Estimation of Nuclear Fuel Cycle Cost and Accident Risk Cost (Statement)

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Japan Atomic Energy Commission

On September 27, the Japan Atomic Energy Commission (JAEC) established the Technical Subcommittee on Nuclear Power, Nuclear Fuel Cycle, etc. (hereinafter the “Subcommittee”), entrusting it with a mission to compile data and other information conducive to the overall assessment of nuclear power generation and the nuclear fuel cycle, and committing thereto the tasks that JAEC had been requested to do by the Cost Estimation and Review Committee of the Energy and Environment Council, namely, (1) to calculate the nuclear fuel cycle cost for nuclear power generation, and (2) to calculate the future risk cost for nuclear power generation. Through the four meetings held since October 11, the Subcommittee conducted calculation and study on these issues. Today, JAEC received the following report from the Subcommittee, together with the relevant reference data.

(1) Calculation of the nuclear fuel cycle cost for nuclear power generation

- As a result of the calculation of the nuclear fuel cycle cost of a model plant (1.2 million kW, modeled after the standard light water reactor (LWR) plants constructed in the past seven years), supposing a discount rate of 3%, the cost for recycling LWR spent nuclear fuel was about 2 yen/kWh according to the full reprocessing model, or about 1 yen/kWh according to the direct disposal model (Tables 1 and 2).
- The cost according to the current reprocessing model, where 50% of the spent fuel is immediately reprocessed and the remaining 50% is reprocessed after being put under temporary storage, is about 1.4 yen/kWh, standing nearly in between the estimated costs according to the above-mentioned two models.
- In comparison with the previous estimation (in 2004) in terms of the current model (because the full reprocessing model was not used in the previous estimation), the cost as estimated this time became more or less smaller than the previous level, despite the increase in the uranium fuel cost expected at the front end of the cycle. This is because the estimation was made by the present value approach, extending the time of reprocessing at the back end of the cycle from three years to twenty years.
- Sensitivity analysis revealed that the dominant cost factors of the nuclear fuel cycle were the reprocessing cost and uranium cost, whereas the landfill disposal cost did not have a significant impact.
    - As for the reprocessing model, if the unit costs of reprocessing and MOX fuel increase 1.5 times, the nuclear fuel cycle cost will increase by about 20%. In the case of direct disposal, if the uranium cost doubles, the nuclear fuel cycle cost will increase by about 35%.

(2) Calculation of the future risk cost for nuclear power generation

- As a future risk cost, the Subcommittee calculated the accident risk cost by first estimating the expected value of damage incurred due to an accident at a model plant, per unit power generation (= cost of damage × frequency of occurrence of accidents[1] / total power generation).
- The cost of damage of a model plant was assumed as about five trillion yen, using the disclosed and verifiable data, and referring to the report of the Management and Finance Investigation Committee for Tokyo Electric Power Co. Inc. However, in consideration of the possibility that the cost of the recent accident will further increase, the estimated cost of damage will need to be reviewed accordingly.
- Opinions were divided among the members of the Subcommittee about the frequency of occurrence of accidents. Some members stated that for the purpose of calculating the cost of a model plant to be constructed in the future, the basis for estimating the frequency level should be in line with the IAEA safety target, 1×10^{-5}/reactor year, whereas other members pointed out that it should be taken as a precondition that the existing reactors should not be put into operation unless this target was accomplished.
- Some others argued that as Japan has had three severe accidents through about 1,500 reactor years of operating experience, the frequency of occurrence of such accidents should be estimated as 2×10^{-3}/reactor year. In response, a counterview was presented, stating that the estimation was supposed to be made without taking into consideration the safety measures to be implemented after the recent accident, so it was unrealistic to use this figure as the frequency of occurrence of accidents at a model plant.
- On condition of an operation rate between 80% and 60%, the accident risk cost was estimated as 0.006–0.008 yen/kWh at the former frequency level, or as 1.2–1.6 yen/kW at the latter frequency level (Table 3).
- There was also an opinion that the causality insurance premiums could form part of the future risk cost. However, an insurance scheme to cover “massive damage arising from an extremely rare contingency” that does not follow the law of large numbers, such as a nuclear power accident, has not yet been established in the real world (e.g. Act on Liability for Oil Pollution Damage).
- From this viewpoint, the Subcommittee estimated the accident risk cost in reference to the U.S. Price-Anderson Nuclear Industries Indemnity Act (Price-Anderson Act), by setting the upper limit for the nuclear plant operator’s burden of cost and adopting the principle of mutual assistance among operators.
- As a result, supposing the total amount of damage is 5–10 trillion yen and the period of payment is forty years, and dividing the total amount by the domestic nuclear power generation, the accident risk cost was estimated as 0.45–0.89 yen/kWh (Table 4).

[1] Rate of occurrence of severe accidents with large release per year

JAEC finds the Subcommittee’s estimation as shown above to be appropriate. The following points should be taken into consideration when applying the estimation results.

- In the process of studying the future policy for nuclear power generation including the nuclear fuel cycle, it is necessary to discuss the issue based on realistic assumptions and from a comprehensive viewpoint, covering the impact of the political and economic climates as well as the trends in technology development.
- Not only the estimation results but also the preconditions and calculation method applied for making the estimation should be disclosed, so as to make the discussion transparent and verifiable. In particular, it should be clearly noted that the estimated future risk cost is an outcome of a quick study and therefore may involve high uncertainty. As the calculation method is made public, re-calculation can be made by applying various conditions.
- It should be clearly stated that as a means to find the best option for the future power source, estimating the power generation cost of a model plant is an appropriate approach, and when making this estimation, it is desirable that the power sources that can be used under the same conditions be compared under the same conditions. For instance, if the accident risk cost is included in the estimation of the cost of nuclear power generation, the future risk cost should also be included in the estimation of the power generation cost using other power sources.
- The calculation of the accident risk cost should be based on the concept of the expected value. As for the frequency of occurrence of accidents, which is one of the cost factors to be used for such calculation, there are two applicable values as indicated in Table 3: one is in line with the IAEA safety target that Japan must at least accomplish, and the other is based on the world’s and Japan’s experience in operating nuclear power plants. We should take the utmost care when applying either frequency level, while taking into consideration the meaning of the value.
- At the same time, in view of the international trends on the handling of the risk cost, such as the Convention on Supplementary Compensation for Nuclear Damage (CSC), the concept of the accident risk cost under the mutual assistance-based compensation scheme seems to be reasonable to a certain extent. If this concept is to be adopted, it is necessary to examine the sharing of the burden between the private sector and the government.

End

Table 1 Nuclear Fuel Cycle Cost of a Model Plant

Costs of Three Cycle Models (1) —Discount rate: 0%, 1%—

(yen/kWh)

Items	Discount rate: 0%			Discount rate: 1%		
	Reprocessing model	Direct disposal model	State-of-the-Art model*	Reprocessing model	Direct disposal model	State-of-the-Art model
Uranium fuel	0.62	0.72	0.62	0.65	0.75	0.68
MOX fuel	0.17	–	0.17	0.16	–	0.12
(Total at the front end)	0.79	0.72	0.79	0.82	0.75	0.80
Reprocessing, etc.	1.10	-	1.10	1.06	–	0.79
Temporary storage	–	0.14	0.07	–	0.12	0.06
High-level radioactive waste disposal	0.24	–	0.24	0.16	–	0.12
Direct disposal	–	0.41–0.48	–	–	0.24–0.28	–
(Total at the back end)	1.34	0.56–0.63	1.41	1.21	0.37–0.41	0.98
Total	2.14	1.28–1.35	2.21	2.03	1.11–1.15	1.78

(Note) The total may not correspond to the sum of all the items due to rounding. (Sending end)

*50% of spent fuel is reprocessed first, and the rest will be reprocessed after interim storage period.

Table 2 Nuclear Fuel Cycle Cost of a Model Plant

Costs of Three Cycle Models (1) —Discount rate: 3%, 5%—

(yen/kWh)

Items	Discount rate: 3%			Discount rate: 5%		
	Reprocessing model	Direct disposal model	State-of-the-Art model	Reprocessing model	Direct disposal model	State-of-the-Art model
Uranium fuel	0.73	0.81	0.77	0.81	0.88	0.86
MOX fuel	0.15	–	0.07	0.14	–	0.04
(Total at the front end)	0.88	0.81	0.84	0.94	0.88	0.90
Reprocessing, etc.	1.03	-	0.46	1.04	-	0.30
Temporary storage	–	0.09	0.05	-	0.07	0.04
High-level radioactive waste disposal	0.08	–	0.04	0.05	–	0.01
Direct disposal	–	0.10–0.11	–	–	0.05–0.05	–
(Total at the back end)	1.11	0.19–0.21	0.55	1.08	0.12–0.12	0.36
Total	1.98	1.00–1.02	1.39	2.03	1.00–1.01	1.26

(Note) The total may not correspond to the sum of all the items due to rounding. (Sending end)

Table 3 Estimation of the Accident Risk Cost based on the Frequency of Occurrence of Damage

Accident Risk Cost of a Model Plant

Frequency of occurrence (/reactor year)	Accident risk cost of the model plant, by operation rate (yen/kWh)			Additional cost per increase in the amount of damage by 1 trillion yen (yen/kWh)		
	Utilization factor 60%	Utilization factor 70%	Utilization factor 80%	Utilization factor 60%	Utilization factor 70%	Utilization factor 80%
1.0×10^{-5} (IAEA safety target for an early large release from an existing reactor)	0.008	0.007	0.006	0.002	0.001	0.001
3.5×10^{-4} （Frequency of severe accidents at commercial reactors around the world; equivalent to once every 57 years[1])	0.28	0.24	0.21	0.06	0.05	0.04
2.0×10^{-3} (Frequency of severe accidents at commercial reactors in Japan; equivalent to once every 10 years[1])	1.6	1.4	1.2	0.32	0.27	0.24

[1] Frequency of occurrence of accidents on the condition that 50 power reactors are in operation

Table 3 Estimation of the Accident Risk Cost in Reference to the Insurance Scheme

Estimation of the Accident Risk Cost under the U.S. Mutual Aid Scheme

- Amount of damage, including expenses for decommissioning reactors, as estimated by the Subcommittee in relation to the model plant: 4.9936 trillion yen
- Exclusively for the purpose of making estimation, the Subcommittee calculated the amount of damage as 5 trillion yen based on the assumption that there is a mutual assistance scheme for nuclear plant operators in reference to the Price-Anderson Act. As a result of sensitivity analysis, the estimated amount of damage nearly doubled to 10 trillion yen.

Amount of damage	Period of payment	Total nuclear power generation [1]	Accident risk cost
5 trillion yen	40 years	280.0 billion kWh	0.45 yen/kWh
10 trillion yen			0.89 yen/kWh

[1] Actual result in FY2010, Energy and Environment Council

  - The amount of damage could be further reduced if it is shared among nuclear plant operators around the world.