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The Outlook for Nuclear Power and its International Aspects

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THE OUTLOOK FOR NUCLEAR POWER AND ITS INTERNATIONAL ASPECTS

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May I say how honoured I am to be a speaker in this debate on the future outlook of nuclear energy development in the world and on the role of international organizations.

It seems that there is hardly a country which would be more suitable to serve as a host forthese discussions than Japan. Starting from a low level in 1945, she has now become the third greatest industrial power of the world. Yet this amazing achievement, due above all to the skill, abilities and discipline of her people, is also dependent on the availability of vast amounts of energy which, in this case, essentially means imported energy. As Table 1 eloquently shows, Japan is critically dependent on energy imports for almost 90% of her total energy needs and for more than 99% of her oil requirements.

It is not surprising, therefore, that the combination of a great reservoir of highly skilled human resources with a great scarcity of natural resources has led this country to launch a vast nuclear power programme. This programme is designed to a achieve a major contribution of nuclear energy to meet the growing needs of a rapidly expanding economy and thus to alleviate the heavy burden of oil imports which the 1973-74 oil crisis has placed upon Japan and which, if I am not mistaken, amounted in 1977 to about 240 million tons of oil worth about 23 billion US$.

Yet the achievement of the objectives which were set immediately after the quadrupling of oil prices in 1973-43 seems to be now open to doubt and it is reported that the Japanese Government's Overall Energy Council finds itself compelled to consider the alternative target for 1985 of 26 ooo MW (e) of nuclear capacity down from a higher figure originally planned.

That Japan is not an isolated cast is evident from Table 2 which shows the downward revisions which have occurred in nuclear power plans throughout the world between 1973 and 1974. For all countries with market economies taken together, there have been reductions of the order of 40% for 1985 and of 38% to 45% for 1990 in the nuclear power estimates. Let me hasten to say that reductions have also taken place in the estimates of growth of total electric power demand, both as a result of the 1975 recession and the existing over-capacity in, for example, the US, and more significantly as a consequence of the lowering of expected future rates of energy demand expansion over the longer term. Nevertheless, the drop in total electric power demand forecasts is smaller than that of nuclear power projections. Both effects are illustrated in Table 3 which shows the evolution of orders for new power plants in the particularly striking case of the USA between 1970 and 1977. As will be seen, the years 1975, 1976 and 1977 are marked by a sharp decrease in both conventional and nuclear orders but the drop in nuclear is steeper and its share in the total of new orders sharply lower than the 50% to 70% which had prevailed over the preceding three years.

These developments, after a 300% to 400% rise in the price of oil, constitute a paradox which cannot be explained by either technical or economic reasons. As we shall see, nuclear power plants have had an excellent operating record and, while their costs have risen they still retain in most countries a marked competitive advantage over fossil-fuelled-fired stations. The causes for the paradox of shrinking nuclear power plants in the face of sharply higher fossil fuel prices must, therefore, be sought beyond technical and economic considerations. They seem to lie in an accumulation of uncertainties which has given rise to doubts and to a variety of nuclear opposition movements. These uncertainties occur on both the national and interational levels and consequently they can only be removed by national and international action in the formulation of which international organizations may have a major role to play.

Let me review briefly the four categories of topics I have just mentioned: the technical status of nuclear power, its economic competitiveness, the obstacles of its expansion encounters and the present and future role of international organizations in coping with these obstacles.

At the end of 1977 there were, throughout the world, 202 nuclear power plants in operation whost total capacity approached 100 00 MW(e) with 17 units with a capacity of 13 500 MW(e) coming on lineduring the year.

Up to that time, 1500 reactor years of civilian nuclear plant operating experience had been accumulated without a single radiation-induced fatality or any significant spread of radioactivity in the environment of a nuclear power plant for peaceful purposes.

With regard to availability, the overall performance of nuclear stations presented in Figure 1 show an average load factor[1] of all reporting nuclear plants remaining practically constant at about 62% over the last five years versus about 70% for base loaded conventional stations. It should be interperted with some care. In particular, the fact that a majority of the stations considered had been operating for less than three years ought to be remembered. A look at Figures 2 & 3, which give the load factor as a function of age, confirms this impression. True, the number of large nuclear stations having more than five years of operation is small, and no reliable statistical inference can be drawn. But there is at least an indication that availability improves with age once the break in problems of the first few years has been overcome.

In This connection, the excellent record of operation of nuclear stations during the harsh winter of 1977 is particularly worth remembering. For the period of the first three months of that year, the load factor of seven nuclear plants in New England USA, averaged 86%, that of the four Pickering Units in Canada more than 90%, and that of five nuclear power plants in Sweden more than 75%.

1/ The load factor is defined as the ratio between the energy that a power plant has produced during the period considered and the energy it could have produced if it had operated at maximum capacity during that period. The operated at maximum capacity during that period. The operating factor on the other hand is the ratio between the time the unit was on line and the duration of the period.

While it is obviously too early to speak of operational statistics for advanced nuclear systems, it is worth noting that the operation of the three fast reactors in the world, RN-360 in the USSR, Phenix in France, and PFR in the United Kingdom, have shown no insuperable technological or safety difficulties. In particular, the problems connected with the steam generators seem to be quite well understood. The firm belief in the future of these systems the been demonstrated not only by the three above-mentioned countries, where bigger commercial sized units are being built or designed, but also through the construction of other prototypes in the Federal Republic of Germany and the start of the construction of a prototype reactor in Japan.

Since the technical operational record can certainly not account for the reduction of future objectives and the dwindling of new orders for nuclear power plants, the next step is to look at the evolution of their costs and or their competitive position.

Table 4 presents a highly simplified, but generally valid, picture of the changes in unit investment costs which have taken place between 1967 and 1977 for nuclear, coal-fired and oil-fired electric power stations in the 1000 MW(e) range. There is hardly any need to stress the approximate character of such generalized estimates, which do not refer to any precise site with its specific local conditions. Subject to this reservation, the Table does, however, point to some interesting conclusions:

(1) The capital costs of nuclear power plants have roughly quintupled over the last ten years when expressed in current US dollars.

(2) They have been multipled by a factor between 2 and 3 when expressed in dollars of constant purchasing power, a procedure which removes the effect of general inflation on the comparison and thus shows the differential increase of nuclear investment costs over and above the rise of the general price level.

(3) The unit capita costs of coal-and oil-fired stations have been multiplied by almost exactly the same factors over this period.

It would be outside the scope of this presentation to engage in an analysis of the causes of these increases in real power investment costs. There is no question that safety and environmental considerations leading to a multiplication of standards, large increases in manpower and materials, lengthened prelicensing and construction times have played a major role in this development but, regardless of the underlying reasons, the main conclusion seems to be that nuclear and conventional stations have been equally affected by these factors and that, as far as capital costs are concerned, the competitive position of nuclear power has hardly been altered by these dramatic changes.

Let us now look at the comparative changes of nuclear and conventional fuel costs summarized in Table 5. There, the position is more complex. First, the comparison had to be restricted to nuclear fuel andooil. The ranges of prices for coal are so wide and the transportation components so important that any generalized cost figures would be meaningless in its case. Secondly, the nuclear fuel costs had to be broken down in some of its major components, uranium enrichment and fabrication. Thirdly, the present economies of reprocessing are so uncretain that it was left out of the comparison. Nevertheless, some interesting conclusions emerge:

(1) The rise in the price of natural uranium, at least for spot deliveries, practically paralleled the rise of the price of oil, growing by a factor of 4 to 6 in current terms and 2 to 3 in real terms.

(2) The cost of enrichment rose much less, increasing by a factor of about 216 to 3 in current and 1.3 to 1.5 in real terms.

(3) Fabrication costs kept pace with inflation and consequently remained constant in real terms.

(4) As a result of these divergent trends, while nuclear fuel costs per Kwh increased from 1.5 - 1.8 mills in 1967 to 5 - 7 mills in 1977, the corresponding costs for the Kwh based

on oil rose much more drastically from a range of 3.5 - 4.4 mills to 21 - 24 mills over the same period. Corrected for general inflation, the figures for nuclear fuel would become 2.5 - 3.5 mills and for oil 10.5 - 12 mills of 1967 purchasing power.

(5) As a result, the fuel cost advantage of nuclear over oil has considerably widened and reaches at present 16 - 17 current mills per kilowatthour produced.

The maintenance of a constant relation between the capital costs of nuclear and fossil stations and a widening favourable margin for nuclear fuel costs lead to the conclusion that whenever the choice of a large electric unit intended for base load duty is restricted to a nuclear and an oil-fired station, the former has an economic advantage which is substantially greater now than before the oil crisis. In the case of coal, the situation is more complex. If coal were priced on the basis of therm parity with oil, the above conclusions would, of course, apply. If it is priced on the basis of production costs, there may be locations near particularly favourable deposits where strip mining is possible, which would give a competitive edge to coal-fired stations. Only detailed studies of specific cases can provide definite conclusions.

It may be argued that, while the present situation is perhaps favourable, little is known about the future. An analysis of possible changes in the main factors does not, however, affect in any way the case for nuclear power.

The present state of uranium resources with 2 million tons of reasonably assured and another 2 million tons of estimated additional reserves amply covers the needs of the maximum nuclear power programmes up to the year 2000. Of course, new discoveries are essential for maintaining forward reserves and meeting the lifetime requirements of the nuclear stations which will be operating beyond the turn of the century, but the present price levels have brough about a major prospecting effort whose first results are rather encouraging. The search for uranium, which had been limited to low-cost deposits in selected countries, has left wide areas of the world unaffected, for instance in Latin America and South East Asia. Hence, there is no reason to believ believe that uranium prices could rise faster than oil prices.

Regarding the other sector of the nuclear fuel cycle, neither the cost of enrichment, where several new processes will be competing with gas diffusion, nor that of fabrication are expected to rise faster than the general price level of industrial goods. Finally, while it is difficult to pinpoint the net benefit or cost of reprocessing and recycling, its influence on total nuclear generating costs can hardly be expected to be significant.

Naturally, in the longer run, increasingly costly uranium ores would have to be mined if today's power plants, which use less than 0.5% of the potential energy obtainable from a unit mass of uranium, were to remain the main basis of expanding nuclear power programmes, but the efforts at present applied to the development of commercial breeder reactors in major industrial countries provide a solid foundation for a nuclear economy whose fuel resources would become practically unlimited, both as a result of a hunderedfold increase in the energy which could be derived from known uranium resources, and the economic possibility of mining euch poorer uranium ores.

Thus, we are brought back to our original question: Considering the technical reliability and the present and future econ economic advantages of nuclear power, what are the reasons for its present difficulties?

The answer requires a brief analysis of a chain of events adding up to a genuine vicious circle. Certain aspects of nuclear power and of its fuel cycle have given rise to doubts and uncertainties, some of which are based on fact, and many on imagination As a result, nuclear opposition movements have grown among private citizens in some countries and restrictive laws and regulations h have been enacted by citizens in some countries and restrictive laws and regulations have been enacted by some governments in others. The campaign unleashed by these groups and the impacts of these regulations have brought about serious difficulties for the decision-makers in the electric power sector, thus reinforcing the initial uncertainties. As a result, delays, cancellations and cost overruns have occurred, which are then used in some quarters as arguments against the reliability of estimates of nuclear power performance and costs.

Let us briefly review the initial uncertainties on which these developments were based, trying to separate the real from the imaginary.

The main problems can be classified under two headings: ecology and non-proliferation.

With regard to the impact of nuclear power on the enviroment, it has, in many respects, become a victim of its own thoroughness. No other source of energy, indeed no industrial technology, has ever been the subject of such comprehensive and detailed analyses of its environmental effects. The results of these studies have led to two major conclusions:

(1) Under normal operating conditions, the release of radioactivity to the environment caused by operating reactors and their fuel cycle infrastructure within the scope of the largest programmes contemplated for the year 2000 would represent a very small fraction of the natural radiation burden.

(2) The mathematical expection of human andproperty damages resulting from nuclear accidents within these programmes is a very small fraction of the overall risks involved in the life style of an industrial society.

However, these generally favourable conclusions do not in any way imply that no work remains to be done on the ecological effects of nuclear power.

Among the major areas which call for additional investigation and action are: further improvements of nuclear safety, decommissioning of nuclear installations and, above all, the closing of the nuclear installations and, above all, the closing of the nuclear fuel cycle, especially with regard to the storage and ultimate disposal of radioactive wastes. At the same time, more thorough analyses of comparative environmental impacts of different energy sources are essential to achieve a reasonable on the consequences of alternative energy strategies.

The other category of problems stems from a very legitimate concern over the possible proliferation of nuclear weapons. However valid thispreoccupation may be, it has sometimes been coupled with a not valid argument according to which the expansion of nuclear civilian power programmes is unavoidably linked with an increased probability of military applications.

Although the history of nuclear energy offers not a single example of such correlation, there still remain lingering doubts which only a comprehensive system of controls and safeguards, freely accepted by all parties, can finally dispel.

As was already mentioned, these primary uncertainties have given rise to a series of actions which have in turn brought about secondary uncertainties in such fields as, for instance, nuclear power plants licensing and construction times, assurances of nuclear fuel supply, ultimate fate ofirradiated fuel, which sometimes outweight the clear economic advantages. While the bulk of the efforts required for the solution of the problems I have just mentioned will have to be borne by national governments, many of them have international implications with which only an international approach can successfully cope.

The question thus arises: what can international organizations do to diminish these uncertainties or, as Under-Secretary Myers of KOE put it recently at the NEA 20th Anniversary in Paris, what contribution can we make to the "management of uncertainties"?

As we have seen, there are still uncertainties, at least in the public mind, on certain technical questions, particularly on certain aspects of nuclear safety and waste management. The IAEA and the Nuclear Energy Agency in Paris have been toiling away for many years to establish internationally acceptable standards, gui guidelines and procedures that will not only help to ensure the safe design, construction, operation and siting of nuclear plants but will also give the necessary reassurance to the public. The limited resources at our disposal mean that all major R and D on nuclear safety must be a national effort. Our own work must concentrate on harmonizing these efforts, on distilling a consensus and on giving this consensus a truly international authority which should at least carry more weight in the public mind than the efforts of national nuclear bodies. For these reasons too, we have brought safety and environment oriented organizations, such as the World Health Organization, the United Nations Environmental Programme, the International Labour Organization and others, fully into our work.

As a result, it may be truly said that international nuclear safety standards today have the full endorsement of the world's health and safety authorities, as well as all its nuclear regulatory authorities. It must also be frankly said, however, that this has not made these standards by any means immune from attack and criticism.

In the Agency we shall continue to complete the comperhensive nuclear safety standards programme which, year by year,is extending its coverage to every aspect of the safety and the current generation of nuclear power reactors. We shall, of course, also continue all other lines of our nuclear safety and waste management work and we shall continue to call upon the best available technical advice for this purpose.

While this work is very valuable, there is one major element which, in my view, is still missing. This is the fact that there has still not been any industrial-scale national or international demonstration of the viability offinal geological disposal of high-level waste. This must become a top priority. The focus of environmental criticism has shifted with time from reactor operation and the risks of reactor accidents and now chiefly concentrates on what it considers to be the main chink in the armour of the nuclear industry, namely, final highlevel waste disposal.

This is an important technological "uncertainty", not in the sense that it is insoluble—far from it—but in the sense that the solution has not yet been demonstrated for the world to see.

However, it must be repeated again that the major uncertainly which nuclear energy must overcome is not technological but political and lies in the changing policies of governments.

At the root of this uncertainty is concern about the further proliferation of nuclear weapons, a concern which made a quantum jump in 1974 and which deepened again last year with reports that nuclear weapons might be spreading to other areas of acute political concern.

We in the IAEA have been working with the problems of proliferation since the very start. In fact, this problems is perhaps the major raison d'etre of the organization. I myself in the early 60's, in annual statements to the General Assembly of the United Nations, tried to draw attention, with scant success at the time, to the growing amounts of plutonium which were bound to be produced by the expansion of nuclear technology and I stressed the consequent need for truly effective and universal safeguards. It is not, therefore, for us to belittle in any way the risk of proliferation but we must try to see it in its true perspective.

The history of the last thirty years has demonstrated that even the most strenuous efforts at control will not prevent the slow but steady spread of the technology needed to produce highly enriched uranium or separate plutonium. I see little prospect that the next thirty years will show us the way of creasting technological or legal barriers against dissemination of industrial technologies - and I don't think this is what we truly want. I repeat what I have said before: I don't believe that a policy of denial could be either realistic or effective. What is, however, necessary now is to strengthen the existing international framework aiming at the non-proliferation of nuclear weapons. I am sure that in this context the IATA can make a major contribution to diminishing the political uncertainty by applying safeguards, what is called full-scope safeguards, effectively and universally in the non-nuclear-weapon States, or to be instrumental in other non-proliferation measures complementary to safeguards. Whether this universality of safeguards can be achieved, or other measures agreed upon, is up to the statemen of the world. It is not a matter within our power in Vienna.

Since 1974, there had been a growing apprehension that even effective safeguards may not be adequate to prevent proliferation if a country already has within its reach the means of producing nuclear explosive material. Debate had focused on the question of detection times or the "timely warning" needed to give diplomacy enough time to act upon the would-be diverter after he has begun the process of diversion but before the explosion takes place.

Until now it has been the LAEA's view that the chief political value of safeguards was to give other countries the continuing assurance that the safeguarded country was not diverting- to remove this particular uncertainty-rather than to give time for international diplomatic action after a decision to divert has already been made. It still seems to use in Vienna that the continuous assurance of not-diversion rather than the last-minute prevention of an intended diversion must remain the main objective of safeguards.

Nevertheless, we would all agree that the world would be a better place if the production of enriched uranium and plutonium were concentrated in as few localities as possible and were preferably undertaken in large, truly commercial plants operated under international or regional auspices. It is also in all our interests that the political uncertainties that have beset the supply of nuclear fuel andparticularly enriched fuel in recent years could be diminished.

These are some of the questions with which INFCE is now engaging itself and in which Japan is taking an active part. As you know, INFCE has eight working groups. No. 1 deals with fuel andheavy water availability; No. 2 with enrichment availability; No. 3 with assurances of long-term supply; No. 4, of which Japan is a co-chairman, with reprocessing andplutonium; No. 5 with fast breeders; No. 6 with spent fuel management; No. 7 with waste management and disposal, and No. 8 with advanced fuel cycle and reactor concepts.

While the main focus of this work is in Vienna and the IAEA is providing meeting services and in some cases a technical secretariat for the working groups, INFCE is an autonomous undertaking and does not form part of the IAEA's programme and is not in any way under our direction.

INFCE is expected to complete its work by the end of next year. It is reasonable to assume that INFCE will develop useful information and new concepts and insights on the problems that face us. To take one ofthe many aspects, it is quite clear that the problems of management of growing quantities of both spent fuel and of separated plutonium during the next few decades, will call for an increasingly close international co-operation.

Another international aspect of particular interest is the assurance of fuel and other technological supplies. Proliferation fears and particularly the misgivings about the spread of plutonium have led in the last two years to major changes in international fuel supply. The first group of changes which Japan, as well as sixteen other countries, has now made a matter of national policy, is enshrined in the so-called "London Guideli Guidelines". I must express my regret that these guidelines do not yet include the requirement for full scope safeguards.

The second and more far-reaching group of changes directed particularly as restraining the reprocessing of spent fuel is contained in the new United States legislation. This legislation is also reflected in an amendment now before the Agency's Board of Governors to the Co-operation Agreement between the IAEA and the US. This agreement has been the main source, in fact practically the only source, of fuel for the IAEA's supplies to the nuclear programme of its Member States. The United States is negotiating similar amendments to its bilateral agreements with other countries as well as in its agreement with EURATOM.

It may be worth while to summarize some of the main conditions upon which the US will generally insist in future export arrangements. I use the phrase "generally insist", I understand

understand that the legislation would permit the President in very special circumstances to make exceptions. The legislation is very complex, and I shall summarize some of the main points as reflected in the suggested amended US/IAEA Agreement.

Firstly, no nuclear material, equipment or facilities may be supplied through the Agency unless, at the date of transfer, there are one or more agreements in force with the importing country which apply safeguards to all nuclear activities in that country or under its control or jurisdiction. In other words, no supply may be made unless, at the time of supply, the importing country is a party to NPT or has concluded agreements which add up to full-scope safeguards. How far this affects exports to nuclear-weapon States is not clear to us at this time.

Secondly, wupply agreements will permit the United States to obtain information about all nuclear material under safeguards in the importing State irrespective of whether the material was of US origin or not. However, in the case of NPT countries, the US need only be informed about inventories of nuclear material coming under the supply agreement—essentially, nuclear material of US origin.

Thirdly, theprior consent of the United States will be required for any arrangements for storing separated Pu, U^{223} or uranium enriched about twenty per cent.

Fourthly, prior US consent will be required for any reprocessing of material originating in the supply agreement or for any alteration of the form or content of certain sensitive materials (Pu, U^{233}, 20%-enriched U^{235} or other irradiated material).

Fifthly, there shall be no enrichment up to twenty percent of U^{235} unless the United States agrees in advance, and no enrichment to twenty per cent or more unless this is foreseen in the supply agreement.

Sixthly, specified standards of physical protection must be applied to all material, equipment or facilities supplied by the United States or originating in such supplies. At a minimum, the levels of protection must be those recommended by the Agency.

Seventhly, no sensitive nuclear technology may be transferred unless the agreement specifically provides for such transfer. Sensitive technologies include enrichment, reprocessing, heavy water production and Pu fuel fabrication as well as other information designated in advance by the United States.

Eighthly, there may be no retransfer of supplied items or produced nuclear material without prior agreement by the United States.

The new legislation also foresees that if the IAEA is not able to apply its safeguards for any reason, the United States' safeguards will be applied in the importing country.

The legislation also contains a number of sanctions to be applied if, for instance, the importing country carries out an unsafeguarded activity, does not permit the Agency to apply safeguards, detonates a nuclear explosive device or otherwise fails to comply with an Agency safeguards agreement.

I have consistently urged that supplies should only take place to NPT countries or to countries which at least have acepted full-scope safeguards. This aspect of the new legislation is, therefore, in my view, a positive development. Whether the successive imposition of increasingly strict bilateral controls in other matters, including restraints on the freedom of action of the importing country to carry out normal nuclear industrial activities even under safeguards—whether such additional restraints will achieve their non-proliferation objects in the run, or will encourage tendencies to national and regional nuclear self-sufficiency, remains to be seen. It seems to me to be difficult to reconcile such actions with Article IV of the NPT.

During the past couple of years, we have in effect seen a return to the policies of the late 1940s and early 1950s when the major suppliers sought to prevent proliferation by rigid and extensive controls. This has now inevitably led to confrontations in the international field, parallelling the confrontations in the national field between the nuclear industry and the violent opposition to it.

I cannot believe that such confrontations will provide the answers that we are seeking. I hope, therefore, that we may soon turn another page and begin the search for international and multinational solutions to our provlems, gradually replacing the barriers of restraint and denial by co-operative undertakings to deal with our fuel cycle problems.

Japan, which is more aware than most countries of the extent to which the supply of energy resources depends upon uninterrupte international co-operation, can play an extremely important part in the promotion of such co-operation. I have already referred to Japan's co-chairmanship of the INFCE Working Group on Reprocessing and Plutonium, but the Japanese initiatives for regional co-operation in the Pacific and South-East Asia could be most helpful. I look forward, for instance, to full Japanese participation in the already-existing regional co-operation agreement (RCA) which is helping to bring the benefits of nuclear science and technology to the countries of the reigon and, particularly, to the solution of their food and agricultural problems.

Japan already plays a very important part in the IAEA. On One of the five Deputy Directors General is a distinguished Japanese scientist-Professor Kakihana-and two of the divisional directors are also distinguished Japanese experts-Professor Saiki and Dr. Haginoya. I hope that this professional contribution to our work can also be matched by even more generous voluntary contributions, for instance, to our technical assistance activities to which, it is true, Japan pays its assessed share, but which it is economically and scientifically in a position to go beyond.

It may seem idealistic to propose that the international community should seek new and far-reaching forms of multinational co-operation in, for instance, the management of spent fuel and of separated Pu, the creation of regional fuel cycle centres, the codification of peaceful nuclear relations and the assured supply of enriched fuel. It must be remembered, however that the development of peaceful nuclear technology has already led to important innovations in international and regional political structures and concepts. The Agency's safeguards system, the nuclear non-proliferation treaty, the multi-national reprocessing and enrichment arrangements already set up, represent advances in international thinking and action that would have been inconceivable a generation ago. It is for this reason that I consider it most important that new initiatives for international co-operation should prevail as soon as possible over the present tendencies towards restraint and denial.

Table 1

Energy Consumption per cadita

and

Energy Self-Sufficiency of some Major Industrial Countries

	Energy Consumption per cadita (Tons of oil equivalent)	Self-Sufficiency (%)	
		Total Energy	Oil
US	8	80	55
Federal Republic of Germany	4	50	4
France	3.2	25	1
Japan	3.2	11	0.2

Table 2

Evolution of Estimates for the World*

Nuclear Capacity from 1973 to 1977**

(1000 MW(e))

For:	1973 Estimate	1977 Estimate
1980	185-215	146-150
1985	475-600	280-370
1990	800-1280	500-700

* Not including the countries with planned economies.

** Based on information submitted by member states to NEA-OECD.

Table 3

Evolution of Orders for Nuclear

and

Conventional Plants in the U.S.A.

(1000 MWe)

	Conventional	Nuclear	Total
1970	30	15	45
1971	16	20	36
1972	16	36	52
1973	26	40	66
1974	34	35	69
1975	11	5	16
1976	5	3.9	8.9
1977	8	5	13

Table 4

Estimated Unit Canital Costs of Nuclear Power Plants

in the 1,000 MW(e) range* - 1967-1977

(US$/Kwe)

	1967	1977 (in 1977$)	1977 (in 1967$)
Nuclear	100-120	500-700	225-350
Coal	80-100	400-550	200-275
Oil	70--80	330-400	165-200

- Variable sites in industrialized countries with different environmental and scismic protection criteria.
- Single nuclear unit in the 1000-1300 MW(e) electric versus two fossil fueled units on the same site.
- Calcium based desulfurization for coal.
- Mechanical draft cooling towers, in all cases.
- Interest during construction and escalation not included.

Table 5

Estimated Costs of Nuclear Fuel and Oil

1967 - 1977

	1967	1977	
		In 1977$	In 1967$
Price of Uranium ($/16/$U_3$08)	6-8	25-42	12.50-21
Separative Work ($/KgSW)	25-30	66-100	33-50
Fabrication ($/Kg of U)	50-60	100-120	50-60
Nuclear Fuel Cost in LWR (Mills/Kwh)	1.5-1.8	5-7	2.5-3.5
Price of Oil ($/varrel)	2-2.50	12-14	6-7
Fuel Costs of Oil Fired Station (Mills/Kwh)	3.5-4.4	21-24	10.5-12