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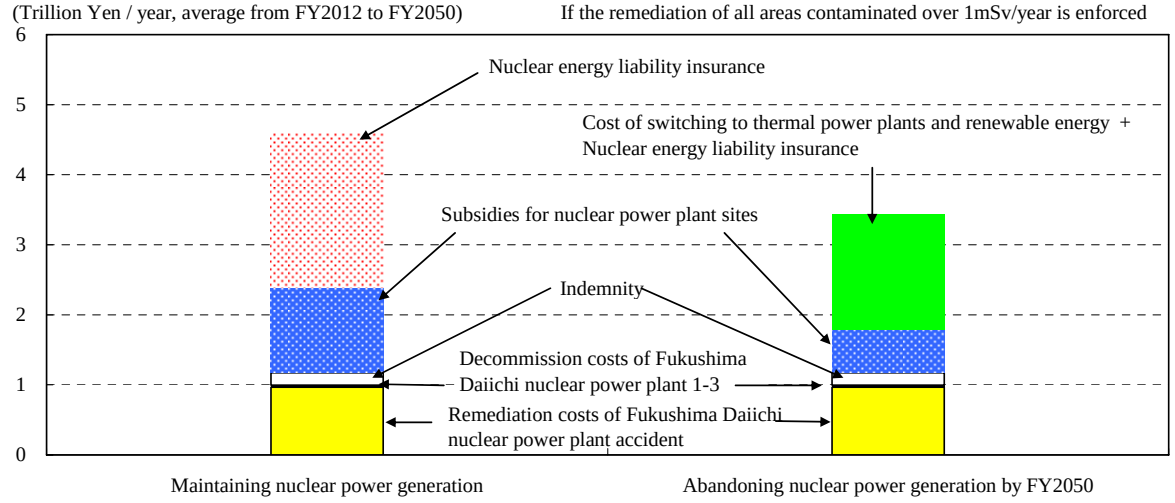
# Energy Saving and Renewable Energy Development Less Costly than Sticking with Nuclear Energy

## －Nuclear Generation Could Cost Twice Government Estimates－

Tatsuo Kobayashi, Senior Economist

In our 38th Medium Term Forecast for the Japanese Economy released in early December[1], we considered and compared the cost of cleaning up the accident at the Fukushima Daiichi nuclear power station and continuing with nuclear power, against the cost of abandoning nuclear power by FY2050 (April, 2050-March, 2051), relying on solar and wind power to the extent that power transmission network upgrades are not required. We concluded that there was no distinct difference between the two. Taking the above forecast a step further, the present report estimates the cost of abandoning nuclear power by FY2050, relying on further energy conservation efforts as well as more widespread use of new forms of energy, including solar, wind, thermal, biomass and low head hydropower. We find that making efforts in both adopting new forms of energy and energy saving would likely be cheaper and more economically advantageous than continuing with nuclear power (Figure 1).

**Figure 1. Comparison between Maintaining Nuclear Plants and "Exit Costs" from Nuclear Power in FY 2050**




Sources: Ministry of Environment, Japan Nuclear Fuel Limited, TEPCO, Nuclear and Industrial Safety Agency, Japan Atomic Energy Commission, and Cabinet Secretariat (Forecast by JCER)

The government's Energy and Environment Council estimated the cost of nuclear power generation while taking into consideration the accident at the Fukushima Daiichi nuclear power station. It concluded that the cost would rise by ¥3.0–¥4.3 per kilowatt hour (kWh) to ¥8.9–¥10.2. However, if the cost of measures to deal with the risk of future accidents is factored into this estimate, the true cost of nuclear power generation turns out to be about ¥22 per kWh, or ¥16 higher and about twice the government's estimate. The reason for this arises from differences in thinking, regarding the probability of future accidents and power plant

[1] "Energy and International Fragmentation, Rebuilding, Decontamination Costs Place Heavy Burden on Japanese Public" (December 2nd 2011) <http://www.jcer.or.jp/research/middle/detail4255.html>

site subsidies.

Under Japanese government targets, new forms of energy (including hydropower) are expected to account for an estimated 27% by FY2050 (or 17% if existing hydropower capacity is excluded). In this analysis, it is estimated that, as prices of fossil fuels rise and efforts are made toward conserving energy, electric power consumed will drop by 17% versus FY2010 levels. On the other hand, if use of nuclear power is to be continued, the establishment of an international joint administration system is essential, to make it possible to share and alleviate the expenses required for accident prevention and cleanup measures. Details of our estimates are as follows.

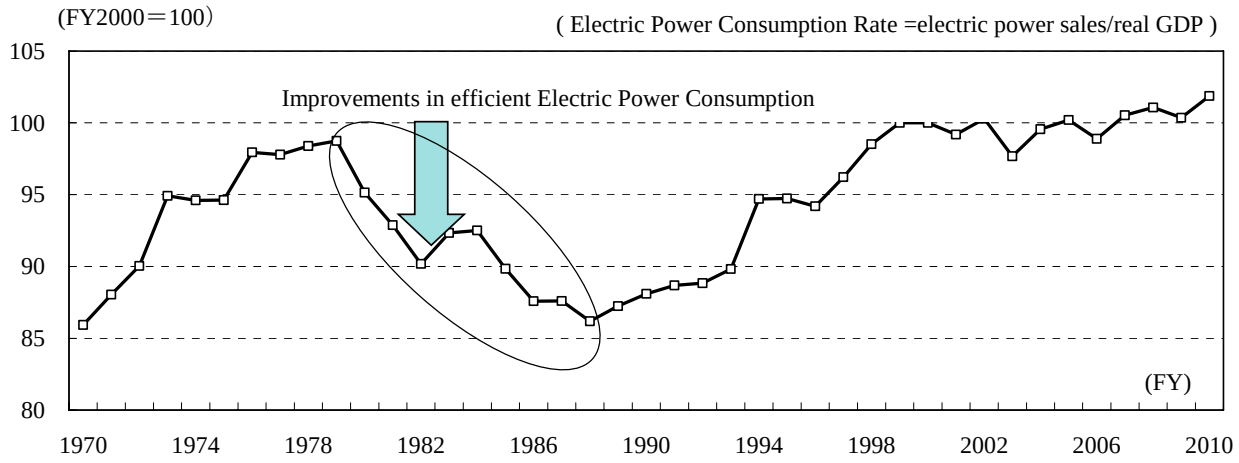
**Key Points**

(1) Government's nuclear power generation cost is about ¥10/kWh, versus our estimate of about ¥20/kWh.
(2) Energy conservation efforts equivalent to those taken during oil crisis would yield a 1.5% annual improvement in energy efficiency.
(3) The volume of energy from renewable sources and conservation can substitute for the total output of all existing nuclear power stations prior to the Fukushima Daiichi accident.
(4) Abandoning nuclear power would increase costs in the short run but likely be more advantageous in long run.
(5) A required condition for continuing with nuclear power would be the establishment of international joint administration to cope with accidents.

## 1. Energy conservation will improve efficiency by 1.5% annually and could cut energy consumption by almost 20%

In our Medium-Term Economic Forecast, we pointed out that shutting down all nuclear power stations would constrain energy supplies and become a drag on economic growth. Thus if energy conservation efforts are promoted through FY2050, to what extent could such negative impacts be eased? At the time of the oil shock, which lasted from the 1970s through the first half of the 1980s, Japan promoted the efficient use of electric power through investment in energy saving and industrial restructuring. As a result, Japan's electric power consumption rate (electric power sales/real GDP) improved by 12.7% between 1979 and 1988 (or about 1.5% per year on average, refer to Figure 2).

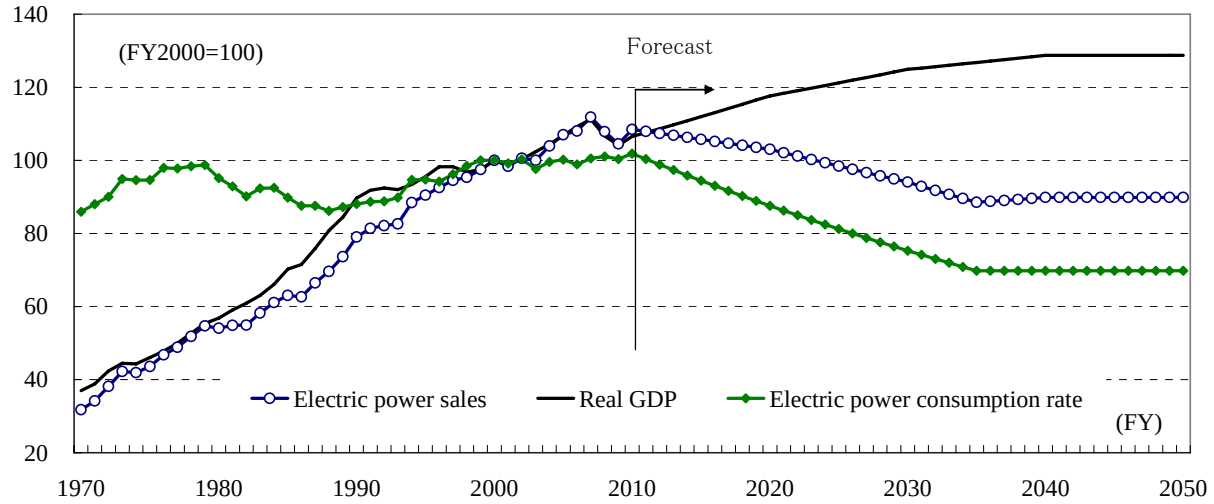
**Figure 2. Electric Consumption Rates Improved with Increasing Resource Prices during the Oil Shock**




Sources: National Accounts, Electric Power Statistics

According to the latest forecasts of the International Energy Agency (IEA), the price of crude oil will rise from recent levels of around $100/barel to $247/barrel by 2035 if present trends continue. We have computed electric power sales (consumption) by assuming that, if the crude oil prices continues to rise, Japan will again achieve improvements (energy saving) in its electric power consumption rate as it did in the wake of the oil shock. Since further declines in Japan's population are expected, we have also assumed that the nation's real GDP growth will gradually slow, reaching zero growth between FY2040 and FY2050. Based on the above assumptions, we find that, by FY2050, electric power consumption (or electric power sales) will fall by 17.5% versus FY2010 levels (refer to Figure 3). If efforts to conserve energy are not made, electric power consumption is expected to rise by about 20% in line with the growth of GDP.

**Figure 3. Increasing Energy Prices could Lead to a Reduction in Energy Consumption by almost 20%**




Sources: National Accounts, Electric Power Statistics

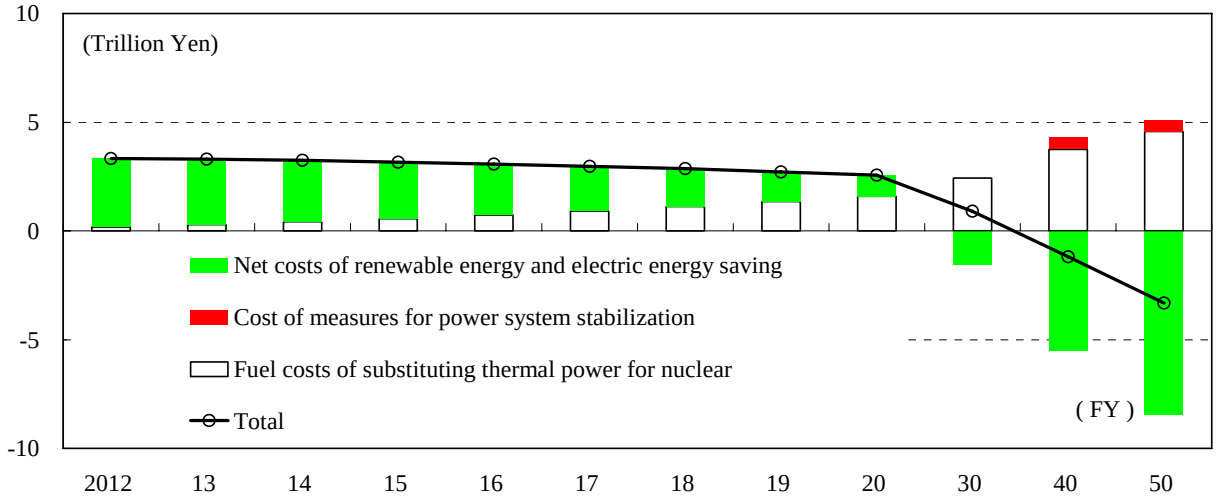
## 2. Fuel savings could exceed ¥8 trillion by FY2050 with renewable energy and energy conservation

Let us consider the costs involved in using new forms of energy and in energy conservation. Huge investments would be required, but since there would also be benefits from reducing fossil fuel consumption, we need to compare the costs versus the gains. In the analysis, we assume that investments in new forms of energy (almost ¥900 billion per year on average) will continue and that, so long as fossil fuel prices continue rising, investment in energy conservation will be at least ¥3 trillion per year on average through FY2050, or about 0.6% of GDP each year. The value of fossil fuel savings will initially be about 1/10 of the invested amount since no immediate payoff can be expected. However, the payoff from the investment will become more apparent as the years go by. Energy savings valued at over ¥8 trillion annually can be expected by FY2050. Even if the increase in fuel costs arising from substituting thermal power for nuclear is deducted, savings of ¥3.3 trillion per year could be expected by FY2050.

[Refer to Figure 4. Since upgrades to the power grid would be required along with the increased use of wind and solar energy, we have assumed here that the total cost of measures for power system stabilization would amount to ¥11 trillion between FY2030 and FY2050 based on the estimates of the Japan Wind Power Association[2].]

[2] "Alternative Scenarios," Japan Wind Power Association.

**Figure 4. Net Benefits of Energy Savings will become a Surplus by the 2030s**




Sources: National Accounts, Electric Power Statistics (Estimated by JCER)

Taking into account the effect of energy savings as shown in Figure 3, new forms of energy such as solar, wind, geothermal, biomass and low head hydropower could provide 17% of the electric power consumed in Japan by FY2050. Total energy generated by new forms of energy would reach 130 billion kWh, with electric power conservation efforts equivalent to another 150 billion kWh. Put together, this is equivalent to the total output of 280 billion kWh that was generated by nuclear power plants prior to the accident at the Fukushima Daiichi nuclear power station, thus substituting fully for the energy generated by nuclear power.

### 3. Cost of abandoning nuclear energy by FY2050 is 3/4 that of sticking with nuclear

Although we have already estimated the cost of continuing the use of nuclear power in Supplement 1 of our Medium Term Economic Forecast[3], further explanation on our methodology are as follows. Since continuing the use of nuclear power would require measures against possible future accidents, reserves for insurance premiums would be needed. We have estimated the cost of insurance premiums by first estimating the decontamination, compensation and decommissioning costs required in regard to the Fukushima Daiichi accident, and then multiplying this amount by a factor representing the probability of future accidents occurring. To take into account the maximum risk of this probability, we adopted the following formula: 2.0 *x* 10-3 (1/500)/ reactor years {this calculates the probability of an accident as severe as in Fukushima occurring in Japan}. Considering the fact that the Nuclear Safety Commission of Japan extended the designated evacuation area from within 10 to 30 kilometers radius from the Fukushima Daiichi plant, we have anticipated that the power plant site subsidies due to be paid will be from four to nine times higher. (The Cost Examination Subcommittee of the government's Energy and Environment Council has not taken account of any increases in power plant site subsidies as might be required for continued use of nuclear energy. It also assumes an accident probability of 1/1600, or one accident in forty years.)

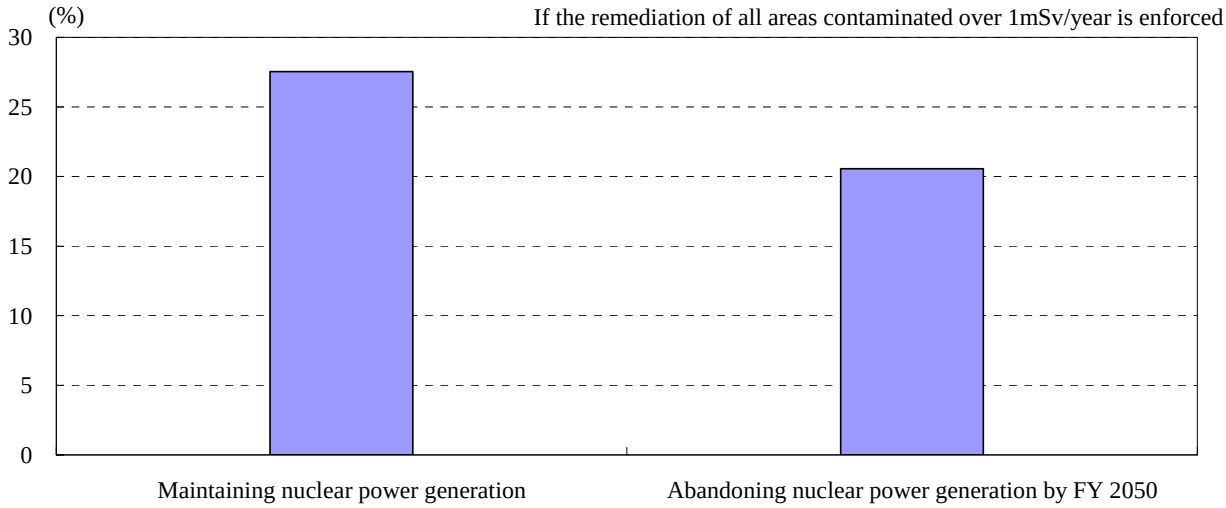
As a result, decontamination and other costs will be substantial, with the expenses required to continue with nuclear power amounting to ¥3.3–¥4.6 trillion annually (insurance premiums accounting for ¥1.4–¥2.2 trillion of this amount). If efforts to adopt new forms of energy and conservation are made, these expenses could be reduced to three quarters of this amount, as indicated in Figure 1. In contrast to our Medium Term Economic Forecast, the present estimates take account of the fact that even if nuclear power is eventually abandoned;

[3] http://www.jcer.or.jp/research/middle/detail4255.html

provisions will have to be made for the possibility of future accidents. However, the amount will be half of that required with the continued use of nuclear power. Since the impact of investment in new forms of energy will be considerable, the expense required in the event nuclear power is abandoned will fall dramatically by FY2050. This is another reason that our present projection differs from our Medium Term Economic Forecast, which concluded that the cost of continuing with nuclear power and that of abandoning nuclear power by FY2050 would be about the same.

In the event that 100% of the affected forests are decontaminated, electricity rates would rise by about 20% if nuclear power is abandoned and about 28% with the continued usage of nuclear energy. In the latter case, the power generation cost of nuclear power stations would rise by ¥16/kWh. Nuclear plant power generation costs, previously at ¥5–¥6, would exceed ¥20, which would be comparable to that of wind or geothermal power generation.

**Figure 5. Whether Maintaining or Abandoning Nuclear Energy, Electricity Prices will increase by 20-28%.**




Note: Estimated by JCER

However, an electricity rate hike could act as a factor in helping to encourage energy conservation. Between FY1973 when the oil shock struck and FY1988 when the electric power consumption rate stopped improving, household electricity rates rose by 77%, while the rate for business firms rose around four-fold (versus the consumer price index and the domestic corporate goods price index, respectively). Whether or not a 20-30% electricity rate hike would precipitate energy conservation is a question we have not analyzed in detail in the present analysis. In a future report, our Medium Term Economic Research Team will attempt to determine the concrete prospects for and means of realizing such an effect by analyzing the structure of inputs and outputs based on input-output tables and energy balance tables.

## 4. Sticking with nuclear power will require provisions against future risk through an international joint administration

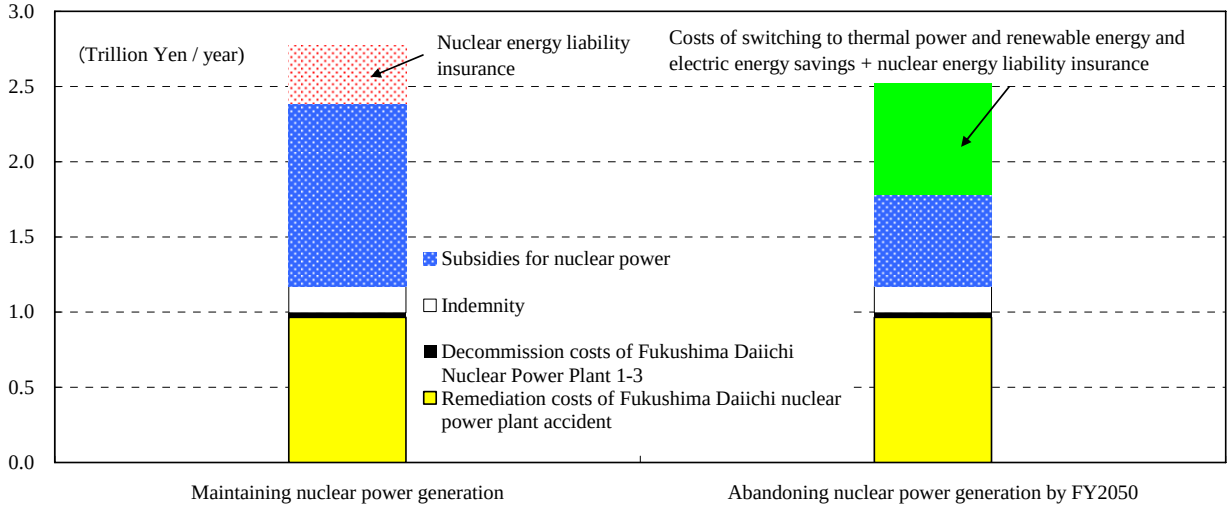
In the present report, our projections show that the cost of abandoning nuclear energy by FY2050 will be lower than continuing with nuclear energy, provided efforts are made to promote new forms of energy and to conserve. However, our assumption that the probability of a future accident will be 1 in 500 has been a major factor in this conclusion. As indicated in the accompanying table, there are many opinions regarding the probability of future accidents. Some observers in the nuclear power industry argue that the probability should be considered to be one in 10,000, which is the safety standard of the IAEA. Such observers argue that, if there are fifty reactors in Japan, a probability assumption of one in 500 would result in an

estimate of one accident every ten years, which, they argue, would be an overestimation and therefore not realistic.

In considering the option of continuing with nuclear power, we have considered what the costs would be in the event that nuclear accident risk management is conducted through an international framework such as the IAEA. In estimating the probability of an accident, we have taken into consideration not only the case of Fukushima but also the Three Mile Island accident in the United States and the Chernobyl accident in Ukraine. The probability of a severe accident is 3.5 *x* 10-4 (which in Japan's case would mean an accident once every fifty-seven years). Estimating the cost of continuing with nuclear power based on this probability estimate results in an annual average cost of ¥2.6 trillion over forty years, which is about 60% lower than estimates made based the assumption of maximum risk (i.e., one in 500 for an accident once every ten years). Even in this case, however, the burden of power plant site subsidies paid to communities where power plants are located would be considerable if use of nuclear power is continued, ultimately resulting in about the same cost.

**Figure 6. If international management for nuclear risk is implemented, costs of maintaining nuclear power generation will decrease.**

(If the remediation of all areas contaminated over 1mSv/year is enforced)




In the future, the use of nuclear energy is expected to increase in emerging nations. Moreover, it is impossible to ignore the risk of severe accidents being caused not only by natural disasters but also by human error or terrorist attacks. We believe it would be advantageous to appeal for the establishment of a joint fund for coping with nuclear power accidents through the IAEA. Of the abovementioned costs required to continue using nuclear power, the cost of premiums for insurance against future accidents is expected to account for an estimated ¥300 billion annually. (Other costs include dealing with the Fukushima nuclear accident.) This would be the amount that Japan would contribute to such a fund if it were to continue with nuclear power, maintaining total energy generated at levels prior to the Fukushima nuclear accident. In order to win the cooperation of emerging nations and other regions in the establishment of the fund, contributions should be made proportional to a country's level of economic development.

## 5. Bold deregulation necessary to promote new forms of energy

In the present report, our projections have anticipated not only an acceleration in the use of wind and solar power, but greater use of other forms of new energy, including geothermal, biomass and low head hydropower. However, the proliferation of geothermal power generation and low head hydropower will require massive deregulation, including the

relaxation of conditions for approving the installation of such facilities within national parks. Furthermore, in order to encourage greater use of sources as wind power and solar power, it will be critical to build ports and other facilities to easily ship large structures, and also to exploit uncultivated land and fallow fields. The establishment of tax-free zones will also be essential as a means of utilizing new forms of energy in the recovery of areas affected by the Great East Japan Earthquake.

**Underlying Assumptions**

In estimating the costs required to cope with nuclear power accidents and adopt new forms of energy, we have made the following assumptions.

**Assumptions regarding nuclear power**

(1) Regarding decontamination expenses

Assumptions regarding the volume of contaminated soil and other material are based on estimates by the Ministry of the Environment (i.e., about 150 to 280 million cubic meters).

The high estimate for cleanup costs reflects the cost of processing low-level radioactive waste (¥1.2 trillion per 600,000 cubic meters), while the low estimate reflects costs for the construction of low-level radioactive waste disposal facilities (¥160 billion per 200,000 cubic meters) plus the ordinary expense for removing rubble (23,000 per cubic meter).

(2) Indemnity

Indemnity is based on the report of the Investigation Committee into the Operations and Finances of Tokyo Electric Power Company (TEPCO Financial Investigation Committee). We based our analysis on two cases; in the first case, the compensation paid in a single fiscal year from the second year onward gradually falls over ten years until it reaches zero (the amount being ¥900 billion in the second year and declining linearly over ten years), and in the second case, the compensation reaches zero in five years.

(3) Reactor decommissioning cost

We have used the amount of ¥1.15 trillion, based on the report of the TEPCO Financial Investigation Committee.

(4) Power plant site subsidies

Power plant site subsidies are based on population estimates for the region surrounding nuclear power plants as estimated by the Nuclear and Industrial Safety Agency. We also assume that if the designated evacuation zone is enlarged from a ten to thirty kilometer radius, then the population will increase four-fold.

**Assumptions made on the extent to which renewable energy is adopted**

(1) Costs of measures for power system stabilization

• According to the Federation of Electric Power Companies of Japan, solar power could provide up to 10 million kW and wind up to 5 million kW with no power system costs (such as upgrades to the transmission grid or installation of storage batteries). However, based on the estimates of the Japan Wind Power Association (¥5.5 trillion), we assume that subsequent use of these sources will result in power system costs amounting to a total of ¥11 trillion between FY2030 and FY2050.
• In making the above assumptions, we assume that owing to the decline in electric power demand, no purchases will be made for the thirty days including the New Year, Golden Week and spring and autumn vacation.

(2) Nuclear power generation

We assume that nuclear power generation will essentially be replaced by thermal power generation.

(3) Solar power generation

• We assume that, from and after FY2011, solar power generation will be installed in 85% of new housing starts (owner-occupied homes) and built-for-sale housing (single-family homes). With the adoption of the surplus power purchasing system initiated in the fall of 2009, the percentage of new housing starts (owner-occupied homes) built with installed solar panels rose by about 20%, from 47% to 68%, between FY2009 and FY2010. We assume that installation increased at the same pace in FY2011. We also assume that, from FY2021 and after, the pace of such installations will fall to 75% owing to a lower feed-in-tariff.

• We assume that about 160 million kW will be installed by FY2020 and about 460 million kW will be installed by FY2050.

• The learning rate is assumed to reach 22%.

(5) Wind power generation

We have assumed that through FY2020 all wind power generation will be terrestrial at 7 million kW. Including offshore wind power generation installed from and after FY2020, we assume total wind power generation at 250 million kW by FY2050.

**Assumptions regarding costs of renewable energy**

(1) Solar power generation

• We expect the system installation price for solar power generation to fall 22% with the doubling of cumulative installed capacity. (We have not assumed advances in technology as a factor in the decline of system installation prices.)

• Purchase prices will fall in proportion with the decline in system installation prices.

• We assume that even after the adoption of the feed-in tariff system, purchases of surplus electricity will be continued with regard to residential electricity. For ordinary households, we assume 60% of electric power generated will be purchased power.

(2) Wind power generation

• With regard to wind power generation, we assume a fixed system installation price of ¥200,000/kW and a purchase price of ¥20/kW.

(3) Solar and wind power

• We assume that facilities having reached the end of their life-span (assumed at twenty years) will be uninstalled and that 90% of facilities will be replaced.

• For crude oil prices, we have used JCER forecasts through FY2020. Prices for subsequent years through FY2035 have been linearly interpolated based on WEO 2011 figures from the IEA ($247.20 as of FY2035). We assume prices after FY2035 will remain unchanged from FY2035 levels.

• We assume a currency rate of ¥80/$1.

(4) Geothermal power

• We uniformly assume a construction unit price of ¥800,000/kW and a feed-in tariff purchase cost of ¥20/kWh.

• We assume an operating rate of 80%.

(5) Biomass energy

We consider only co-firing of waste and coal, assuming construction expense at zero. The purchase cost is assumed at ¥20/kWh.

(6) Low head hydropower

We have assumed a construction cost of ¥800,000/kW and a purchase cost of ¥20/kWh.

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



**Japan Center for Economic Research (JCER)**
Nikkei Inc. Bldg. 11F 1-3-7 Otemachi, Chiyoda-ku, Tokyo 100-8066, Japan
Phone: +81-3-6256-7710 / FAX: +81-3-6256-7924