COST STRUCTURE ANALYSIS OF COMMERCIAL NUCLEAR POWER PLANTS IN JAPAN BASED ON CORPORATE FINANCIAL STATEMENTS OF ELECTRIC UTILITY COMPANIES

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ABSTRACT

In this paper, we analyze past and current cost structure of commercial nuclear power plants in Japan based on annual corporate financial statements published by the Japanese electric utility companies, instead of employing the conventional methodology of evaluating the generation cost for a newly constructed model plant. The result of our study on existing commercial nuclear plants reveals the increasing significance of O&M and fuel cycle costs in total generation cost. Thus, it is suggested that electric power companies should take more efforts to reduce these costs in order to maintain the competitiveness of nuclear power in Japan.

INTRODUCTION

As the Japanese electric power market moves toward the deregulation in recent years, cost reduction becomes a more imperative issue for the electric utility industry. Given this, it is important for the electric industry to keep competitiveness of nuclear power, whose share exceeds 30% of total power generation in 1996.

Traditional cost analysis based on estimated future costs for a newly constructed plant can be useful for decision making in ordering new power plants. However, as the number of new orders is declining toward the future, it is becoming more important for corporate management to assess the real trends of cost structure of all power plants instead of economics of single unit. We have employed an alternative approach for this issue by focusing on the financial records of the corporate management, and thus, extracted the possibility of cost saving in electric power industry. Specifically, we analyzed past and current cost structure of commercial nuclear power plants operating in Japan, based on annual corporate financial statements (1971-1995) published by Japanese electric companies.

APPROACH

In this paper, we took all nuclear power plants of the nine major electric utility companies in Japan into account, except the four commercial reactors (Tokai, Tokai-2, Tsuruga-1, 2) of Japan Atomic Power Company (JAPCO) and two prototype reactors (Advanced Thermal Reactor “Fugen” and Fast Breeder Reactor “Monju”) of Power Reactor and Nuclear Fuel Development Corporation (PNC).

We adopted the data of nuclear power operating expenses in financial statements of nine electric companies to analyze the cost structure of commercial nuclear power plants. The Japanese electric utility expenses as a whole are classified by three categories in the financial statements i.e., operating expenses, financial expenses and non-operating expenses. The operating expenses represent about 90% of total electric utility expenses.

We looked into the items classified in nuclear power operating expenses, a component of the overall operating expenses, and recomposed them into three categories. The main items in each category are as follows.

(1) capital cost items
- fixed assets tax, depreciation, decommissioning cost of nuclear power facilities,
- interest payment

(2) O&M expense items
- personal expenses (salary, welfare expenses, contract payment), repair expenses,
- other expenses (consumption supplies expenses, rent, damage insurance charge,
- miscellaneous expenses, 10% of miscellaneous tax (corresponding to all taxes excluding nuclear fuel tax[1])

(3) fuel cycle expense items
- fuel expenses, spent fuel reprocessing expenses, waste treatment and disposal expenses (excluding high-level waste disposal expenses),
- 90% of miscellaneous tax (corresponding to nuclear fuel tax)

In this study, we included the interest payment in capital costs, although interest payment is only given in the overall financial expenses and its breakdown for each type of power source is not available. We estimated the interest payment for each power source, by using the data of ‘Construction Works In Progress’ (CWIP) and ‘Electric Utility Fixed Assets’ (EUFA), which are available for each power source.

$$\text{IP-N} = \text{IP-T} \times \frac{\text{CWIP-N} + \text{EUFA-N}}{\text{CWIP-T} + \text{EUFA-T}}$$

We employed the following formula for estimating the interest payment for each power source:

Total of Interest Payment:	IP-T
Total of Construction Works In Progress:	CWIP-T
Total of Electric Utility Fixed Assets:	EUFA-T
Interest Payment for Nuclear Power:	IP-N
Construction Works In Progress for Nuclear Power:	CWIP-N
Electric Utility Fixed Assets for Nuclear Power:	EUFA-N

‘CWIP’ is the expected total construction costs excluding the actual expenditure up to the year, whereas ‘EUFA’ is the asset value of completed plant at a given year. In this paper, all expenses and costs are expressed in the total of nine electric companies and in 1990 constant yen, using GDP deflator.

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[1] The reason for including 90% of miscellaneous tax into fuel cycle cost is to consider the nuclear fuel tax. The rest (10% of miscellaneous tax) is classified into O&M cost as various taxes. It is estimated based on interview with an utility official.

COST STRUCTURE OF NUCLEAR POWER GENERATION

Evaluated Generation Cost for Each Power Source by a Newly Constructed Model Plant and by Financial Statements

Figure 1 shows the traditional power generation cost comparison, which was published by The Institute of Energy Economics (IEE), Japan since 1982 (T.Yuasa et al, 1992, 1993, 1995). This assessment is based on the assumption that a model plant with up to date technology is constructed and commenced its operation at the year of the assessment. In Figure 1, it is clear that nuclear power generation, compared with the other power sources, has kept its competitiveness. However, its margin with the other sources has been narrowing since 1986, especially with liquid natural gas (LNG).

Then, we turn to the generation cost estimated in this report by financial statements. This cost is calculated simply by dividing total expenses by total power output in each fiscal year. Figure 2 shows the change in generation costs for each power source for the period of 1971-1995. 'Fossil power generation' represents the total of oil, LNG and coal, since breakdown of each type of fuel is not available in the financial statements.

Although there are similarities in the two cost estimates, the cost estimate by financial statements has been fluctuated more than the cost estimated by 'a model plant' method, and the nuclear power generation cost exceeded fossil power generation cost in the early 1970s and in 1986 and 1988. Judging from these results by financial statements, we believe it is useful to look at the costs by financial statements more carefully.

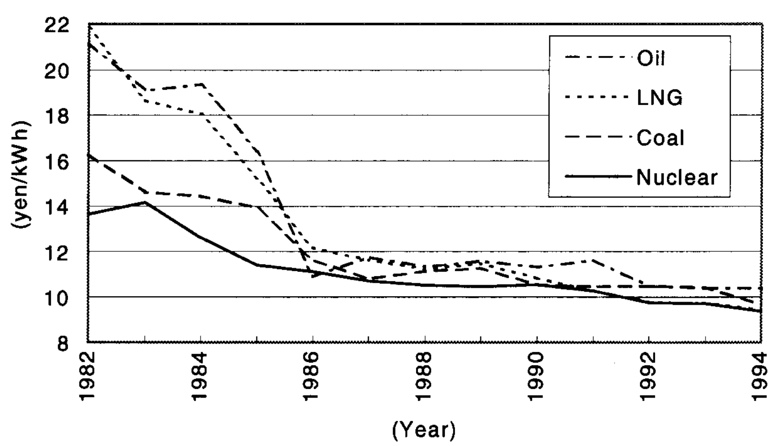

Figure 1 Power Generation Cost Comparison by a model lant method by IEE. (Note) There was no estimate published in 1993, and oil was excluded in the 1994 evaluation. The estimates in 1992 are used for these vacancies.

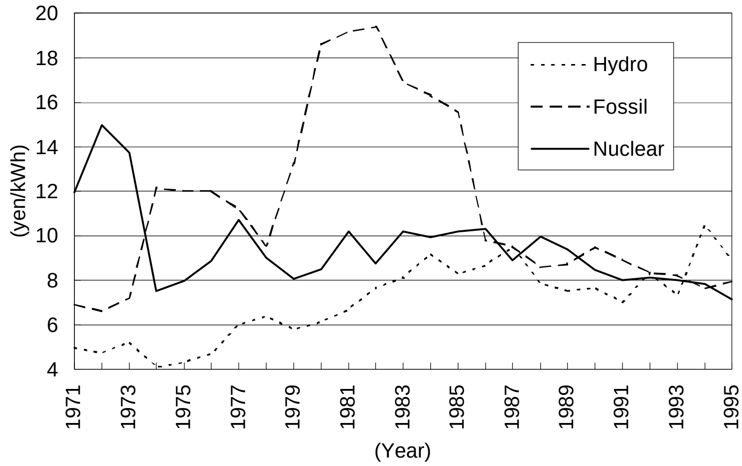

Figure 2 Power Generation Cost by Financial Statements

Cost Structure of Nuclear Power Generation

In this chapter, we analyze the cost structure of nuclear power generation to identify the possible reasons for the cost fluctuation throughout the last 25 years and recent downward trends. Figure 3 and 4 show the trend of nuclear power generation cost and its composition throughout the past 25 years, 1971-1995.

Firstly, we find that capital cost has had the largest influence on power generation cost, and that it has been decreasing steadily since the latter half of 1970s, and is now at 3.5 yen/kWh in 1995, compared with 6.6 yen/kWh in 1977. The share of capital cost in total nuclear power generation costs has also been decreasing throughout the last 25 years, from 73 % in 1971 to 47 % in 1995. Secondly, the share of O&M cost has been increasing steadily, from 12% in 1971 to 33% in 1995, while the O&M cost itself has been relatively constant in the last 10 years. Lastly, the fuel cycle cost and its share have been fluctuating significantly throughout the period: It was 15% (1.7 yen/kWh) in 1971, but increased to 30% (3.2 yen/kWh) in 1985, and was stabilized to 20% (around 1.6 yen/kWh) in the 1990s. Further details of each cost category are analyzed below.

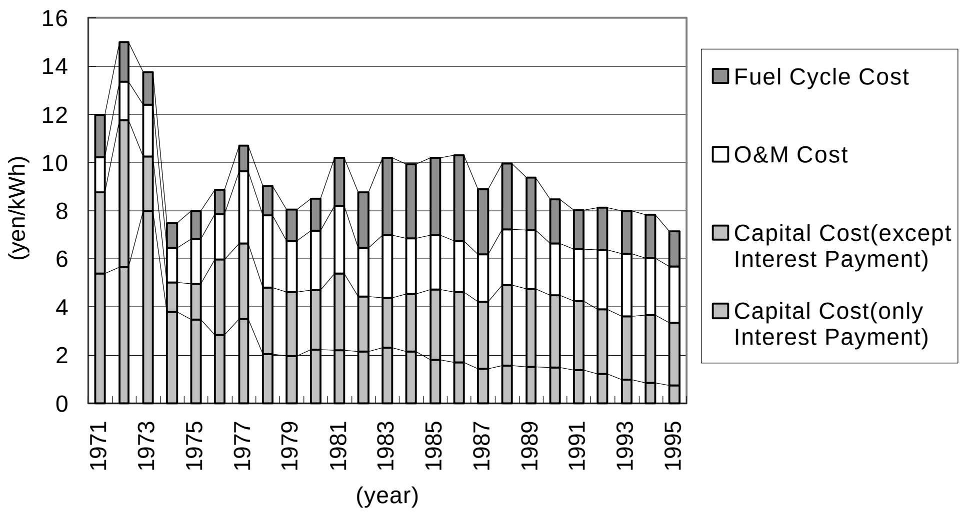

Figure 3 Nuclear Power Generation Cost by Financial Statements

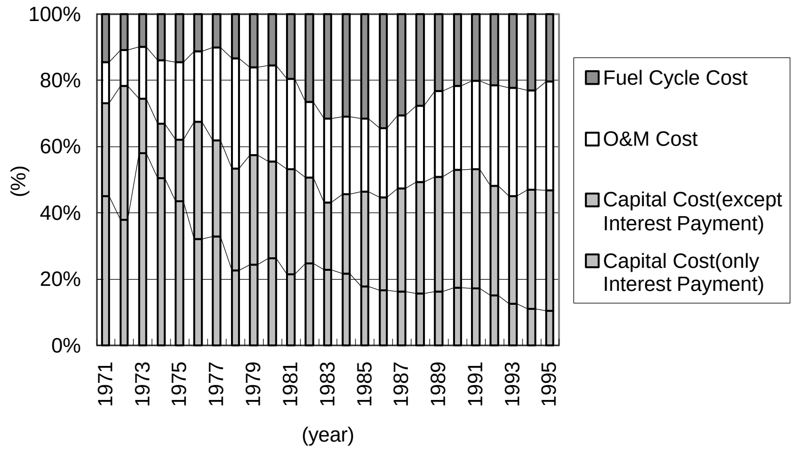

Figure 4 Composition of Nuclear Power Generation Cost

Analysis of Capital Cost: Influence of Interest Payment

As mentioned previously, capital cost, which occupies the largest share in total nuclear power generation cost, has been decreasing gradually throughout the last 25 years. We found that this is mainly due to the decrease in the interest payment, whose share dropped significantly, from 45% in 1971 to 11% in 1995 as in Figure 4.

Let’s examine possible explanations of this decline of interest payment. We decomposed the total interest payment for nuclear into two groups, the interest payment for ‘CWIP’ and the other for ‘EUFA’. We estimated each category of interest payment by the following formulas:

$$\text{Interest Payment for 'CWIP' (Nuclear)} = \text{IP-N} \times \frac{\text{CWIP-N}}{\text{CWIP-N} + \text{EUFA-N}}$$

$$\text{Interest Payment for 'EUFA' (Nuclear)} = \text{IP-N} \times \frac{\text{EUFA-N}}{\text{CWIP-N} + \text{EUFA-N}}$$

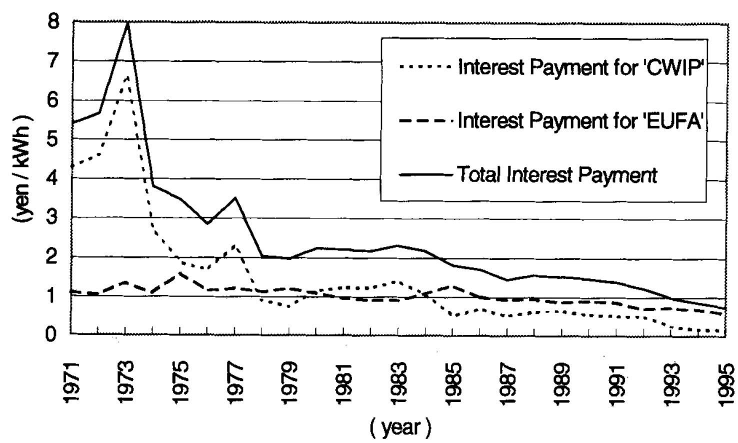

Figure 5 Change of Total Interest Payment for Nuclear Power and Its Breakdown for Each Category (‘CWIP’ and ‘EUFA’**)**

Figure 5 shows a change of total interest payment for nuclear power and its breakdown for each category. It is clear that the interest payment for 'EUFA' had been relatively constant throughout the last 25 years, while the interest payment for 'CWIP' dropped dramatically in the 1970s, and followed closely the declining trend of total interest payment. This means that the interest payment had been greatly influenced by 'CWIP'. There are two possible explanations for the declining of interest payment for 'CWIP', one is the decline of total unit construction cost and the other is the decline of number of new nuclear power plants orders. However, our analysis does not show that either one of them is a major factor. Figure 6 shows that unit construction cost has increased in the last 25 years, although the cost declined slightly in the early 1970s. Besides, the unit construction costs of the first unit of each power station are about 50% higher than those of the succeeding plants, since extra costs (i.e., cost for the common-used facility in the same site) is attributed to the first unit. The construction costs of succeeding units have been relatively constant since the 1980s. Therefore, we conclude that unit construction cost is not a major factor for the decline of interest payment for 'CWIP'. On the other hand, Figure 7 shows the number of new nuclear power plant orders in each year and the long-term interest rate for the utility industry in the last 20 years (the data before 1973 are not available). It is also clear these numbers have not been a major factor for the decline of interest payment for 'CWIP' except for 1972 and after 1992. The only remaining explanation of the decline can be the decline of interest rate itself, although it may not explain fully the total decline of interest payment for 'CWIP'. Although our analysis is not conclusive yet, it is clear that there is no single factor to explain the decline of interest payment. We believe it is important to investigate this question further in more detail.

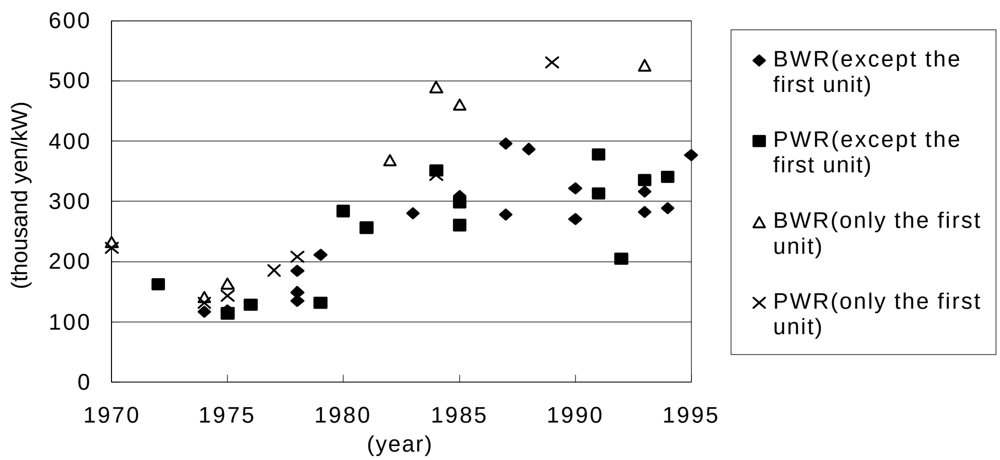

Figure 6 Unit Construction Cost of Nuclear Power Plants in Japan (MITI, 1965-1996)

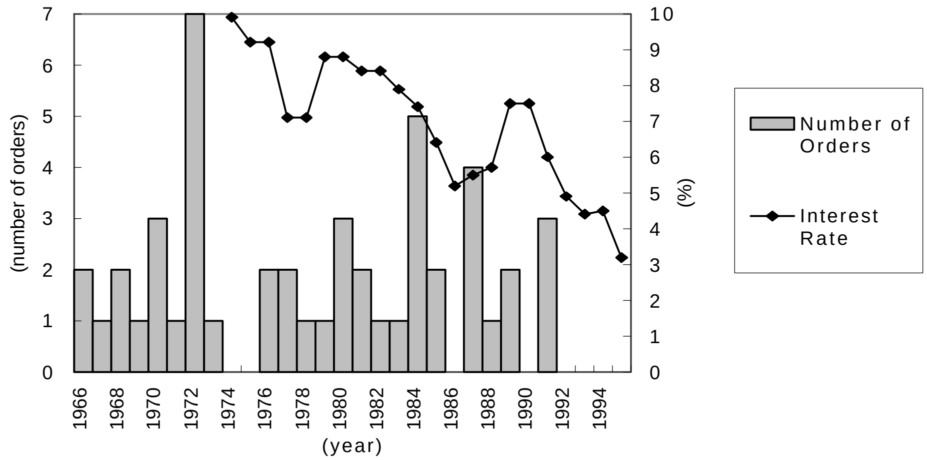

Figure 7 Number of New Nuclear Power Plants Ordered in Each Year and The Long-Term Interest Rate for The Utility Industry (MITI, 1974-1995)

Analysis of O&M Cost : Influence of Repair Cost

Figure 8 shows the composition of O&M cost by the three categories of O&M cost (See APPROACH); personal expenses, repair expenses and others. The share of repair expenses had been increasing steadily until 1986 then remained at about 60%, the largest share in total O&M cost. Therefore we paid our attention to the repair expenses.

Figure 9 shows a change of repair expenses and repair cost (per kWh) of nuclear power. In the latter half of 1970s, repair cost as well as repair expenses have been increasing continuously. This rapid increase in 1975-1977 was primarily due to the long inspection duration. This is confirmed by the low utilization factor (42-52%) for this period. However, since 1980 repair cost has remained rather stable, around 1.3 yen/kWh, although total repair expenses have been continuously increasing. One of the primary reasons for stabilization of repair cost is possibly the improvement of utilization factor. However, considering the fact that the nuclear power plants will be getting older in the future and repair expenses are likely to increase, repair cost can increase. Therefore, O&M cost will become more important in order to reduce the generation cost .

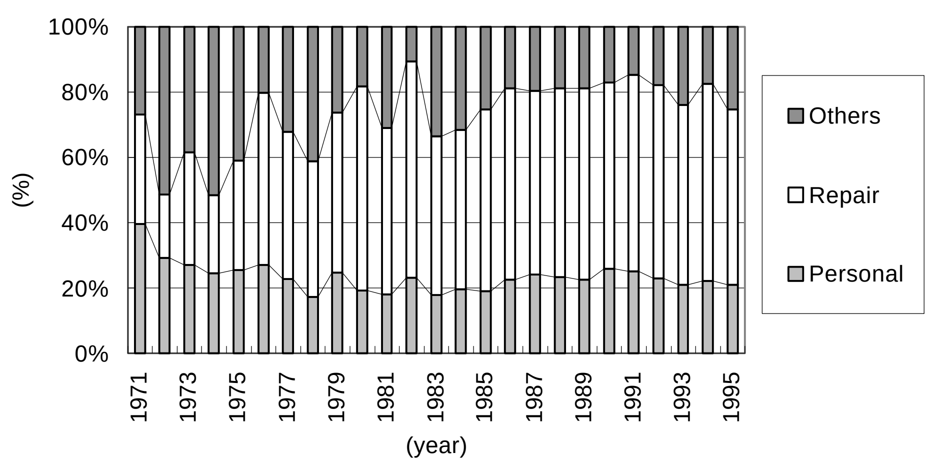

Figure 8 Composition of O&M Cost

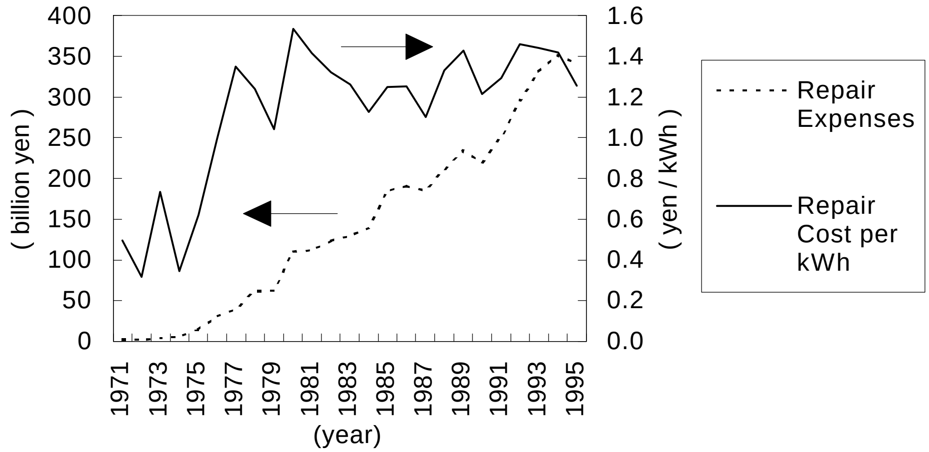

Figure 9 Repair Expenses and Repair cost for Nuclear Power Generation

Analysis of Fuel Cycle Cost: Uncertain Factors of Back End Cost

Figure 10 shows the decomposition of fuel cycle cost by four categories (SEE APPROACH); fuel, reprocessing, waste treatment and disposal, and tax. It is found that the remarkable increase of the fuel cycle cost for the period 1981 to 1990 is attributable to the reprocessing cost introduced to the electricity rate under the new rate regulation since 1981. The share of reprocessing cost reached 50% of the fuel cycle cost but it has been decreasing since then and was about 20% in 1995. The possible explanation for this initial increase of reprocessing cost is the inclusion of reprocessing costs for the old spent fuel when the new rate regulation was applied. Another possible reason for the fluctuations of fuel cycle cost is the rate regulation reform[2] on the provision of reprocessing expenses in 1990 and 1995. Also, Figure 10 shows the potential growing importance of waste treatment and disposal cost, whose share increased steadily in the 1970s and again since 1985. The fuel cycle cost is greatly influenced by the uncertain factors of back-end costs such as reprocessing and waste disposal. Hence, it is not easy to foresee the trend of fuel cycle cost in the future. In particular, it is most likely that fuel cycle cost will become higher, if HLW disposal cost, which has not yet been appropriated to be collected, is included in the electricity charge in the near future. Then, fuel cycle cost can become more important factor to determine the economics of nuclear power in the future.

[2] From 1981 to 1989, according to the rate regulation, the total reprocessing expenses was calculated based on total nuclear fuel burn-up during the given fiscal year. The regulation has been changed to assign 75 % of total burn-up since 1990, and only 70 % since 1995.

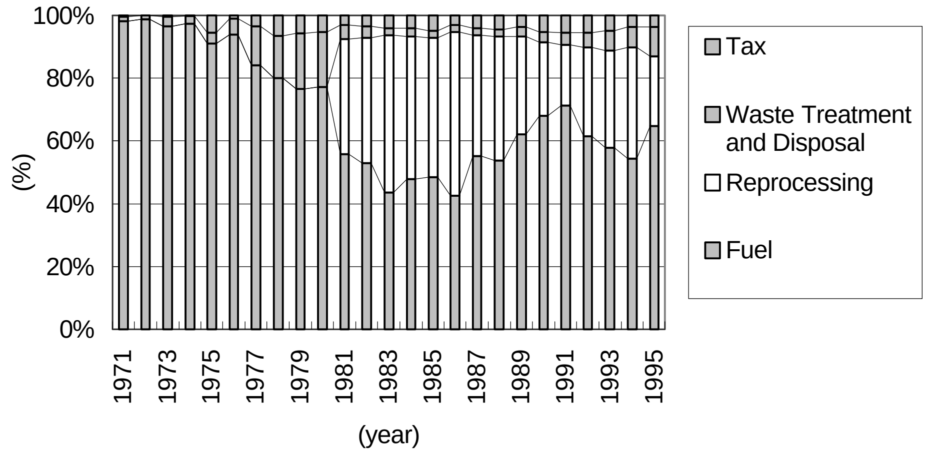

Figure 10 Composition of Fuel Cycle Cost

CONCLUSION

In this report, we analyzed the cost structure of all nuclear power plants in Japan based on financial statements. The results are as follows. (1) The generation cost of nuclear power estimated by financial statements has been fluctuated more than the cost estimated for a model plant, and has been decreasing since late 1980s. (2) The main reason for this decline is the decrease of interest payments. Although interest rate may explain this declining trend partially, it is important to investigate this issue in more detail. (3) Meanwhile, the share of O&M cost has been increasing steadily throughout the past 25 years. (4) Fuel cycle cost is greatly influenced by the back-end of fuel cycle, especially reprocessing cost.

Judging from these results, electric power companies should pay more attention to the reduction of not only the construction cost for new plants, but also interest payment, O&M cost and fuel cycle cost for existing plants, in order to keep competitiveness of nuclear power in the near future.

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KEY WORDS

Financial statements, nuclear power generation cost, O&M cost, fuel cycle cost.