A Valuation Study of Fuel Supply Stability of Nuclear Energy

Background

In the recent nuclear energy policy discussions *1, it was called for to visualize superiority of nuclear energy in terms of supply stability. Such external economy of nuclear power, however, has not been necessarily quantified and presented explicitly.

Objectives

In order to assess potential benefits of nuclear power with regard to its characteristics of fuel supply stability, the following three aspects are valuated under the Japanese energy and electricity mix:

a) economic stability; i.e. nuclear power's contribution to the whole energy and electricity mix in terms of resistance to fluctuation and/or fuel price hikes,

b) procurement stability; i.e. natural uranium, the raw fuel material for nuclear power generation, is being imported from more reliable sources through adequately diverse markets than in the cases of oil and natural gas, and,

c) passive reserve effect; i.e. fuel materials as running stocks at power stations and fuel service facilities could maintain nuclear power generation running for a certain duration under unexpected disruption of fuel supply.

Principal Results

In this study, fuel supply stability is assumed as robustness against instabilities and uncertainties surrounding Japan's energy resource acquisition and supply of energy services. In this respect, the following three features were picked up and analyzed quantitatively. The major findings are summarized as follows:

1. Economic Stability.

A simulation of Japan's optimal power generation mix up to the year 2030 showed that, in the case of fossil fuel price doubling over the base case settings, the average generation cost in 2030 will rise by 2.3 JPY/kWh than the baseline result when the new addition of 13 units of nuclear power reactor is realized as currently planned, and by 3.5 JPY/kWh if the new addition is limited to the 3 units currently under construction or preparation, respectively. When the price hike of fossil fuel is as much as 5 times, the magnitude of generation cost increase goes up to 9.4 and 13.8 JPY/kWh, respectively. These figures are explained as mitigation of 30% in the additional expenditure by an average household consuming 300 kWh per month with addition of 10 units of nuclear power (Fig.1).

2. Procurement Stability.

We induced an index of procurement stability through quantifying those factors such as; global distribution of resources, global market structure, distribution of Japan's imports as well as socio-political stability of those countries with resource deposits and export. Under the current circumstances, quantification of risk rank of each fuel showed that procurement risk of uranium fuel is as low as one third of oil, while coal is as good as uranium fuel. Applying the results to evaluation of Japan's primary energy mix, the study revealed that the primary energy structure has evolved with remarkable improvements in its robustness since the period of the oil crises in 1970s (Fig.2).

3. Passive Reserve Effect.

The nuclear fuel cycle system contains significant amount of fuel materials as normal running stock at power reactors and fuel cycle facilities. In Japan, as of the end of 2006, those stored materials corresponded to 2.35 times Japan's annual fuel needs, which can be further enhanced by recycling recovered materials from spent nuclear fuel reprocessing. In the longer run, more advanced recycling can improve the self-sufficiency of nuclear fuel dramatically.

Future Developments

Each of the analyses should be reviewed whenever notable changes and developments take place in any of those fuel segments and markets. As an extension of the study, we strive to develop meaningful indices of energy security.

Main Researcher: Koji Nagano, Dr. Eng.
Senior Researcher, Energy Technology Policy Sector, Socio-economic Research Center

Reference

K. Nagano et al, 2008 “A Valuation Study of Fuel Supply Stability of Nuclear Energy”, CRIEPI Report Y07008 (in Japanese)

*1 : See “Japan's Nuclear Energy National Plan” Nuclear Energy Subcommittee (2005)

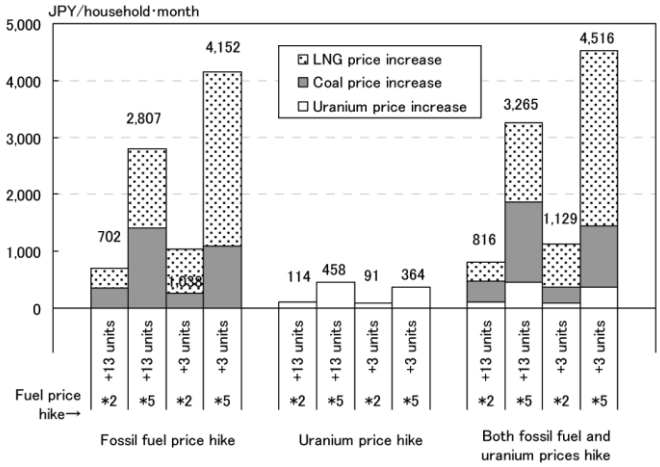


Fig.1 The impacts of fuel price hikes to Japan's generation mix: additional burden per average household in 2030.

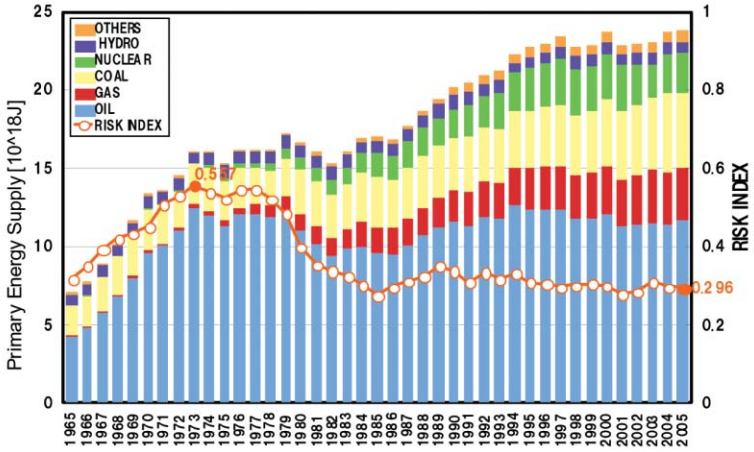
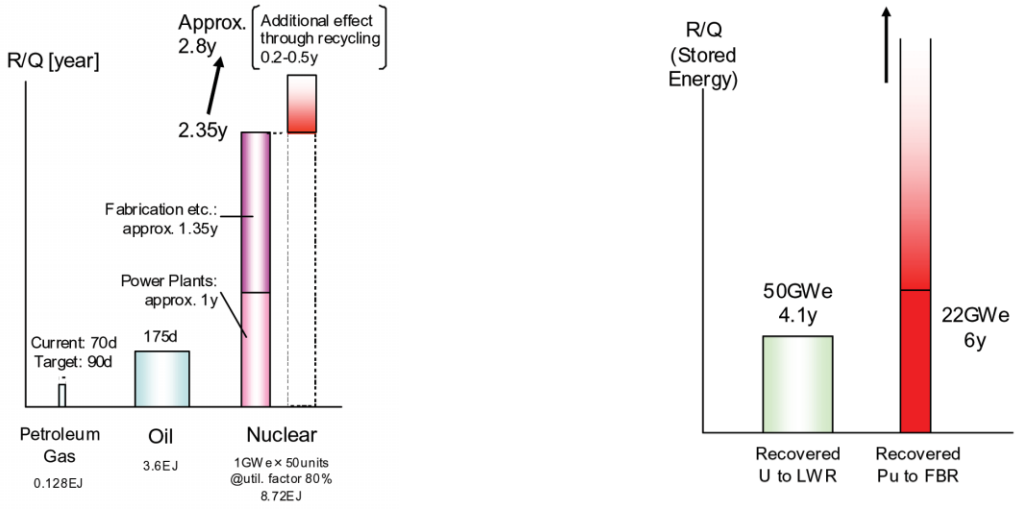


Fig.2 The historical evolution of Japan's primary energy mix and its procurement stability index.

RISK INDEX: The procurement stability index reflects instability of energy mix induced from global resource distribution, global trade share, Japan's import structure of each energy resource as well as socio-political risks of countries with resource deposits or exports. The RISK INDEX has its maximum value 1 when all the primary energy needs are met solely by imported oil, while its minimum value 0 when the energy supply is preoccupied by domestic risk-free sources, such as hydro and other renewables.



(a) The short-term reserve effect. (b) The long-term effect by recycling.

Fig.3 The passive reserve effect of Japan's nuclear power system: comparison of stored energy.

[Note] R/Q : stored energy divided by energy amount consumed annually.
The total energy quantity stored in each reserve is shown on the bottom of (a). d: day, y: year.
The width of bar reflects annual energy consumption of each energy source, meaning the area of each bar equals to the total energy quantity stored.