PROPOSAL:
A Renewable Energy Promotion Policy for Achieving a Low-carbon Society

February 2009

Committee on Renewable Energy Promotion Policy for Achieving a Low-carbon Society
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Preface

The world has come to a critical turning point in its transition to a low-carbon society. At the G-8 Hokkaido Toyako Summit in 2008, world leaders declared that the Parties to the United Nations Framework Convention on Climate Change would share a goal of reducing global greenhouse gas emissions by 50% by the year 2050. Under these circumstances, many countries are aggressively introducing renewable energy. Globally, photovoltaic power generation is growing at an annual rate of 60%, while solar thermal systems are increasing at an annual rate of more than 15%.

In Japan, there is still insufficient use of renewable energy. For example, Japan is introducing photovoltaic power generation at a rate of about 30% lower than the world’s average, while utilization of solar thermal energy have been decreasing. In July 2008, the Cabinet approved the “Action Plan for Achieving a Low-carbon Society” in its initiative to promote the use of renewable energy produced from photovoltaic or other renewable energy sources. To fulfill its 6% reduction target for the 2008-2012 period under the Kyoto Protocol and to build a low-carbon society from 2020 to 2030 or 2050 in line with the Action Plan, Japan is strongly required to promptly reinforce renewable energy production.

The promotion of renewable energy would also help revitalize the economy and increase job opportunities. At a time when we are faced globally with a serious financial crisis and devastated economies, a number of countries, including the United States and Korea, have initiated a so-called “New Deal Policy” in an effort to revive the economy and boost employment. For Japan, reinforcement of renewable energy deployment would be required to restructure the national/local economies and employment.

In this Proposal, we have reviewed Japan’s policy for promoting renewable energy to achieve a low-carbon society. In particular, we have focused more attention on photovoltaic power generation because it is an ubiquitous source of energy, with the huge potential of significant contribution to the development of Japanese industries. In this Proposal, a specific policy is presented with respect to the adoption of solar generation toward 2020 and 2030.

We hope this Proposal will facilitate the understanding of the significance of promoting renewable energy and encourage public discussion of the implementation of relevant
policies, including a cost allocation mechanism, thus contributing to increased production of renewable energy.

Committee on Renewable Energy Promotion Policy for Achieving a Low-carbon Society

This Committee was funded by the Ministry of the Environment, Government of Japan.
Overall Summary

1. Significance of renewable energy promotion and the content of this Proposal

Toward the ultimate goal of containing the air concentration of greenhouse gases below a level that does not artificially affect the climate, countries are sharing the objective of reducing global greenhouse gas emissions by 50% from the present level by 2050. In line with this move, Japan has set a long-term target of a 60 to 80% emissions reduction from the current level by 2050. To fulfill such reduction targets for greenhouse gas emissions, it is essential to shift to energy sources that can substantially reduce CO2 emissions compared with fossil fuels rather than concentrating energy-saving efforts on the existing energy portfolio. In this respect, renewable energy should be an important alternative.

According to the International Energy Agency (IEA) and the National Institute for Environmental Studies of Japan, to achieve substantial reductions in greenhouse gas emissions all over the world, including developing countries, we are required to take all options into consideration, including nuclear power generation and fossil fuel-fired power generation accompanied with CO2 capture and storage, and implement all appropriate measures possible at a fast rate unprecedented in history. Especially, in the fight against global warming in developing countries, the adoption of renewable energy has also the advantages of flexibility in installation in accordance with growing energy demand, with smaller investment costs and shorter lead time, and easier operation and maintenance than other means of energy supply.

Now that a substantial reduction in greenhouse gas emissions is indispensable for sustainable development of human beings, we can no longer accept the notion that combating climate change issues would impose a heavy burden on economic growth. It is now globally recognized that countries would be able to achieve international competitiveness, stimulate employment, and establish energy security only if they build a low-carbon society faster than others. Major countries are now aggressively promoting a so-called Green New Deal policy, and implementing a diversity of measures for promotion of renewable energy as part of the policy.

In this Proposal, renewable energy is defined as a type of energy that is inexhaustible and permanent (flow-type) and produces little environmental burden. The Proposal presents some analytic findings concerning the output of renewable energy necessary to achieve a low-carbon society achieving, the nature of policy on the promotion of renewable energy, measures to overcome non-economic barriers for the adoption, the future course of the electricity supply-demand system, costs and effects of promotion, and ways to allocate related costs. In the discussion, special focus was placed on photovoltaic power generation because Japan has significant technological strengths in this field and thus is able to contribute to the construction of worldwide anti-warming policies, while helping itself
regain high economic vitality and ensure energy security. In this Proposal, specific policies are presented with a timeline set for 2020 and 2030 for large-scale introduction of photovoltaic energy.

2. Japan's present status of renewable energy, production targets, and estimated output based on potential and feasible outputs

Heavily dependent on imports for fossil fuels, Japan is among the countries most seriously required to consider how to secure energy in 50 to 100 years in order to achieve a sustainable society. Unfortunately, however, the country has seen little increase in renewable energy consumption since 1990. While Western countries are setting up aggressive renewable energy targets, Japan is still maintaining an extremely low target.

Available statistics and data on the potential and feasible outputs of renewable energy indicate that renewable energy sources, including photovoltaic power generation, retain high production potential and promise substantial feasible output for the future.

With an eye to the year 2050, the estimated output (practicable maximum output, taking into account several factors, such as economic efficiency) of renewable energy was calculated for 2020 and 2030 on the basis of the feasible output. The results indicated that, while in 2005 renewable energy accounted for 5% of total primary energy supply (crude oil equivalent of 29.33 million kiloliters (including large-scale water power generation)), it is possible to increase its ratio to about 10% in 2020 (crude oil equivalent of 53.31 million kl (including large-scale water power generation)). In addition, while renewable energy represented 9% of the country’s total electricity output in 2005 (99.0 billion kWh (including large-scale water power generation)), it would be possible to increase its ratio to about 18% in 2020 (186.8 billion kWh (including large-scale water power generation)).

3. Specific policies for promotion of renewable energy

To achieve the estimated output discussed in the above chapter, it is important to analyze the effects of policy options and, based on the analysis, find an appropriate combination of options on the premise that costs, technology, market size, and other factors need to be organically linked to one another.

First, the Japanese society must share an idea of how we should use energy, including renewable energy, in the future. The conventional view from the energy supply side is not enough when we formulate a promotion policy. Instead, we should adopt views from the energy demand side, which reflect the characteristics of decentralized energy. That is, we need to review policies for electricity, heat, and fuels with close attention to the way energy is used by end users.
Next, renewable energy sources are more costly than fossil fuels in producing electricity or heat because of technical difficulty in cost reduction and the lack of a carbon pricing system in Japan. To transform the conventional energy supply-demand system into a renewable energy-based system, a new mechanism is required to appropriately allocate additional costs that have been traditionally born by renewable energy suppliers.

Benefits from the promotion of renewable energy could be enjoyed by the entire nation. The public and businesses are becoming more conscious of the importance of, and acceptable to, promoting renewable energy. In light of these circumstances, it is urged to establish a program of allocating necessary costs widely among people and promoting the use of renewable energy across the country through public cooperation.

Because renewable energy sources are at different technological levels (development stage, demonstration stage, or commercialization stage) and in different market phases (introductory phase, promotion phase, or saturation phase), we need to combine appropriate policies, depending on their respective circumstances.

Japan should concentrate its efforts on some specific fields: (a) photovoltaic power generation, which can contribute to the construction of a global low-carbon society, while enhancing the country’s international competitiveness, (b) wind power generation, which provides tremendous output potential on oceans, (c) geothermal power generation, which can bring Japan magnificent potential rarely seen in other countries, (d) small-scale water power generation, which can be achieved by taking advantage of the geographical characteristics of the country, which has a large amount rain and numerous steep rivers, and (e) biomass utilization, which can flexibly conform to varying regional characteristics, and (f) solar heat and geothermal heat production, which can provide low and medium temperatures for heating and water supply.

First, to promote renewable electricity, Japan and Western countries have adopted such systems as installation subsidy programs, Renewables Portfolio Standard (RPS) programs, net metering, and Feed-in Tariffs (FIT). These programs can be characterized as follows.

- **Installation subsidy program**
  Under the installation subsidy program, the government pays part of the cost of introducing renewable energy. This program provides an effective subsidy at the early stage of deployment, which often requires a heavy initial investment. As a disadvantage of the program, a budget cap is set each year on the total amount available from the government, and considerable administrative costs add up under the program.

- **RPS program**
  The RPS program obligates power companies to supply certain amounts of
renewable energy to consumers. The program aims to enhance cost-effectiveness of energy by encouraging low-cost competition among renewable energy sources. On the other hand, renewable energy sources having relatively high installation costs will have difficulty gaining broad acceptance because renewable energy sources, which vary widely in cost and technology, are left to compete face to face in the market. In addition, profitability of investment to renewable energy is uncertain as future RPS certificate prices are unpredictable.

- Net metering
Net metering is a variation of pricing laws. Power companies purchase surplus electricity from consumers. In Japan, a voluntary net metering scheme named "Surplus Electricity Buyback Program" has been provided by the power companies. The surplus electricity is purchased by the power companies, at a price close to the consumer electricity prices. It can be categorized as a variation of FIT (a Feed-in Premium with no premium). On the other hand, Japan’s current buyback program, provided voluntarily by power companies, is yet to be institutionalized to ensure long-term purchases.

- Feed-in tariffs (FIT)
The feed-in tariffs are also variations of pricing laws. Power companies are obligated to purchase all amounts of electricity obtained by renewable energy generation at a predetermined price. Because it is possible to estimate the payback period under this system, it can accelerate investments in renewable energy. The most important factor in institutional design is pricing. Lower buyback prices can discourage investments, whereas higher prices can lead to excessive supply, which could result in erratic installation costs. It is also necessary to periodically revise buyback prices in accordance with progress in cost reduction or deployment speed.

Of the programs described above, detailed analysis was made by the European Commission and the IEA concerning the RPS and FIT programs based on actual cases of renewable power deployment in a number of countries. The analytical results showed that the FIT, adopted by several countries, including Germany and Spain, is highly effective and efficient in introducing such technology as photovoltaic power generation that requires considerable installation costs.

Japan enforced an RPS program in April 2003 as part of its renewable energy policy. Since then, all power companies have fulfilled their targets in excess, and such accumulated excess is now limiting the development of the renewable energy market. Because of these low targets, Japan has been unsuccessful in achieving cost reductions by economies of scale. Currently RPS certificates, which should be an incentive to adopt renewable energy, are purchased by only some power companies thus failing to work a pricing mechanism in the market. In addition, though it is estimated that power companies are bearing heavier deployment costs with the progress of the program, the accurate amount of the cost is not
Known. Neither, there are no official frameworks that states by whom and how those costs should be paid.

To increase renewable energy production by improving the current RPS, it is essential to secure cost transparency, together with higher deployment targets. The deployment cost should be explicitly paid to the power companies, allowing them to collect the cost from electricity charges. The deployment capacity targets should be raised significantly to invoke cost reduction. However, under the RPS, only the energy sources with the lowest cost are preferred. Thus, in order to deploy renewable energy sources that demand relatively high initial investments, we need to reinforce the current support program. For example, Italy has adopted an FIT program for photovoltaic power generation, in addition to the RPS.

With respect to the renewable heat policy, it is important not only to provide financial support but also to encourage effort on the part of consumers, as well as suppliers. Obligation of installation is an example; Spain and some other countries oblige buildings and households to adopt renewable energy upon construction or refurbishing.

To increase the utilization of solar thermal energy, the governments may adopt solar obligations, which legally obligate utilization of a specified fraction of heating demands with solar energy in new/refurbished buildings. Or it would be possible to develop a “green heat certificate” system, as is currently discussed by the Tokyo metropolitan government as a program which provides incentives proportional to the utilized amount of solar thermal energy.

Fuel policies for renewable energy may include the promotion of biofuels for transportation and solid fuels such as wood pellets. For increased production of biofuels for transportation, it is required to improve the environment for advanced utilization of biofuels by solving problems associated with fuel standards and vehicle types and by switching from E3 ethanol gasoline (3% ethanol and 97% gasoline) to E10 (10% ethanol and 90% gasoline), in addition to incentives such as tax benefit under a current program.
4. Promotion of photovoltaic power generation

Photovoltaic power generation for Japan is strategically important among others for following reasons: (a) Japan demonstrates its strengths as a top world leader in technological development and can contribute to the construction of a global low-carbon society enhancing its international competitiveness through further industrial efforts; (b) its massive introduction will reduce the initial investment cost thanks to economies of scale, (c) photovoltaic power generation is applicable all over the world with ubiquitous solar energy, and (d) Batteries of plug-in hybrid and electric vehicles, in which Japan also has technological advantages, can be utilized as storage cells of photovoltaic electricity in future. In our analysis, with a special focus on photovoltaic power generation, production targets were set for 2020 and 2030, and expected output was calculated based on an analysis of alternative promotion measures that could realize these production targets.

In line with the global long-term target of a 50% reduction in greenhouse gas emissions by 2050, we determined that photovoltaic power generation should be a critical option to combat global warming for Japan and other developed and developing countries. Under this concept, we set up a target of reducing installation costs of photovoltaic power generation to the level of retail electricity prices between 2020 and 2030. More precisely, the cost of photovoltaic power generation would almost equal electricity charges for business use (14 yen/kWh) in 2030 and would fall below the cost of thermal power generation (7 yen/kWh) in 2030.

To promote photovoltaic power generation in Japan and to achieve its cost targets by economies of scale, we estimated that the capacity target should be set at 37.0 million kW for 2020 (about 25 times the current level) and at 79.0 million kW (about 55 times the current level). Assuming that photovoltaic power introduction will grow during the 2030-2050 period as fast as before 2030, it will top 173 GW (173 million kW), which is necessary to achieve Japan's 70% greenhouse gas emissions reduction in 2050 (according to the National Institute for Environmental Studies’ 2005 Japan Low-carbon Society Scenario: Feasibility Review of 70% Greenhouse Gas Reduction), and the figure is also compatible with Japan’s long-term goal of cutting greenhouse gas emissions by 60 to 80% from the present level by the year 2050.

In promoting photovoltaic power generation, we attach importance to our domestic market for several reasons: (a) the development of the domestic market also enhances and maintains a global market competitiveness as seen in the past in the semiconductor market; (b) the domestic introduction gradually reduces its installation costs together with its production costs; and (c) introduction of photovoltaic power generation is a visible action in the business and household sectors, which discharge more greenhouse gases every year.

The 2020 photovoltaic power capacity target of 37 million kW is projected to be achieved if the government not only introduce photovoltaic power generation systems widely into the
public sector but also provides an aid package to households and businesses to enable them to harvest their investments in a 10-year period, during which the performance of solar panels is generally guaranteed.

The 2030 photovoltaic power capacity target of about 79 million kW will be achieved by (a) aggressive adoption by the public sector of photovoltaic power generation systems (installation at 90% or more of feasible potential), (b) providing support to consumers to enable them to harvest their investments within 10 years, (c) adopting innovative technologies by encouraging technical development, (d) providing financial support (interest subsidies, low-interest loans, etc.), and (e) reinforcing educational activities for the public to recognize the significance of photovoltaic power generation and its economic advantages.

On the assumption that the 2020 target is achieved, the share of Japanese businesses in the global photovoltaic generator market would be at least 30% and 20% in 2020 and 2030, respectively.

Compared with other renewable energy sources, photovoltaic power generation involves costly initial investments. Measures to shorten the payback period to 10 years may include a considerable raise in targets or setup of a production target only for solar heat under the RPS, or the introduction of an installation subsidy program or a FIT, or a combination of any of these measures.

Under the RPS program, the government sets a supply target but leaves the price formation to the market. For this reason, it is almost impossible to institutionalize the concept of shortening the payback period to 10 years for the purpose of achieving the target. This Committee analyzed the effects of Japan's installation subsidy program currently in place and the FIT program already adopted in some countries.

Under the installation subsidy program, installation costs are shouldered by the government, and the amount of subsidy peaks right after the adoption of the program (470,000 yen/kW with a budget of 760 billion yen). On the other hand, under a FIT program, installation costs are borne by consumers. While the electricity buyback price will peak right after the program is adopted (55 yen/kWh), total costs will peak in 2025 at about 400 billion yen.

When the installation subsidy program and the FIT are compared, the latter would be a better option as a measure for setting the payback period at 10 years because, in the former, a cap is imposed annually on the government contribution, because it is not clear how long the program will be continued, and because administrative costs may increase to sustain the program. If the cost of introducing photovoltaic power generation is sufficiently reduced in the future, an RPS program with a substantially higher supply target may be effective.
5. **Overcoming non-economic barriers and approaches from the demand side**

For increased production of renewable energy, it is necessary to promote a policy for overcoming non-economic barriers, in addition to a financial support policy. In promoting the production of renewable energy, it is essential to review relevant systems and their operation, where necessary, and establish a program to build a consensus among concerned parties. With respect to barriers between existing systems, a provision should be set forth to connect power grids to renewable energy on a preferential basis (the priority connection provision), as seen in Germany.

An analysis partly based on past surveys on the demand side concerning the utilization of electricity and heat suggests that over 80% of the electricity consumers are relatively receptive of the quality of renewable energy, including voltage and frequency fluctuations exceeding the current standard. Low-temperature heat demand for hot water and heating, which can be supplied from solar and geothermal sources, is expected to amount to 31.76 million kL, accounting for 55% of total household energy.

6. **Direction of the electricity supply-demand system in line with increased power generation from renewable energy**

To significantly increase electricity generation from renewable energy sources, it is crucial to improve the operation and facilities of electricity supply-demand systems step by step, including the existing power systems.

Characterized by sharp output fluctuations, certain types of renewable power generation, such as photovoltaic power generation and wind power generation, are faced with some demand-supply problems. These problems may be solved not by controlling or compensating individual output fluctuations in conventional practice but by having the whole system cope with such fluctuations and by increasing production, while gradually shifting under a new concept to a next-generation supply-demand system having higher efficiency and quality.

To be more precise, devices such as a voltage regulator may be installed where necessary to address problems of regional characteristics, including voltage fluctuations. In line with increasing power generation for renewable energy, total system output is leveled out even though there are sharp fluctuating outputs from individual systems, as high-frequency fluctuations cancel out, resulting in smoother fluctuations (“the leveling effects”). In solving supply-demand balance problems, we would be able to make the best use of the regulating ability of existing power systems by accurately evaluating the leveling effects.

In addition, by determining the still required capacity of storage battery with the premise of the supply-demand adjustment that utilizes the adjusting ability of individual devices
maintained at consumers ("smart grids" adopted in Western countries), we could achieve sufficient stability and minimum cost of power systems.

To solve problems with Japan’s vulnerable energy supply structure and to achieve significant increases in renewable energy, it is necessary to shift to a new electricity supply-demand system that can be operated in a smarter and more advanced manner through a coordinate network of large power supplies, decentralized power sources, individual demands, and storage cells. Such progress in the electricity supply-demand system, including the power system, can be achieved by formulating an appropriate and timely combination of operational measures and infrastructural improvements.

With respect to short-term operational measures, it is indispensable to start considering how to gradually advance the electricity supply-demand system, including the power system by improving the entire supply-demand plan in accordance with increasing generation of photovoltaic and other renewable energy, while maintaining the supply-demand balance by making the best use of the adjustment ability of existing thermal power plants and by enhancing daytime storage capacity at pumped storage power plants. Over a medium term, while continuing short-term measures, we should enhance maximize the utilization of renewable electricity by taking into consideration power cuts during long holidays or other specific times when the supply-demand balance is difficult to maintain. In the long term, it is essential to raise the availability cap by expanding area tie lines and to develop an advanced system for predicting renewable energy output, including photovoltaic power generation, based on weather forecasts or by other means.

Next, concerning infrastructural improvements, we are urged, in the short-term, to conduct a study to clarify the characteristics of renewable energy generation and, where necessary, apply voltage control measures, such as voltage regulators, to high-voltage power distribution lines. In the medium term, while continuing these short-term measures, we should adopt an energy management system and storage cells, as well as a power (smart grids) where consumers use an autonomous coordinating function based on information and communication technology. In the long term, we should build an integrated system to raise distribution voltages, including CO2 emissions reductions by containing voltage rises and reducing distribution loss through adoption of photovoltaic power generation, and at the same time, we are required to shift to an electricity supply-demand system that can harmoniously integrate distributed with power supplies with large-scale centralized power supplies.

Further, in reviewing electricity supply-demand systems, we are urged in the short term to standardize consultation procedures for grid interconnection. It would also be important to review the regulations on system voltage ranges (upper voltage limits). In the medium term, it is required to maintain thermal power generation to flexibly cope with the supply-demand conditions for electricity. In the long term, we need to development an open market to ensure transparency.
Based on the above discussion, this Committee estimates that up to a total of 3.5 trillion yen would be needed by 2030 to build an electricity supply-demand system competent enough to handle increasing renewable energy generation.

7. Cost of producing renewable energy and specific effects of increases production

In the discussion above, we have clarified the estimated output of renewable energy, measures to achieve the targets, and the direction of the electricity supply-demand system to handle increasing production. Then, how much it would cost to achieve energy output appropriate to benefits expected for the nation. As shown below, this Committee concludes that the costs calculated for the production of renewable energy will be acceptable to the public, and that the benefits of renewable energy produced would sufficiently exceed the costs.

First, in our analysis, additional costs of introducing renewable energy generation equipment during the 2010-2030 period are estimated at 17 trillion yen for photovoltaic power generation, 1.1 trillion yen for small-scale water power generation, 0.5 trillion yen for geothermal power generation, and 2.3 trillion yen for biomass power generation. Including the costs of 3.5 trillion yen required to install electricity supply-demand systems, the total costs for the 2010-2030 period are estimated to amount to 25 trillion yen.

Next, we conducted analysis to determine the effects of the achievement of production targets on CO2 emissions reduction, the self-efficiency of energy supply, the economy, and employment. In this analysis, two cases were assumed for fossil fuel prices: they will stay either flat or increase:

With respect to CO2 emissions reduction in Japan, we estimate the annual CO2 emissions reduction of 47 million tons in 2020 (about 4% from the year 1990) and 96 million tons in 2030 (about 8% from the year 1990) from the level at which renewable energy production stays in the lower case under the Kyoto Protocol. It is projected that these levels of CO2 emissions reduction will generate cumulative economic benefits worth 400 to 600 billion yen until 2020 and 1.5 to 2.3 trillion yen until 2030.

In addition, Japan's energy self-sufficiency is expected to increase to about 10% in 2020 from the current 5% and 16% in 2030, thanks to the CO2 emissions reduction accompanied by controlled demand.

A saving on fossil fuels in electricity and heat will amount to 500 to 800 billion yen in 2020 (a cumulative saving of 2.9 to 4.0 trillion yen to the year 2020) and to 800 to 1,400 billion yen in 2030 (a cumulative saving of 9.9 to 16 trillion yen). Assuming the industrial structure as of 2000, increased exports of photovoltaic general systems resulting from the development of
domestic markets are projected to add a cumulative total in GDP of 26 trillion yen to the year 2020 and 48 trillion yen to the year 2030. Thus, we estimate that economic benefits will significantly exceed corresponding costs.

With respect to employment, 590,000 and 680,000 jobs will have been created by 2020 and 2030, respectively, in the renewable energy fields, including the manufacture, installation, and maintenance of solar panels.

In addition to providing those quantitative benefits, renewable energy will contribute to the management of risks, including natural disasters, because the energy sources are geographically decentralized.

8. Cost allocation

Production of renewable energy is directly associated with Japan’s fight against global warming and its energy security policy. In light of this fact, it is desired that the related costs should be allocated widely and evenly to the public by way of taxes and electricity charges.

Assuming that electricity companies pass all their buyback costs to their electricity bills under a FIT program, consumers would have to shoulder an annual average of 0.86 yen/kWh between 2011 and 2030 with a maximum of 1.14 yen/kWh in 2021. With a monthly electricity consumption of 300 kWh at ordinary households, they would pay an additional monthly charge of 258 yen between 2011 and 2030, with a maximum of 341 yen.

In designing a FIT program, the following considerations should be given to cost allocation:

- To avoid unfair adverse effects on lives of citizens, exceptional measures should be taken, including a ban on passing cost to electricity charges for minimum electricity consumption necessary in daily life. (Currently, the electricity charges per kilowatt hour for households incrementally increase in three brackets. The new program may, for example, impose no charges on monthly consumption below 120 kWh.)

- Industries consuming large amounts of electricity should be granted exceptional treatment, for example, a discount on industries whose electricity consumption accounts more than 10% of production.

- To avoid unfair treatment of those who have produced renewable energy for years before the FIT program, a measure should be taken to buyback their electricity at a fixed price.
In addition to the measures described above, it is necessary to ensure the profitability of energy providers, such as electricity companies and gas suppliers, by taking into consideration the fact that energy demand may top out with declining population and advancement of energy-saving policies, and that renewable energy will be produced on an increasingly larger scale. To be more specific, we need to discuss an ideal pricing system under which both suppliers and consumers can enjoy economic benefits from increased production of renewable energy.

9. Conclusion

This Proposal has intended to show that increased production of renewable energy will contribute to our effort in environmental preservation, economic growth, and energy security. In this respect, there is a broad consensus of opinion among experts from a variety of fields that Japan should pursue renewable energy more aggressively.

It is hoped that this Proposal effectively motivates the implementation of relevant policies for drastic increases in Japan in renewable energy production accompanied by wide allocation of costs to the public and for helping the country achieve a global low-carbon society.
Members of the Committee on Renewable Energy Promotion Policy for Achieving a Low-carbon Society

[Chairman]:

Hidefumi Kurasaka  Professor at Faculty of Law and Economics, Department of Policy Studies, Chiba University

[Committee Members]

Shuichi Ashina  Post doctorate fellow at National Institute for Environmental Studies

Tetsunari Iida  Chairman of the Institute for Sustainable Energy Policies

Masa Ohara  Section chief in charge of environmental policy, the Bureau of Environment, Tokyo Metropolitan Government

Michio Kondo  Chairman of the National Institute of Advanced Industrial Science and Technology, The Research Center for Photovoltaics

Kae Takase  Director at Governance Design Laboratory

Tetsuo Tezuka  Professor at Graduate School of Energy Science, Kyoto University
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<tr>
<td><strong>5th</strong>&lt;br&gt;January 16, Friday, 2009&lt;br&gt;9:30 to 12:00</td>
<td>• About the Proposal (draft)  &lt;br&gt; • Calculation of estimated output  &lt;br&gt; • Form of production from short-term, mid-term, and long-term perspectives  &lt;br&gt; • Cost estimate and cost allocation</td>
</tr>
<tr>
<td><strong>6th</strong>&lt;br&gt;February 2, Sunday, 2009&lt;br&gt;15:00 to 18:30</td>
<td>• About the Proposal (draft)</td>
</tr>
</tbody>
</table>
1. Significance of the promotion of renewable energy and the content of this Proposal

1.1 Significance of the promotion of renewable energy

To achieve the ultimate goal of stabilizing the air concentration of greenhouse gases at a level where the climate is free from human effects, world leaders have mutually agreed to halve greenhouse gas emissions from the present level by the year 2050. In line with this commitment, Japan has set up a goal of cutting greenhouse gas emissions by 60 to 80% by the same year (Figure 1-1).

Figure 1-1 Global and Japan's long-term targets for greenhouse gas emissions

To achieve such significant reduction in greenhouse gas emissions, it is indispensable not only to promote energy savings under the existing energy portfolio but also to replace existing energy sources with others that substantially cut CO2 emissions, compared with fossil fuels. In this respect, renewable energy sources are an appropriate alternative (Figure 1-2).

Figure 1-2 IEA BLUE Map Scenario for energy technologies (scenario of a 50% GHS emissions reduction from the current level being achieved by 2050)

Source: IEA “Energy Technology Perspectives 2008: Scenarios and Strategies to 2050,” 2008
International Energy Agency (IEA) suggested in its analysis that to achieve significant reductions in all countries, including developing nations, we are required to implement all possible measures, such as nuclear power generation and thermal power generation accompanied by CO2 capture and storage (CCS) at a rate unprecedented in human history (Figure 1-3).

![Figure 1-3 IEA's analysis of rates of introduction of technologies in global power generation sectors](image)

Note: The following three rates of introduction are compared:
- The current rate (the highest rate in history for the nuclear sector alone)
- Rate of introduction (2005-2050 average) under ETP’s ACT Map Scenario (introduction of existing technologies and those currently under development)
- Rate of introduction (2005-2050 average) ETP’s BLUE Map Scenario (50% GHG emissions reduction by 2050)

Source: IEA “Energy Technology Perspectives 2008: Scenarios and Strategies to 2050,” 2008

According to the National Institute for Environmental Studies’ 2005 Japan Low-carbon Society Scenario: Feasibility Review of 70% Greenhouse Gas Reduction, Japan must fulfill at least all its targets for renewable energy, nuclear power generation, and thermal power generation with CCS in order to attain its target of reducing 60 to 80% CO2 emissions by the year 2050 (Figure 1-4).
Specifically, when anti-warming measures for developing countries are taken into consideration, it is of utmost importance to promote renewable energy, because the energy source require only small facilities, a shorter installation time, with less installation cost, and easier operation and maintenance than other energy sources (Table 1-1).

Table 1-1 Characteristics Comparison of Energy Sources

<table>
<thead>
<tr>
<th></th>
<th>Nuclear power generation</th>
<th>Thermal power generation + CCS</th>
<th>Renewable energy generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit capacity</td>
<td>Generally, 0.3 to 1.5 million kW</td>
<td>Generally, 0.1 million kW</td>
<td>Medium and small water power: tens of kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Solar power : up to hundreds of kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wind power: thousands of kW</td>
</tr>
<tr>
<td>Lead time*</td>
<td>About 20 years or longer</td>
<td>About 10 years</td>
<td>— (Shorter than 10 years)</td>
</tr>
<tr>
<td>Inspection intervals</td>
<td>• Shorter than 13 months</td>
<td>• Shorter than 4 years for steam turbines, 3 years for gas turbines, and 2 years for boilers</td>
<td>• No legally required periodical inspection</td>
</tr>
<tr>
<td></td>
<td>• 2 to 3 months</td>
<td>• 1 months</td>
<td></td>
</tr>
</tbody>
</table>

*The period between a site application and the start of operations
Today substantial greenhouse gas emissions reduction is vital for the sustainable development of human beings. The claim that anti-global warming measures will generate heavy economic burden is not receiving wide acceptance any more. Instead, it is now widely believed that countries will be able to create new jobs and consolidate its energy security policy on when they build a low-carbon society ahead of other countries.

To combat the climate change and achieve a sustainable society, we need to shift from stock-type fossil fuels to flow-type renewable energy sources.

Since stock fossil fuels are destined to run out in the long run, society will unavoidably shift to flow-type energy sources. Japan’s earlier shift would have the following effects:

(1) Contribution to the establishment of a global low-carbon society

By aggressively promoting the production of renewable energy, Japan would be able to set a global standard for promoting renewable energy production, as well as contributing to the construction of a low-carbon society in the country.

In addition, Japan would also be able to develop and accumulate technology and know-how related to renewable energy. Such technology and know-how would contribute to achieving a global low-carbon society.

The increased production of renewable energy in Japan would develop a profound awareness in the public of energy savings and CO2 emissions reduction. In line with changes in technology and values, the market economy will shift to a low-carbon society in the long-term.

(2) Contribution to energy security

Any uncertainties over imports of fossil fuels would bring about immeasurable adverse impact on Japan would.

In the long-term, the prices of fossil fuels are projected to increase, partly due to economic growth in emerging countries. In this regard, increased production of renewable energy in Japan will contribute to reinforcement of its energy security.

Also, increased production of renewable energy will ensure safety and security for regional economies by providing security measures, including backup power supplies to respond to disasters.
(3) Contribution to economic recovery

Renewable energy markets will expand globally as countries move toward a low-carbon society.

Japan’s renewable energy industry will be able to play an important role in global markets if the government establishes measures to substantially increase renewable energy production and accumulate technology and know-how, thus achieving cost cuts under mass-production systems.

Increased production of renewable energy will create additional demand in a wide range of segments, including the manufacture of new electricity and heat generation systems and the construction of infrastructures such as power distribution systems.

Because production of renewable energy will generate new demand generated in the domestic and overseas markets, it would help Japan overcome its serious economic downturn triggered by the financial crisis in the United States.

(4) Contribution to job creation

Growing production of renewable energy will create new jobs. Specifically, local jobs will be created in businesses engaged in construction and maintenance of facilities related to renewable energy.

Major countries are aggressively promoting “Green New Deal” policies. As part of such policies, a wide range of measures are now in place, with a focus on renewable energy. For instance, the Barack Obama administration of the United States announced that U.S. would raise the production target for renewable energy, committing to creating 5 million jobs by investing 150 billion dollars.

Japan should direct more attention to the role of renewable energy in job creation.

(5) Creation of social capital to be handed down to the next generation

The effects of increased renewable energy production are not limited to temporary economic recovery. Renewable energy equipment and devices installed are added to social capital.

1.2 Definition of renewable energy and the content of this Proposal

In this Proposal, “renewable energy” is defined as “inexhaustible, permanent (flow-type) energy sources that generates little environmental burden, including CO2 emissions.” The analysis in this Proposal was focused on estimated output of renewable energy for the
construction of a low-carbon society; policy for promotion of renewable energy; ways to overcome non-economic barriers for increased production of renewable energy; the future direction of the electricity supply-demand system; costs and specific effects of increased production; and cost allocation.

Among renewable energy sources, photovoltaic power generation attracted our special attention because we would be able to take advantage of our technological supremacy in this sector in our fight against global warming not only in Japan but on a global basis as well. Further, photovoltaic power generation would contribute to Japan’s economic growth and energy security policy. Based on this analysis, this Committee reviewed a number of specific policies to sufficiently increase renewable energy production toward 2020 and 2030.

Renewable energy generation as defined in this Proposal is composed of “photovoltaic power generation,” “wind power generation,” “biomass power generation,” “solar heat utilization,” “biomass/waste heat utilization”, which are altogether defined as “new energy,” in addition to “water power generation,” “geothermal power generation,” “ocean-thermal energy conversion,” “wave power generation,” “tidal power generation,” and “ocean current power generation” (Figure 1-5, Table 1-2, Table 1-3).

Figure 1-5 Definition of “Renewable Energy” and “New Energy

Source: Compiled on the basis of materials from Agency for Natural Resources and Energy.
Table 1-2 Definition of “Renewable Energy” in Major Countries

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Technical Properties</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water power</td>
<td>Water power</td>
<td></td>
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<tr>
<td>Geothermal heat</td>
<td>Geothermal heat</td>
<td></td>
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<tr>
<td>Solar light</td>
<td>Solar light</td>
<td></td>
</tr>
<tr>
<td>Solar heat</td>
<td>Solar heat</td>
<td></td>
</tr>
<tr>
<td>Tidal power</td>
<td>Tidal power</td>
<td></td>
</tr>
<tr>
<td>Wave power</td>
<td>Wave power</td>
<td></td>
</tr>
<tr>
<td>Ocean force</td>
<td>Wind power</td>
<td></td>
</tr>
<tr>
<td>Wind power</td>
<td>Biomass</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>Landfill gas</td>
<td></td>
</tr>
<tr>
<td>Solid</td>
<td>Sewage gas</td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td>Biogas</td>
<td></td>
</tr>
<tr>
<td>Biogas</td>
<td>Heat pump</td>
<td></td>
</tr>
<tr>
<td>Renewable</td>
<td>Waste</td>
<td></td>
</tr>
<tr>
<td>community</td>
<td>Forest waste</td>
<td></td>
</tr>
<tr>
<td>waste</td>
<td>Energy crop</td>
<td></td>
</tr>
</tbody>
</table>


Table 1-3 Definition of Renewable Energy

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Technical Properties</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photovoltaic power generation</td>
<td>Direct conversion of solar light into electricity by using a solar cell (a semiconductor). Cells may be based on silicone (crystalline or film), chemical compounds, or organic substances (dye-sensitized). A photovoltaic power generation system is composed of solar cells, DC-AD inverter, interconnection equipment, and other devices. Many households use a 3- to 4-kW type.</td>
<td>○ ○</td>
</tr>
<tr>
<td>Solar thermal power generation</td>
<td>Solar light is collected by a heat collector to produce high-temperature high-pressure steam, which is used to generate electricity in a steam turbine. This system is adopted in many countries but not used in Japan because the country receives much scattering light.</td>
<td>- -</td>
</tr>
<tr>
<td>Solar heat utilization</td>
<td>Hot water and steam is produced in a solar water heater place on rooftop to be used for hot water supply and heating systems. In addition, an absorption chiller may be used to produce cool air for air conditioning. Solar heat appliances have a high energy conversion efficiency and is highly cost-effective because they are relatively inexpensive.</td>
<td>○ N/A</td>
</tr>
<tr>
<td>Energy Type</td>
<td>Technical Properties</td>
<td>Remark</td>
</tr>
<tr>
<td>-----------------------------</td>
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<td>--------------------------------</td>
</tr>
<tr>
<td>Passive solar system</td>
<td>A system for collecting solar heat through openings in a house or building specifically designed for solar heat collection by taking into consideration topographic and geographic conditions. Also heat storage material or heat insulating material may be used for the purpose of “passively” using solar energy. Solar light may also be taken directly for lighting.</td>
<td>-</td>
</tr>
<tr>
<td>Biomass/waste generation</td>
<td>Power generation by directly burning general waste (only biomass components) or wood-based biomass. Also sewage, food waste, animal waste may be used for methane fermentation (biogas). Gas engine generation is also another type of waste generation. A cogeneration system is available to use exhaust heat while producing energy. Compared with systems based on fossil fuels, this type of generation system is costly because it is operated in a small scale.</td>
<td>○</td>
</tr>
<tr>
<td>Biomass/waste heat utilization</td>
<td>Use of direct heat by burning general waste (only biomass components) or wood-based biomass or use of biogas generated from food or animal waste.</td>
<td>○</td>
</tr>
<tr>
<td>Biomass/waste fuel production</td>
<td>Refuse-derived fuels (RDF) manufactured by crushing, drying, treating with preservatives, or compressing waste (burnable garbage); pellet fuels made by crushing, drying, and molding wood-based resources; bioethanol made by ethanol fermentation of biomass; or biodiesel fuels made from food invitation leaflet waste.</td>
<td>○</td>
</tr>
<tr>
<td>Wind power generation</td>
<td>Wind is converted into rotational energy using blades on a windmill. Rotational energy is then converted into electricity by a generator. A wide range of systems, including megawatt-level large-scale wind power systems and small units. Problems with full-fledged introduction of wind power generation include cost reduction, output fluctuations due to wind conditions, and bird strikes.</td>
<td>○</td>
</tr>
<tr>
<td>Water power generation</td>
<td>Large-scale</td>
<td></td>
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<tr>
<td></td>
<td>Small-scale</td>
<td></td>
</tr>
<tr>
<td>Energy Type</td>
<td>Technical Properties</td>
<td>Remark</td>
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<tr>
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</tr>
<tr>
<td><strong>Geothermal power generation</strong></td>
<td>Conventional Steam is collected from high-temperature geothermal water and used to drive a steam turbine, which then generate electricity. A binary cycle type system uses hot water as well as steam. Where natural hot water or steam is scarce, hot rock found deep under the ground is artificially crushed with water pressure and fed with water to collect hot water and steam (hot rock electricity generation).</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Binary</td>
<td>○</td>
</tr>
<tr>
<td><strong>Geothermal heat utilization</strong></td>
<td>Hot water retained underground is pumped out to utilize water and steam. Heat thus collected can be used for heating facilities and gardening, as well as in hot spas. A recently commercialized thermal heat system uses the underground for collecting heat in winter and discharging heat in summer for cooling.</td>
<td>-</td>
</tr>
<tr>
<td><strong>Snow and ice</strong></td>
<td>Deposited snow and ice are cut out and kept in storage facilities to be used for cooling in public buildings, condominiums, and other structures. Also used to keep crops cooled.</td>
<td>○</td>
</tr>
<tr>
<td><strong>Thermal energy</strong></td>
<td>Heat pumps and heat exchangers are operated to collect heat by exploiting temperature differences between ambient air and water sources, such as river water, underground water, and seawater, or geothermal heat. Waste heat from plants and subways may also be used.</td>
<td>○</td>
</tr>
<tr>
<td><strong>Ocean-thermal energy conversion</strong></td>
<td>Ocean temperatures are 20 to 30°C on the surface and 4 to 6 at a depth of 800 to 1,000 m. These temperature differences are used to rotate turbines to produce electricity. Ammonia, which has a high boiling point, is used as a working fluid. Appropriate temperature differences for power generation are found in the sea area between 40°N and 40°S, including Japan’s exclusive economic zone.</td>
<td>-</td>
</tr>
<tr>
<td><strong>Wave power generation</strong></td>
<td>Energy in waves is used for electricity generation. Small wave power generators are already in global use in buoys. Large-scale systems are usually installed on breakwaters and produce tens to hundreds of kilowatts of electricity.</td>
<td>-</td>
</tr>
<tr>
<td><strong>Tidal power generation</strong></td>
<td>A flood gate is installed at a point where a large tidal range is available (near the mouth of a bay). The flood gate is closed at high tide to retain seawater within the bay. Seawater is then used to rotate mills for power generation by taking advantage of a tidal range generated at low tide. The world’s largest tidal power generator with a capacity of 240,000 kW was built in 1967 on the mouth of River Rance in France.</td>
<td>-</td>
</tr>
<tr>
<td><strong>Ocean current power generation</strong></td>
<td>A turbine is installed on an ocean current, and electricity is generated from its rotational force.</td>
<td>-</td>
</tr>
</tbody>
</table>
Source: compiled based on a number of materials.

Note: New-energy Law: the Act on Special Measures for the Promotion of New Energy Use, etc.
RPS Law: the Act of Special Measures for the Use of New Energy by Electricity Businesses
○: Means that the Act of Special Measures for the Use of New Energy by Electricity Businesses is applicable.
N/A: The RPS Law applies to electricity but not to heat utilization.
2. Present status of renewable energy, production targets, and estimated output based on potential and feasible outputs

2.1 The present status in Japan of renewable energy production and its targets, as compared with Western countries

Heavily dependent on imports for fossil fuels, Japan is urged to rethink how to secure energy in 50 to 100 years from now in order to achieve a sustainable society (Figure 2-1).

![Energy self-sufficiency of major countries (2005)](image)


Compared with European countries, which have shown a vigorous growth in renewable energy production, Japan has seen little increase in the production since 1990 (Figure 2-2).
Change in renewable energy output in Japan (based on General Energy Statistics)

![Change in renewable energy output in Japan](image)

Figure 2-2 Change in renewable energy output in Japan

Source: Based on the use of large-scale water power for commercial users, natural energy, and geothermal and waste energy from General Energy Statistics

As Western countries, such as Sweden, Denmark, Germany, and Spain, are putting up aggressive production targets for renewable energy, Japan remains among the countries setting up the lowest level of targets (Figure 2-3, Figure 2-4).

![The proportion of renewable energy to total primary energy supply](image)

Figure 2-3 The proportion of renewable energy to total primary energy supply (results and targets)

- The values of the year 2005 are based on the prime energy supply given by IEA. (The values of Japan are based on the Long-term Prospect of Supply and Demand of Energy (LPSDE)(METI, 2008), and the Urgent Proposal by the New and Renewable Energy Subcommittee, etc. The value of China is based on the year 2006.)
- The targets for the year 2020 of EU nations are based on final energy consumption. The values of Japan
are based on the supply of primary energy in the maximum case of the LPSDE. The value of China is based on the primary energy supply given by IEA.

Source) IEA “Renewables Information 2008”, IEA, EU Directives (January 2008)/ (2001); REN 21, “Renewables 2007;”and China’s “Mid-and long-term renewable energy development plan” (August 2007), etc.

Figure 2-4 The proportion of renewable energy-based electricity to total electricity (Results and targets)

1) The values of the year 2005 are based on electricity output given by IEA.
   The total electricity output includes home-generated and consumed energy. (The values of Japan are based on the LPSDE.
   The value of China is based on the year 2006

2) Future target years of EU nations, Japan and China, and the U.S. (President Obama’s pledge) are 2010, 2020, and 2025, respectively

Source) IEA “Renewables Information 2008”, IEA, EU Directives (January 2008)/ (2001); REN 21, “Renewables 2007;”and China’s “Mid-and long-term renewable energy development plan” (August 2007); and President Obama’s pledge “New Energy for America.”

2. 2 Potential and feasible outputs of renewable energy

Based on a number of statistics concerning the potential output (possible maximum output calculated without giving consideration to restrictive factors such as economic constraints) and the feasible output (possible maximum output calculated by giving consideration to restrictive factors such as economic constraints) of known renewable energy sources, it is estimated that renewable energies, including photovoltaic power generation, have sufficient output potential as a main energy source for the future (Table 2-1).
### Chart 2-1 Evaluation list for potential output and feasible output

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Photovoltaic power generation</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential output</td>
<td>1.2 M kW</td>
<td>–</td>
<td>1.2 M kW</td>
<td>44.35 M kW</td>
<td>246.55 M kW</td>
<td>–</td>
<td>16.1 M kW</td>
<td>–</td>
</tr>
<tr>
<td>Feasible output (2020)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td>Feasible output (2030)</td>
<td>–</td>
<td>–</td>
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<td>–</td>
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<tr>
<td><strong>Solar heat utilization</strong></td>
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<tr>
<td>Potential output</td>
<td></td>
<td></td>
<td>12 M kW</td>
<td>–</td>
<td>35.42 M kW</td>
<td>–</td>
<td>27.22 M kW</td>
<td>–</td>
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<tr>
<td>Feasible output (2020)</td>
<td></td>
<td></td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>–</td>
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<tr>
<td>Feasible output (2030)</td>
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<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td><strong>Wind power generation (On-land)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Potential output</td>
<td>13.5 M kW</td>
<td>–</td>
<td>35 M kW</td>
<td>14.28 M kW</td>
<td>1.71 - 3.4 M kW</td>
<td>6.87 M kW</td>
<td>–</td>
<td>5.74 M kW</td>
</tr>
<tr>
<td>Feasible output (2020)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td>Feasible output (2030)</td>
<td>–</td>
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<td>–</td>
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<td>–</td>
</tr>
<tr>
<td><strong>Wind power generation (On-shore)</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Potential output</td>
<td>1) 66 M kW 2) 40 M kW 3) 56 M kW</td>
<td>1) 67 B kW 2) 120 B kW 3) 37 B kW</td>
<td>1) 1.36 M 88 M kW 2) 794.88 M kW 3) 126.02 M kW</td>
<td>1) 478.55 M kW 2) 81.93 M kW</td>
<td>–</td>
<td>1) 9.1 M kW 2) 28.23 M kW</td>
<td>–</td>
<td>1) 5.8 M kW 2) 6.9 M kW</td>
</tr>
<tr>
<td>Feasible output (2020)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1) 5.7 M kW 2) 9.3 M kW 3) 19.3 M kW</td>
<td>–</td>
<td>–</td>
<td>1) 5.8 M kW 2) 6.9 M kW</td>
</tr>
<tr>
<td>Feasible output (2030)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Note**
- Case 1 is a reference case when the growth curve is maintained.
- Case 2 is when power generation is implemented by PV2030.
- Case 3 is when technological development is entrusted to industries.
- Case 4 is when power generation is implemented by NEDO PV2030.
- Case 5 is when technological development is completed ahead of schedule and the practical application of large-scale power generation is achieved around 2030.
- Case 6 is a vision case when about 5% of electricity demand is supplied.
- Case 7 is a vision case when about 10% of electricity demand is supplied.
<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential output</td>
<td>69.3 M kW</td>
<td>2.10 M kW (1.58 M kW + 0.52 M kW)</td>
</tr>
<tr>
<td>Feasible output (2020)</td>
<td>–</td>
<td>1.32 M kW (1.0 M kW + 0.32 M kW)</td>
</tr>
<tr>
<td>Feasible output (2030)</td>
<td>–</td>
<td>–</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential output</td>
<td>–</td>
<td>12.305 M kW</td>
</tr>
<tr>
<td>Feasible output (2020)</td>
<td>–</td>
<td>10.38 M kW</td>
</tr>
<tr>
<td>Feasible output (2030)</td>
<td>–</td>
<td>14.64 M kW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential output</td>
<td>–</td>
<td>0 M kW (back liquid)</td>
</tr>
<tr>
<td>Feasible output (2020)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Feasible output (2030)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Note:**
- Potential output: 1) is the amount of resources at the point shallower than the depth of geothermal basement at temperatures 150°C or more for steam-type power generation. 2) is the amount of resources at temperatures 200°C or more for binary-type power generation.
- Feasible output: 1) is based on a base scenario whereby the developable amount of resources in strategic regions -- is fully developed in 2050. The value is the sum of the intermediate value (which is considered as geothermal power generation) and the hot spring power generation by using both hot spring residual heat and reduced hot liquid from geothermal power generation. 3) is based on a dream scenario whereby 50% of 950 MW - the amount of resources at the points shallower than the depth of geothermal basement at temperatures 150°C or more - can be developed in 2050. The value is the sum of the intermediate value (which is considered as geothermal power generation) and the hot spring power generation of the best scenario.
2. 3 Estimated output of renewable energy

For photovoltaic power generation, estimated output was calculated using the formula presented in Section 4. The estimated output of other renewable energy sources was calculated based on available statistics presented in Section 2.2.

(i) Wind power generation

For land and ocean wind power generation, Alternative Scenario (about 5% of total electricity demand in 2040) assumed by the Japanese Wind Power Association was employed. The wind power production in 2030 matches NEDO’s Wind Power Generation Road Map.

(ii) Small-scale water power generation

It was assumed that all new power plants under 1,000 kW estimated for 2050 by the Japanese Association for Water Energy Recovery would be constructed as planned. This calculation is based on the presumption that 70% of the potential for ordinary rivers nationwide would be developed and that 2,000 kW would be developed on agricultural, industrial, and city-water waterways on every first-class river system.

(iii) Geothermal power generation

The best scenario provided by the Geothermal Research Society of Japan and the Japan Geothermal Developers’ Council (two times all developable resources in the priority development areas under a NEDO-NEF survey would have been developed by 2050) was employed and used directly in this Proposal.

(iv) Biomass/waste power generation

It was assumed that the lower case under the Kyoto Protocol target would be achieved by 2010, and that thereafter, the upper case target would be achieved and maintained.

(v) Solar heat utilization

For single houses, the output of solar heat was estimated on the basis of the penetration rate of photovoltaic power generation for single houses, by considering its competitive nature against photovoltaic power generation on roof surface. For 2020 and later years, it was assumed that on-veranda heating systems would become more common in collective housing. At the same time, we assumed that passive and active solar systems would be more widely used. Non-residential heat systems were assumed to be introduced to 10% of the facilities on the basis of a projection by the Solar System Development Association.
(vi) Other heat sources

With respect to other heat sources combined, it was assumed that the lower case of the Kyoto Protocol Target Achievement Plan would be achieved by 2010, and that thereafter the upper case would remain achieved. Geothermal heat pumps were projected to reach 220,000 kiloliters by 2030 in accordance with the base scenario compiled by from the Geothermal Research Society of Japan and the Japan Geothermal Developers’ Council.

With an eye toward the year 2050, the estimated output (practicable maximum output, taking into account several factors, such as economic efficiency) of renewable energy was calculated for 2020 and 2030 on the basis of the feasible output. The results indicated that, while in 2005 renewable energy accounted for 5% of total primary energy supply (crude oil equivalent of 29.33 million kiloliters (including large-scale water power generation)), it is possible to increase its ratio to about 10% in 2020 (crude oil equivalent of 53.31 million kl (including large-scale water power generation)) (Table 2-2).

In addition, while renewable energy represented 9% of the country’s total output in 2005 (99.0 billion kWh (including large-scale water power generation)), it would be possible to increase its ratio to about 18% in 2020 (186.8 billion kWh (including large-scale water power generation)) (Table 2-3).
### Chart 2-2 Estimated output of renewable energy

<table>
<thead>
<tr>
<th>Achieved output and estimated output</th>
<th>2005</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photovoltaic power generation</td>
<td>1.42 M kW</td>
<td>37 M kW</td>
<td>79 M kW</td>
</tr>
<tr>
<td></td>
<td>(0.35 M kl)</td>
<td>(9.06 M kl)</td>
<td>(19.34 M kl)</td>
</tr>
<tr>
<td>Wind power generation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-land: 1.08 M kW (0.44 M kl)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-land: 10 M kW (3.99 M kl)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-shore: 1 M kW (0.6 M kl)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small-scale water power generation</td>
<td>0.11 M kW</td>
<td>1.74 M kW</td>
<td>3.02 M kW</td>
</tr>
<tr>
<td></td>
<td>(0.16 M kl)</td>
<td>(2.43 M kl)</td>
<td>(4.21 M kl)</td>
</tr>
<tr>
<td>Geothermal power generation</td>
<td>0.52 M kW</td>
<td>1.04 M kW</td>
<td>1.62 M kW</td>
</tr>
<tr>
<td></td>
<td>(0.73 M kl)</td>
<td>(1.45 M kl)</td>
<td>(2.27 M kl)</td>
</tr>
<tr>
<td>Biomass and waste power generation</td>
<td>2.23 M kW</td>
<td>5.19 M kW</td>
<td>5.19 M kW</td>
</tr>
<tr>
<td></td>
<td>(2.52 M kl)</td>
<td>(5.86 M kl)</td>
<td>(5.86 M kl)</td>
</tr>
<tr>
<td>Solar heat utilization</td>
<td>24 PJ</td>
<td>51 PJ</td>
<td>87 PJ</td>
</tr>
<tr>
<td></td>
<td>(0.61 M kl)</td>
<td>(1.31 M kl)</td>
<td>(2.25 M kl)</td>
</tr>
<tr>
<td>Other heat</td>
<td>297 PJ</td>
<td>380 PJ</td>
<td>380 PJ</td>
</tr>
<tr>
<td></td>
<td>(7.68 M kl)</td>
<td>(9.82 M kl)</td>
<td>(9.82 M kl)</td>
</tr>
<tr>
<td>Total</td>
<td>12.49 M kl</td>
<td>34.51 M kl</td>
<td>53.12 M kl</td>
</tr>
<tr>
<td></td>
<td>(2%)</td>
<td>(6~7%)</td>
<td>(10~12%)</td>
</tr>
<tr>
<td>Large-scale water power</td>
<td>45.75 M kl</td>
<td>48.33 M kW</td>
<td>48.53 M kW</td>
</tr>
<tr>
<td></td>
<td>(17 M kl)</td>
<td>(19 M kl)</td>
<td>(19 M kl)</td>
</tr>
<tr>
<td>Total renewable energy</td>
<td>29.33 M kl</td>
<td>53.31 M kl</td>
<td>71.91 M kl</td>
</tr>
<tr>
<td>Ratio to total domestic supply</td>
<td>5%</td>
<td>10~11%</td>
<td>14~16%</td>
</tr>
<tr>
<td>of primary energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Reference)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Maximum Output Case” in the LPSDE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(20.36 M kl)</td>
<td>(32.02 M kl)</td>
</tr>
</tbody>
</table>

Note) Domestic supply of primary energy in 2020 is shown in a range, because it is based on the estimation results from Measures Case I to Case II proposed by National Institute for Environmental Studies at the third Mid-term Target Review Committee on January 23, 2009. In addition, domestic supply of primary energy in 2030 is shown in a range: the lower limit is the Maximum Output Case in the LPSDE; and the upper limit is the linear-interpolated value of the Measure Case I in 2020, using the value of hydrogen-photovoltaic and wind power generation from the Scenario B in the interim report of the Japan Low Carbon Society Scenarios toward 2050 planned by National Institute for Environmental Studies.
Chart 2-3  Estimated output of renewable energy

<table>
<thead>
<tr>
<th>Source of renewable energy</th>
<th>2005</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photovoltaic power generation</td>
<td>1.5 B kWh</td>
<td>40.1 B kWh</td>
</tr>
<tr>
<td>Wind power generation</td>
<td>1.9 B kWh</td>
<td>20.1 B kWh</td>
</tr>
<tr>
<td>Small-scale water power generation</td>
<td>0.7 B kWh</td>
<td>10.7 B kWh</td>
</tr>
<tr>
<td>Geothermal power generation</td>
<td>3.2 B kWh</td>
<td>6.4 B kWh</td>
</tr>
<tr>
<td>Biomass and waste power generation</td>
<td>11.1 B kWh</td>
<td>25.8 B kWh</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18.4 B kWh</strong></td>
<td><strong>103.1 B kWh</strong></td>
</tr>
<tr>
<td>Large-scale water power</td>
<td>81.3 B kWh</td>
<td>84.6 B kWh</td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td><strong>99 B kWh</strong></td>
<td><strong>186.8 B kWh</strong></td>
</tr>
</tbody>
</table>

Note) The figures in ( ) in the Total column show the proportion of renewable energy-based electricity output to total electricity output in each year. In addition, the electricity output in 2020 is shown in a range, because it is based on the estimation results from Measures Case Ⅰ to Case Ⅲ proposed by National Institute for Environmental Studies at the third Mid-term Target Review Committee on January 23, 2009.

3. Specific policies for promotion of renewable energy

3.1 Perspectives of increased production

On the premise that, to achieve the estimated output discussed in Chapter 2, costs, technology, market size, and other factors need to be organically linked to one another, it is important to estimate the effects of policy options and, based on the estimates, find an appropriate combination of options.

To discuss renewable energy production policy for Japan, we should address the following perspectives:

(i) Sharing an idea of energy utilization in the future

While recognizing the significance and benefits of renewable energy, we should achieve a paradigm shift once the Japanese society shares an idea how to use different types of energy, including renewable energy.

(ii) Promoting demand-pull production by taking advantage of decentralized energy

The conventional view from the supply side is not enough when we formulate a promotion
policy. Instead, we should take into consideration views from the demand side (demand-pull), which addresses the fact that renewable energy is a decentralized type.

To make the most of decentralized renewable energy, it is important to make a paradigm shift with the participants of all members of society through the following activities:

- The government and power companies should provide or improve their respective energy network services.
- Consumers and individuals should endeavor to produce necessary energy on their own and buy or sell surplus energy via the energy network.
- Administrative bodies, especially local governments, should take initiative in implementing promotion policies appropriate to the situation in the region.

(iii) Promotion of production from a point of view of end users

Instead of seeing things from a point of view of suppliers of energy, such as electricity and gas, we should adopt views from the demand side, which reflect the characteristics of decentralized energy. That is, we need to review policies for electricity, heat, and fuels with close attention to the way energy is used by end users.

(iv) Effort and cooperation of the public

At this time, renewable energy sources are more costly than fossil fuels in producing electricity or heat because of technical difficulty in cost reduction and the lack of a carbon pricing system in Japan. To transform the conventional energy supply-demand system into a renewable energy-based system, measures are required to cover additional costs that have been traditionally born by end users.

Benefits from the promotion of renewable energy can be enjoyed by the entire nation. The public and businesses are becoming more conscious of the importance of, and acceptable to, promoting renewable energy. In light of these circumstances, it is urged to establish a program of allocating necessary costs widely among people and promoting the use of renewable energy across the country through public cooperation.

(v) Selection of policies appropriate to technological level and market development for renewable energy

Because renewable energy sources are at different technological levels (development stage, demonstration stage, or commercialization stage) and in different market phases (introductory phase, promotion phase, or saturation phase), we need to combine appropriate policies, depending on their respective circumstances.
3.2 Japan’s important renewable energy fields

At this point of time, Japan should address the following fields of renewable energy:

(i) Photovoltaic power generation

Long-time world leader in development and promotion of renewable energy, Japan is expected to contribute to the construction of a global low-carbon society, while strengthening its international competitiveness. It is now necessary to set up a promotion policy based on the achievements of the environmental, industrial, and energy policies.

(ii) Wind power generation

With long coast lines, Japan has a high potential for wind power generation. It is therefore essential to formulate a promotion policy reflecting the geographical advantage.

(iii) Geothermal power generation

Characterized by active volcanoes, Japan represents about 10% of global geothermal energy potential. It is therefore essential to work out a promotion policy reflecting the geographical advantage.

(iv) Medium- and small-scale water power generation

With numerous turbulent rivers and heavy precipitation, Japan provides sufficient amounts of potential energy sources required for water power generation. It is therefore essential to formulate a promotion policy reflecting the geographical advantages.

(v) Biomass utilization

It is required to utilize different types of biomass available across different regions.

(vi) Heat utilization

We are required to implement measures to use renewable heat energy sources, such as solar heat and geothermal heat, to respond to growing demand for low- and medium-temperature heat, especially demand for hot water supply and heating systems.
3.3 Future production policies

IEA’s study titled “Deploying Renewables” presents a variety of policies appropriate to individual renewable energy sources (Figure 3-1). Based on the classification made by IEA, we analyzed production policies on electricity, heating, and fuel systems.

Figure 3-1 Combination of production policies in response to the maturity of technologies
Source) IEA “Deploying Renewables,” 2008

(1) Renewable electricity policy
(i) Features and issues concerning possible options

Based on Japan’s experience and precedents in Western countries, four promotion policies are expected to be effective: (A) an installation subsidy program, (B) Renewables Portfolio Standard (RPS) program, (C) net metering, and (D) feed-in tariffs (FIT), as described below.

A: Installation subsidy program

Under the installation subsidy program, the government pays part of the cost of introducing renewable energy. This program effectively provides a subsidy at the adoption stage, which often requires a heavy initial investment. As a disadvantage of the program, a cap is imposed each year on the total amount available from the government, and considerable administrative costs add up under the program.
This program is effective for a single fiscal year, and thus it is uncertain how long the program will continue, making it extremely difficult for investors in renewable energy and device manufactures to plan their investments. This is also the case with preferential tax treatments.

In addition, the operation of the installation subsidy program requires heavy administrative costs. Other problems have been pointed out, including the concentration of administrative work on a certain period of the fiscal year.

B: RPS program

The RPS program permits the government to obligate power companies to supply certain amounts of renewable energy to consumers. The program aims to enhance cost-effectiveness of energy by encouraging low-cost competition among renewable energy sources. On the other hand, renewable energy sources involving relatively high installation costs will have difficulty broad acceptance because renewable energy sources, which vary widely in cost and technology, are left to compete face to face in the market. In addition, profitability of investment to renewable energy is uncertain as future RPS certificate prices are unpredictable.

C: Net metering

Net metering is a variation of pricing laws. Power companies purchase surplus electricity from consumers. The surplus electricity is purchased at a price close to the market prices by the utility. It can be categorized as a variation of FIT (a Feed-in Premium with no premium).

In Japan, a voluntary net metering (Surplus Electricity Buyback) program is playing a certain role in promoting household photovoltaic power generation. On the other hand, Japan’s program lack powerful incentives for significant production increases because the payback period is extremely long (currently 30 years) at a buyback price of 23 yen/kWh – the current price of electricity sold to consumers. In addition, the program, implemented voluntarily by power companies, does not ensure long-term purchases.

D: Feed-in tariff (FIT)

Under a feed-in tariff, electricity obtained from renewable energy power generation is purchased by power companies at a fixed price on a voluntary basis. Cost and the technological level associated with each renewable energy source are taken into consideration in determination of energy prices. If an appropriate price is set, it becomes possible to accurately estimate the payback period, which would help accelerate investments in renewable energy. By increasing the transparency of costs allocated and added to electricity charges, it is possible to ensure the steady operation of the program in the long run.
The most important factor in institutional design is pricing. Lower buyback prices can discourage investments, whereas higher prices can lead to excessive supply, which could result in erratic installation costs. It is also necessary to periodically revise buyback prices in accordance with progress in cost-saving technology or spread of the scheme.

Of the programs described above, detailed analysis has been made concerning the RPS program and the FIT scheme by the EC Commission and the IEA based on actual cases of renewable power production in several countries.

The analytical results showed that the FIT, adopted by several countries, including Germany and Spain, is highly effective and efficient in introducing technology, such as photovoltaic power generation, that requires substantial installation costs (Figure 3-2, Figure 3-3).

(Note) Quota: Fixed quantity system (RPS mechanism)
TGC: Tradable Green Certificates
Tender: Tendering system


Figure 3-2 Evaluation of feed-in tariffs / the RPS in EU (1)
A separate analysis was conducted by IEA with respect to FIT programs, with the following findings:

- Although relatively costly, most FIT programs would be more effective than RPS programs or renewable energy certificates.¹

- In a number of European countries, FIT programs have been highly successful in land wind power generation, when used under a secure investment system, under relaxed regulations and low institutional barriers, and under appropriate line interconnection conditions. With a relatively small subsidy, the programs are less costly than PRS programs or renewable energy certificates.²

- FIT programs may promote the dissemination of costly technologies, such as photovoltaic power generation.

The following table describes representative policies adopted by a number of countries (Table 3-1):

---

¹ IEA, Energy Technology Perspectives 2008, Jun 2008  P.218
² IEA, Deploying Renewables : Principles for Effective Policies (Sep 2008)  P.174−178
### Chart 3-1 Renewable energy promotion and cost burden scheme in major countries (1/2)

<table>
<thead>
<tr>
<th>Responsible people</th>
<th>Target energy</th>
<th>Target output</th>
<th>Policy outline</th>
<th>Cost burdens</th>
<th>Effect on household electricity charges</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feed-in tariffs (FIT)</strong></td>
<td>Wind, biomass, photovoltaic, water, biogas, and geothermal power generation</td>
<td>• The proportion of renewable energy to total electricity supply in 2010 shall be 12.5% or more. In 2020, 20% or more.</td>
<td>• Buyback obligations (at the prices set by individual renewable energy) are imposed on power distribution businesses.</td>
<td>• Buyback obligations are imposed on power distribution companies. Costs shall be paid on to customer charges. However, electricity-intensive manufacturers whose annual power consumption is beyond 100 M kWh (which is expanded to 10 M kWh according to revised EEG) and whose electricity cost accounts for 20% or more of total added value (which is expanded to 15% according to revised EEG) will bear 0.05 й/kWh at maximum. This is applied to railway/tram companies whose annual power consumption is 10 M kWh or more.</td>
<td>• The total cost burden on household customers caused by feed-in tariffs, which corresponds to “RPS equivalent” is about 440 й per household/month.</td>
</tr>
</tbody>
</table>

| **Feed-in tariffs (FIT)** | Photovoltaic power generation, wind power generation, etc. | • According to “Renewable Energy Project 2005-2010,” the capacity for photovoltaic power generation facilities will be expanded to 400MW, and the area of heat-generating facilities using solar energy to 4.9 million m² by 2010. | • Buyback obligations (at the prices set by individual renewable energy) are imposed on power distribution businesses. | • Costs shall be paid on to customer charges. To decrease the burden on electricity customers from the increased electricity output under feed-in tariffs, there is a provision stipulating that the threshold values of cumulative output shall be set by energy source, and that purchase prices of energy sources that reach the thresholds shall be reviewed. In 2007, purchase prices of photovoltaic power generation reached the threshold values, the prices were driven down in 2008. | • According to the forecast of the Federal Ministry for the Environment, Germany, the cost burden on household customers caused by feed-in tariffs will hover at high level, but the buyback cost related to photovoltaic power generation will continue to increase. |

| **Obligation to buy renewable energy-based electricity** | Methane gas, biogas, wind (on-shore wind), wind (off-shore wind), photovoltaic (entire France), photovoltaic (islands), geothermal (entire France), geothermal (islands), biomass, meat-and-bone meal combustion, small-scale (36 kVA or less), household garbage, co-generation, and water power generation | To 21% of total electricity consumption in 2010 (Basic Act on Energy Policy) | • Operators of power distribution systems are obliged to buy renewable energy-based electricity at a fixed price for a certain period. | • Cost shall be paid on to electricity charges. The cost collected as electricity charges shall be go through “Public Service Fund.” This organization guarantees the balance between the fixed purchase price and avoidable costs to power distribution companies. | |

### Chart 3-1 (Cont.)

**Change in renewable energy production costs in household electricity charges**

<table>
<thead>
<tr>
<th>Year</th>
<th>Other taxes and public charges</th>
<th>Production and transmission of electricity/sales costs</th>
<th>Environmental tax</th>
<th>Renewable electricity costs</th>
<th>Monthly burden on electricity charges (Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>1999</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2000</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2001</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2002</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2003</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2004</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2005</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2006</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2007</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2008</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2009</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
<tr>
<td>2010</td>
<td>9,050 yen</td>
<td>18,460 yen</td>
<td>3,260 yen</td>
<td>1,980 yen</td>
<td>35 yen</td>
</tr>
</tbody>
</table>
In November 2008, Renewable Obligation (U.K., from April 2002) Renewable Obligation (Austria, from April 2001) Mandatory Renewable Energy Target (Austria, from April 2001 )

Buyers of wholesale electricity from the power grids of facilities with 100,000 kW or more.

Water, wave, tidal power, ocean energy, wind, solar energy (including water heaters), geothermal, hot rock, energy crops, wood waste, agricultural waste, food waste, bagasse (sugarcane crushed stalk), black liquid, landfill gas, sewage treatment gas, biomass in general waste. Concerning the existing facilities, only the facilities whose energy sources exceed the average electricity output of three years before 1997 will be the target.

9.5 billion kWh will be additionally produced by 2010. In addition, because the power generation from renewable energy exceeded the mandatory amount, the target electricity output from renewable energy will be risen to 45 billion kWh.

Seeking specific production targets for responsible people. As the RPS, Renewable Energy Certificates trading among enterprises are allowed.

Basically, costs shall be past on to electricity charges. It is estimated that the annual average output between 2003 and 2007 is 5.4 billion kWh; initial costs are about 190 million AUS $ on average; and its effect on electricity charges is 0.097 AUS ¢/kWh. From 2008 to 2012, the output, initial costs, and its effect on electricity charges will increase to 8.5 billion kWh, 310 million AUS $, and 0.144 AUS ¢/kWh, respectively. The average output and costs from 2013 to 2020 will be almost the same as those from 2008 to 2012; and the effect on electricity charges will decrease to 0.123 AUS ¢/kWh.

Seeking specific production targets for responsible people. As the RPS, Renewable Energy Certificates trading among enterprises are allowed.

Basically, costs shall be past on to electricity charges.

In 2004 (three years after the RPS was enforced), costs for implementing the RPS shouldered by household electricity customers accounted for 2% of electricity charges. (See the figure below.)

Estimations of annual additional burdens on electricity charges for general households

- 2006: About 10 pound (2,000 yen), about 0.8 pound (170 yen) per month
- 2015: About 20 pound (4,000 yen), about 1.7 pound (330 yen) per month

*1 pound = 200 yen

Source) "Overseas renewable energy output and costs and renewable energy support policy" (Central Research Institute of Electric Power Industry, 2007); “Actual conditions of RPS” (Materials of the 29th New and Renewable Energy Subcommittee (Advisory Committee for Natural Resources and Energy, Agency for Natural Resources and Energy); and “Electricity businesses in overseas countries” (Supplement, first book, 2006)
(ii) Japan’s current renewable electricity policy

Japan’s current renewable electricity policy is composed of an RPS program, a installation subsidy program, and a surplus electricity buyback program, the last of which is implemented voluntarily by power companies.

The RPS was adopted in April 2003 following deliberations at the subcommittee on development of new markets under the New Energy Subcommittee of the Advisory Committee on Natural Resources and Energy. The subcommittee compared the PRS against the FIT with respect to advantages and disadvantages. Specifically, a report titled “Comparison between Feed-in Tariffs and Renewable Energy Certificates (draft)” presented at the subcommittee meeting (3rd, October 25, 2001) disclosed the view of the Resources and Energy Agency, which selected the RPS program. The view is summarized as follows.

Assurance of effects
   Under the FIT program, it is impossible to determine appropriate prices, whereas the RPS program enables the determination of effects because the amount of renewable energy is clearly defined.

Cost reduction incentives and social cost allocation
   The RPS program fails to give power companies cost reduction incentives, while the RPS program encourages competition among power companies.

Fairness in cost allocation
   Under the FIT, the fairness of cost allocation may not be observed due to uneven geographical distribution of wind power sources. On the other hand, the RPS enables fairer allocation of costs through sale and purchase of renewable energy certificates.

From above discussion, the subcommittee concluded in 2001 that the RPS program would be the best option as Japan’s new energy promotion scheme.

However, based on the current status of the RPS program and overseas systems, the program may be evaluated as follows.

Assurance of effects
   Under Japan’s current RSP, targets are set only for short terms, making it difficult for investors to project profitability. It is also intricate to determine appropriate amounts of energy to be assigned to power companies, leading to extremely low production targets. This has resulted in power companies well exceeding their respective targets and past surpluses being carried forwards, thus frustrating the development of markets.
Cost reduction incentives and social cost allocation

The current low production targets under Japan’s RPS program is preventing the expansion of production and obstructing cost-cutting efforts.

Limited certificates market

Under the current RPS system, buyers of RPS values are limited to a small number of power companies. This fact prevents the pricing function from working properly in the market.

Fairness in cost allocation

The current RPS program does not permit power companies to pass their RPS costs to consumers in electricity charges. Amid liberalization of electricity, it is effectively impossible to achieve the cost pass-through mechanism. We are unable to determine the fairness of cost allocation because it is not yet made clear who actually shoulder how much.

Upon discussion at the Subcommittee for the RPS Law in 2007 after the introduction of the RPS program, the government established a policy of doubling the price of photovoltaic power generation certificates. This reflected the findings of a comparison between photovoltaic power generation and other new energy sources: photovoltaic power generation has great potential for technological innovation and would help achieve substantial price cuts and increased production through creation of demand; and, photovoltaic power generation is geographically less concentrated than wind power, water power, or geothermal power generation.

To maintain the current RPS program and achieve increased renewable energy production at the same time, we would need to substantially raise the target output (to be assigned to individual power companies), clarify mid- and long-term targets, and “visualize” the cost of introduction, in order to establish a system to permit power companies to pass their costs to electricity charges.

Because the RPS program fails to facilitate the adoption of power supplies that require relatively heavy installation costs, a policy should be employed to combine other systems with the RPS in order to make available such costly renewable energy sources. For instance, Italy employs both RPS and FIT for photovoltaic power generation.

(2) Renewable heat policy

With respect to the heat policy for renewable energy, it is important not only to provide financial support but also to encourage effort on the part of consumers, as well as suppliers. Spain and some other countries oblige businesses and households to adopt renewable energy when constructing a new building or refurbishing one. Some energy technologies may require financial support, and others may not. For the former, study for the adoption of
such technology can be made obligatory. For the latter, the adoption of such technologies should be made mandatory.

To increase the utilization of solar heat, the central and local governments may adopt solar obligations, which mandate the coverage of a specified fraction of heating needs with solar energy in building or refurbishing a structure, or a green heat certificate system as currently discussed by the Tokyo metropolitan government as a program to provide incentives in accordance with the amount of solar heat consumed.

(3) Renewable fuel policy

Fuel policies for renewable energy may include the promotion of biofuels for transportation and solid fuels such as wood pellets. For increased production of biofuels for transportation, it is required to improve the environment for advanced utilization of biofuels by solving problems associated with fuel standards and vehicle types and by switching from E3 ethanol gasoline (3% ethanol and 97% gasoline) to E10 (10% ethanol and 90% gasoline), in addition to incentives such as tax benefits under a current program.

4. Promotion of photovoltaic power generation
4.1 Setting targets

Photovoltaic power generation for Japan is strategically important among others for following reasons: (a) Japan demonstrates its strengths as a top world leader in technological development and can contribute to the construction of a global low-carbon society enhancing its international competitiveness through further industrial efforts; (b) its massive introduction will reduce the initial investment cost thanks to economies of scale, (c) photovoltaic power generation is applicable all over the world with ubiquitous solar energy, and (d) Batteries of plug-in hybrid and electric vehicles, in which Japan also has technological advantages, can be utilized as storage cells of photovoltaic electricity in future.

In our analysis, with a special focus on photovoltaic power generation, capacity targets were set for 2020 and 2030, and expected output was calculated after analysis of alternative promotion measures that could realize these targets.

(1) Background to targets

The Action Plan for Achieving a Low-carbon Society approved by the Cabinet in July 2008 proposed a long-term target of reducing global greenhouse gas emissions by 50% from the present level by the year 2050. The plan requires Japan to achieve a 60 to 80% reduction from the present level.

In line with the long-term target of halving global greenhouse gas emissions by 2050,
photovoltaic power generation should be a main option for Japan and other countries, including developing nations, to combat global warming. From this perspective, we discussed how to set up targets for photovoltaic power generation.

According to an IEA analysis, in order to achieve a 50% in greenhouse gas emissions by 2050, photovoltaic power generation must compete favorably against other energy sources in price between 2020 and 2030 (Figure 4-1).

Photovoltaic power generation with sufficient cost competitiveness would not only help Japan reduce emissions not only in the country but also on a global basis with its technology, while bringing a benevolent environmental, economic, and energy cycle in its economy, employment, and energy security.

Based on the IEA analysis, this Committee set forth an objective of reducing costs of introducing photovoltaic power generation to the level of retail electricity prices. A capacity target was established in accordance with this objective.

![Figure 4-1 Roadmap for the promotion of photovoltaic power generation by scenario](image)

Source: IEA “Energy Technology Perspectives 2008: Scenarios and Strategies to 2050,” 2008

(2) Target for photovoltaic electricity generation

In order to reduce the cost of photovoltaic power generation in Japan to the level of retail electricity prices, we should cut the cost to the level of commercial electricity charges (14 yen/kWh) by 2020 and to the level of the cost of thermal power generation (7 yen/kWh) by 2030. The targeted cost of 14 yen/kWh is comparable to the current fuel cost of oil-based thermal power generation or natural gas-based thermal power generation. The targeted cost of 7 yen/kWh is sufficiently lower than the current fuel cost of coal-based thermal power generation in Japan plus a Kyoto mechanism credit price or lower than the future fuel cost of coal-based thermal power generation plus CCS costs (Table 4-1).
Chart 4-1 Cost targets for the promotion of photovoltaic power generation

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 yen/kWh</td>
<td></td>
<td>7 yen/kWh</td>
</tr>
<tr>
<td>• Equivalent to electricity charges for commercial users</td>
<td>• Equivalent to or surpass thermal power unit price</td>
<td></td>
</tr>
<tr>
<td>• Comparable to fuel prices for oil-based thermal power generation or natural gas-based thermal power generation</td>
<td>• Much less expensive than fuel prices for coal-based thermal power generation + CO2 price</td>
<td></td>
</tr>
</tbody>
</table>

It is estimated that, to achieve these cost targets by producing photovoltaic electricity on economies of scale by 2020 and 2030, the domestic market in these years must be worth 37 million kW (25 times the 2005 level) in 2020 and 79 million kW (55 times the 2005 level) in 2030.

These capacity targets were calculated on the assumption that the unit prices of solar power systems and their installation would decline along the learning curve in line with increases in cumulative output and cumulative additional output. When cumulative output doubles on the learning curve and costs decline by $\alpha$, then “1-$\alpha$” is called “progress rate.” While the progress rate for photovoltaic generation modules is estimated at 77% in the IPCC Fourth Assessment Report, at 89% by European Photovoltaic Industry Association, and at 83% by IEA, we estimate the rate at 80% (Figure 4-2, Figure 4-3).
Assuming that photovoltaic power output will grow during the 2030-2050 period as fast as before 2030, it will top 173 GW (173 million kW), necessary to achieve Japan’s 70% greenhouse gas emissions reduction in 2050 (according to the National Institute for Environmental Studies’ 2005 Japan Low-carbon Society Scenario: Feasibility Review of 70% Greenhouse Gas Reduction), and the figure also fulfills Japan’s long-term goal of cutting greenhouse gas by 60 to 80% from the present level by 2050 (Figure 4-4).

If this capacity target is achieved, Japan will become the world’s largest producer of photovoltaic electricity after overtaking Germany in 2015 (Figure 4-5).
In promoting photovoltaic power generation, we attach importance to our domestic market for several reasons: (a) the development of the domestic market also enhances and maintains a global market competitiveness as seen in the past in the semiconductor market; (b) the domestic introduction gradually reduces its installation costs together with its production costs; and (c) introduction of photovoltaic power generation is a visible action in the business and household sectors, which discharge more greenhouse gases every year.

As Japan’s share in the global market shrank from 23% in 2004 to 6% in 2007, its share in global photovoltaic power production fell from 55% in 2004 to 24% in 2007. It is urgent therefore that Japan establish policies to expand its domestic market (Figure 4-6).
**Figure 4-6 The need for expanding the domestic market**

* Source: JPEA, “Change in shipping volume of solar panels in Japan”

“Photovoltaic energy production of Japanese businesses” does not include overseas production of Japanese businesses or their affiliated businesses.

4.2 Feasibility of achieving capacity targets

To attain the 2020 and 2030 photovoltaic electricity capacity targets, it is crucial to encourage the general public and businesses with high awareness to introduce it now. Promotion policy should include at least two support packages: (a) support to consumers to ease financial burden, which will expands the domestic market and reduce production cost, and (b) support to Japanese businesses in technological development. Of these measures, it is indispensable to create a virtuous cycle of increased product and reducing costs by reinforcing support to consumers, which has long been set aside in the Japan’s policy of renewable energy (Figure 4-7).
Figure 4-7  Virtuous cycle of increased introduction and decreased facility unit prices enabled by support for the demand side

(i) 2020 capacity target for photovoltaic electricity (37 million kW)

It is estimated that the 2020 capacity target for photovoltaic electricity (37 million kW) will be achieved if incentives are provided for households and businesses to enable them to recover their investments in a 10-year period, which is a warranty period of solar panels, along with the public sector’s initiative in installing solar systems (Figure 4-8, Figure 4-9).

Our estimates indicate that, even if no other support policy than the RPS program is implemented, the cost of photovoltaic electricity will almost equal household electricity charges (23 yen/kWh) in 2018. Assuming that the current installation subsidy program (assumed to provide a subsidy of 70,000 yen/kWh as of 2010 and thereafter cover 13% of the cost of installing solar systems in line with declines in system prices) and the power companies’ voluntary buyback program (23 yen/kWh) will continue to 2018, and that the subsidy program will be abolished in 2019, with power companies buying back surplus electricity at 6.4 yen/kWh, the production of photovoltaic electricity would be at most 8.0 million kW, far below the target of 14 million kW (10 times the current level in 2020) under the Action Plan for Achieving a Low-carbon Society in 2090.
Figure 4-8 The need for the support of burden reduction for photovoltaic energy producers; and the payback period and introduction rate to be used for estimating capacity targets

Nikkei 09 Questionnaire: Nihon Keizai Shimbun, January 19, 2009
Nikkei 08 Questionnaire: Nikkei Inc. “Nikkei Plus 1”, August 16, 2008

* The payback period was estimated under the following assumption: production capacity 3.5kW; operation rate 12%; electricity charge 23 yen/kWh; and buyback of surplus electricity 23 yen/kWh. When an option in a questionnaire had a range of prices (e.g. 500,000 yen to 1,000,000 yen), an intermediate value was used.

Figure 4-9 Analyses of production capacity achievement policy until 2020

Left: The RPS + the public sector’s initiative in introduction of energy
Middle: The public sector’s initiative in introduction of energy + surplus electricity buyback program + subsidies
Right: The public sector’s initiative in introduction of energy + support policy for the demand side to recover investments in 10 years

It is estimated that accelerated introduction of photovoltaic power generation into the public sector, accompanied with support to consumers to shorten the payback period to 10 years, will enhance Japan’s international competitiveness through price cuts resulting from
expansion of the domestic market. This would help domestic businesses increase their share in global output of photovoltaic electricity. At the same time, the penetration rate for domestic households would reach 14%. On the other hand, if accelerated introduction of photovoltaic power generation into the public sector is accompanied with the surplus electricity buyback program and the installation subsidy program, then it is estimated that domestic businesses will suffer continued declining shares in the global market, with the domestic penetration rate staying below 5% (Figure 4-10, Figure 4-11).

Figure 4-10 Change in domestic market share and domestic enterprises’ share until 2020

Left: The public sector’s initiative in introduction of energy + surplus electricity buyback program + subsidies
Right: The public sector’s initiative in introduction of energy + support policy for the demand side to recover investments in 10 years

* “Photovoltaic energy production of Japanese businesses” does not include overseas production of Japanese businesses or their affiliated businesses.

Figure 4-11 Outlook for the introduction of photovoltaic power generation to single houses

Left: The public sector’s initiative in introduction of energy + surplus electricity buyback program + subsidies
Right: The public sector’s initiative in introduction of energy + support policy for the demand side to recover investments in 10 years

(ii) 2030 production capacity for photovoltaic electricity (79 million kW)

The 2030 capacity target will be achieved by implementing the following measures: (a) the
public sector’s initiative in introducing photovoltaic electricity (installation at 90% of installable sites), (b) a support package for enabling consumers to shorten the payback period to 10 years, (c) dissemination of innovative technologies through encouragement of technological development, (d) financial support (including interest subsidies and low-interest loans), (e) educational activities on photovoltaic power generation and its economic benefits (Figure 4-12).

As discussed above, the 2020 and 2030 capacity targets for photovoltaic electricity are considered achievable and the figures may be used as estimated outputs.

Assuming that this estimated output is realized, the photovoltaic electricity penetration rate is projected to be 14% for new single houses and 14% (about 4.2 million units) for all single houses in 2020. In 2030, the penetration rate will be 28% for new single houses and 31% (about 9.1 million units) for all single houses (Figure 4-13).

If the 2020 target is achieved, the share of Japanese manufacturers in the global photovoltaic generator market would be at least 30% and 20% in 2020 and 2030, respectively (Figure 4-14).
Figure 4-13: Outlook for the introduction of photovoltaic power generation to housing when the target for photovoltaic power generation for 2030 are achieved.

Figure 4-14: Outlook for Japan’s share in the global market and the share of Japanese businesses in global photovoltaic energy production, when the target for 2030 is achieved.

Domestic market share (introduction): Japan’s share in the global market
Domestic enterprises’ share (production): the share of Japanese businesses in global photovoltaic energy production
“Photovoltaic energy production of Japanese businesses” does not include overseas production of Japanese businesses or their affiliated businesses.

In this case, the unit price in 2020 of photovoltaic power generation equipment will be 250,000 yen/kW for industry use and 270,000 yen/kW for household use, while the cost of photovoltaic electricity will be about 14 yen/kWh for industry use and about 15 yen/kWh for household use. In 2030, the unit price of photovoltaic power generation equipment will be 170,000 yen/kW for industry use and 180,000 yen/kW for household use, while the cost of photovoltaic electricity will be about 6 yen/kWh for industry use and about 7 yen/kWh for household use. These figures would enable us to contribute to fight against global warming not only in Japan, but on a global basis as well.
4.3 Policy for shortening the payback period to 10 years

Compared with other renewable energy sources, photovoltaic power generation involves costly initial investments. Measures to shorten the payback period to 10 years may include a considerable raise in supply targets or setting a supply target only for photovoltaic power generation under the RPS, establishment of an installation subsidy program, or a FIT, or a combination of any of them.

Under the RPS program, the government sets a supply target but leaves the price formation to the market. For this reason, it is almost impossible to institutionalize the concept of shortening the payback period to 10 years for the purpose of achieving the target. This Committee analyzed the effects of Japan’s installation subsidy program currently in place and the FIT program already adopted in some countries. (Table 4-2). This analysis is based on the assumption that no other measures are taken than the public sector initiative in introducing photovoltaic power generation and a support package for shortening the payback period to 10 years.
Table 4-2: Comparison among subsidy program, RPS, and feed-in tariffs

<table>
<thead>
<tr>
<th>Comparison</th>
<th>RPS*</th>
<th>Subsidy program</th>
<th>Feed-in tariffs (FIT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortening payback period</td>
<td>• Because this policy aims at defining output targets and the market decides certificate prices, it is difficult to forecast the payback period.</td>
<td>• Although there is no assurance for electricity buyback, it is possible to forecast the payback period according to the amount of subsidies.</td>
<td>• It is possible to forecast the payback period by assuring electricity buyback.</td>
</tr>
<tr>
<td>Support target</td>
<td>Support for power generation</td>
<td>Support for facilities</td>
<td>Support for power generation</td>
</tr>
<tr>
<td>• Installation will be phased in from places with good conditions.</td>
<td>• Installation will be possibly phased in even at places with poor conditions, if support is received. (e.g., installation angles, shadow, snow, and installation directions)</td>
<td>• Installation will be phased in from places with good conditions.</td>
<td>• Because the support is based on metering, it is easy to grasp the decrease in emissions of CO2.</td>
</tr>
<tr>
<td>Support cost bearers</td>
<td>Power companies</td>
<td>Tax burden</td>
<td>Electricity consumers</td>
</tr>
<tr>
<td>• Because this is obliged to power companies, it is difficult to impose on electricity charges.</td>
<td>• This is expenditure from public finance.</td>
<td>• Various combinations of cost burdens (e.g., added prices to electricity charges and compensation from public finance) are possible.</td>
<td></td>
</tr>
<tr>
<td>Occurrence time of support costs</td>
<td>During power generation</td>
<td>During introduction</td>
<td>During power generation</td>
</tr>
<tr>
<td>• The burden on power companies get either heavier or lighter, depending on the prices of RPS certificates.</td>
<td>• The initial burden on the government is heavy.</td>
<td>• The initial burden on electricity consumers is comparatively light, because it is based on electricity output.</td>
<td></td>
</tr>
<tr>
<td>• The initial burden on power companies is comparatively light, because it is based on electricity output.</td>
<td>• If facility prices decreases, the cost burden on installers also decreases.</td>
<td>• Because the purchase at a certain price persists, the cost burden continuously occurs during the duration of this system.</td>
<td></td>
</tr>
<tr>
<td>• Because the purchase at a certain price persists, the cost burden continuously occurs during the duration of this system.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumers’ preference</td>
<td>Introduction is determined based on certificate prices or buyback prices set by power companies.</td>
<td>If subsidies are not sufficient, consumers may postpone the introduction of facilities until their prices become low.</td>
<td>Setting an adequate purchase price will provide a motivation for early introduction.</td>
</tr>
<tr>
<td>• If the payback period is the same, consumers will prefer an increase in electricity selling prices to subsidies offered at initial investment.</td>
<td></td>
<td>If the payback period is the same, consumers will prefer an increase in electricity selling prices to subsidies offered at initial investment.</td>
<td></td>
</tr>
<tr>
<td>Management costs</td>
<td>Management costs concerning RPS occur.</td>
<td>Management costs for application and assessment occur.</td>
<td>If costs are collected through added electricity charges, the balance between income (proportional to total electricity sales) and expenses (proportional to purchases of renewable energy) varies depending on power companies. Therefore, coordination among power companies is necessary.</td>
</tr>
</tbody>
</table>

* Based on the current systems in Japan, a surplus electricity buyback program concerning photovoltaic power generation (residential) is included to evaluate the RPS.

Under the installation subsidy program, it is estimated that the payback period can be shortened to 10 years by 2011 only if the subsidy is increased to 470,000 yen/kW (totaling

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3 Yoshikuni Yoshida, “Evaluating the possible prevalence of residential photovoltaic power generation based on preference analysis,” 2007
780 billion yen) from the current level (70,000 yen/kW). Around 2030, each household would need a subsidy of 100,000 yen/kW. Government expenditure would peak in 2011 at 760 billion yen. Including installation costs for the public sector, a total of 1.7 trillion yen would be required, while government spending would decline annually (Figure 4-15).

Under the FIT program, the payback period could be shortened to 10 years by 2011 only if the purchase price is increased to 55 yen/kWh from the current level (23 yen/kWh). Total costs shouldered by consumers would peak in 2025 at 400 billion yen. Around 2023, electricity generated by households would be purchased at 23 yen/kWh. Government expenditure would peak in 2011, when the public sector would need a total of 900 billion yen to install solar systems, and thereafter government expenditure would decline annually (Figure 4-16).

Figure 4-15 Occurrence time of total costs (Subsidy program)

The cost burdens on power companies show a decrease in profits due to decreased electricity sales. Surplus electricity is virtually supposed to be taken by power companies without cost.

*1) The output and the cost burden for public installation are the same in the cases of the subsidy program and feed-in tariffs. In addition, because the bar graph does not include profits (reduced electricity charges) derived from the utilization of electricity generated by public-installed photovoltaic power, the cumulative value is different from “total burdens.”

*2) The production target for photovoltaic power is 79 M kW (in 2030). Here, among necessary measures to achieve the target, only the public sector’s initiative in introduction of renewable energy and the support policy to recover investments in 10 years are considered. Therefore, the target is not achieved in 2030.
Objects of buyback are all electricity output, not limited to surplus electricity. The buyback period at a fixed price is 15 years, and after the 16th years, power companies are supposed to purchase only surplus electricity at a thermal power generation cost equivalent (6.4 yen/kWh).

*1) The output and the cost burden for public installation are the same in the cases of the subsidy program and feed-in tariffs. In addition, because the bar graph does not include profits (reduced electricity charges) derived from the utilization of electricity generated by public-installed photovoltaic power, the cumulative value is different from “total burdens.”

*2) The production target for photovoltaic power is 79 M kW (in 2030). Here, among necessary measures to achieve the target, only the public sector’s initiative in introduction of renewable energy and the support policy to recover investments in 10 years are considered. Therefore, the target is not achieved in 2030.

When the installation subsidy program and the FIT are compared, the latter would be the better option as a measure for setting the payback period at 10 years because, in the former, a cap is imposed annually on the government contribution, because it is not clear how long the program will be continued, and because administrative costs may increase to sustain the program. If the cost of installing photovoltaic power generation is significantly reduced in the future, an RPS program may be adopted under a considerably high production target.

5. Overcoming non-economic barriers and approaches from the demand side

5.1 Overcoming non-economic barriers

Issues concerning noneconomic barriers were identified and examined on the basis of a renewable energy commercialization flow regarding (a) location survey and design, (a) construction, and (c) operation and maintenance (Table 5-1).

Specifically, it is important to review systems and their operation as necessary and set up a
consensus formation mechanism so that relevant location and construction regulations do not unnecessarily restrict the introduction of renewable energy.

Following a precedent in Germany, we should discuss a priority connection system to remove barriers separating emerging and existing businesses.

Current institutional and business practices are imposing exacting requirements on the quality of electricity produced from renewable energy, constituting a noneconomic barrier to the introduction of renewable energy.

One solution is to ease the restrictions on a quality variance in electricity for electrical appliances using renewable energy. If any consumers demand higher quality, any form of assistance may be considered to enable them to improve the quality, for instance, by installing private power generators, batteries, or any other devices.
### Chart 5-1 Overview of bottlenecks of systems and measures for renewable energy promotion (1/3)

<table>
<thead>
<tr>
<th>Issues along the project flow</th>
<th>Location survey and design</th>
<th>Construction</th>
<th>Operation and maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electricity</strong></td>
<td>The following are necessary:</td>
<td>The following are necessary:</td>
<td>The following are necessary:</td>
</tr>
<tr>
<td></td>
<td>・Relaxing the regulations of the Factory Location Law (deemed green space, approved by Industrial Structure Council)</td>
<td>・According to the Building Standards Law, if modules are used as roofing materials or external wall materials, it is necessary to meet the requirements about “structural strength,” “fire-safety,” “durability,” and “safety.”</td>
<td>・To deal with the following problems, line stabilization measures are necessary when power generation is introduced in volume: (1) more difficult reverse power flow due to voltage increase in power grids; (2) lack of frequency adjustment capabilities; and (3) generation of surplus electricity (supply-and-demand balance)</td>
</tr>
<tr>
<td></td>
<td>・Enhancing product value (higher conversion efficiency, higher technology including long-lasting products, higher design, etc.)</td>
<td>・Preventing inappropriate construction and standardizing installation stages and construction methods to reduce cost.</td>
<td>・Preventing isolated operation and unnecessary parallel off.</td>
</tr>
<tr>
<td></td>
<td>・Promotion and enlightenment to solve the lack of home builders’ understanding of photovoltaic power generation</td>
<td>・Improving conversion efficiency (smaller installation area)</td>
<td>・For line interconnection, it is necessary to deal with frequency change (The flexible use of interregional interconnection lines can be a countermeasure.)</td>
</tr>
<tr>
<td></td>
<td>・The purchase of surplus electricity by power companies is a voluntary effort. Therefore, a long-term investment plan will remain uncertain. A long-term assured support policy for promoting investment is necessary.</td>
<td>・Developing simplified installation methods.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>・According to the Natural Park Law, the regulations in target areas should be followed and approval is required.</td>
<td>・Due to the enforcement of the revised Building Standards Law and its Enforcement Order in June 2007, structural calculation and Minister’s approval are required.</td>
<td>・Preparing for the new Building Standards Law and its Enforcement Order in June 2007, structural calculation and Minister’s approval are required.</td>
</tr>
<tr>
<td></td>
<td>・According to the Forest Law, if a development area is over 1ha, approval is required.</td>
<td>・The Road Law stipulates that permission should be required for occupancy of roads and traffic controls during construction.</td>
<td>・For line interconnection, it is necessary to deal with frequency change (The flexible use of interregional interconnection lines can be a countermeasure.)</td>
</tr>
<tr>
<td></td>
<td>・According to the Law for Natural Environment Conservation, the regulations in target areas should be followed and approval is required. In addition, off-limits areas cannot be developed.</td>
<td>・Tightened regulations on land use and the amendment of the Building Standards Law</td>
<td></td>
</tr>
<tr>
<td></td>
<td>・Clarifying and simplifying procedures for water rights licensing and renewal based on the River Law, specifying license standards, and clarifying hearing procedures for prefectural governors.</td>
<td>・The key for well sinking is consensus building between surrounding autonomous (which are concerned about hot spring decay) and hot spring industries. Measures to promote this are required.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>・Clarifying and simplifying administrative procedures for reducing initial investment burdens (We need to consider a support policy. We should develop low-cost and simplified power generation systems.)</td>
<td>・Reducing initial investment burdens (We need to consider a support policy. We should develop low-cost and simplified power generation systems.)</td>
<td></td>
</tr>
<tr>
<td></td>
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Chart 5-1 Overview of bottlenecks of systems and measures for renewable energy promotion (2/3)

<table>
<thead>
<tr>
<th>Bottlenecks in the relationships with existing operational forms</th>
<th>Electricity</th>
<th>Wind power generation</th>
<th>Other (Biomass, geothermal, small-scale water power, etc.)</th>
</tr>
</thead>
</table>

- The use of biomass-based waste according to the Waste Disposal and Public Cleansing Law should be reviewed to make it effective and efficient in response to the actual situations of the utilization of renewable energy.
- According to the Electricity Utilities Industry Law, procedures such as construction planning, before-use safety control screening, new use notification, appointment of chief engineers, and safety codes are necessary.
- Because the required volume in the RPS is short-term and small-scale, they have become buyers' markets. Accordingly, the purchase prices are not high enough to promote investment. A long-term and secure support policy to promote investment is required.

Chart Comparison among systems concerning line interconnection of renewable energy in three countries

<table>
<thead>
<tr>
<th>Priority connection</th>
<th>Japan</th>
<th>Germany</th>
<th>U.K.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost bearer</td>
<td>Power companies</td>
<td>Power companies</td>
<td>Power companies</td>
</tr>
<tr>
<td>Enhancement cost</td>
<td>Power companies</td>
<td>Line operators (added to electricity charges)</td>
<td>Power companies</td>
</tr>
<tr>
<td>Imbalance cost</td>
<td>Cost burdens are to be examined.</td>
<td>Imbalance settlement is exempted.</td>
<td>Imbalance settlement is adopted.</td>
</tr>
<tr>
<td>Preferential price</td>
<td>RPS/voluntary surplus electricity buyback program</td>
<td>Feed-in tariffs</td>
<td>RPS* According to Energy Bill passed in November, feed-in tariffs concerning natural energy facilities up to 5,000 kW will be introduced by 2010.</td>
</tr>
</tbody>
</table>

* RPS
<table>
<thead>
<tr>
<th>Issues along the project flow</th>
<th>Heat</th>
<th>Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location survey and design</strong></td>
<td><strong>&lt;Solar heat&gt;</strong>&lt;br&gt;The following issues are to be improved.&lt;br&gt;- Not always economically efficient. In some cases, it is difficult to recover investments.&lt;br&gt;- The development of new, attractive products is delayed.&lt;br&gt;- Not connectable to gas/oil water heaters. Weak hot-water pressure.&lt;br&gt;- The improvement of design as a building unit is delayed.&lt;br&gt;- Lack of the linkage among energy businesses and home builders. (Because excellent competitive technologies (PV, eco cute, etc.) emerged, housing manufacturers and household equipment dealers shifted their sales resources to the new technologies.)&lt;br&gt;- No effective support policy was adopted. At the age of low interest rates after the 90s, there were few merits in low-interest financing systems, and subsidies were limited to a part of forced recycle-based systems in the market.&lt;br&gt;- Lack of promotion and enlightenment</td>
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<tr>
<td><strong>Construction</strong></td>
<td><strong>&lt;Solar heat&gt;</strong>&lt;br&gt;- Panels, a tank, and gas water heaters are separated, and interconnected movement is difficult. This should be improved.&lt;br&gt;- Poor construction performance (construction technology is behind.) Improvement (e.g. the unification of standards) is required.</td>
<td><strong>&lt;Solar heat&gt;</strong>&lt;br&gt;- It is necessary to establish economically efficient production technology.&lt;br&gt;- According to the House Quality Assurance Law, biomass-based fuel is limited to 3%. For large-scale production, higher concentrations are required.&lt;br&gt;- For developing infrastructure for large-scale production, it is necessary to decide on the policy of either direct mixing of bioethanol or ETBE.</td>
</tr>
<tr>
<td><strong>Operation and maintenance</strong></td>
<td><strong>&lt;Solar heat&gt;</strong>&lt;br&gt;- To secure a certain level of accuracy in issuing Green Certificate, it is necessary to considerably reduce heat measuring costs.&lt;br&gt;- It is necessary to secure the safety and security of solar heating equipment.</td>
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<tr>
<td><strong>Bottlenecks in the relationships with existing operational forms</strong></td>
<td></td>
<td><strong>&lt;Biofuel&gt;</strong>&lt;br&gt;- Planning international &quot;sustainable biofuel standards&quot; (Now under review at related ministries.)&lt;br&gt;- Planning a sustainable biofuel scenario with developing countries, with international trading in perspective.&lt;br&gt;- Considering how the domestic market should be, including the House Quality Assurance Law and current supply chain.</td>
</tr>
</tbody>
</table>

5.2 Approach to introduction of renewable energy based on actual practice among consumers

Analysis partly based on past surveys on the demand side concerning the utilization of electricity and heat suggested that over 80% of the electricity consumers surveyed are relatively receptive of the quality of renewable energy, including voltage and frequency fluctuations exceeding the current standard (Table 5-2).

Low-temperature heat for hot water supply and heating systems can be provided from solar and geothermal sources. These low-temperature needs are expected to amount to 31.76 million kL, accounting for 55% of total household energy.

Chart 5-2 Business types and electricity demand by electricity quality need in industrial and operational sectors

(Electricity demand: performance of 2006)

<table>
<thead>
<tr>
<th>Electricity quality need</th>
<th>Business type (Major Group in the Standard Industrial Classification)</th>
<th>Electricity demand (M kWh)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>High quality</td>
<td>Manufacturers (textile, electrical equipment, information and communication equipment, electronic parts &amp; devices, and precision instruments)</td>
<td>51,427</td>
<td>7%</td>
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<tr>
<td></td>
<td>Electricity, gas, heat supply, and water</td>
<td>14,836</td>
<td>2%</td>
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<tr>
<td></td>
<td>Information and communication</td>
<td>8,660</td>
<td>1%</td>
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<td></td>
<td>Finance and insurance</td>
<td>5,920</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Real estate (not applied to common space)</td>
<td>14,834</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Medicine, welfare</td>
<td>27,307</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td>122,983</td>
<td>17%</td>
</tr>
<tr>
<td>Non-high quality allowed</td>
<td>Agriculture, forestry &amp; fisheries, mining, and construction</td>
<td>22,703</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Manufacturers (other than those above)</td>
<td>345,387</td>
<td>47%</td>
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<tr>
<td></td>
<td>Transportation</td>
<td>13,679</td>
<td>2%</td>
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<td></td>
<td>Wholesales and retails</td>
<td>94,202</td>
<td>13%</td>
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<tr>
<td></td>
<td>Restaurants and lodging</td>
<td>46,179</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>Education, learning support</td>
<td>25,940</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Complex service</td>
<td>2,904</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Service</td>
<td>55,175</td>
<td>7%</td>
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<tr>
<td></td>
<td>Civil service</td>
<td>6,754</td>
<td>1%</td>
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<tr>
<td></td>
<td>Subtotal</td>
<td>612,923</td>
<td>83%</td>
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<tr>
<td>Total</td>
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<td>735,906</td>
<td>100%</td>
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6. Direction of the electricity supply-demand system in line with increasing production of renewable electricity

6.1 Awareness raising and institutional reform for the promotion of renewable electricity

In Japan, nine regional power systems are connected by interconnection lines. “Simplicity and short distances” is an important factor for individual power systems. That is, they are more economical and more reliable when power supplies are located closer to consumers, and when transmission lines and distribution lines are more simply configured. In practice, power supplies have been located farther from points of consumption due to growing electricity demand and larger power systems. To achieve significant increases in renewable energy production, it is essential to gradually improve the operation and facilities of the electricity supply-demand system.

Characterized by sharp output fluctuations, certain types of renewable power generation, such as photovoltaic power generation and wind power generation, are faced with some demand-supply problems. These problems may be solved not by controlling or compensating individual output fluctuations in conventional practice but by having the whole system cope with such fluctuations and by increasing production, while gradually shifting under a new concept to a next-generation supply-demand system having higher efficiency and quality.

- Conventional concept: Only minimal amounts of renewable electricity are in practical use. Renewable energy causes problems with the operation of power systems and is inferior as a power source.

- New concept: Renewable electricity will be a fundamental power source. The production of renewable energy should be maximized in order to achieve a low-carbon society and improve Japan’s energy self-sufficiency.

To be more precise, devices such as a voltage regulator may be installed where necessary to cope with problems of regional character, including voltage fluctuations. In line with increasing production of renewable energy, total system output is leveled out even though there are sharply fluctuating outputs from individual systems, as high-frequency fluctuations cancel out, resulting in smoother fluctuations (“the leveling effects”). In solving supply-demand balance problems, we would be able to make the best use of the regulating ability of existing power systems by accurately evaluating the leveling effects.

In addition, it is desired to stabilize the operations of power systems and minimize the cost of constructing power systems by determining the necessary capacity of storage cells to be installed on the basis of the supply-demand adjustment function that use individual devices at consumers (“smart grids” adopted in Western countries) (Figure 6-1).
To solve problems with Japan's vulnerable energy supply structure and achieve significant production of renewable energy, it is necessary to shift to a new electricity supply-demand system that can be operated in a wiser and more advanced manner through a coordinated network of large power supplies, decentralized power sources, and storage cells. Such progress in the electricity supply-demand system, including the power system, can be achieved by formulating an appropriate and timely combination of operational measures and infrastructural improvements (Table 6-1).
Chart 6-1 Infrastructure construction, operational improvement, and institutional approaches for line stabilization

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<tr>
<td></td>
<td>Photovoltaic power generation: 4.82 M kW</td>
<td>Photovoltaic power generation: 37 M kW</td>
<td>Photovoltaic power generation: 79 M kW</td>
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<td></td>
<td>Wind power generation: 3 M kW</td>
<td>Wind power generation: 11 M kW</td>
<td>Wind power generation: 20 M kW</td>
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**Operational improvement**
- Flexible operation of pumped-storage power generation (pumping during daytime) [Trial stage]
- Expanding the consumption cap of interregional interconnection lines (flexible operation) (*In particular, the regulations on possible line interconnection which are caused by the regional gap in wind power generation can be temporarily relaxed.)
- Considering the future image of the power line system (smart grid)
- Considering specifications of a power conditioner (PCS) with an output adjustment and communication function added for the line interconnection of renewable energy-based electricity.
- Considering specifications of energy management equipment for housing, buildings, and regions.

**Infrastructure construction**

| <<Demand side>> | ("It is important to determine the effect of the mass production of renewable energy-based electricity, in order to estimate the necessary amount of batteries, For this purpose, experimental research should be conducted by installing output monitoring samples at geographically decentralized locations. )
| <<Supply side>> | Considering increases in distribution voltage (This makes it possible to reduce voltage increases and distribution loss.)
| | Installation of voltage regulators to high-voltage lines ("However, it is unnecessary if voltage is increased.")

| <<Demand side>> | Development and the introduction of a remodeled power conditioner (PCS) with an output adjustment and communication function added
| | Development and introduction of an energy management system for housing, buildings, and regions
| | Partial introduction of batteries
| | Use of an emergency stock of power supplies
| | Increasing distribution voltage (This makes it possible to reduce voltage increases and distribution loss.)
| | Installation of voltage regulators to high-voltage lines ("However, it is unnecessary if voltage is increased.")
| | Smart grids (smart meters, demand response, flexible operation of lines by using coordinated control of decentralized power supplies and battery systems)

| <<Supply side>> | Widespread use of a remodeled power conditioner (PCS) with an output adjustment and communication function added
| | Widespread use of an energy management system for housing, buildings, and regions
| | Introduction of batteries
| | Use of an emergency stock of power supplies
| | Use of EV batteries

| Institutional review | Standardizing consultation procedures for line interconnection
| | Relaxing the regulations on the line interconnection guideline, "a rule of producing electricity at the same time and in the same amount as is needed"
| | Relaxing the regulations on the scope of system voltages (relaxing the upper limit voltage)
| | Clarifying the operation status of interregional interconnection lines and achieving efficient operation.

| | The transparency of imbalance costs and the development of an open market
| | Examining the possibilities of the structural reform of power businesses based on "Flip Incentive"

| | The transparency of imbalance costs and the development of an open market are required as a precondition.
6.2 Short-term initiatives in promoting renewable electricity (photovoltaic and wind power generation) (to 2012)

Short-term production targets would be achieved simply by making improvements to the operation of existing power systems, including a response to voltage-related problems caused by differences in regional output and network characteristics.

In the introduction phase of renewable energy, we should start discussing from new perspectives how the power system should be in the future.

Governments in Western countries have started full-fledged discussions on a new power system called “smart grid.” Smart grids, based on information technology, adjust electricity demand, supply-demand conditions, and outputs from distributed power supplies. They could help reduce the required capacity of electric power facilities, enable the more efficient utilization of a power system composed of decentralize power supplies and existing large centralized power sources, and at the same time facilitate mass-production of renewable energy.

Japan is urged to start discussion on how to install smart grids so that the country can build a flexible and strong power system and realize a low-carbon society based on renewable energy.

As part of its effort, Japan should discuss the output and communication functions of power conditioners (PCS) for system interconnection of renewable electricity, as well as working out specifications on energy management equipment for households, buildings, and regions.

In preparation for interconnection of large amounts of photovoltaic to low-voltage systems, the regulations on system voltage limitations should be liberalized to reduce the quantity of voltage regulators, while, where necessary, installing voltage regulators on high-voltage systems. As a more radical solution, the distribution voltage should be switched from 6kV/100-200V to 20kN/400V in order to decimate voltage increases in the distribution system (cutting the number of voltage regulators) and decrease distribution loss. This should be taken into consideration in discussions on the future power system.

With respect to infrastructures, to calculate the mid- and long-term cost of installing storage cells, it is indispensable to determine the effects (outputs and output fluctuations) of the mass-production of renewable electricity. Data concerning electricity generation characteristics are obtainable on a short- and mid-term basis from minute-by-minute data that are collected from a number of monitoring samples at geographically distributed locations. A comprehensive analysis of the relationship between the output and corresponding effects would enable the determination of the required capacity of storage cells and their configuration. Because the cost of installing storage cells accounts for a
large part of the total cost of introducing renewable electricity, it is essential to estimate the required capacity with considerable accuracy.

As to institutional aspects, different unstandardized interconnection procedures are used by different power companies, who are responsible for system interconnection management. Theses results in enormous costs on the part of those who desire to apply for interconnection. In addition, information asymmetry is causing inequitable terms and conditions of business. Based on these facts, it is essential to standardize interconnection procedures.

Renewable electricity is highly susceptible to natural conditions. In controlling frequencies, expect for voltage fluctuations, and in controlling supply-demand conditions, it is not always necessary for power systems to maintain balances by using individual renewable energy sources. For this reason, the system interconnection guidelines should be amended to ease the requirement of “producing electricity at the same time and in the same amount as needed.”

As another measure, the regulations on system voltage ranges may be relaxed to raise maximum voltage limits in preparation for voltage rises resulting from interconnection of a large number of photovoltaic power systems to low-voltage power grids. Also, it is important to gain market trust by ensuring transparency in electricity management through disclosure of more information concerning the operation of interregional interconnection lines and at the same time by achieving efficient operations.

6.3 Mid-term initiatives in reconstructing the power system (to 2020)

As part of operational improvement, facilities and equipment in the existing power system may be used in a more flexible manner to address surplus-electricity problems with photovoltaic power by, for instance, coordinating daytime operations of pumped storage power plants.

In operation of renewable energy generation systems, if we seek to make the best use of all electricity obtained from every individual system, we could fail to maintain overall optimization because we would need to install additional equipment such as storage cells. For this reason, it is recommended that a top priority should be placed on controlling surplus electricity in order to achieve optimal economic efficiency.

To overcome Japan’s vulnerable energy supply structure and build a sustainable low-carbon society, we are urged to introduce a new electricity supply system under which large-scale power supplies and decentralized energy sources function in coordination.

To achieve this purpose, major power companies and new medium and small electricity
suppliers should share views about equipment, operation, and cost allocation related to the future system. Then, we are urged to review laws and regulations and other institutional aspects, standardize relevant procedures, and promptly start capital investments.

In improving infrastructures, the demand side may be encouraged to install advanced power conditioners furnished with an output control and communications function or to develop and introduce a residence/building/community energy management system.

As to the supply side, voltage regulators may be installed where necessary to be connected to low- and high-voltage grids. In addition, a measure should be developed to handle increases in distribution voltage (a shift from 6 kV/100-200V to 20 kV/400V) to match the concept of the future power system, which should be worked out through discussion.

It is also desired to integrate the control of decentralized power supplies with the conventional centralized control of large-scale power supplies.

The suggestions made above are already being discussed and standardized in Western countries and are reflected in their concept of “smart grids.” A smart grid is a technology combining a demand response mechanism with a smart meter. The technology is designed to create coordination among large-scale decentralized power supplies, medium- and small-scale decentralized power supplies, and battery systems. A “smart grid” also refers to a power system that is flexibly operated using this technology.

On the basis of the discussion on the future power system, Japan should start shifting to smart grids as its future power system in order to introduce larger amounts of renewable electricity as its primary energy source in the long run.

As an important part of the institutional review, a transparent open electricity market, in addition to infrastructures (equipment and control procedures), must be built to ensure that individual pieces of equipment are installed and operated in coordination.

6.4 Long-term strategy for reconstructing the power system (to 2030)

In operational improvement, coordination should be developed among consumers, decentralized power supplies, and storage systems by, for example, using weather forecasts and data and taking advantage of photovoltaic properties. Top priority should be given to renewable energy to achieve economic efficiency and surplus reductions.

In improvement to infrastructure, a stronger power system should be constructed through coordinated control on both the demand and supply sides. Measures on the demand side may include the promotion of residential/building/communication energy management systems; the dissemination of storage cells, the utilization of emergency power supplies,
and the adoption of EV vehicle batteries. Measures on the supply side should include
increases in distribution voltage and the promotion and sophistication of smart grids.

In institutional review, a transparent open electricity market must be built for power systems
that can perform coordinated control of large-scale power supplies and medium and small
decentralized power sources so that energy imbalance costs and other information are
disclosed.

6.5 Cost of improving the electricity supply-demand system

The cost of system stabilization related to interconnection of renewable electricity to the
power system was calculated taking into consideration the more flexible operation, expected
institutional review, and the potential construction of smart grids. The cumulative cost of
system stabilization by option amounts to 900 billion yen to 2030 (in 2010 value) and to 3.5
trillion yen to 2030 (in the 2010 value).

As previously discussed, in calculating the mid- and long-term cost of installing storage cells
in order to improve Japan’s power system, it is indispensable to determine the effects
(production output and output fluctuations) of the mass-production of renewable electricity.

Data concerning electricity generation characteristics are obtainable on a short- and
mid-term basis from minute-by-minute data that are collected from a number of monitoring
samples at geographically distributed locations.

A comprehensive analysis of the relationship between the output and corresponding effects
would enable the determination of the required capacity of storage cells and their
configuration. Because the cost of installing storage cells accounts for a large part of the
total cost of introducing renewable electricity, it is essential to estimate the required capacity
with considerable accuracy.

According to an estimate of the Agency for Natural Resources and Energy’s Subcommittee
on System Stability Policy and Cost Allocation for Mass Production of New Energy of the
Study Group on Low-carbon Electricity Supply Systems, the cumulative system stabilization
cost of 4.6 to 6.7 trillion yen would be required to produce 53 million kW of photovoltaic
electricity (40 times the present level) in 2030.

Although this Committee estimated the cumulative output of photovoltaic electricity was
estimated at 79 million, higher than the Agency’s estimate, it is estimated that the cumulative
cost of improving the electricity supply-demand system will amount to 3.5 trillion yen to 2030
(Table 6-2).
## Chart 6-2 Cumulative costs by option of system stabilization

<table>
<thead>
<tr>
<th>Estimated output</th>
<th>Until FY 2020</th>
<th>Until FY 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subcommittee on Cost Burden</strong></td>
<td>14.32 M kW (Maximum Case of the LPSDE)</td>
<td>53.21 M kW (Maximum Case of the LPSDE)</td>
</tr>
<tr>
<td><strong>This Committee</strong></td>
<td>37 M kW</td>
<td>79 M kW</td>
</tr>
</tbody>
</table>

### Output control (year-end and New Year holidays and Golden Week)

- **Subcommittee on Cost Burden**
  - (According to the output in FY 2020, output control is considered to be unnecessary.)
- **This Committee**
  - Not allocated, just as on the right.
  - → 0 yen

### Power distribution measures

- **Subcommittee on Cost Burden**
  - (Unknown)
  - To deal with the voltage increases caused by the reverse power flow from the photovoltaic power generation, distribution measures are taken (installation of voltage regulators (SVC), the separate installation of pole transformers, and the conversion of bank sending voltage regulators) from 2011. In FY 2030,
  - SVC: 15 million yen × 24,000 places
  - Pole transformer: 200,000 yen × 1.1 million places
  - Bank sending voltage regulator: 800 million yen × 40 places
  - → Cumulative amount: 0.44 trillion yen (present value of 2008)

### Batteries on the customers side

- **Subcommittee on Cost Burden**
  - (Unknown)
  - The estimation is based on the assumption that the installation of batteries on the customers side does not cause reverse power flow.
  - The target output is estimated to be 1.2-1.5 times as much as the 230 M kWh as the battery capacity, which is supposed to be needed for surplus electricity measures on the power line side; therefore, it is assumed that the target output will be 280-350 M kW.
  - Assuming the unit price of a battery (FY 2011-2019: 42,400-29,600 yen/kWh; FY 2021-2030: 25,000 yen/kWh) and the introduction rate,
  - → Cumulative amount: 4.81-6.01 trillion yen (present value of 2008)
<table>
<thead>
<tr>
<th>Until FY 2020</th>
<th>Until FY 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>This Committee</strong></td>
<td><strong>This Committee</strong></td>
</tr>
<tr>
<td>In the initial year, FY 2018, if the amount for 3.0 hours is introduced to the public sector, → <strong>9.43 trillion yen (present value of 2010)</strong></td>
<td>• According to the above, the output control during end-year and New Year holidays will allow the output of 28 M kW without surplus electricity measures. • Therefore, batteries for 280-350 M kWh (11.1-13.9 hours of 53.21-28 M kW) are excessive. • Further output control will help narrow down the battery capacity. • This estimation assumes that 150 M kWh batteries (three hours of 28 M kW-79 M kW) will be installed. • According to this estimation, the 28 M kW level will be achieved in FY 2018. Therefore, if the use of batteries is initiated in FY 2018 and they are introduced with constant acceleration (assuming that the unit price of a battery is the same as above), → <strong>Cumulative amount 2.49 trillion yen (present value of 2010)</strong></td>
</tr>
<tr>
<td><strong>Subcommittee on Cost Burden</strong></td>
<td><strong>Subcommittee on Cost Burden</strong></td>
</tr>
<tr>
<td>(According to the output in FY 2020, surplus electricity measures are considered to be unnecessary).</td>
<td>• After FY 2020, when the output of photovoltaic power generation exceeds 13 M kW, surplus electricity measures shall be taken by installing batteries on the power line side. • The battery capacity required for surplus electricity measures on the power line side is estimated to be 230 M kWh. • If 90% of this is controlled by batteries, and the remaining 10% is controlled by pumped-storage power generation, → <strong>Cumulative amount: 3.60 trillion yen (present value of 2008)</strong></td>
</tr>
<tr>
<td><strong>This Committee</strong></td>
<td><strong>This Committee</strong></td>
</tr>
<tr>
<td>Not allocated, just as on the right.</td>
<td>• This estimation does not assume the installation of batteries on the power line side. • In the materials of the second Subcommittee on Cost Burden, “land cost” is allocated for the installation of batteries on the power line side. However, it is considered to be difficult to have space for battery installation inside and around substation facility sites in urban areas. Therefore, the cost may increase by using underground space.</td>
</tr>
<tr>
<td><strong>Subcommittee on Cost Burden</strong></td>
<td><strong>Subcommittee on Cost Burden</strong></td>
</tr>
<tr>
<td>(Unknown)</td>
<td>• Additional cost generated by the decreased power generation efficiency of thermal power plants where part-load operation is performed as a backup to respond to the output change affected by climate change, which is due to the mass production of photovoltaic energy. • Based on the target output of about 700 M kWh in FY 2030 (estimation of the Federation of Electric Power Companies of Japan), → <strong>Cumulative amount: 0.23 trillion yen (present value of 2008)</strong></td>
</tr>
<tr>
<td><strong>This Committee</strong></td>
<td><strong>This Committee</strong></td>
</tr>
<tr>
<td>Just as on the right, according to the output of photovoltaic power generation based on this estimation, → <strong>Cumulative amount: 0.13 trillion yen (present value of 2010)</strong></td>
<td>• Based on the assumption that the target output of each year is proportional to the output of photovoltaic power generation, the cost per target output (present value of 2008) is estimated so that it will be consistent with the total measure costs (present value of 2008). • Based on the cost per target output, measure costs are allocated in response to the output of photovoltaic power generation in this estimation. → <strong>Cumulative amount: 0.42 trillion yen (present value of 2010)</strong></td>
</tr>
<tr>
<td><strong>Subcommittee on Cost Burden</strong></td>
<td><strong>Subcommittee on Cost Burden</strong></td>
</tr>
<tr>
<td>(Unknown)</td>
<td>• Concerning the discharge and charge loss of batteries and pumped-storage power loss, the loss rate is estimated to be 30%. Based on the target output of about 200 M kWh in FY 2030 (estimation of the Federation of Electric Power Companies of Japan), → <strong>Cumulative amount 0.06 trillion yen (present value of 2008)</strong></td>
</tr>
<tr>
<td><strong>This Committee</strong></td>
<td><strong>This Committee</strong></td>
</tr>
<tr>
<td>Just as on the right, according to the output of photovoltaic power generation based on this estimation, → <strong>Cumulative amount: 0.03 trillion yen (present value of 2010)</strong></td>
<td>• Based on the assumption that the target output of each year is proportional to the output of photovoltaic power generation, the cost per target output (present value of 2008) is estimated so that it will be consistent with the total measure costs (present value of 2008). • Based on the cost per target output, measure costs are allocated in response to the output of photovoltaic power generation in this estimation. → <strong>Cumulative amount: 0.11 trillion yen (present value of 2010)</strong></td>
</tr>
</tbody>
</table>
Until FY 2020 | Until FY 2030
---|---
Understanding photovoltaic power generation output | 1. Concerning the output of photovoltaic power generation, based on the 400 billion yen as measure costs for producing 53 M kW (estimation of The Federation of Electric Power Companies of Japan), → 0.26 trillion yen (present value of 2008)
- Subcommittee on Cost Burden (Unknown) | -
| This Committee Just as on the right, if it is generated evenly every year, → Cumulative amount: 0.16 trillion yen (present value of 2010) | - Assumed as research and development costs, which will occur evenly every year evenly, → Cumulative amount: 0.26 trillion yen (present value of 2010)
Total amount | 5.39—6.70 trillion yen (present value of 2008)
- Subcommittee on Cost Burden (Unknown) | 3.56 trillion yen (present value of 2010)
- This Committee 0.92 trillion yen (present value of 2010) | 3.56 trillion yen (present value of 2010)


Note 1) The discount rate of measure costs shown in the materials for the third Subcommittee on Cost Burden is 3%, which is converted to the present value of 2008.

Note 2) Because this is based on the installation of batteries on the customers side, the installation on the power line side and pumped-storage power generation are outside the scope of the assumption in this Proposal. (Therefore, they are written in pale in this chart.)

7. Cost of producing renewable energy and specific effects of increased production

7.1 Cost of producing renewable electricity

To encourage nationwide discussion on the promotion of renewable energy, we first need to determine and “visualize” the total costs of production necessary for policy implementation.

In our analysis, the additional cost of introducing renewable energy generation equipment during the 2010-2030 period is estimated at 17 trillion yen for photovoltaic power generation, 1.1 trillion yen for small-scale water power generation, 0.5 trillion yen for geothermal power generation, and 2.3 trillion yen for biomass power generation. Including the costs of 3.5 trillion yen required to install electricity supply-demand systems, the total costs for the 2010-2030 period are estimated to amount to 25 trillion yen.

Investments in equipment used for renewable energy would decline with a decrease in production cost. Around 2020, when renewable energy production will reach a targeted level, system-related costs would start increasing. Overall, however, the equipment cost and the system cost combined are projected to start declining around 2021 (Figure 7-1).
Figure 7-1 Costs for increased production of renewable energy-based electricity

7.2 Effects of renewable energy production on CO2 emissions reductions and on the economy

An analysis was conducted to determine the effects of the achievement of production targets on CO2 emissions reduction, the self-efficiency of energy supply, the economy, and employment. In this analysis, two cases were assumed for fossil fuel prices: they will either stay flat or rise in accordance with IEA’s World Energy Outlook 2008 estimate.

With respect to CO2 emissions reduction in Japan, we estimate the annual CO2 emissions reduction of 47 million tons in 2020 (about 4% from the year 1990) and 96 million tons in 2030 (about 8% from the year 1990) from the level at which renewable energy production stays in the lower case under the Kyoto Protocol. This emissions reduction will generate cumulative economic benefits worth 400 to 600 billion yen to 2020 and 1.5 to 2.3 trillion yen to 2030. This estimate was made on the assumption that credit prices will increase because an increase in crude oil prices would cause LNG prices to rise, resulting in higher price competitiveness of coal.

7.3 Effects on energy self-sufficiency

Japan’s energy self-sufficiency is expected to increase from the current 5% to about 10% in 2020 and 16% in 2030, thanks to CO2 emissions reductions accompanied by controlled demand. In the evaluation of the energy self-sufficiency, nuclear power generation was excluded because Japan depends on imports for uranium fuels.
7.4 Economic effects of fossil fuel savings and industrial development

Savings on fossil fuels in electricity and heat will amount to 500 to 800 billion yen in 2020 (a cumulative saving of 2.9 to 4.0 trillion yen to the year 2020) and to 800 billion to 1.4 trillion yen in 2030 (a cumulative saving of 9.9 to 16 trillion yen). Assuming the industrial structure as of the year 2000, increased exports of photovoltaic generation systems resulting from the development of domestic markets are projected to add a cumulative total in GDP of 26 trillion yen to the year 2020 and 48 trillion yen to the year 2030. Thus, we estimate that economic benefits will significantly exceed corresponding costs.

7.5 Effect on employment

It is estimated that 590,000 jobs and 680,000 jobs will be created in 2020 and 2030, respectively.

7.6 Other effects

In addition to quantifiable benefits presented above, renewable energy will bring in unquantifiable benefits because of its property of being decentralized, including benefits related to such matters as disaster risk management.

Chart 7-1 Concrete effects of the promotion of renewable energy

(1) Effects on CO2 emissions reduction

<table>
<thead>
<tr>
<th></th>
<th>Reduction (MtCO2)</th>
<th>Reduction rate from 1990 (base year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>47</td>
<td>About 4%</td>
</tr>
<tr>
<td>2030</td>
<td>96</td>
<td>About 8%</td>
</tr>
</tbody>
</table>

The emissions of the base year is regarded as GHG emissions (1.261 billion t-CO2) of the Kyoto Protocol basic year.

(2) Economic effects of CO2 emissions reduction

<table>
<thead>
<tr>
<th></th>
<th>Economic effects of the substitution of fossil fuel (trillion yen)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single year 2020</td>
</tr>
<tr>
<td>Credit price</td>
<td>0.1</td>
</tr>
<tr>
<td>Increased credit price</td>
<td>0.1</td>
</tr>
</tbody>
</table>
(3) Effects of an improved energy self-sufficiency ratio

<table>
<thead>
<tr>
<th>Year</th>
<th>A: Renewable energy output</th>
<th>B: Domestic supply of primary energy</th>
<th>A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2006</td>
<td>30</td>
<td>586</td>
<td>5.1%</td>
</tr>
</tbody>
</table>

2020

<table>
<thead>
<tr>
<th>Case</th>
<th>A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>reference (LPSDE)</td>
<td>7.2%</td>
</tr>
<tr>
<td>Case I</td>
<td>9.7%</td>
</tr>
<tr>
<td>Case II</td>
<td>10.1%</td>
</tr>
<tr>
<td>Case III</td>
<td>10.6%</td>
</tr>
</tbody>
</table>

2030

<table>
<thead>
<tr>
<th>Case</th>
<th>A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>reference (LPSDE)</td>
<td>9.9%</td>
</tr>
<tr>
<td>Case I</td>
<td>13.7%</td>
</tr>
<tr>
<td>Case II</td>
<td>15.6%</td>
</tr>
<tr>
<td>Case III</td>
<td>16.2%</td>
</tr>
</tbody>
</table>

1) The domestic supply of primary energy in this Proposal in 2020 is based on the estimation results of Measure I to Measure III proposed by National Institute for Environmental Studies at the third Mid-term Review Committee on January 23, 2009.

2) Concerning domestic supply of primary energy in 2030, Case I is regarded as the same as that of LPSDE and the values of the Case II and III are the linear interpolated values of each case in 2020, using the value of hydrogen-photovoltaic and wind power generation from the Scenario B in the interim report of the Japan Low Carbon Society Scenarios toward 2050.

(4) Economic effects of fossil fuel savings

<table>
<thead>
<tr>
<th></th>
<th>Economic effects of the substitution of fossil fuel (trillion yen)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single year 2020</td>
</tr>
<tr>
<td>Fixed fuel prices</td>
<td>0.5</td>
</tr>
<tr>
<td>Increased fuel prices</td>
<td>0.8</td>
</tr>
</tbody>
</table>

(5) Effects of increased production of renewable energy on employment creation

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross value added (trillion yen)</th>
<th>Gross value added (excluding direct effects, trillion yen)</th>
<th>Employment created (10,000 people)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>5.0</td>
<td>3.4</td>
<td>59</td>
</tr>
<tr>
<td>2030</td>
<td>5.6</td>
<td>3.8</td>
<td>68</td>
</tr>
</tbody>
</table>

5 The numerator of the self-sufficiency is the renewable energy in the Long-term Prospect of Supply and Demand of Energy, excluding steam and electricity generated by waste heat recovery. And the denominator is domestic supply of primary energy.
# Chart 7-2 Costs of promoting renewable energy and specific effects of promotion

( **Summary** )

(Discount rate 3%、Converted to 2010 value)

<table>
<thead>
<tr>
<th>Effects</th>
<th>2020 (cumulative)</th>
<th>2030 (cumulative)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fixed fuel prices</td>
<td>Increased fuel prices</td>
</tr>
<tr>
<td>(1) Economic effects of fossil fuel savings</td>
<td>2.2</td>
<td>3.3</td>
</tr>
<tr>
<td>(2) Economic effects of CO2 emissions reduction</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>(3) Effects of increased production of photovoltaic, wind, small-scale water, and geothermal power generation on expanding gross value added</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Total ((1) + (2) + (3))</td>
<td>29</td>
<td>30</td>
</tr>
</tbody>
</table>

| Costs                                                                  | 13                | 13                | 25                | 25                |

1 Fixed fuel prices are correspondent to fixed credit prices; and increased fuel prices to increased credit prices.

2 The added value expansion effects related with direct effects are assumed to be allocated to costs. Here, only the cumulative amount of the added value expansion effects related with primary and secondary spillover effects is calculated.
8. Cost allocation

8.1 Appropriate cost allocation to businesses, the public, and governments

Production of renewable energy is directly associated with Japan’s fight against global warming and its energy security policy. In light of this fact, it is desired that the related costs should be allocated widely and evenly to all sectors of the nation by way of taxes and electricity charges.

Assuming that power companies pass all their buyback costs to their electricity bills under a FIT program, consumers would have to shoulder an annual average of 0.86 yen/kWh between 2011 and 2030 with a maximum of 1.14 yen/kWh in 2021. With a monthly electricity consumption of 300 kWh by ordinary households, they would pay an additional monthly charge of 258 yen between 2011 and 2030, with a maximum of 341 yen (Figure 8-1).

![Figure 8-1 Monthly cost shouldered by common households](image)

8.2 Considerations to people’s lives, energy-consuming businesses, and renewable energy producers

In designing a FIT program, the following considerations should be given to cost allocation:

- To avoid unfair adverse effects on the lives of citizens, exceptional measures should be taken, including a ban on passing costs to electricity bills for minimum electricity consumption necessary in daily life. (Currently, the electricity charges per kilowatt hour for households incrementally increase in three brackets. The new program may, for example, impose no charges on monthly consumption below 120 kWh.)
• Businesses consuming large amounts of electricity should be granted exceptional treatment, for example, a discount on businesses whose electricity consumption accounts more than 10% of production.

• To avoid unfair treatment of those who have produced renewable energy for years before the FIT program, a measure should be set up to buyback their electricity at a fixed price.

![Diagram of Electricity Consumption and Cost Burdens](image)

**Figure 8-2 Constitution of meter rate lighting system and allocation of cost burdens**

### 8.3 Review of the energy pricing system

It is necessary to ensure the profitability of energy providers, such as power companies and gas suppliers, by taking into consideration the fact that energy demand may top out with declining population and advancement of energy-saving policies, and that renewable energy will be produced on an increasingly larger scale. To be more specific, we need to discuss an ideal electricity pricing system under which both suppliers and consumers can share economic benefits from increased production of renewable energy.

### 9 . Conclusion

This Proposal has intended to show that increased production of renewable energy will contribute to our effort in environmental preservation, economic growth, and energy security. In this respect, there is a broad consensus of opinion among experts from a variety of fields that Japan should pursue renewable energy more aggressively.

It is hoped that this Proposal effectively motivates the implementation of relevant policies for
drastic increases Japan’s renewable energy production accompanied by broad allocation of costs to the public and for helping the country achieve a global low-carbon society.