Nuclear power

Nuclear power development – the challenge of the 1980s

by Sigvard Eklund*

In pursuing my theme of *Nuclear power development – the challenge of the 1980s* I will analyse the data that is available, mainly that stored in the International Atomic Energy Agency's computer, to forecast what will happen in the nuclear field during the decade which has just started. By the word *challenge* I want to underline the potential which nuclear energy possesses to contribute to the solution of the world's energy problems.

Existing energy systems have a remarkable inertia and the fact that nuclear power now provides 8% of the world's generation of electricity is in itself proof of the potential that nuclear energy has already realized, and the inroads it has made in domains which earlier were reserved for conventional sources of power. This means also that nuclear energy itself already possesses a substantial amount of inertia and will be with us for a considerable time, even if its further growth is not actively promoted by decision-makers.

Although we like to think that the future is ours and can be formed according to our wishes and intentions, it is a fact that the next few, say five, years are already committed to developments decided upon by people in charge before today. As a consequence, the developments in nuclear energy within our societies in the next five years can be foreseen with a rather high degree of accuracy, on the assumption, of course, that peace will prevail and the need for energy will develop along the same pattern as in the past. It is unfortunately much more difficult to interpret what the crystal ball indicates may happen in the energy field five to ten years from now.

Energy conservation

It is obvious that waste of energy should be avoided whenever possible, and remarkable results have already been achieved in a number of countries by different conservation measures. I would here especially mention the promising development of heat pumps driven by electricity from, for example, a nuclear power station. They seem to offer tremendous possibilities for energy conservation for individual house or district heating. Heat pumps of 10MW will soon be common in several industrialized countries. In the Federal Republic of Germany sales of heat pumps increased from 36 000 units in 1979 to some 100 000 in 1980. In my own country, Sweden, they have been doubling every year over the past few years. When man's ingenuity has enabled him to produce almost unlimited amounts of cheap energy, it is a pity not to make full use of that achievement in order to improve his living conditions.

Consequently, I do not agree with those who, in Sweden, say that although surplus electricity is available and electricity is a very convenient form of energy for heating apartments and houses, it should not be used for such purposes because it requires large power stations which do not fit the philosophy of the "green wave". In other words, I believe that reason will return again when people appreciate that there is energy to be used and, at the same time, they will understand and approve, by democratic means, its production.

Present position and future prospects for power reactors

The actual situation of nuclear power and the most probable forecast of its development up to the year 1990 are best demonstrated graphically.

Figure 1 presents the number and power of reactors now operating or under construction, and their distribution over different geographical areas*. In spite of the current situation in the USA, the installed capacity of the nuclear power plants under construction there will almost treble by 1990. The same will be true for Canada. The only other industrialized countries which have large rates of increase are France, Japan and the USSR. At last year's IAEA General Conference in Vienna Minister Nakagawa indicated that Japan will try to install 53 GW of nuclear power by 1990.

On the other hand, the developing countries** have limited plans, and no great increase is foreseen in the

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* The term OECD countries refers to the 24 countries members of the Organization for Economic Co-operation and Development (OECD), including Japan. OECD Pacific is composed of Australia, Japan and New Zealand. CPE stands for countries with a centrally planned economy and comprises the 13 socialist countries.

** The exact definition of a developing country is a matter of some difficulty. For the purpose of this article, the term applies only to those countries which qualify for technical assistance from the United Nations and which do not belong either to the group of OECD countries or to the group of centrally planned economy countries of Europe.

Table 1. Estimates of total and nuclear electrical generating capacity by main country groups (GWe)

Country group	1980 Total	1980 Nuclear	1980 %	1985 Total (average)	1985 Nuclear	1985 %	1990 Total (average)	1990 Nuclear	1990 %
OECD North America	710	57	8	890	130	15	1065	150	14
OECD Europe	440	45	10	580	105	18	735	150	20
OECD Pacific	180	15	8	255	25	10	340	50	15
Centrally Planned Europe	370	16	4	545	35	6	745	75	10
Total for industrialized countries	1700	133	8	2270	295	13	2885	425	15
Asia	130	3	2	235	10	4	400	20	5
Latin America	100	0 3	0 3	130	3	2	180	10	6
Africa and Middle East	65	_	_	80	2	3	120	3	3
Total for developing countries	295	3	1	445	15	3	700	33	5
World total	1995	136	7	2715	310	11	3585	458	13

number of developing countries committed to nuclear power in the 1980s, above the eight countries already having nuclear power plants in operation or under construction. Some four to five additional countries are now considering nuclear power, like Egypt, but not all are likely to make a commitment.

The first table presents the estimates of total and nuclear electricity generating capacity in the world and its distribution among industrialized and developing countries and among country groups. In 1980, nuclear capacity in the world amounted to 136GWe or 7% of the nearly 2000GWe total installed electrical capacity. Industrialized OECD and centrally planned European countries have almost 98% of the nuclear capacity in the world, whereas developing countries have only around 2%. In 1990 nuclear generating capacity will be about 458GWe

Figure 1. Reactors in operation or under construction throughout the world as of 1 February 1981.

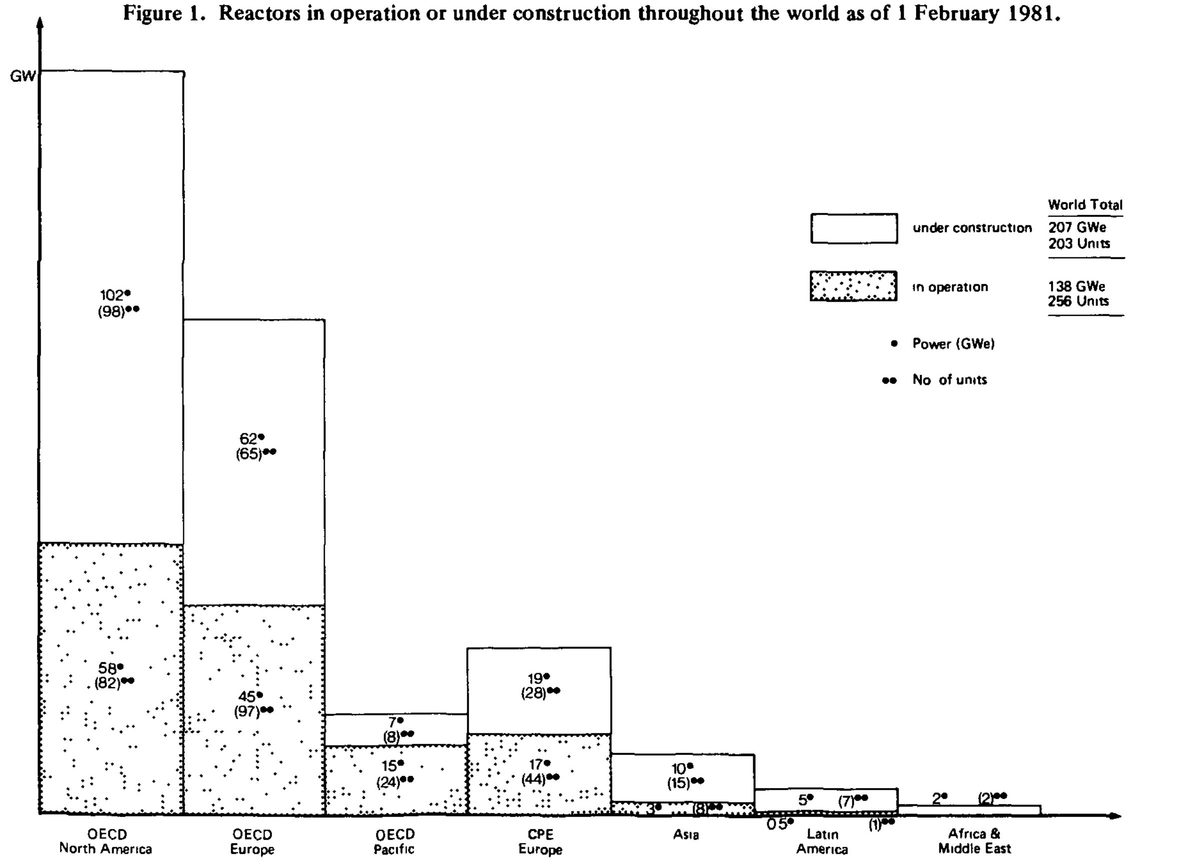


Table 2. Estimates of total and nuclear electricity generation by main country groups (TWh)

	1980			1985			1990		
Country group	Total	Nuclear	%	Total (average)	Nuclear	%	Total (average)	Nuclear	%
OECD North America	2760	290	11	3455	800	23	4230	885	21
OECD Europe	1780	215	12	2280	640	28	2890	885	31
OECD Pacific	725	60	8	1070	150	14	1430	315	22
Centrally Planned Europe	1780	80	5	2620	225	9	3575	450	13
Total for industrialized countries	7045	645	9	9425	1815	19	12 125	2535	21
Asia	665	15	2	1060	65	6	1815	100	6
Latin America	375	2	0.5	485	15	3	695	50	7
Africa and Middle East	225	–	–	320	10	3	480	15	3
Total for developing countries	1295	17	1	1865	90	5	2990	165	6
World total	8340	662	8	11 290	1905	17	15 115	2700	18

or about 13% of the world's estimated total generating capacity.

The next table presents estimates of total electricity generation and the share of nuclear power on a world-wide basis and by the main country groups up to the year 1990 (Table 2). The percentage of electricity generated by nuclear power stations is slightly higher than the percentage of nuclear capacity depicted in Table 1, since nuclear power plants are normally used for base-load generation. It shows again that OECD and centrally planned European countries will continue to be the countries with the largest share of nuclear generation in the next 10 years. It also shows that Latin America and Asia – without Japan – will start to acquire substantial electricity generation by nuclear power at the end of this decade.

Figure 2 depicts the age distribution of operational reactors more than eight years old. As shown, a total of 97 reactors have been in operation for more than eight years and 32 for periods between eight and ten years. 159 out of the 256 reactors operating in the world are less than eight years old. Six reactors have already been in operation for more than 20 years. Altogether around 2200 reactor years of experience have now been accumulated, and the technology of nuclear power has reached a state of maturity, safety and reliability.

How have these reactors performed? Figure 3 summarizes the load and operating factors between 1975–1979. The load factor is a measure of performance in that it is the energy actually produced divided by the energy which could have been produced with operation at maximum power for the whole time. The operating factor is a measure of availability, being the time in operation divided by the total time.

It is interesting to note that since 1975 there has been a slow increase in both factors until 1979 when both dropped significantly. We still have to confirm this by analysis of data but it appears that the drop is due to regulatory action after the TMI accident. As the 1978 and 1979 data are based on 156 and 176 reactor units respectively, there is no doubt about the significance of the drop. In this context it should be mentioned that data from the last World Energy Conference indicate that the unavailability of nuclear units has generally been similar to that of fossil-fuel plants of a comparable size – about 30 to 35%.

Referring to Table 3, the year 1980 was again not promising in terms of new orders. Only 19 reactors with a total capacity of 18GWe were ordered in France, the Federal Republic of Germany, Japan, the Republic of Korea, Romania and the UK. However, 12 orders for reactors – with a total capacity of 13GWe – were either cancelled or postponed in the USA. Thus the total net capacity increase was only 5GWe.

Comparing the general nuclear situation in 1980 with the period up to 1990 it seems at first sight that we have now reached the lowest ebb. However, appearances are deceptive. Figure 4 depicts the amount of nuclear capacity to be added annually during the period 1981–1990, based on reactors under construction or fully committed for construction. In 1981 about 43GWe will be added to nuclear capacity, for the period 1982–1985 an annual addition of between 30 and 35GWe will be made, and beyond 1987 the added nuclear capacity will be in the range 15 to 25GWe each year. The picture becomes darker, however, when we consider the starting date of reactor construction for the same period (Fig.5). Construction of slightly more than 10GWe will begin in

Figure 2. Age-distribution of reactors more than eight years old.

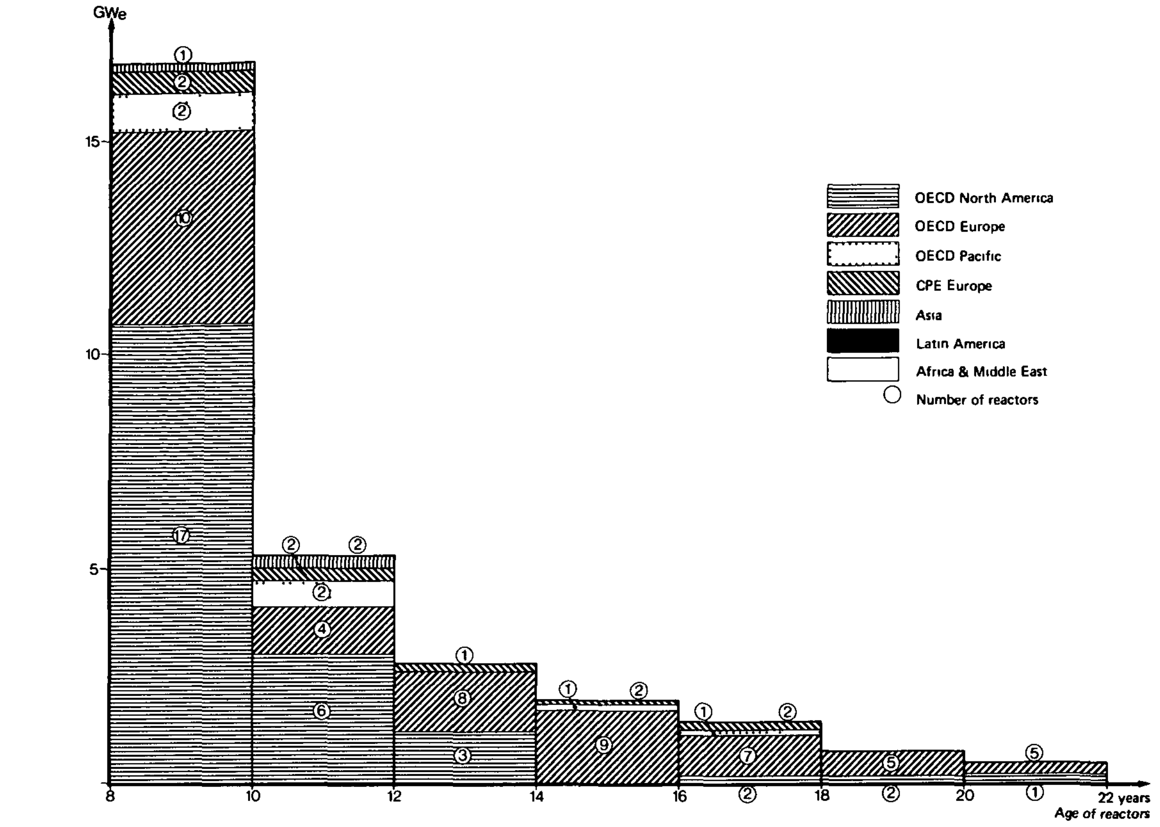


Figure 3. Average load and operating factors for the years 1975 to 1979
(for all plants excluding prototypes and those starting operation in the second half of the year).

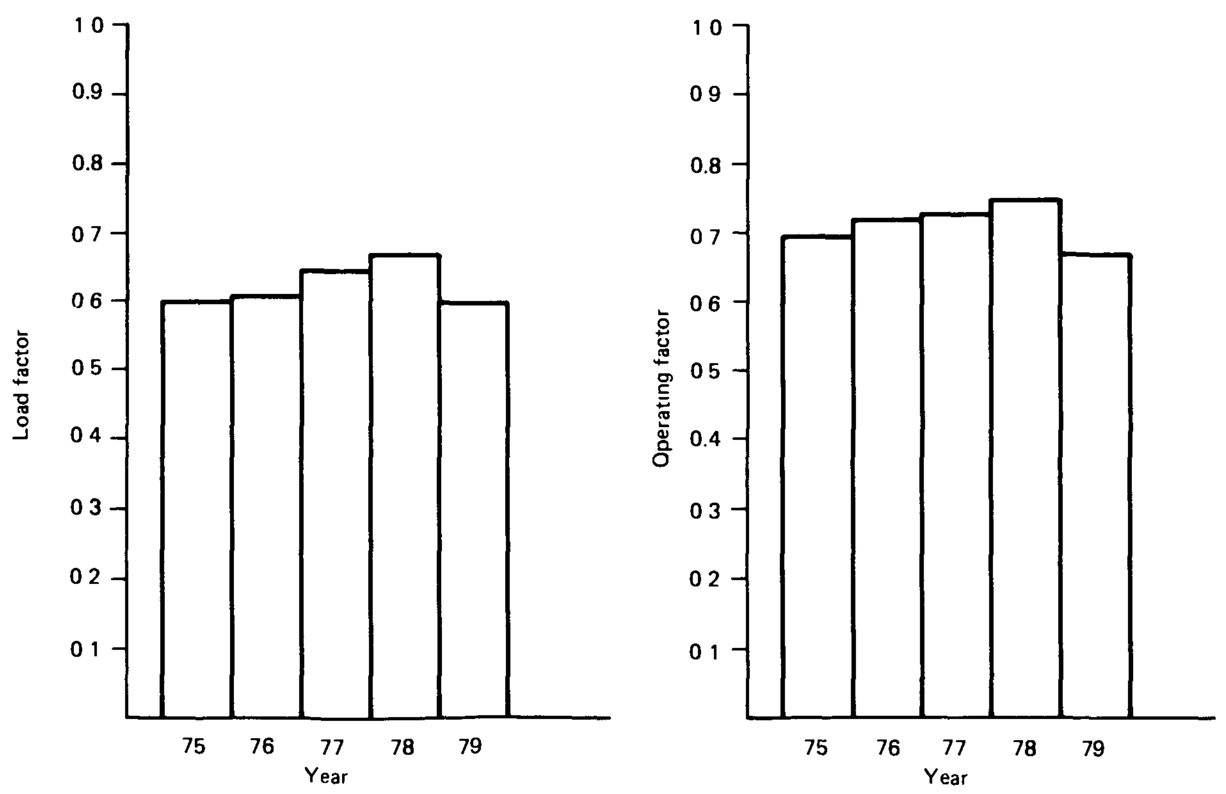


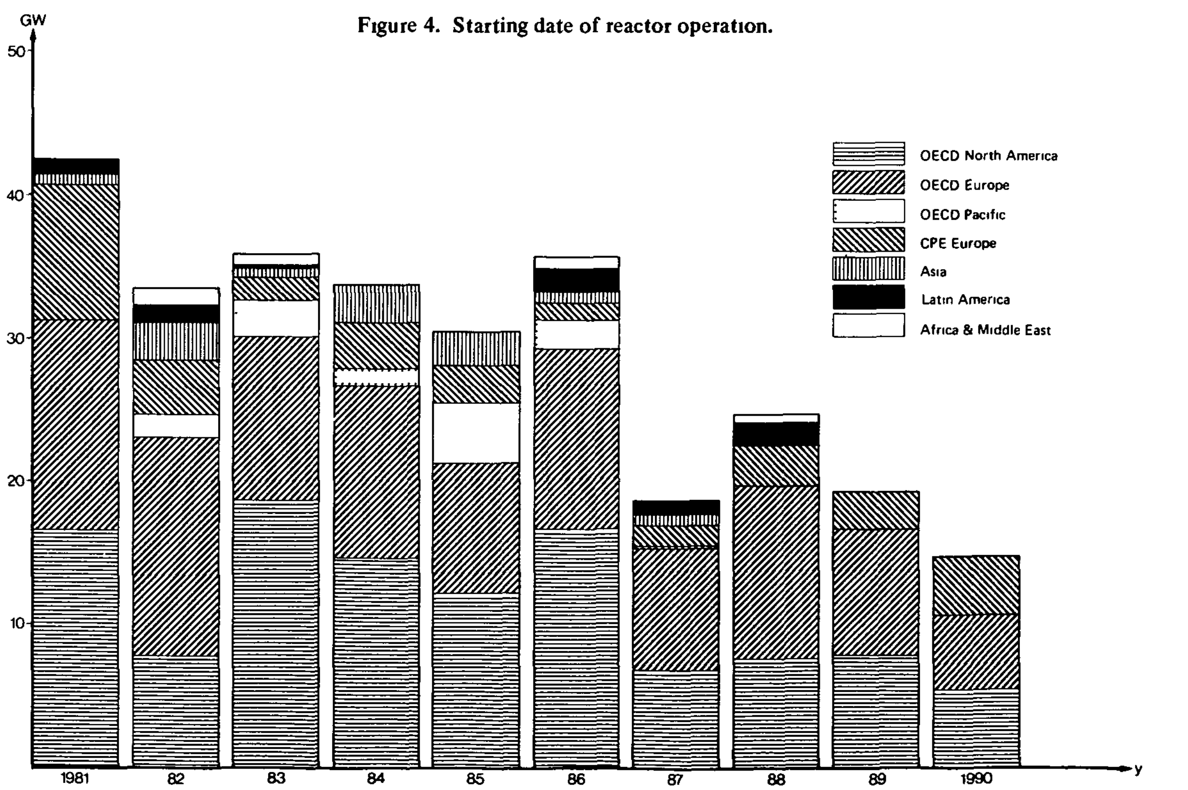
Table 3. Orders and postponements of nuclear plants during 1980

	Orders and letters of intent sent during 1980		Cancellation and postponement during 1980	
	Number of reactors	Power (GWe)	Number of reactors	Power (GWe)
OECD North America	–	–	12	13
OECD Europe	12	12	–	–
OECD Pacific	4	4	–	–
Centrally Planned Economy (Europe)	1	0 6	–	–
Asia	2	2	–	–
Latin America	–	–	–	–
Total	19	18.6	12	13

1981 and about 52GWe in 1982. After 1982 construction of nuclear power plants already committed drops drastically: to about 12GWe in 1983 and 1984, and to below 5GWe for the years after 1985. (These figures, however, do not include the centrally planned economies.)

The last two figures illustrate the large difference which exists between different countries in lead-times from commitment to commercial operation for plants now under construction. The averages of these lead-times are: for Japan (8 plants under construction), 61 months; for France (29 plants), 63 months; for the Federal Republic of Germany (10 plants), 82 months; and for the USA (85 plants), 121 months. The difference may be almost exclusively due to the more or less complicated regulatory procedures for construction permits, operating licenses, etc. If new individual plants are not committed now, and if we take into account the long lead-times just mentioned, a general slow-down of nuclear power programmes beyond the year 1990 is likely, with serious consequences for the nuclear industry in many countries.

Figure 4. Starting date of reactor operation.



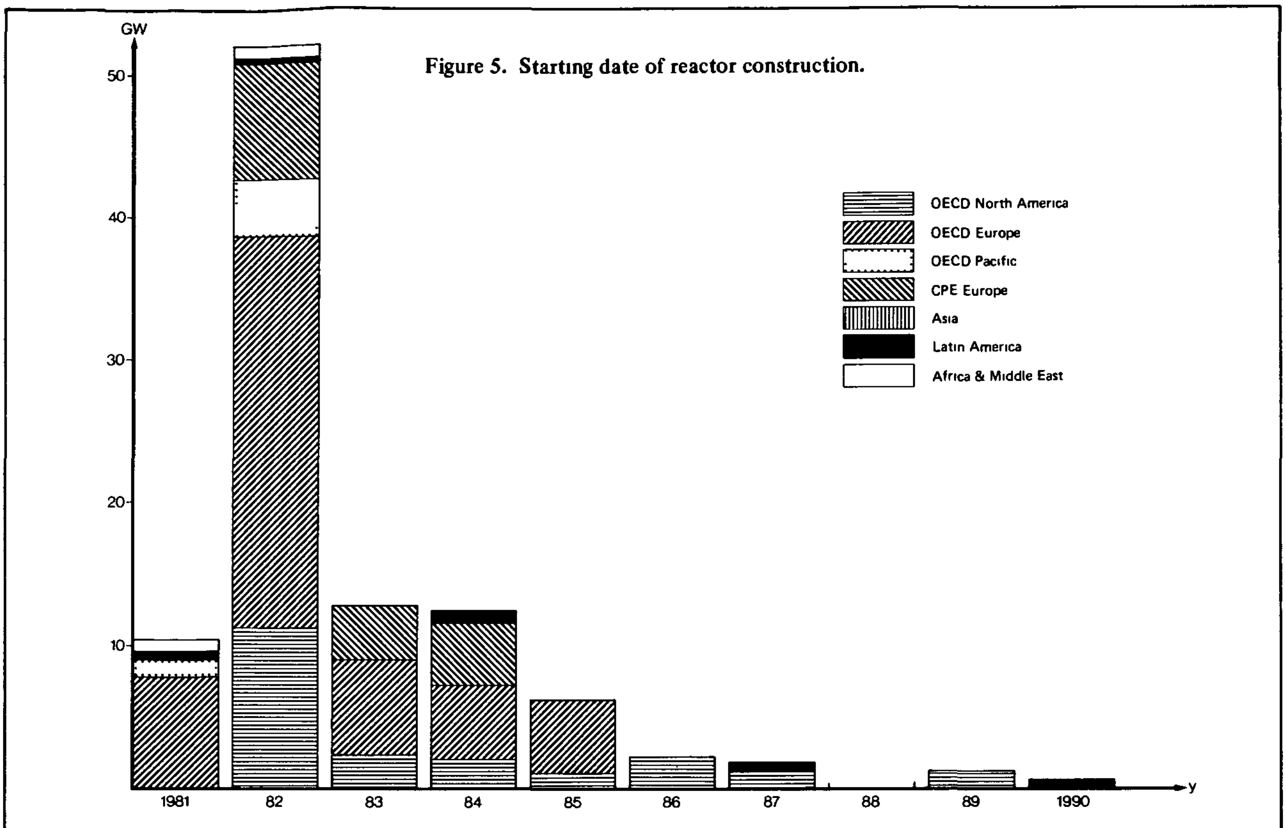


Figure 5. Starting date of reactor construction.

The challenge of the fuel cycle

After this outline of power reactor development in the 1980s, it is natural to turn to the provision of fuel during the decade and to other aspects of the fuel cycle. The challenge arises both at the very beginning and at the back-end of the fuel cycle.

With regard to natural uranium, the challenge of the 1980s is to reconcile a much-reduced demand from existing and planned nuclear reactors with the present and likely future overcapacity in the uranium mining industry. Present industry-based forecasts of uranium requirements and production, as shown in Figure 6 are therefore quite pessimistic and they reflect the industry's concern about uncertainties in the rate of future additions to installed nuclear generating capacity.

Since it reached its peak in 1978 the market for uranium has more or less continuously declined. In February 1981 prices for uranium sank to US$65 per kg of uranium on the spot market, which in real terms is less than half its 1978 value of US$112/kg U. Because of the general perception that additional uranium will be readily available from new production and from stockpiles, there is little hope for a turn-around. One result of this trend will be drastic changes in the geographical distribution of uranium production, as shown in Figure 7. During this decade uranium production should grow considerably in Australia and Canada where large new mines are under development, while production from the USA and Africa should remain static, and decrease in relative importance. This also implies that developing countries will have little chance of attracting

Figure 6. Uranium requirements and production.

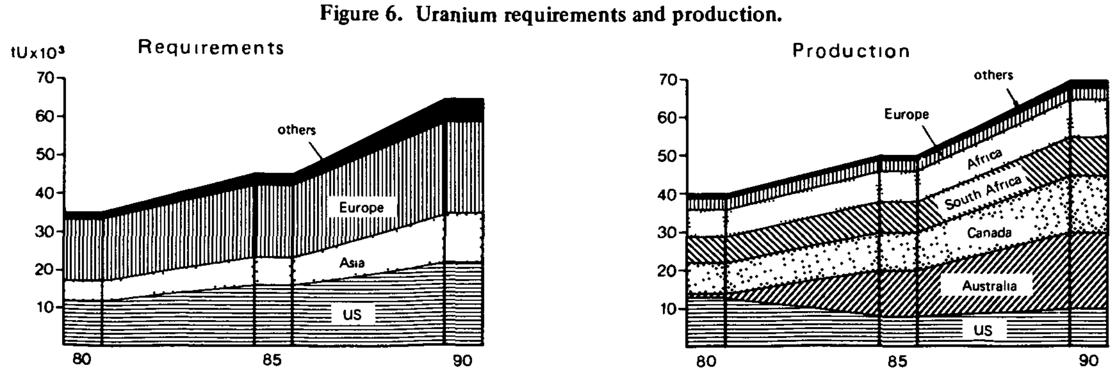


Table 4. Estimated maximum uranium production capability

	1980		1985		1990	
	Number of countries	Capability ktU/yr	Number of countries	Capability ktU/yr	Number of countries	Capability ktU/yr
OECD North America	2	30	2	30	2	42
OECD Europe	3	4	3	5	5	7
OECD Pacific	2	2	2	14	2	21
Africa	4	14	5	18	6	23
Latin America	1	< 1	3	3	4	5
Asia	2	< 1	2	< 1	3	2
Total	14	50	17	70	22	100

Table 5. Capacities of isotopic enrichment plants

	1980			1985		
	Number of countries	Number of plants	10^6 swu	Number of countries	Number of plants	10^6 swu
OECD North America	1	3	21 000	2	4–6	35 300–44 300
OECD Europe	4	7	3 880	4	9	12 880
OECD Pacific	2	1	30	2	3–4	300
Centrally Planned Europe	1	1	7 100	1	1	7 100
Asia	–	–	–	–	–	–
Latin America	–	–	–	1	1	180
Africa and Middle East	1	1	6	1	1	200–300
World total	9	13	32 016	11	19–22	55 960–65 060

Annual needs for 1 GWe LWR ~ 110 X 10^6 swu.

Table 6. Capacities of fuel fabrication plants (for LWR only)

	1980			1985		
	Number of countries	Number of plants	Ton U/yr	Number of countries	Number of plants	Ton U/yr
OECD North America	1	6	2 900	1	7	3 300–3 700
OECD Europe	6	13	3 510	7	14	4 860
OECD Pacific	1	4	990	1	4	1 050
Centrally Planned Europe			Figures not available			
Asia	1	1	21	1	1	21
Latin America	–	–	–	–	–	–
Africa and Middle East	–	–	–	–	–	–
World total	9	24	7 421	10	26	9 231–9 631

Yearly amount of fuel loaded in 1 GWe LWR ~ 30 tons.

capital for new uranium ventures, and will be particularly affected by low uranium prices.

One additional point should be made with regard to the availability of assured supplies of uranium now and in the future. Table 4 shows an estimate of maximum technically attainable production from the known resource base for the years 1980, 1985, and 1990. These figures are considerably higher than those for estimated uranium requirements and production, and they indicate the large reserve capacity built into the existing industry. But until the dismal conditions of the present uranium market are reversed there must be considerable concern about the uranium industry's ability to define and develop additional production centres for the decades beyond 1990.

Most of the reactors in operation or planned for the decade require enriched uranium. Table 5 presents the capacities of isotopic enrichment plants in 1980 and 1985. Taking into account that the estimated total nuclear capacity of 458GWe in 1990 requires a capacity of approximately 50 000 tons separative work units per year, and that this will be available in 1985, over-production could be expected in the near future if all newly-committed facilities were to be built.

No problems are expected in regard to the capacity of fuel fabrication plants (Table 6) as the available capacity of around 9500 tons uranium per annum in 1985 is in accordance with the requirements of the estimated 310GWe capacity in the same year.

The forecast of spent fuel storage capacity shows that during the 1980s no major problems are foreseeable on a world-wide or regional basis. However, it must be stressed that an overall comparison of spent fuel arisings and available storage capacity does not reflect the real situation, because the spent fuel cannot be freely distributed among the available storage locations. Therefore, some individual States and utilities will have inadequate storage capacities and some alternative storage techniques will have to be used – shipments to other pools, cask storage, double stacking of spent fuel, etc.

The major storage problems are, however, likely to occur in the following decade – 1990 to 2000. Figure 8 summarizes data available to the Agency from the International Fuel Cycle Evaluation and International Spent Fuel Management studies. The 1990 data suggest that the problems might be resolved regionally, whereas the data for the year 2000 indicate that major alternatives for storage must be explored. Due to the lack of new reactors the at-reactor storage capacity ceases to grow while the arisings continue to increase. This implies that the additional needs for spent-fuel management will have to be met by away-from-reactor storage as well as by reprocessing or by final disposal of spent fuel. The studies show, moreover, that even if the projected reprocessing capacities are in fact achieved on schedule, there will be a significant amount of fuel to be stored or disposed of.

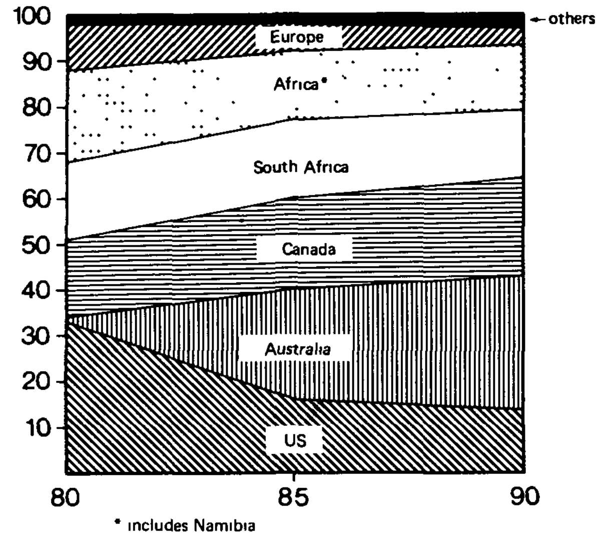


Figure 7. Relative participation of various regions in uranium production.

As shown in Table 7, the available capacity in 1980 of 1150 tons of uranium per annum represents only about 20% of the capacity needed to reprocess all irradiated fuel; in 1985 the theoretically available capacity of 5075 tons uranium/year would be enough to reprocess around 50% of the spent fuel arisings. Everybody will agree that in some countries decisions are needed to implement large-scale industrial reprocessing. This is essential so as to provide the basis for long-term commitments for international institutional arrangements and to restore confidence in this part of the nuclear fuel cycle, which is so important for the introduction of fast breeder reactors.

Finally, during the 1970s it has become evident that the safe management and disposal of radioactive waste is of central importance for the further development and acceptance of nuclear power. Nuclear waste managers generally agree that proper underground disposal of radioactive waste can provide the necessary long-term isolation and thus the protection of both man and the environment.

Many countries have extensive programmes to explore the suitability of repository sites in geological formations in their territories and to establish national systems for the long-term management of radioactive wastes. Some countries set up special national organizations to deal with these issues. In addition much progress has been made on the various conditioning and packaging techniques for all types of radioactive wastes that are necessary prior to storage and disposal.

In the coming decade significant progress is expected in many more countries in defining and implementing appropriate waste management systems for their national nuclear power programmes. This will include the

Table 7. Capacities of reprocessing plants (only for LWR fuel)

	1980			1985		
	Number of countries	Number of plants	Ton U/yr	Number of countries	Number of plants	Ton U/yr
OECD North America	–	–	–	1	3	2 550
OECD Europe	4	5	840	5	7	2 115
OECD Pacific	1	1	210	1	1	210
Centrally Planned Europe			Figures not available			
Asia	1	1	100	1	2	200
Latin America	–	–	–	–	–	–
Africa and Middle East	–	–	–	–	–	–
World total	6	7	1 150	8	13	5 075

Yearly amount of fuel unloaded in 1 GWe LWR ~ 30 tons.

management of low- and intermediate-level waste, the interim storage of high-level waste, as well as the definition of sites and in a few countries possibly the construction of repositories for high-level and alpha-bearing waste. In several advanced countries, high-level wastes will be solidified and prepared for storage and disposal on an industrial scale.

As is now the case, the storage and disposal of radioactive wastes will be a matter for national control. However, regional and even international solutions, including the acceptance of wastes from other countries in national repositories, may have to be sought for the storage and disposal of high-level wastes. This would offer an advantage to countries with small nuclear programmes and no intention to reprocess spent fuels. To meet the needs of all parties, this matter may have to be examined in an international forum. One related prerequisite may be a consensus concerning the basic safety requirements to be applied.

In co-operation with other international organizations, the Agency's radioactive waste management programme will contribute to reaching international consensus on how to ensure safe disposal of radioactive wastes, with the prime objective of supporting national solutions. To address these issues and concerns, the Agency plans to hold an International Conference on Radioactive Waste Management in 1983 where the safe management of all types of radioactive wastes will be considered.

Economics of energy

A review of the challenge of the 1980s would not, however, be complete without mentioning the economic aspects of energy supply. The dramatic rise in energy

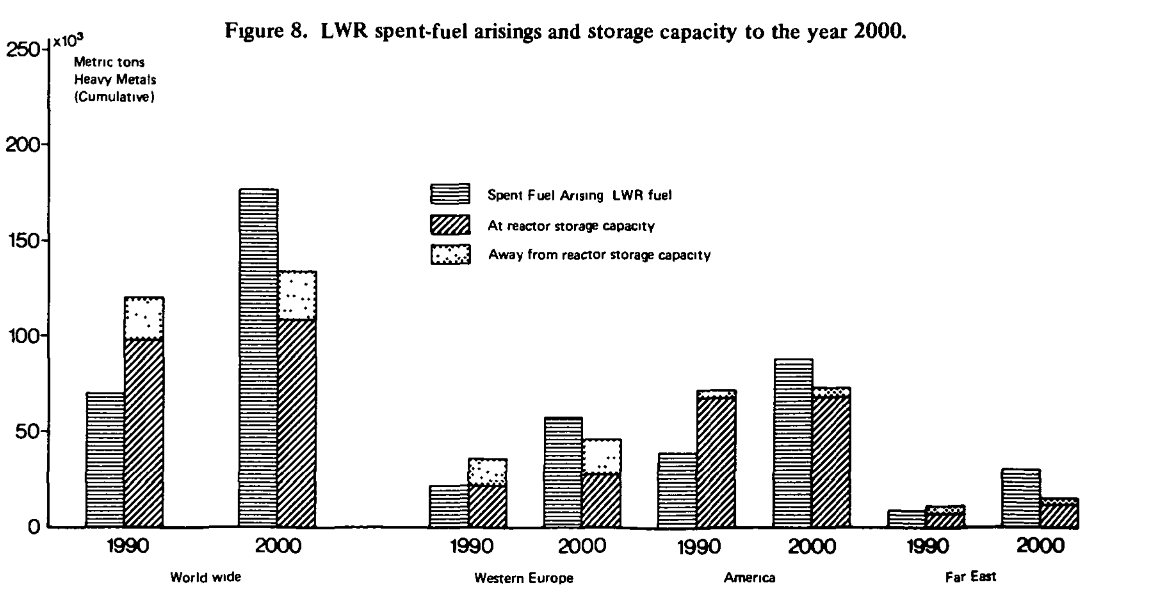


Figure 8. LWR spent-fuel arisings and storage capacity to the year 2000.

costs, driven by oil price increases since 1973–1974, has played a significant role in world-wide inflation and consequently economic recession and unemployment. All countries – both industrialized and developing – are faced with the problem of finding reliable energy supplies at acceptable cost. Nuclear power can offer an alternative immediately.

Nuclear-generated electricity is already much cheaper than electricity from oil-fired power stations. In comparing costs of electricity from nuclear and coal-fired power plants, the result depends on a number of factors and there is no single global answer. However, the picture is generally favourable to nuclear.

The key economic factor for coal-generated electricity is the cost of coal. For nuclear power, the key factors are the plant's investment cost and its performance. One of the challenges for nuclear power in the 1980s will be to achieve shorter licensing and construction times, in order to reduce investment costs.

Nuclear power plants are much less affected by the costs of fuel resources than are fossil-fuelled power plants. Doubling the price of uranium would increase the cost of nuclear generated electricity by only 10%; a doubling of fossil fuel prices would lead to a 65% increase in the costs of electricity from fossil-fired power plants. Thus, those countries with large commitments to nuclear power are less affected by price increases for fuel.

Realizing the economic promise of nuclear power will, however, require concerted action to overcome the problems of public acceptance which have severely retarded its growth. This has resulted in the continuing large-scale use of oil and coal for electricity generation, even though the economics favours nuclear. For example, large nuclear power plants can produce electricity at costs which are 25–50% lower than the costs of electricity from coal-fired power plants. Over 30 years of operation, this would save enough money to build one or two new nuclear power plants. The savings are even greater in relation to oil-fired power plants.

Technical maturity and attitude to accidents

The technical improvements in proven reactor types during the 1980s will probably only be minor and mainly based on the experience gained during the last three decades that nuclear power reactors have been operating and, as mentioned earlier, during which time 2200 power reactor years of experience have been accumulated. It should be recognized that experience will increase rapidly during the 1980s. At the beginning of the decade 250 reactor years' experience are to be added each year, in the middle about 450, and in 1990 some 600, i.e. the accumulated experience then will be some 6000 reactor years.

This should make possible the increased standardization of plant design through co-operation between manufacturers, owners and regulatory authorities which, besides its direct impact on costs, would also diminish the licensing time and lead-times from commitment to commercial operation, to say nothing of its contribution to the safety of the plant.

The additional regulatory requirements make plants more complex and a balance must be maintained between the effects of such new requirements added and weaknesses which may be introduced by the increased complexity. It is to be hoped that the extreme difficulties caused by backfitting during construction and operation can be avoided. These requirements, and not new reactor orders, now keep the nuclear industry busy in some leading countries.

There are bound to be failures in power reactor systems, as in every other complex technology. But it must also be recalled that up to now there has not been a single fatal accident caused by radiation in a nuclear power plant devoted to peaceful purposes. The many built-in barriers to prevent release of dangerous amounts of radioactivity to the biosphere have, up to now, fulfilled their purpose.

The increased use of nuclear power should also be followed by its acceptance as a natural part of our environment in the minds of the public and news media. A steam-valve leakage or turbine-trip in a nuclear power station should have no more news value than similar happenings in a conventional power station. Words are misused these days. If, for example, the incident at Three Mile Island can be called "a catastrophe", one would hope that any future accidents could be similar "catastrophes"!

But TMI was catastrophic from the economic point of view. It will probably be essential for utilities in the future to see to it that they, by mutual arrangements, share the economic burden which an accident may impose on them.

Small reactors for developing countries

To what extent will developing countries make use of nuclear power during the decade? An elevenfold increase is foreseen but is limited to half a dozen countries. The reason is that promotional work in the field of nuclear power has to consider the consistent trend by designers and manufacturers towards units with a generating capacity of 1000–1300MW. Units of such size require the existence of a prepared infrastructure in the receiving country. I am here referring to an electric grid of sufficient capacity as well as to the manpower and facilities necessary to cope with routine maintenance and emergency situations.

An old rule of thumb says that no unit in an electric grid should generate more than 10% of the total capacity. Economy of scale has led to the development of very large stations which means that they can only be incorporated in systems with capacities of at least 5000 to 7000 MW, which in turn leads to the conclusion that these large reactors can only be introduced in a very few developing countries. We have recently learned that some reactor manufacturers are now studying the possibility of constructing much smaller nuclear power reactors where what has been lost with regard to economy of scale is compensated for by simplification in the design, while still maintaining the same degree of safety as the larger units.

It is certain, however, that developing these small units, marketing them, and getting them licensed, will take a considerable time. In the meantime, I can only hope that the switch to nuclear energy by developed countries will ease the pressure on the crude oil market and make it possible for developing countries to expand their conventional electric systems to the size and infrastructural maturity required for the incorporation of nuclear reactors.

Nuclear safety

Developments in nuclear safety can be said to fall into three different categories, namely: regulations; operational safety; and safety systems.

The primary challenge during the 1980s will be to set regulatory priorities among the outstanding safety issues in such a way that significant disturbances to old and new nuclear plants are minimized. It is appropriate to recall the importance of international harmonization of nuclear standards, in particular harmonization at the level of basic criteria and approaches, and also the contribution made by the NUSS (Nuclear Safety Standards) programme of the IAEA. Another point to be made is the assurance of public safety through a balanced trilogy of design-operation, siting, and emergency planning.

Operational safety has been improved by a marked development in two major areas in which, nonetheless, efforts will have to continue: evaluation of operating experience and consideration of the human factor. It is becoming difficult to identify the few significant items out of an increasing flood of event reports from national and international exchanges. The human element has, after Three Mile Island, been recognized as a factor which influences safety and must be taken into account in the design, operation, maintenance, and management of plants. The IAEA should, in full co-operation with Member States and with full consideration of different conditions prevailing in different countries, attempt to establish criteria of competence for operating and maintenance staff. The use of simulators for analysis of systems behaviour should become standard.

Much effort has been spent on hypothetical core-melt accidents. The evolutionary changes which are expected for heat removal, its power supply and emergency cooling will probably make work on theoretical core-melt accidents less urgent.

The Agency's conference in September 1982 on Nuclear Power Experience should give Member States and their utilities a most valuable survey of the vast amount of experience already accumulated today over some 2200 years of reactor operation.

The choice for the future

There is a very vocal minority which does not want to accept nuclear energy and which has a considerable political influence. It may become pro-nuclear if faced with an energy shortage caused by an oil blockage, or if the energy-related financial burden would drastically affect the whole economy of a country, the social life and standard of living of its people; nobody wants this to happen. It might become even more anti-nuclear if there were to be accidents in nuclear plants, irrespective of whether these accidents affected the nuclear part or not. Every effort must therefore be made to ensure objective reporting by the public media so that unfair comparisons are not made between failures in nuclear plants and failures in other technical undertakings of the same complexity.

Let us further recall that thermal reactor systems only represent a temporary contribution to the energy provision of the world, on a time-scale comparable to that of oil. A long-term contribution presumes the development of fast systems, breeders, whereby nuclear energy could make a long-lasting contribution to the world's energy problems; in other words, like coal, but with much less environmental impact – although nuclear involves other problems as well. Unfortunately, the dynamics of the technical development are not considered when the politicians plan for the future.