Study of Potential for the Introduction of Renewable Energy (FY 2010)

Summary

focused on Tohoku and Kanto regions

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Important Notes and Definitions

[Important Notes]

1. Comparison between different energies … The estimation results are shown in terms of the installed capacity (kW). However, as the standard capacity factor (ratio of the actual power output of a power plant over a period of time to the theoretical power output if plant had operated at its full capacity over the same period) varies from one renewable energy to another (for example, photovoltaic power generation is not feasible at night), the conversion factor to the generated electric energy (kWh) also varies from one such energy to another. Caution is, therefore, required for any comparison between different types of energy.

2. Handling of already developed potential … The estimation results include the power generation potential which has already been developed. However, as some power generation potential is developed from a viewpoint other than the commercial viability of development, simple comparison does not provide an accurate picture.

[Definitions]

- Abundance … The amount of energy resources which can be theoretically estimated by the feasible area for system installation, mean wind velocity, river discharge or other relevant factors. It excludes the amount of energy which is difficult to utilise based on the current technological level and does not take various limiting factors (land inclination, legal restrictions, land use, distance from a residential area and others) into consideration.

- Introduction potential … The amount of energy resources which take various limiting factors for energy collection and utilisation into consideration. This amount is a portion of the abundance.

- Possible introduction amount under scenario … This is a portion of the introduction potential which can hopefully be realised for actual use under a specific scenario (assumptions) for project viability. For each type of renewable energy, the unit construction cost and other conditions are assumed to conduct a simulation on project viability and the outputs of those projects where the internal rate of return before tax is approximately 8% or higher totalised (the year of realisation is not considered). In general, the actual amount of energy developed is anticipated to be lower than the possible introduction amount under scenario. It could exceed the possible introduction amount under scenario, however, as the introduction potential may be developed disregarding the economic profitability.

  The following two basic scenarios were considered to estimate the probable introduction amount: (i) introduction of a system to purchase the entire amount of energies generated using renewable energy resources (feed-in tariff system) and (ii) cost reduction as a result of technological innovation. Using these scenarios, a feasible amount of commercially profitable energy development was estimated.

  i . Basic Scenario 1 (FIT scenario) … This scenario assumes the continuation of the present cost level and the actual purchase at the purchase price at the start of the FIT system and for the period as specified by the Act on Special Measures Concerning the Purchase of Electric Power Originating from Renewable Energies by Operators of Electric Utilities (FIT Act) which was approved by the Cabinet in March, 2011.

  ii . Basic Scenario 2 (technological innovation scenario) … This scenario assumes a substantial cost reduction for equipment, etc. through technological innovations and the maintenance of the purchase price at the start of the FIT system and for the purchase period as specified by the FIT Act.

  iii. Reference scenarios … Reference scenarios where the introduction of a subsidy system and changes of the specific conditions for each type of renewable energy are assumed were also considered to analyse the likely changes of the introduction potential and probably introduction amount.

Photovoltaic (PV) Power Generation (Non-Residential#)

1. Assumptions

Capacity Factor	Required Area	Solar Cell System Cost	Auxiliary Equipment Cost	Installation Cost *2	FIT Purchase Price	FIT Purchase Period
12%*1	67 W/m^2	¥390,000/kW	¥140,000/kW	¥77,000/kW	¥24, 36 or 48/kWh	15 or 20 years

*1 The impact of the orientation of the installed system on the annual generation amount of electric energy was also considered.

*2 An additional installation cost of ¥10,000 ~ 20,000/m^2 was added in those cases where a system is installed to windows or a roof with a complicated shape. For abandoned farmland, a transmission line construction cost of ¥10 million/km and annual rent of 6% of the land price were considered because (i) it is likely to be located far from the existing transmission grid and (ii) it will no longer be used for farming.

Potential of residential building … Ordinary houses were excluded from the scope of estimation as it would be inappropriate to estimate the probably introduction amount from residential installation using the income and expenditure simulation for commercial PV power generation operation.
NEDO estimated the residential PV power generation potential in 2004.
Potential (i.e. abundance) … Detached houses: 101 million kW; apartment buildings: 106 million kW
Introduction potential (total potential around 2030 based on the technological development scenario) … Detached houses: 37.1 ~ 53.1 million kW; apartment buildings: 8.2 ~ 22.1 million kW

2. Estimation Results

The estimation results indicate the need for a lower cost through technological innovation and a subsidy in addition to FIT if PV power generation is to spread to non-residential properties.

Installed Capacity (million kW)	Introduction Potential	FIT Scenario	FIT*1 + Technological Innovation*1 Scenario	FIT +Subsidy*2	FIT + Subsidy *2+ Enlarged Area of Installation *3
Public Buildings (schools, city halls, etc.)	23	0	0 ~ 10	0 ~ 10	10 ~ 20
Power Stations and Factories, etc.	29	0	0.2 ~ 14	0 ~ 14	14 ~ 20
Low Use or Unused Land (final disposal sites, etc.)	27	0	0 ~ 1.3	0 ~ 1.3	1.3 ~ 2.9
Abandoned Farmland (that which has become woodland or waste land)	70	0	0 ~ 47	0	43 ~ 58
Total	150	0	0.2 ~ 72	0 ~ 26	69 ~ 100

*1 The estimation assumed a reduction of the system cost by ½ ~ 2/3, a purchase price of ¥ 36/kWh and a purchase period of 15 years.

*2 A subsidy to cover one-third of the project cost was assumed and the various FIT purchase prices in the earlier table were used.

*3 An installation area was assumed to be enlarged at factories, power stations, water supply/sewerage facilities and other sites while the various purchase prices in the earlier table were used.

3. Geographical Distribution

One distinctive feature of PV power generation is the little geographical bias of its distribution as shown in the map here. Nevertheless, the areas along the Sanriku coast, the northern part of the Kanto Region, Yamanashi Prefecture, Boso Peninsula and Izu Peninsula enjoy comparatively better conditions.

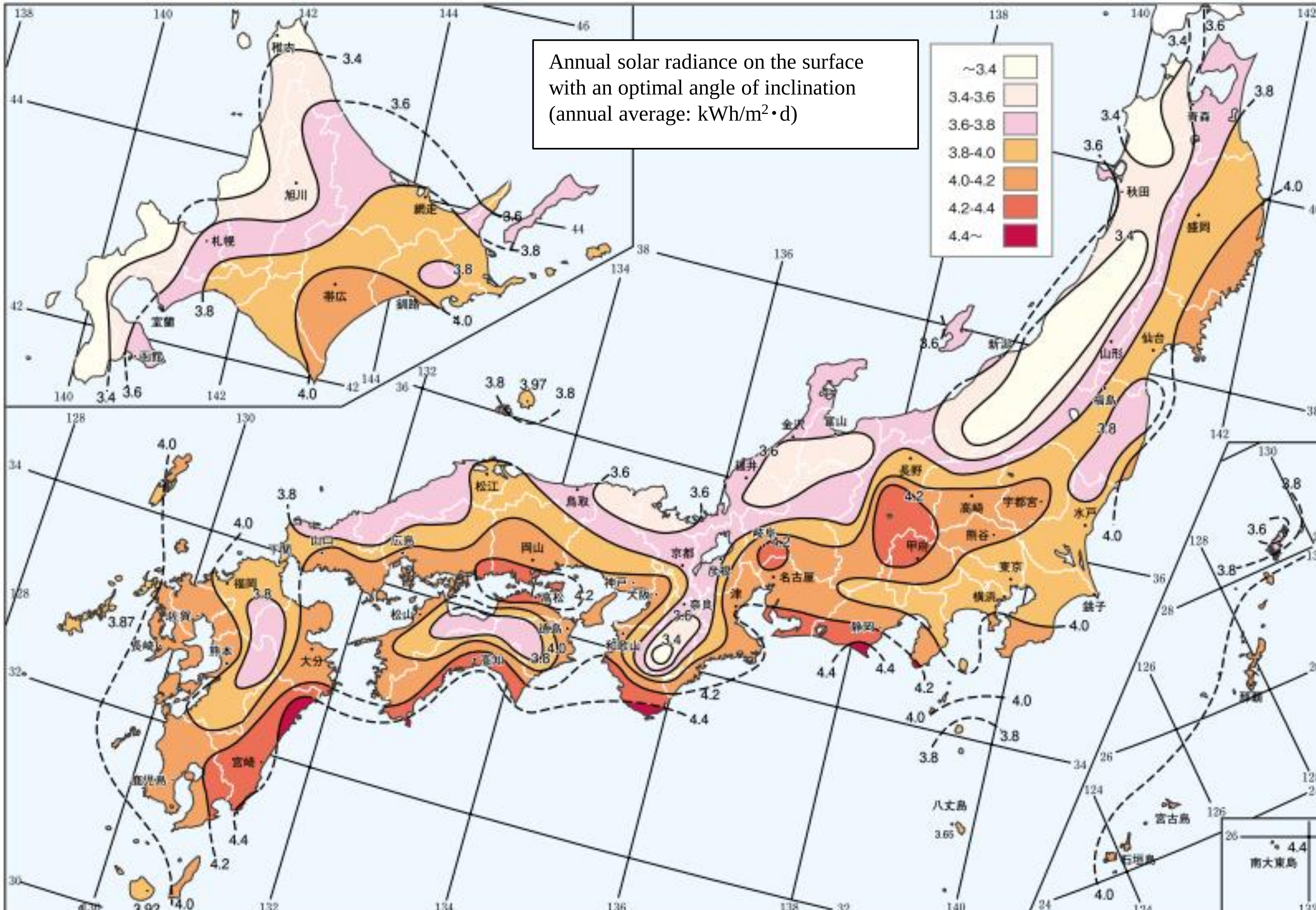


Fig. Annual solar radiance on the surface with an optimal angle of inclination in Japan (kWh/m^2・d)

Source: NEDO, Guidelines for PV Power Generation Field Test Project (Design, Construction and System), 2010

Wind Power Generation

1. Assumptions

Capacity Factor	Required Area	Turbine System and Construction Cost	Road Improvement Cost*	Transmission Line (66 kV) Construction Cost*	Survey and Design Cost*	FIT Purchase Price	FIT Purchase Period
Depends on wind velocity 6.5 m/s → 24% 7.5 m/s → 31%	10,000 kW/km^2	¥250,000/kW	¥8.5 million/km (assumed linear distance x 2)	¥5.5 million/km	¥46.7 million (20,000 kW power plant assumed)	¥15 or 20/kWh	15 or 20 years

* For offshore wind power generation, the foundations/floating platform cost, transmission line construction cost and survey and design cost were separately estimated from those in the table based on the assumption that these costs would vary depending on the water depth.

2. Estimation Results

The estimation results suggest <u>an extremely large introduction potential</u> of wind power generation. However, a strong geographical bias exists as shown on the map on the following slide. In the case of the Hokkaido and Tohoku Regions for example, the estimated introduction potential exceeds the existing power supply capacity (7.42 million kW for Hokkaido and 16.55 million kW for Tohoko). To determine the short to medium-term introduction potential, <u>it is necessary to examine various factors, including the limitation of the inter-regional system linkage capacity</u>. These factors were not examined this time.

Installed Capacity (million kW)	Abundance	Introduction Potential	FIT Scenario	FIT*1 + Technological Innovation*1 Scenario	FIT＋ Subsidy*2	FIT + Technological Innovation + Subsidy*3
Onshore	1,300	280	24 ~ 140	270	130 ~ 260	280
Offshore	—	1,600	0 ~ 3	140	0.3 ~ 330	1,200
Total	—	1,900	24 ~ 140	410	130 ~ 590	1,500

*1 The estimation assumed a reduction of the wind turbine system and installation cost by half and a reduction of the civil engineering cost by 1/5, a purchase price of ¥20/kWh and a purchase period of 15 years.

*2 A subsidy to cover one-third of the project cost was assumed and the various FIT purchase prices in the earlier table were used.

*3 A subsidy to cover one-third of the project cost was additionally assumed for the FIT + Technological Innovation Scenario.

3. Geographical Distribution

As shown on these maps, there is a strong geographical bias in the distribution of introduction potential. The Tohoku Region has many sites with excellent commercial viability.

Area	Introduction Potential	FIT Scenario
Tohoku Electric Power Area	300 million kW	9.8 ~ 40 million kW
Tokyo Electric Power Area	83 million kW	0.25 ~ 2 million kW

The introduction potential in the table can be translated to the generated energy listed below assuming a capacity factor of 24%.

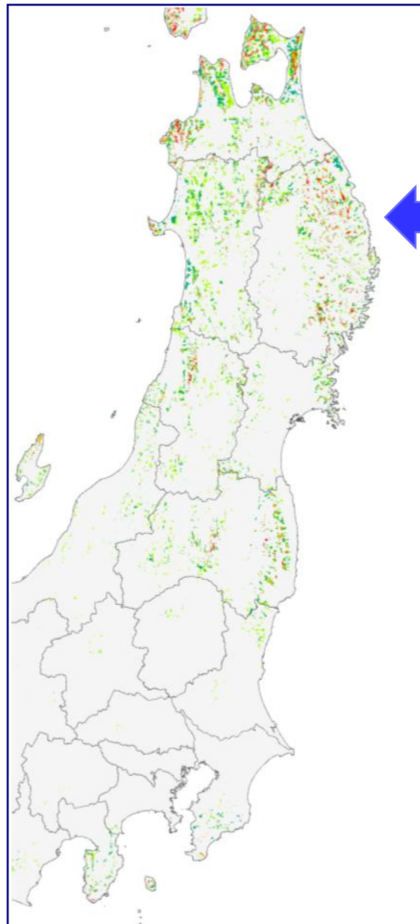
Tohoku Electric Power Area: 630 billion kWh/year
Tokyo Electric Power Area: 180 billion kWh/year

In the case of the FIT Scenario, the assumed capacity factor of 24% produces the following generated energy.

Tohoku Electric Power Area: 21 ~ 83 billion kWh/year

Tokyo Electric Power Area: 0.53 ~ 4.2 billion kWh/year

As mentioned earlier, to determine the short to medium-term probable introduction amount, it is necessary to examine the limitation of the inter-regional system linkage capacity and other factors.



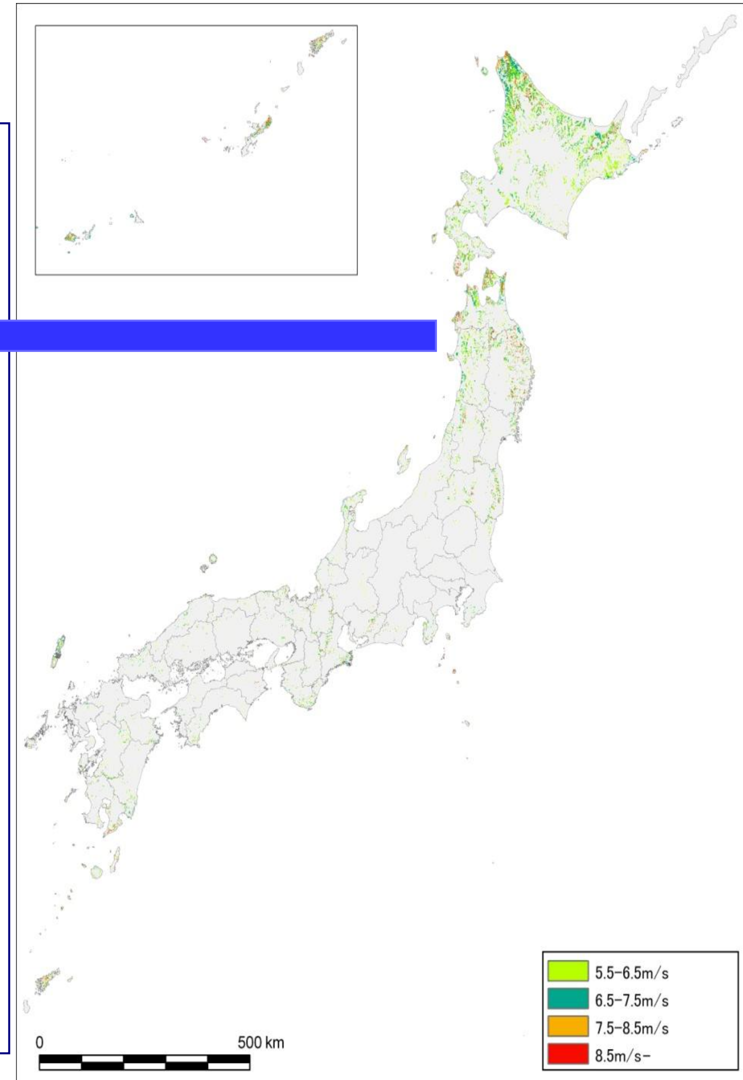


Fig. Distribution of Introduction Potential of Onshore Wind Power Generation

Small and Medium-Scale Hydropower Generation (Installed Capacity < 30,000kW)

1. Assumptions

Capacity Factor	Generation System Cost	Road Improvement Cost	Transmission Line (LV) Construction Cost	FIT Purchase Price	FIT Purchase Period
65%	Use of the calculation method listed in the NEDO’s Small and Medium-Scale Hydropower Generation Handbook	¥5 million/km (linear distance x 2 assumed)	¥5 million/km	¥15 or 20/kWh	15 or 20 years

2. Estimation Results

The estimated probable introduction amount and other values for small and medium-scale hydropower generation are shown in the table below. In this estimation, it was assumed that water would be taken at the upper end of a certain section (called a “link”) of a river or agricultural canal and discharged at the lower end of the link. To avoid any adverse impacts on existing water use, a section where the rate of discharge would be the lowest was selected for the link along with dates with a high intake level. It must be noted that consideration of the maintenance discharge in addition to these selection criteria has likely put the estimation results on the conservative side.

Moreover, work related to hydropower generation may be conducted for purposes other than actual power generation. As such, the simulation results for all scenarios are even more conservative. These estimates must, therefore, only be used for reference purposes and are placed in brackets in the table.

Installed Capacity (million kW)	Abundance	Introduction Potential	FIT Scenario	FIT*1 + Technological Innovation*1 Scenario	FIT＋ Subsidy*2	FIT + Technological Innovation + Subsidy*3
Rivers	17	14	(0.9 ~ 2.8)	(4)	(2.4 ~ 5.2)	(7.1)
Agricultural Canals	0.32	0.3	(0.16 ~ 0.2)	(0.2)	(0.22 ~ 0.26)	(0.29)
Water Supply, Sewerage and Water for Industrial Use*4	0.18	0.16				
Total	17	14	(1.1 ~ 3)	(4.3)	(2.7 ~ 5.4)	(7.4)

*1 The estimation assumed a reduction of the generation system cost by half, reduction of the civil engineering cost by 1/5, a purchase price of ¥20/kWh and a purchase period of 15 years.

*2 A subsidy to cover one-third of the project cost was assumed and the various FIT purchase prices in the earlier table were used.

*3 A subsidy to cover one-third of the project cost was additionally assumed for the FIT + Technological Innovation Scenario.

*4 These figures are quoted from the FY 2009 Study. The probable introduction amount was not estimated for any of the scenarios.

3. Geographical Distribution

As the introduction potential is high in the Tohoku and Kanto Electric Power Areas, it is essential to conduct field surveys, primarily focusing on those river systems.

Area	Introduction Potential
Tohoku Electric Power Area	4.3 million kW
Tokyo Electric Power Area	2.1 million kW

This introduction potential can be translated into the following generated energy.

Tohoku Electric Power Area: 24 billion kWh/year

Tokyo Electric Power Area: 12 billion kWh/year

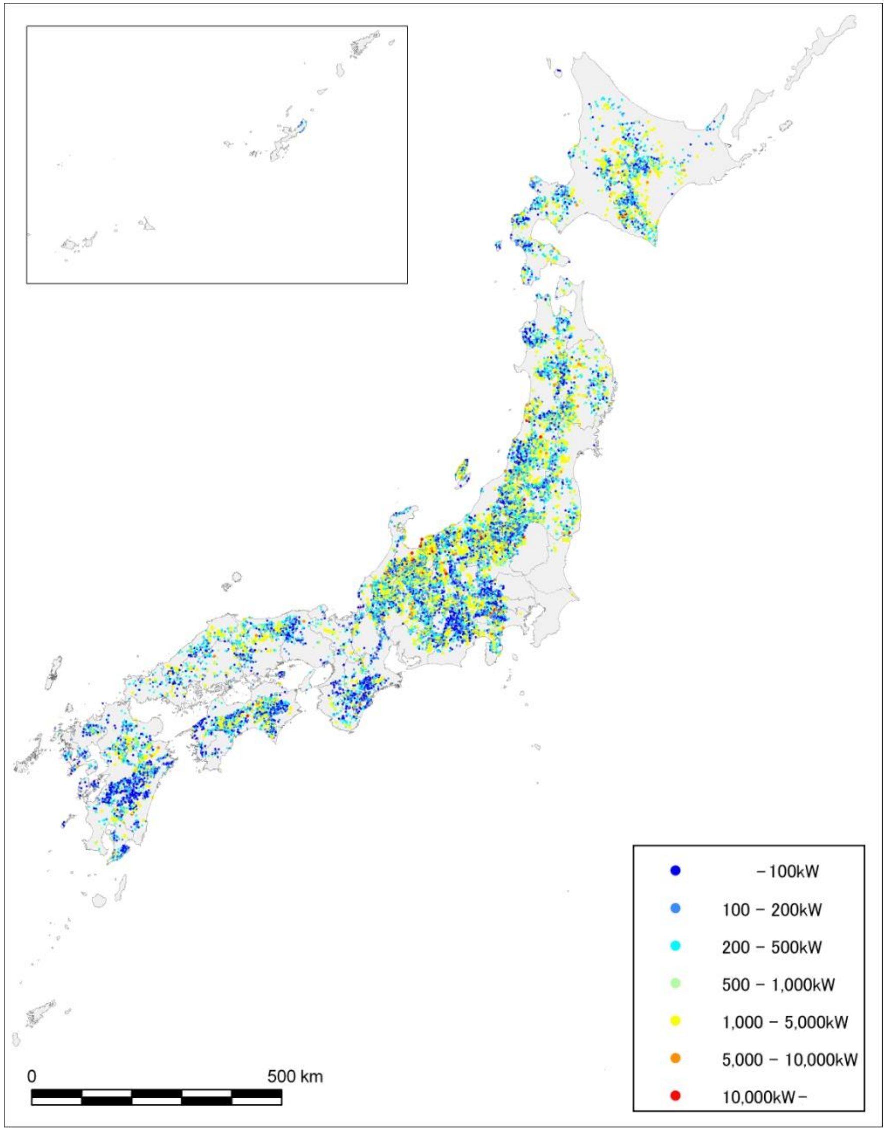


Fig. Distribution of Introduction Potential of Small and Medium-Scale Hydropower Generation (Rivers)

Geothermal Power Generation

1. Assumptions

Capacity Factor	Extended Reach	Geothermal Resources Survey	Production and Return Well Construction	Pipeline Installation	Generating Facility	Land Acquisition and Preparation	FIT Purchase Price	FIT Purchase Period
< 5,000 kW: 70% > 20,000 kW: 80% Hot spring: 90%	1.5 km*1	¥3.5 billion*2	¥13.1 billion*2	¥6.1 billion*2	¥200,000/ kW	¥2.3 billion*2	¥15 or 20/kWh	15 or 20 years

*1 This was not considered in the FY 2009 Study.

*2 These are for the case of 50,000 kW and other values were used to correspond to the estimated generating capacity at each site.

2. Estimation Results

The estimated probable introduction amounts and other values for geothermal power generation are shown in the table below. For this estimation, the geothermal density distribution map prepared by Muraoka of the AIST and others were used. When data for micro river systems in individual areas is required, the more detailed evaluation of resources will be required.

For hot spring power generation, Muraoka et.al. estimated using hot spring data produced by Kanahara et. al. This type of power generation is essentially included in the category of hydrothermal resources with a temperature range of 53°C ~ 150°C. However, as it uses natural hot spring sites or developed hot spring sites, the commercial viability data is quite different from the ordinary development of hydrothermal resources. As such, the probable introduction amount for hot spring power generation is separately listed in the table for the development of hydrothermal resources with a temperature range of 53°C ~ 150°C.

Installed Capacity (million kW)	Abundance	Introduction Potential	FIT Scenario	FIT*1 + Technological Innovation Scenario*1	FIT＋ Subsidy*2	FIT + Technological Innovation + Subsidy*3
Development of Hydrothermal Resources (150℃～)	24	6.4	0.51 ~ 4.1	4.5	1.5 ~ 4.3	4.6
(53～150℃)	9.6	7.8	0	0	0	0
Hot Spring Power Generation*4	(0.72)	(0.72)	0.57 ~ 0.68	0.72		
Total	33	14	1.1 ~ 4.8	5.2	1.5 ~ 4.3	4.6

*1 The estimation assumed a reduction of both the generating system cost and the civil engineering cost by 1/5, a purchase price of ¥20/kWh and a purchase period of 15 years. For hot spring power generation, a reduction of the generating system cost by half was assumed.

*2 A subsidy to cover the total cost of surveying and drilling was assumed and the various FIT purchase prices in the earlier table were used.

*3 A subsidy to cover the entire cost of surveying and drilling was additionally assumed for the FIT + Technological Innovation Scenario.

*4 The current prevailing cost of hot spring power generation is said to be ¥120 million for a 50 kW system (¥2.4 million/kW). Given the fact that some business operators are aiming at achieving a cost of ¥0.25 ~ 0.3 million/kW (for a system of 50 kW or larger) for the start of commercial operation in FY 2011, a power generation cost of ¥0.5 million/kW was used here.

3. Geographical Distribution

As shown on the map, there is a strong geographical bias in the distribution of the introduction potential. The Tohoku Region has many sites with excellent commercial viability.

Area	Introduction Potential	FIT Scenario
Tohoku Electric Power Area	3.5 million kW	0.2 ~ 1 million kW
Tokyo Electric Power Area	1.4 million kW	0 ~ 0.22 million kW

The introduction potential in the table can be translated to the generated energy listed below assuming a capacity factor of 75%.
Tohoku Electric Power Area: 23 billion kWh/year
Tokyo Electric Power Area: 9.3 billion kWh/year

In the case of the FIT Scenario, the assumed capacity factor of 75% produces the following generated energy.
Tohoku Electric Power Area: 1.3 ~ 6.8 billion kWh/year
Tokyo Electric Power Area: 0 ~ 1.4 billion kWh/year

In these areas, there are many hot spring sites where the temperature and quantity of hot water are suitable for hot spring power generation.

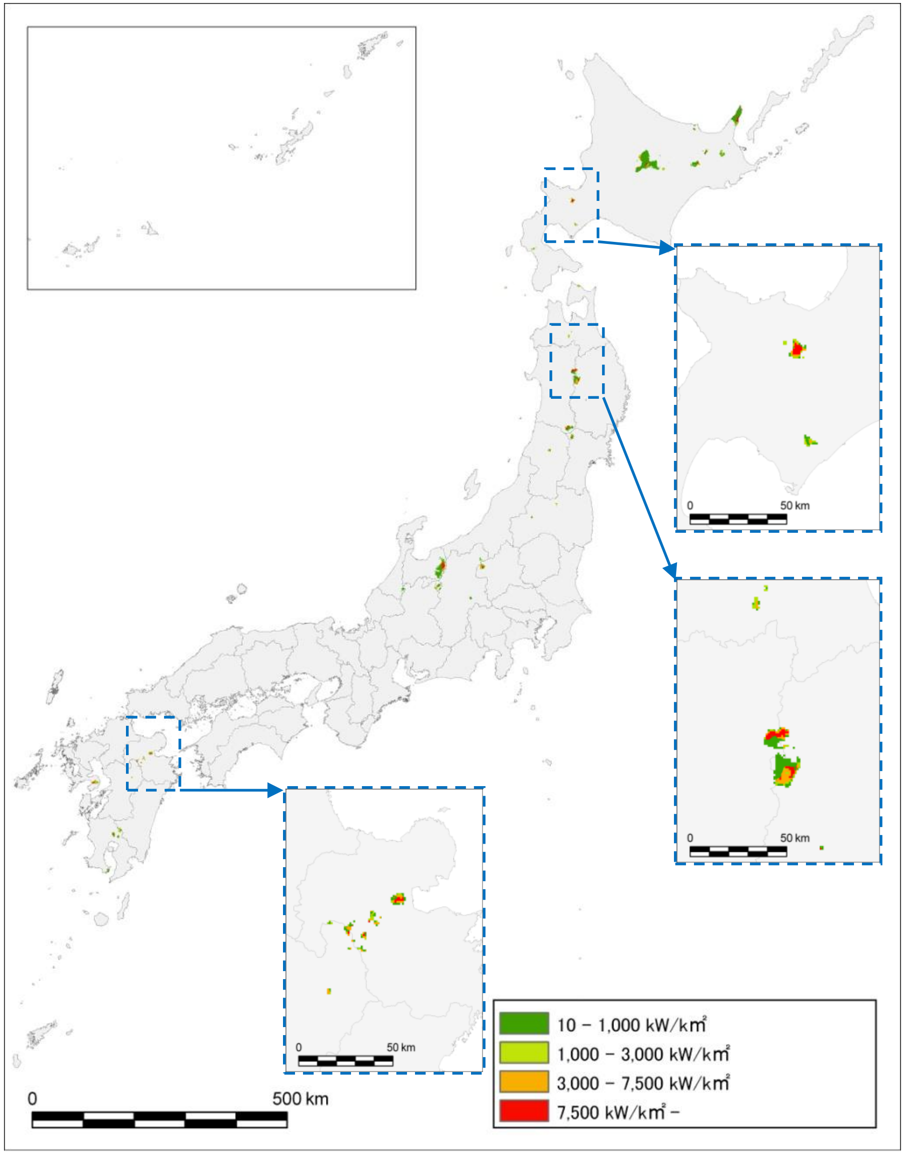


Fig. Distribution of Introduction Potential of Geothermal Power Generation (Hydrothermal Resources, over 150℃)

References

- Statistics on Power Generation (FY 2009)

	Installed Capacity (million kW)	Power Demand (billion kWh/year)
Nationwide	203.97	858.5
Tohoku Electric Power Area	16.55	79.0
Tokyo Electric Power Area	64.49	280.2
Photovoltaic (PV) Power Generation (including Housing; Nationwide)	2.63	-
Wind Power Generation (Nationwide)	2.19	—
Small and Medium-Scale Hydropower Generation (Nationwide)	9.55	—
Geothermal Power Generation (Nationwide)	0.53	—

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