# Estimation of the Containment of the Outflow of National Wealth through the Use of Nuclear Power Generation

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According to the FY2011 Trade Statistics (Bulletin) released by the Ministry of Finance on April 19, the balance of trade obtained by subtracting imports from exports was a negative 4,410.1 billion yen (nominal basis), which marked the largest trade deficit on record. After the Great East Japan Earthquake, concerns about the safety of nuclear power plants increased, and nuclear power plants throughout Japan remain unable to restart even after scheduled inspections have been completed. A response consisting of increased burning in the form of LNG and oil thermal power, along with rapidly rising crude oil prices caused by heightened tensions in the Middle East associated with the "Arab Spring" and suspicions of nuclear development in Iran, are the main factors that led to an enormous outflow of national wealth. In this paper, I perform a comparative examination of the replacement of nuclear-generated power with oil, LNG and coal energy (not considering the restrictions on the capacity of thermal power generation facilities) from the perspective of how the use of nuclear power in Japan has contributed not only to the stable supply of power, but also to containing the outflow of national wealth.

The results of the estimation indicate that the amount of national wealth outflow contained was 44,004.1 billion yen after deducting the value of uranium and nuclear fuel imports (4,380.8 billion yen) from the value of additional imports of crude oil, which was 48,384.9 billion yen if economically inferior oil thermal power was used as an alternative during the period from when nuclear power generation began in FY1965 until FY2010. Furthermore, even when using coal, the most economical thermal power of the energy types estimated, as an alternative, additional imports amounted to 18,918.9 billion yen, and the amount of national wealth outflow contained was 14,538.1 billion yen.

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## 1. Introduction

According to the FY2011 Trade Statistics (Bulletin) released by the Ministry of Finance on April 19, the balance of trade obtained by subtracting imports from exports was a negative 4,410.1 billion yen (nominal basis), which marked the largest deficit on record, exceeding even the 3,127.8 billion yen deficit of FY1979 caused by the second oil crisis. Exports were down 3.7% year-on-year to 65,281.9 billion yen, with declines in areas such as semiconductors and other electronic components along with automobiles, while imports were up 11.6% to 69,692.0 billion yen due to increases in areas such as crude oil and LNG.

The main cause of the increase in imports was increased burning of LNG and oil thermal power after the Great East Japan Earthquake, due to nuclear power plants throughout Japan remaining unable to restart following completion of scheduled inspections because of increased concerns about the safety of nuclear power plants, and rapidly rising crude oil prices caused by heightened tensions in the Middle East associated with the “Arab Spring” and suspicions of nuclear development in Iran. A significant increase in imports was recorded due to LNG imports increasing 52.2% year-on-year, and crude oil imports increasing 21.9%.

As stated above, the balance of trade in FY2011 led to an enormous outflow of national wealth caused by the prolonged suspension of nuclear power generation, and in this paper, I perform a comparative examination of power generated by nuclear power being replaced by oil, LNG and coal energy (not considering the restrictions on the capacity of facilities) from the perspective of how the use of nuclear power in Japan has not only provided a stable supply of power, but also contained the outflow of national wealth.

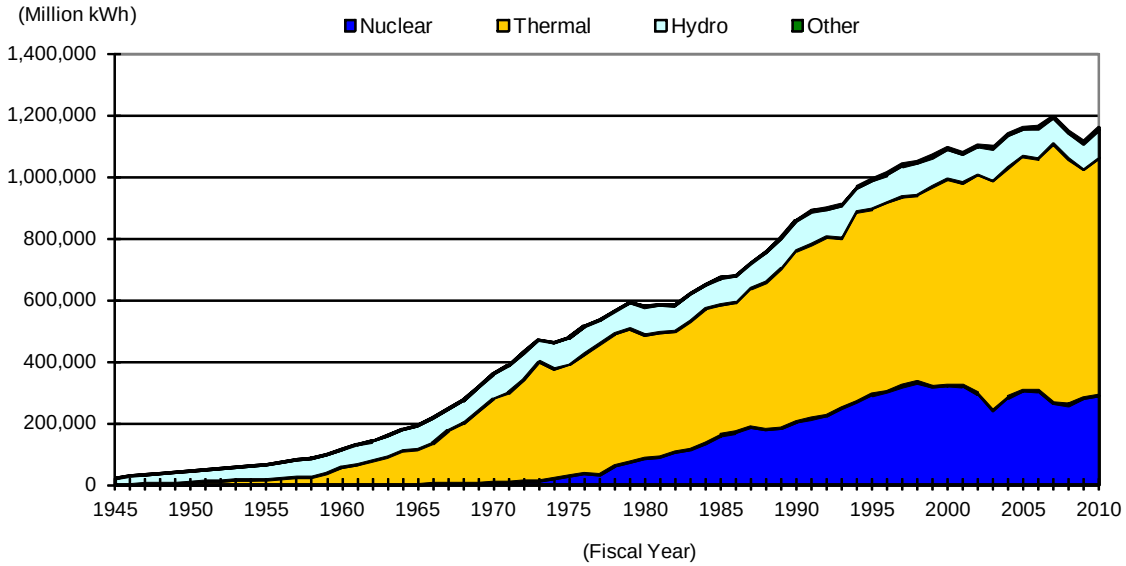
## 2. Amount of Power Generated

Figure 2.1 shows the total amount of power generated in Japan by general electricity utilities (10 power companies), other power companies and private power. The composition of power sources in Japan was initially “hydro supported by thermal,” and centered on hydropower generation. As the economy recovered after the war, the construction of thermal power plants increased in response to rising power demand, and the share of thermal power surpassed that of hydropower in FY1962 as Japan entered the era of “thermal supported by hydro.” Furthermore, power generation began at the Japan Atomic Power Company’s Tokai Power Station, Japan’s first nuclear power plant used for

commercial power generation, in November 1965, and nuclear power generation continued to increase consistently until after 2000, accounting for approximately 30% of power generation. In recent years, that share has since fallen to around 25% due to factors such as the suspension of Tokyo Electric Power's Kashiwazaki-Kariwa Nuclear Power Plant as a result of the discovery of a cover-up of problems (2002) and the Chuetsu Offshore Earthquake in Niigata prefecture (2007).

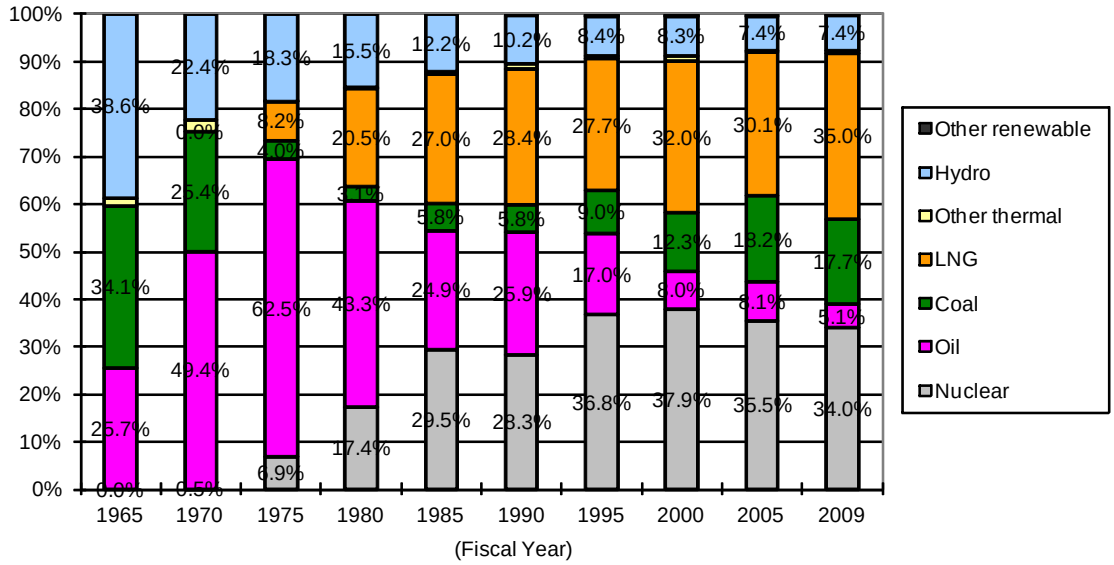
Moreover, as indicated in Figure 2.2, as a result of the diversification of power generation methods since the oil crisis, the composition of power generated by general electricity utilities changed, with the share of nuclear power increasing to the mid-30% range, while LNG and coal thermal power also had significantly increased shares.

Figure 2.1. Amount of Power Generated in Japan




(Source) Handbook of the Electric Power Industry

Figure 2.2. Amount of Power Generated by General Electricity Utilities




(Source) Handbook of the Electric Power Industry

## 3. Estimation Method and Assumptions

The amount of national wealth outflow contained was estimated using the following method. First, the following formula was used to convert the amount of power generated by nuclear power into fuel consumed when replacing it with oil[1], LNG and coal as alternative power sources.

(Example) Formula for conversion into crude oil consumption

$$\text{Converted Crude Oil Consumption Volume (k}\ell) = \frac{\text{Nuclear Power-Generated Power Volume (kWh)} \times 860\,(\text{kcal/kWh})}{\text{Crude Oil Calorific Value (kcal/k}\ell) \times \text{Oil Thermal Power Thermal Efficiency (\%)}}$$

The consumption volume obtained above was multiplied by the import unit price (Japan CIF unit price) each year based on trade statistics, to estimate the value of imports of alternative fuel, and the value of imports of uranium and nuclear fuel was subtracted from this amount to determine the amount of national wealth outflow contained.

The value of imports of uranium and nuclear fuel has been extracted using the following item numbers based on Ministry of Finance trade statistics starting in FY1965, when the Tokai Nuclear Power Plant began generating power. However, the nomenclature under trade statistics includes

[1] Normally, fuel oil, crude oil and light oil are consumed as fuel for oil thermal power, but in this paper, the volume and value of the crude oil conversion is estimated from the perspective of "national wealth outflow."

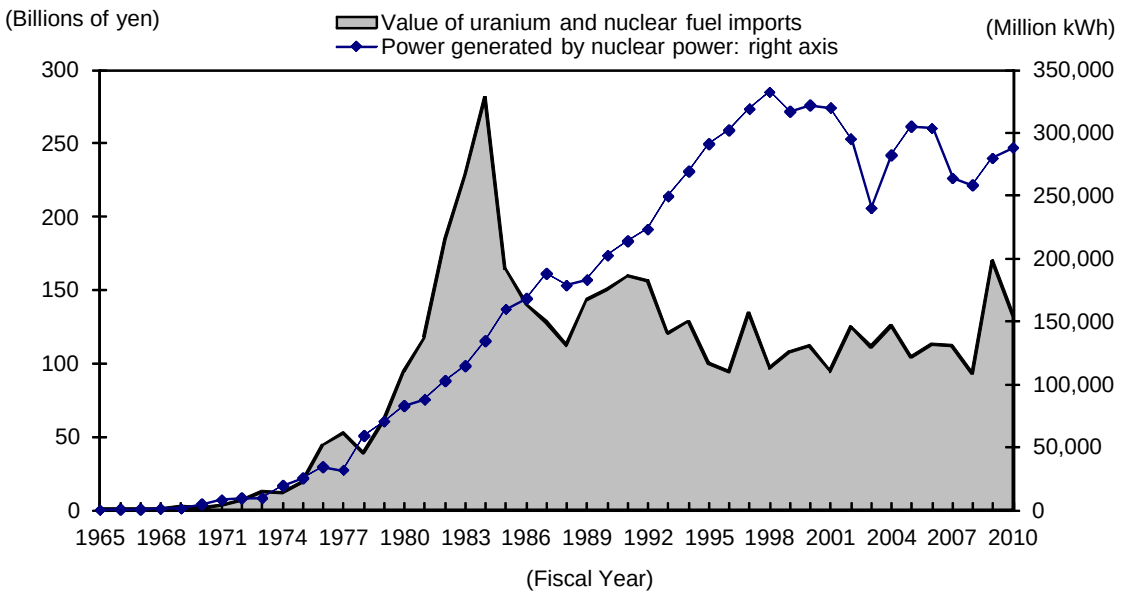
fuel and samples for research reactors and standard samples for equipment calibration, and although it does not strictly represent the amount of fuel imported for the power generation business, imports for power generation are believed to account for the majority, and in this paper was deemed to be the value of fuel imports for nuclear power generation.

Table 3.1. Uranium and Nuclear Fuel Item Codes in Ministry of Finance Trade Statistics

| Fiscal Year | Item Code |
|---|---|
| 1965~1971 | 515.110 |
| 1972~1975 | 515.111 |
| 1976~1987 | April~December 1988: 2850.031<br>From January 1988: 2844.20.090, 8401.30.010, 8401.30.090 |
| 1988~2000 | 2844.20.090, 8401.30.010, 8401.30.090 |
| 2001~2010 | 2844.20.090, 8401.30.000 |

The results of statistics for each year concerning the above items are shown in Figure 3.1, and although there is some variation year by year, imports have generally been between 100 billion yen and 150 billion yen, and the cumulative total for the period from FY1965 until FY2010 is 4,380.8 billion yen.

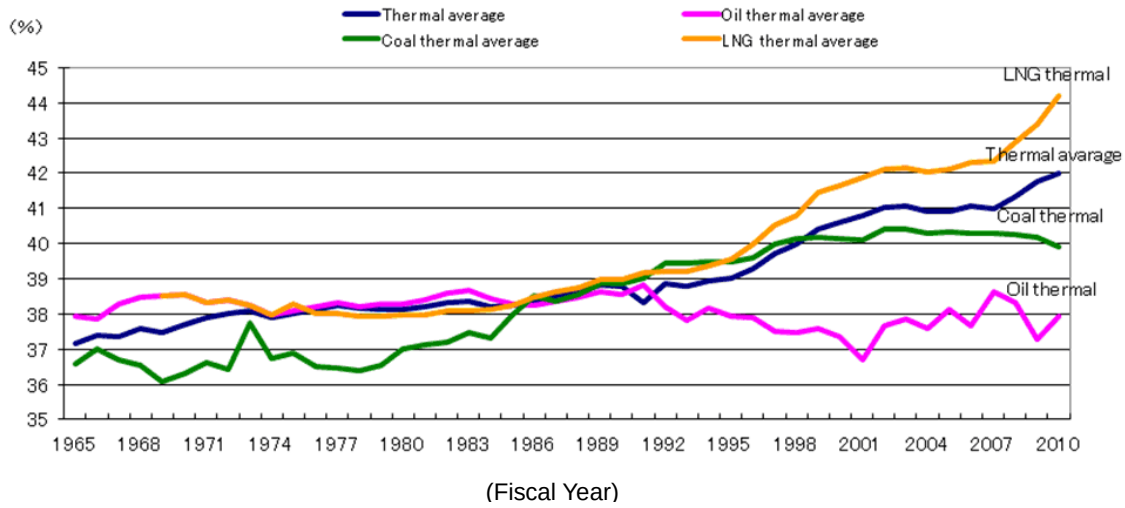
Figure 3.1. Value of Imports of Uranium and Nuclear Fuel and Amount of Nuclear Power Generated




(Source) Ministry of Finance Trade Statistics, Handbook of the Electric Power Industry

The thermal efficiency necessary for calculating the amount of fuel consumed when thermal power generation is used as a replacement has been constantly improving when looking at the thermal power average, and the high efficiency of LNG thermal power is particularly conspicuous (Figure 3.2). This is because combined cycle power generation facilities using LNG as fuel have been employed when replacing aging thermal power plants and implementing new facilities, and the high calorific value exceeds 50% in the latest combined cycle systems. Meanwhile, oil thermal power has remained around 38% in recent years as facilities have aged, and capacity utilization has declined due to a ministerial summit of the IAE adopting measures in 1979 to prohibit the new construction of oil thermal power plants as a base load power source in an effort to reduce dependence on oil following the second oil crisis. The estimates in this paper utilize the average value of each company's supply plans for FY2010 for which actual values have not been published, and actual values for FY1969 for the thermal efficiency of LNG thermal power between FY1965 to 1968 when there were no actual values available due to no such plants being in operation.

Figure 3.2. Thermal Efficiency

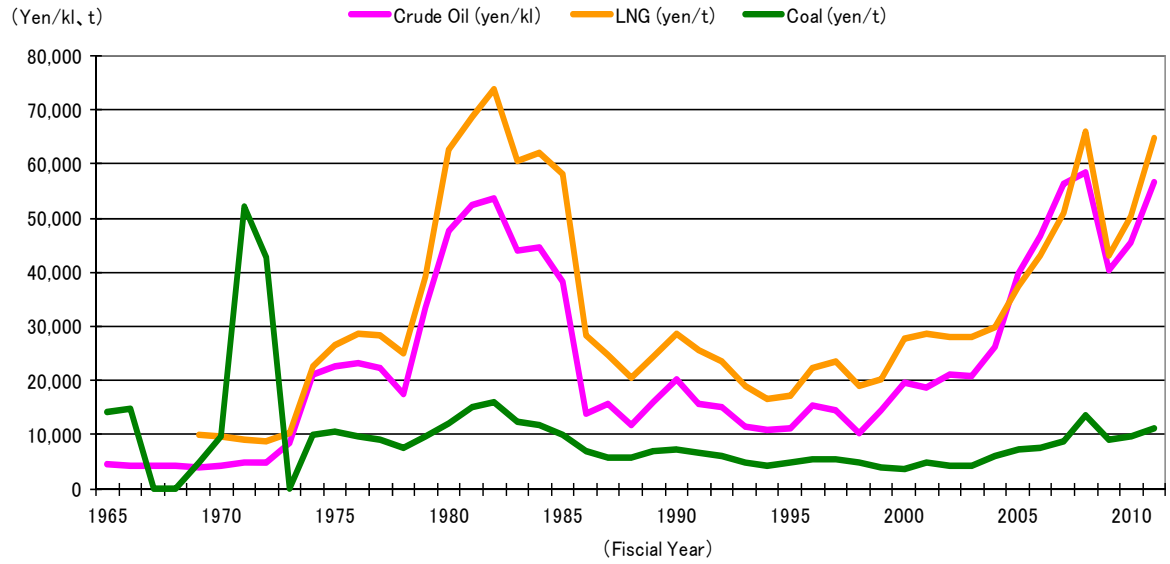



(Source) Electricity and Gas Industry Department, Agency for Natural Resources and Energy, Ministry of Economy, Trade, and Industry ed., "Overview of Electric Power Supply and Demand" for each year

The import clearance CIF unit price of oil, LNG and coal is shown in Figure 3.3, and it can be seen that the import unit prices of oil and LNG are nearly linked because movements in the price of LNG are determined based on the price of crude oil. It also indicates that although the import unit prices of oil and LNG have fluctuated greatly, coal has had relatively few fluctuations. In this paper,

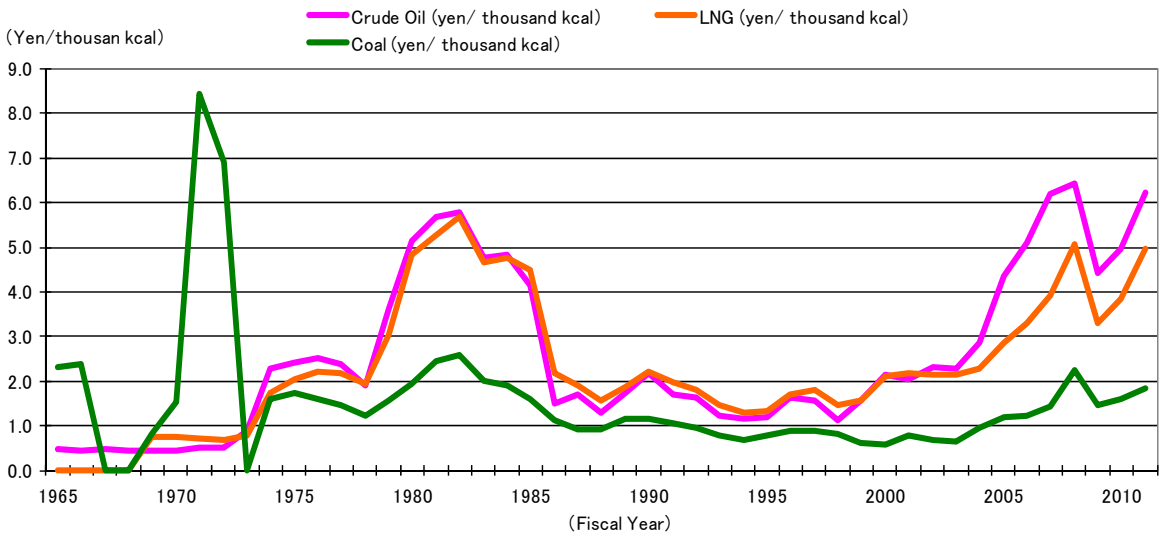
the value for FY1969 is used for the LNG import unit price for FY1965 to FY1968 before the import of LNG began, and the import unit prices for FY1966 and FY1972 are used for the period immediately following FY1967-1968 and 1973, when there were no coal imports.

Figure 3.3. Customs Clearance CIF




(Source) Ministry of Finance, "Monthly Trade Statistics"

Figure 3.4. Customs Clearance CIF under Calorific Parity Conditions




(Source) Ministry of Finance Trade, "Monthly Trade Statistics"

## 4. Estimation of the Effect on Containing the Outflow of National Wealth

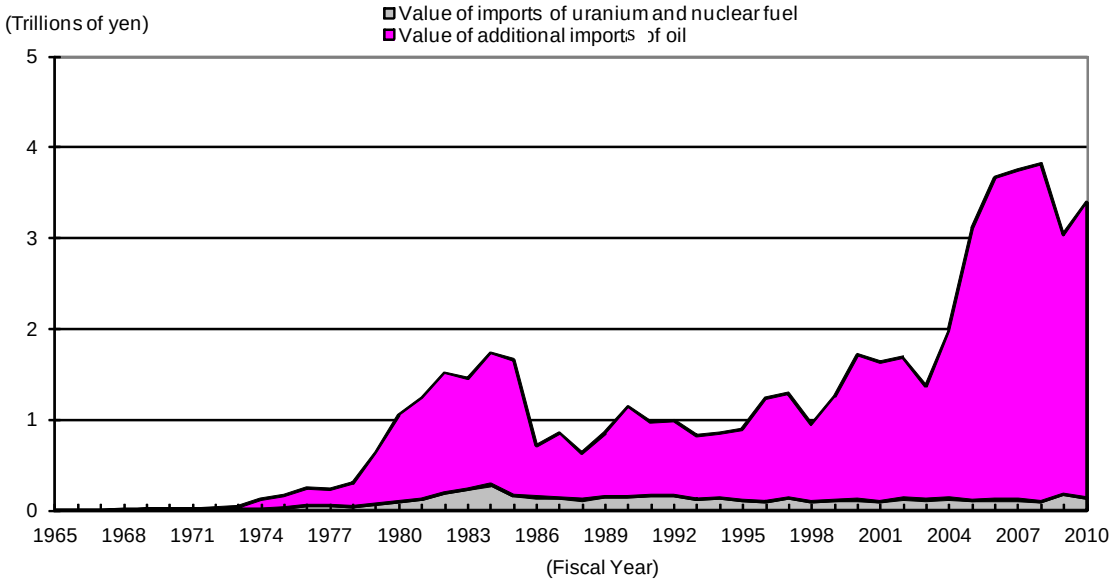
(1) Replacement with Oil Thermal Power

Of the three energy sources compared here, replacement of nuclear power with oil thermal power led to the highest cost. This is because oil thermal power is inferior to others in terms of thermal efficiency, and is a more expensive form of energy than LNG and coal when comparing the fuel unit price under fuel parity conditions. Also, as indicated in Figure 4.1, the value of additional imports of crude oil was 3.6 trillion to 3.7 trillion yen in FY2007 and 2008 when oil prices rose to historical highs. The amount of national wealth outflow contained was 44,004.1 billion yen after deducting the value of uranium and nuclear fuel imports (4,380.8 billion yen) from the value of additional imports of crude oil, which was 48,384.9 billion yen if oil thermal power was used as the only alternative during the period from when nuclear power generation began in FY1965 until 2010. Furthermore, even when only looking at the most recent five years when crude oil prices rose sharply (FY2006-2010), the effect on containing the outflow of national wealth was 16,378.8 billion yen.

(2) Replacement with LNG Thermal Power

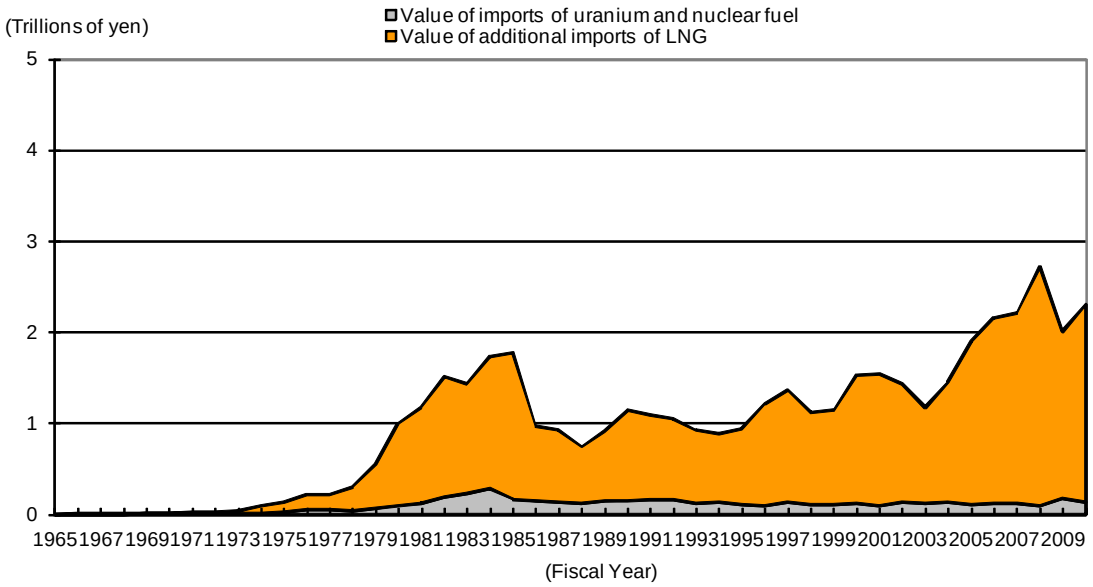
The cumulative total value of additional imports of LNG from FY1965 to 2010 when using LNG thermal power as a replacement for nuclear power was 40,483.8 billion yen. This is approximately 20% less than the value of additional imports when replacing nuclear power with oil thermal power, but the main factor behind this is the difference in the thermal efficiency of LNG thermal power and oil thermal power as seen in Figure 3.2. Since Tohoku Electric Power first adopted the combined cycle in 1984, use of this highly efficient method of power generation has spread rapidly, and is currently found in most newly constructed gas-fired thermal power plants. In the 1,500°C-class gas turbine power generation facilities that are cutting edge for commercial facilities, thermal efficiency based on the high calorific value is as high as 54%. As a result of the above, the cumulative amount of national wealth outflow contained by the use of nuclear power was 36,103.0 billion yen in this case, and 10,122.1 billion yen in the most recent five years.

Figure 4.1. Results of Estimation of Replacement by Oil Thermal Power




(Source) Ministry of Finance Trade Statistics used only for the value of uranium and nuclear fuel imports.

Figure 4.2. Results of Estimation of Replacement by LNG Thermal Power



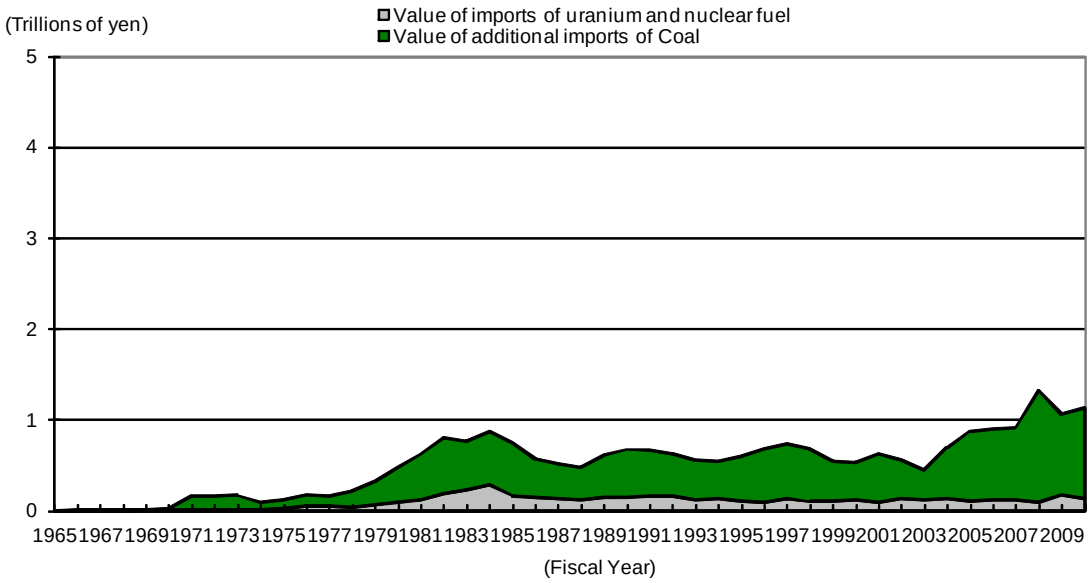

(Source) Ministry of Finance Trade Statistics used only for the value of uranium and nuclear fuel imports.

(3) Replacement with Coal Thermal Power

The cumulative total value of additional imports of coal from FY1965 to 2010 when using coal thermal power to replace nuclear power was 18,918.9 billion yen. The reason the value of

additional imports is significantly less than those for oil or LNG is because the fuel unit price of coal is considerably less, as shown under calorific parity compared in Figure 3.4. Furthermore, in recent years, highly efficient facilities using supercritical pressure and extra supercritical pressure boilers have been introduced in coal thermal power generation, and although not as efficient as LNG thermal power, the high level of thermal efficiency has been a contributing factor. For the above reasons, the amount of national wealth outflow contained by the use of nuclear power when replaced by coal thermal power was 14,538.1 billion yen.

Figure 4.3. Results of Estimation of Replacement by Coal Thermal Power




(Source) Ministry of Finance Trade Statistics used only for the value of uranium and nuclear fuel imports.

## 5. Conclusion

Since March 11 of last year, the mass media has tended to simply emphasize the disadvantages of nuclear power, but as shown in the above estimates, without nuclear power generation tens of trillions of yen in national wealth would have flowed out of Japan; it is necessary to dispassionately evaluate the enormity of the role played by nuclear power, both in terms of a stable energy supply and economic terms. In addition, according to our estimates, if the amount of power generation accounted for by nuclear power in the power source composition of 2010 were to be replaced by thermal power, this could reach a cumulative total of 13 trillion yen by 2015 and 24 trillion yen by 2020, giving rise to concerns about an entrenched trade deficit and deterioration of the current account.[2] Although there are growing expectations for distributed power sources, including the

[2] Materials distributed at 32nd Fundamental Policy Committee meeting
http://www.enecho.meti.go.jp/info/committee/kihonmondai/32th/32-6.pdf

widespread introduction of renewable energy such as solar power, discussion of the benefits of scale, or economic advantages provided by the development and use of large-scale power sources is being neglected. As described above, in order to resolve issues directly linked to national power and national interests, such as the stable supply of energy and maintaining and improving the international competitiveness of the economy and industry, it is necessary to quickly establish a healthy nuclear power safety regulatory system and resume operation of nuclear power plants that are confirmed as being safe.

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