (IPR) in Vienna since 1992.[21] The chief sponsor of this group has been the Japanese government. The 'framework' agreed upon involves improved declarations of plutonium stockpiles by states, including separated plutonium and plutonium in irradiated fuel. Plutonium in weapons states removed from warheads and military stockpiles will be included in the reports of states as soon as it is declared to be not for defence purposes. The guidelines for a plutonium reporting system also include detailed provisions on the control of international transfers and on the storage of separated plutonium. There will be a system of end-use certificates to ensure that no plutonium is exported until both the exporter and the recipient governments, 'understand, and are satisfied with the intended end-use, the amounts involved, and the timetable.' [22] There is also an understanding that the storage of plutonium will be controlled to avoid an undue increase in the number of sites where it is held.

At various times during the past 5 years, the US has proposed a wider agenda and scope for the IPR. The reporting of highly-enriched uranium (HEU) inventories was not included due to European and Russian opposition. They argued that HEU was a valuable, internationally-traded commodity (unlike plutonium) and that information on inventories was proprietary or confidential. This was against the background of Russian HEU sales to Germany and elsewhere for research reactor and other uses, and as European enrichment companies have sought to enter into trade agreements with Russian over blended-down weapons HEU. The US also sought to include guidelines for a specific timetable to reduce stocks of civil plutonium within IPR. This was also rejected by the other parties who face large and growing plutonium stockpiles for the foreseeable future.

Convention on spent fuel and radioactive waste

In September 1997 a diplomatic conference agreed the text of a new Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.[23] Its primary aim is to encourage greater harmonisation and co-operation between state in the management of radioactive waste, which is now recognised as a generic problem with international consequences.

The text deals with radioactive waste, civil spent fuel and materials of military origin which have been transferred to the civilian side. The Convention establishes a binding reporting system of radioactive waste and spent fuel, and on measures taken by each state to manage these materials. It provides for peer reviews of national waste management programmes and sets standards for national legal and regulatory frameworks and infrastructures. The Convention also contains provisions for the discharge of radioactive wastes and handling of radiation sources that are no longer in use.[24] Radioactive waste and spent fuel are treat almost identically, but in two separate chapters (hence a 'Joint Convention') on the insistence of countries like India who claim that spent fuel is a resource not a radioactive waste.

International repositories

Over the past three years there has been a developing interest in the concept of international or regional repositories within the IAEA. A small Expert Group met to consider technical, economic and safety aspects of this concept in Vienna in late 1994. Since then a number of unofficial activities have continued. The most recent expression of interest in international repositories came in a speech by the IAEA Director General Hans Blix in June 1997.[25]

The regional repositories concept developed within the IAEA following a series of Waste Management Advisory Programme (WAMAP) missions to countries in southern Africa. The IAEA discovered that a number of these countries held in store small quantities of long-lived radioactive waste in the form of radium needles which had been used in cancer treatment between the 1940s and 1970s. The amounts of material are very small. In Kenya, for instance, some 20-25 grams of radium is contained in about 100 needles. Although many other medical radioisotope sources can be disposed of in near-surface sites, radium, with a half-life of 1600 years, is unsuitable for this disposal method. Alternative disposal sites are not available, and the regulatory and industrial infrastructure does not exist for the safe final disposal of these wastes. A White Paper was produced by the IAEA which proposed that South Africa, as a neighbour country with the infrastructure necessary to handle these wastes, should be approached with a view to disposing of them, either in a borehole or in association with spent fuel wastes. The South African government studied the idea, but rejected it.

The IAEA's Expert Group was wound up in 1995, but work has continued in an ad hoc group sponsored by the Atomic Energy Corporation of South Africa (AEC) and Germany's Gesellschaft für Nuklear-Service (GNS). This group has had a wider remit, being concerned with international approaches to all radioactive wastes, other than milling and mining waste. The group aims to produce a 'platform document' which can be used by national governments in their own considerations of proposals for regional repositories. Many of the issues considered are similar to those discussed in the IAEA's previous assessments. For instance, the group is concerned with the composition of parties to a regional repository. Agreement exists that industrialised countries with large nuclear programmes should manage their own radioactive wastes, and that legitimate interested parties in regional repositories will be states with small nuclear programmes, and weak radioactive waste infrastructures. In general, the host country will be a larger state with strong nuclear and waste infrastructures. Moreover, the regional repository concept assumes that existing waste management companies and organisations will handle these wastes, and does not envisage the creation of new 'international' entities.

The group developed some basic criteria for identifying potential host countries: a) the country must have an established nuclear and radioactive waste management infrastructure; b) the country must have existing technical and regulatory infrastructures for handling radioactive waste; and c) country must have a suitable land mass (referring to a preference for a large continental country). The group has published a list of countries it believes would be prime targets to seek a home for spent fuel inventories: Pakistan; Armenia; Slovenia; Netherlands; Brazil; Argentina; South Africa; and the Czech Republic. All of these countries are projected to have spent fuel inventories of less than 1000 tonnes by the year 2010.[26]

Commentary

Few similarities exist between the international arrangements currently being considered. IPR is concerned with increasing confidence that civil (and military) stocks of fissile materials are being securely managed. The radioactive waste convention, and the international repositories concept are attempts to encourage common standards to be adopted, and the sharing of facilities and know-how. These concepts are all developments of earlier ideas which are now being applied to new problems: growing civil plutonium stockpiles; nuclear weapons dismantlement; and the absence of nuclear waste infrastructures in many countries. IPR is primarily concerned with providing political assurances to other countries, while the convention and international repositories concept aims to improve safety and environmental management.

A common theme of all these proposals is that from the perspective of security and environmental protection, the management of nuclear materials is a global concern which must be handled through co-operation between countries. This represents something of a development from the assumption of nuclear autarky (that countries should strive for independence in nuclear affairs) which prevailed during the 1970s. The notion that the common good may be served through co-operation has again emerged. A crucial difference is that all co-operative ventures in the future will need to take much more account of public and political acceptability. The proponents of each of the proposals being considered today are highly aware of the legal and political obstacles which they face.

Finally, what does previous experience in international co-operation in radioactive waste management tell us about the main factors for success and failure? First, in general, discussions between governments have not led to concrete arrangements (the only exceptions are IPR and the Joint Convention). Effective multinational schemes have all emerged from trade in nuclear fuel services (the development of a global reprocessing industry in the 1970s, for instance), although governments were involved at all stages to provide political assurance and backing. However, since the mid-1970s a norm of 'self-sufficiency' has existed in relation to reprocessing wastes. All wastes generated during reprocessing are routinely sent back for storage and disposal in the state of origin.

Internationalisation of spent fuel and radioactive waste management has also been impeded by developments such as the Basel Convention (on transfers of hazardous wastes), the London Convention (on sea dumping of hazardous and radioactive wastes), and numerous other international agreements (the Bamako Convention, the Lomé IV Convention and so on) which have steadily moved to close off international transfers of hazardous materials. In general, there has been a shift from establishing international norms of safety, and towards outright bans on such movements.

5. Recent proposals for an Asian cooperative framework

Over the past five years there has been a flowering of mainly Japanese proposals for greater cooperation in nuclear affairs in Asia. One of the key drivers has been Japanese sensitivity about misperceptions about their own intentions in having by far the largest and most sophisticated nuclear programme in the region, including an ambitious fuel services capability. These proposals

frequently go under the general title of 'Asiatom', in reference to the European fuel supply and safeguards agency EURATOM. *Atoms in Japan*, the house journal of the Japan Atomic Industry Forum has carried major coverage of meetings on international cooperation in Asia, and there is clearly an effort in industry and government circles to begin a multilateral discussion.

A recent assessment of proposals for an Asian nuclear cooperation framework has concluded that it would need to take a rather different form to EURATOM, but that there are four potential areas for cooperation: nuclear safety; spent fuel and other radioactive wastes; public acceptance; and non-proliferation.[27] What is striking however, is that there seems little consensus among the different Japanese proposals, or between the Japanese and non-Japanese proposals. One of the primary reasons for this appears to be a clash of interests. Whereas Japan is interested in legitimising its plutonium programme, the other mature nuclear states - ROK and Taiwan - have few interests in conceding this legitimacy, because for different reasons they have been disqualified from pursuing such a policy themselves - ROK through the 'Non-Nuclear Korean Peninsula' policy, and Taiwan as a result of US policy dating back to the mid-1970s. Meanwhile ROK and Taiwan have quarrels of their own. ROK has complained bitterly about Taiwan's recent plan to ship radioactive waste to the DPRK.[28]

6. Conclusions

There has been a long history of discussion about internationalising the management of spent nuclear fuel and fissile materials. Many of the basic issues which led to a desire for international control persist today - the awareness that the security and environmental dimensions of the nuclear fuel cycle are global, and the realisation that all countries face difficulties and enormous costs in overcoming political opposition to fuel cycle and waste activities. However, the desire for international control has also been balanced by a desire, particularly amongst countries with growing nuclear programmes, to maintain independence over fuel management policy, and the emerging consensus that the rule of 'self-sufficiency' applies to the management of toxic radioactive wastes. If the management of spent fuel or radioactive wastes can be done on an international basis, this could only occur if clear environmental and security advantages were likely. This would probably require the movement of materials towards countries with larger and more highly developed nuclear infrastructures and regulatory institutions. With the international reprocessing business unable to overcome its economic or environmental disadvantages, and gradually shrinking early next century, there will be no alternative for almost all nuclear programmes but to find politically acceptable ways of securely storing their spent fuel, pending final disposal to a repository, probably on their own territory.

Endnotes

[1] L A Dunn, The Nuclear Non-Proliferation Treaty: Issue of Compliance and Implementation, *PPNNP Issue Brief No 9*, Mountbatten Centre, University of Southampton, February 1997, p 1.

[2] There is currently no obligation on NWS to accept IAEA safeguards, although under 'voluntary offer' agreements all the NPT NWS have made available their civil facilities for inspection should the IAEA designate them for safeguards. The regional EURATOM safeguards system is applied to all civil nuclear facilities in France and the UK, and the US has offered to place all fissile materials extracted from nuclear weapons that are excess to defence requirements under IAEA safeguards.

[3] Also known as 'direct use' materials, that is, materials which are relatively accessible for use in nuclear explosives devices.

[4] Argentina-Brazil Agency for Accounting and Control of Nuclear Materials created in 1991.

[5] Uranium Institute, *Core Issues*, no 4 August-September 1997, London, p 25.

[6] T Suzuki, Nuclear Power in Asia: Issues and implications of 'Asiatom' proposals, paper to *UN Symposium on Regional Co-operation in North East Asia*, Kanazawa, June 2-5, 1997.

[7] I am dependent here on the arguments put forward by T Suzuki.

[8] In addition, research reactors operate in Algeria, Argentina, Australia, Austria, Bangladesh, Chile, Denmark, DPR Korea, Egypt, Greece, Indonesia, Iran, Iraq, Israel, Libya, Malaysia, Norway, Peru, Philippines, Poland, Portugal, Thailand, Turkey, Venezuela, Vietnam, Yugoslavia and Zaire (27 countries).

[9] Fuel from the following countries is expected to be reprocessed: Belgium, Bulgaria, Czech Republic, France, Germany, Hungary, Italy, Japan, Netherlands, Russia, Slovakia, Spain, Sweden, Ukraine, United Kingdom, and the United States. See: D. Albright, F. Berkhout and W. Walker, *World Inventory of Plutonium and Highly Enriched Uranium 1996*, SIPRI/OUP, Oxford, 1997, pp 223-237.

[10] We take the Cogema standard that about 0.8 m3 of vitrified HLW are produced per tonne of fuel reprocessed.

[11] K.J. Schneider et al., *National Briefing Summaries: Nuclear Fuel Cycle and Waste Management*, PNL-6241, Rev.2, Pacific Northwest Laboratories, April 1991; and I.W. Leigh, *International Nuclear Waste Management Fact Book*, Pacific Northwest Laboratories, May 1994.

[12] Article IX, paragraph A of the IAEA Statute says that,
'Members may make available to the Agency such quantities of special fissionable materials as they deem advisable and on such terms as shall be agreed with the Agency.'
Paragraph H states that,
'The Agency shall be responsible for storing and protecting materials in its possession...In storing special fissionable materials...the Agency will ensure the geographical distribution of these materials in such as way as not to allow concentration of large amounts of such materials in any one country or region of the world.'
Article XII, A.5 says that the Agency has the right,
'...to require deposit with the Agency of any excess of any special fissionable materials recovered or produced as a by-product over what is needed...in order to prevent the stockpiling of these materials...'

[13] An OECD/NEA study forecast in 1977 that by 1990, forty-six countries outside the centrally-planned economies would be operating commercial reprocessing facilities, many of them small plants (less than 50 tonnes/year). OECD/Nuclear Energy Agency, *Reprocessing of Spent Nuclear Fuels in OECD Countries*, Paris, January 1977.

[14] V. Meckoni, R.J. Catlin and L.L. Bennett, 'Regional Nuclear Fuel Cycle Centres: IAEA Study Project', IAEA-CN-36/487, Vienna, 1977.

[15] J Bernanek, The use of international fuel storage schemes and international fuel cycle activities in a regional context, in D Howlett and J Simpson (eds), *East Asia and Nuclear Non-Proliferation*, papers to the Twelfth PPNN Core Group Meeting, Shizuoka, Japan, 28-29 November 1992, pp 72-75.

[16] IAEA, *Expert Group on International Plutonium Storage: Report to the Director General*, IAEA-IPS/EG/140, Rev.2, Vienna, 1 November 1982.

[17] IAEA, *Final Report of the Expert Group on International Spent Fuel Management*, IAEA-ISFM/EG/26, Rev.1, Vienna, July 1982.

[18] A copy of this report is included.

[19] For example: IAEA/Board of Governors, *Radioactive Waste Management: Safety Fundamentals and Safety Standard S-1 Relating to Radioactive Waste Management*, GOV/2769, Vienna, 2 November 1994.

[20] For example: The General Conference of the IAEA adopted a resolution in September 1994, asking the Director General of the IAEA '...to consider further measures that would enhance international co-operation...' in radioactive waste management. IAEA, GC(XXXVIII)/RES/6, Vienna, 23 September 1994.

[21] Belgium, China, France, Germany, Japan, Russia, Switzerland, the UK and the US..

[22] M Hibbs, States to disclose via IAEA plutonium inventories soon', *NuclearFuel*, June 30, 1997, pp 6-7.

[23] IAEA, *The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, GOV/INF/821-GC(41)/INF/12, September 5, 1997, Vienna.

[24] PPNNP, *Newsbrief*, no 39, 3rd Quarter 1997, Mountbatten Centre, University of Southampton, pp 7-8.

[25] M Hibbs, Examine international repository, Blix urges fuel cycle symposium, *NuclearFuel*, June 19, 1997, pp 15-16. Blix argued that the forthcoming Joint Convention (see above) '...appears to restrict...' the legitimacy of multilateral programmes which would entail the transfer of nuclear waste or spent fuel from one country to another.

[26] M Hibbs, op cit, p 16.

[27] T Suzuki, op cit, 1997, pp 11-12.

[28] J-H Kim, Statement to 8th International Conference for Nuclear Cooperation in Asia, Tokyo, March 3, 1997.