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《**Review**》

Prospect for Promotion of Nuclear Power Development in Japan*

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1. The Basic Concept on Construction of Electric Sources

(1) Since the first oil crisis, the development of electric sources in place of oil, including nuclear power generation, coal and LNG-fired thermal power generation and so forth, has been promoted positively to attempt to diversify electric sources. However, it is considered that this greatly contributes to the stabilization of electric supply and the suppression of supply costs.

with respect to the diversification of electric sources on a long-term basis, by referring to the outlook on the international fuel situation (taking into consider ation supply characteristics such as economic efficiency of each electric source, stability of fuel supply and load follow-up), balanced electric sources must be constructed, so that the most effective supply may be made depending on the fluctuation of demand for power. The capability of power supply is roughly divided into three categories: the base power supply capability, operating at an almost always constant output;the peak power supply capability supplying the necessity at peak time and operating in proportion to load fluctuation of demand for power; and the middle power supply capability, playing an intermediate role between them. Since the base power supply capability plays the main part, an electric source superior in both phases of long-term economic efficiency and stability in procuring fuel should be appropriate. As for the peak and middle power supply capability, electric sources which require less capital and are excellent in load following-up because it is least utilized annually and required to follow up the load; and those having intermediate characteristics are appropriate to the former and the latter, respectively.

In view of this, consideration of power supply characteristics provides the basis for the construction of electric sources on a medium- or long-term basis: namely, nuclear energy generatron; coal-fired thermal power generation; natural-flow type hydroelectric power generation; and geothermal power generation should be appropriate to the base power supply capability, coal-fired thermal power generation and LNG-fired thermal power generation to the middle power supply capability, and oil-fired thermal power generation, LPG-fired thermal power generation, hydro-electric power generation with adjusting reservoirs and pumped storage hydroelectric power generation to the peak power supply capability.

(2) of the base power supply capability, cap-

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ital expenses in the natural-flow type hydroelectric power generation and geothermal power generation using pure domestic energies account for the most part of power generation costs. Consequently, although it offers excellent long-term economic efficiency, the inital cost is relativly high. For this reason, the steady development of such resources, while attempting to reduce the initial cost, is preferred.

As the base power supply capability, nuclear energy generation and coal-fired thermal power generation are hopeful for the future because of their high-quantity potential.

Nuclear power generation is equivalent to storing fuel because if the power plant is loaded with fuel once, it will not need to be replaced for about one year. Since its percentage of fuel is low and that of capital expenses is high, the advantage is that long-term economic efficiency is excellent, and that the power generating costs against the fluctuation of fuel prices ane stable. In addition, by establishing the system for uranium enrichmenr and reprocessing of spent fuel domestically, it is possible to utilize the uianium and plutonum obtained thereby as to "domestically" available energy,so to speak, so that a stable supply of fuel can be secured. Thus, by considering the excellent characteristics of nuclear power generation and strengthening resolve to deal with the various tasks ahead, including improvements in safety in the final disposition of radioactive wastes and safety as well as economic efficiency of decommissioning plant technology, it is preferred to develop nuclear power generation aggressively as appropriate to the nucleus of the base power supply capability.

Since coal resources are abundantly available, particularly in the region of the pacific Basin, coalfired thermal power generation is superior in stability of supply and economic efficiency to other fossil fuels; it is suitable for development as next to nuclear power generation to be appropriate to the base power supply capability.

(3) As for the middle power supply capability, coal and LNG-fired thermal power generating plays the main part.

By making the most of properties constituting clean energy, LNG-fired thermal power generation plays a part as power supply capability in the central portions of demand in Tokyo Bay and Osaka Bay where environmental regulations are severe; the advantage is that thermal efficiency and load following-up are improved when it is employed in the form of combined cycle generation. As a result, LNG-fired thermal power generation has been positively developed as the nucleus of substitute electric sources for oil, corresponding to the need for environmental protection in the central portions of demand in the regions of Tokyo Bay and Osaka Bay. On the basis of such properties, it is preferred to develop LNG-fired thermal power generation as the substitute electric source for oil in the central portions of demand while improving the terms and conditions of LNG transactions.

Turning to coal-fired thermal power generation. Although it was far inferior in economic efficicncy to fossil fuels such as oil before the second oil crisis, its relative position of advantage to oil and LNG-fired thermal power generation is economically increasing because of a spiral price hike of oil at the time of the second oil crisis. Such a position will be maintained on a long-term basis. In addition, improvements in the techniques of environmental protection allow the development of thermal power generation to be positively accelerated.

In consideration of the necessity of correcting the imbalance between thermal power sources, because the percentage of LNG-fired thermal power generation is becoming higher than that of coal-fired thermal power generating, the latter should be positiuely developed as appropriate to the middle power supply capability on a long-term basis.

(4) As for the peak power supply capability, hydroelectric power generation with adjusting reservoirs should also be developed steadily and continuously because it is completely domestic, though points for development have recently been restricted.

Regarding oil-fired thermal power generation, such power generating plants are understood to be undesirable as a rule according to international agreements at the International Energy Agency and so on. On the other hand, the already built oil-fired thermal power generating plants are now regarded as the most economic electric sources appropriate to peak power supply capability with a low percentage of capital expenses and low utilization factor because they are equipped with facilities which are amortized, though their fuel costs are high. For this reason, the already constructed oil-fired thermal power generating plants should be converted to peak power supply capability along with the development of substitute electric sources while the load following-up capability is improved.

Since pumped storage hydroelectric power generation offers superior characteristics unknown to other electric resources, including the instant load following-up capability and so on, it has been developed as appropriate to peak power supply capability to supply a certain percentage of the increased demand as a target. However, because the growth of demand for power is expected to remain at a low level in the future and because the existing oil-fired thermal power generating plants can be largely utilized in the field of peak power supply capability in company with the development of substitute electric sources for oil, their development should be minimally required.

(5) In addition to the above points, in consideration of the progress of construction of each substitute electric source for oil, the target scale of facilities and electric energy to be generated at the end of fiscal 1990 and 1995 has been set up.

The balance between power demand and supply has been so planned as to maintain a reserve rate of 8~10% for the electric energy required to stabilize power supply.

2. Targets and Tasks of Development by Electric Sources

(1) Nuclear Power Generation

① Development Target

Nuclear power generation is an excellent electric source with stability and economic efficiency in supplying a large amount of electric energy and therefore it is preferred to continue its development in a positive manner as the nucleus of the base power supply capability by making every effort to secure opeerational safety.

However, the planning, designing and construction of nuclear power generating plant is still restrictive and, because the lead time is long, this aspect must be thoroughly deliberated before examining the target of development. In view of this, the target in 1995 has been set at 48 million kW, while that in 1990 being set at 34 millin kW.

② Future Tasks

i. Attempts have already been made to maintain safety and operational control and to promote improvements and standardization in nuclear power generation. These efforts have enabled stable power generation to be carried out at a high level. It may safely be said that the technology of the light-water reactor has come to stay.

Importance should be attached to further improvements the reliability of nuclear power generation as the percentage of the same in the total electric supply increases. This requires fortifying the measures for preventing accidents and troubles by positively utilizing information about operating experiences at home and abroad up to the present; maintaining and improving the disposition of operators and repairmen; and further promotion of standardization.

ii. Uranium ore is refined and enriched. The spent nuclear fuel is then re-processed. This produces uranium and plutonium which can then be re-utilized as fuel. The sequence of these processes is called the nuclear fuel cycle. Such a cycle must be established if nuclear power generation is to become equivalent to home-produced energy. Moreover, this re-processing steps are extremely important with a view to control high level radioactive waste matter contained in the fuel used with safety and in a compact form. At present, although the nation relies on overseas concerns for almost all of the enrichment of uranium, which is the core of the nuclear fule cycle, and reprocessing of the fuel spent, a national system must be established as quickly as possible in consideration of the above problems to hormonise with the atomic policy as a whole.

Regarding low level radioactive wastes, it is now safely stored within the premises of the power plant to be disposed of on land and in the ocean. Efforts must be paid to obtain the understanding of those at home and abroad at an early date so as to carry out disposal of the wastes in the ocean, while the storage of the waste matter in facilities outside the premises of the power plant as a phase of its disposition on land should be developed.

For the high Level radioactive wastes, the construction of a pilot plant in connection with solid disposition and storage technology must be promoted. The final disposition must also be viewed from the development of its disposition in geological strata and related technology.

Measures taken for the decommissioning of nuclear power plants by the electric utilities will be on schedule in concrete terms in around 1995. Fundamentally, application of the existing technologies is considered capable of dealing with the decommissioning of reactors but technological development must be further promoted to aim at improvements in safety and economy.

The final disposition of radioactive wastes and measures to be taken after the decommissioning of nuclear power plants are attracting the attention of people living in affected communities and so these measures must be presented to these people in the right of economic and technological factors so that the they are readily understood.

iii. Since the expenses for constructing a nuclear power plant are increasing from year to year, it has become an important task to endeavor to reduce the construction costs with safety remaining the major prerequisite. As a result, this makes in the first consideration in the promotion of standardization, rationalization of design, shortening of the construction period, review of purchasing methods and rationalization of quality control.

iv. In view of promoting local consensus where a nuclear power plant is located, the replenishment of public acceptance measures relating to the necessity and safety of the plant must be carried out.

v. Although nuclear power generation in Japan is mainly represented by light-water reactors at present, in order to ease the restriction of uranium resources imposed on this country on a long-term basis, the plutonium recovered by reprocessing the spent fuel must be effectively utilized.

For this reason, the basis of the long-term nuclear power developmet policy in Japan rests upon employing plutonium as fuel, developing and utilizing a fast breeder capable of generating much more plutonium than it has consumed; the development of fast breeders should be further positively promoted.

In the meantime, until the fast breeder reactor is put to commercial use, attempts must be made to effectively utilize plutonium through recycling through an advanced thermal reactor and a light-water reactor.

(2) Coal-Fired Thermal Power Generation

① Development Target

Since there are abundant coal resources widely deposited in the region of the Pacific Ocean, coal-fired thermal power generation offers excellent supply stability and is superior in economic efficiency to other fossil fuels such as LNG. Consequently, it must be posiitively developed, while considerating environmental preservation, as the base power supply capability next to nuclear power generation. It must be developed with the possibility of the middle power supply capability on a long-term basis.

with this in mind, the target in 1995 has been set at about 21 million Kw, while that in 1990 is set at 14 million Kw in consideration of lead time.

② Future Tasks

i. Since the supply of domestic coal is restricted, demand for coal, which is expected to increase in the future, has to rely on imports. Accordingly, an important task is to introduce a large amount of overseas coal stably and less expensively for a long period of time. For this, importance must be placed in the fact that a series of coal chains starting with production of coal up to transport and consumption must be established to plan for the ration-alized dispersion of supply sources.

Oil-fired thermal power generation is supposed to play the part of coping with the fluctuation of demand for power associated with variations of business trends as electric sources for supplying power elastically. However, coal-fired thermal power generation is also expected to play the same role on a long-term basis. Thus, when coal is procured, an important task is to secure not only stability but also elasticity of supply. It is suggested in view of this to thoroughly examine the long-term contract and the utilization of spot coal before overseas coal is purchased.

ii. As the development of coal-fired thermal power gener-ation progresses,a large amount of coal ash is expected to be produced and simultaneously the development of technology for effectively utilizing the ash for cement, roadbed materials, and artificial lightweight aggregate, must be pursued. At the same time the regulation of the market must be implemented. Moreover, it is also necessary to reduce the amount of dischaged ash within the premises of the power plant by means of an ash ramover at the coal mine or a storage terminal. we must also effectively process and utilize the ash at large scale ash centers.

iii. Regarding coal-fired thermal power generation, it is expected to play the part as the middle power supply capability on a long-term basis. Generally, in order to improve the economic efficiency of the middle power supply capability, extremely effective measures must be introduced which will include reducing the burden of capital expenses when the utilization factor is smaller than that of the base power supply capability. For this reason, in the construction of a coal-fired thermal power plant, importance should be attached to: promoting the effective utilization of coal ash; planning to reduce the scale of the ash processing facility, and promoting the rationalzation of harbors and coal storage facilities by the utilization of coal centers.

iv. To plan the further effective utilization of coal, extra-critical-pressure technology to improve thermal efficiency, and highly efficient

Table-1. Long-term Electricity Demand Outlook

(Unit: TWh. Figures in parentheses indicate percent component ratios)

Classification \ Fiscal Year	1982	1990	1995	Annual growth rate 82/90 (%)	Annual growth rate 90/95 (%)
Industrial sector	317.9(60.9)	376(57.1)	425(55.3)	2.1	2.5
Other sectors	203.8(39.1)	282(42.9)	343(44.7)	4.1	4.0
Gross demand	521.7 (100)	658 (100)	768 (100)	2.9	3.2
(Demand breakdown)					
Electric utilities	471.4 (90.4)	602 (91.5)	708 (92.2)	3.1	3.3
Auto-producers	50.3 (9.6)	56 (8.5)	60 (7.8)	1.2	1.5
Maximum power demand (GW)	93.19	128	152	4.0	3.5
Annual load factor (%)	61.3	57.1	56.5	—	—

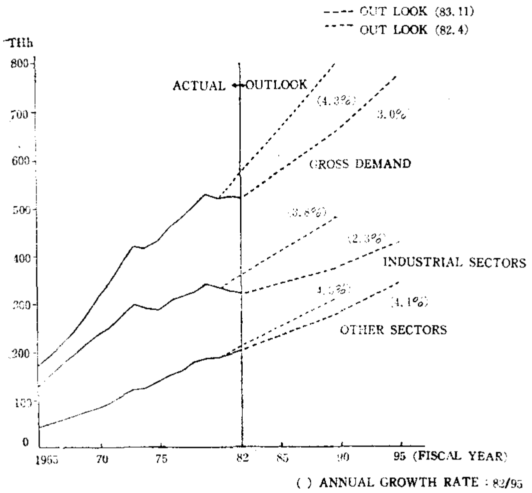

Fig. 1. Long-Term Electricity Demand Outlook

dust processing technology in view of environmental preservation must be established. On a long-term basis, development must be positively made in promoting technologies: of multiple power generation by low calorie coal gasification aimed at enlarging the kinds of utilizable coal; fluidised bed burning; low grade coal utilization; and converting coal into slurry to reduce handling costs.

Table-2. Installed Capacity of Electric Power Plants (Unit: GW)

	at the end of FY1982	(%)	at the end of FY1990	(%)	at the end of FY1995	(%)
Nuclear	17.18	12.3	34	19	48	23
Coal	6.65	4.8	14	8	21	10
LNG	20.21	14.5	40	23	43.5	21
Hydro	32.19	23.0	38.5	22	42	21
Conventional	18.24	13.0	20.5	12	22.5	11
Pumped Storage	13.95	10.0	18	10	19.5	10
Geothermal	0.18	0.1	0.6	0.3	1.5	0.7
Oil & LPG	63.43	45.3	50	28	49	24
Total	139.84	100.0	177.1	100	205	100

Table-3. Generation of Electric Power Plants

	Generation(TWh)						Fuel Consumption		
	FY1982	(%)	FY1990	(%)	FY1995	(%)	FY1982	FY1990	FY1995
Nuclear	101.8	19.5	190	28	285	35	—	—	—
Coal	35.5	6.8	65	10	95	12	14.82×10^6t	26×10^6t	38×10^6t
LNG	79.2	15.2	165	24	170	21	13.77×10^6t	29×10^6t	30×10^6t
Hydro	77.4	14.8	92	13	101	13	—	—	—
Conventional	74	14.2	82	12	89	11	—	—	—
Pumped Storge	3.4	0.6	10	2	12	2	—	—	—
Geothermal	1	0.2	4	0.6	10	1	—	—	—
LPG	5.9	1.1	10	2	10	1	1.08×10^6t	1.08×10^6t	1.08×10^6t
Oil	20.39	39.0	140	20	115	14	48.99×10^6kl	34×10^6kl	28×10^6kl
Others	17.8	3.4	19	3	19	2	—	—	—
Total	522.5	100.0	685	100	805	100	—	—	—

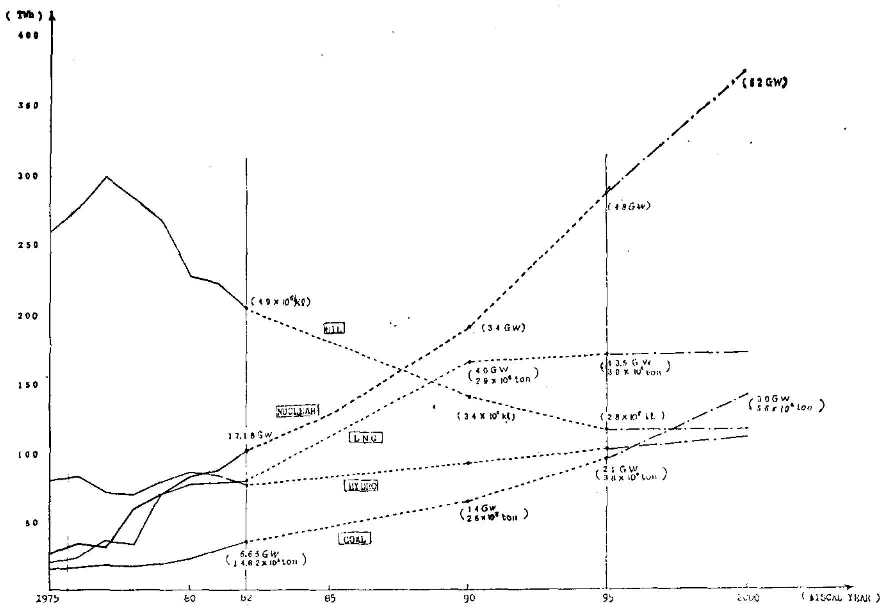

Fig. 2. Long-Term Electricty Supply Outlook

Table-4. The Cost of Electric Power Generation by Source(Commissioned in FY 1983)

source \ cost	Construction Cost (10^3 yen/kw)	Generation Cost (Sendingend) (yen/kwh)	Ratio of Fuel Cost included (%)
Hydro	approximately 610	approximately 20	approximately —
Oil	130	17	75
Coal	230	14	40
LNG	180	17	65
Nuclear	300	12.5	25

Notes: (1) Generation Costs are for model plants to be commissined in fiscal year 1983.

(2) Model plants have the following capacity.
Hydro (Conventional): 10~40MW
Oil fired thermal: 600MW class 4 units
Coal fired thermal: 600MW class 4 units (Overseas coal)
LNG fired thermal: 600MW class 4 units
Nuclear: 1100MW class 4 units

(3) Capacity factor of hydro plant is 45% while those of other are 70%.

(4) Costs are for the year of commission.