

July 19, 2011

FY2020 Nuclear Generating Cost Treble Pre-Accident Level

– Huge Price Tag on Fukushima Accident Cleanup –

Tatsuo Kobayashi, Senior Economist

Most observers now believe it will take several decades to clean up the accident at Tokyo Electric Power Company's Fukushima Daiichi nuclear power station which took place in the wake of the Great East Japan Earthquake.¹ "Impact to last Decade or more if Existing Nuclear Plants Ceasing" ([http://www.jcer.or.jp/eng/research/pdf/pe\(iwata20110425\)e.pdf](http://www.jcer.or.jp/eng/research/pdf/pe(iwata20110425)e.pdf)), we estimated it would reach ¥5.7 to ¥20 trillion over the next ten years. Based on this estimate, we have calculated the estimated cost of electric power generation from nuclear plants. By fiscal year 2020 (April 1, 2020 – March 31, 2021), the generation cost of 1 kilowatt hour (kWh) of electric power from nuclear plants could reach ¥17, or about three times that of pre-accident levels (¥5.4 – ¥6.4). These results make it difficult to argue that nuclear energy has any cost advantages over renewable forms of energy, such as wind power.

1. Generation cost rising to ¥7 on accident cleanup costs

The costs required to cleanup the accident at the Fukushima Daiichi nuclear power plant as indicated in the above proposal include the cost of decommissioning the reactors, as well as the cost of income compensation payments to residents evacuated from the twenty mile danger zone around the plant and the cost of buying up land within that zone. Our proposal does not consider the cost of compensating for damage incurred by the industries of surrounding regions or prefectures or the marine, agriculture and forestry industries.

Table 1. Estimated Cost of Fukushima Daiichi Nuclear Plant Cleanup

(¥ Trn)

	Purchase of land within 20 km	Income compensation	Decommission reactors	Total
Fukushima Daiichi cleanup	4.3	0.63	0.74 ~ 15	5.7 ~ 20

Note: Our estimate for the cost of purchasing land is based on official land values for the relevant cities and towns while that for income compensation is based on average salaries in Fukushima Prefecture. The estimate of costs for decommissioning the reactors is based on cleanup costs required following the accidents at Three Mile Island and Chernobyl. We also assumed income compensation would be made for a period of ten years.

If we consider the costs required to clean up following the Three Mile Island accident in 1979, the cleanup costs for the Fukushima disaster are likely to reach about ¥5.7 trillion over ten years, or ¥570 billion per year. If it is possible to remove the fuel rods from the

¹ *Nihon Keizai Shimbun*, July 10, 2011, morning edition, and other media.

damaged reactors, costs would be in line with those following Three Mile Island. But if, as occurred at Chernobyl, a core meltdown has made it impossible to remove the fuel rods, leaving only the option of provisional measures such as construction of a sarcophagus, then the cleanup will not be completed in ten years. We have assumed that, in that case, total cleanup costs would reach ¥20 trillion, equivalent to the cost of the damage incurred in the Chernobyl accident. Judging from the information provided in the news media, ten years or more will be required before the accident can be brought to a close. This strongly indicates that the cleanup costs will ultimately reach or exceed ¥20 trillion.

How will this ¥5.7 to ¥20 trillion in cleanup costs affect the cost of electrical power generation? Table two divides these cleanup costs by the total energy generated from nuclear power plants in FY2010, expressing the results in terms of cost per kilowatt hour.

Table 2. Fukushima Daiichi Cleanup Cost Per kWh (Divided by Total Energy Generated in FY2010)

Adding cleanup costs to generation costs of nuclear power plants: (1) TEPCO nuclear plants only or (2) all nuclear plants nationwide	Cleanup costs expressed as generation cost per kWh over ten years
(1) TEPCO nuclear plants	6.8 – 23.9
(2) All nuclear plants	2.0 – 6.9

Note: Dividing annual cleanup costs of ¥570 billion to ¥2 trillion by total energy generated by (1) TEPCO nuclear plants and (2) all nuclear plants nationwide. Source: Ministry of Economy, Trade and Industry, “Regarding the Nuclear Power Plant Capacity Utilization Rate in FY2010.”

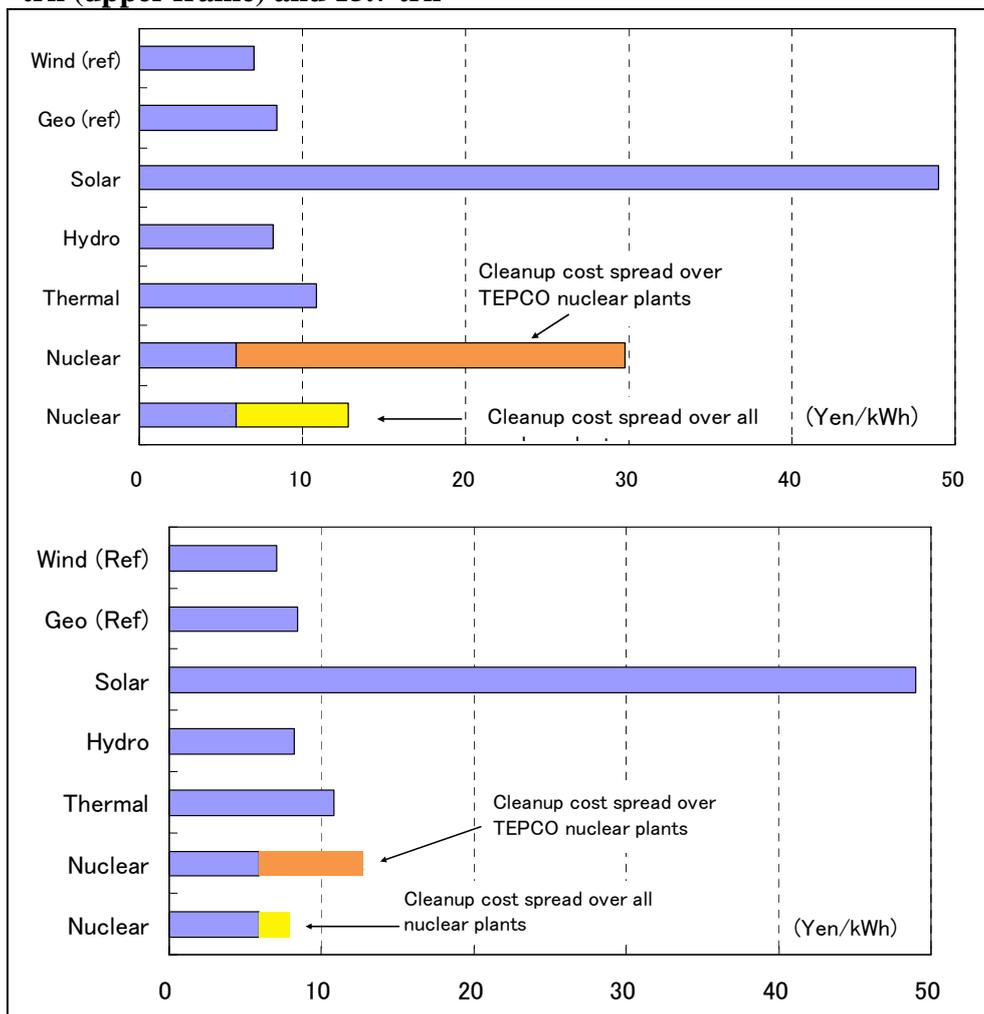
The impact on the generation cost per kilowatt hour differs greatly depending on whether the cleanup cost is distributed over TEPCO nuclear plants alone or all nuclear plants nationwide. In fact, distributing the cost over TEPCO’s nuclear power plants alone results in a per kilowatt hour cost of ¥24 . Distributing the cost over all nuclear plants nationwide results in a cost of ¥7 . (Both of these examples use a cleanup cost estimate of ¥20 trillion).

In the event that every electric power company takes measures against a major accident, the per kilowatt hour cost would be in the region of ¥24. If measures against the risks of nuclear power are adopted by the nation as a whole, it would likely add an additional ¥7 to the cost of nuclear energy per kilowatt hour.

2. Is the cost of nuclear in line with that of wind?

We have compared the costs of a sampling of power plants based on information publicly available in the (FY2008) securities reports of the respective companies and on government-related websites.

Figure 1. Generation Costs Compared: Assumed Cleanup costs ¥20 trn (upper frame) and ¥5.7 trn



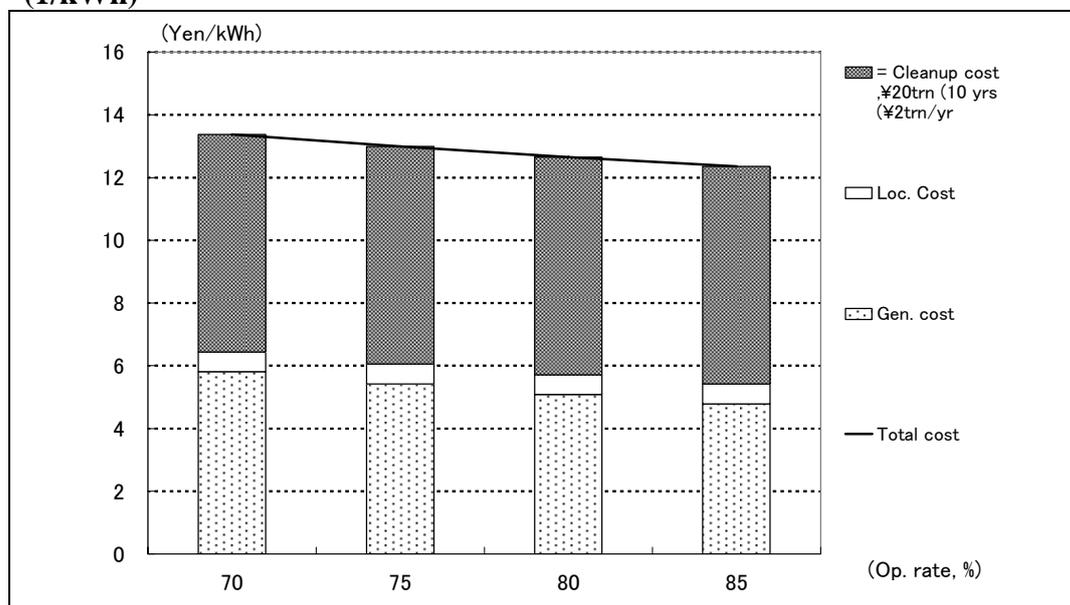
Note: Estimates on nuclear plants take account of the government’s power plant location measures (about ¥0.6 per kWh). Estimates also include expenses for the entire nuclear fuel cycle, including reprocessing of spent nuclear fuel and ultimate disposal (¥19 trillion over forty years according to government and electric power industry estimates). However, in view of the fact that nuclear fuel cycle plans are not moving ahead smoothly, these estimates may be too low. We have assumed that the cleanup costs for the Fukushima Daiichi accident will be ¥5.7 to ¥20 trillion over ten years (¥570 billion to ¥2 trillion annually) as estimated by JCER on April 25. The blue and yellow portions of the bars indicate the distribution of cleanup costs over all nuclear power plants nationwide while the blue, yellow and red portions indicate distribution over TEPCO nuclear plants only.

With regard to thermal power plants, we have assumed a capacity utilization rate of 50% and have applied a weighted average based on the total energy generated by coal, oil and natural gas (in FY2008). We have also assumed a capacity utilization rate of 45% for hydropower. Data for wind power and geothermal are reference values and assume they are placed in favorable locations.

Next, we consider mainly a scenario in which the accident cleanup costs will be ¥20 trillion. In Figure 1, we have calculated the power generation cost of nuclear plants prior to the accident. We have assumed a capacity utilization rate of 70% to 85% and have found the generation cost by adding costs associated with the government’s plant location measures (¥0.6) to the ¥5.3/kWh average cost prevailing at that time. The pure generation cost at a capacity utilization rate of 70% (recent capacity utilization rates being about 60% to 70%) would be ¥6.4. At a capacity utilization rate of 85% it would be ¥5.4. The cost therefore

differs according to the capacity utilization rate. In the event that the costs of the recent accident cleanup are distributed over all nuclear power plants, the range would be ¥12.4 to ¥13.4 (Figure 2).

Figure 2. Variation in Generation Cost with Assumed Operating Rate (¥/kWh)



The Ministry of Economy, Trade and Industry (METI) released a cost list for renewable energy (Table 3) in conjunction with METI’s proposed feed-in tariff scheme. Comparing this with the power generation cost of nuclear power as we have calculated them shows that the generation cost of nuclear energy is essentially in line with that of wind power.

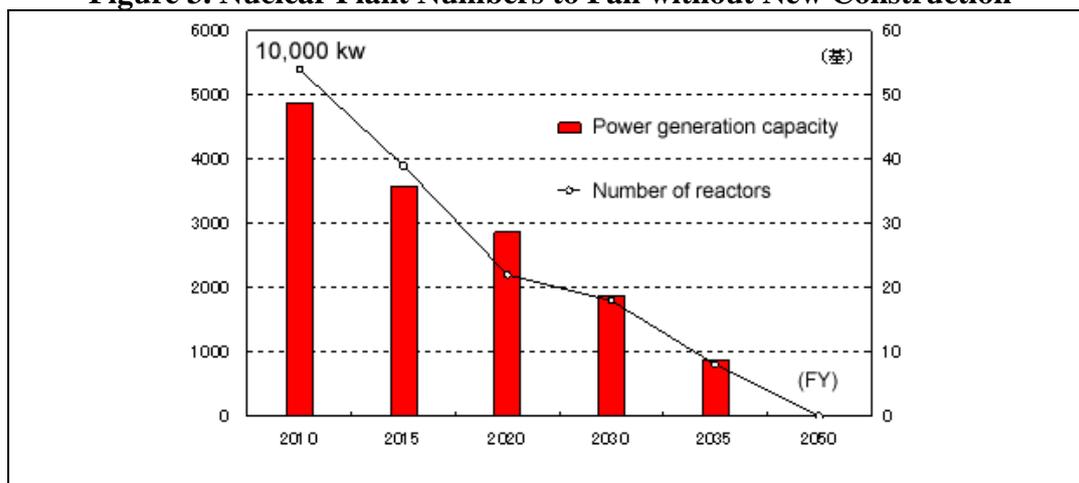
Table 3. Generation Cost of Renewable Energy (METI estimates)

Generation method	Cost per kWh
Photovoltaic	42
Small to medium hydroelectric	22
Geothermal	17
Biomass	15
Wind	12

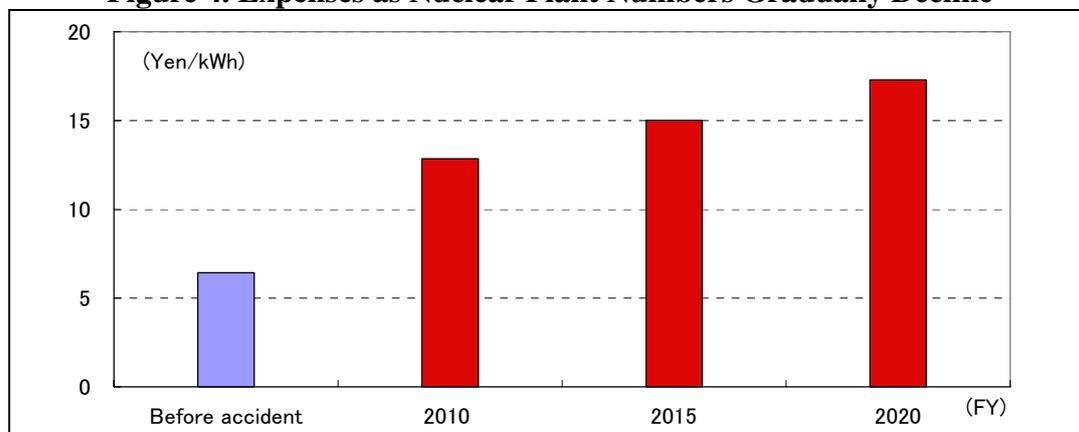
Source: “Project Team concerning the Feed-In Tariff” (Fourth Round, March 24, 2010).

3. Nuclear generation cost ¥17 kWh in FY2020

Given the impact of the accident at Fukushima Daiichi, nuclear power is certain to experience a net decline. Even if those existing plants passing stress tests remain in operation, no nuclear plants will remain in operation in Japan by 2050 so long as no new reconstruction is permitted and existing plants are shut down forty years after startup (Figure 3).

Figure 3. Nuclear Plant Numbers to Fall without New Construction

In estimating the cost of nuclear power in FY2015 and FY2020, we have assumed that Fukushima Daiichi, Fukushima Daini and the Hamaoka nuclear station will be decommissioned, with each of the remaining nuclear plants being decommissioned in turn when reaching forty years of operation. We estimate total energy by subtracting the capacity of nuclear plants ceasing operation from the total energy generated in FY2010. Our assumed capacity utilization rate is 70%, the level prevailing before TEPCO's Kashiwazaki Kariwa nuclear station was shut down due to the Chuetsu Offshore Earthquake.

Figure 4. Expenses as Nuclear Plant Numbers Gradually Decline

Note: Values prior to accident represent generation costs when capacity utilization was at 70%.

As nuclear plants are gradually decommissioned and total energy generated falls, the generation cost per kilowatt hour will rise proportionally. As already mentioned, total energy generated in FY2015 will be 70% of the level generated in FY2010, and in FY2020 it will be 60%. The generation cost per kilowatt hour will correspondingly rise from about ¥13 to ¥17. If the accident cleanup can be completed by FY2020, it will once again fall to about ¥6, but it will remain high for at least ten years and the cleanup cost for the Fukushima Daiichi accident will weigh heavily on the cost of nuclear power.

For inquiries regarding this paper, please contact Tatsuo Kobayashi of the JCER Economic Research Department at t.kobayashi@jcer.or.jp. *Please change {at mark} to @