PROSPECTS FOR NUCLEAR POWER, NUCLEAR SCIENCE & TECHNOLOGY

MOVING INTO THE NEXT CENTURY

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Forty years ago, the prospects for the use of nuclear power as a main source of energy were considered immense. Ship propulsion, electricity production, and industrial heat were applications of high interest and large investments were made to develop peaceful uses of nuclear technologies.

For commercial ship propulsion, the technology proved to be adequate but several difficulties arose. They were related mainly to radiation and safety controls required by port authorities. Time has shown that the mobility of the commercial nuclear vessels was not as convenient as for other sources of propulsion and cost advantages were not achieved for the classes of commercial ships being considered.

The use of industrial heat involved several branches of industry requiring specific conditions of temperature and pressure for steam. They ranged from low-temperature applications for district heating to very high temperature applications for processing of steel, glass, and cement. Technology varied from the recovery of heat from light-water reactors (LWRs) to researching specific designs involving high-temperature reactors cooled by gas. Again, as in the case of ship propulsion, nuclear applications for industrial heating proved to be technologically viable but they could not compete on the market with conventional sources.

The situation was different for nuclear power in the production of electricity. Installed nuclear capacity worldwide grew rapidly during the 1970s and 1980s. *(See graph, page 44.)*

By the mid-1990s, nuclear power's share of total electricity production had surpassed 17%, which is about the same as the share for hydropower. Nuclear power reached that level in 30 years, about one-third of the time it took for hydropower to achieve its share.

Other evidence of nuclear power's competitiveness in the early 1970s can be assessed by comparing the percentage of electricity supplied by several energy sources. *(See table, page 44.)* From 1973-93, nuclear power's contribution grew tenfold while gas, the next fast-growing fuel, barely doubled its contribution to total electricity generation.

Looking more closely at the data makes it clear that the growth rate of nuclear power, although impressive, was not homogeneous throughout the period. In several cases, government policies and subsidies played a role in shaping the picture. In addition, several regional aspects related to the use of nuclear power became apparent.

What of the future? Based on historical data and the IAEA's projections, estimates of nuclear power's future contribution can be made under different assumptions. Projections of nuclear's share of power generation in this article are based on a low-growth scenario for the period up to 2020.

Historically, the data clearly show that nuclear prospects started to decline by mid-1985. *(See graph, page 45.)* The projected consequence is that from a market share of more than 16% in 1997 the expected share may fall to 13% by 2010. *(See table, page 45.)*

In short, nuclear power will contribute a smaller yet still significant share of total electricity production into the next century. Its contribution is expected to be comparable to hydropower, which also shows a continuous reduction in its market share in the long range.

LOCAL REALITIES

Understanding the reasons behind this projected reduction is important to fuller analysis of trends. To form a clearer picture of the real situation and projections for nuclear power, we made a field study to eleven countries in Asia, Latin America, and Africa, where local realities are dictating decisions.

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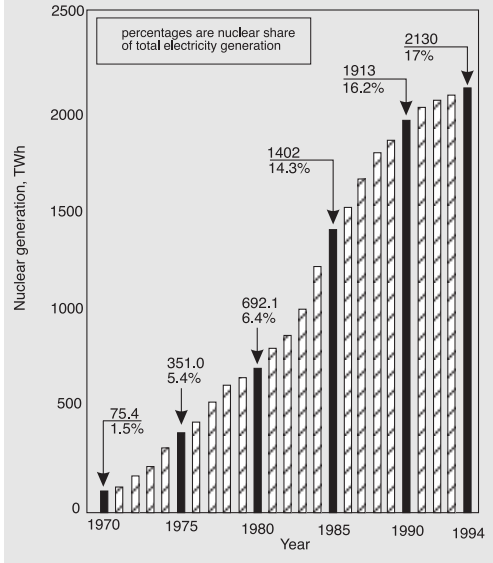
NUCLEAR POWER GENERATION, 1970-94



Source: IAEA/PRIS

ELECTRICITY SUPPLY BY SOURCE, 1973-93

POWER SOURCE	SUPPLY (TWh)	IN 1973 (% total)	SUPPLY (TWh)	IN 1993 (% total)	GROWTH (%)
COAL	2032	37.5	4436	36.6	92
OIL	1462	23.8	1182	9.8	-19
GAS	700	11.4	1631	13.4	133
NUCLEAR	197	3.2	2148	17.8	990
HYDRO	1276	20.8	2256	18.6	76
OTHERS	202	3.3	456	3.7	125
TOTAL	6139	100.0	12,108	100.0	97

Source: Extracted from data reported in International Energy Data: National Energy Profiles, World Energy Council, 1995.

As is well known, a systematic historical analysis of the spread of the use of nuclear power for electricity generation shows a well-defined trend. It leads from the first plants installed during the 1950s in the United States to new nuclear power plants in Europe, and then to Asia.

Some reasons behind this trend were:

■ The leadership in developing commercial nuclear technology was in the United States during the 1950s. Then, and in subsequent decades, the competitiveness of nuclear power was dictated by the perception that the new source represented a technology breakthrough, and as such opened the opportunity to produce energy for multiple applications and at very low prices.

■ Interest grew in European countries. During the 1970s, nuclear technology leadership turned over to Europe where nuclear power was taken as an important alternative energy source for countries with a scarce supply of fossil fuels. This was a result of the energy crisis related to the oil embargos of the decade.

■ Countries in Asia developed significantly. During the 1990s the technology leadership for power production reflected a new shift in the direction of Asia, with Japan at the center. Nuclear power was perceived as a costly way to produce electricity but with the advantage of lowering dependency on the supply of materials and energy imports. Long-range fuel supplies could be assured by reprocessing or by other technological alternatives. This, in turn, makes nuclear power almost a "national resource" even for countries that do not have their own uranium resources. Alongside the issue of having cheap energy supplies, other key issues emerged, such as the diversity of supply and long-range control of energy sources. These issues gave an edge to nuclear power plants, as long as the additional costs were reasonable.

These changing tendencies and perceptions of nuclear power's expected importance for a specific country suggest that future trends will be difficult to evaluate. The main lesson learned from the field study is the confirmation that the understanding of local realities is a fundamental factor if projections of future energy demand are to be done properly.

The competitiveness of energy sources cannot be evaluated globally but, instead, must be done on a local or regional level. This is especially true when nuclear energy is involved. The opinion of local stakeholders and the possibility of hearing different and conflicting opinions is needed to analyze the most probable course for the use of a technology such as nuclear energy.

The field study's conclusion about trends for nuclear power indicated a diversity of situations among different countries. The range includes:

■ Countries where there are no clear projects for nuclear power. In these cases, very little can be said about the atom's possible contribution to electricity generation in the future. This is the case for Thailand and Indonesia.

■ Countries where the contribution of nuclear power is decreasing, as in Argentina, Mexico and South Africa;

■ Countries where the contribution of nuclear power is small but growing, as in Brazil, China, and India;

■ Countries where the contribution of nuclear power is large and where the tendency is to keep it large, as in the Republic of Korea.

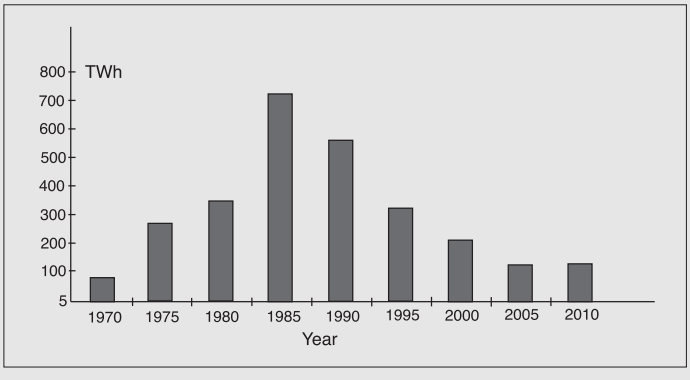
ESTIMATES OF TOTAL ELECTRICITY GENERATION AND CONTRIBUTION BY NUCLEAR POWER

Country Group	1997 Total Elec. TW.h	1997 Nuclear TW.h	1997 Nuclear %	2000 Total Elec. TW.h	2000 Nuclear TW.h	2000 Nuclear %	2010 Total Elec. TW.h	2010 Nuclear TW.h	2010 Nuclear %	2020 Total Elec. TW.h	2020 Nuclear TW.h	2020 Nuclear %
North America	4050	707.3	17.5	4173	678	16	4610	616	13	5092	419	8.2
				4298	692	16	5240	687	13	6387	859	13
Latin America	880	20.9	2.4	976	20	2.1	1350	25	1.8	1797	22	1.2
				1034	20	1.9	1644	32	1.9	2387	69	2.9
Western Europe	2678	838.2	31.3	2792	836	30	3114	837	27	3339	639	19
				2892	836	29	3684	882	24	4602	1013	22
Eastern Europe	1725	250.8	14.5	1725	287	17	2051	307	15	2626	230	8.8
				1777	298	17	2274	372	16	3208	482	15
Africa	384	12.6	3.3	419	13	3.0	606	13	2.2	897	13	1.5
				425	13	3.0	676	13	2.0	1102	33	3.0
Middle East and South Asia	949	9.1	1.0	1099	10	0.9	1790	24	1.4	2915	46	1.6
				1146	12	1.0	2152	39	1.8	4040	89	2.2
South East Asia and the Pacific	494			556			863			1341		
				572			977	4.7	0.5	1669	54	3.2
Far East	2782	437.5	15.7	3130	446	14	4632	706	15	6857	835	12
				3221	448	14	5246	895	17	8545	1335	16
World Total	13924	2276.3	16.3	14869	2291	15	19017	2529	13	24864	2204	8.9
				15365	2319	15	21894	2925	13	31940	3933	12

Note: In projections for 2000, 2010, and 2020, the different rows, where applicable, represent low and high estimates.

Source: *Energy, Electricity and Nuclear Power Estimates for the Period up to 2020*, IAEA, July 1998 edition.

INCREMENTAL CONTRIBUTIONS OF NUCLEAR-GENERATED ELECTRICITY, 1970-2010



These different stituations suggest that nuclear power will be used for a long time to come to varying degrees. Over the years, the reasons that led countries to select nuclear power plants have changed dramatically. But there is little doubt that society will use this technology to produce electricity in the foreseeable future.

Though it has fallen short of its potential, nuclear power remains in position to contribute to electricity needs as a lasting and diverse source of energy based on science and technology. This is the key factor to be addressed when considering how useful the application of nuclear power could be for a specific country.

Even more important is the need to understand that the nuclear science on which nuclear power is based is common to all other peaceful nuclear applications in medicine, agriculture, industry, science, and other fields. This extends the the technology's overall impact to society. In the United States, a 1992 study found that non-power peaceful applications related to nuclear science and technology involve expenditures of $357 billion dollars per year and an associated 3.7 million jobs, of which 1.6 million are directly associated with the nuclear field. It also indicated that the US industry for non-power nuclear applications appears to be over four times larger than the nuclear power industry. This mirrors the pattern experienced by almost all other countries engaged with nuclear science and technology.

The lowering of early expectations for nuclear power and the direct influence of market forces on energy decisions seem to have leveled the playing field. But these and other forces also have promoted a closer look at the technology in all its peaceful applications, relative to its specific advantages and limitations for the production of electricity and other uses. ❐