REGULATORY REFORMS AND STRUCTURAL CHANGES IN THE ELECTRIC POWER INDUSTRY: THE U.S. EXPERIENCE AND ITS IMPLICATION TO JAPAN

by

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(1981)

Submitted to the Sloan School of Management
in Partial Fulfillment of
the Requirements for the Degree of
Master of Science in Management

at the

Massachusetts Institute of Technology

May 1991

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Abstract

The electric power industry has become increasingly competitive and deregulation are required to facilitate new entry. Main competitive factors are inter-energy competition for fuel of heat-supply among gas, oil and power, shift to self-generation from purchasing power, power wholesale or retail by cogeneration. As fuel cells improve, entry barriers to electric power markets will become lower. Under such competitive pressure, the electric power industry is required to reduce costs and prices and to provide more diversified service.

This thesis attempts to extract some universal lessons from the U.S. experience in regulatory reforms and structural changes of the industry, and to clarify its implication to the future directions of the emerging deregulation in the Japan electric power industry.

This thesis finds five underlying forces of the U.S. regulatory reforms: governmental policy shift in favor of deregulation; diminished economies of scale in generation; potential of self-generation; loss of incentives for utilities to invest in new capacity; and profit incentives for new entrants by decoupling prices and costs. Examination of the Japan's current situation shows that the first three forces exist in Japan but that several Japan specific factors also exist. Study of such factors concludes that wholesale markets should be opened up gradually because of diminished economies of scale in generation, threat of new entrant rationale, and energy efficiency, and that utilities should be given more deregulation and flexibility in pricing, but that retail markets should not be opened up because of economies of vertical integration, cream-skimming and inefficient bypass problems.

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Acknowledgments

This thesis was made possible by the extensive assistance and support of many people.

I would first like to express my sincere gratitude to Professor Paul L. Joskow for his guidance and assistance throughout the course of my work in formulating the study, narrowing down the issues, picking up the main points, presenting the results and finishing the thesis.

I would like to thank Mr. Hisao Kibune and Mr. Naoya Sugai who gave me their constructive advice and information on the study of the on-going deregulation of the U.S. electric power industry.

I would also like to thank Dr. Shinichi Senshu, Mr. Norio Chino and Mr. Tsutomu Yamamoto who gave me their insightful advice and very important information on the study of the current situation of the Japan electric power industry.

I wish to extend a note of thanks to Dr. Toshio Fujii, Mr. Yoshinobu Nagano, Mr. Nobuya Minami, Mr. Kiyoshi Ishii, Mr. Shigeyuki Kuninobu, Mr. Hiroshi Yoshikoshi, Mr. Makoto Satake, Mr. Masatake Kakinuma, Mr. Michio Isaka, Mr. Tohru Tonegawa, Mr. Naomi Hirose and my colleagues at the Tokyo Electric Power Company for providing me with an opportunity to study at the Alfred P. Sloan School of Management, Massachusetts Institute of Technology.

Finally, I would like to gratefully acknowledge the support of my wife, Shigeko, and my two sons, Yuhei and Taiji, with whom I have been fortunate to share much more time, experiences and fun in the U.S. than in Japan, and the as well as the encouragement of my father, mother and mother in law.

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I. Introduction

This thesis attempts to study the U.S. experience in regulatory reforms and structural changes of the electric power industry, and its implication and applicability to the future directions of the emerging deregulation of the Japan electric power industry.

Background of the deregulation of the Japan electric power industry is that the business environments of the industry have become increasingly competitive and generated various requests for regulatory reforms to facilitate new situations. Among the major factors promoting competition are inter-energy competition for local-heat-supply business among gas, oil and electric power companies, large industrial customers' shift from purchasing power to self-generation, emergence of cogeneration, and partial deregulation in retail power sales by cogenerators. Moreover, as fuel cells improve their performance in terms of energy efficiency and environmental protection, entry barriers to generation markets are expected to become lower.

If one makes a brave try at writing a scenario of the future deregulation, one might imagine that cogenerators will retail power to off-site customers by sending it through transmission lines of electric power companies. Customers will be provided with more options of power supply including conventional electric power companies and several cogenerators. Cogenerators will be provided with free access to transmission and distribution networks of electric power companies and with wheeling service by electric power companies.

Under the increasing pressure of competition, the electric power industry is required to reduce costs and prices and to provide much more variety of service to meet diversified customer needs.

Regarding deregulation in the electric power industry, the U.S. has longer experience than Japan. Since the Public Utility Regulatory Policy Act (PURPA) was enacted in 1978, the U.S. electric power industry has experienced unanticipated evolution of deregulation, particularly in wholesale generation markets, for more than ten years. However, it was energy crisis, not deregulation, that PURPA was originally designed to tackle. Deregulation was just a byproduct of PURPA. Why deregulation has proceeded so much with a help of PURPA is that several underlying forces have already become ripe to push it.

Thus, this thesis first studies those underlying forces of regulatory reforms and structural changes in the U.S., and finds five forces: governmental policy shift in favor of deregulation; diminished economies of scale in generation; loss of incentives for incumbent utilities to invest in new capacity; profit incentives for new entrants by decoupling prices and costs; and large potential of self-generation.

Regarding Japan, the current situation of the industry is examined comprehensively to lay the groundwork for accessing the applicability of the U.S. experience to Japan. Among various regulatory issues, independent cogeneration is chosen and studied in more detail.

Then, the applicability of the essence of the U.S. experience to Japan is accessed by examining whether Japan has the five underlying forces of regulatory reforms and structural changes recognized in the U.S. experience. Except two forces: loss of incentives for incumbent utilities to invest in new capacity; and profit incentives for new entrants by decoupling prices and costs, the other three forces are recognized in Japan, too. Also, besides the U.S. five underlying forces, five Japan specific factors: tightness of demand and supply; large incumbent electric power companies; small new entrants; little regulation by local government; and more priority on national energy security, are recognized and discussed.

At last, desirable directions of regulatory reforms in the future are discussed based on the Japan's current situation, the applicability of the U.S. five underlying forces and the five Japan specific factors. Wholesale markets, retail markets and regulation of electric power companies are discussed separately. From the viewpoints of diminished economies of scale in generation, exposition of electric power companies to the threat of new entrants, and energy efficiency rationale, wholesale markets are desired to be opened up step by step and several practical steps of this opening up are discussed. In the long run, it is desirable that competitive wholesale markets including cogenerators, IPPs and less regulated incumbent electric power companies are attained. On the other hand, retail markets are not desired to be opened up based on economies of vertical integration, the "cream-skimming" problem and inefficient bypass. Regulations of electric power companies are desired to be reduced, and more flexibility in pricing and incentive regulations are discussed.

In principle, wise choice of energy supply structure is a balanced mixture of the two alternative which complement each other, that is, on-site small energy production systems are added to make up the shortcomings of scale-ecomony-driven nuclear energy. To evolve the Japan energy supply structure to such a balanced structure, it is necessary to reshuffle the current industry structure by deregulation.

II. Regulatory reforms and structural changes in the U.S.

2-1 Wholesale markets and retail markets

In the electric power industry, competition takes place on two levels. One is wholesale markets, where customers are distribution utilities; and retail market, where customers are final users.

a. Wholesale markets

The conventional form of competition in wholesale markets has been taking place between existing regulated utilities in supplying electricity to distribution utilities. This kind of competition is represented by so-called "coordination transactions," which encompass the short term purchases and sales of electricity engaged in by interconnected integrated utilities in order to make it possible to economically use generating plants owned by proximate utilities and to improve reliability. [Joskow 1989]

This competition has been emerging and promoted by regulatory agencies in the U.S. "On the past decades, the FERC staff has been increasingly willing to accept mutually satisfactory negotiated coordination contracts between integrated utilities that are de facto unencumbered by the rigid cost of accounting principles that are used to set retail rates. This flexible regulatory approach has been critical for encouraging the development of an active wholesale market for energy and capacity associated with facilities built to serve the expected requirements loads of the seller but which are temporarily excess to these needs." [Joskow 1989]

Recently, new entrants have been emerging and active in wholesale markets. They are unintegrated non-utility generators (NUGs), which have been encouraged by federal and state regulations issued after 1980 along with the Public Utility Regulatory Policy Act of 1978 (PURPA). Specifically, they are called QFs (specific cogeneration and small power production facilities qualified by PURPA) or IPPs (independent power producers).

b. Retail markets

Competition in retail markets has been taking place mostly between existing regulated utilities in supplying electricity to final customers. On the border of their exclusive franchises, some utilities compete to attract industrial customers to locate plants in their own franchises. Some large industrial customers arrange access to several utilities over transmission networks in order to reserve more choices of cheap electricity. It is also included in this kind of competition whether to buy from utilities or to own self-generations.

This kind of competition has not been active in the U.S. "There has been little serious contemporary public policy interest in encouraging competing suppliers of electric distribution service to serve the same geographical areas or in broad deregulation of retail electricity prices". This is because "it is generally acknowledged that the distribution and transmission (encompassing transportation, coordination and reliability functions) of electricity have natural monopoly characteristics." "This implies that electricity should continue to be distributed to final customers (retail service) by franchised monopoly distribution companies subject to price regulation". [Joskow 1989] In addition, there are few new entrants in retail markets. In fact, cogenerators other than distribution utilities is forbidden to do retail business in most states if they must use public rights of way to distribute power.

Therefore, competition in wholesale markets including new entrants is encouraged most and expected to develop greatly in the future in the U.S. This is the current main concern of deregulation.

2-2 Historical context

In the 1970's, electricity price increase was filed frequently because of several economic shocks such as oil shocks, large increase in input prices, increase in inflation rate, high interest rate, increase in environmental protection costs due to new regulation, increase in construction costs of nuclear power plants, decline in capital utilization due to slow down of demand growth, and diminished growth of productivity, especially due to full exploitation of efficiency in generation. This down-turn of business environments, frequent increase of price, and ineffective regulatory treatment of such unanticipated turmoils have raised questions about the traditional regulatory regime of the electric power industry.

To tackle the energy crisis after the first oil shock in 1973, PURPA (Public Utility Regulatory Policy Act) was enacted in 1978, which originally aimed at energy conservation. Rather than pursuing the original purpose, PURPA has promoted a lot of new entrants into electricity generation business. This is because PURPA treats QFs (specific cogeneration and small power production facilities qualified by PURPA) favorably in three ways: a utility is obliged to buy electricity from a QF; and its price should reflect the costs that the utility avoids (the "avoided cost principle") by purchasing from the QF compared to the best alternative available to the utility to meet its load; and unlike the conventional utility business, QF business is not subject to the cost-of-service regulation. Moreover, several tax incentives in favor of QFs were introduced along with PURPA. For investment in new QF equipment, investment credit was introduced, where the tax credit was 10% of the purchase price of the corresponding assets. In addition to this special investment credit, ordinary 10% investment credit was allowed to QFs, whereas it was not allowed to utility investment in gas or oil burning power plants. Also, depreciation was allowed to be accelerated for QFs by shortening asset's life from 15 to 5 years. As a result, QF business was perceived to be very sure and profitable, and it was boosted by various regulatory facilitation of implementing PURPA.

At the same time, utilities have come to rely more on purchase from outside suppliers such as QFs for additional capacity to meet their load, because utilities have become very reluctant to invest in building their own new power plants, especially large-scale plants, in order to avoid financial and regulatory risks. Through the past cases of price increase, regulatory procedures have been changing. Some part of construction costs of new power plants were disallowed to enter rate base by prudence review, and rate increase was phased in and delayed to avoid rate shock.

The explosive boom of QF business has brought an excess capacity problem to utilities, because growth of electricity demand slowed down due to frequent price increase and energy conservation. Also, payments to QFs, which were determined by standardized long-term contract with rigid price formulas in the early 1980's, have become excessive and a heavy burden to utilities, because oil and gas prices have declined unexpectedly since the mid-1980's.

To fix those problems, competitive bidding, evaluation of non-price conditions, and milestone review of QF projects have been introduced. Particularly, competitive bidding system is expected to promote competitive wholesale electricity markets. Under the system where utilities fix capacity that they call for bids of, utilities restore the discretion to choose their desired mix of generating alternatives and to assure no more capacity at market price than the necessity to meet their load. The system has made people aware that price competitiveness is a key factor in the wholesale market. Even if it is not a QF, any power producer which supplies utilities with electricity economically and reliably can win contracts. Moreover, to fix the rigidity of the competitive bidding system, competitive negotiation system has been introduced and provides more flexibility in setting price formulas and non-price conditions.

As good plant sites with enough thermal demand for QF's cogeneration are exploited, independent power producers (IPPs), which are not a QF, have been emerging with strong cost competitiveness as a new player in wholesale markets. However, further development of IPPs and more competitive wholesale markets is prevented by Public Utility Holding Company Act (PUHCA) and limited access to transmission networks, although transmission access has been opened up gradually and IPPs have recently been recognized as a player of the electric power industry in the regulatory regime. PUHCA requires those firms holding subsidiaries of utility business to be subject to strict regulation by Securities and Exchange Commission (SEC). An IPP needs to arrange access to the in-between transmission networks of other utilities to wheel its electricity to the buying utility, if it is located outside the service area of the buying utility. Also, most of competitive bidding systems or competitive negotiation systems did not include IPPs as a bidder.

Now, to further deregulation and pursue more efficiency, amendment of PUHCA and open access to transmission networks are considered by legislatures, regulatory agents and industry associations. Also, Demand-side Management (DSM), and Least Cost Planning (LCP) or Integrated Resource Planning (IRP) come to be required in some bidding projects.

2-3 Underlying forces

It is no doubt that PURPA was a crucial turning point toward deregulation in wholesale markets while bringing unexpected by-products. However, the deregulation has been driven by several underlying structural forces: governmental policy shift in favor of deregulation; diminished economies of scale in generation; loss of incentives for incumbent utilities to invest in new capacity; and profit incentives for new entrants by decoupling prices and costs. Deregulation is a consequence of resonance of these underlying forces.

a. Governmental policy shift in favor of deregulation

Governmental policy shift in favor of deregulation is a global trend, which emerged in the U.S. and other developed countries in the 1970's. This policy shift aimed at "a small government" and more efficiency in private sectors by promoting freer economic activities in order to strengthen supply sides in the age of slow down of economic growth after oil shocks.

Generally speaking, one of the strong supports for deregulation is the conventional wisdom that the threat of new entrants or competitive pressure can force incumbent firms to improve efficiency even in industries having natural monopoly characteristics. In the mid-1980's, this conventional wisdom developed into a new emerging economic theory, that is the "theory of contestable markets" or "contestability theory."

Whereas there is still much reservation to apply the contestability theory to the electric power industry, it is very important that the theory has provided a motive for regulatory reforms by showing that entry and price regulation is not a right answer even for industries which are in practice allowed monopoly based on the natural monopoly rationale, i.e. economies of scale and economies of scope. It has come to be widely acknowledged that governmental interventions should be reviewed according to contestability conditions such as sunk costs for entry and exit. Moreover, to achieve efficient allocation of resources, governments should more rely upon market mechanisms by enhancing contestability of markets and assuring the threats of new entrants than upon governmental interventions into markets.

The electric power industry is not an exception for such policy review. It is no longer guaranteed that the traditional entry and price regulation is the right answer simply because the industry has natural monopoly characteristics, although the contestability theory itself is too ideal and not practical in terms of assumption of contestability conditions as critics point out. Originally, the theory shows that efficient allocation of resources can be achieved through free competition of firms even in those markets which are considered to need some governmental interventions to fix market failures in the conventional micro-economic theory. If free entry and exit with no cost is guaranteed, threats of new entrants will force incumbent firms to achieve efficient allocation of resources. In the real world, however, there are very few industries where contestability conditions, particularly free entry and exit with no costs, are satisfied perfectly. For example, the U.S. airline industry is not contestable due to several entry barriers such as hub and spoke systems, scare gates and slots, frequent flier programs, and computer reservation systems. However, the case of the U.S. airline industry shows that even if contestability is not fully achieved, efficiency and social welfare will improve by keeping an industry opened up and enhancing contestability to some extent.

Another support for regulatory reforms is question about economic inefficiency and X-inefficiency of the traditional regulated utilities. "Given that electric utilities are insulated from competition and subject to cost-of-service regulation it is only natural to hypothesize that they face diminished incentives to minimize costs and that the regulated rates they are allowed to charge may depart from the most efficient (first and second-best) prices," and although "the magnitude and causes of the inefficiencies and reliability of the results are very uncertain," some studies find evidence of inefficiencies [Joskow 1989]. The fact that some IPP businesses are viable indicates the existence of such inefficiencies.

b. Diminished economies of scale in generation

Economies of scale in generation have become questionable, which provides a motive to question the efficiency of the existing industry structure. This is because economies of scale in generation is one of the sources of "public interest" rationale for monopoly, although "the combination of economies of scale, economies of multiproduction, and economies of vertical integration provide the primary public interest rationale for the emergence of vertically integrated electricity supply firms with de facto legal monopoly franchises to provide retail service to a specific geographical area, subject to price regulation [Joskow 1989]." Generation of electricity may only be a temporary natural monopoly, since the tendency for average costs to decline with plant size may not continue indefinitely [Weiss 1975] [Schmalensee 1979]. However, loss of economies of scale in generation does not necessarily guarantee that more efficient alternative forms of industry structure will exist.

According to the cross-section analysis of firm-level economies of scale in generation with trans-log type cost functions by Christensen & Greene [1976], economies of scale were almost fully exploited by most of utilities in 1970, although definite economies of scale were found in most utilities in 1955. In other words, economies of scale in generation had been diminishing from 1955 to 1970.

According to Greene [1983] and Joskow & Rose [1985], economies of scale in generation have been almost diminished since oil shocks. Its causes are a jump of input prices after oil shocks, slow down of technological progress, almost full exploitation of efficiency improvements through scale up of generation unit sizes and improvement of thermal efficiency per unit, increase of environmental protection costs due to tighter regulation, and decline of capital utilization due to slow down of demand growth.

Thus, it can be argued that some third party firms besides incumbent utilities may generate electricity with comparative efficiency and be viable if economies of scale exist no longer. There is a ground to introduce competition into generation markets since some competitors can viably stay in the markets.

On the other hands, economies of scale in transmissions and distributions are considered to be still significant [Schmalensee 1979], [Joskow 1989]. Economies of multi-product production are also considered to be significant because efficiency can be greatly improved by linking dispersed generating facilities over transmission networks and coordinating them economically to meet fluctuating loads and to maintain reliability. This coordination is very crucial for supply of electricity, a unstorable product whose demand varies widely from second to second [Joskow & Schmalensee 1983], [Joskow 1989]. Also, economies of vertical integration are considered to be significant in terms of economical operation of various generating facilities under fluctuating loads, reliability of electric power system, quick and appropriate response to emergencies, economical coordination of maintenance plans, and efficient investments in generation and transmission systems. Economies associated with horizontal integration are likely to be significant as well in terms of coordination and reliability [Joskow 1989]. Such economies can be achieved by extensive cooperation between proximate owner of generating and transmission capacity over an interconnected electric power network.

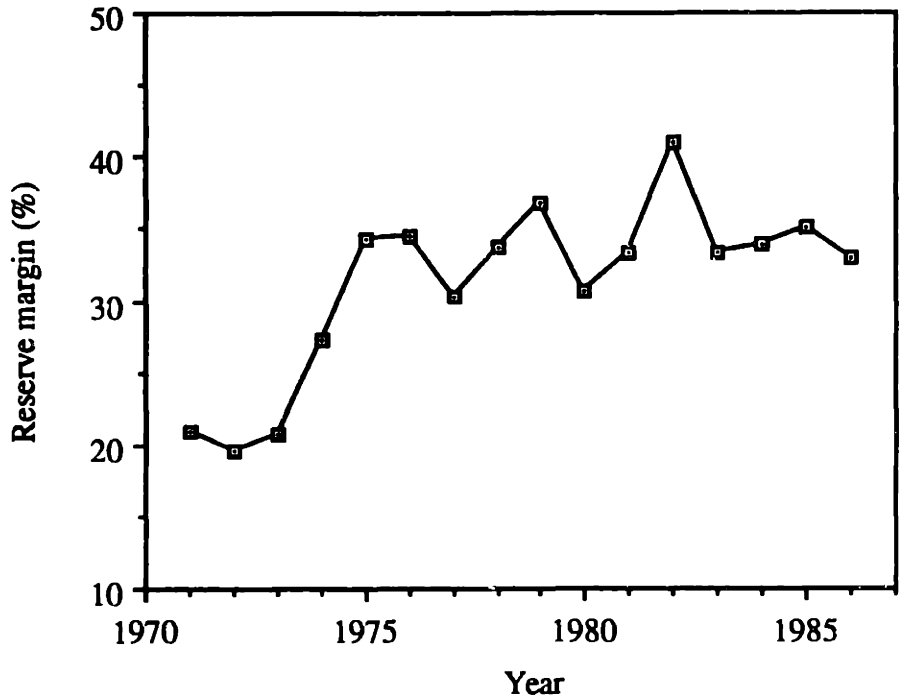
Therefore, on the level of the whole firm, efficiency gain from deregulation of generation markets should be compared to loss of economies of vertical integration from separation of generations. In a general sense, efficiency loss is considered to be greater than efficiency gain, and deintegration of electric power system for the purpose of introducing competition does not necessarily improve economic efficiency as a whole, although there might be some room for third party firms to enter generation markets with more efficient generation technology.

c. Loss of incentives for incumbent utilities to invest in new capacity

Incentives for incumbent regulated utilities to invest in new capacity had been sharply diminished in the late 1970's and early 1980's. This is because as the costs of supplying electricity increased, the regulatory process in rate-making had become so punitive and regulatory risk had increased greatly as follows.

First, regulatory lag in approving price increase worked to maintain prices below the accounting cost-of-service and earned returns below the cost of capital. Second, based on the discretionary concepts of "prudence" and the "used and useful", regulatory commissions often disallowed some fraction of costs of new capacity invested by utilities. Most of new capacity was large nuclear and coal-burning generating plants. However, these investments later turned out to be much more costly than had been expected. Moreover, those new plants resulted in excess capacity (which is shown as high reserve margin in Figure 2-1), combined with an unanticipated slow down of

Figure 2-1
Reserve margin of capacity at peak load in U.S.



demand growth (Figure 2-2, 2-3), and consequently, such excess capacity would have led to large increases in the size of the rate base.

"Utilities learned that if they built a large new generating plant, there was a very good chance that they would not fully recover their investment in it," and "the results appears to be a sort of generating investment minimization effect." [Joskow 1989] Utilities have been responding to the increased regulatory risk in two ways: to stay passively within regulation; to escape from regulation; and to escape into loopholes in regulation.

Utilities that stay passively within regulation give up building large generating plants themselves or build only small generating plants with short construction periods to reduce regulatory risk. As a result, electric utility capital expenditures have been decreasing (Figure 2-4), and utilities have come to rely more upon third party suppliers.

Figure 2-2
Percentage changes in electricity sales (kWh) and economic activities (GNP)

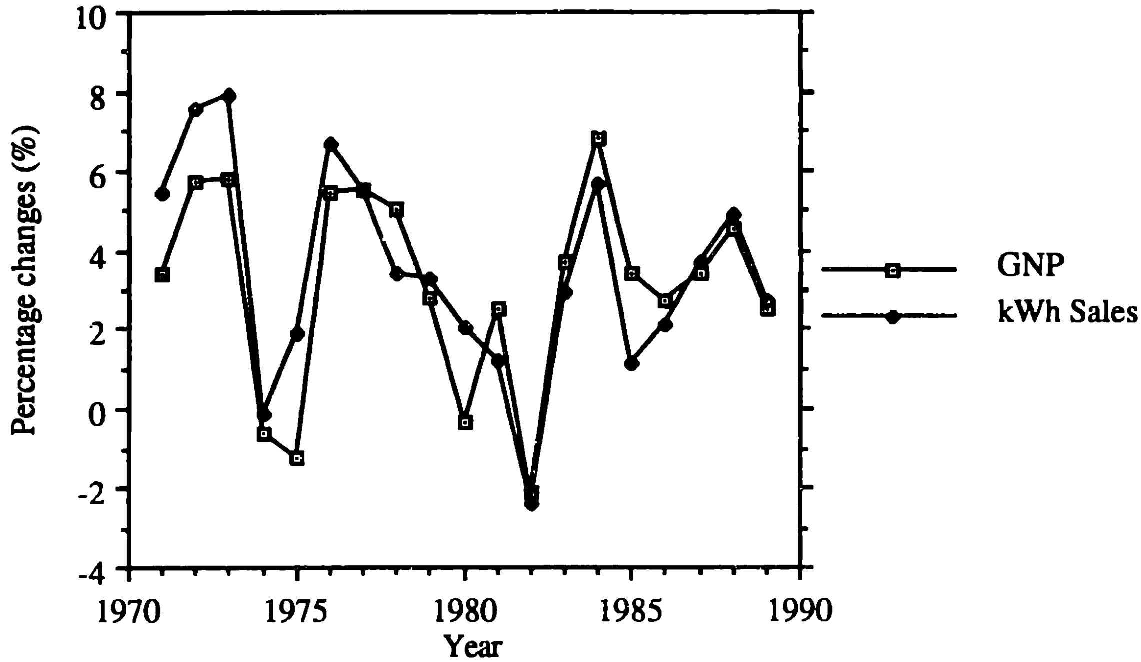


Figure 2-3
Percentage changes in peak load (kW)

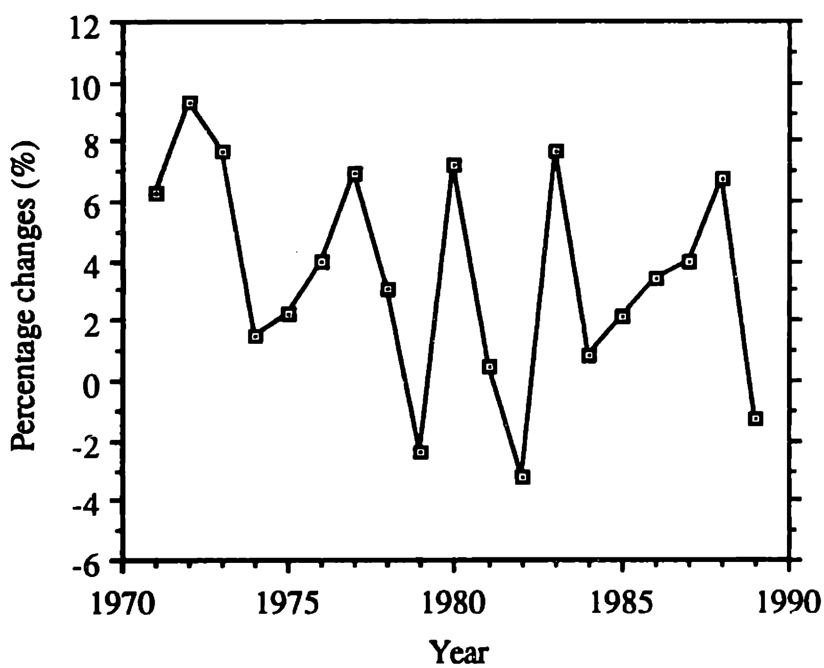
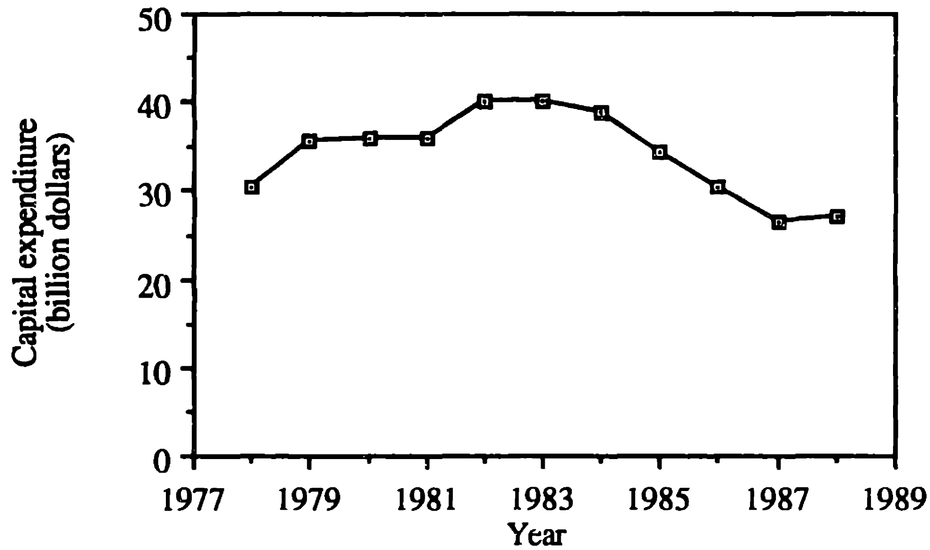


Figure 2-4
Electric utilities capital expenditures



Utilities that escape from regulation own QF or IPP business, which is not subject to the traditional cost-of-service regulation although utility ownership of QFs or IPPs is restricted by PURPA or PUHCA respectively. According to PURPA, a utility can invest in a QF if their share-holding proportion is less than 50%. According to PUHCA, a utility can invest in an IPP if the share-holding proportion of every shareholder is less than or equal to 10%, if the IPP is located within the state to which the utility service area belongs and within the franchise of other utilities, or if the IPP is run by partnership. Also, some utilities diversify their business activities into unregulated business areas by utilizing their real estates and financial capacity.

d. Profit incentives for new entrants by decoupling prices and costs

New entrants into generation wholesale markets as QFs or IPPs are given strong profit incentives by decoupling of prices and costs, because QF business itself is not subject to price, profit and cost-of-service regulation. This is also because IPP business is not included in rate bases of utilities and not subject to the traditional cost-of-service regulation. Prices for QF business are determined with reference to the "avoided cost" principle, that is the principle of opportunity cost or market price, whichever of the three typical contract processes: rigid standard offer contract approach; highly structured competitive bidding approach; and more flexible competitive negotiation approach. Thus, although QF and IPP businesses are risky in that they are not guaranteed to cover their costs, decoupling of prices and costs brings opportunities for them to earn large profit if they succeed in large cost reduction through their own efforts after contracts. If they are lazy enough to increase costs above the prices determined under contracts, they will lose money. Therefore, such profit incentives based on the principle of "work-and-you-will-be-rewarded" will attract entrepreneurs and improve total efficiency and social welfare.

Long term contract approach has improved incentives for those new entrants by reducing business risk because it guarantees a long term commitment of buying utilities, whereas risk will rather increase if long term contracts are so rigid that pre-determined prices are not adjusted flexibly in response to changes in outside conditions such as economic environments.

Incentives for those new entrants also have been improved because the potential of generation wholesale markets have been recognized since PURPA opened up the markets for entrepreneurial independent suppliers unencumbered by cost-of-service regulation.

e. Large potential of self-generations

Self-generations (or non-utility generators (NUGs)) held a much smaller portion of the total generating capacity in the U.S. than in other major developed countries (Table 2.1). In 1983, it was 2.4% in the U.S., while 9.6% in Japan, 16.1% in West Germany, 9.0% in France, and 5.7% in the U.K. Simple inference from these numbers can suggest that there was much room for the U.S. users to switch from utilities to sel-generation by building their own generating facilities in the early 1980's. Moreover, there may still now remain some room, because the number remained at 4.5% in 1988 (Figure 2-5).

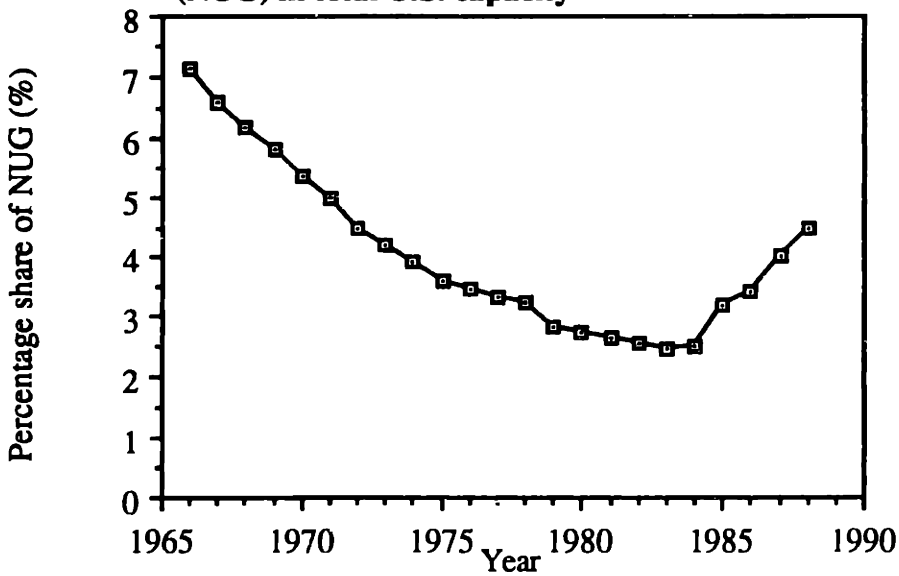
Table 2-1

Percentage share of self-generation (NUG) to total generation capacity

Year	U.S.	Japan	W. Germany	France	U.K.
1983	2.5 %	9.4 %	16.2 %	9.6 %	6.1 %
1987	4.0 %	8.9 %	14.1 %	7.5 %	5.8 %

Source: The Statistics of Overseas Electric Power Industries published by the Japan Electric Power Information Center, and the Electric Power Industry Manual published by the Japan Electric Association.

Figure 2-5
Percentage share of Non-Utility Generation (NUG) in total U.S. capacity



2-4 Essence of the U.S. experience

- If contracts are long term and if prices are decoupled with costs and pre-determined in favor of third party suppliers, unlimited obligation of purchase from third party suppliers may cause a rush on the business and lead to excess capacity for utilities. In addition, third party suppliers may crowd out economical plants of utilities even if the third party suppliers turned out later to be not economical.
- Fixed prices for purchase from third party suppliers may entrap the suppliers and utilities into rigid situation that prices fail to respond flexibly to environmental changes such as input price changes and to reflect reality, and that payment to the suppliers may be either too high or too low.
- "Avoided cost principle" is very difficult to put to practical use, although the principle is epoch-making and very meaningful in terms of introducing a sense of market prices, departing from average cost

pricing and creating profit incentives for third party suppliers who are not subject to cost-of-service regulation.

- Long-term contracts reduce business risk for third party suppliers because they guarantee a long term commitment of buying utilities, and they promote competitive markets by attracting more new entrants.

- Competitive bidding and competitive negotiation systems can fix shortcomings of "avoided cost principle" by introducing market mechanism, and by fixing capacity needs that utilities call for bid of, they can prevent excess capacity problems associated with unlimited purchase obligation .

- Even in competitive bidding and competitive negotiation systems, flexibility in pricing and non-price conditions to respond future changes in outside conditions are important in reducing business risk for both parties concerned.

- Although the electric power industry is not a contestable market, to keep utilities exposed to the threat of entry of third party suppliers into generation business, that is, to create competitive wholesale markets, may be helpful in pressing utilities to operate more efficiently, achieving more efficient equilibrium, and improving social welfare.

III. Current Situation in Japan

3-1 Industry structure

a. Integrated electric power companies

Only ten integrated electric power companies are allowed to serve each of ten franchised areas which cover the whole Japan (Table 3-1). They are all investor-owned. Nine of the ten serve four main islands of Japan and they were established in 1951 based on the restructuring plan after World War II. One serves a prefecture of southern small islands (Okinawa) and it was privatized in 1987. They are given exclusive rights and obligation in each franchised area to supply power. None except the ten electric power companies can retail power to general customers in Japan. Their power rates are regulated by and have to be approved by the Ministry of International Trade and Industry (MITI) based on the Electric Power Industry Act (EPIA) of 1964. The ten companies own 77% of the generating capacity including self-generation in Japan and generate 75% of the power (Table 3-2), while the rest is held by generation and wholesale companies, and self-generation.

Unlike the U.S., Japan has no electric power companies which have gas retail business, although they use a huge amount of natural gas for fuel of gas burning power plants. Gas retail business is done by about 250 private or municipal gas companies which are regulated by the Gas Industry Act of 1923 and are given an exclusive franchised area to supply gas.

Table 3-1

Japan integrated electric power companies in the fiscal year 1989

Name of companies	Electricity sale (Gwh)	[share] (%)	Capacity (Mw)	Revenue (billion $)	Number of customers (thousand)
Tokyo EPCo	204,452	33.3	43,338	29.2	22,066
Kansai EPCo	112,305	18.3	30,173	15.0	24,737
Chubu EPCo	93,668	15.3	21,375	12.4	20,359
Kyushu EPCo	51,013	8.3	13,300	7.8	6,720
Tohoku EPCo	49,769	8.1	10,058	7.5	6,181
Chugoku EPCo	39,498	6.4	9,219	5.7	4,437
Hokuriku EPCo	20,156	3.3	3,954	2.6	1,644
Hokkaido EPCo	19,245	3.1	4,876	3.3	3,111
Shikoku EPCo	18,749	3.1	5,423	2.8	2,413
Okinawa EPCo	4,443	0.7	902	0.7	594
Total	613,297	100.0	142,618	87.2	66,414

Source: Electric Power Industry Manual 1990 from Japan Electric Association.

Table 3-2

Sectors of Japan electric power industry in the fiscal year 1990

Sector	Capacity (MW) Hydro	Thermal	Nuclear	Total	[Share]	Generation (GWh)
Integrated utilities	26,593	89,527	26,497	142,618	76.6	593,490
Generation & wholesale	9,729	12,846	2,783	25,358	13.6	111,226
Self-generation	1,160	16,930	165	18,256	9.8	94,080
Total	37,483	119,304	29,445	186,231	100.0	798,756
[Share (%)]	20.1	64.1	15.8	100.0		

Source: Electric Power Industry Manual 1990 from Japan Electric Association.

b. Generation and wholesale companies

In addition to the ten integrated electric power companies, there are twenty two private companies and thirty four public corporations, which sell power wholesale to the above nine integrated electric power companies. There are two major private companies: the Electric Power Development Company (EPDC), which was jointly established as a corporation having a special status by the government and the nine integrated electric power companies in 1952 based on the Electric Power Development Promotion Act; and the Japan Atomic Power Company, which was jointly established by the nine integrated electric power companies and several electric equipment manufacturing companies in 1957 in accordance with government policy. Twenty private companies, most of which are joint businesses of integrated electric power companies and large industrial customers, jointly generate thermo-electric and hydro-electric power. All public corporations are owned and run by local governments, and they generate hydro-electric power.

c. Self-generation

Many industrial customers such as steel, chemical, cement, oil, and paper companies own generating capacity and generate power themselves. Although the proportion of self-generation for self-consumption in the total power consumption had decreased from 15.1% in 1971 to 9.6% in 1983, it recently has been gradually increasing since 1983 (Figure 3-1), and it reached 11.5% in 1990. The reasons are that large industrial customers have shifted from purchase of power to self-generation due to decline in energy prices, especially oil price, since mid-1980's (Figure 3-2), and that co-generations has recently been installed increasingly. Almost all large industrial customers broke the records of percentage share of self-generation in their own total power demand in 1990 for the first time in the last two decades (Figure 3-2).

In the long run up to the year 2000, self-generation for self-consumption is expected to grow at 1.6% annually, and its proportion will decline to 10.2%, because the Japanese economy is expected to structurally shift to a less electricity consuming economy, whereas cogeneration will diffuse much more.

Figure 3-1
Percentage share of self-generation in total Japan capacity and generation

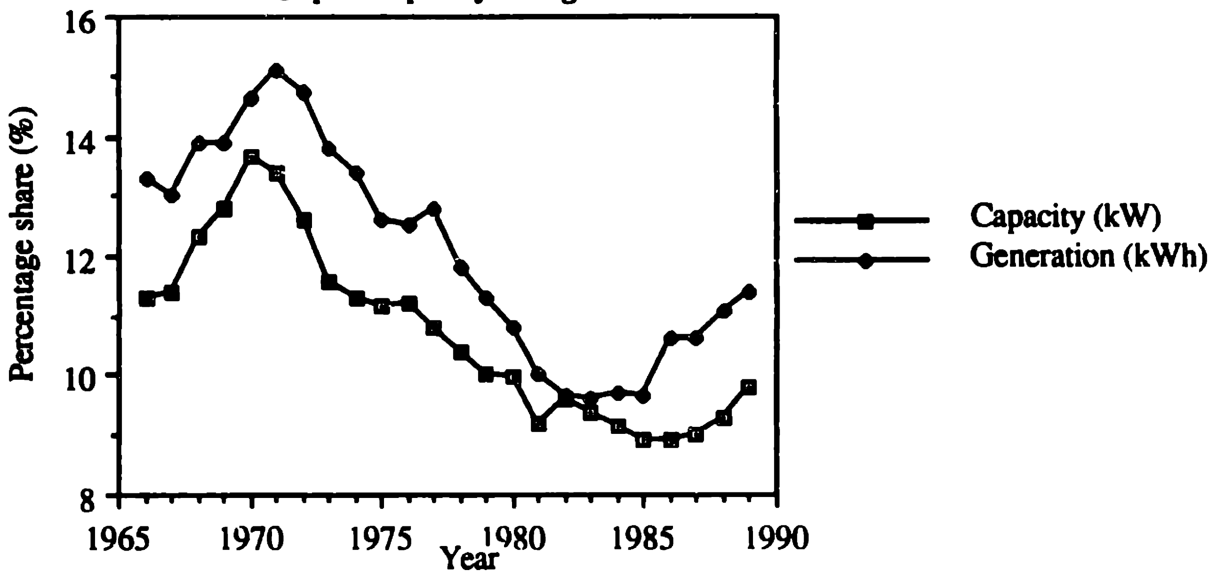
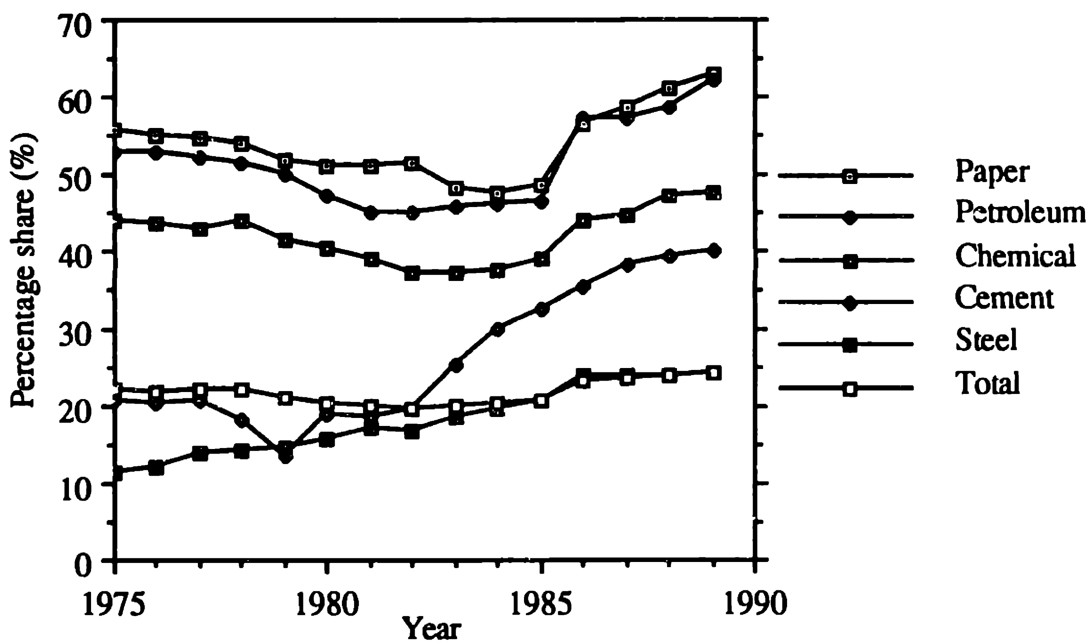


Figure 3-2
Percentage share of self-generation in total power demand of large industrial customers

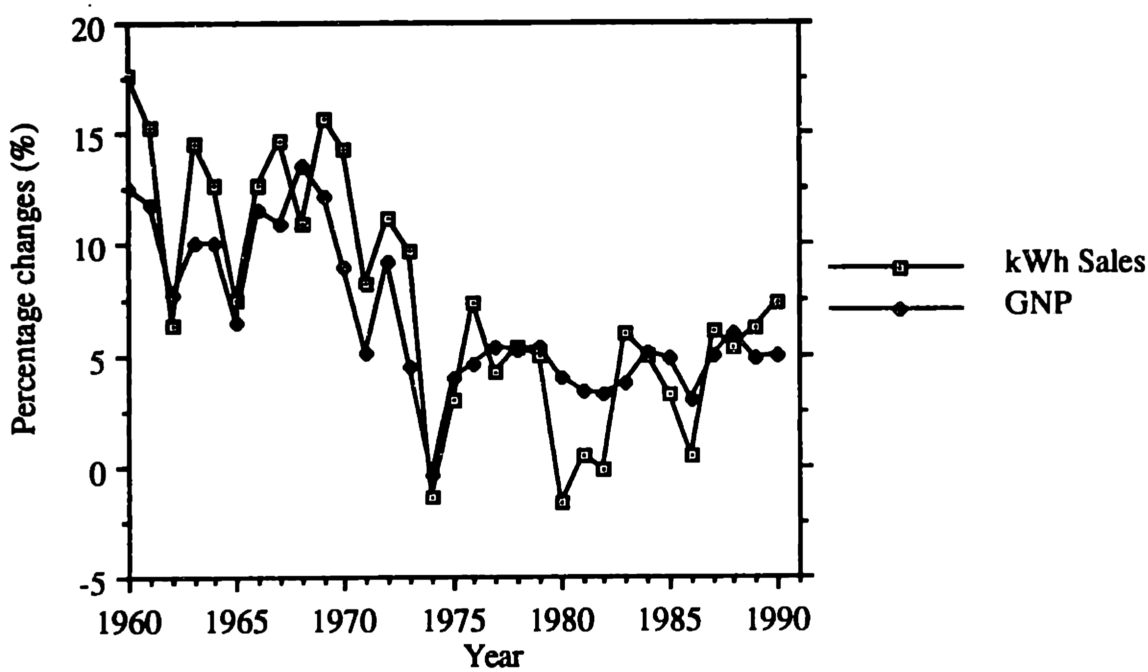


3-2 Demand

a. Electricity (kWh)

Demand has been increasing steadily and strongly (Figure 3-3). Electricity sale (not including self-generation) has increased by 3.2 % annually on the average from 1980 to 1990, and particularly, for the last 2 years, it increased very sharply, that is, 6.2% in 1989 and 7.6% in 1990. In the long run up to the year 2000, it is expected to increase by 2.8% annually on the average by the 1991 forecast of the Japan Electric Power Research Committee (EI).

Figure 3-3
Percentage changes in economic activities (GNP) and electricity sales (kWh)

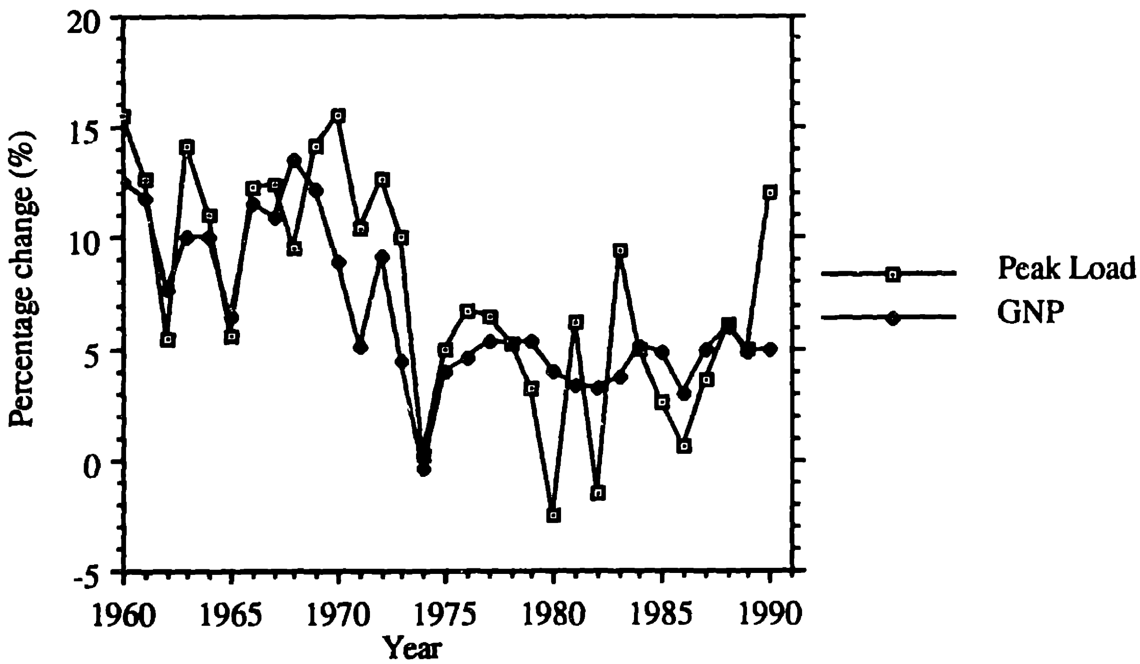


This growth rate is based on the forecast of steady growth of the Japanese economy. In the past, real GNP grew by 4.4% annually on the average from 1980 to 1990. Thus, GNP elasticity of demand for electricity (kWh) is 0.73, which is almost the same as the conventional number used in planning. According to several economic research institutes, real GNP is expected to grow steadily by around somewhat less than 4.0% annually in the future, which brings 2.8% of the growth rate of electricity sales.

b. Peak load (kW)

Peak load has been increasing more sharply (Figure 3-4). It has increased by 4.9% annually on the average from 1980 to 1990. In addition, the growth rate has come to more fluctuate depending upon the temperature, and in 1990, a heat wave brought 12.1% increase from 1989.

Figure 3-4
Percentage change in economic activities (GNP) and peak load (kW)



Even by the moderate forecast of EI's 1991 version based on the year 1989 with a normal summer, peak load is expected to increase by 3.1% and to reach 178,840 MW, which is 36,140 MW greater than 142,700 MW in 1990.

However, peak load might increase more sharply. Like GNP elasticity of demand for electricity (kWh), GNP elasticity of peak load (kW) is calculated to be 1.1, which is much higher than the conventional number used in planning. Under the steady economic growth, peak load might increase by around 4% annually greater than the above forecast of 3.1%.

In addition, peak load has come to be more fluctuating and uncertain. In general, electricity demand hits a peak in summer afternoon, particularly in late-August right after t[illegible] "Obon" vacation associated with the "Festival of Souls." Coinc[illegible]ly, a very popular national tournament of high school baseball teams is usually held in the same period, and people turn on TV to watch it, especially the final game, all over Japan. It pushes up the peak load. Among the main factors pushing up the peak load are business activities, diffusion of electric appliances, and air-conditioning. The first two factors bring a stable and structural increase in peak load, because they come from increase in production level and introduction of more electricity consuming equipments such as robots and factory automation devices. On the other hands, electricity consumption for air-conditioning is very sensitive to the temperature, and its share in the increase of peak load has become large, about 50% in 1990. For residential customers, there are many structural factors pushing up demand for air-conditioning: warming in urban areas due to waste heat; improvement of living standard; more diffusion of air-conditioners; and scale up and power up of air-conditioners, which more than cancel improvement in efficiency and energy conservation. For commercial customers, demand for air-conditioning grows greatly because of several factors: increase in total floor space for office use due to active investments in construction of office buildings; expansion of unit size of office; and diffusion of office automation devices such as computers.

Moreover, peak load tends to coincide on the hour level in most part of Japan, because such a clear sky that the temperature sours can easily cover most of the small country of Japan. Also, because everyone in Japan is back to work in late-August right after the nation-wide "Obon" vacation, peak load concentrates on only a several days.

Therefore, it has become much tougher to forecast peak load, and it needs more reserve margin at peak time than the present target of 8 to 10%.

3-3 Supply

As of March 31, 1991, Japan total generating capacity was 186,231 MW, of which about 90% is used for the electric power industry and about 10% is used for self-generation (Table 3-2).

Now, Japan is faced with great difficulty in increasing capacity to keep up with demand growth because peak load has been souring so rapidly. At the summer peak of 1990, reserve margin went down below 5%, which was the first time in the last 17 years (Figure 3-5). Tokyo Electric Power Company (TEPCO), the largest in Japan, which has been faced with upsurge of demand because of one point concentration of economic activities to Tokyo metropolitan area from all over Japan, has got through the tight situation of supply and demand by asking of air-conditioners, which more than cancel improvement in efficiency and energy conservation. For commercial customers, demand for air-conditioning grows greatly because of several factors: increase in total floor space for office use due to active investments in construction of office buildings; expansion of unit size of office; and diffusion of office automation devices such as computers.

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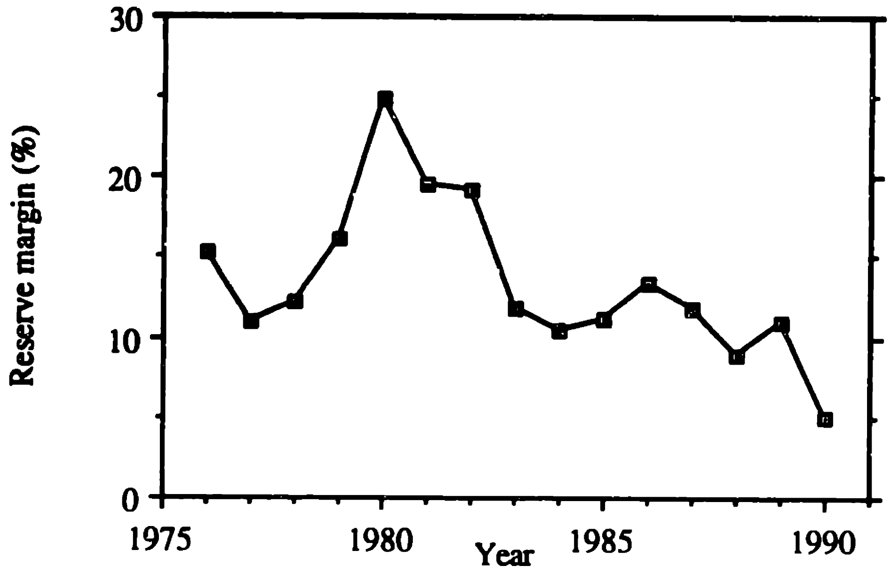
Figure 3-5
Reserve margin of capacity at peak load in Japan



other electric power companies to send power through the nation-wide coordination system with interregionally connected transmissions, asking large industrial customers to reduce demand, and stopping power supply to some large industrial customers based on special contracts with provisions of interruption of power supply. Chubu Electric Power Company, the third largest in Japan, experienced a scarce reserve margin of 2.3% last summer.

Several problems in power development are expected to delay the plan of capacity increase. Public ill-feeling and several opposition movements against nuclear power did and will bring a delay in nuclear power development, while nuclear power is considered to be the main source of capacity increase. Incidentally, in the last two years, two important and unbelievable accidents happened at nuclear power plants of the top two electric power companies. They have been considered to keep high safety levels. In addition, global trends in favor of environmental protection associated with clean air, acid rain and global warming throws a shadow over development of coal-burning power plants. According to the government plan of 1990 based on the 1989's results (the 1990 Interim Report submitted by the Demand and Supply Subcommittee of the Electric Power Industry Council, an advisory council to the minister of MITI, empowered by EPIA), the electric power industry needs 227,700 MW of generating capacity in the year 2000 (Table 3-3, Table 3-4), which needs an additional 62,880 MW compared to the capacity in 1989. Of the 62,880 MW, 21,300 MW (34%) is expected to be achieved by nuclear power, 28,480 MW (29%) by coal-burning, 17,240 MW (27%) by gas-burning, and 8,370 MW (13%) by hydro-power, while oil-burning decreases by 4,430 (7%). However, if considering rapid increase of peak load and several problems in development of nuclear and coal-burning power, the future supply capability can be acknowledged to be very uncertain.

Also, construction periods have been becoming longer, and there are not so many good sites for large-scale power plants left in the small, densely populated land of Japan. Particularly for nuclear power plants, the number of newly developed sites has been declining. Of the existing sixteen nuclear sites, one was approved by MITI in the 1950's, five in the 1960's, eight in the 1970's and only two in the 1980's. Recent increase in nuclear capacity is mainly achieved by adding new units to the existing nuclear sites. Moreover, newer plant locations have been becoming farther from markets, especially Tokyo metropolitan area.

Table 3-3

Long-term plan of generating capacity

Types of generation by fuel	1988		2000		2010	
	Capacity (MW)	Share (%)	Capacity (MW)	Share (%)	Capacity (MW)	Share (%)
Nuclear	28,700	17.4	50,000	22	72,000	27
Thermal						
Natural gas	33,060	20.1	50,300	22	53,000	20
Coal	11,120	6.7	29,600	13	40,000	15
Geothermal	180	0.1	1,000	0.4	3,500	1
Oil	55,630	33.8	51,200	22	40,200	15
Methanol	-	-	-	-	100	0.4
Sub-total	99,990	60.7	132,100	58	137,700	52
Hydro						
Conventional	19,130	11.6	21,500	9	25,000	9
Pumped storage	17,000	10.3	23,000	10	26,700	10
Sub-total	36,130	21.9	44,500	19	51,700	19
On-site small	-	-	1,100	0.5	5,700	2
Total	164,820	100	227,700	100	267,000	100

Source: 1990 Interim Report from the Demand and Supply Subcommittee of the Electric Power Industry Council. On-site small generating facilites include fuel cell, photovoltaics, wind power and the like.

Table 3-4

Long-term plan of generation

Types of generation by fuel	1988 Generation (GWh)	1988 Share (%)	2000 Generation (GWh)	2000 Share (%)	2010 Generation (GWh)	2010 Share (%)
Nuclear	177,600	26.6	329,000	35	473,000	43
Thermal						
Natural gas	141,400	21.2	188,000	20	201,000	18
Coal	63,600	9.5	156,000	16	163,000	15
Geothermal	1,100	0.2	6,000	1	21,000	2
Oil	194,400	29.2	163,000	17	105,000	10
Methanol	-	-	-	-	4,000	0.3
Sub-total	400,500	60.1	513,000	54	494,000	45
Hydro						
Conventional	80,100	12.0	85,000	9	99,000	9
Pumped storage	8,500	1.3	16,000	2	19,000	2
Sub-total	88,600	13.3	101,000	11	118,000	11
On-site small	-	-	3,000	0.3	25,000	2
Total	666,800	100	946,000	100	1,109,000	100

Source: 1990 Interim Report from the Demand and Supply Subcommittee of the Electric Power Industry Council. On-site small generating facilites include fuel cell, photovoltaics, wind power and the like.

Moreover, unanticipated accidents at nuclear power plants may result in serious shortage of supply capability at peak time. Because of the accident at the second unit of Mihama nuclear power plant of Kansai Electric Power Company (KEPCO), the second largest in Japan, on February 9, 1991, the operation of the unit has been stopped and under detailed investigation by both KEPCO and regulatory authorities. Coincidentally, the second unit of Takahama nuclear power plant of KEPCO has also been stopped and under the detailed investigation, because both units share the common design and parts at the point related to the accident. As a result, KEPCO is expected to lose 1,300 MW at peak time this summer. The same situation might recur and become more serious, because such common designs have well prevailed across electric power companies in Japan and there are basically only two types of nuclear power plants, BWR and PWR.

3-4 Retail prices

a. Regulation

Rate levels and rate structure for retail are regulated by MITI, a department of the national government, not by local governments, based on "cost-of-service" (or "rate of return") approach. Regulatory proceedings in Japan are almost the same as those in the U.S. in terms of rate filings and formal hearings. For price regulation, Japan has three principles: allowable cost-of-service; fair return; and equity across customers.

"Fair return" is calculated by multiplying "rate base" by "fair rate of return." Japan uses the depreciated original cost rate base which includes: book value of fixed assets for utility business; 50% of cost of construction in progress without interest expenses; book value of fixed assets of nuclear fuel; postponed assets; operating capital; and government-specified investments for R&D and resource development.

"Fair rate of return" is 8.00%, which has been the same since the introduction of the rate base approach in Japan in 1960. Assumptions behind this number are that debt equity ratio is 50 % (debt : equity = 50 : 50), and that effective rates of return for equity and debt are 8.5 % and 7.5 %, respectively. Although that number was sometimes argued to change in accordance with fluctuating interest rates, it has remained unchanged based on the following reasons: majority of finance is long-term; long-term stability of rate levels is desirable; and re-calculation under the recent situation yields almost the same number. However, it is reported by some news sources that "fair rate of return" was temporarily revised to be 7.2% at the rate decrease in 1988 although the official number is still 8%.

The nine integrated utilities independently filed rate changes over twenty years until the first oil shock in 1973, whereas they increased rates simultaneously in 1951, 1952 and 1954 just after the present industry structure was established in 1951. However, since the first oil shock, the nine integrated utilities have filed rate changes almost simultaneously (Table 3-5), because differences in revenue and cost structures across utilities have shrank. This is also because changes in economic conditions such as rapid appreciation of the yen, surge in oil price and high interest rates have come to affect utilities' performance in the same way.

Table 3-5

Past rate change

Year	1974	1976	1981	1986	1987 (Temporary)	1988 (Temporary)	1989
Change rate (%)	+ 57	+ 22	+ 51	+51	- 5	- 7	- 5 (-18)

Note: In 1987 and 1988, rate was temporarily changed to reflect rapid decline of input prices.

- 5 % in 1989 is compared to the rates just after the 1988 rate change.

- 18 % in 1989 is compared to the rates just after the 1986 rate change.

b. Rate levels

Average prices (yen/kWh) are shown in Table 3-6 for the whole Japan and in Table 3-7 for each electric power company, calculated by dividing revenue by energy sales.

Japan has internationally comparable rate (price) levels, if prices are compared properly. This result is inconsistent with the conventional wisdom that price levels in Japan are very high internationally. If prices are adjusted by foreign exchange rates for currency difference and are compared across countries, prices are higher in Japan than in other major advanced countries (Table 3-8). However, this foreign exchange rate approach is not reasonable because electricity is non-tradable service in case of Japan.

Table 3-6

Average price level by load categories in fiscal year 1989

	Load categories				
	Residential	Commercial	Small Industrial	Large Industrial	Total
Average price (yen/kWh)	24.8	23.4	21.0	13.2	17.2
(cent/kWh)	17.7	16.7	15.0	9.4	12.3

Note: Average revenue = (Revenue) / (Electricity sales) for each load category.

Currency difference is adjusted by the exchange rate of 140 yen/US dollar.

Table 3-7

Average price level by electric power companies in the fiscal year 1989

Electric power companies	Average price (yen/kWh)	Average price (cent/kWh)	Price index
Tokyo EPCo	19.3	13.8	100.7
Kansai EPCo	18.1	12.9	94.3
Chubu EPCo	17.9	12.8	93.1
Kyushu EPCo	20.7	14.8	107.6
Tohoku EPCo	20.4	14.6	106.1
Chugoku EPCo	19.6	14.0	102.0
Hokuriku EPCo	17.8	12.7	92.6
Hokkaido EPCo	23.1	16.5	120.5
Shikoku EPCo	20.5	14.6	106.6
Okinawa EPCo	21.8	15.6	113.4
Total	19.2	13.7	100.0

Note: Average revenue = (Revenue) / (Electricity sales) for each load category.

Currency difference is adjusted by the exchange rate of 140 yen/US dollar.

Price index is assumed to be 100 for the avearge price of total Japan.

Table 3-8

Average prices adjusted by foreign exchange rates in 1986

Country	Utility	Average price in local currency (per kWh)	Exchange rate	Average price in yen (yen/kWh)	Price index
U.S.	Commonwealth Edison	8.40 cent	169.55 yen/$	14.24	65
	Consolidated Edison	12.84 cent		21.77	99
	Pacific Gas & Electric	8.19 cent		13.89	63
U.K.	Engand Wales	4.64 peny	242.67 yen/pound	11.26	51
France	EDF	44.35 centimes	24.72 yen/Fr	10.96	50
West Germany	Total	18.52 pfenning	78.24 yen/DM	14.49	66
Korea	KEPCO	65.51 won	0.19 yen/won	12.45	57
Japan	Total	21.93 yen	-	21.93	100

Note: Average price is (Total revenue) / (Total electricity sales) for ecah utility.

Price index is assumed to be 100 for the average price of Japan.

Thus, to compare prices of electricity, a non-tradable service, two kinds of approaches are employed here: to compare prices which are adjusted by purchasing power for currency difference; and to compare amount of energy (kWh) that can be purchased with typical hourly wages in each local currency. These three approaches yield the same results that prices in Japan is comparable to those in other advanced countries (Table 3-9, 3-10).

Table 3-9

Average prices adjusted by purchasing power in 1986

Country	Utility	Model average price in local currency (per kWh)	Exchange rate	Average price in yen (yen/kWh)	Price index
U.S.	Commonwealth Edison	12.35 cent	223.0 yen/$	27.54	112
	Consolidated Edison	14.70 cent		32.78	134
U.K.	London Distribution	6.52 peny	391.2 yen/pound	25.51	104
France	EDF	78.79 centimes	29.8 yen/Fr	23.49	96
West Germany	Rhine West	27.91 pfenning	89.9 yen/DM	25.10	102
Japan	Tokyo EPCo	24.55 yen	-	24.55	100

Note: Model average prices are calculated for the model consumption that 250 kWh per year = 3,000 kWh per year is consumed.

Price index is assumed to be 100 for the average price of Japan.

Table 3-10

Average prices adjusted by power purchased by hourly wage in 1986

Country	Utility	Model average price in local currency (per kWh)	Hourly wage in local currency	Power purchased by hourly wage (kWh)	Price index
U.S.	Commonwealth Edison	12.35 cent	9.73 US$	79	84
	Consolidated Edison	14.70 cent		66	100
U.K.	London Distribution	6.52 peny	4.11 pound	63	105
France	EDF	78.79 centimes	33.28 Fr	42	157
West Germany	Rhine West	27.91 pfenning	16.80 DM	60	110
Japan	Tokyo EPCo	24.55 yen	1,713.88 yen	66	100

Note: Price index is assumed to be 100 for the average price of Japan.

c. Rate structure

Rate structure is basically a "two-part tariff," which consists of monthly connection fees and monthly usage charges. Rates vary according to service categories depending on voltage, power load and so on. To meet seasonal and time of day variations in demand, peak load pricing is applied to a small fraction of large customers who choose it and is planned to be applied more. "Demand-supply adjustment services" offer several special discount rate contracts with conditional interruption of power supply in case of tight demand-supply situations such as summer peak load.

Among special features in Japan's rate structures is an increasing block rate tariff for residential customers. This tariff was introduced just after the first oil shock in order to promote energy savings and to reflect increasing incremental costs of additional capacity mainly because of high inflation rate. The tariff has three levels: cheapest rate for the first 120 kW, which is considered to cover the civil minimum; an moderate rate, 40% above the first level, for the next 130 kW; and high rate, 10% above the second level, for usage over 250 kW. This rate difference has been reduced recently.

d. Cross-subsidization

Cross-subsidization across power-load categories such as residential, low voltage, high voltage, and extra high voltage services does not seem to exist. This is because the principle of "equity across customers" in price regulation is reflected in setting price levels, as shown in the fact that price differences across those load categories seem to be reasonable (Table 3-6). It is generally acknowledged that fair allocation of common fixed costs of generation and transmission is achieved by the following formula:

Allocation ratio = [2 * (Peak load ratio in yearly peak load day)
+ (Year-around energy consumption ratio)
+ 0.5 * (Peak load ratio at summer peak load hour)
+ 0.5 * (Peak load ratio at winter peak load hour)] / 4

However, it can be argued that residential and commercial customers are subsidized by industrial customers and enjoy lower rates than they would in case of subsidy-free pricing. This is because air-conditioning demands of residential and commercial customers play a leading role in pushing up a summer peak from a base load, and because a large portion of common fixed cost of generation and transmission is attributable to a summer peak load. Marginal cost is much higher around a peak load level than around a base load level. Fully distributed costs for residential and commercial customers might be somewhat higher than those calculated under the above formula.

Also, cross-subsidization across geographical markets, for example between urban and rural customers, seems to exist. Under the current rate structure, there is no difference in prices across geographical markets, although the nine electric power companies cover very wide franchises including both metropolitan and rural areas. However, because economies of scale in distribution networks can be exploited more in high demand density areas such as large cities than in low demand density areas, it is very likely that urban customers are subsidized by rural customers and enjoy lower rates than they would in case of subsidy-free pricing. Whereas this cross-subsidization is justified by the concept of social equity in the political context of income distribution, it may come to be an issue of "cream-skimming" when deregulation allows small new entrants at the same time that regulation is still maintained for incumbent utilities to be obliged to assume universality of supply. However, this may not be the case for central business and commercial districts in Tokyo where TEPCO is investing heavily in very costly underground substations and distribution networks.

3-5 Performances of electric power companies

a. Financial performances

Figure 3-6, 3-7 and 3-8 show rate of return on equity (ROE), debt equity ratio and earned rate of return on rate base of Tokyo Electric Power Company (TEPCO). In terms of rate of return on equity, since the 1950's, TEPCO's performance has greatly improved, and has been stable and moderately good for the last decade except the two years of oil shocks. Its rate of return on equity is comparable to the average of Japanese firms (Figure 3-9). At the same time, however, debt equity ratio has also increased greatly since the 1950's, and utility business has become highly leveraged by debt and has increased potential volatility in earnings. Debt equity ratio reached 86.9%, which was far more than 50% assumed in determining "fair rate of return." This is in part why rate of return equity has improved so much.

Figure 3-6 Rate of return on equity (ROE) in Tokyo EPCo

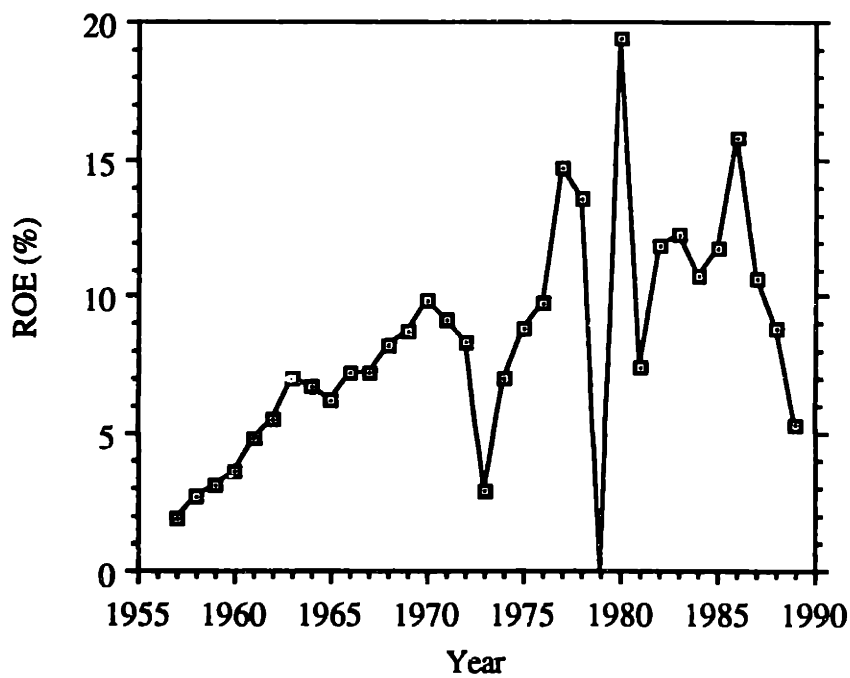


Figure 3-7 Debt equity ratio in Tokyo EPCo

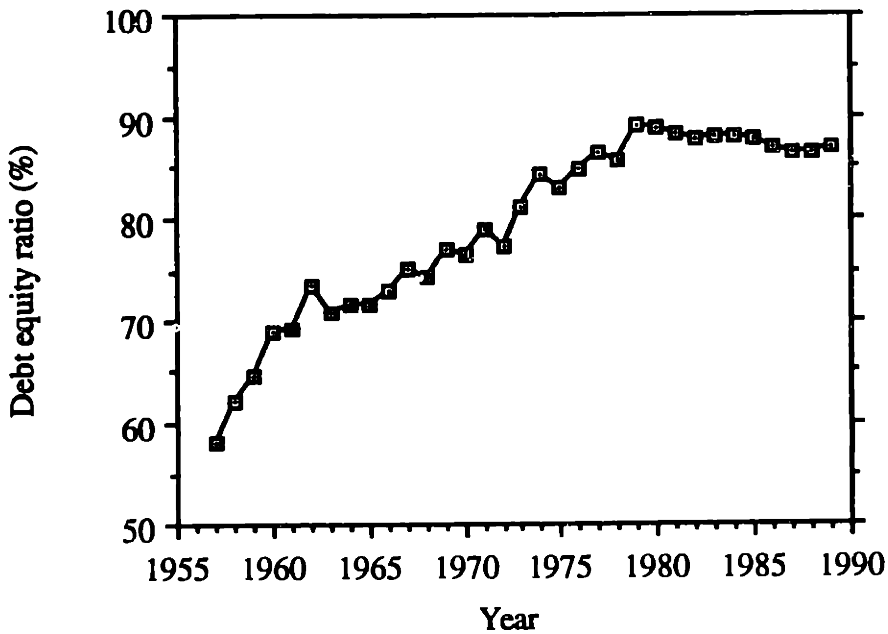


Figure 3-8 Earned rate of return on rate base in Tokyo EPCo

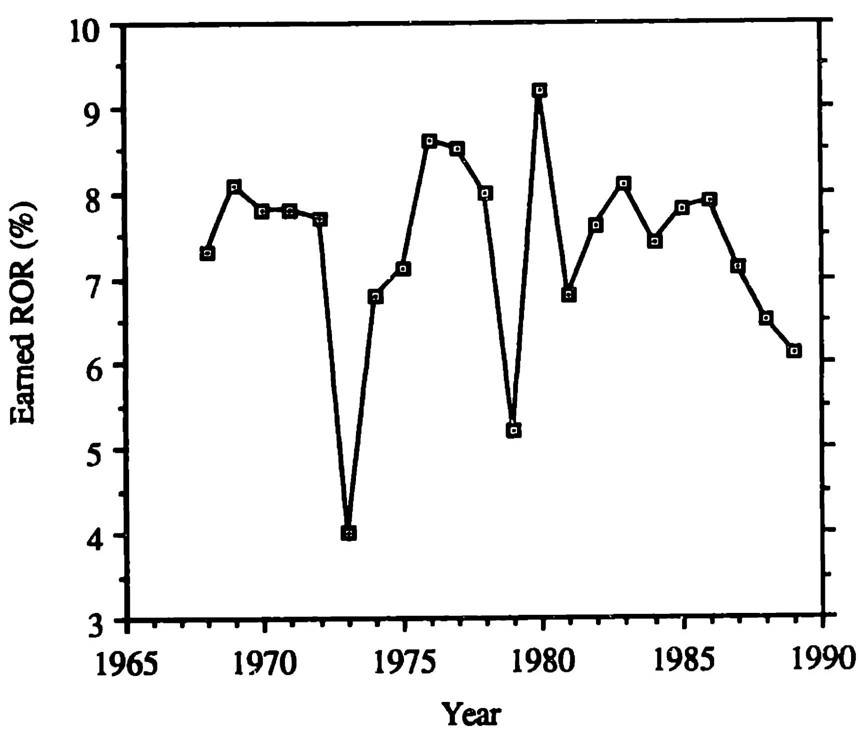
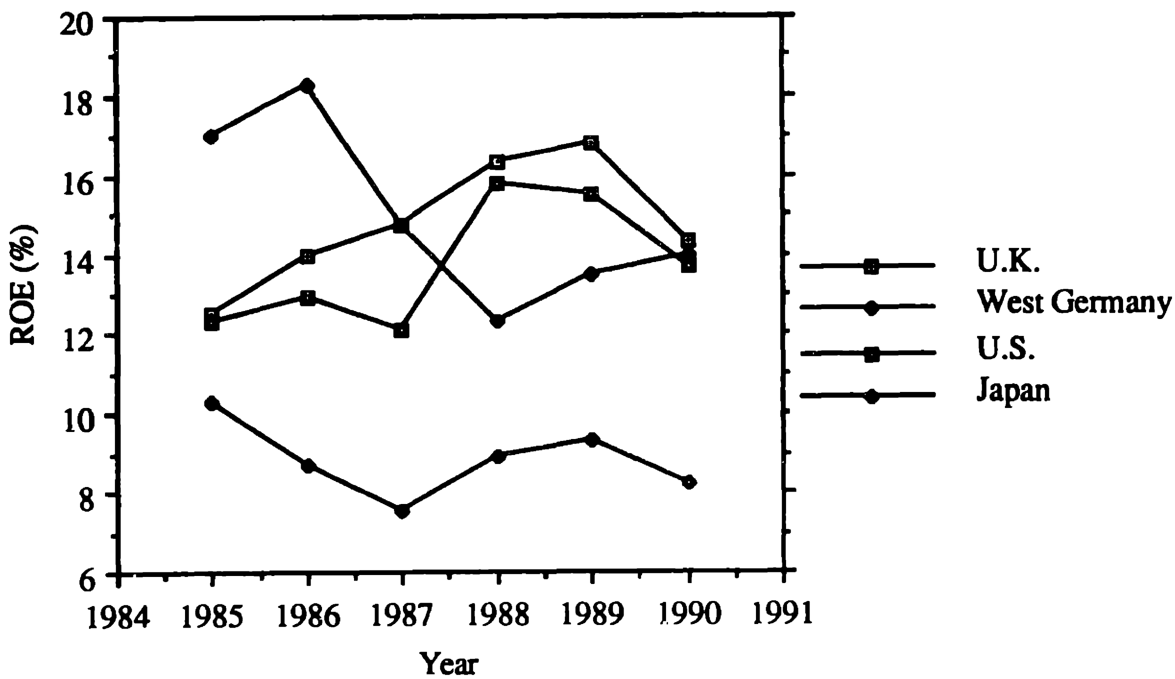


Figure 3-9 Rate of return on equity (ROE) in major countries



Earned rate of return on rate base has been stable around 8%, i.e. the allowed "fair rate of return" in cost-of-service regulation, for the last two decades except the two years of oil shocks and except the last two years. This fact indicates that unlike the U.S., Japan experienced no serious regulatory lag in rate makings. This indication is also supported by the timeliness of the past rate changes (Table 3-5).

However, rate of return on rate base has been declining since 1987 and reached 6.1% in 1989. It does not seem to be reasonable to think that the decline is coming from efficiency loss in production of the electric power company. Rather, the decline seems to have happened partly because the current allowed "fair rate of return" seems to have been reduced to 7.2%, which is 10% less than the official number of 8%, and partly because the yen is less appreciated than and oil price is higher than assumed in the current rate makings. Foreign exchange rate of the yen is around 140 yen per dollars whereas 124 yen per dollars in the assumption. Oil price is around 20 dollars per barrel whereas 16.5 dollars per barrel in the assumption. Since the mid-1980's, electricity prices have gradually been reduced, reflecting drop in imported input prices due to decline in oil price and appreciation of the yen, but the decrease seems to have been too much to cover costs.

b. Technical performances

Japan have maintained much higher quality of power supply than other major advanced countries. Table 3-11 shows time of failure of power supply per customer per year. Japan shows an outstanding record. On the other hand, it can be argued that the quality of power supply in Japan seems to be too high and that it is one of the reasons for high electricity prices in Japan.

Table 3-11

Minutes (time) of power failures per customer per year

Year	1982	1983	1984	1985	1986
U.S.	92	76	73	-	-
U.K	400	356	288	274	260
Farnce	70	89	54	67	71
Japan	37	25	15	39	10

3-6 Capital investment and capital cost

Capital investment of the electric power industry plays an important role in the Japanese economy. The nine integrated electric power companies are expected to spend 4 trillion yen (30 billion dollars) in 1991, and its proportion of the total capital expenditure of the private sector in Japan is 6%. About one third of the amount will be spent on generating facilities, another one third on transmission and distribution systems, and the remaining one third on improvements of old facilities. According to requests from the government, major electric power companies sometimes move up its capital expenditure ahead of schedule in order to stimulate the Japanese economy as a help for government fiscal policy.

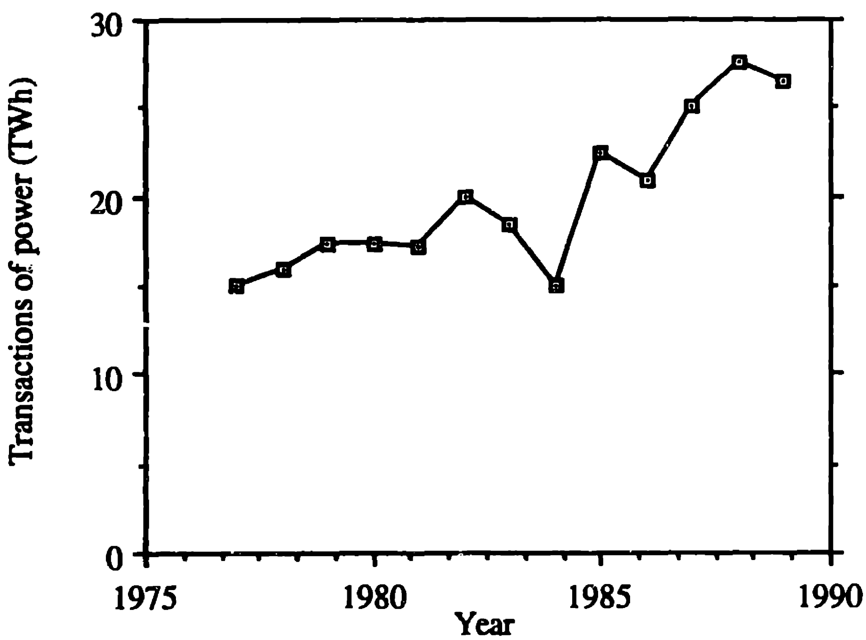
Capital cost is increasing because capital investments remain large and because interest rates have increased greatly since 1990 when the 5 year period of super low interest rates ended. Most of capital investments are financed by debt. The average debt-equity ratio of the nine electric power companies was 83%, which was much higher than 40%, the average of the Japanese private sector, and 30%, the average of all manufacturing industries in 1990. Outstanding debt of the nine companies was 22 trillion yen (160 billion dollars), and interest payment was 1.5 trillion yen (11 billion dollars) in 1990.

However, Japanese electric power companies still hold advantage in getting finance because they keep good credit-worthiness. TEPCO is assigned AAA for corporate bond by Standard & Poor's, a U.S. credit-rating company, since 1990. There are only 5 other Japanese companies (NT&T, Toyota, Matsushita, Hitachi, and Mitsubishi Real Estate) given AAA.

3-7 Power pool and coordination transactions

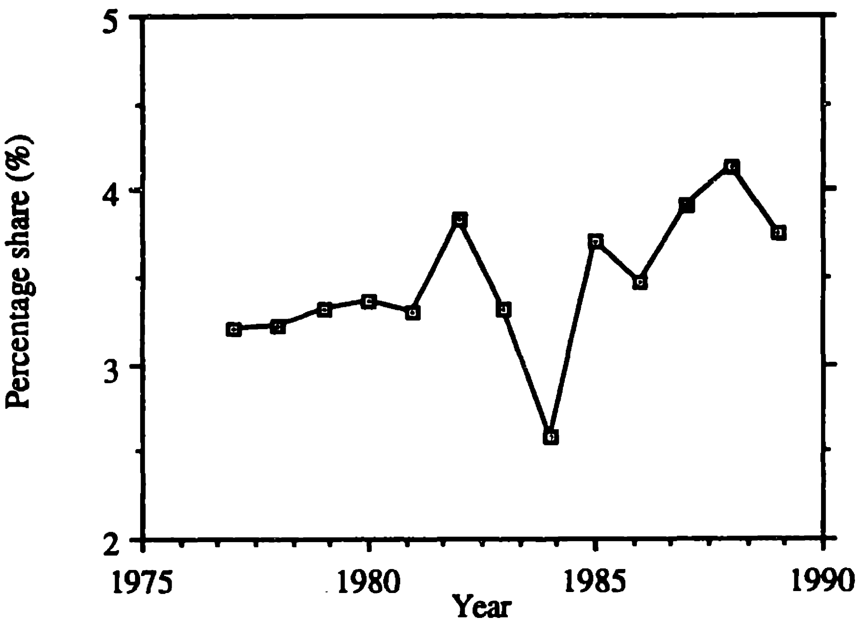
Coordination transactions of power through the nation-wide power pool and coordination system with interregionally connected transmission networks has been increasing at a rate of 6% on the average for 5 years. Its total volume of coordination transactions was about 30,000 GWh in 1990, about 5% of the total generation of the electric power industry (Figure 3-10, Figure 3-11).

Figure 3-10
Coordination transactions of power among the Japan nine EPCos.



In order to improve the power pool and coordination system and to cover difficulties that each company is faced with in increasing its own generating capacity, various capital investments are planned. Computer system at the Central Load Dispatching Liaison Office will be improved, and capacity of frequency converter stations which link the 50-Hz system of eastern Japan and the 60-Hz system of western Japan will be increased.

Figure 3-11
Percentage share of coordination transactions of power in total Japan generation



To create incentives for electric power companies with sufficient capacity to sell power through the coordination system, rate level and structure for coordination transactions have been improved by MITI. Rates for coordination transactions covering emergencies are a fuel cost plus an extra amount. The fuel cost was 5 to 9 yen/kWh (4 to 7 cents) on the average in 1990. The extra amount was 1.9 or 3.8 yen/kWh before, depending on emergency level. This extra amount has been increased by 50%, and one more level of emergency has been added.

However, the coordination has not yet reached such a situation that power plants are planned on the premise of freer nation-wide power exchange over the power pool. Such a situation may accelerate the trend that power plants are located farther away from markets. Some analysis concludes that transmission cost will exceed generating cost if transmission distance exceeds about 600 Km (400 miles).

3-8. Independent cogeneration

Cogeneration is a system that generates power by a heat engine and at the same time utilizes exhausted heat. As a heat engine, a diesel engine, a gas engine and a gas turbine, or a fuel cell is used. The remaining heat exhausted after generation is utilized to meet demand of heating, air-conditioning, hot water, and steam used in manufacturing process. Cogeneration can achieve high energy efficiency above 70% when power load is well balanced with heat load, while energy efficiency of conventional thermal power plants is around 40%.

Cogeneration has developed generally for self-generation of large industrial users in Japan. Cogeneration for commercial operation of electric power companies has not developed so far in Japan, because exhaust heat is very difficult to utilize or to send to customers in the conventional large-scale power supply systems of electric power companies which locate power plants far away from markets.

Recently, thanks to technological developments and a decline in oil and gas prices, cogeneration has increased rapidly to pursue low cost energy among not only industrial users but also commercial users such as hotels and hospitals (Figure 3-12, Figure 3-13). Particularly, scope of business of commercial cogeneration users is expanding and including office building, local area supply of heat and so on.

Figure 3-12
Total capacity of cogeneration under operation

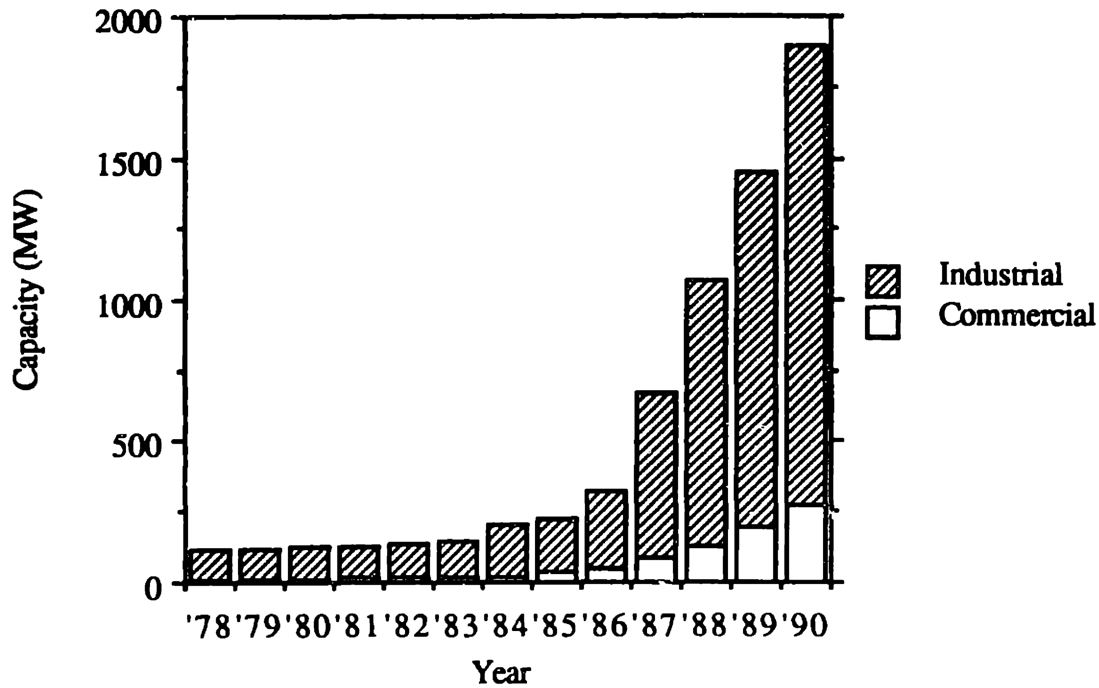
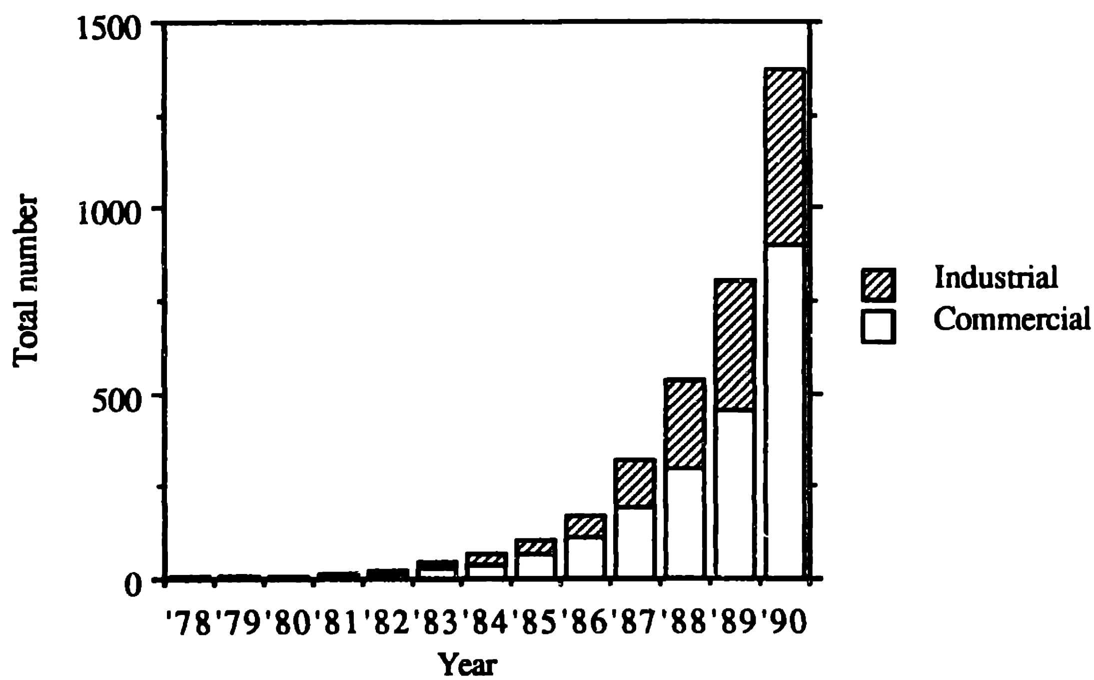


Figure 3-13
Total number of cogeneration under operation



Some large industrial users of cogeneration (it might be better to call them self-generations rather than cogeneration) wholesale their excess power to electric power companies based on long-term contracts, as are they in the U.S. However, such contracts are limited to large scale cogenerators that supply good quality of electricity with high reliability. These contracts and prices are not regulated and are made through negotiations between interested companies. Since electric power companies have no legal or regulatory instructional obligation to buy such power from cogenerators and because they maintain discretion to buy it, they exercise a large monopsony power.

No industrial users of cogeneration have ever retailed power to general customer, although there is some room allowed in the Electric Power Industry Act for companies other than electric power companies to do retail business.

No commercial users of cogeneration have ever wholesaled electricity to electric power companies, because electric power companies have no obligation to buy it. Electricity from small cogeneration of commercial users is perceived to be low quality and to bring fluctuation of voltage if connected to integrated power supply networks. Moreover, reliability of supply is considered to be too low to be counted on as an additional capacity. Cogenerators are not allowed even to flow electricity into integrated power supply networks, and when they are connected to the networks, some preventive equipments are required, for which guideline was provided by government in 1986.

A few commercial users of cogeneration have been allowed to retail electricity to those final customers who have some special relation with the suppliers. Such retail business has been strictly regulated and limited to special relationship between suppliers and customers. However, it has been a little deregulated since 1987. Also, backup power service for cogenerators doing retail business has been provided by electric power companies since 1986, whereas backup power service for customers of such cogenerators are not yet allowed.

3-9. Independent small power production facilities

Garbage burning power plants are the only recognizable independent small power production facilities in Japan. Almost all of them are owned and operated by local governments. They wholesale electricity to electric power companies along with individual contracts with prices based on fuel costs for thermal power plants of electric power companies. Because of exclusive franchise of electric power companies and locality of garbage burning power plants, electric power companies exercise a monopsony power. The average price is around 5 yen (3.7 cents).

However, in order to comply with the national energy policy to improve the total efficiency of national energy use, electric power companies are considering to change their pricing rule for those plants that can provide a stable and reliable supply in the long term. Some portion of fixed costs of those plants will be added in new prices, which are expected to be around 9 yen (6.7 cents).

3-10. National energy policy direction

The first priority of the national energy strategy is to assure stable supply of energy, that is, national energy security, according to the report submitted in 1989 by the Comprehensive Energy Survey

Council, an advisory council to the minister of MITI. The second priority is to solve global environmental problems, particularly the global warming.

However, this national energy strategy seems to be a lame duck, that is, a supply-side strategy rather than a comprehensive strategy. There are no strategies about the future prices and costs of energy. There is no description about what the future prices of oil and electricity will be in the year 2000. Demand is simply expected to grow steadily along the extrapolation line based on the current situation under such assumption that there are neither structural changes nor strategical control of demand. Only one exception is that target is set for energy savings with no effects on the standard of living in the future. In short, demand is treated as given in this national energy strategy. Thus, this strategy is mostly supply-side strategy. The major concern is how to secure supply capability simply to meet the future demand. There is no argument about dynamics of supply and demand with consideration of prices. As a whole, the Japanese national energy strategy is to secure whatever they want when they enjoy the current standard of living and improve it steadily at the current pace.

Among the major practical policies to achieve this supply-side strategy are to pursue the maximum efficiency of energy use and energy savings, and to pursue the diversification of energy sources of nuclear, natural gas, coal, oil, hydroelectric, geothermal, and new energy alternatives such as photovoltaics, wind and fuel cell.

The corresponding policies for the electric power industry is considered to be to secure supply capability to meet the future demand, to pursue the diversification of generation fuels by increasing nuclear capacity, and to gradually introduce on-site generating facilities such as fuel cells, conventional cogeneration, and new generating technologies using photovoltaics and wind. The total capacity of on-site generating facilities is planned to reach 1100 MW (0.5% of the total generating capacity) in the year 2000 and 5700 MW (2.1% of the total generating capacity) in 2010.

Therefore, an expected regulatory direction is to maintain the present scale-economy-driven structure of the industry in order to secure a huge increase in supply capacity to deal with a rapidly growing peak load, and at the same time, to deregulate cogeneration gradually and carefully with no effects on the plan of securing future supply capacity in order to improve energy efficiency. Thus, deregulation should not cause any serious deterioration of business performance of electric power companies, which are a key player in securing the future capacity.

IV. Independent cogeneration in Japan

4-1 Recent diffusion

a. Commercial users

Both the number and capacity of cogeneration for commercial users have been rapidly increasing since 1985 (Figure 3-12, 3-13), and 616 plants with 275 MW was under operation as of March 31, 1991 (Table 4.1). The average plant capacity installed each year was 400 KW in 1985, 300 KW in 1986, 410 KW in 1987, 410 KW in 1988, 430 KW in 1989, and 500 kW in 1990.

Among cogeneration technologies, diesel engine holds the first place for commercial users. Diesel engine (DE) accounts for 54% in number and 63% in capacity, gas engine (GE) is 44% and 27%, and gas turbine (GT) is 2% and 10%, respectively. The average plant capacity is 1900 KW for gas turbine, 520 KW for diesel engine, and 280 KW for gas engine.

The reason for the popularity of diesel engine is that low heat-power ratio of diesel engine matches well with most commercial users' demand, which is low heat-power ratio (Table 4.3), whereas diesel engine has many disadvantages such as heavy weight, high level of noise and vibration, and high level of NOx and smuts concentrations in exhaust. Heat-power ratio for diesel engine is around 1.0, much lower than that for other technologies (Table 4.4), because of high efficiency of generation.

Table 4-1

Installed cogeneration by commercial users

Fiscal year	Gas turbine #	Gas turbine Capacity (kW)	Gas engine #	Gas engine Capacity (kW)	Diesel engine #	Diesel engine Capacity (kW)	Total #	Total Capacity (kW)
1974					1	300	1	300
1978					1	12,400	1	12,400
1980					1	96	1	96
1981			2	328	2	1,440	4	1,768
1982			3	1,089			3	1,089
1983	4	3,280	10	785	2	1,696	16	5,761
1984	1	800	6	413	2	790	9	2,003
1985			19	7,392	14	5,790	33	13,182
1986	1	3,000	28	2,591	16	7,947	45	13,538
1987			29	10,598	51	21,939	80	32,537
1988	4	3,400	34	9,642	68	30,700.5	106	43,742.5
1989	1	3,920	70	23,500	81	38,529	152	65,949
1990	3	11,880	67	18,619.6	95	52,341	165	82,840.6
Total	14	26,280	268	74,957.6	334	173,968.5	616	275,206.1
	(2%)	(10%)	(44%)	(27%)	(54%)	(63%)	(100%)	(100%)

Source: Survey by the Japan Cogeneration Research Society

Table 4-2

Installed cogeneration by industrial users

Fiscal year	Gas turbine #	Gas turbine Capacity (kW)	Gas engine #	Gas engine Capacity (kW)	Diesel engine #	Diesel engine Capacity (kW)	Total #	Total Capacity (kW)
1970					1	60,500	1	60,500
1971					1	11,000	1	11,000
1975	1	25,000					1	25,000
1977					1	10,000	1	10,000
1980	1	7,700					1	7,700
1981	1	1,200	2	160	1	600	4	1,960
1982			3	225	1	2,600	4	2,825
1983	1	1,500	8	1,312			9	2,812
1984	3	51,300	5	288.5	2	7,950	10	59,538.5
1985	1	1,000			2	1,300	3	2,300
1986	7	77,300	10	7,016	5	4,956	22	89,272
1987	11	165,305	13	9,247	46	135,742	70	310,321
1988	21	125,780	24	13,469	67	217,545	112	356,794
1989	23	107,820	27	16,844	63	190,067	113	314,731
1990	28	184,080	18	5,993	74	175,572	120	365,645
Total	98	747,985	110	54,581.5	264	817,832	472	1,620,398.5
	(21%)	(46%)	(23%)	(3%)	(56%)	(51%)	(100%)	(100%)

Source: Survey by the Japan Cogeneration Research Society

Table 4-3

Ratio of heat demand to power demand at different users

Commercial users		Industrial users	
Users	Heat-power ratio	Users	Heat-power ratio
Hotel	1.5 - 2.5	Chemical	3.1
Hospital	2.5 - 3.0	Pulp, paper	4.4
Office	0.4 - 0.9	Textile	2.3
Department store	0.3 - 0.7	Lumber, wood-work	5.2
Supermarket	0.1 - 0.5	Rubber	2.4
Restraunt	2.0 - 2.5	Furniture, ornaments	1.1
Gymnasium	2.0 - 2.5	Steel	0.8
Wedding celebration hall	1.7 - 1.8	Printing, publication	0.3
Building of many offices	0.3 - 1.4	Machine	0.2
Building of many shops	0.4 - 1.5	Non-ferrous metals	0.1

Source: The Statistics of Petroleum Products Consumption Structure by the Ministry of International Trade and Industry. Heat-power ratio is an annual average ratio of heat demand to power demand. 860 kcal = 1 kWh.

Heat-power ratio = (annual fuel consumption) / (annual power consumption).

Table 4-4

Heat-power ratio of cogeneration for planning

Types of cogeneration	Heat-power ratio	
	Capacity < 150 kW	150 kW < Capacity < 2,000 kW
Diesel engine	1.1	1.1
Gas turbine	_	1.7 - 2.5
Gas engine	1.6	1.6

Source: Cogeneration Planning Manual by the Japan Cogeneration Research Society.

Heat-power ratio = [Collectable heat capacity (Mcal / h)] / { 0.86 * [Generating capacity (kWh / h)]}

b. Industrial users

Both the number and capacity of cogeneration for industrial users have been rapidly increasing since 1987 (Figure 3-12, Figure 3-13), and 472 plants with 1,620 MW was under operation as of March 31, 1991(Table 4-2). The average plant capacity installed each year was 4,100 KW in 1986, 4,400 KW in 1987, 3,200 KW in 1988, 2,800 KW in 1989, and 3,000 kW in 1990.

Among cogeneration technologies, diesel engine and gas turbine account for a large fraction. It is distinctive that gas turbine takes a large fraction for industrial users. Diesel engine (DE) accounts for 56% in number and 51% in capacity, gas turbine (GT) is 21% and 46%, and gas engine (GE) is 23% and 3%, respectively. The average plant capacity is 7600 KW for gas turbine (GT), 3100 KW for diesel engine (DE), and 500 KW for gas engine (GE).

The reason for the popularity of diesel engine is the same as for commercial users, whereas there are more industrial users with high heat-power ratio than commercial users (Table 4.3).

The reason for the popularity of gas turbine is that gas turbine can collect 100% heat as a form of high pressurized steam, which most industrial users use as process steam in factories, and which is more convenient than hot water in transporting heat to various places in a large factory. Also, level of NOx and SOx concentrations in exhaust is much lower in gas turbine than in diesel engine and gas engine. Moreover, gas turbine is easier to connect to an integrated power supply system and to operate in parallel with the integrated system.

4-2 Regulatory regime and its evolution

Cogeneration are regulated by various kinds of laws: Electric Power Industry Act; Heat Supply Industry Act; Gas Industry Act; Fire Service Act; Building Standards Act; High Pressure Gas Regulation Act; Self-generation Qualification System; various labor regulations; and various environmental regulations on air pollution, water pollution, noise, and vibration.

Under the leadership of the Natural Resources and Energy Agency affiliated to the Ministry of International Trade and Industry, various deregulations and new regulations have been introduced since 1986 (Table 4.5).

Table 4-5

Evolution of deregulation to accommodate cogeneration

Mar.	1984	Tax incentives for cogeneration such as investment credits and acceleration of depreciation were introduced.
Aug.	1986	Guideline for connecting cogeneration to integrated power supply systems was established.
Apr.	1987	The Fire Services Act was deregulated.
Nov.	1987	Backup power service for cogeneration was introduced.
Feb.	1988	Emission standards for soot and smoke from fixed heat engine was established.
Apr.	1988	Financing of the Japan Development Bank was expanded and allowed to cogeneration.
May	1988	Legal requirement of chief electric engineers was deregulated.
May	1988	Legal requirement of periodical inspections was deregulated for small gas turbine generating facilities.
Aug.	1988	Calculation formula for self-generation capacity for fire-fighting purposes was
Nov.	1988	Specified retail service of power within a building was deregulated.
Dec.	1988	Emission standards for NOx from fixed heat engine was established by several local governments such as Tokyo.
Apr.	1989	Guideline for installing cogeneration in buildings was established. revised.
Jun.	1990	Guideline for connecting direct current generating facilities such as fuel cell and photovotaics to high voltage transmission networks was established.
Apr.	1990	Safety standards for new energies by the Electric Power Industry Act was deregulated.

4-3 Tax incentives

A new tax system in favor of cogeneration has been introduced since 1984, which offers selection out of two options: investment credit and special accelerated depreciation. These are very similar to the tax incentives established for promotion of QF business in the U.S.

Investment credit is a reduction in income tax liability granted to firms that buy new equipment of cogeneration. This item is a credit, in that it is deducted from the tax bill, not from pretax income. The tax credit is 7% of the purchase price of the corresponding assets purchased.

Special accelerated depreciation is an increase of upfront depreciation cost. In addition to ordinary depreciation costs, 30% of the purchase price of the corresponding assets purchased is allowed to enter the first-year depreciation cost ahead of the ordinary schedule. This will decrease the first year pretax income and increase the later year pretax incomes.

4-4 Current regulatory issues

a. Power influx from cogeneration into integrated power supply system

If excess power from cogeneration is allowed to flow into the integrated power system of electric power companies, cogeneration will achieve more efficient design and lower costs. Cogeneration always produces power and heat simultaneously, because it generates power by a heat engine which needs high-temperature gas and utilizes exhaust heat from the heat engine for heat demand which is generally low temperature. Thus, if any fraction of power generated by cogeneration is allowed to flow into the integrated power supply system of electric power companies, cogeneration systems can be designed and operated simply to match with heat load regardless of power load. Otherwise, conventional cogeneration has to be a closed system which balances heat and power loads only within the system. Allowance of such influx of excess power from cogeneration into the integrated power supply system is expected to bring various benefits: more efficient design of cogeneration; increase of utilization of cogeneration; rapid diffusion of cogeneration; and increase of total energy efficiency of the nation.

The mainly controversial point of this issue is that power generated by cogeneration is low quality in terms of AC wave, and brings fluctuation of voltage if connected to integrated systems. Power influx of cogeneration to the integrated power supply system at an extra high voltage (above 7,000 V) is allowed and provided with a technical guideline by regulatory authorities. However, power influx at a high voltage (6,000 V) or a low voltage (200 V or 100 V) is not allowed, and even connection of cogeneration to the integrated power supply systems at such voltages is not yet allowed although connection is expected to allowed in the near future. The government is doing an on-site experiment about such influx, and thus it will take several years to allow such influx.

<u>b. Power wholesale to electric power companies</u>

As a next step after allowing power influx, if cogeneration is recognized to be a source that can provide a good quality, stable and reliable supply of power to electric power companies in the long term, it is beneficial to introduce a new system that requires electric power companies buy such power at some reasonable prices under long term contracts. If prices and contract conditions such as supply time, power quality and dispatchability are properly determined, such a new system will be beneficial for both cogenerators and electric power companies. This is because cogenerators can secure long term commitment of electric power companies and long term reliable sources of revenue. That is also because electric power companies can secure additional low-cost capacity as on-site production facilities that can quickly respond to load variations. Since on-site production facilities have an advantage that they are located within markets such as Tokyo, they are expected to supplement the rigid conventional scale-economy-driven power supply system, which controls huge power flowing from outside into markets over transmission networks, and to increase its reliability and stability. Electric power companies themselves are planning to install on-site production facilities within markets for that purpose when fuel cells are developed for practical use. In any case, this power wholesale issue is very important in promoting cogeneration for both industrial and commercial users. Furthermore, opening up of such a wholesale business of cogenerators may take a first step toward development of competitive wholesale markets.

The mainly controversial point of this issue is price and supply conditions. It is generally acknowledged that it is at night when cogenerators are faced with low power load and can sell power to electric power companies. However, during such hours, electric power companies are also faced with low power load and need not to buy power because they keep operating base-load power plants even at a lower efficiency level by reducing output. Therefore, if electric power companies buy back power from cogenerators, buy-back-prices should be low, for example, below marginal costs of base-load gas-burning power plants which are operated somewhat below the maximum efficiency level in order to meet lowered load.

c. Specified retail supply of power

Retail business of cogenerators was deregulated within the concept of "specified retail supply" in 1987, while general retail supply of power is still strictly regulated and allowed only to integrated electric power companies. This deregulation have enabled an owner of cogeneration to get permission from MITI to retail power to customers who stay within the only one independent building in which the cogeneration system is installed and all of which or a part of which the owner of cogeneration owns exclusively or owns jointly with others. Instead of the owner, an agent who is entrusted to manage the building and cogeneration by the owner can do the same thing. However, it is argued that this deregulation is simply a small step in exploiting merits of cogeneration. This kind of retail power sales can occur in many states in the U.S.

In addition, this special treatment of retail power business thanks to deregulation is not applied if customers are supplied with power by both an owner of cogeneration and an electric power company. The owner of cogeneration is not allowed to retail power to customers who are already supplied by the electric power company. Also, the electric power company need not to provide backup power service to customers to whom the owner of cogeneration already have permission to retail power, whereas backup power service for cogenerators has been already introduced. In that case, the electric power company takes no responsibility of power supply, which is usually required in exchange for exclusive franchise. On the other hand, in case of the U.S., utilities must supply backup power service to those customers who are supplied with power by cogenerators.

d. Cream-skimming and flexible pricing

More deregulation of retail business is asked by cogeneration users, particularly such commercial users that can cover high demand-density areas such as business districts in Tokyo. Some gas companies which are planning centralized heat supply business to local areas are strongly demanding it.

However, as is seen in many regulated industries, further deregulation of retail business is opposed by regulators and electric power companies. One of main grounds for the opposition is the idea of "cream skimming."

"Cream skimming" means that cogeneration firms will enter only high demand-density areas, that is, very profitable markets, and then win the markets by setting lower prices than electric power companies which have to cover low demand-density areas within their exclusive franchise. As a result, average cost for electric power companies will increase and social equity will be reduced.

Generally speaking, "cream skimming" can occur at any time in any market where pricing is not proper unless the market is regulated. From the viewpoint of social welfare and economic efficiency in pricing, the existence of the potential problem of "cream skimming" indicates that price structure of electric power companies is not proper. As discussed before, between geographical markets, there seems to be substantial cross-subsidization, which attracts new entrants pursuing profits.

However, such cross-subsidization is justified by the concept of social equity in income distribution under the current regulatory regime. As discussed before, the social equity concept requires uniformity of rate level and structure across customers, even across customers of geographically different markets, some of which are high demand density and need low costs, but others of which are low demand density and need high costs. Electric power companies are burdened with supply obligation within large exclusive franchise where social equity in income distribution cannot inherently go without cross-subsidization. In pricing, social equity and efficiency are trade-off.

The logic of "cream skimming" is reasonable. It is natural to assume that if retail business is freely allowed to cogeneration firms and if at the same time the conventional supply obligation within exclusive franchise is not relaxed to electric power companies, cogeneration firms will give priority to profit pursuit rather than social equity in income distribution, enter the most profitable first, and continue to enter profitable markets in order of profitability until no profits are expected. They can easily assess such profitability simply by comparing their own prices with officially approved prices of electric power companies. Because electric power companies are burdened with supply obligation within exclusive franchise and cross-subsidized price structure regulated by the social equity concept, they cannot flexibly respond to such competitive situation. As a result, electric power companies will lose profitable markets such as central business districts and increase the proportion of unprofitable markets such as rural areas. "Cream skimming" can occur more easily in electric power business than other similar network business such as telecommunication. This is because whereas telephone business whose crucial competitive advantage is large size of network and high accessibility to other customers over the network, that is to say, positive network externalities, electric power business do not have such network externalities. In the current electric power supply networks which cannot yet provide communication and information service to final customers over distribution lines, relation between an electric power company and its customers is just a unilateral one from a supplier to customers, and there is no relation among customers. Thus, profitable areas in networks will be easily taken away. Then, average costs for electric power companies will increase, and price level will increase. Increased price level will more expand profitable markets for cogenerators and attract more new entrants, and electric power companies will lose more markets.

This series of events of "cream skimming" forms a vicious spiral and it will continue endlessly. In addition, large price discrimination will unintentionally be created geographically between high and low demand-density areas, and social inequity might be a matter. If retail business is deregulated, the possibility of such a vicious spiral should be considered, and some restriction should be imposed on entry of cogenerators into retail business or some flexibility of pricing should be given to electric power companies, so that some proper market equilibrium be achieved.

Particularly, flexibility of pricing is very important in putting electric power companies on an equal footing with cogenerators which are not encumbered with the social equity concept. Under more competitive environments, flexible pricing will help electric power companies to provide customers with more variety of choices to meet well diversified customer needs. Flexible pricing in case of the electric power industry should be such pricing that price reflects cost properly at each time of day and year according to seasonal and time of day variation of load and that electric power companies can respond flexibly and quickly to change in competitive environments by changing price. Such pricing is expected to send customers a proper signal in a form of economic cost of power.

Among the major practical forms of flexible pricing are discounted price for Demand Side Management (DSM) programs and spot price. DSM programs are systematic programs designed to influence the amount and timing of power consumption of customers by varying price and service levels for the purpose of reducing the cost of power supply, securing the reliability of power supply and reducing environmental pollution.

Conventional, simple forms of DSM programs are the demand-supply adjustment service which provides customers with discounted prices in exchange for some conditional interruption of supply at peak time and the night-only service with low prices for use of motors and power equipment for water heating purpose. In the current price structure, however, these services are highly limited. Under competitive environments, variety of these services should be expanded more in terms of customer categories, load size, discount rates, time of supply and other conditions, and various kinds of package service should be provided to customers depending on total quality level of power supply.

Spot price is calculated and provided to customers several hours or several days ahead of their consumption time. Thus, spot price can reflect cost more properly at each time of day and year, and it can promote more efficient consumption behavior of customers. Since spot price can be revised frequently according to cost and market conditions, it is expected to overcome the rigidity of the conventional seasonal or time of day prices. Also, in the future when high technologies for measurement and telecommunication are developed, real-time bilateral communication between an electric power company and its customers will become possible and real time pricing, an advanced form of spot pricing, can be introduced.

Furthermore, cost-of-service regulation should be reviewed and might be substituted, or at least should be supplemented, by incentive regulation. The basic purpose of cost-of-service regulation is to protect consumers by preventing a natural monopoly from setting monopoly price, and at the same time, to secure utility service, one of the necessities of life, by guaranteeing the viability of the monopoly. In addition, cost-of-service regulation sometimes introduces political considerations into pricing, as is discussed before in the case of cross-subsidization based on the social equity concept. Also, cost-of-service regulation provides little incentives for regulated monopolies to reduce costs. Under competitive environments, even regulated firms have to make efforts to reduce costs and to respond flexibly to markets in terms of pricing. Regulation must not obstruct such competitive efforts of regulated monopolies, but must facilitate them. Therefore, if retail power business is deregulated to some extent, cost-of-service regulation need to be substituted by, or at least supplemented by, a new regulatory system that provides regulated firms flexibility of pricing and incentive mechanisms to facilitate cost reducing and profit pursuing efforts by decoupling prices or revenues from the actual costs incurred by regulated monopolies. The U.S. has experience in such a new system as incentive regulation, which is represented by yardstick schemes and indexing schemes such as the price cap approach. Although the U.S. experience shows that incentive regulation is difficult to implement in practice, particularly in terms of determining the optimal benefit sharing fraction [Joskow & Schmalensee 1986], incentive regulation should be considered as an alternative to improve the flexibility of pricing in stead of the current cost-of-service regulatory regime.

e. Excessive competition

Another strong ground for the opposition to further deregulation of retail power business is the idea of "excessive competition." Some people think that if retail power business is deregulated, excessive competition will occur because electric power business including cogeneration needs large sunk costs which make it difficult to go out of the industry. Then, excessive competition might lead to some monopolized market in the long run. However, excessive competition is an extreme case and its cause can be handled with appropriate contracts, prices, and supply conditions.

The extreme logic of excessive competition is as follows. Since competition increases the number of choices to customers, customers will easily switch suppliers if price difference is significant. Because the electric power industry is not contestable and does not guarantee free entry and exit due to substantial sunk costs, suppliers quitted by customers will be in trouble in covering fixed cost and have to raise prices to cover it. Raised prices will expand price difference, which increases further the disadvantage of the suppliers. As a result, this series of events forms a vicious spiral. In such a market, in order to restrain customers from taking opportunistic behavior and switching suppliers easily, long-term contracts will prevail and suppliers will try to create some market power. As a result, the market will lead to vertical and horizontal integration, that is to say, a monopolized market, in the long run.

Although the logic has some persuasive power, excessive competition does not necessary lead to monopolized markets in practice. Rather, long-term excessive competition may have benefit of driving down costs and driving out inefficient suppliers through market selection mechanism, even if there are substantial sunk costs. If market transactions of power are disciplined with appropriate contracts, prices and supply conditions, markets are likely to keep their competitiveness at the same time to prevent monopolization.

4-5 Fuel cell as potential force of structural change

Fuel cells are expected to be a leader of cogeneration technologies and on-site power plants in the near future. Among their major advantages are high efficiency of generation above 40% regardless of load and capacity, low level of NOx concentration, low noise, low vibration, and high total energy efficiency around 80%. Three types of fuel cell technologies are being developed in parallel: Phosphoric Acid Fuel Cell; Molten Carbonic Fuel Cell; and Solid Electrolysis Fuel Cell. These three technologies are expected to be put to practical use in this customers will be in trouble in covering fixed cost and have to raise prices to cover it. Raised prices will expand price difference, which increases further the disadvantage of the suppliers. As a result, this series of events forms a vicious spiral. In such a market, in order to restrain customers from taking opportunistic behavior and switching suppliers easily, long-term contracts will prevail and suppliers will try to create some market power. As a result, the market will lead to vertical and horizontal integration, that is to say, a monopolized market, in the long run.

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Since fuel cells are very innovative in the generating technology, they are expected to bring a structural change to the whole energy industry including the electric power, gas, oil, and local heat supply industries. Fuel cells use natural gas or methanol as fuel and are being developed over a wide range of capacity. Fuel cells over 100 MW are expected to substitute some fraction of the conventional thermal power plants. Fuel cells between 1 and 50 MW are expected to be used for on-site power plants located within market areas. Several MW fuel cells will be used by industrial users, and local heat and power supply businesses, and fuel cells between 50 and 500 kW will be used by commercial users.

Therefore, effects of technological changes associated with fuel cells should be taken into account when the future regulatory regime of the electric power industry is discussed.

V. Regulatory reforms and structural changes in Japan

5-1 State of the U.S. underlying forces in Japan

To assess the applicability of the U.S. experience to Japan, it is helpful to examine whether Japan has the same five underlying forces of regulatory reforms and structural changes as those recognized in U.S., and if not, what are the effects of its absence on the applicability.

a. Governmental policy shift in favor of deregulation

This underlying force exists in Japan, too.

Such a policy shift is a global trend and Japan is also not an exception. For example, three monopoly public corporations of the Japan National Railways, the Nippon Telegraph and Telephone, and the Japan Tobacco and Salt were privatized in 1986, 1985 and 1985, respectively. In the domestic airline industry, since 1985, pricing flexibility such as discounted fares has been introduced and entry restriction has been deregulated through approval of double- or triple-tracking. In addition, deregulation is under way in the trucking industry, the distribution industry, the financial service industry including banking and securities business.

In Japan, deregulation is perceived to be the key to the long-term economic policy of stimulating domestic economic activities and developing domestic demand in order to shift the Japanese economy from an export-driven economy to a domestic-demand-driven one. In addition, as the global economy becomes more borderless and as the trade friction between the U.S. and Japan continues, deregulaticn will go further because regulation is perceived to have created nation specific non-tariff barriers.

b. Diminished economies of scale in generation

This underlying force exists in Japan, too.

According to the time-series analysis from 1969 to 1984 with translog-type cost functions by Awada, Itoh and Nakanishi [1987], economies of scale in thermal power generation in Japan was already fully exploited around 1970, and since then, production scale has entered the stage of increasing average cost, that is to say, production scale has exceeded the most efficient scale where average cost is minimum and equal to marginal cost. In addition, the most efficient production scale became smaller from 1980 to 1984.

Using the same approach, Nakanishi [1988] found almost the same results for the whole generation facilities in Japan and that since 1974, production scale has entered the stage of increasing average cost.

Instead of approved maximum capacity, Shinjoh [1990] used real economic values of assets as a capital-stock variable and applied almost the same approach to the time-series data from 1978 to 1985 of the nine major electric power companies in Japan. His finding was that economies of scale in thermal power generation still existed but they were small and declining for all companies. In addition, the smaller an electric power company, the larger economies of scale in thermal power generation. On the other hand, economies of scale in nuclear power generation were fully exploited at the top two companies (TEPCO and KEPCO) around 1981, when nuclear power generation exceeded 28,000 MWh at each of the two company, and since then, production scale has entered the stage of increasing average cost. However, at the other smaller companies, economies of scale in nuclear power generation still existed, but they were declining.

As a whole, economies of scale in generation are almost fully exploited at Japanese electric power companies, particularly at large companies.

c. Loss of incentives for incumbent utilities to invest in new capacity

This underlying force seems not to exist in Japan.

Since the first oil shock in 1973, electricity prices have been increased three times and decreased two times: increase by 57% in 1974, 22% in 1976 and 51% in 1981, and decrease by 18% in 1988 and 5% in 1989 (Table 3-5). As discussed in the section of "3-5 Performance of electric power companies, a. Financial performance", however, there seems to have been no regulatory lag through these price changes. In addition, unlike the U.S. utilities, Japanese electric power companies did not experience disallowance of any fraction of new capacity construction cost to enter rate bases through those rate increase cases, mainly because there was no serious excess capacity in Japan and the growth of demand was still relatively steady (Figure 3-3, 3-4). Thus, they have not lost motivation to invest in new capacity.

Rather, the government did not want electric power companies to slow down their capital investments, because they played a leading role in stimulating the Japanese economy through their huge capital expenditures, which were 7 - 10% of the total capital expenditures in the private sector during the decade since 1975 and is expected to be 6% in 1991, as discussed in the section of "3-6 Capital investment and capital cost."

Moreover, because the growth of demand, particularly a summer peak load, is rapid, electric power companies and the government have to hurry up capacity increase. It is generally acknowledged that rapid and huge increase of capacity can be achieved mainly by expanding the conventional scale-economy-driven power supply system. Thus, electric power companies are driven into a tight corner to invest in new capacity, whether they lose incentives to do so or not. This is a clear contrast to the U.S. situation in the late 1970's and the early 1980's when the U.S. electric utilities were faced with very sluggish growth of demand.

On the other hand, electric power companies are faced with great difficulty in developing new power plant sites. From this perspective, there might be some room for independent power producers to enter power generation and wholesale markets, and they might be helpful to meet a rapid increase in a peak load, if some appropriate regulatory reforms are introduced.

d. Profit incentives for new entrants by decoupling prices and costs

This underlying force does not explicitly exist in Japan.

As discussed in the U.S. experience, however, this can be accomplished by charging electric power companies with the obligation to purchase power from third parties at proper prices and contract terms and conditions. It must be noticed that such obligations should be accompanied by flexible contract systems such as competitive bidding and negotiation systems in order to protect electric power companies from a significant burden of unlimited purchase obligations.

In fact, there are a few small actions that have implicit intention to create profit incentives for third party generating facilities to supply power to electric power companies, although these actions are not accompanied by any regulatory reforms of charging electric power companies with purchase obligations. Such implicit, small actions are represented by increase of prices for coordination transactions of power among electric power companies, and increase of prices for garbage-burning power producers that supply power to electric power companies, as are discussed in the sections of "Power pool and coordination transaction" and "independent small power producers."

However, these changes of prices still remain within the principle of "cost-based pricing." There have been no movements toward decoupling prices and costs yet. Also, incentive regulations such as "price cap" have not yet been introduced to any industry in Japan and are not expected to be introduced in the near future.

e. Large potential of self-generations

This underlying force seems to exist in Japan.

The proportion of self generation in the total generating capacity in 1987 was 8.9% in Japan, 4.0% in U.S., 14.1% in West Germany, 7.5% in France, and 5.8% in U.K. Self-generation grew only in the U.S. between 1983 and 1987, while that in the other countries declined (Table 2.1). In number, thus, there might not appear to be so much room for more development of self-generation in Japan, particularly for large industrial customers (Figure 3-2).

However, self-generation has been growing in Japan since 1986. Particularly, cogeneration has been growing rapidly in these days, as shown in the sections of "3-8 independent cogenerators" and "IV

Independent cogeneration in Japan." It is generally acknowledged that this trend will continue in the next several years.

Moreover, since Japan has trouble in building enough capacity to meet demand and since it is certain that independent power producers are helpful in meeting capacity needs, it is important to promote them in such a way that capacity development plans of electric power companies are not affected seriously and that quality of power supply is not harmed.

Similarly, although cogenerators which has been emerging among industrial and commercial users are too small in capacity to meet those huge capacity needs that Japan is faced with, even cogenerators are somewhat helpful in meeting capacity needs, and thus they should be promoted in the same way as independent power producers.

5-2 Japan specific factors

Several Japan specific factors can be recognized in the current situation in Japan. They are not recognized in the U.S. situation that have promoted regulatory reforms and structural changes since the late 1970's. The applicability of the U.S. experience to Japan may be affected by the following Japan specific factors.

a. Tightness of demand and supply

Japan is faced with tight situation of demand and supply owing to the high growth of the peak load, as discussed in the sections of "3-2 Demand" and "3-3 Supply." In Japan, the peak load has increased by 5% annually for the last decade and is expected to increase by more than 3% annually for the next decade. In the U.S., the peak load increased by around 2% annually from the late 1970's to the mid 1980's.

Although new entrants of large-scale independent power producers which are large enough to substitute the conventional thermal power plants could help to meet such capacity needs, they are not expected to grow sufficiently. This is because it is as difficult for them to find plant locations as electric power companies, and because it seems to be difficult for them to attract investors in financing their projects better than electric power companies which have AAA-class credit-worthiness and strong financial power as discussed in the section of "3-6 Capital investment and capital cost."

In addition, it seems to be risky to count on inexperienced independent power producers for additional capacity at peak time under the tight situation of demand and supply. Since the reserve margin at peak time has recently been low, it is necessary for electric power companies to coordinate closely a variety of generating facilities. Thus, when some inexperienced independent power producers are integrated into the network supply system of electric power companies, the high quality of power supply in Japan (discussed in the section of "3-5 Performances of electric power companies, b. Technical performances) may decline. Therefore, to integrate them into the network system, careful and long-term experiments on coordination between independent power producers and electric power companies will be essential in maintaining the high quality of power supply.

b. Large incumbent electric power companies

On the average, Japanese 9 electric power companies which hold 77% of the Japan's total generating capacity (Figure 3-2) are much larger in scale than the U.S. 276 investor-owned electric utilities which hold 74% of the U.S. total generating capacity. Their average generating capacity is 15,000 MW in Japan compared to 2,000 MW in the U.S.

This large scale is helpful in coordinating various capacity expansion plans within a single company and in financing big projects.

c. Small new entrants

Third party power producers that have recently been emerging in Japan are generally of a small scale whereas those in the U.S. mainly consist of mid-size generation-specialized ventures, that is, IPPs. Those new entrants in Japan consist of not only industrial cogeneration users but also commercial cogeneration users. Thus, the average capacity of those new entrants is much smaller in Japan, that is, 400 KW for commercial users and 3,600 KW for industrial users. On the other hand, in the U.S., the average capacity of IPPs is 300,000 KW [Washington International Energy Group's report], while the average capacity of QFs during 1980 -1990 is 20 KW.

Generally speaking, third party power producers can be viable in two forms: to achieve high efficiency in generation by pursuing economies of scale and efficient operation; and to achieve high efficiency in the total energy use in cogeneration by acquiring enough customers for both power and heat load. The first form is represented by large-scale power producers such as the U.S. IPPs. They have to locate outside markets, far away from urban areas, in order to pursue scale economies in the same way as electric utilities do. If prices are set reasonably high for electric power companies to purchase power from IPPs, IPPs will develop rapidly because such high prices provide large profit incentives. However, such IPPs are not expected to grow soon and sufficiently because of the difficulty in finding plant locations as discussed in "Tightness of demand and supply" in this section. The second form is represented by cogenerators located in urban areas. Except local heat and power supply businesses in large-scale urban redevelopment projects or new residential town development projects, such cogenerators have to be small in size because of the difficulty in acquiring enough customers to balance power and heat load and because of the strict regulation on retail power sales. Therefore, in Japan, new entrants are expected to be only small cogenerators, as seen in the current situation. Compared to the large size of incumbent electric power companies, the small size of new entrants has serious disadvantage for new entrants in political economy context as discussed later.

d. Little regulation by local government

In Japan, the electric power industry is regulated only on the national government level by Ministry of International Trade and Industry (MITI), whereas it is regulated on the two levels in the U.S.: federal and state governments. In the U.S., some states can experiment on regulatory reforms with several advanced ideas such as incentive regulations, and competitive bidding and negotiation systems. However, Japan has no test sites for such experimental regulatory reforms.

e. More priority on national energy security

Diffusion of cogeneration may have much more impact on the "national energy security" issue in Japan than in the U.S. "National energy security" is a matter of externalities. That is, if some energy sources are switched to less risky sources by introducing on-site small generating facilities such as new energies, or if some fuel is saved by introducing high-efficiency generating facilities such as cogeneration, "national energy security" will improve. Particularly, in Japan, 85% of energy depends on foreign sources, and this oversea dependence ratio is much higher in Japan than in the U.S. Thus, regulatory policy that changes the mixture of energy sources may have much more impact on the "national energy security" issue in Japan than in the U.S.

Cogeneration has ambiguous effects in terms of externalities. Fuel for cogeneration is mostly natural gas, almost all of which is imported in Japan. If cogeneration is diffused at the expense of nuclear power, which is considered to be a quasi-domestic energy resource because of the long life of fuel in nuclear reactors and the large potentiality of fuel use after reprocessing, then natural gas import will increase, substituting the quasi-domestic energy, and oversea dependence ratio will increase. As a result, the "national energy security" will deteriorate. Without special treatments such as tax, the social cost of this declined "national energy security" is not included in prices in competitive market transactions. Thus, there is a negative externality in terms of "national energy security."

On the other hand, diffusion of cogeneration will decrease the total energy consumption because of its high energy efficiency, and then the "national energy security" will improve. However, the benefit of this improved "national energy security" is already included in prices of competitive market transactions because higher efficiency will be reflected in lower prices as the leverage of diffusion of cogeneration.

Thus, there is no externality in terms of "national energy security."

However, cogeneration has positive externality in terms of global warming. If cogeneration is diffused at the expense of natural-gas-burning, oil-burning, or coal-burning power plants, cogeneration is expected to reduce emission of carbon dioxide because of its energy efficiency. The benefit of this improved quality of environment is not included in prices in competitive market transactions. Thus, there is a positive externality in terms of environment quality other than "national energy security."

Careless regulatory promotion of cogeneration may lead to deterioration of "national energy security." Efficient resource allocation will be achieved when marginal social cost is equal to marginal social benefit. However, marginal social cost and marginal social benefit may not reflected in market prices of cogeneration. Thus, it may lead to market failure. If regulators think that power production by cogeneration is smaller than the optimal level and if they put much more weight on the positive side of cogeneration in terms of externalities, they might introduce some subsidy to cover the difference between the assumed marginal social benefit and market price, to promote cogeneration and to fix the assumed market failure, which provides a rationale for such government interventions. If government interventions such as subsidy are excessive in promoting cogeneration, much larger number of cogeneration will be diffused than the assumed optimal level. However, it is very crucial but very difficult to estimate what energy sources will be substituted by cogeneration, how much marginal social benefits and marginal social costs will be, and what the effects of governmental interventions will be. Therefore, government interventions such as subsidization or taxation should be carefully examined beforehand in the case of cogeneration because the total effects of cogeneration on externalities such as "national energy security" and global warming are ambiguous.

In short, in Japan, "national energy security" is much more focused on in terms of externalities than in the U.S. Careful consideration of various externalities should be given to any plan of regulatory reform.

5-3 Political economy context

a. Interest group theory of regulation

According to the terminology of "interest group theory of regulation" by Wilson [1980], an intermediate of "entrepreneurial politics" and "interest group politics" is expected to emerge in politics associated with a prospective deregulation in cogeneration in the electric power industry in Japan. "Entrepreneurial politics" is likely to emerge in a such situation that a policy confers general (though perhaps small) benefits at a cost to be borne chiefly by a small segment of society. "Interest group politics" is likely to emerge when both benefits and costs are narrowly concentrated.

The primary cost of the prospective deregulation associated with cogeneration is narrowly concentrated on one interest group, that is, the conventional integrated electric power companies, which have a strong incentive to organize and exercise political influence and which in fact already have a politically very influential industry association.

However, it is not clear whether the primary benefit of the deregulation is narrowly concentrated or widely distributed. Some beneficiaries such as gas companies, oil companies and industrial users of cogeneration are narrowly concentrated but have less political influence.

As a whole, the political economy context discussed below in more detail indicates that the deregulation in cogeneration will not proceed fast and far ahead.

b. Bearer of deregulation costs

Although deregulation may have negative effects on public interests and bring additional costs to the general public, electric power companies are considered to be the only major bearer of the cost of deregulation in cogeneration. There is great possibility that electric power companies have discouraged more cogeneration and have locked out independent power producers. Electric power companies are afraid of the possibility that once competition is allowed in some areas, competitors will continually focus on the restrictions that define the boundary between allowable and unallowable competition and present arguments for moving the boundary. Deregulation might proceed much further than everyone expects, and at last to perfect competition. This kind of scenario actually happened in the U.S. telecommunication industry, which was monopolized by the AT&T.

In fact, no electric power companies have bought power from cogenerators and the nine electric power are buying only 5% of the whole self-generation power in Japan. It was not until 1986 that electric power introduced backup power service for cogenerators, but they have not yet introduced backup power service for customers of cogenerators' retail power sales. In addition, by offering heat-pump facilities supplied with power through the transmission networks, electric power companies are actively competing for local heat supply business with gas and oil companies which offer cogeneration.

c. Beneficiaries of deregulation

Oil companies are generally a big business and might be well organized under a very influential industry association. However, they have been under excessive competition for a long time and cogeneration will not be a critical issue because the major fuel for cogeneration is natural gas, not oil.

Industry users of cogeneration can be organized by each industry under each industry association. Some industries such as steel and chemical have strong political influence. However, it seems to be very difficult for all users over various industries to be well organized to exercise political influence.

Gas companies have particularly strong incentives to organize and exercise political influence, because their main product, i.e. natural gas, is the major fuel for cogeneration and fuel cells, and because they might be able to make great strides by entering an electricity market, that is to say, a growing and huge market, with the leverage of cogeneration and fuel cells. However, there are many (247) gas companies which are generally small, and 30% of them are run by municipality, although top three companies are moderately big businesses.

Manufacturing companies of cogeneration or fuel cells are another beneficiary. But, some of them also make electric power equipment, and others are foreign companies. It seems to be difficult to organize them, although there is the Cogeneration Research Association, which consists of researchers, users, makers, fuel suppliers and so on, and which still remains an information service center.

The general public is another beneficiary because of improved total energy efficiency followed by decline of energy prices and because of reduced emission of carbon dioxide to delay global warming. However, they will put much smaller weight on such benefit than other major household concerns such as income tax, sales tax and social security programs.

d. Regulators

There are two more main players in this politics as regulators: the Ministry of International Trade and Industry (MITI), which is responsible for regulation of the electric power industry; and the Environment Agency. Although the Environment Agency is active in supporting deregulation from the viewpoints of energy efficiency and global warming, it has not enough political power to stand on a par with MITI, whereas the Environmental Protection Agency is very powerful in the U.S. On the other hand, MITI is deliberate and negative in rapid deregulation, and go together with electric power companies to some extent.

As a whole, the driving force of deregulation in cogeneration seems to be weaker than its counter power. From the perspective of political economy, therefore, progress of cogeneration is expected to be slow, unless big technological innovation occurs to bring revolutionary structural change to the industry.

5-4 Desirable directions in the future

Based on the U.S. experience and Japan's specific situations, some desirable directions for regulatory reforms and structural changes in Japan in the future can be worked out. For each of wholesale and retail markets, these desirable directions are discussed as follows.

a. Wholesale markets

Wholesale generation markets should be gradually opened up not only for independent power producers but also for cogeneration and fuel cells of commercial users and industrial users, because economies of scale in generation are almost fully exploited, and because keeping electric power companies exposed to the threat of new entrants will force them to make every effort to be efficient. The idea of the threat of new entrants is the primary ground for the current policy trend in favor of deregulation.

The present time seems to be the right time to begin opening up wholesale generation markets. Japan is now faced with tight situation of demand and supply, that is to say, radical growth in demand and difficulty in building enough capacity, and this situation is expected to continue for the next decade. Under such radical growth in demand, new entrants can be accepted easily into generation markets because the size of pie becomes larger enough to accommodate new entrants without squeezing incumbents. In addition, it is certain that new entrants provide new capacity and ease the difficulty which incumbents have in building enough capacity.

However, the speed of opening up wholesale markets should be slow in order to avoid any disorder to be brought in the electric power industry under the tight situation of demand and supply for the next decade. Particularly, deregulation should be such that plans of capacity expansion of electric power companies are not delayed or obstructed and that quality of power supply is not deteriorated.

In addition to the above two reasons (diminished economies of scale and threat of new entrants), which have been important in the U.S. case, the energy efficiency rationale is also important in Japan. The energy efficiency rationale comes from such an ideal utilization of energy as follows: because high-temperature thermal energy produced by burning fossil fuel has very high potential but is not so convenient to utilize, the high-temperature heat should first be converted by the most efficient heat engine into convenient energy form, i.e. electricity, as much as possible, and then the remaining low-temperature and low-potential heat should be used for process steam, heating, air-conditioning or hot water supply. This ideal utilization of energy can be achieved by cogeneration under some appropriate conditions. If cogeneration meets such conditions, its high efficiency is sure to bring low cost energy. Opening up wholesale markets will help cogeneration to achieve its high efficiency to become more economical enough to be a profitable business, because existence of buyers in wholesale markets will reduce the power load constraint that limits the discretion in efficient design of cogeneration. As a whole, social welfare will improve.

When wholesale markets are opened up to independent power producers and cogenerators, retail markets should be treated carefully in regulatory reforms. This is because there is some possibility that electric power companies may suffer from inefficient bypass if retail markets are opened up to them at the same time that wholesale markets are opened up. In order to prevent such inefficient bypass, retail markets must not be opened up or retail prices and service conditions must be carefully determined to avoid arbitrage. However, because the latter is difficult in practical when so many supplier exist, the former is a reasonable solution.

As a first step to open up wholesale markets gradually, coordination transactions of power between electric power companies should be expanded so that they can sell power at market prices, instead of cost-based prices, not only in emergencies but also under long-term contracts to other electric power companies which are short of power. It can be achieved easily because coordination transactions already exist and are now expanding, and because electric power companies have free access to the nation-wide power pool at the present level of transactions. Free access will help to create competitive markets among electric power companies. In introducing market prices into wholesale markets, regulators should carefully monitor the issue of cross-subsidization between competitive wholesale business and ordinary electric utility business subject to cost-of-service regulation. As coordination transactions develop the nation-wide competitive wholesale market, rules for wheeling service should be worked out in terms of pricing and allocation of additional construction costs.

As a second step, cogeneration for industrial users and commercial users should be facilitated more through regulatory reforms. First of all, in addition to influx into extra high voltage lines, power influx into high voltage and low voltage lines should be allowed after the experiment by Agency of Industrial Science and Technology, and be expanded gradually with careful check of network reliability. Allowance of such power influx will help to design cogeneration more efficiently so that cogeneration can be operated simply to match with heat load regardless of power load.

Although there are no strict restrictions on backup power service for cogenerators, prices for backup power service for cogenerators should reflect such benefits for cogenerators that cogenerators do not have to take any risk of power supply failure of their own cogeneration. In other words, backup power service provides cogenerators with insurance against power supply failure to their own customers. Thus, prices for backup power service should be something like a premium of such insurance service.

As a third step, electric power companies should be given the obligation to buy back power from those cogenerators that can provide stable and reliable supply in the long term. Also, strict restrictions should not be imposed on the conditions of power supply from cogenerators. In exchange for charging electric power companies with such unlimited purchase obligation, cogenerators should take legal responsibility for the amount and time of supply. Also, electric power companies should be able to vary buy-back-prices depending on supply conditions and the quality of power supplied from cogenerators. Because such power is helpful for peak load but almost worthless during night when the most efficient base-load nuclear power plants are operated at a low output level at the expense of efficiency, it is reasonable to vary buy-back-prices for power according to time of day and season. Buy-back-prices for power at peak time should be equal to or somewhat less than proper average cost of thermal plants of electric power companies. Those prices should not be equal to avoided cost at peak time because avoided cost at peak time is generally too high for electric power companies to afford, and because the purpose of allowing power influx is to help cogenerators to pursue efficient designs. However, if power supply from some cogenerators can be counted on for capacity purpose to meet a peak load and if electric power companies are faced with emergencies that they cannot secure enough capacity, buy-back-prices may be equal to marginal cost at peak load. On the other hand, buy-back-prices for power at off-peak time should be equal to or somewhat less than proper avoided cost of base-load power plants operated at a low efficiency level, although such prices might be too low for cogenerators to afford.

In addition, buy-back prices should be properly regulated in order to prevent electric power companies from exercising monopsony power. Since cogenerators in Japan are generally small in capacity and are highly constrained in site decision by non-power business conditions, there are great possibility that electric power companies exercise monopoly power and that competitive wholesale markets will not develop. Although it is natural that strict regulation is harmful in developing competitive wholesale markets, it is also very harmful to leave markets alone.

However, wholesale markets should not be opened up to third party suppliers such as IPPs until competitive wholesale markets develop well among electric power companies.

For purchase contracts between electric power companies and cogenerators, flexible negotiation systems including long-term and short-term contracts are essential in reducing business risk and promoting more cogeneration. In theory, negotiation systems will give flexibility to reduce business risk and be better than standard contract forms, as far as negotiation process does not increase transaction costs of electric power companies too much. Thus, electric power companies should be given the discretion to choose between several options such as long-term contracts, short-term contracts, negotiation systems, and standard contract forms, depending on the quality and conditions of power supply.

As a fourth step, IPPs should be allowed to enter wholesale generation markets after the following three conditions are satisfied: the wholesale markets whose main transactions are coordination transactions among electric power companies develop well in terms of market-driven pricing and wheeling arrangement; small cogenerators are technically integrated well into the power supply system; and the tight situation of demand and supply is eased. In order to give IPPs profit incentives, cost-of-service regulation should not be applied to IPPs, as electric power companies are paid market prices for coordination transactions. Also, IPPs should be accommodated in the same institution of wheeling arrangement as electric power companies. Then, competitive negotiation systems should be introduced. As these systems develop, difference between IPPs and large cogenerators will diminish.

b. Retail markets

Retail markets should not be opened up beyond the current specified retail power sales allowed to cogenerators because of the following three reasons: wheeling over transmission and distribution networks will undermine economies of multiproduct production and economies of vertical integration, while wheeling will not undermine economies of scale in transmission and distribution; as far as the current rigid and cross-subsidized price structure is not replaced by more flexible pricing schemes, "cream-skimming" problem will undermine the performance of the conventional regulated electric power companies and bring much higher prices to their customers; and electric power companies may suffer from inefficient bypass if retail markets are opened up at the same time that wholesale markets are opened up. Further deregulation in retail markets might lead to deintegration of the conventional electric power companies.

In order to dodge the pressure of opening up retail markets, regulators should charge electric power companies with unlimited purchase obligation from cogenerators which can provide a stable and reliable supply of power in the same way as discussed in the previous section of opening up of wholesale markets. Prices and contracts should be flexible depending on quality and conditions of power supply as discussed before.

In addition to cogenerators, customers of cogenerators should be provided with backup power service. Prices for backup power service for those customers should reflect such benefits for them that they do not have to take any risk of power supply failure of their cogeneration suppliers. In other words, backup power service provides those customers with the second source of power supply, that is to say, insurance against power supply failure of their first supplier. Thus, prices for backup power service should be something like a premium of such insurance service.

In short, power produced by cogenerators should not be sold directly to general customers, but can be sent through the conventional electric power company systems to general customers.

c. Regulation of electric power companies

As deregulation proceed further, electric power companies should be given flexibility in pricing so that electric power companies can respond flexibly and quickly to changes in competitive environments by changing prices as discussed in the section of "4-4 Current regulatory issues, d. Cream-skimming and flexible pricing."

In the long run, some incentive regulations such as price cap should be introduced to electric power companies so that like IPPs, electric power companies are given profit incentives to compete effectively at wholesale markets.

However, in order for incentive regulations to work well, appropriate profit sharing mechanisms should be built in electric power companies. It might take a long time because the current electric power companies seem to have no profit sharing mechanisms among shareholders, management and workers.

Shareholders are treated very poorly, because whatever the stock price is, they have been paid a dividend of 50 yen (= 36 cents) per share each year, i.e. 10 percent on the face value of the stocks (500 yen), for a long time except when companies showed a loss. The current stock prices of Tokyo Electric Power Company at the Tokyo Stock Exchange Market are around 4,000 yen (= 28.6 dollars), and thus the current dividend yield is around 1.25%.

Management do not seem to be paid so much, and unlike CEOs in the U.S., they are not generally given any compensation program linked with performances of their firms. Even if their firms make huge profits, their bonuses will not increase. Rather, in such a case, they will try to reduce official profits by increasing maintenance expenditures in order to avoid critics from regulators and customers who will request reduction of prices.

Also, workers will not be paid special bonuses or given significant wage increase even if their firms make huge profits.

Therefore, in addition to regulatory reforms and industry structural changes, structural changes of companies themselves will be necessary in order for incentive regulation to work well and to urge electric power companies to make more efforts to be efficient.

VI. Conclusion

6-1 Summery

Although economies of scale in generation seem to be almost fully exploited according to several studies of the electric power industry, a quick and easy-going way of deregulation is not necessarily effective from the viewpoint of public welfare, if one considers economies of scale in transmission and distribution, economies of multiproduct production, economies of vertical integration, and huge sunk costs.

However, some mechanisms to promote competition will be necessary in the conventional integrated electric power supply system from the perspective of long-term energy policies as follows. The essence of Japan's energy policy is to improve "national energy security" by switching from the risky energy source of oil to less risky energy sources of other fossil fuel such as natural gas and coal, making every effort to utilize energy as efficiently as possible, and at the same time, switching gradually from those fossil fuels to renewable or recyclable energy.

There are two major alternatives of renewable energy: scale-economy driven nuclear energy, which is considered to be quasi-home-produced energy if reprocessing facilities and the nuclear fuel cycle are completed within Japan; and on-site (located within market areas) small energy production systems using natural energy such as biomass, solar, photovoltaics, wind and geothermal energy. It is not reasonable and impossible to choose one out of these two alternatives because of the uncertainty of the future in technological innovation, environmental conditions, and social and economic environments.

Thus, wise choice of energy supply structure is a balanced mixture of the two alternatives, that is, on-site small energy production systems are added to make up the shortcomings of scale-economy-driven nuclear energy. The two alternatives complement each other.

To evolve the energy supply system to such a balanced-mixture system from the current scale-economy-driven system without losing anyone of the following three: economies of scale; economies of vertical integration; and efficiency of on-site-small-production, it is important to reshuffle carefully the conventional electric power industry and at the same time, to improve efficiency by pressing players to pursue their own profits appropriately during the transition time. Reshuffling will make the industry structure more loose and provide new room for entrepreneurs to seek profits. During this period, the main driving force to promote structural changes of the industry further is profit-seeking efforts of each player.

Therefore, slow and careful but finally large deregulation is needed.

6-2 Future research

Pricing and contracts will be very important issues during the transition period when competition and partial regulation are mixed in the electric power market. There are a huge variety of prices such as: wholesale prices for coordination transactions, buy-back from various cogenerators and buy-back from various independent power producers; retail prices for Demand Side Management programs, backup power service and conditional power interruption service; and wheeling prices for electric power companies, cogenerators and large customers. Such prices will vary depending on the conditions of power supply. In addition, contracts deal with non-price conditions of power supply. Prices and contracts have a great influence on what the market equilibrium will be, and therefore they should be paid great attention.

Bibliography

G. Brook, "The Regulatory Change in Telecommunications: The Dissolution of AT&T," in L.Weiss and M. Klass, editor, Regulatory Reform: What Really Happened?, Little, Brown and Company, 1986.

S. Brown and O. Sibley, The Theory of Public Utility Pricing, Cambridge University Press, 1986.

L. Cristensen and W. Greene, "Economies of Scale in U.S. Electric Power Generation," Journal of Political Economy 84, 1976.

W. Greene, "Simultaneous Estimation of Factor Substitution, Economies of Scale, Productivity, and Non-neutral Technical Change," in A. Dogramaci, editor, Development in Econometric Analysis of Productivity, Kluwer. Nijhoff Publishing, 1983.

L. Hyman, America's Electric Utilities: Past, Present and Future, Public Utilities Reports, 1988.

J. Moorhouse, editor, Electric Power: Deregulation and the Public Interest, Pacific Research Institute for Public Policy, 1986.

P. Joskow, "Regulatory Failure, Regulatory Reform and Structural Change in the Electric Power Industry," Brookings Papers on Economic Activity: Microeconomics, 1989.

P. Joskow and N. Rose," The Effect of Technological Change, Experience, and Environmental Regulation on the Construction Cost of Coal-Burning Generating Units," Rand Journal of Economics Vol. 16, No. 1, Spring 1985.

P. Joskow and R. Schmalensee, "Incentive Regulation in the Electric Power Industry," Yale Journal of Regulation, December 1986.

P. Joskow and R. Schmalensee, Market for Power, MIT press, 1983

R. Schmalensee, The Control of Natural Monopolies, Lexington Books, 1979.

W. Weiss, " Antitrust in the Electric Power Industry," in A. Phillips, editor, Promoting Competition in Regulated Markets, Brookings Institution, 1975.

J. Q. Wilson, "The Politics of Regulation," in J. Q. Wilson, editor, The Politics of Regulation, Basic Books 1980.

Agency of Natural Resources and Energy, Ministry of International Trade and Industry, Challenge to New Trends in Energy: Interim Report of the Comprehensive Energy Survey Council, MITI Information Research Society, 1990.

H. Awada, "A study of Deregulation of the Electric Power Industry," Public Utility Research Vol.39, No.2, 1988

Demand and Supply Subcommittee, Electric Power Industry Council, Interim Report of the Demand and Supply Subcommittee, 1990.

Editorial Committee for the Electric Power Industry Course, Electricity Rate, Electric Power New Publishing, 1961.

Electric Power Industry Annual Report Committee, The Current Situation of the Electric Power Industry, Japan Electric Association,1988, 1989, 1990.

Y. Nishino, "Introduction of Competition and Deregulation in the Electric Power Industry," Electric Power Industry Economic Research No.25, Central Research Institute of Electric Power, 1988.

Planning Bureau, Japan Economic Planning Agency, editor, Economic Theory of Deregulation, Printing Bureau of Ministry of Finance, 1989.

Public Utilities Department, Agency of Natural Resources and Energy, Ministry of International Trade and Industry, Perspective of the Cogeneration Age, MITI Information Research Society, 1987.

Public Utility Law Working Group, Monopoly and Competition in the Energy Supply Market in Japan, Japan Energy Law Research Institute, 1990.

K. Shinjoh, "Economies of Scale in the Electric Power Industry," in T. Hayashi, editor, Public Utility and Deregulation, Toyo-Economic New Publishing, 1990.

Electric Power New Publishing, Energy Forum, No.411 and 420, 1989, No.422, 423, 429, 430 and 431, 1990, No.433, 434, 435 and 436, 1991.