Summary and Evaluation of Cost Calculation for Nuclear Power Generation by the "Cost Estimation and Review Committee"

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Executive summary

In December 2011, following the accident at Fukushima Daiichi Nuclear Power Plant, the government published a report covering the cost estimation for each power generation method. This is a comprehensive response to various questions raised over the conventional cost estimates made by the government, and is considered to become the central axis of discussions to follow from now on. This report states the cost for nuclear power generation at above 8.9 yen/kWh, and is in no way inferior to 9.5 to 9.7 yen/kWh for coal-fired thermal power or 10.7 to 11.1 yen/kWh for LNG thermal power. However, this cost for nuclear power generation is based only on an aggregate value of accident-related countermeasures that can be evaluated as of now, and depending on what transpires in the future, the cost could rise even more.

On the other hand, for renewable energy, the report estimates that onshore wind power generation is around 9.9 to 17.3 yen/kWh, indicating that under favorable conditions, the level of cost is equivalent to that for thermal and nuclear power generation. Although residential solar power generation is currently priced high at 33.4 to 38.3 yen/kWh, with the rapid fall in production costs, it is estimated that it could fall to as low as 9.9 yen/kWh by the year 2030. However, this calculation does not take into account the cost for providing protection measures for the power distribution network system when large quantities from unstable power sources are introduced. In this sense, this could be considered to be the lower limit. From now on, it will be required to assess these uncertain factors in details, and to further the accuracy of our understanding of power generation costs through comparison with other domestic and external cost estimation results.

1. Introduction

On December 19, 2011, the Cost Estimation and Review Committee established within The Energy and Environment Council released a report[1)] stating the results of power generation cost estimation for various types of power generation, such as thermal, nuclear and renewable energy. The details of their calculation method were accompanied by an excel file that contains the actual calculation table. We have never seen a transparency level this high regarding the comprehensive evaluation of power generation cost that involved the full-scale efforts of the government. This document provides the background leading to this cost estimation and its overall summary.

2. Background to the power generation cost estimation

Conventionally in Japan, power generation costs by source was evaluated based on a report by the Subcommittee to Study Costs and Other Issues [2)] published in 2004. According to this report, assuming a discount rate of 3%, a 40-year operation life, and a capacity factor of 80% (45% in case of hydro power), nuclear power generation is said to be a cheaper power source at 5.3 yen/kWh than other generation methods, such as 11.9 yen/kWh for general hydro power, 10.7 yen/kWh for oil-fired thermal power, 6.2 yen/kWh for LNG thermal power and 5.7 yen/kWh for coal-fired thermal power. However, nuclear power could cost more and is not necessarily cheaper than other power sources under all circumstances. Following the expression used in the report, the profitability of nuclear power generation "is not inferior in comparison with other power sources."

Against this backdrop, there were views raised mainly by those opposed to nuclear power generation that these

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cost estimation results were not appropriate. This issue became the center of focus after the accident at Fukushima Daiichi Nuclear Power Plant on March 11. In some media, the truth or false of the "fable of nuclear power generation being low cost" was widely reported and the estimation by Blackburn et al.[3] stating that "with the rise in nuclear power generation costs and the fall of solar power generation costs, the level of the two are already at par with each other, and in a couple of decades, nuclear power will be more expensive and solar power will become even cheaper" was much publicized.

The problems of the conventional power generation cost estimation in Japan can be summarized as follows:

(1) Opacity of cost estimation methods

In the report by the 2004 Subcommittee to Study Costs and Other Issues, although the premise for the calculation is described in detail, it is not possible to reproduce the calculated results based on the specified data. While this made it impossible to verify the cost estimates on one hand, on the other hand, this made it possible to "evaluate" the cost independently by using inaccurate methods and make a claim that the cost estimation made by the Subcommittee to Study Costs and Other Issues was incorrect.

(2) Skepticism surrounding the use of the model-plant method

According to the book written in 2010 by Professor Kenichi Oshima of Ritsumeikan University entitled "The Political Economics of Renewable Energy," [4] an evaluation of actual data obtained from corporate financial statements (*Yuka Shoken Hokokusho*) shows that when the cost of pumped storage power generation is included in nuclear power, the unit cost for nuclear power rises to 12.23 yen/kWh and is higher compared with 9.9 yen/kWh for thermal power and 3.98 yen/kWh for general hydro power (excluding pumped storage). Based on this result, the tone of some of press reports indicated that the result of cost estimation based on the model-plant method adopted by the Subcommittee to Study Costs and Other Issues is imaginary and is not founded on actual conditions and that in terms of actual money incurred, the cost for nuclear power is higher.

(3) The presence of "hidden costs"

In the above estimation by Professor Oshima, costs associated with location; R&D expenses for nuclear power generation; and costs required for pumped storage power generation have been added to the cost of nuclear power. These costs, which had not been recorded in conventional power generation costs, are called "hidden costs" and because of these, many argued that nuclear power generation should have actually been much more costly.

(4) Cost increase after the Fukushima accident

With the Fukushima Daiichi Nuclear Power Plant accident, many naturally started to argue that damage caused by an accident at a nuclear power plant should be booked automatically as costs. In addition, some speculated that improvements in safety measures implemented after the accident will raise the construction unit cost for nuclear power generation facilities, leading to an increase in power generation costs.

(5) Assessment of nuclear fuel cycle costs

The 2004 Subcommittee to Study Costs and Other Issues assessed the total operation cost of back-end operations of the nuclear fuel cycle to be 18.8 trillion yen. And using a discount rate between 0% and 4%, the committee estimated the nuclear fuel cycle cost to be 1.83 to 1.43 yen/kWh (including both the front and the back end), and assessed the overall cost for nuclear power generation (at 80% capacity factor) to be 5.0 – 5.6 yen/kWh. However, there is speculation that the assessment of back-end costs in particular was much smaller, in view of the delays in the plans for the Rokkasho-mura reprocessing plant and the progress of high-level radioactive waste disposal plans, etc.

(6)　Comparison with the power generation unit cost indicated in the “application for reactor establishment permit”

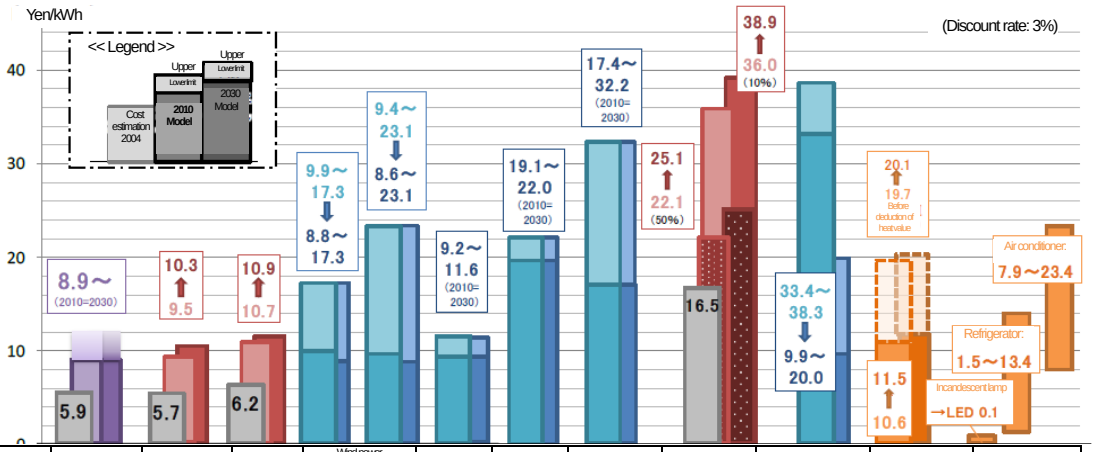
“Application for reactor establishment permit” is an application for obtaining a review on security safety, etc. by administrative agencies when power companies are planning to construct nuclear power plants. The application includes detailed data on the design, geological and foundation conditions, etc. of the subject nuclear reactor. In this document, there is a list for the “power generation cost.” Although its calculation method is not provided at all, it shows the cost in yen to be more than a dozen/kWh or even higher. This number is apparently higher than the one given by the Subcommittee to Study Costs and Other Issues. This has given rise to speculation that the power companies themselves are actually evaluating a higher cost for nuclear power generation.

Based on these points, the “Cost Estimation and Review Committee” this time has targeted complete transparency -- incorporating as many elements as possible – in re-conducting cost estimates while securing its objectivity. Although the committee members do not include all the leading experts and research organizations in Japan, it has become possible to incorporate diverse opinions from a wide selection of members including the aforementioned Professor Oshima. It may be accurate to say that this became possible only because of a crisis situation triggered by the Fukushima Daiichi Nuclear Power Plant accident.

3.　Cost estimation results by the “Cost Estimation and Review Committee”

The power generation cost indicated in the report by the “Cost Estimation and Review Committee” is as indicated in Figure 1. Please note that this is one example of the cost estimation and is not the “Power generation cost finalized by the Committee.” Even with such annotation, the risk which always occurs is that only these summarized figures are much publicized with undue notice in the media. However, this is inevitable when writing reports. Rather, the persons receiving this information should understand the contents accurately and should acknowledge the amount of uncertainty that exists in the figures listed here and how the cost could fluctuate depending on the situation. In this document, only the results are stated because of limited space. However, it goes without saying that further detailed studies will be necessary.

[Points for cost estimation]
- Model-plant method (established based on power plants that began operations within the last seven (7) years and the history of the amount of subsidies for the last three (3) years)
- Added social costs, such as CO2 countermeasure costs, nuclear power accident risk response costs, policy expenses, etc.
- Models for 2020 and 2030 have been estimated by incorporating rise in fuel costs and in CO2 countermeasure costs, and price reduction through technical innovation.



	Nuclear power	Coal-fired thermal power	LNG thermal power	Wind power: Onshore	Wind power: Offshore, embedded	Geo-thermal power	Micro hydro power	Biomass power (dedicated wood burning)	Oil-fired thermal power	Photovoltaic (residential)	Gas co-generation	Energy saving
Scenario, etc.	Nuclear fuel recycle current model	New policies scenario	New policies scenario	stagnant→fall	stagnant→fall	-	-	-	New policies scenario	Reference→paradigm shift	New policies scenario	-
Capacity factor	70%	80%	80%	20%	30%	80%	60%	80%	50%, 10%	12%	70%	-
Years of operation 2010 Model(2030 Model)	40 years	40 years	40 years	20 years	20 years	40 years	40 years	40 years	40 years	20 years (35 years)	30 years	-
Notes - Point Red: Increase factor Blue: Reduction factor Black: Other (including notation related to introduction potential)	8.9 yen is lower limit, increments in 0.1 yen for every 1 trillion yen spent on damages from an accident in excess of 5.8 trillion yen. Rationalization by next generation light water type reactors not included quantitatively.	Increase in fuel costs, CO2 countermeasure costs Increase in generating efficiency	Higher weighting for fuel costs Increase in generating efficiency Key to the merits of using shale gas depends on resource strategy.	Possible cost reduction through mass production effect Expansion of location requires restrictions/system changes and power distribution network reinforcement.		Promising as a stable power source. Problem exists with the cost of power lines. Requires solving location-related issues to expand the quantity of possible introduction.	Stable power generation possible. Many possible locations	Fuel cost will fluctuate by the collection and transport of unused forest thinning, etc.	Mainly increase in fuel costs	Possible reduction in cost by 50% with mass production effects. Even further reduction may be possible with the realization of next generation solar cells. Distribution network system enhancement measures necessary for mass introduction.	When use of heat is considered, it could be about the same as a large-scale concentrated power source. Big merit to users when power cost cuts (industrial, operational 13.7 yen) are considered.	Variance depending on equipment Large merit when considering reduction in power charges (residential: 20.4 yen)
Approach from now on	- Accident cost for nuclear power: figures to be reviewed as soon as the latest information becomes available. - Cost reduction by technical innovation and mass production effects: Review of estimate results and incorporation into cost estimates by taking heed of any progress made in technical renovation and trends in proliferation of the energy source. - Distribution system stabilization measures: Estimate for each scenario once the scenario of energy mix has been decided. - Economic effect: Analyze and estimate cost as a macro effect, when scenario of energy mix has been decided.											

Source:　Cost Estimation and Review Committee Report [1)]

Figure 1.　Power generation cost of major power sources

As uncertainties remain in the amount of damage caused by the accident, the “lower limit” of the cost of nuclear power generation has been indicated at above 8.9 yen/kWh. This is broken down into 2.5 yen/kWh for capital costs, 3.1 yen/kWh for operation and maintenance costs, 1.4 yen/kWh for nuclear fuel cycle costs, 0.2 yen/kWh for additional safety measures, 1.1 yen/kWh for policy expenses and more than 0.5 yen/kWh for response to accident-related risks. What used to be booked as “power generation costs” (capital costs, operation and maintenance costs, nuclear fuel cycle costs and safety measures) comes to approximately 7.3 yen/kWh, slightly higher than the conventional estimate of 5 ~ 6 yen/kWh. Around 1.6 yen/kWh is required in addition as policy expenses and the cost for response to accident-related risks.

On the other hand, in relation to the increase in fossil fuel costs, costs for both coal-fired thermal power generation and LNG thermal power generation are increasing and the former comes to 9.5 ~ 9.7 yen/kWh (10.3 ~ 10.6 yen/kWh in 2030, in case CO_2 countermeasure cost has increased), the latter to 10.7 ~ 11.1 yen/kWh (similarly 10.9 ~ 11.4 yen/kWh). In other words, a comparison of nuclear power, thermal power and renewable power (to be mentioned later) sources end up being a reproduction of the cost estimation in the 2004 report, which stated that the “profitability of nuclear power generation is not inferior in comparison with other power sources.” However, the focus of the cost estimation this time is the positioning of this cost estimate as the “lower limit,” indicating that it could become higher depending on the amount of damage caused by the accident. Specifically,

this points to an increase of 0.09 yen/kWh in accident risk costs for every 1-trillion-yen increase in the amount of damage. When the amount of damage is in the order of 10 trillion yen (0.9 yen/kWh increase in accident risk costs), the abovementioned result does not change, but an increase in the damage to the tune of 50 trillion yen (similarly 4.5 yen/kWh) greatly impairs the relative superiority of nuclear power generation.

Regarding renewable energy power generation, the salient feature is to envisage the "possibility" of a significant reduction in costs, especially in solar power, etc. in the future. Specifically, while the cost for residential-use solar power generation is estimated to be 33.4 ~ 38.3 yen/kWh in 2010 (with a 20-year operation life), the estimate is 9.9 ~ 22.0 yen/kWh for 2030 (with a 35-year operation life). For wind power, while it is 9.9 ~ 17.3 yen/kWh for onshore installation in 2010, "the possibility of cost reduction" brings the cost to 8.8 ~ 17.3 yen/kWh for onshore and 8.6 ~ 23.1 yen/kWh for off-shore in 2030.

However, this cost estimation does not include costs related to measures for distribution network systems when renewable energy like solar and wind are introduced. In this sense, these costs for renewable energy power generation are also the "lower limit," similar to those for nuclear power. This being the case, the conclusion is that "even though there are issues to be addressed" regarding measures for distribution network systems, costs related to renewable energy sources can be equal to those for thermal and nuclear power under favorable wind conditions or when costs have been reduced significantly.

Also to be noted is that this cost estimation has been conducted for co-generation and energy savings as well. Specifically, when acknowledging the value of using generated heat, in addition to power generation, gas co-generation could be cost-competitive. As for energy savings, for example, the use of LED will cost less than 0.1 yen/kWh in facility costs only and when considering its energy saving merits in homes (reduction in electricity bills), it will amount to the net amount of 20.3 ~ 20.4 yen/kWh in negative costs (merit is far greater than cost) indicating a very strong cost competitiveness. It can be said that when thinking of the future of power-related supply and demand in Japan, the highest priority should be placed on the promotion of energy saving to the maximum.

4. Evaluation of cost estimation results

As mentioned above, the cost estimation this time was conducted and founded on many questions raised against the cost estimation made by the "Subcommittee to Study Costs and Other Issues" in 2004. So, has this cost estimation provided clear answers to the questions and criticisms raised? How much new results are there? The evaluation of the cost estimates from those viewpoints is described as follows:

(1) Transparency of the cost estimation method

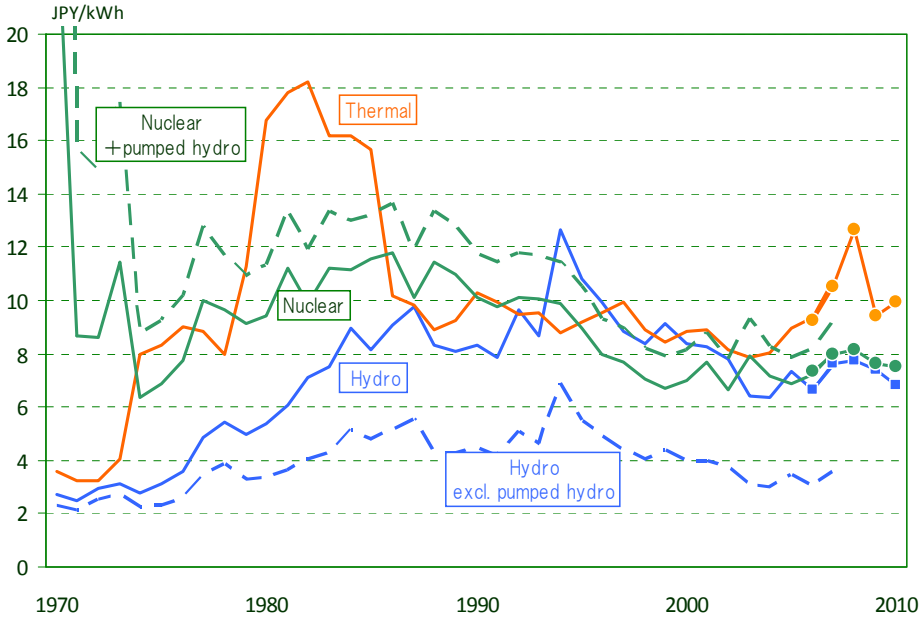
The most salient feature of the study this time is exhaustively organizing various elements employed in the calculation and releasing the excel files used for the cost estimation, as mentioned previously. We should give kudos to the huge amount of labor spent on this task. Generally speaking, the specific method of calculation under the term of "a method using model plant" normally varies from person to person, and the release of a comprehensive excel file, as was done this time around, could have a deficit: it could cover up the variances of each method in the future discussions, and could result in implicitly forcing a de-facto standard to the estimators. For example, in the world-wide referenced cost estimation by OECD [5)], interest, etc. accrued during the construction of the power plant is included in the calculation. This cannot be calculated in the excel sheet released this time, but this point is considered to be minor compared with its merit: it enables those without detailed knowledge of these types of calculation to easily compute by changing the conditions. It is expected in future that various people who have taken an interest in power generation costs and make a statement about them will use these data for their own calculation and hold discussions based on quantitative evidence.

(2) Comparison vs data from corporate financial statements

This cost estimation is based on the model-plant method and will differ slightly from the cost estimates that are based on actual numbers obtained from corporate financial statements (*Yuka Shoken Hokokusho*). This has been addressed on page 72 of the report in the form of a comparison table with the cost estimation results by Professor Oshima.

In this comparison, the 8.9 yen/kWh "lower limit" for nuclear power does not differ greatly from the cost estimation figure for the power generation unit cost as presented by Professor Oshima based on data from corporate financial statements (*Yuka Shoken Hokokusho*). However, if the supposition of the author is correct, then the unit cost by the "corporate financial statement method" indicated in this chart is the "power generation unit cost" estimated by Professor Oshima. And the "total unit cost" separately including development unit costs and location unit costs will be higher than this figure. On the other hand, the cost estimation using the model plant includes these development and location unit costs, leading to a belief that the subject of comparison is not necessarily the same.

The "total unit cost" of nuclear power estimated by Professor Oshima averaged 10.68 yen/kWh between 1970 and 2007 and averaged 8.93 yen/kWh between 2000 and 2007. So 8.9 yen/kWh, the cost estimation for this time based on the model-plant method, is lower than the former and about the same level as the latter.



Source: 1970 ~ 2007: Oshima [4]. 2006 ~ 2010 The Institute of Energy Economics, Japan [6]

Figure 2. Power generation cost estimation based on corporate financial statements (*Yuka Shoken Hokokusho*)

Generally, the cost of nuclear power generation calculated based on the corporate financial statements has been on a downward trend every year. This is said to stem from accelerated depreciation as a result of a drop in the number of construction of new nuclear power plants most recently, especially in the 2000s [7]. But this is not accurate. The cost of nuclear power indicated in the corporate financial statements has declined along with the drop in long-term lending rates. Therefore, when considering future power generation costs, it is more appropriate to use the most recent data that reflect lower interest rates compared with the 1980s, when interest rates were high. In fact, the total unit cost of nuclear power generation in the 2000s culled from data in the corporate financial statements is almost equal to the cost estimation made this time around based on the model-plant method. In any

case, it is clear that this statement is incorrect: “the cost estimation for nuclear power was cheaper using the model-plant method, but was actually higher when using actual data.” That said, an important area in research in the future will be a detailed comparison between power generation costs and the breakdown of the data in the corporate financial statements.

The corporate financial statements do not mention the comparison with power generation unit costs described in the “application for reactor establishment permit.” As mentioned above, there is no indication of how the unit cost stated in the “application for reactor establishment permit” has been calculated. And because there is no comparison made with other power sources, this has been considered to be inappropriate to use in evaluating power generation costs. In any event, this unit cost refers to power generation cost for the “initial year” or “legal service life” and assuming a 40-year operation of a nuclear power plant, we must consider the fact that the cost would be even lower. Identifying the calculation method for the power generation cost stated in the “application for reactor establishment permit” and comparing it with that based on the model-plan method could be a useful topic of discussions in the future.

As for thermal power, the model-plant cost estimation for coal-fired thermal is a very high number, but the average number for coal-fired thermal and LNG thermal power is equal to the cost estimate using data from corporate financial statements. With the steep rise in fuel prices, fuel costs make up 70% to 80% of total costs for LNG thermal power in particular, meaning power generation costs are determined mostly by the primary fuel price, the thermal efficiency and the carbon price. In considering Japan’s energy security, we should remember that the cost of thermal power generation is determined primarily by fuel prices. The cost of oil-fired thermal power is high at over 20 yen/kWh partly due to the price of oil per calorific value being higher than the price for natural gas or coal. Also, the high cost is partly because the calculation incorporates the average heat efficiency (39%) of aging oil-fired thermal power plants (start-up: 1987 ~ 1998). In Japan, oil-fired thermal power generation has been used continuously in response to peak demand and emergency power supply. This demonstrates the fact that costs alone do not simply dictate power source selection.

The hydro power generation cost estimation based on data from corporate financial statements is significantly lower than that derived from the model plant method. This is because the capital cost of fully depreciated hydro power plants cannot be evaluated from the corporate financial statements.[6)] In evaluating these cost estimates, we can say that the one using the model-plant method is more objective.

The geo-thermal power generation cost is estimated at 9.2 ~ 11.6 yen/kWh using the model-plant method and is slightly higher than 8.9 yen/kWh [7)] using data from corporate financial statements for FY 2009 and FY 2010. This is because the geo-thermal plants currently in operation are located in places with favorable conditions. And like hydro power, there may be some effects of depreciation of geo-thermal power generation plants.

(3) Comparison vs cost estimation by the “Subcommittee to Study Costs and Other Issues” of 2004

The cost estimates by the “Subcommittee to Study Costs and Other Issues” of 2004 showed the cost of nuclear power generation at 5.9 yen/kWh based on an assumed discount rate of 3% and a capacity factor of 70%. In comparison, the model-plant method used this time around estimates the total at 8.9 yen/kWh. This is based on an increase of 0.2 yen/kWh in capital costs, a 1.0 yen/kWh rise in operation and maintenance costs, a 0.1 yen/kWh decline in nuclear fuel cycle costs, and an additional increase of 1.6 yen/kWh for policy expenses and costs for responding to accident-related risks. The increase in operation and maintenance costs here mostly stems from the repair rate, the miscellaneous charge rate and the change in the construction unit cost. (The repair rate and miscellaneous charge rate are presumed proportional to construction costs. Therefore, an increase in the construction unit cost has a large impact on operation and maintenance costs.) Specifically, the construction unit cost is presumed to have increased from 279,000 yen /kW in the 2004 cost estimate to 350,000 yen/KW in the latest calculation, but this rise is appropriate judging from nuclear power plant construction costs in the past.

While such differences exist, the actual difference in the cost estimation of 2004 and the latest one can be

explained mostly by changes in various factors. The main point here is that the latest cost estimation includes a higher evaluation of “1.6 yen/kWh and over” for policy expenses and costs for accident-related risks.

(4) “Hidden costs” and evaluation of cost increase after the Fukushima accident

As mentioned above, the most notable item in the latest cost estimation is the so-called “hidden costs” that are set at “1.6 yen/kWh and over” for an additional increase.

Location unit costs, development unit costs and pumped-storage power generation costs are among those considered to be “hidden costs” for nuclear power. The latest cost estimation does not include pumped-storage power generation costs. But this is considered acceptable because pumped-storage costs are not always incurred in nuclear power generation and costs required for network systems such as those related to the mass introduction of renewable energy have not been added. Development and location unit costs which have been added as “policy expenses” this time are estimated at 319.3 billion yen in this calculation based on the FY2011 budget. This total is then divided by the total amount generated in FY2010, resulting in 1.1 yen/kWh, and is added on to the total number for hidden costs. These expenses have been added to hidden costs for nuclear, thermal, general hydro and co-generation power, and not to other renewable energy, because it is not considered appropriate to “define the power generation cost by dividing the budgeted amount for the power source by the nominal amount of power generation in the most recent period.” On the other hand, for nuclear power, also added on to the total is the cost related to advanced R&D for fast breeder reactors, etc., not the current power generation using light water reactors. Because of this, we cannot avoid critics from saying that the evaluation of these “policy expenses” seems to be excessive for nuclear power, while some costs related to renewable energy should be added. However, given that the amount of excess in nuclear power is still less than 1 yen/kWh, its impact on the overall evaluation is minor.

Costs of safety measures related to the Fukushima accident is estimated at 0.2 yen/kWh based on the assumption of a 70% capacity factor and expense of 19.4 billion yen per power plant for safety measures instructed by the government to date. There is a high possibility of additional safety measures and thus 0.2 yen/kWh should be considered as the “lower limit.” However, in terms of the scale of expenses, the important area to examine here is the costs for responding to accident risks, as mentioned below.

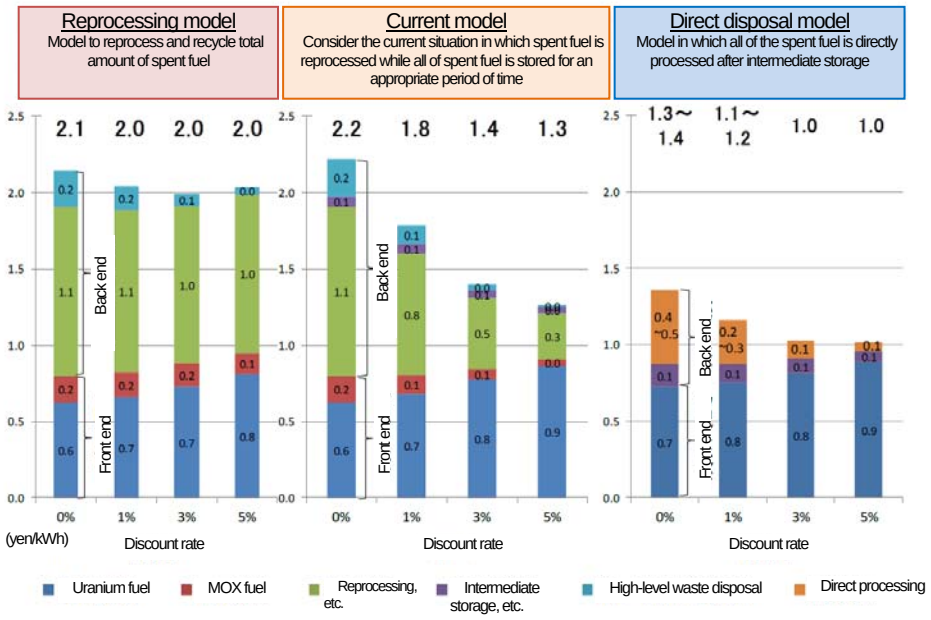
As for costs of accident-related risks, the total amount is estimated at 5.8 trillion yen, which incorporates the estimation provided by the Japan Atomic Energy Commission as well as additional costs for reactor decommissioning and compensation for damages after the accident. Based on this number and the premise that operators will all share such costs, cost for accident-related risks is computed at 0.5 yen/kWh. This number is obtained by dividing 5.8 trillion yen by 40 years of service life for the model plant and then by 272.2 billion kWh, the total amount of power generated in Japan in FY2010.

There are two points to be noted here. The first point is that this 5.8 trillion yen estimate is at the current stage, meaning that the cost of reactor decommissioning or the cost of liabilities has yet to be fixed, and calculations have not been made for intermediate storage facilities, the final disposal facilities or the effects on human life and the body. Therefore, this estimate should be considered as the “lower limit.” And as mentioned above, this will result in an increase in costs at a rate of 0.09 yen/kWh, should the amount of damage increase by 1 trillion yen (1 trillion yen, divided by 40 years, and divided by 272.2 billion kWh). The second point is that this is only one estimate result using a single method, out of many cost estimates, and depending on other method, the same 5.8-trillion-yen estimate for damages could yield a different amount of increase in costs. In fact, results will vary widely depending on whether 3.5×10^{-4} -- the probability of accidents based on the global operation record for nuclear power plants -- is used or 2.0×10^{-3} -- based on the operation record of nuclear power plants in Japan -- is used, or neither of them are incorporated in the calculation like this time. These points are controversial, and we need to keep in mind that this cost estimation is just one among the many methods being used.

(5)　Nuclear fuel cycle cost

For nuclear fuel cycle costs, the model-plant cost estimation utilizes results from a study conducted by the Japan Atomic Energy Commission. These costs are as follows based on a discount rate of 3%: 1.4 yen/kWh for “current model” (50% of the spent fuel is stored for 20 years and then reprocessed, while the remaining 50% is to be stored for 50 years and then reprocessed); 2.0 yen/kWh for the “reprocessing model” (all spent fuel to be reprocessed after 3 years); and 1.0 yen/kWh for the “direct disposal model” (all spent fuel to be directly disposed of after 54 years). Of special note is the result for “current model,” which is almost at the same level as 1.5 yen /kWh, the result yielded by the 2004 Subcommittee to Study Costs and Other Issues. “Nuclear fuel cycle costs” include both the front- and the back-end costs and all costs for reprocessing and waste disposal. The breakdown of 1.4 yen/kWh for the “current model” is as follows: 0.77 yen/kWh for uranium fuel; 0.07 yen/kWh for MOX fuel; 0.46 yen/kWh for reprocessing; 0.05 yen/kWh for intermediate storage; and 0.04 yen/kWh for high-level radioactive waste disposal. For example, high-level radioactive waste disposal requires a staggering cost of 2.7 trillion yen. However, because the total amount to be processed is large, its effect on the cost per unit of power generation amount is relatively small.

The feature of this cost estimation, compared with that made in 2004, is that the abovementioned costs are evaluated by newly reflecting the latest figures, and that a sensitivity analysis was conducted based on a 50% increase in the unit cost for reprocessing and MOX fuel. This sensitivity analysis is believed to have been conducted in response to the question of whether the back-end costs in the 2004 cost estimation was excessively small given the delay in plans for the Rokkasho-mura reprocessing facility. A 50% increase in the unit cost for reprocessing and MOX fuel would raise the cost of the nuclear fuel cycle in the “current model” from 1.4 yen/kWh to 1.64 yen/kWh. This 50% rise in costs would exceed the cost increase related to a 5-year delay and a construction cost increase of 3 trillion yen from the current reprocessing plan (the construction cost of the Rokkasho reprocessing facility is 2.2 trillion yen, and the additional capital investment of 3 trillion yen is equal to a complete scrapping and building of the reprocessing facility). This cost estimation shows that the impact of the delay in the reprocessing plan and additional capital investment in the reprocessing facility on overall nuclear power generation costs is not large, so long as it is within a realistic range.



Source:　Cost Estimation and Review Committee Report [1)]

Figure 3.　Nuclear fuel cycle cost

(6)　The cost of renewable energy

The salient feature of solar and wind power generation in this study is that they incorporate the “possibility” of a significant reduction in costs by 2030. For example, for residential solar power generation, the current construction unit cost of 480 ~ 550 thousand yen /kW will be reduced to 189 thousand yen/kW, at the least, by 2030 based on the “Paradigm shift scenario.” This, in turn, is expected to reduce the cost of power generation down to 9.9 yen/kWh, which is on par with nuclear and thermal power generation. This is based on a forecast by Greenpeace and European Photovoltaic Industry Association (EPIA)[8] for the amount of introduction of solar power generation system. They estimate that the global capacity of solar power generation facilities will reach a maximum 1,844,940 MW by 2030, and in the course of reaching this production capacity, the development of a learning curve at a progress rate of 80% is presumed to reduce costs. This estimate for global capacity of solar power generation facilities is almost 3 times larger than the introduction amount of the most ambitious scenario among the forcast by International Energy Agency (IEA) [9], in which the greenhouse effect gas concentration is to be stabilized at 450 ppm (450 scenario). How Greenpeace and EPIA reached these figures is not necessarily clear. However, we should note that this forecast is far higher than any supply and demand forecasts for solar power generation among those for entire energy made by organizations like the IEA or the Department of Energy (US-DOE).[10]

Solar power generation costs are expected to fall further and this is expected to come not only from the effects of mass production but also from technical innovation. For example as indicated in Figure 4, in the cost reduction scenario by New Energy and Industrial Technology Development Organization (NEDO), the target is to achieve 7 yen/kWh or even lower by 2030. However, cost reduction will not be achieved by simply following the mass production effect curve. Cost cuts will come from the introduction of technical innovations that differ from conventional methods, resulting in a phased reduction in costs. As indicated, in order to cut solar power generation costs, R&D must be actively pursued. It is also necessary to keep a close watch on how far costs will fall.

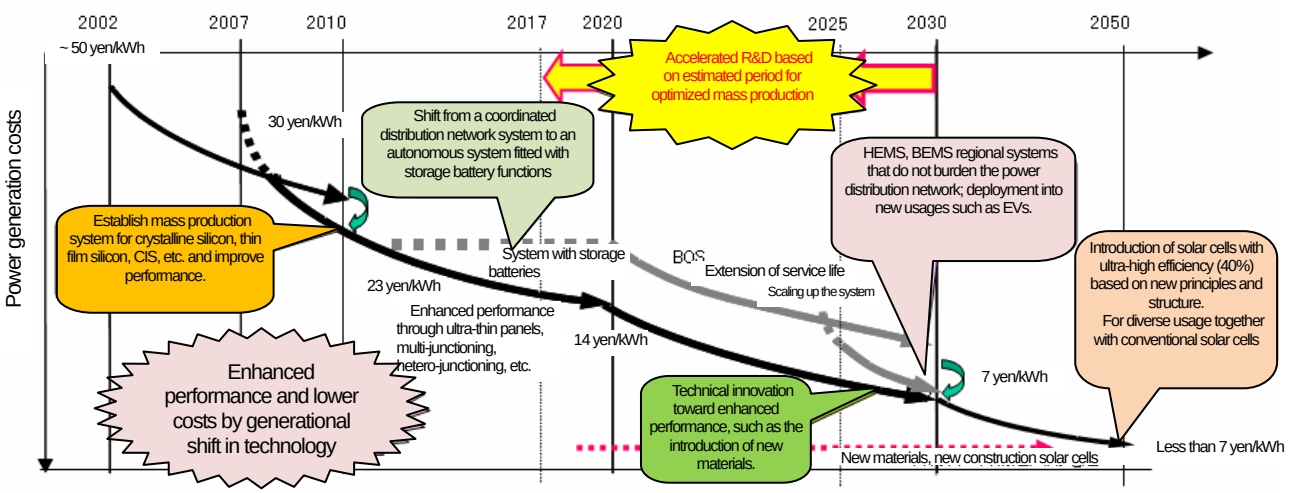


Figure 4. Cost reduction scenario for solar power generation

Source: NEDO[11)]

5. The challenges that lie ahead

As can be seen, the “Cost Estimation and Review Committee” report provides full answers to the conventional questions and clearly indicates the remaining challenges as the issues that need to be addressed. For example, the inappropriateness of adapting the cost estimation results by Blackburn, et al to Japan has been pointed out in the past [6) 12)], and the report also reconfirms this view. Although many arguments still need to be resolved, we believe that discussions concerning power generation costs in Japan will be based on this report from now on.

Thermal power generation costs are largely dependent on fuel and carbon prices, and solar power generation costs are affected by trends in the reduction of construction costs. Nuclear power generation costs are impacted by the amount of future costs incurred for the Fukushima Daiichi Nuclear Power Plant accident. It is important to review the results based on the latest conditions in the future where appropriate.

In this cost estimation, costs related to the electricity grid have not been incorporated. As mentioned in the report, this must be revisited when drawing up the energy mix for Japan in the future. The actual selection of power source should not be determined by costs alone. In that sense, while keeping the model-plant cost estimation in mind, the study of energy mix must be made from a broad perspective.

The model-plant cost estimation is based on total construction costs incurred during a specific life time of the nuclear power plant, from its construction to its closing. However, in terms of deciding whether to operate or close an existing nuclear power plant, it is necessary to consider the cost of operating a power plant which has been already constructed. Evaluating this type of scenario is also issue to be addressed in the future. Another issue to be addressed and studied is the comparison of these results with the results of cost estimates using other methods. As mentioned above, in Japan, there are power generation cost estimates that are based on corporate financial statements and there are power generation costs stated in the “application for reactor establishment permit.” A study of their similarities and differences and the reasons behind them should prove to be very useful in deepening the understanding of the actual status of power generation cost. In addition, overseas power generation cost estimates tend to indicate a separate trend from the results of the estimation for this time; comparing the two results would lead to a further understanding of the characteristics of each cost estimation method and the salient features according to each nation. A more accurate understanding of power generation costs through these endeavors will be required in the future.

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