3.1: INTRODUCTION

The nuclear repository siting process requires consideration of a large number of geo-political factors. As we have seen in the proceeding chapter that the nuclear waste production in developed countries of Europe, America and Asia have come to a stage where a new approach seems inevitable. The problem clearly calls for multinational or international solutions. But there have been very little progress in this direction as yet towards achieving such solutions beyond co-operation in research and development, some international standards-setting (as in the International Atomic Energy Agency’s Voluntary Safety Guidelines pertaining to nuclear material transport), and the now suspended ocean dumping program for low-level waste supervised by the organization for Economic Cooperation and Developments Nuclear Energy Agency. As long as the bureaucrat and politicians fear that they will be accused of allowing their country to become a nuclear dustbin, no nation is going to take another nation’s spent fuel or high-level waste for permanent disposal.

As reprocessing is gaining momentum in most of the developed countries, multinational solutions to the problems of spent-fuel storage and disposal are all the more needed as an alternative to reprocessing. The plans and commitments of European and Japanese Nuclear Industries for reprocessing is bound to create stocks of plutonium, far in excess of what is needed for the early breeders or other experimental
reactors. The plutonium surplus is leading to the introduction of plutonium fuel in light water reactors. This, in turn, will increase the risk of nuclear proliferation and terrorism for everyone and the risk of needless political troubles for the nuclear industry. Principally, reprocessing commitments could be reduce so that only the needs of experimental and demonstration breeders are fulfilled and the rest of the spent fuel is placed in interim storage or commuted to retrievable disposal in deep geologic repositories. But commercial reprocessing has gathered a strong momentum recently.

This chapter examines first the transnational problems of spent fuel and high-level waste disposal, paying particular attention to the geologic and economic constraints that make international solutions so essential, and the political constraints that make them so hard to reach. It then examines the factors that govern reprocessing and the introduction of plutonium fuel inspite of being uneconomic.

3. 2 GEOLOGIC DISPOSAL AND NATIONAL BOUNDARIES:

Although the large countries like USA, Russia, China etc. may find a geologic disposal site within themselves but countries like those of Europe, Japan, etc. are not the suitable places for disposal with few exceptions. According to a geological survey conducted in Europe, it was found that some areas were ‘good’ from the standpoint of tectonic stability, where the others were described as ‘mediocre’ are ‘bad’. The map roughly showed most of the Mediterranean basin, including all of Italy, the Balkans, Greece and Turkey was labeled as very bad because of the frequency of earthquakes and the presence of geothermal fields and volcanic activity. The greater part of France and most of the rest of
Western Europe was rated as mediocre because it is an area which was once tectonically active and which has not yet come entirely to rest. The only areas that are considered good are Russia and most of Scandinavia, which like much of Canada are underlain by Precambrian crystalline rock, and have been 'quiet' for many millions of years.

The waste problems of the smaller countries like that of Europe, point out clearly the severe geologic and political constraints that the national boundaries place on the search for the repository sites. For e.g. a country like Switzerland where all of the areas is considered very 'bad' and the rest half as mediocre, finding a repository seems difficult. But with more than five reactors operating, Switzerland must eventually find a place to dispose of much of its spent fuel and perhaps some reprocessing wastes. Switzerland's alpine region is clearly unsuitable for a repository for high-level waste because of its heavy faulting. If geologically acceptable site could be found at all, it would be in the granite and gneiss that underlies densely populated northern Switzerland, south of river Rhine. But in 1980, an advisory panel of Swiss government that even this region offered a doubtful prospect as the presence of thermal springs means that water is circulating at great depths where it gets heated up.

Since 1980, the Swiss Nuclear Waste Agency, NAGRA, has been trying to gather geologic data by drilling nearly a dozen deep bore-holes. Out of the bore-holes drilled, first these produced disappointing results, one revealing a major displacement, and two granite formations of interest were overlain by carboniferous layers, (Nuclear Fuel, 1984), while just across the Rhine in Southern Germany it rises to the
surface, where technically it would be more accessible but politically the German granite is beyond the reach of the Swiss.

Belgium also faces geological constraints in seeking a place to dispose of their own nuclear waste. At their nuclear research center at Mol, the Belgians have sunk a shaft some 220 meters deep to explore the properties of a thick clay layer, as clay is the only disposal medium in Belgium. And clay has major limitations, it presents major difficulties due to its plastic formation. The clay has to be frozen before sinking a shaft into it, but this was however managed, as Belgians had demonstrated by creating an experimental chamber in the clay. The more fundamental problems is that as the conductivity of clay is extremely low so it acts like a thermal shield. Unless the waste were allowed to cool over a period of about seventy-five years or more, the buildup of heat could be unacceptably high. The clay would be hot, undergo structural changes, and lose its excellent absorptive capacity. According to Gilbert Eggermont, Physicist and Science Advisor to the Federation Generale du Travail de Belgique (Belgium’s Socialist Leaning Trade Union) and an articulate critic of his country’s nuclear program, if final disposal has to be so long delayed, Belgium has no solution to its nuclear waste problem (Book).

3.2.1 **AUSTRIA’S INITIATIVE IN EGYPT:**

Austria is another European country which due to its political and geographic constraints has not been able to work out a waste disposal problem. But recently it had tried to reach an agreement with the Third World countries, Iran and Egypt. But the agreement failed due to the November 1978 referendum in which the Austrian voters decided not to
start up the country's one power reactor, located at the village of Zwentendorf on the river, Danube, about 20 miles west of Vienna.

Initially, the Austrians’ expected to sign a contract with France’s COGEMA at La Hague to reprocess the spent fuel from Zwentendorf reactor, and return the waste to Austria for disposal. But most of Austria being covered by Alps and hence nearly faulted geologically, there could be only very few places to look for repository siting. Among them the most promising seemed Waldviertel, a mountainous and forested region adjacent to Czechoslovakia. But in early 1977, government’s plan failed due to strong pressure from the people. By this time nuclear power had become such a hot political issue in Austria that none of the political parties wanted to take responsibility for the start up of the Zwentendorf Reactor (Walter C Patterson, 1979).

In early 1978, news began to circulate that the Austrian officials are negotiating with Iran and Egypt to establish a waste repository. Plans could not be worked out with Iran but a daily Salzburger Nachrichten, in its July 10, '78’s issue, carried a story headlined “Sadat Agrees to Atomic Waste Repository”; a subhead added, ‘Contract Almost Completed --- Waiting for the USA’. The fuel for the reactor was of United States origin, and plans for the reprocessing of such fuel were subject to US approval under its policies for preventing the spread of nuclear weapons. Since Egypt was in a politically sensitive part of the world, it was assumed that US might object to any fissionable material being sent there. But since November 1978, referendum was on the heals, so no solution to the problem appeared.

But a contract was negotiated whereby Austria would build, at its own expense, a repository in the Sahara, Austria was to give Egypt a
billion shilling in advance as 'good will' money and provide certain infrastructure improvements. Egyptians had readily agreed but Farouk-El-Baz, who was President, Sadat's science adviser explained that the proposed repository project was a bad idea, (Constrance Holden, 1979) reasons being: one, no means of permanent disposal for high-level waste had yet been demonstrated anywhere in the world, hence there was no proven method that could be applied in Egypt; second, the kind of detailed geographical and geologic informations that would be necessary for the selection of a repository site was lacking, and third, Egypt lacked the scientific and technical infrastructure necessary to support the proper construction and safe operation of a radioactive waste repository.

Egyptian parliament had eventually recommended that the project be put on hold, some members had viewed nuclear energy as a technological marvel in which Egypt was not going to be allowed to share unless the industrialized nations were given a compelling incentive, such as the promise of access to a Egyptian waste repository. Although President Sadat was pleased enough to have the repository plan studied and publicly debated, but no binding commitments were ever made. The future of the projects was rendered moot by the Austrian referendum.

The International Atomic Energy Agency (IAEA) had viewed the Austrian initiative in Egypt as the start of a significant international experiment with such a initiative, one could think of some international area in Egypt where waste from different countries could be stored with diplomatic immunity established for the area in question or it could be the other way where a host country would cede some degree of sovereign contract for the sake of creating an international enclave in which the participating countries would have assured rights of use and access. But
to persuade Egypt or any other country for that matter would be really a very difficult task. In this case the negotiations took places only between Austria and Egypt, no other country was actually brought in to discussion, and apart from IAEA's role in reviewing plans for the project, no internationalization of the facility apparently was contemplated.

3.2.2 MULTINATIONAL INITIATIVE IN EUROPE

The effort to bring about international nuclear waste disposal cooperation is a matter of the greatest political sensitivity. In Europe, there have been several multinational ventures to develop commercial nuclear services and technology, among them Eurochemic, a reprocessing project in Belgium; Eurodif, a huge uranium enrichment plant at Tricastin in the Rhone valley; and the Superphenix breeder project at Creys-Malville in which France has been joined by several other countries, most notably Italy and Germany. But in the nuclear waste field, multinational collaboration has not gone beyond the co-ordination and sponsorship of research and the development of safety guidelines and standards by the European community, the Organization for Economic Cooperation and Development, and the International Atomic Energy Agency.

The European Community's involvement in waste management research began in 1975. The total five year budget for its 'direct' and 'indirect' action program in waste management research from 1980 to 1984 was $130 Million (Serge Onlowski, 1980)

The indirect action program supported geologic and other research by individual community countries - the French looking at granite, for instance, the Germans at salt, and the Belgians and Italians at clay. It
### Table 3

Distribution of radioactive waste disposal between the oceans (Tbq)

<table>
<thead>
<tr>
<th></th>
<th>Atlantic</th>
<th>Panific</th>
<th>Arctic</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactors with and</td>
<td>1 000</td>
<td>4.3</td>
<td>88 800</td>
<td>89 804</td>
</tr>
<tr>
<td>without fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid low-level waste</td>
<td>44 252</td>
<td>818.0</td>
<td>588</td>
<td>45 658</td>
</tr>
<tr>
<td>Liquid low-level waste</td>
<td>&lt;0.001</td>
<td>456.0</td>
<td>764</td>
<td>1 220</td>
</tr>
<tr>
<td>Total</td>
<td>45 252</td>
<td>1278.3</td>
<td>90 152</td>
<td>136 682</td>
</tr>
</tbody>
</table>
can be seen in the table showing the national plans for disposal of high-level waste and spent-fuel (chapter 2).

The European community, it should be noted, is the only existing multinational entity that has both the money and the incentive to develop a 'European' nuclear waste management system.

The one international effort involving the actual disposal of waste has been that undertaken by the OECD's Nuclear Energy Agency (NEA) in co-ordinating and monitoring the disposal of low-level waste in the North Atlantic. The NEA's role has been to oversee compliance with rules adopted by the International Atomic Energy Agency pursuant to the London Dumping Convention of 1972. Till 1982, the United Kingdom, Belgium, the Netherlands, and Switzerland had been dumping low-level waste at a designated site some 500 miles south-west of England, (the amount and time of disposal can be looked into through the given table ) Japan was eager to begin dumping in the Pacific under Nuclear Energy Agency's supervision, but only if it could gain the confidence of Pacific Island Nations.

There has been no sea dumping since 1982. In February 1983, the London Dumping Convention adopted a resolution calling for a two-year moratorium on sea disposal, to study scientifically the risks involved. The Netherland's government announced that it would honour the moratorium, and later decided to give up sea dumping altogether. The other three governments intended to continue dumping, but found that they could not, for the British National Union of Seamen refused to crew the 'Atlantic Fisher' the ship that was carrying out the dumping for all four nations. Since then these nations have been in the difficult position of having to convince the London Dumping Convention majority that dumping
does no harm to either humans or the environment (Stephanie, Cooke, 1985). In this way, this first multinational venture in waste disposal was more of a symbol of trouble than of progress.

The lack of progress towards multinational solutions to nuclear waste problems is regretted by a number of people in the nuclear industry. A report by the Nuclear Energy Agency’s Group of Experts had taken note of the present situations and commented that ‘present national borders have no real significance given the long term hazard of radioactive waste’. (NEA, 1977) Nuclear Energy Agency, ‘Options’ Concepts and Strategies for the Management of Radioactive Waste Arising from Nuclear Power Programs, report by NEA group of experts, September 1977 (Paris, Organisation for Economic Cooperation & Development, 1977) p.61. In its 1980 report the working group on waste management and disposal of the International Nuclear Fuel Cycle Evaluation, had pointed out that multinational repositories could offer greater economic efficiency for countries with smaller nuclear programs, and solve the problems of countries lacking suitable geologic formations when the number of disposal sites is reduced, the work of IAEA of safeguarding and maintaining accountability for spent fuel would be made easier. Some prominent industry people saw international collaboration and consensus on nuclear waste disposal as essential to public trust.

While there was a perception of need, there was much scepticism that multinational repositories would ever be a practical political possibility. Andre’ Finkelstein of the French Commissariat a L’Energie Atomique saw the very concept of such repositories as pie in the sky. The concept of multinational solutions was strongly favoured by other experts but enormous obstacles were also seen on the way. Most important being
public acceptance, own waste is easily accepted but it certainly ends where foreign waste is concerned.

The studies and plans of the European community for a European waste disposal system has been occasionally publicity criticized. The European parliament, the European community's Economic & Social Committee, and the Commission of European Communities had contemplated action plans to establish standardized waste management practices, a European network of disposal sites and a European waste management agency.

One major IAEA effort in multinational waste management never really got around to the problem of finding a host state. Actually, this initiative - the International Spent fuel Storage (ISFS) project proposed by the Carter Administration as a non-proliferation measure - never got anywhere because an ISFS working group set up by the IAEA could not overcome its sharp discussions on the reprocessing issue. The United States wanted fuel vendor nations to insist that their foreign customers also agree to dispose their spent fuel to the international storage facility once it was established. But nations such as France, the United Kingdom, and Germany saw much as contrary to their ongoing or planned commercial reprocessing ventures. Retrievable surface storage, not geologic disposal, was all that was contemplated but the hang-up over reprocessing was paralyzing. Since past several years the ISFS working group has been inactive.

But recently the prospects for multinational repositories seems to be improving. At the IAEA's twenty-ninth General Conference in Vienna in September 1985, it was noted that a few countries have actually
offered to accept waste from abroad; like the offers extended by China to European utilities and by the Soviet Union to the Austrian owners.

3.2.3 CHINESE AND SOVIET INITIATIVES:

In early 1984, China had made the first offer to accept spent fuel from European utilities. It was reported in trade press that initially a German firm which owns the consortium Inter-Nuclear services had suggested and was to be the agent for the China Nuclear Energy Industry Corporation. A Letter of Intent describing the proposed services was signed by representatives of the Chinese Corporation and the German consortium's three parent companies viz.: German Trading Firm of Alfred Hampel, nuclear supply company Nukem and Nukem's subsidiary Transnuclear, on January 14, 1984 (Michael Weisskopf, Washington Post, 1984). The Chinese would charge $1512 per Kg. of Spent fuel received, whereas COGEMA was charging its foreign customers about $ 900 per Kg. for reprocessing; but the service provided by the Chinese would also include transportation and final waste disposal (Nuclear Fuel, July 16, 1984). The Chinese fee would exceed more than fivefold the per-kilogram charge estimated by the Department of Energy for geologic disposal of spent fuel in the United states. If 4,000 tons of spent fuel were received by the turn of the century, China would earn as much as $ 6 billion in foreign exchange. According to sketchy information available, the waste disposal site would be in the Gobi Desert.

Utilities in more than a half-dozen countries, Germany, Austria, Switzerland, Belgium, the Netherlands, Spain and Italy were reported to be interested in the Chinese offer. The then Director of the Austrian National Utility Consortium, Walter Fremuth, had been to China for talks with Chinese Nuclear Energy Officials, and a commercial contract was
expected to follow had the nuclear reactor issue been solved. (Padraic Sweeney, July 5, 1984). Some German utilities were also interested in the Chinese offer but they feared that it would upset their reprocessing facility plan. The government had reportedly given its approval for German utilities to ship a modest amount of fuel (up to 150 tons) to China, but only under certain conditions: Ann MacLachlan, Nuclear Fuel, 1986)

⇒ shipments could not be made if they would keep German reprocessing and spent fuel storage facilities from being fully utilized,
⇒ the Chinese price would have to be competitive with alternative offers, and
⇒ some of China's nuclear business would have to be reserved for the German Vendor Kraftwerk Union.

But the Chinese offer was not free from controversy. The basic questions that arose were absent adherence to the international safeguards regime and US non-proliferation policy. According to US policy, the fuel of US origin could not be sent to another country without its consent. But the Austrian's in their discussions with the Chinese, found a way by which the problem of third-party consent could be avoided: Austria would buy fuel from the Chinese and if the fuel was reprocessed by the Chinese, the plutonium thus obtained would not be reexported and would be used only in China's Civilian Nuclear Program. (Padraic Sweeney) China had long refused to sign the Nuclear Nonproliferation Treaty, and had not joined the International Atomic Energy Agency but now it was interested in joining it.
The Chinese initiative seems to have encouraged a Soviet counter offer, which was limited to Austrian fuel. In 1985, the then Soviet foreign minister, Andrei Gromyko made a formal offer to then Austrian Chancellor Fred Sinowatz to accept fuel from Zwentendorf if this reactor was started up (Ann MacLachalan and Padric Sweeney, Nucleonics Week, 1985). The Soviet Union had been taking back Soviet supplied fuel from its East European allies in routine, but this was the first time the Soviets had offered to take spent fuel of non-Soviet origin. But in case of Austria, none of these offers were of any relevance till the fate of their nuclear reactor remained undecided.

The Chinese and Soviet initiatives may be of limited relevance to the political problem faced by democratic nations in Europe that are attempting to establish multinational waste repositories. The political reservations discouraging such arrangements may not be easily dispelled despite the significant commercial advantages that could come to countries willing and able to accept spent fuel from foreign utilities.

The developed countries are expressing interest in establishing a regional-multinational repository whereby a site in a host country would accept radioactive wastes from other countries. The approach holds some economic, technological, and safety advantages, particularly for countries in the same geographical region. A prerequisite for such an approach is the achievement of consensus among the relevant countries and regions, in particular regarding the transboundary movement of radioactive wastes. The IAEA recently has assessed some of the major factors involved in the process of building consensus among interested countries on the various issues entailed in such a regional approach.
In principle, the basic issues involved in a regional-multinational repository are not much different from those related to national projects. But there are some qualitative differences related to the characteristics of the accepted wastes, the liability of partner countries, the division of responsibilities, the application of any required safeguards, and the ownership and transfer of waste materials.

Such regional repositories, which would build upon the best international practices in radioactive waste management, could give some countries the option of not building their own national sites, thereby holding down the total number of repositories world-wide. Additionally, they could provide an alternative for countries with unfavorable conditions for siting their own disposal sites. Disadvantages include the fact that a regional repository may increase transportation activities. It also may be difficult to establish a durable system which can survive changing political or institutional situations and which can assure the long-term collaboration of all partner countries. One of the most challenging tasks associated with such an approach is negotiating agreements which provide partner countries with assurances that all technical, political, and financial obligations will be fulfilled.

It has been several years now the Nuclear Energy Agency of the OECD has been tip toeing around a proposal for studying how an international waste repository might be established. The resolution proposing this study was rejected in favor of another calling for a study of the 'preconditions' to be met before an international repository could be considered. Although nothing happened but some representatives including Germany had expressed their concern that the kind study proposed might threaten national efforts to establish repositories. For e.g.
Germany feared that the critics of Gorleben salt dome might argue that Germany should put aside the Gorleben project and look to an international solution to its waste problems.

However, the NEA committee had set up a group to define the parameters of an international repository. Although the group had found no legal, institutional or other reasons why establishment of a multinational repository should not be feasible in principle. And the siting would be economically advantageous to the host country yet it was concluded that establishment of a multinational repository will not be politically possible anywhere until one of the nuclear power countries has established its own repository. The current efforts going on in America and other developed countries to find a suitable site to dispose off wastes are of international importance.

Availability of first national, then multinational or international repositories could offer all countries the alternative of direct geologic disposal of their spent fuel, which could be especially attractive if it included a retrieval capability that would pressure the reprocessing option for at least several decades. For this would be useful in the present context of premature development of commercial reprocessing - an activity which involves expensive production of plutonium fuel for light water reactors when already abundance of cheap uranium fuel is available.

3.3 REPROCESSING AND THE DRIFT TOWARDS THE USE OF PLUTONIUM FUEL:

Recently there have been drift towards reprocessing among the developed nations of Europe, Asia and America. Therefore, it
Flow chart of options for back-end of nuclear fuel cycle

- Fuel fabrication
  - Reactor
  - Discharged fuel
    - Storage at reactor
      - Recycled plutonium away-from-reactor
        - Long-term storage away-from-reactor
          - Direct disposal of spent fuel and high-level wastes
            - Recycled plutonium and uranium for high light-water reactors
  - Reprocessing
    - High-level waste
      - Low and intermediate-level waste disposal
        - Recycled uranium and plutonium
becomes necessary to look into the realities underlying the interest of these nations in commercial reprocessing and into the resulting economic and political burdens for the industry and the risks for the public. Due to inevitable drift towards reprocessing, large stocks of plutonium are build up.

The commitments to the major programs of commercial reprocessing were made from assumptions which proved unrealistic.
-- first, it was assumed that reprocessors would keep the wastes from reprocessing of foreign fuel but it proved wrong.
-- second, it was assumed that reprocessing is an essential step in waste management and disposal, and
-- third, which is most fundamental to the entire undertaking was the assumption that early use of the separated plutonium would be economically justified if not in breeders, then in light water reactors.

By early 1980s it was proved that the latter two assumptions were wrong but still there was no cut back in contractual commitments between French and British reprocessors and their customers, nor did it prevent Germans and Japanese from proceeding with plans to establish major reprocessing facilities of their own. Even in America it was assumed that reprocessing and plutonium recycling would be a practical necessity sooner or later, and probably sooner.

In industry, generally, normal practice has always been of the responsibility for wastes to remain with the enterprise that produces them. With this belief, before the mid '70s nobody seems to have doubted that reprocessors would accept responsibility for the radioactive waste generated, whether the waste came from the reprocessing of domestic or foreign fuel, Nations such as Austria, Switzerland and Netherlands which
had no plans for reprocessing on their own, saw this as a major advantage and their utilities could ship spent fuel to La Hague or Windscale, without worrying about the wastes from the reprocessing of the fuel. Similarly, the German and Japanese utilities looked to the French and the British to take their spent fuel, reprocess it and dispose of the wastes since their own domestic reprocessing facility would take time to start.

But after the mid 1970s, it was felt that it was impossible politically for the reprocessors to keep and dispose of foreign waste. The citizens had become fearful that their country was about to become a nuclear dustbin, which was voiced in the United Kingdom in 1975. The UK was entering into contracts with the Japanese fuel at THORP facility. In May of 1975, British Friends of the Earth published an article entitled “Windscale to be World Capital for Radioactive Waste?”. Few months later, on October 21, 1976, ‘London Daily Mirror’ gave its own hyped-up version of the story with bold headlines on front page “Plan to Make Britain World Nuclear Dustbin.”

The story started off an uproar. The “Mirror” was applauded for ‘sparking off a public debate on Britain’s nuclear dustbin problems’ which was long overdue (Denis Hayes “May 1976). The “Dustbin Debate” was to be held in March 1976. It was announced in the Parliament that British Nuclear Fuels could take on foreign business only if the contracts allowed the company the option of shipping back to its customers their share of the wastes.

The new policy giving the reprocessors the option to returns wastes to the customer did not harm COGEMA’s and BNFL’s foreign business. Reprocessing was still looked upon as a necessary and
inevitable step in the nuclear fuel cycle, and even though the customer utilities could expect to have their share of waste returned but for a period of time they would gain a respite by sending their spent fuel to La Hague or Windscale. Moreover, in certain countries - Sweden, Germany and Japan in particular - the utilities had to have the means for spent fuel full reprocessing as a condition of reactor licensing and licensing renewal. In all countries, the nuclear industry had the mounting pressure to show that the waste was effectively managed. And reprocessing showed that at least something was done.

Much of the fuel in the European countries was of American origin, and under US law and non-proliferation policy, non-nuclear weapon states could not have fuel or uranium of American origin reprocessed without US permission. Permission for reprocessing was neither denied nor granted. Since US also did not have any permanent disposal facility for itself, to accept foreign spent fuel could hardly be realistic.

3.3.1 REPROCESSING IS ESSENTIAL IN WASTE DISPOSAL:--

The several countries, reprocessing has been made important by enshrining it in laws and regulations. But now, it is widely believed even by the countries with reprocessing facilities that reprocessing is not an aid to waste management, the containment imperative could be better met by keeping radionuclides locked up in fuel rods then by generating multiple streams of gasous aqueous, and solid wastes by chopping up the rods and dissolving the fuel. The International Nuclear Fuel Cycle Evaluation's working group on radio active waste management reported in 1980 that wastes from any of the fuel cycles studied, including spent fuel from the
once through cycle, “could be managed and disposed of with a high degree of safety” (International Nuclear Fuel Cycle Evaluation, INFCE/PC/2/9) And it is since then that these have been favourable international reviews of the Swedish plans for direct disposal of spent fuel. Secondly there is no reason why spent fuel cannot be emplaced in repositories in hard rock in way that permits retrieval.

In a study conducted by US Department of Energy, the cost of geologic disposal of spent fuel will not be more than about $300 per Kg., whereas the reprocessing costs borne by COGEMA's foreign customers is varied by reported between $800 to $900 per Kg. (US Department of Energy, “Nuclear Waste Fund Fee Adequacy: An Assessment,” DOE/RW-0020 (February 1985); And that is not all, to this reprocessing should be added the cost of disposal of high-level and low-level reprocessing wastes.

3.3.2 REPROCESSING IS JUSTIFIED BY PLUTONIUM RECYCLING

In 1990, the thought behind reprocessing which is underway in France, Germany, Belgium, Japan, USA etc. has varied somewhat from country to country, but a common element has been an expectation that plutonium fuel will find an early and economically defensible use. The French have emphasized an early deployment of commercial breeders. Germany and several other countries have emphasized on the use of plutonium fuel in light water reactors commonly referred to as thermal recycling. The British feel that the economic conditions are yet not right for commercial breeders. And it is widely felt that use of plutonium fuel in light water reactors by countries with advanced nuclear programs could lead other countries including non-nuclear weapon states, to undertake
reprocessing and plutonium fuel fabrications themselves, which would result in increased risk of nuclear weapons proliferation.

In early '70s, it was assumed that the plutonium recycling in either breeder or thermal reactors will pay off economically. The prospects for an economically supportable breeder program now seem particularly remote, even though as late as the end of the '70s the French Commissariat a l'Énergie Atomique entertained the hope of a major and relatively early commitment to breeders. In an article in "Science" in early '79, C. Piesse L. Zaleski, nuclear attache at the French embassy in Washington D.C. and senior vice-president of the European Nuclear Society, foresaw a rising demand for uranium around the world and the possibility of a growing French dependency on uranium imports. The way to overcome this problem and stabilize the uranium demand, he wrote, was to introduce commercial breeders on a large scale before the year 2000. This would serve also to get rid of the large amount of plutonium that will be produced by the end of the century. (Zaleski, 1979) But by '80s uranium had become abundant and cheap, at the same time the prospect for rapid growth of nuclear energy in the United States and elsewhere has disappeared. The breeder reactor itself, with its special construction requirements, is so expensive to build that the cost of electricity from the French Superphenix reactor is now expected to be at least twice that of electricity from the light water reactor.

The complexity and high cost of establishing an overall breeder system are the other problems associated with building individual breeder reactors. Breeder fuel cannot be conveniently reprocessed and fabricated in the plants built for light water reactor fuel and thermal recycling. Several facilities should be built and five times more plutonium will be present in breeder reactor, as a result the radioactivity will also be
correspondingly greater (Bertrand Barrie, 1984) The cost of an overall breeder system is exceptionally great and at present seems unaffordable.

Although, thermal recycling is less demanding than the breeder in its technology and capital requirements, its own economic prospects are poor, at least for the next few decades. A major advantage of thermal recycling is that no new reactor is required. The light water reactor that operates in uranium fuel can also be made to operate on plutonium fuel. Bertram Wolfe, general manager of General Electric's Nuclear Fuel and Special Projects Division, and Burton Judson manager of advanced engineering in GE's Uranium Management Corporation, have concluded that the 'cost of plutonium recycle has clearly gotten out of hand, and attempts should be made to bring the situation back to rationality (Bertram Wolfe, 1984). By this they mean that the great bulk of spent-fuel should be kept in retrievable storage to await the breeder. Direct disposal of spent fuel is preferable, only if economic consideration are considered dominant.

3.3.3 GROWING ACCUMULATION OF SPENT-FUEL :

Although some countries of Europe and Asia are committed to reprocessing, yet the greater part of spent fuel they will generate by the year 2000 AD will not have been processed by that time. Much of it will be generated in the four countries - France, Germany, UK and Japan which expect to have reprocessing plants working. Only a few countries have deliberately chosen to have none, or very little of their spent fuel reprocessed; Sweden is a notable case. Nevertheless the reality is that all of the nuclear power countries will see large accumulations of
unreprocessed fuel, with the total almost certainly exceeding 50,000 tons or more than 2/3rd of the total generated. An even larger backlog will develop unless all of the 3,500 tons of annual capacity planned is in service and operating efficiency is at much higher levels than that yet achieved by reprocessing plants.

Even with an annual generation of about 6,500 tons beyond the year 2000, the backlog will grow steadily larger unless reprocessing capacity is greatly expanded. But even if reprocessing capacity were doubled to 7000 tons a year by the turn of this century and the reprocessing operated at 75 percent efficiency over the following two decades the backlog by the year 2020 would be on order of 75,000 tons. The actual accumulation barring an abrupt renewal in the fortunes of nuclear power, is likely to be larger than that.

For the nuclear industry, the growing of backlog spent fuel could well become both an economic nuisance and a political embarrassment. By the turn of the century the nuclear power industry, in the interest of gaining greater public trust, may have to begin the deep geologic disposal of some of the spent fuel and high-level waste to demonstrate that custodial case will not be forever necessary. At hard-rock sites, the fuel could be emplaced retrievably for a period of 50-100 years. If not longer, thus leaving reprocessing and plutonium recovery option open in hope of a possibility that the breeder will some day be both needed and practicable. At the same time, the waste could be removed, should the repository site in the end be found unacceptable. But this brings us to the starting point, for no geologic disposal site has yet been found and certified as clearly unacceptable. And for a number of nations, the best but not the only solution will lie in multinational or international repositories which as yet are not in sight.
To Conclude, an international system of spent fuel and waste management is still very much needed, despite a few encouraging signs. An important and unanswered question for several countries is what form should the waste take. Reprocessing capacity for the new future will not suffice to prevent the buildup of large backlog of spent light water reactor fuel. The Swedes have definitely opted for direct geologic disposal of their spent fuel. The Germans have not ruled out direct disposal but are officially committed to reprocessing. The French and Japanese are firmly committed to reprocessing. If the reprocessing and the recycling of plutonium in light water reactor remain as economically unfavourable as they appear to be now, the collapse of reprocessing as a commercial enterprise is likely by the end of this century.

The reprocessing services offered by COGEMA and BNFL are only a stopgap solution. The international organisations such as IAEA and regional like that of European community, OECD's Nuclear Energy Agency have felt severely constrained by the extreme political sensitivity of proposals for multinational management of spent fuel. The few bilateral and multilateral initiatives seen to date, including Austria's approach to Egypt and the Chinese and Soviet initiatives, have either suffered from political or commercial opportunism or are of limited relevance to democratic societies. But if one or more democratic countries with well established nuclear technology were to demonstrate safe geologic disposal within their own boundaries, multinational initiatives would be encouraged.

Another solution could be the retrievable disposal of spent fuel in hard rock formations such as granite would help prevent the buildup of backlogs of fuel in surface storage, leaving the reprocessing option for
future open. But there appears to be little interest in such a compromise solution.

But since most of the countries looking for geologic disposal sites are caught in procedural, legal and political morass from which some way of escape must be found in order to proceed.
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