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Renewable Energy Policies and the Energy Transition in Japan

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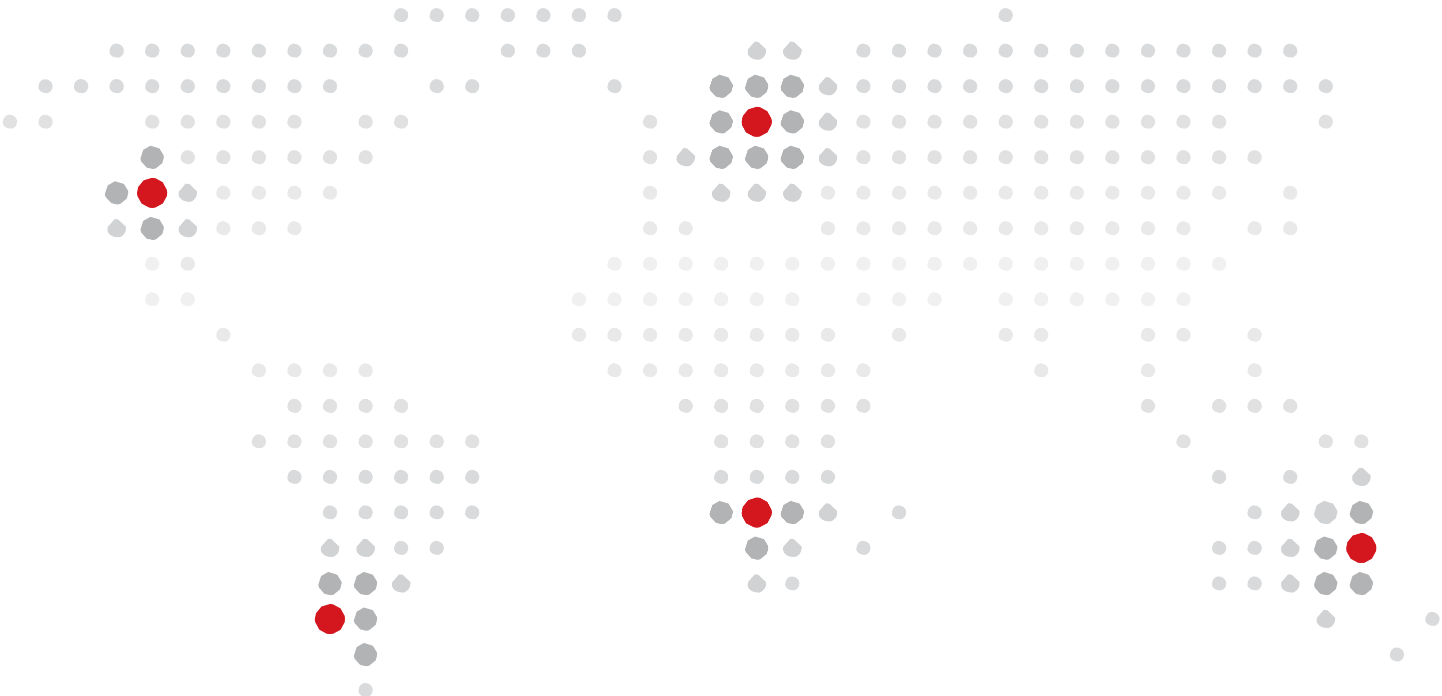

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Foreword

Tackling climate change will not be possible without a significant contribution from Asia. Although most Asian countries currently have relatively low levels of per capita greenhouse gas emissions and historically Asia's contribution to global climate change has been limited, Asia now contributes already substantially to global greenhouse gas emissions. This is both because of the region's large population and relatively robust economic growth. According to economic forecasts, Asia's share of global greenhouse gas emissions will grow dramatically in the coming decades. At the same time, millions of people in the region will be affected by climate change. Serious environmental pollution has resulted from the burning of fossil fuels. Health risks due to air pollution already affect millions of Asians.

There are signs of growing interest in renewable energies in many parts of Asia out of energy security and environmental concerns as well as to bring electricity to energy poor regions. With dropping renewable energy prices there is growing investment in the sector in Asia. This makes it increasingly possible to talk about the beginning of energy transitions, which are occurring in the region. Greater use of renewable energy may lead to more socially and environmentally just energy structures. We still know, however, little about the actual social and political contributions, costs and implications of renewable energy expansion.

The Friedrich-Ebert-Stiftung decided to examine these questions with a series of country studies in Asia. The studies address the political and social factors that drive, but also hamper socially just energy transitions. To this end, authors from China, India, Indonesia, Japan, the Philippines, the Republic of Korea (South Korea), Thailand, and Vietnam worked together with Miranda Schreurs, Professor of Environmental and Climate Policy in the Bavarian School of Public Policy, Technical University of Munich to provide an in-depth analysis of the situation in their respective countries.

The country case studies provide insights into the status of climate and energy policies, their socio-economic implications and the actors involved in developing and implementing those policies. Two of the important questions that motivated this comparative study were whether renewable energy development was contributing to a more socially just energy structure and which factors foster and impede political acceptance of renewable energy development.

In the case of Japan, the Fukushima nuclear accident occurred in March 2011 led to a fundamental revision of the Japanese government's energy policies. Countermeasures taken against climate change in Japan historically depended on nuclear power plants as nuclear energy has been viewed positively by most of the society prior to the Fukushima nuclear accident. After the accident, the share of nuclear energy dropped to zero at once. Nevertheless, GHG emissions have been decreasing because of renewable energy development and energy saving measures.

This report outlines Japan's renewable energy policy and the state of the energy transition in the country. It includes current prospects for climate change policy and the status of electrical power systems including nuclear power issues, status sand support policy of renewable energy as well as social issues and political feasibility.
Furthermore, long-term vision and scenarios for promoting an energy transition are discussed, including community power and credit systems. Finally, policy recommendations are proposed for promoting energy transition in Japan.

By highlighting the opportunities and providing specific recommendations to achieve a socially just energy transition, we hope that this study can help to contribute to the debate on a transition towards a low carbon future in Japan.

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1. **Background**

1.1 Current status and prospects for climate change policy

In Japan, the emissions of Green House Gases (GHG) in Fiscal Year (FY) 2015 were about 4% higher than in FY 1990. This trend is problematic considering that the target for Japan's Nationally Determined Contribution (NDC) for FY 2030, submitted to the United Nations in July 2015, is a reduction of 18% as compared to FY 1990.[1] This GHG reduction target was calculated based on projections from "the long-term energy supply and demand outlook" which was determined by the Ministry of Economy, Trade and Industry (METI) in May 2015.[2] Based on the "Strategic Energy Plan" in 2014, it was assumed that in FY 2030 the share of nuclear power generation would be around 20 to 22% and the share of renewable energy power generation around 22 to 24% (the "Power source mix"), as shown in Fig. 1.

This power source mix means that the total share of non-fossil fuel power generation should be 44% in FY2030. In the light of this target, METI has requested all retail electricity companies to target a non-fossil power supply share (nuclear power plus renewable energy) in FY 2030 of 44% or more. The intention is for this to be done under the planned Act on Sophisticated Methods of Energy Supply Structure.[3] For this purpose, a new private organization was established by the industry of large power supply companies to cooperate in order to achieve the target by FY2030.[4] Additionally, METI plans to make a new wholesale market for non-fossil electricity, including both nuclear and renewable energy. However, since compliance with this Act is voluntary, the target share of non-fossil power generation will be difficult to achieve without increasing the share of renewable energy beyond the target, as there is no possibility of achieving the nuclear target under the difficult situation facing nuclear energy in Japan.

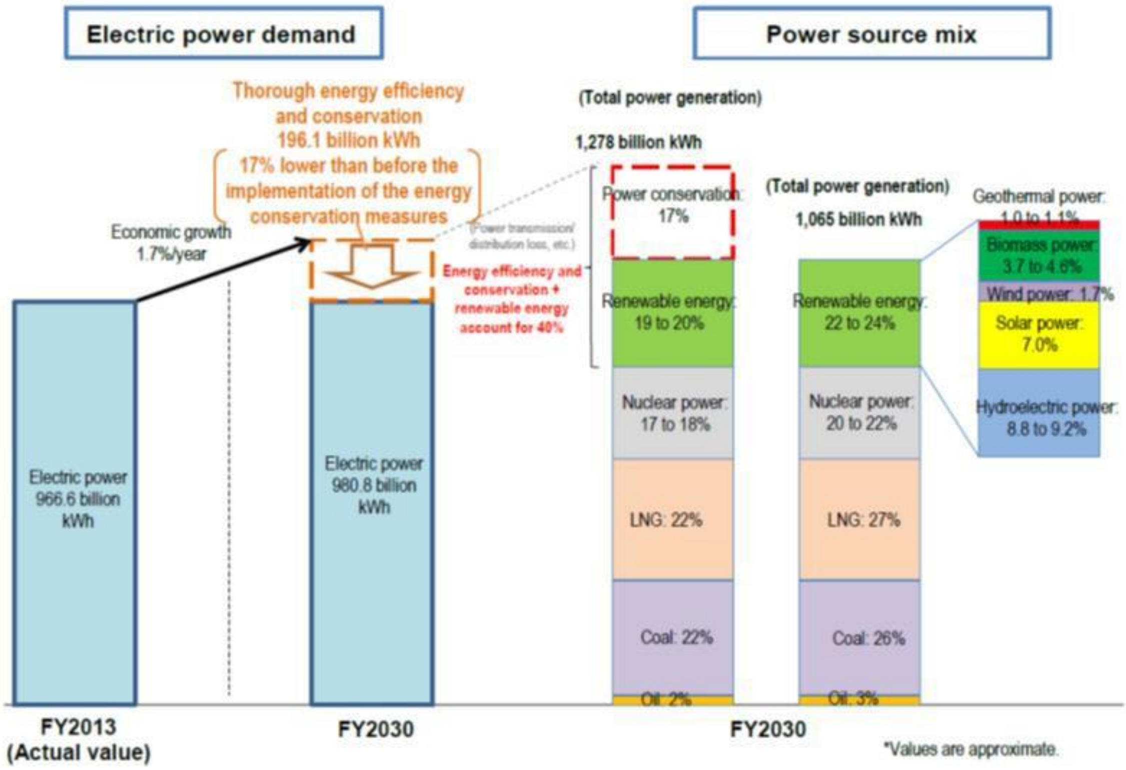

Fig. 1. Power source mix in the long-term energy supply and demand outlook of FY2030, by METI

Countermeasures taken against climate change in Japan historically depended on nuclear power plants, as nuclear energy was viewed positively by most of society prior to the Fukushima nuclear accident. After the accident, the share of nuclear energy dropped to zero in FY2014, and Japan still obtained less than 2% of its electricity from nuclear power in FY2016. Nevertheless, GHG emissions have been decreasing since FY2014 because of renewable energy development and an established system for energy saving.

Japan had made some progress in reducing emissions before the Fukushima nuclear accident. Japan's Kyoto Protocol target was a 6% reduction in GHG emissions (defined as the five-year average of 2008 to 2012 emission levels, compared to 1990 emission levels). Japan's GHG emissions average for those five years was a 1.4% increase over the base year. However, Japan exceeded its target, achieving an 8.4% reduction compared to the base year with a combination of domestic emissions reductions and credits obtained through the Clean Development Mechanism (CDM) of 5.9%, and domestic forest coverage (3.9%).

1.2 Status of the electrical power system after the Fukushima accident

The accident at the Tokyo Electric Power Company (TEPCO) F1-NPP occurred in March 2011. It led to a fundamental revision of the Japanese government's energy policies. At that time the country was already under international pressure regarding its climate change policies. As an industrialized country, Japan was called upon to accept greater responsibility for climate change mitigation and adaptation, especially by developing countries. The government decided to focus on nuclear energy, as nuclear power generation had in the past offered a reliable path for GHG emission reduction. The Japanese government and dominant industry players still tend to stick to medium-term targets to preserve nuclear power plants. Government and industrial sectors fear that serious countermeasures for climate change will stagnate if only decentralized renewable energy and energy conservation are relied upon. However, many citizens, especially members of environmental NGOs, are uneasy about a return to nuclear energy and argue that such governmental actions could slow progress on renewable energy development.

After the Fukushima reactors exploded, Japan's remaining nuclear reactors were shut down to await the regulatory inspection conducted by the Nuclear Regulation Authority (NRA) under new nuclear safety regulations.[5] The NRA was established after the Fukushima accident and in accordance with the Act for Establishment of the Nuclear Regulation Authority, released in 2012. There were 53 operable reactors in 2011. After the accident, nine reactors were permanently retired by the utilities, plus the reactors of F1-NPP (those damaged in the accident in March 2011). There are now 43 operable nuclear reactors, but only five of them have been restarted after receiving NRA permission. Another seven reactors are awaiting local government permission as of August 2017. The NRA is continuing its inspection of 14 reactors, while the remaining 17 reactors have not been inspected yet.[6]

The former administration of Naoto Kan started a feed-in-tariff (FIT) scheme for all renewable energy technologies in July 2012. Renewable energy capacity, especially photovoltaic, has grown rapidly as a result. Still, the situation is challenging for other renewable energies such as wind, biomass, geothermal, and small hydro. Earlier targets to reduce GHG emissions have been lowered, and today, Japan's GHG emissions are considerably higher than they were in 1990. Initially, liquid natural gas (LNG) and mostly coal were imported to meet the share of electricity generation that nuclear energy had previously supplied, as renewables and energy savings were unable to fully cover the electricity production loss. There is still much uncertainty in the system, but also many possibilities for change and for moving towards a system with a far higher share of renewable energy.

2. Case study of renewable energy policy in Japan

2.1 Position of renewable energy in Japan

The share of power generated from renewable energy, including large hydro, was steady from the 1990s until FY 2010 at around the 10% level, as shown in Fig. 2. As a result of the increasing capacity of solar photovoltaic (PV), mainly supported through the FIT scheme, the share of renewable energy in the total power generation reached about 14.8% in FY 2016, as shown in Fig. 3 and Table 1. In contrast, after the Fukushima accident, the share of nuclear power generation fell below 10% in FY 2011 and was less than 2% in FY 2016. This means that nowadays more electricity is generated from renewable energy than from nuclear energy. The share of electricity generated by fossil fuel-based power generation has exceeded 85% since FY 2012, although due to the increase in renewable energy since then, there has been a decreasing trend in fossil-fuel power generation and CO_2 emissions since 2013, as shown in Fig. 4. From FY 2013 on there appears to be a decoupling in progress: Gross Domestic Product (GDP) has gradually risen while electricity demand and CO_2 emissions have dropped. This is considered to be caused by the combined contributions of energy saving and a growing role for renewable energy.

Table 1. Trends of the power generation mix in Japan (Source: METI and ISEP)

Unit [TWh (%)]	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Fossil Fuel	759 (65.4)	895 (80.4)	975 (88.5)	975 (88.3)	939 (87.7)	870 (84.5)	872 (83.5)
Nuclear	288 (24.8)	102 (9.1)	16 (1.5)	9 (0.9)	0 (0.0)	9 (0.9)	17 (1.7)
Renewables	114 (9.8)	117 (10.5)	111 (10.1)	120 (11.0)	132 (12.5)	150 (14.5)	155 (14.8)
Total	1,116 (100)	1,113 (100)	1,101 (100)	1,104 (100)	1,071 (100)	1,029 (100)	1,044 (100)
Hydro	91 (7.8)	92 (8.2)	84 (7.6)	85 (7.8)	86 (8.2)	91 (8.9)	78 (7.5)
Solar PV	4 (0.4)	6 (0.5)	8 (0.7)	15 (1.4)	22 (2.1)	34 (3.3)	50 (4.8)
Wind	4 (0.4)	5 (0.4)	5 (0.4)	5 (0.5)	5 (0.5)	5 (0.5)	6 (0.6)
Biomass	12 (1.0)	12 (1.1)	12 (1.1)	13 (1.1)	16 (1.5)	16 (1.6)	18 (1.7)
Geothermal	3 (0.2)	3 (0.2)	3 (0.2)	3 (0.2)	3 (0.2)	3 (0.2)	2 (0.2)

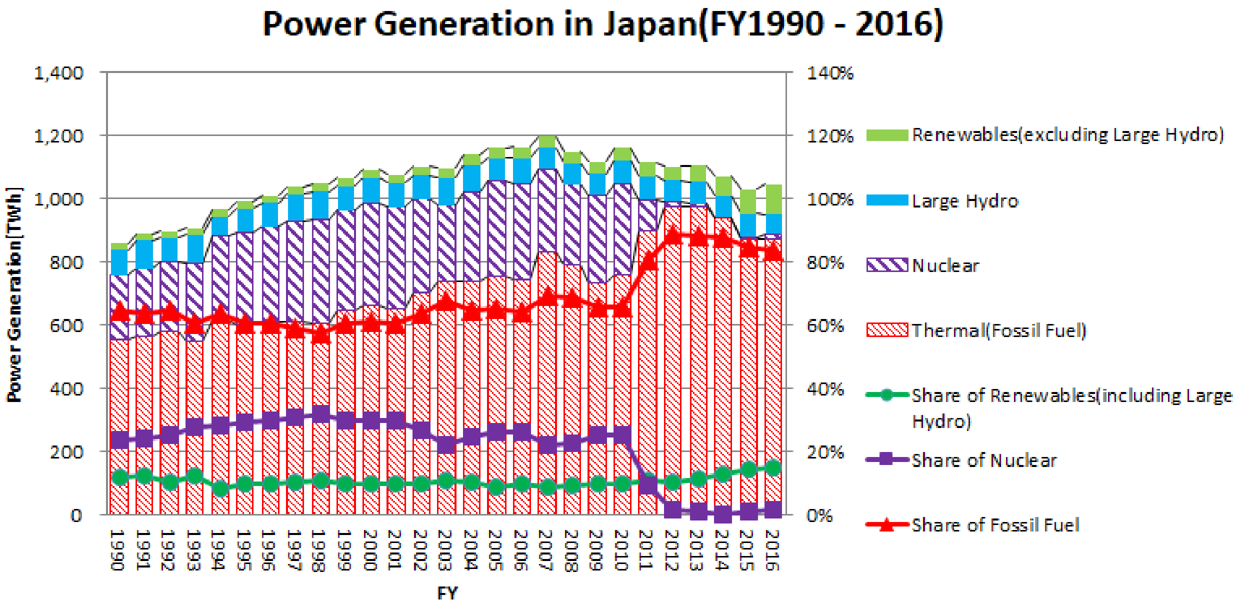

Fig. 2. Trends of Power Generation in Japan (Source: ISEP)

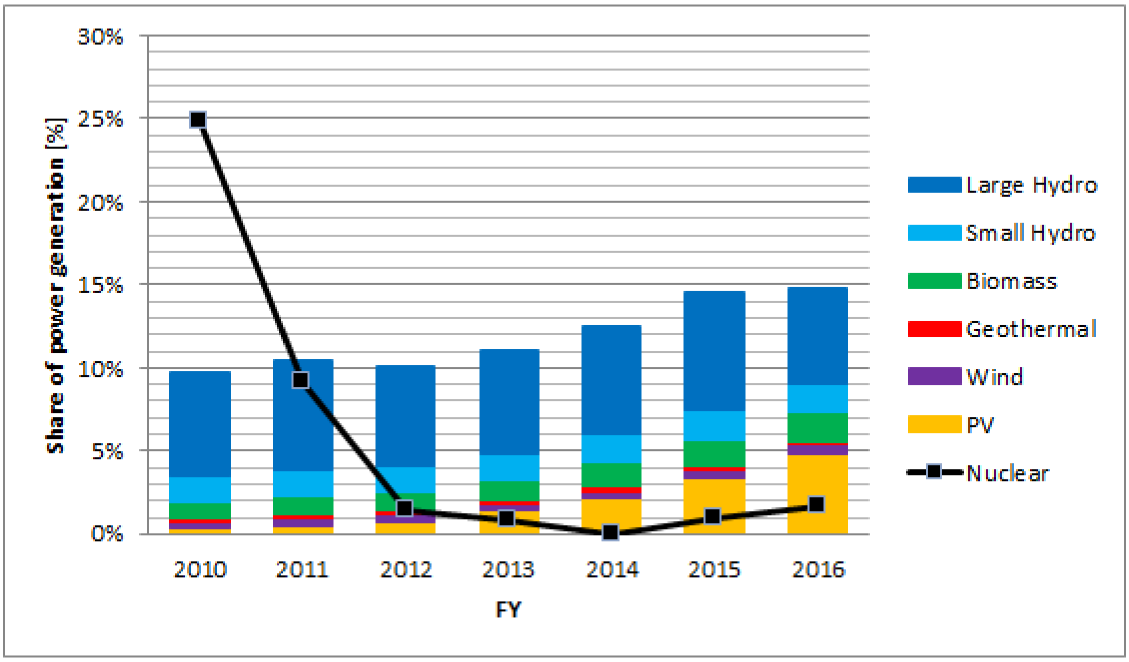

Fig. 3. Trends of Renewable Energy Power Generation in Japan (Source: ISEP)

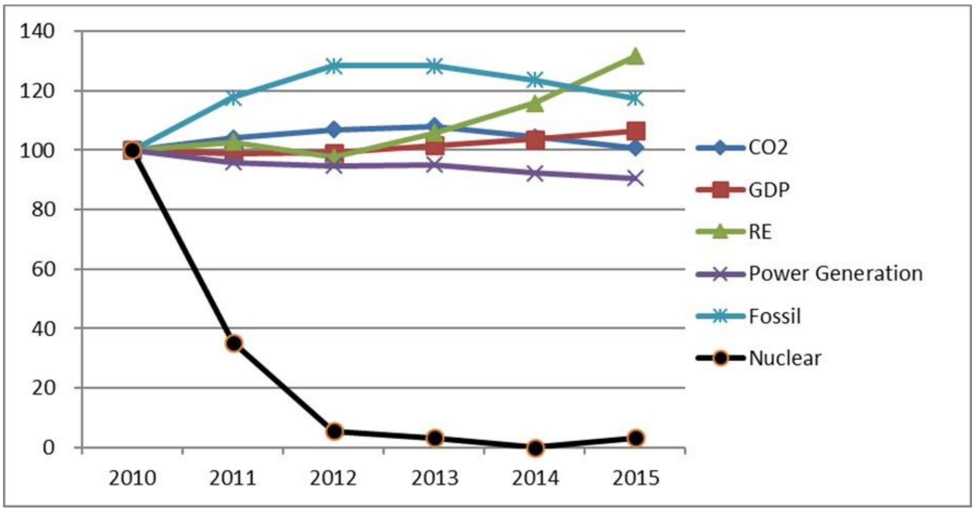

Fig. 4. Energy Transition after Fukushima NPP Accident in Japan (Source: ISEP)

2.2 State of energy mix and support policies of renewable energy

At the end of FY 2016, the estimated cumulative capacity of renewable energy power generation facilities was about 50.4 GW, excluding large-scale hydropower exceeding 10 MW. This was an increase of about 16% over the previous year, as shown in Fig. 5 and Table 2. Solar PV has played a major role since FY 2013, reaching 39 GW at the end of FY 2016. Cumulative solar PV capacity was about 19% larger than the previous year. Compared with FY 2010, the period before the introduction of the FIT system, the total capacity of renewable energy excluding large hydropower had increased by about 3.7 times, but during the same period the capacity of solar PV increased by 10 times. Aside from solar PV, the capacity of wind power increased 1.4 times, and biomass increased 1.2 times. The development of geothermal and small hydropower remained stagnant.

Table 2. Trends of capacity of renewable energy in Japan (Source: METI and ISEP)

Unit [GW]	1990	1995	2000	2005	2010	2012	2014	2015	2016
Solar*	0.03	0.07	0.4	1.5	3.9	7.3	23.7	32.9	39.0
Wind	0.0	0.01	0.1	1.1	2.5	2.6	2.9	3.1	3.4
Geothermal	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Small Hydro**	3.1	3.1	3.2	3.2	3.2	3.3	3.3	3.3	3.3
Biomass***	0.5	0.8	1.6	2.6	3.3	3.3	3.5	3.8	4.1
Total	3.8	4.5	5.8	8.9	13.4	17.0	33.9	43.6	50.4

*Capacity of Solar PV is AC (grid connection) based.

**Capacity of Small Hydro is 10 MW and under.

*** Capacity of Biomass excludes co-firing with coal.

In FY 2016, taking into account the contribution from general electric utilities, other power generation companies, and private power generation, the total volume of generated electricity in Japan was estimated to be 1044 TWh. In FY 2016 the share of renewable energy, including large hydro, in total power generation (including non-utility-based generation) was estimated at 14.8% as shown in Table 1. Solar PV accounted for about 4.8% of total electricity generation, second only to hydropower generation (7.5%), as shown in Fig. 6. The share of biomass power generation increased to about 1.7%, triggered by good incentives for woody biomass under the FIT scheme. In contrast, the share of wind power generation stood at only 0.6%, one-eighth the level of solar PV. Wind power faces several barriers such as difficulties with grid connection and prolonged environmental impact assessments. Thus, despite the large potential for wind power generation in Japan, the share of wind power in the electricity mix remains limited. Similarly, the share of geothermal power generation is only 0.2%. This is caused by the long-term development process for new plants started after the Fukushima accident, and a decrease in the amount of generated steam due to a lack of maintenance of steam wells and limited new well development.

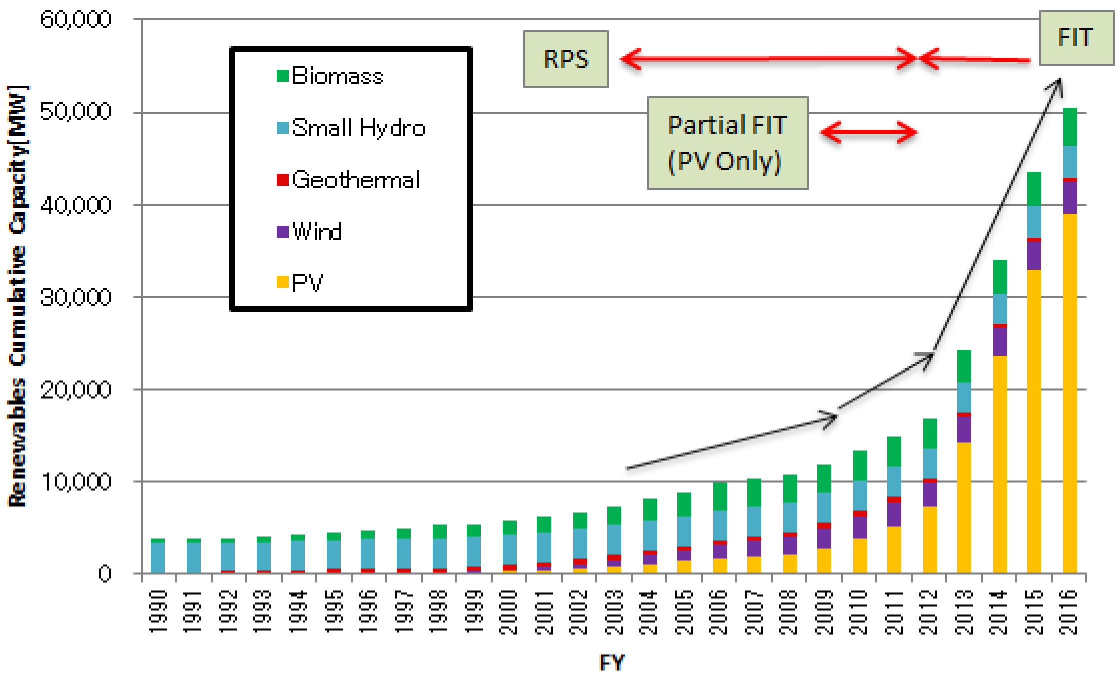

Fig. 5. Trends of Renewable Energy Capacity in Japan (Source: ISEP)

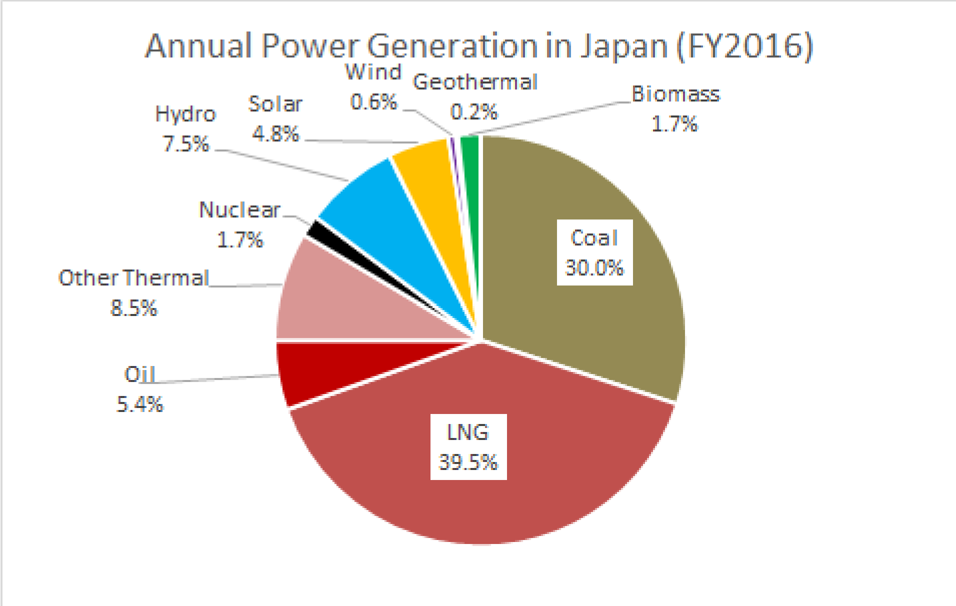

Fig. 6. Balance of power generation in FY 2016 in Japan (Source: METI, ISEP)

The cumulative capacity of solar PV in Japan reached 42 GW (direct current output-based capacity of solar panel) at the end of 2016. In the same year, about 8.6 GW of solar PV capacity was added. As a result of this large increase in solar capacity, Japan's cumulative capacity of solar PV surpassed that of Germany (41 GW) by the end of 2016, as shown in Fig. 7. While Germany installed only 1.2 GW of PV in 2016, Japan installed 8.6 GW. That means that in Germany, additional capacity of PV installation peaked in 2013. Basically, most of the solar PV facilities introduced before the FIT system in Japan were residential-type systems with a capacity of less than 10 kW. However, by the end of FY 2016, solar PV capacity supported by the FIT system reached 39 GW (alternating current (AC)-based capacity, including transition to FIT from Renewable Portfolio Standard (RPS)), of which the capacity share of residential PV under 10 kW fell to 25%, as shown in Table 3. Most PV capacity (75%) came from non-residential use with a capacity of more than 10 kW. The share of large-scale solar projects with capacities exceeding 1 MW reached nearly 30%. In FY 2016 just 6.2 GW of solar PV capacity was connected to the grid; nevertheless, 9.2 GW of PV capacity was connected in FY 2015, of which the installed residential solar energy is only 0.8 GW and solar PV for non-residential use is 5.4 GW.

Table 3. Trends of Cumulative Solar PV Capacity (Source: METI, ISEP)

(Unit: GW)	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
Under 10 kW	4.7	5.7	7.0	7.8	8.6	9.4
Over 10 kW, under 1 MW	0.2	0.8	4.6	10.0	14.7	17.7
Over 1 MW	0.02	0.2	2.1	5.2	8.9	11.4
Total	5.0	6.6	13.7	23.1	32.2	38.5
Share of residential (under 10kW)	95%	85%	51%	34%	27%	25%

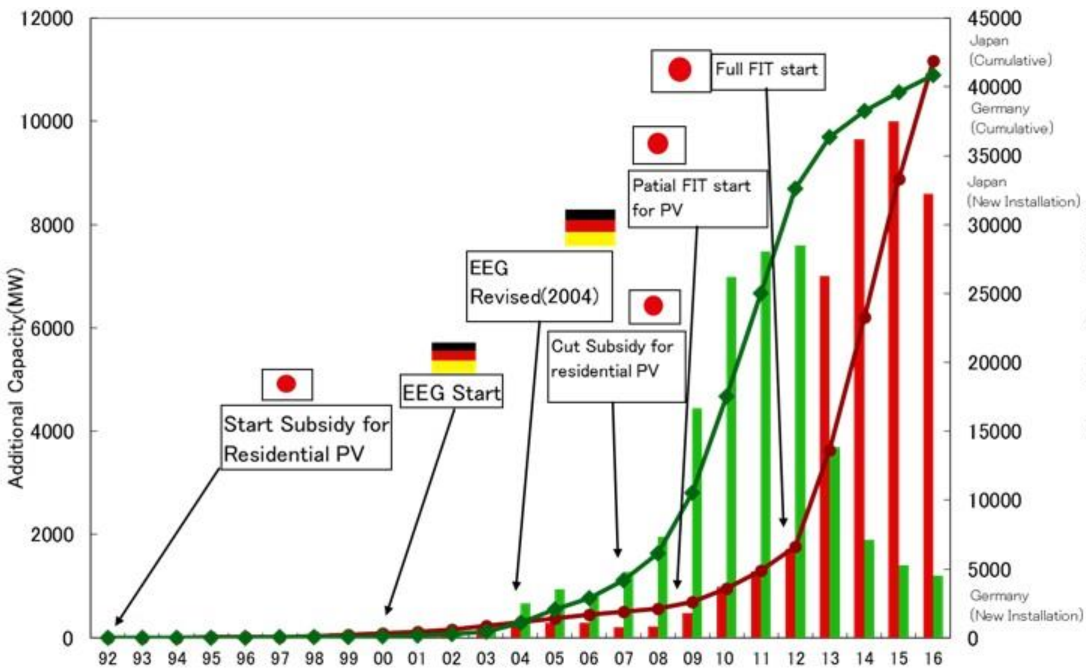

Fig. 7. Trends of Solar PV in Japan and Germany (Source: IRENA)

At the end of FY 2015, wind power generation reached a cumulative installed capacity of 3.17 GW.[7] The annual injection volume was about 220 MW in FY 2014 but it rose to 250 MW in FY 2015, as shown in Fig. 8. By the end of FY 2016 the cumulative installed capacity had reached 3.4 GW, but the annual installed amount was only 300 MW. The full-scale integration of wind power generation still takes time due to prolonged legal environmental impact assessment (EIA) procedures and constraints of grid connection, even after starting the full FIT system. Since 2012, EIA legislation has been applied to large-scale wind farms and geothermal plants of over 10 MW capacity. These EIA procedures take as long as 3–4 years because they are the same lengthy standard procedures used for large-scale fossil fuel plants. At the end of FY 2016, there were about 6 GW of facilities that had been certified by the FIT system but had not started operation. In addition, by the end of FY 2016, facilities undergoing EIA procedures apparently had a total capacity of over 10 GW.

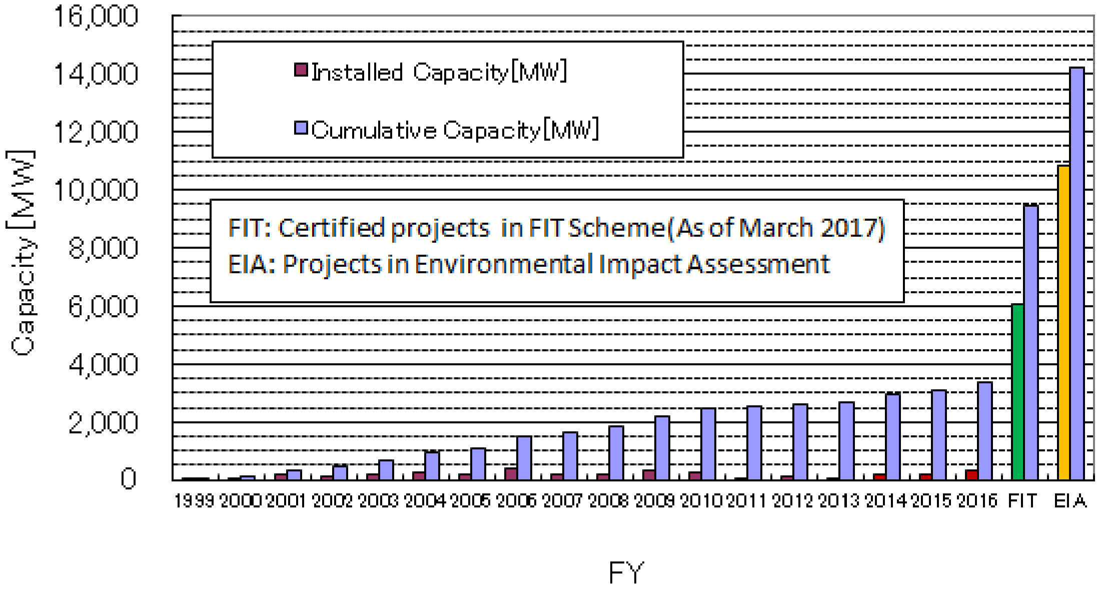

Fig. 8. Trends of wind power capacity in Japan (Source: JWPA)

No geothermal power plants had been introduced since 2000 because of the lack of incentives and effective support measures. However, since the introduction of FIT, about 5 MW of geothermal power plants have been introduced every year, up to FY 2015. Also, considerable geothermal resource exploration and development has been started nationwide, and issues such as deregulation within natural park areas and social agreements with hot spring businesses are being raised. The Ministry of Environment (MoE) regulated the development of renewable energy sources within national parks in order to protect the natural environment. Recently some types of exploration have been permitted, such as oblique explorations outside the central area. Social agreements have become key issues in the development of new geothermal resources, so as not to threaten hot spring sources for geothermal production.

Before the FIT system was introduced, biomass power plant capacity had increased due to the introduction of power generation from biomass waste, mainly from municipal waste and industrial waste such as wood residue. Since the start of FIT, the utilization of abundant domestic forest resources has begun to increase. Especially with regard to "unused timber" such as domestic thinned timber, which is subject to a high purchase price under the FIT scheme, domestic resources have been increased sufficiently to satisfy domestic demand. Along with the construction of a supply chain for raw material procurement, the integration of relatively large-scale biomass power generation exceeding 5 MW output has started in various places. There are, however, many cases where the procurement of unutilized timber remains difficult from a cost perspective. Moreover, the capacity of biomass power plants certified under the FIT system have increased rapidly since 2015. These certified plants are fueled with "general timber" from imported biomass resources, including wood chips, wood pellets as woody biomass, and palm kernel shells (PKS) as agricultural residue. A challenge with the use of overseas biomass is assuring that it was harvested legally and sustainably. Once FIT was enacted, 297 MW (39 facilities) of biomass power plants making use of unused timber were newly introduced. On the other hand, 330 MW (20 facilities) of biomass power plants making use of general timber were newly installed. In addition, 11 GW (340 facilities) of biomass power plants making use of "general timber" were certified to make use of the FIT scheme as of the end of FY 2016, while only 200 MW capacity of biomass power plants for unused wood was certified for the FIT scheme.

2.3 Reform of the electrical power system for renewable energy

In order to promote renewable energy robustly in Japan, it is necessary to reform the electrical power system to make it more suitable for a high penetration of renewable energy. The legal separation of grid ownership from power generation will be planned by each major utility by 2020, following the unbundling already taking place in EU countries. It is also necessary to set higher targets for renewable energy integration; however, renewable energy targets are still relatively low in Japan compared with EU countries. To achieve higher renewable energy targets, both "priority connection", which preferentially connects renewable energy power plants to the power transmission network, and "priority dispatch", which preferentially supplies electricity from renewable sources, are considered to be important; both are already implemented in Europe. Currently, existing power supplies such as those from nuclear power plants and coal-fired power plants are given priority in Japan, due to the grid connection rule of "open access" and "first-come basis" based on the electricity business Act. This connection rule greatly limits the opportunities for renewable energy producers to obtain grid connections.

There are three big issues for the grid connection of renewable energy in Japan. The first issue is the limited physical space available for grid connection, without considering congestion management of the grid system. The second issue is the abnormally high cost of grid connection, linked to the construction of a major grid system at the expense of power generation companies. The third is the so-called "connectable amount" of renewable energy, especially solar and wind power, to the grid. In several regions, utilities set a "connectable amount" for renewable energy such as solar PV and wind. This system was introduced to limit the capacity of renewables to enter the grid, as utility companies claim they need to be able to balance supply with demand and argue that renewable energy can upset this balance. Once a "connectable amount" is decided upon by the government for each utility in a region, renewable energy producers are required to limit or curtail their production if this amount is exceeded. This will then apply over a thirty-day period, and takes place without compensation.

Utilities that produce power with non-renewables such as coal and nuclear have a clear advantage under this "first-come basis" rule, because they are much less limited in their connectable amount than companies focused on renewables. Based on discussion and the Long-Term Cross-Regional Network Development Plan issued by the Committee of OCCTO (Organization for Cross-regional Coordination of Transmission Operators), which was established in April 2015 as the first step in reforming the power system,[8] the development of a major grid system is being considered where the utility also acts as a transmission company (TSO). Since FY 2016, TSOs have become a part of major utilities such as Kansai Electric Power Company (KEPCO) or affiliates of a holding company, such as the Tokyo Electric Power Company (TEPCO) Power Grid company.

2.4 Goals of the energy strategy and renewable energy integration

The Japanese government's Fourth Strategic Energy Plan, which was passed by the Cabinet in April 2014, is based on the 2010 Third Strategic Energy Plan. The Fourth Energy Basic Plan, which has become the basis of Japan's current energy policy, was reviewed and debated by the National Council. This process, however, was not completed until three years after the Fukushima accident, in part because of a change in government. Under the Energy Basic Plan, renewable energy is regarded as "a promising and diversified domestic energy source", and although it is mentioned that "it will accelerate the integration to the utmost for about three years from 2013 and then proactively thereafter", no medium- to long-term vision or goal is set. In the power supply plan for FY 2014, the proportion of fossil fuels was more than 80%, while nuclear power generation was zero. The low production of nuclear energy at this time was caused by the rethinking of energy policies after the Fukushima accident and new safety tests for each nuclear reactor. As it is very important to reduce dependency on fossil fuels in terms of energy security and climate change countermeasures, nuclear power generation is regarded in this Plan as an "important baseload power supply," and is accredited with "excellent stable supply ability and efficiency". This latest Strategic Energy Plan relies on nuclear power generation, which is still associated with huge accident risks and economic efficiency problems even after the Fukushima accident.[9]

In Japan, the target for introducing renewable energy is not clearly defined in the recent Strategic Energy Plan; the plan merely states that it aims at exceeding the level indicated in the previous Strategic Energy Plan. The targets for electricity generated from renewable energy indicated in the Third Strategic Energy Plan (2010) were 13.5% (141 TWh) of total electricity generation in 2020, and about 20% (214 TWh) in 2030. In January 2015, a report on the "Long-term energy supply and demand outlook" was deliberated, including in relation to the energy mix target for 2030 for Japan. The discussion was in a subcommittee of METI.[3] The outlook was released officially by METI in July 2015. It set a target for renewable energy of 22 to 24% (250 TWh) of total power generation in 2030. This target is considerably lower than the 2020 targets in European countries, which are in general more than 30% for renewable power generation. In particular, the target for variable renewable energy such as wind power generation and solar PV is suppressed, due to the priority given to the "connectable amount" in the electric power system.

The Energy Supply Structure Improvement Law states that retail electricity companies are to achieve the target for the electricity share of non-fossil sources such as nuclear power and renewable energy by 2030. However, as long as the government and utilities continue to focus on nuclear power as an important energy source, arguing that it is without CO_2 emissions and low-cost, this non-fossil energy target will not be achievable. It will be very difficult to achieve the target for nuclear energy, given the critical issues such as safety and lack of social acceptance. Instead, the government should strive to obtain this 2030 target for non-fossil sources in the electricity mix by focusing on renewable energy.

The share of annual power generation by nuclear power plants was zero for the first time in 2014, and GHG emissions decreased by about 3% compared to 2013 due to increasing renewable energy. This became possible because of the dramatic energy conservation measures which were taken after the Great East Japan Earthquake. Being already one of the most energy-efficient industrialized countries, Japan has cut back its electricity demand by more than 10% since the Fukushima nuclear crisis. This trend of energy conservation is another major step towards making an energy transition.

3. Social aspects of an energy transition

3.1 Issues facing electrical power system reform and electricity liberalization

In Japan, the liberalization of electricity retailing began in April 2016. Liberalization enables households and small businesses to freely choose between new retail electricity companies registered by METI and 10 major electric power companies (EPCOs) that have traditionally acted as monopolies. Residential customers such as individuals and small businesses are now able to choose which electricity they purchase, considering for example the percentage of renewable energy or nuclear power it contains.

Large business establishments and plants which have high or ultra-high voltage contracts over 50 kW have reaped the benefits of liberalized electricity retailing by power producers and suppliers (PPSs) since 2005. After the total liberalization of electricity retailing began in April 2016, as shown in Fig. 9, the sales share of the new licensed retail companies excluding the 10 major EPCOs reached about 11.4% of the total electric power demand as of June 2017. And the share of those new retail companies reached over 20% in the areas of Tokyo, Kansai and Hokkaido in June 2017.

Regarding total electricity retailing liberalization, the licensing of retail companies based on the review of the Electricity and Gas Market Surveillance Commission (EGC) is proceeding, and more than 400 new retail companies had been licensed by September 2017. By 30 June 2017, the number of consumers switching from the 10 major EPCOs to other retail companies had reached almost 3.8 million, or about 6.0% of all customers. As various websites that compare electricity prices are launched, attention is focused on keeping electricity prices low. Only half of the companies are making their power supply structures open to the public, based on the EGC guideline established in April 2016.

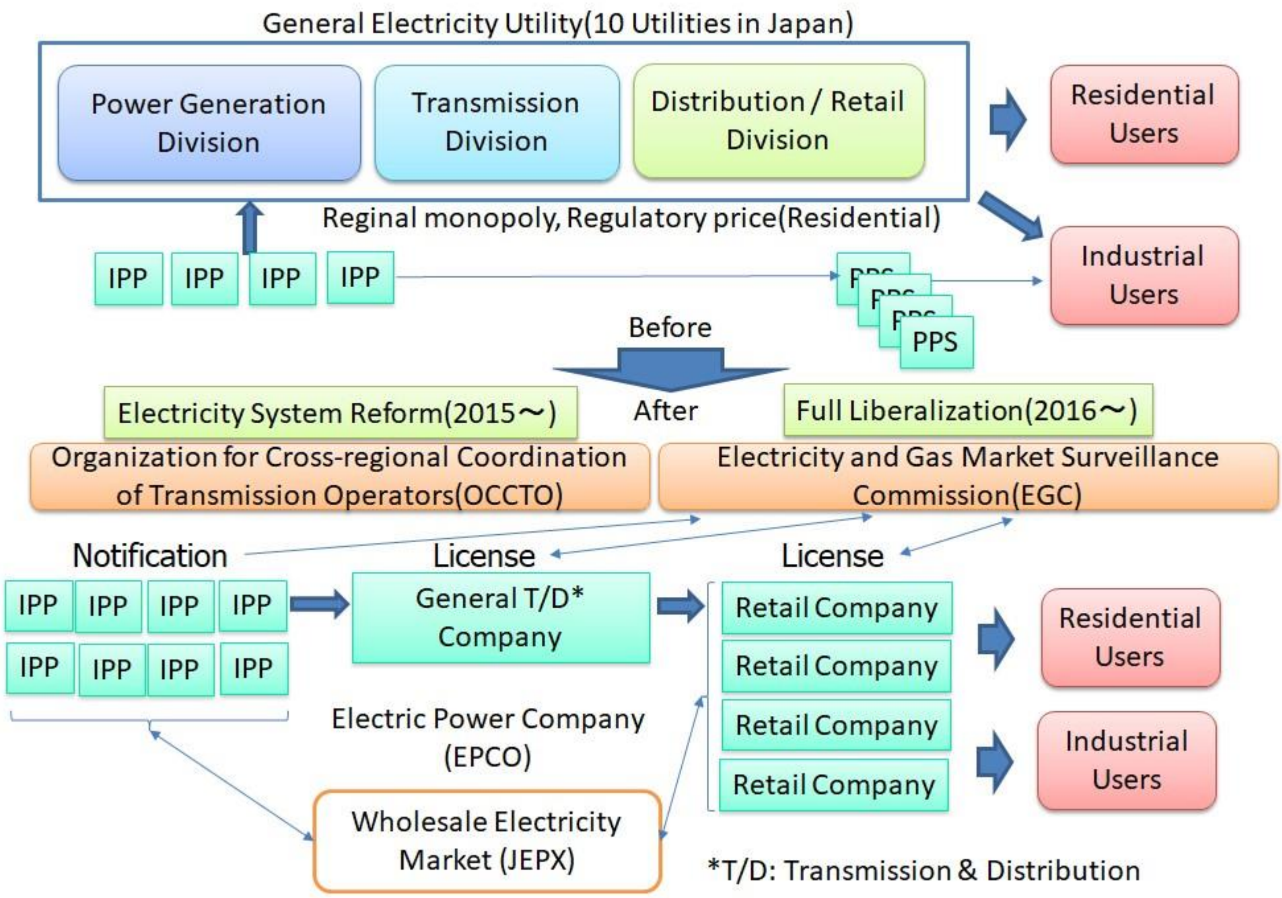

Fig. 9. Electricity System Reform and full liberalization in Japan (Source: ISEP)

The "connectable amount" for solar and wind power is defined by designated electric utility companies and general electrical transmission and distribution business operators. The "connectable amount" excludes the three metropolitan areas of Tokyo, Kansai, and Chubu. This is a substantial constraint for areas where the qualified capacity exceeds the "connectable amount". Particularly for solar power generation, the qualified facilities exceed the "connectable amount" in most areas excluding the three major metropolitan areas. For example, the connectable amount has been exceeded by almost a factor of two in Hokkaido, Tohoku and Kyushu. With regard to wind power generation, Hokkaido Electric Power Co., Ltd. has exceeded the connectable amount.

The utilization of interconnection lines connecting major utilities (TSOs) to each other is also important for wide area coordination, as shown in Fig. 10. However, currently these lines are used exclusively for emergencies. In order to solve the coordination issues, OCCTO investigated this situation and set new operation rules or new guidelines. OCCTO plays a broad role in the promotion of "cross-regional management of electrical businesses". The "Guidelines for Services for Electricity Transmission and

Distribution" provide basic rules concerning the implementation of work procedures related to power transmission and distribution over a wide area. Various procedures related to the connection of power supplies and priority dispatch are defined.

Regarding the cost of grid connection, the power producer occasionally has to pay part of the development costs of the backbone grid network. These costs should be included in the transmission costs of transmission system operators; that is, the large utilities in Japan. In 2015 METI and OCCTO formulated guidelines related to the cost burden of transmission lines. The guidelines set up rules of cost sharing between the TSOs and power producers. However, the cost of grid connection by renewable energy is still relatively high under this rule because it is not based on the concept of priority access for renewable energy.

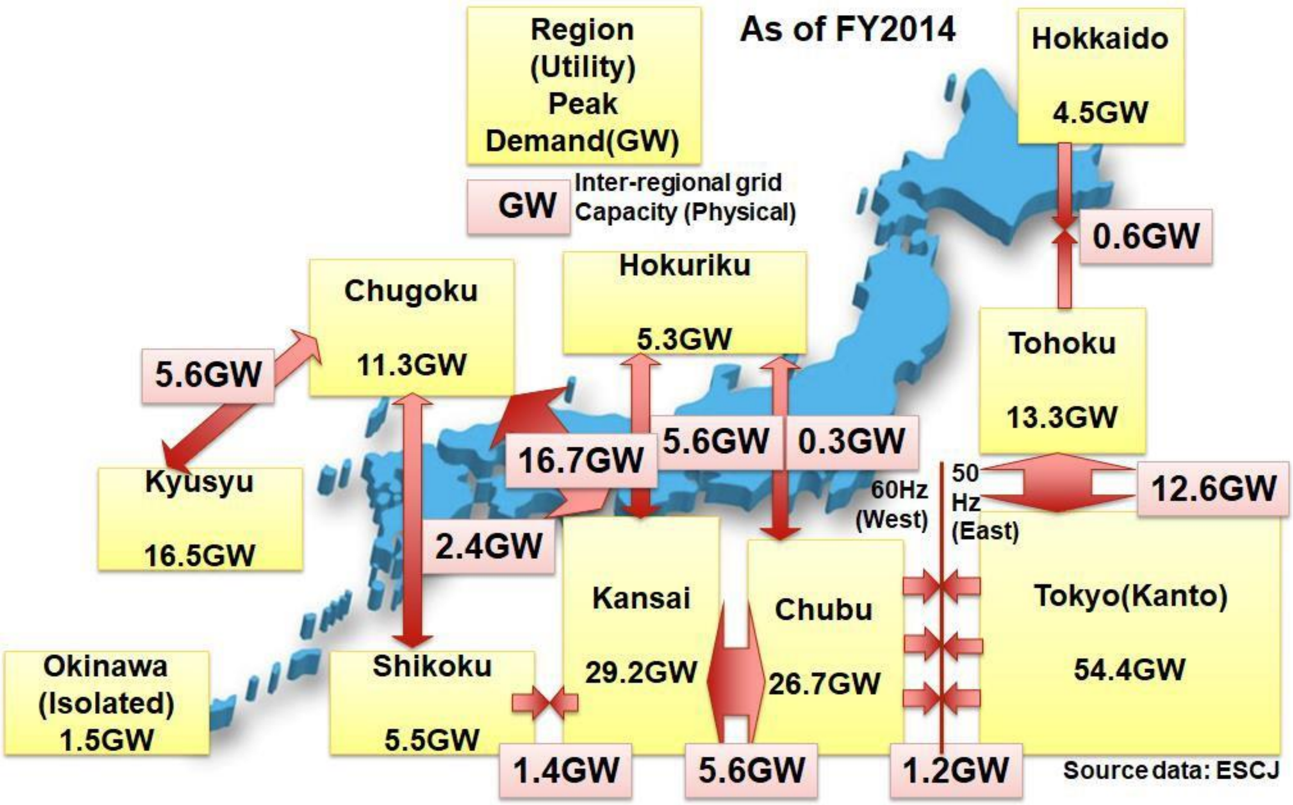

Fig. 10. Interregional grid connection of large utilities in Japan (Source: ESCJ)

3.2 Issues of the electricity market and the electricity price system

From the viewpoint of consumer rights, it is necessary to launch a mechanism enabling consumers to select their favored electricity source from among multiple retail electricity companies. For this purpose, as already realized in Europe, it is obligatory to display breakdowns of electricity prices and the power supply composition, and to disclose information from power generation companies, transmission and distribution companies, and the wholesale electricity trading market. Further, it is necessary for consumers to be able to check the breakdown of electricity prices and the power supply configuration with their monthly electricity forms, or from the Internet page. It is important to know where electricity was generated, how it is traded, and how it can be delivered to consumers. An indication of the power supply mix – that is, the shares of renewable, nuclear, and fossil fuel-based power generation – which is displayed in many other countries, was not specified in the guidelines published by the EGC in January 2016. In the revision of June 2017, the power generation mix was simply listed as a desirable target. For the future, it should be possible for consumers to evaluate and compare retail electricity providers based on their power supply composition and electricity fees.

3.3 Employment by Renewable Energy and Regional Economic Effects

According to the International Renewable Energy Agency (IRENA), approximately 390,000 jobs related to the renewable energy field were created in Japan in 2015.[10] Investment in renewable energy in Japan reached about JPY 4 trillion (USD 39 billion) in 2015, but fell by half to about JPY 1.7 trillion (USD 15 billion) in 2016 due to the decline of the cost of solar PV power generation, which was higher in Japan than overseas.

Fukushima Prefecture, which was seriously damaged in the 2011 Great East Japan Earthquake, formulated a revised "Fukushima Prefecture Renewable Energy Promotion Vision" in March 2012.[11] In this vision, Fukushima aims for a renewable energy share of 40% in the primary energy supply by FY 2020. Fukushima Prefecture also plans to undertake some large-scale energy projects, such as geothermal power generation and offshore wind power generation, pursuing a 64% renewable energy target by 2030. In addition, this vision aims at covering 100% of the energy demand by renewable energy by 2040. This is the first time in Japan that a prefectural government has set a goal of 100% renewable energy.

The regional economic effects of renewable energy can be estimated from the research based on Fukushima's scenario of 100% renewable energy in the prefecture by 2040.[12] The research shows that the regional economic benefit at the investment stage is compelling relatively early on, at about the 10% level, compared with the investment amount. In order to raise the regional economic benefit at the investment stage, it is necessary not only to involve regional financial institutions and construction companies but also to stimulate the involvement of local companies in the manufacturing and operations processes of facilities. The regional economic effect at the business operation stage, after construction, can be expected to be several times larger than at the investment stage. This is because the business operation stage will be of long duration, making it necessary to prepare long-term plans covering not only the first ten-year investment stage, from business development to equipment introduction, but also the 20-year business management stage, which more than doubles the regional economic effect.

3.4 Discussion of a long-term strategy for the transformation towards a low-carbon society

Under the Paris Agreement, each party is to submit a "low-carbon long-term strategy" to the United Nations Framework Convention on Climate Change (UNFCCC). Japan committed itself to formulate and submit a long-term climate strategy. As of August 2017, four of the G7 countries had submitted a long-term strategy to the United Nations, thereby strengthening the pressure on Japan to formulate a strategy as soon as possible. The MoE and METI started the process of formulating a strategy by establishing several councils to start considering targets for their long-term strategy.

Specifically, in July 2016, the MoE started the "Long-term Low-Carbon Vision Subcommittee" at the Global Environment Committee of the Central Environment Council, to deliberate the long-term vision for a low-carbon society by 2050 and beyond. During the deliberations, interviews were conducted with numerous experts and organizations. Based on a compilation of the interview data, a draft document formulating a long-term low-carbon vision was proposed in March 2017.[13] In this vision, the basic idea was to develop a plan that simultaneously addresses climate change issues as well as economic and social issues on the Japanese political agenda. The discussants saw the keys to a substantial long-term GHG reduction as being innovation in technology and a transformation of the economic and social system towards a more sustainable lifestyle. Carbon emission reductions can be achieved by simple measures applied in daily life, such as energy saving, giving preference to energy gained from renewable sources, and a fuel shift in the transport sector (e.g. electrification, hydrogen, etc.). Through "green" investments in industries in both domestic and overseas markets, Japan can increase its market share of low-carbon products and services. Also, Japan has the potential to increase the number of low-carbon Compact Cities and to further decentralize its energy system. In this vision, various measures are proposed for reducing emissions, including carbon pricing, development and disclosure of environmental information, regulatory methods, promotion and diffusion of innovative technology development, and smart land use.

For the purpose of formulating the Japanese long-term climate strategy,[14] environmental NGOs held a meeting and made public recommendations in November

2016.[15] The NGOs, including Green Alliance Japan, have proposed the development of a long-term low-carbon vision, with a steady emission reduction through carbon pricing, environmental taxes, and emissions trading.[15] It is urgent to review the Strategic Energy Plan and the targeted energy mix for 2030, since measures must be implemented in each sector of power, heating, and transport. As Japan should have a 40–50% reduction target by 2030 and an 80% reduction target by 2050 (both compared to 1990), the path to zero carbon emissions should be set out beyond 2050. Several NGOs, including Green Alliance Japan, propose achieving 50% or more renewable energy by 2030, without nuclear power, and aim to create a society with 100% renewable energy in the long term.[20]

In contrast to the long-term low-carbon vision of MoE, METI established a long-term Climate Change Policy Platform in July 2016 and announced its long-term low-carbon plan in April 2017.[16] The consideration process of this platform was led by two discussion groups, the "Domestic Investment Expansion Task Force" and the "Overseas Deployment Strategy Task Force". In METI's plan, sustainable development and GHG reductions were set as major objectives. Three game-changing countermeasures for climate change form the core of METI's long-term strategy. These are: "international contributions to achieve global target"; "achieve carbon-neutrality in the product lifecycle"; and "obtain carbon-neutrality by innovation".

4. Policy enforceability and feasibility of an energy transition

4.1 Development of FIT system regarding electricity market

In Japan, the bill containing the full FIT system was approved by the Cabinet of Ministers on March 11, 2011, shortly before the Great East Japan Earthquake and the TEPCO F1-NPP accident. The approval process for FIT legislation was speeded up by the impact of the Fukushima accident. It was approved by Parliament in August 2011 and came into effect under the former administration of the Democratic Party on July 1, 2012.[17] In the five years after the FIT system was introduced there was rapid growth, especially in the market of solar PV. FIT certification cases up to March 2017 reached over 96 GW, of which 89% was solar PV. The cumulative capacity of solar PV starting operations by the end of FY 2016 was 36 GW or more. Among these, certified large-scale solar plants exceeding 1 MW reached nearly 40 GW, accounting for about 42% of the total certified capacity. Larger-scale facilities tend to be more profitable because of lower unit costs. The tariff of JPY 40/kWh in 2012, for example, was put in place for solar PV with a capacity of over 10 kW, as shown in Table 4. As a result, a large number of large-scale solar PV projects of over 10 kW have progressed extremely well, as shown in Table 3.

Table 4. FIT tariffs in JPY/kWh, excluding consumption tax, after FY2016 (Source: METI)

<table>
<tr><th>RE</th><th>Category</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th></tr>
<tr><td rowspan="3">Solar PV</td><td>Under 10 kW</td><td>42</td><td>38</td><td>37</td><td>33</td><td>31</td><td>28</td><td>26</td><td>24</td></tr>
<tr><td>10 kW and over, under 2 MW</td><td rowspan="2">40</td><td rowspan="2">36</td><td rowspan="2">32</td><td rowspan="2">29</td><td rowspan="2">24</td><td>21</td><td colspan="2">TBD</td></tr>
<tr><td>2 MW and over</td><td colspan="3">Bidding</td></tr>
<tr><td rowspan="3">Onshore Wind</td><td>Under 20 kW</td><td colspan="6">55</td><td colspan="2">TBD</td></tr>
<tr><td>20 kW and over</td><td colspan="5">22</td><td>21</td><td>20</td><td>19</td></tr>
<tr><td>20 kW and over (replace)</td><td colspan="5">N/A</td><td>18</td><td>17</td><td>16</td></tr>
<tr><td>Offshore Wind</td><td>20 kW and over</td><td colspan="2">N/A</td><td colspan="6">36</td></tr>
<tr><td rowspan="2">Geothermal</td><td>15 MW and over</td><td colspan="8">26</td></tr>
<tr><td>Under 15 MW</td><td colspan="8">40</td></tr>
<tr><td rowspan="4">Small-medium Hydro</td><td>5 MW and over, under 30 MW</td><td colspan="5">24</td><td colspan="3">20</td></tr>
<tr><td>1 MW and over, under 5 MW</td><td colspan="5">24</td><td colspan="3">27</td></tr>
<tr><td>200 kW and over, under 1 MW</td><td colspan="8">29</td></tr>
<tr><td>Under 200 kW</td><td colspan="8">34</td></tr>
<tr><td rowspan="7">Biomass</td><td>Methane fermentation</td><td colspan="8">39</td></tr>
<tr><td>Unused wood (2 MW and over)</td><td colspan="8">32</td></tr>
<tr><td>Unused wood (under 2 MW)</td><td colspan="3">32</td><td colspan="5">40</td></tr>
<tr><td>General wood (20 MW and more)</td><td colspan="5">24</td><td colspan="3">21</td></tr>
<tr><td>General wood (under 20 MW)</td><td colspan="8">24</td></tr>
<tr><td>Waste</td><td colspan="8">17</td></tr>
<tr><td>Recycled wood</td><td colspan="8">13</td></tr>
</table>

Fig. 11 shows the flow and economic effects of the FIT scheme for FY 2016 in Japan.

In FY 2015, the total cost for FIT payment was about USD 16 billion (JPY 1800 billion), and for the total surcharge, about USD 12 billion (JPY 1300 billion), which makes a difference of avoidable cost of about USD 4.5 billion (JPY 500 billion). In 2016, investments in the renewable energy market in Japan were estimated at about USD 16 billion by the United Nations Development Program (UNEP) and Bloomberg New Energy Finance (BNEF).[18] Employment in the renewable energy sector in Japan was estimated by IRENA as being over 390,000 jobs in 2015.[19] FIT purchased cost and surcharge trends for customers are shown in Fig. 12. The total FIT purchased cost was estimated at over JPY 2 trillion in FY 2016. Based on this purchased cost and avoidable cost for utilities, the surcharge being paid by each consumer was estimated to be 1.5 cents/kWh (JPY 1.6/kWh) in FY 2015. This surcharge will increase to 2.4 cents/kWh (JPY 2.6/kWh) in FY 2017. This level of surcharge may pose a burden for some consumers of electricity, especially heavy industrial users. However, the surcharge is only about 10% of the electricity price for residential users. There have been no real complaints.

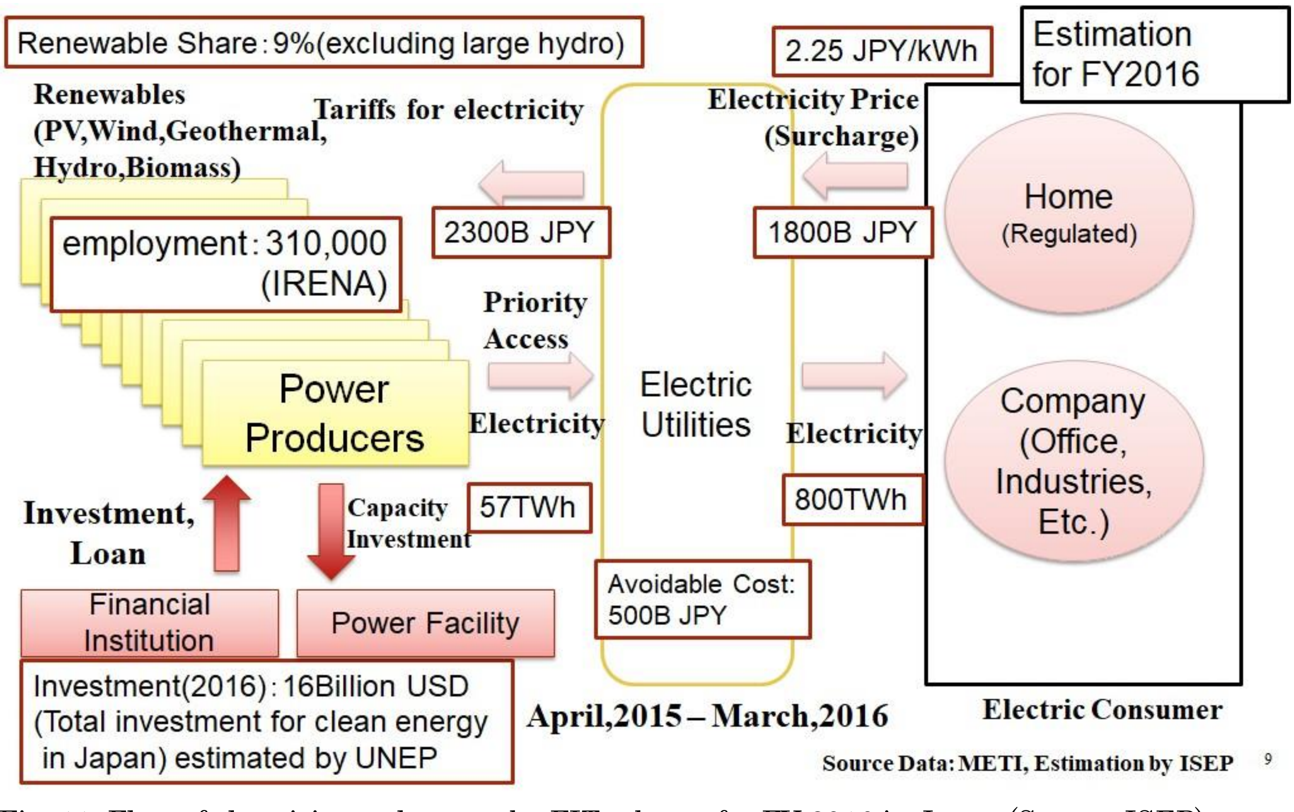

Fig. 11. Flow of electricity and money by FIT scheme for FY 2016 in Japan (Source: ISEP)

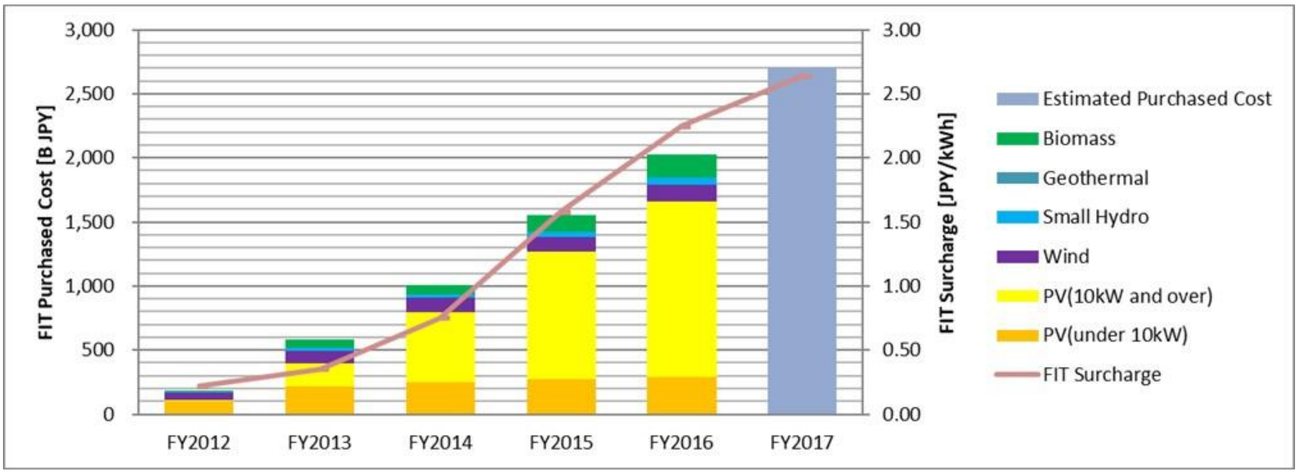

Fig. 12. Trends of FIT purchased cost and surcharge in Japan (Source: METI, ISEP)

Since the start of the FIT program, facilities accounting for over 34 GW of capacity have newly started operations, with 95% of this being solar PV, as shown in Fig. 13. When transition from pre-FIT is included, over 42 GW of capacity started operations by the end of 2016. However, about 55 GW, or about 57% of the certified facilities (96 GW) were not operating at the end of 2016. To deal with this situation, a revised FIT system was legislated in May 2016 and became effective in April 2017. In the revised FIT system, basically all facilities are required to have a contract for grid connection with a utility before certification. Further, all certified facilities under the FIT program must adapt to the new conditions set for FIT certification. That is, they must have a proper business plan along with business guidelines for each renewable energy technology.

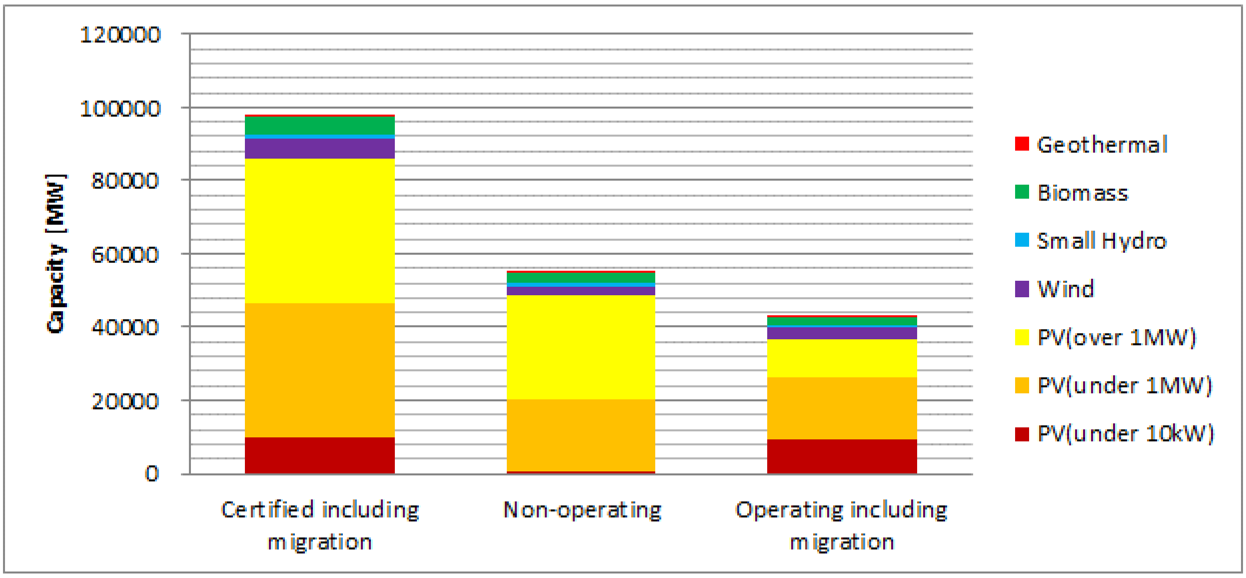

Fig. 13. Status of FIT-certified and operating capacities by the end of 2016
(Source: METI. Graph: ISEP)

Since April 2014, data from electric power facilities approved in the FIT scheme have been published with a three-month delay by cities, towns and villages on the website of the Agency for Renewable Resources and Energy (ANRE) to fulfill an information disclosure requirement. The amounts of electricity produced nationwide have started to be published in the Electricity Statistics of ANRE, but there is scope for improvement in the statistical preparation and disclosure of information on renewable energy.

If we look at the status of facility approval for each electric company, we see that for Kyushu Electric, when pre-FIT approvals are included, approximately 20 GW of facilities had already been approved by March 2016, as shown in Fig. 14. This is equivalent to the capacity of all of Kyushu Electric's facilities at the end of FY 2012, which was about 120% of the maximum power demand in FY 2013. For Tohoku Electric, the approval rate was equal to almost 80% of its entire capacity and 100% of its maximum output, as shown in Fig. 14. For Kanto, Chubu, and Kansai, in each of which there is a large demand for electricity, approvals stopped at 20–40% of capacity. Looking at the broad regions of Eastern Japan (50 Hz) and Mid-to-Western Japan (60 Hz), which have hitherto been trading electric power via interconnection lines between companies, the ratio of approved renewable energy facilities is equivalent to about 50% of the maximum output. As for renewables introduced by power generating facilities under the FIT program (compared with the total prior to the FIT transition), we can see that even for Kyushu Electric, which has the highest ratio of implementation, they stopped at about 30% of the maximum demand. Looking at the broader area of Mid-to-Western Japan (60 Hz), an even lower level of capacity of 20% became the upper limit for renewables.

To address the string of connections for renewable energy sources being withheld, the Grid Connection Working Group (Connection WG) was established under the auspices of METI, the Advisory Committee for Natural Resources and Energy, and the New and Renewable Energy Sub-Committee, and through the deliberations of this group each of the major utilities made suggestions for acceptable upper limits for the capacity of wind and solar power, the so-called "allowable connection amounts" (for solar, as shown in Fig. 16, and for wind, as shown in Fig. 17). If the FIT scheme is read in a straightforward manner, it states that if the suppression of the output exceeds a maximum amount of 30 days in a year, the major utilities will be compensated for curtailment. However, utilities interpreted this "allowable connection amount" as a method of avoiding compensation for the curtailment of over 30 days. In contrast, Germany has a system for compensation of lost profits due to curtailment of output. This rule of an allowable connection amount was not specified in the Special Measures Act, but it has since been used in official government documents. In fact, the amounts have been calculated each year for each region and confirmed by the Grid Working Group organized by METI.[21]

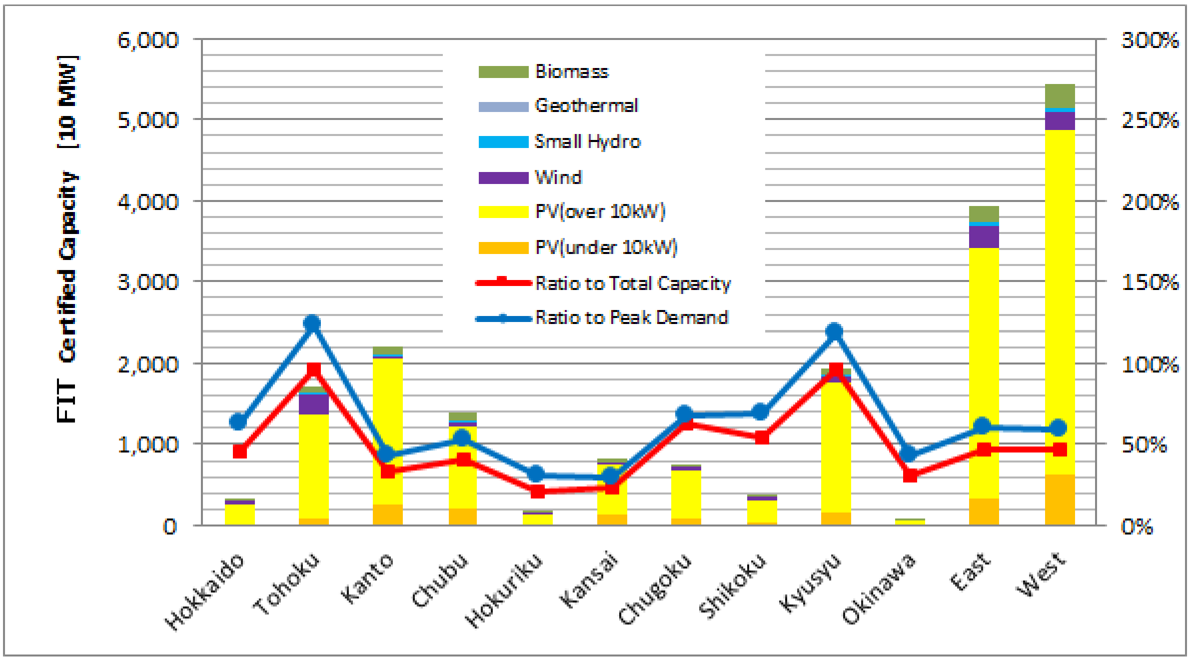

Fig. 14. FIT certified capacity in each utility at end of 2016 (Source: METI. Graph: ISEP)

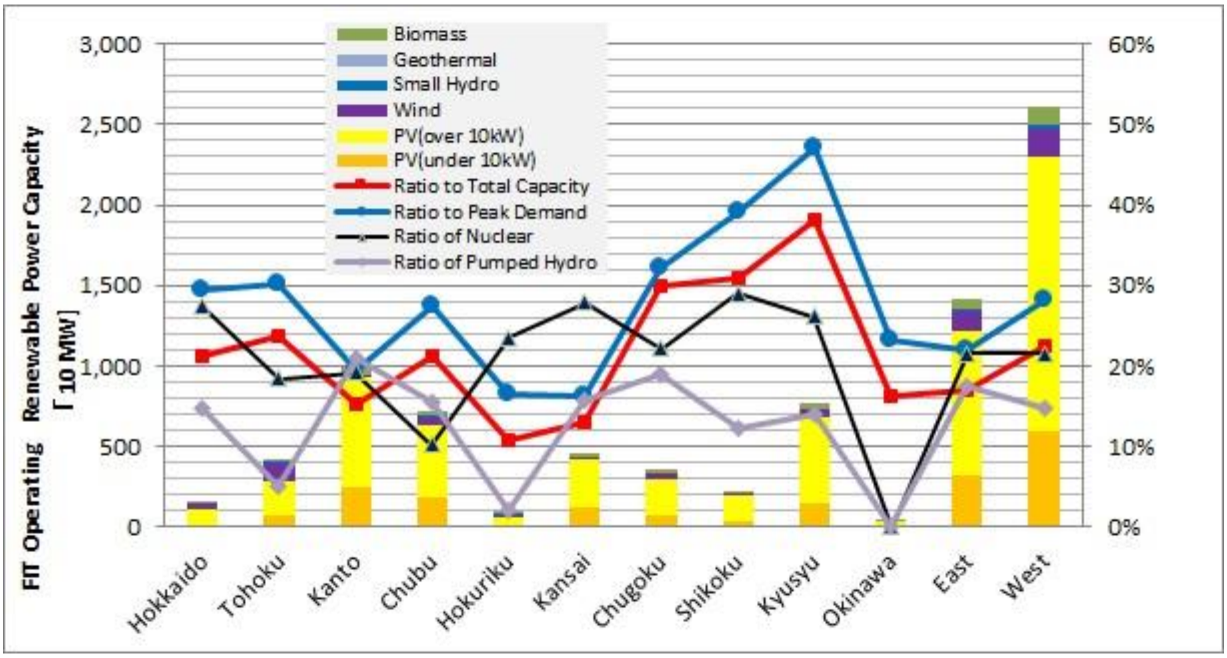

Fig. 15. Renewables capacity in each utility at end of 2016 (Source: METI; Graph: ISEP)

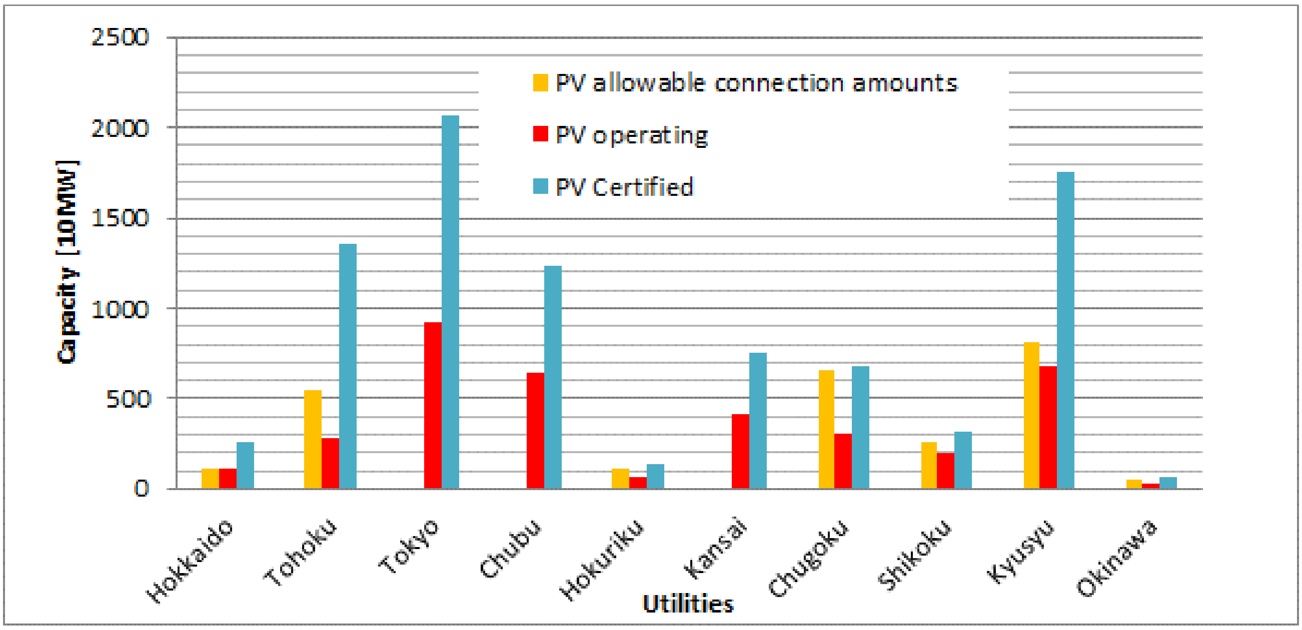

Fig. 16. Status of solar PV capacity in each utility (Source: METI. Graph: ISEP)

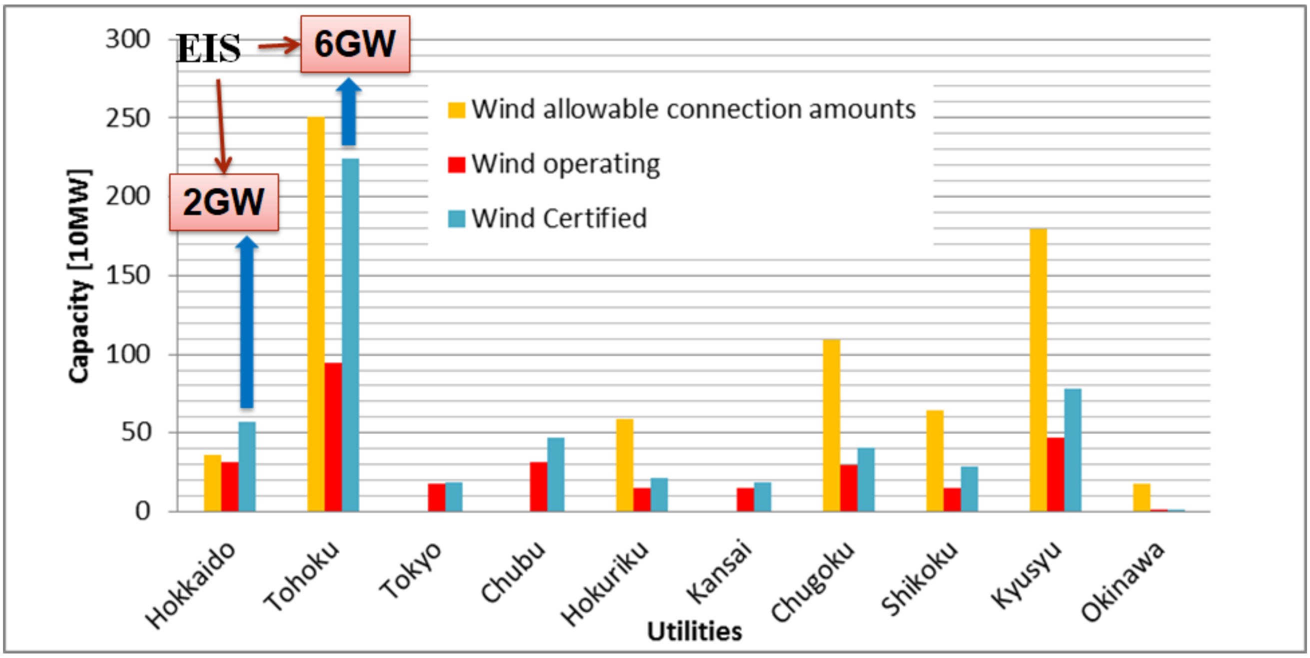

Fig. 17. Status of wind capacity in each utility (Source: METI. Graph: ISEP)

Major utilities (TSOs) in Japan tend to argue that if an "allowable connection amount" is not established, the stable supply of electricity will be threatened, essentially often interpreting the term as a technical limit. But in fact it is no more than a single guideline in the restrictions of the law, as written above. From an international viewpoint, there are almost no countries other than Japan setting upper limits to connections (an "allowed connection amount"), and more than 10 years of experience shows that connecting large amounts of renewable energy is technically feasible. In the context of global trends, using a supposedly technical reason for setting an upper limit to connections of renewable energy is the same as sending a message to the world that

Japan does not have the technological ability to connect a large amount of renewable energy to the grid. However, on 14 May 2017, the peak supply of renewable energy surpassed 87% (solar PV: 71%) of consumption demand in the Kyushu Electric area, as shown in Fig. 18. In reality, Kyushu Electric Company has managed well a high penetration of variable renewable energy (VRE) such as solar PV by controlling thermal power and pumped hydro. However, if more nuclear power will start to operate, Kyushu Electric would have to curtail solar PV promptly, in accordance with the rule by OCCTO.

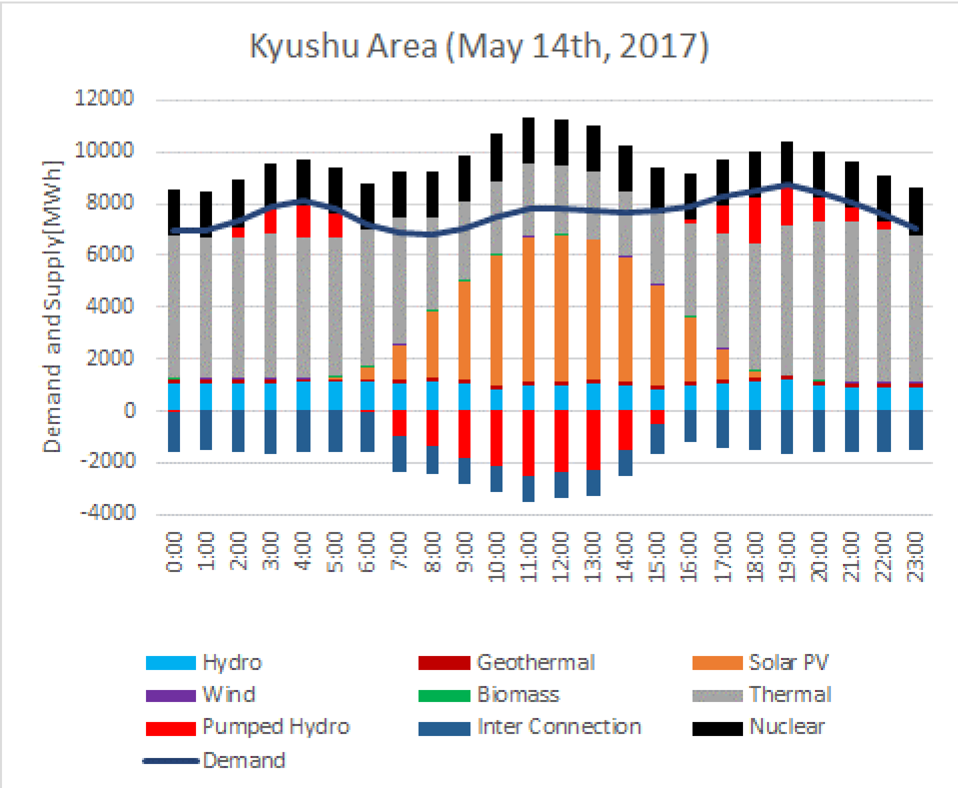

Fig. 18. Daily trends of supply and demand in Kyushu area on 14 May 2017 (Source: Kyusyu Electric and ISEP)

4.2 Relief policies for nuclear power to overcome difficulties in liberalization

After the Fukushima accident and the liberalization of the electricity retail market, the former position of nuclear power generation as a “baseload power supply” should have changed fundamentally. Indeed, under the liberalized electricity pricing system, it will become more and more difficult to maintain nuclear power generation, which involves enormous damage compensation expenses and requires a large amount of funding for safety measures. Still, the government (and especially METI) continues to provide the nuclear industry with relief policies in order to preserve the existing electric power system. The support of the relief policies given to nuclear energy is a major obstacle to building a new electric power system that gives priority to renewable energy, as in the electricity markets in Europe.

Various relief policies for nuclear power were adopted by METI. The damage compensation costs tied to the Fukushima accident as well as the decommissioning costs for the reactors which experienced meltdowns have already reached USD 136 billion (JPY 15 trillion), and are expected to exceed USD 180 billion (JPY 20 trillion) in the future. Initially, government bonds were used to compensate the damage costs incurred by TEPCO. The nuclear damages compensation and decommissioning support organization is supporting TEPCO, using a large amount of money not as a debt but as a gift, based on new measures supporting compensation for damage caused by the Fukushima accident. The cost of damages caused by the Fukushima accident have already exceeded JPY 6 trillion, and the decommissioning costs of the Fukushima Daiichi Nuclear Plant are expected to expand dramatically beyond JPY 2 trillion, the cost originally assumed by TEPCO. In order to keep TEPCO alive, the Government has placed the cost of the accident on electricity consumers.

All the nuclear operators (nine big utilities including TEPCO, JAPC and JNFL) paid USD 1.5 billion (JPY 161 billion) in FY 2016 as a general obligation fee to support nuclear accident compensation. Originally, the accident compensation costs of the Fukushima Daiichi Nuclear Power Plant that TEPCO was supposed to bear were to be recovered through TEPCO's "special obligation fee" for recovering the Fukushima accident: USD 1 billion (JPY 110 billion) in FY 2016. That means that these fees are added to the electricity prices of all nuclear power companies and all retail electricity companies. It is obvious that the costs of the accident that are supposed to be covered with these fees added to the transmission fee will be huge, exceeding JPY 20 trillion. This will increase the overall electricity price. This means that electricity from nuclear plants should no longer be considered as "cheap".

While the country's energy policy has undergone substantial redesign and electric power system reforms are progressing, full liberalization of the electricity retail market began only in April 2016. Until now, nuclear power generation was promoted by major electric power companies under the policy of promoting nuclear power by the government. In addition to various subsidies, before the liberalization, nuclear-related costs were collected on top of electricity fees under the regulated tariff system. However, the regulated tariff system for electricity will be eliminated by 2020 for liberalization, and only the transmission fee that collects the cost of transmission and distribution will be subject to the regulated fee system. Since this transmission fee is paid not only by major nuclear power companies but by all electricity consumers, a high degree of transparency and fairness is required. The cost of decommissioning reactors and the cost of damage caused by the Fukushima Daiichi nuclear accident should be paid solely by the nuclear power company, but TEPCO is trying to recover some of these costs by passing them to consumers. The part of compensation for the damage cause by the Fukushima accident will be included in the transfer fee starting in 2020.

Despite the Fukushima accident, the government and the utilities are eager to maintain nuclear power plants as "baseload power supply" and to establish a "non-fossil value trading market" with renewable energy because nuclear power plants have had so many difficulties since the liberalization which began in FY 2016. The non-fossil value trading market is a system that treats renewable energy and nuclear power plants as non-fossil power sources and trades their values on the market for the retail electricity companies, which have a mandatory target of a non-fossil fuel share over 44% by 2030. This non-fossil value of nuclear power focuses only on the reduction of CO_2 emissions, ignoring all of the problems and risks, including nuclear waste issues. And as electricity generation from nuclear power plants currently involves the highest costs and highest risks, basically it is not marketable. After the initial trading of only renewable energy in FY 2018, trading the value of nuclear is planned to start by 2020.

4.3 Future vision for promoting an energy transition

Thinking about a long-term climate and energy strategy is necessary for setting corresponding renewable energy installation targets. In the National Strategic Energy Plan, little foresight is shown. It is important to consider and understand the risk of catastrophic accidents associated with nuclear power. With most of Japan's nuclear power plants not operating, maintaining energy security has focused far too heavily on overseas fossil fuels. This is also problematic when considering the threat of serious climate change. It is also problematic if Japan continues to rely heavily on fossil fuels. Considering these problems, it is important to strive for a full-scale energy saving program over the long term, and for carbon neutrality by around 2050. The renewable energy target for 2030 must also be formulated by back-casting targets based on visions which tackle climate change. A network of environmental NGOs, CAN-Japan, advocates reducing GHG emissions by 40–50% compared to 1990 and increasing the electricity share of renewable energy to 45% by 2030.[20] These goals are supported by several domestic environmental NGOs (ISEP, WWF Japan, KIKO network, CASA, etc.).

The report released by the MoE in 2015 described the possibility of introducing renewable energy (RE) based on various preconditions.[21] In the low-RE scenario of the report, the renewable share power generation in 2030 will be about 20%, the same level as the power mix target from METI. However, in the high-RE scenario, the renewable share of power generation would exceed 30% in 2030.

In February 2011, WWF International announced that the world was able to achieve "100% renewable energy at the global level by 2050". WWF Japan also conducted a study for Japan. In November 2011, WWF Japan published its "Energy scenario proposal for decarbonizing society with 100% renewable energy".[22] This report is based on the premise that energy demand will be reduced by half by 2050. It shows that it is technically feasible to examine whether the remaining energy demand can be covered 100% from domestic renewable energy, including not only electricity but also heat and fuel. Furthermore, in March 2013, the cost was calculated of shifting to a society with a renewable energy share of 100%. It showed that the annual investment needed would be equal to about 1.6% of Japan's GDP. Because this is domestic investment, however, unlike the cost of importing fossil fuels, it would lead to domestic demand and expansion of employment. In September 2013 a cost calculation and a technical requirement assessment were made for a smart electric grid system capable of integrating large amounts of renewable energy. The assessment came to the conclusion that 100% renewable energy is feasible and economical for Japan in the future.

The Japan Photovoltaic Energy Association (JPEA) revised its "JPEA PV Outlook 2030" in August 2012 with an article called "To implement a more than USD 100 billion industry by 2030". JPEA is an industrial organization of solar PV manufacturers and related businesses. In the report, they describe how the high necessary investment could be realized. Furthermore, in February 2014, an article entitled "FIT opens new solar power market" described how the producers of solar PV will extend the market to foreign countries based on the achievements of the FIT scheme in Japan. The forecast for the domestic introduction of renewable energy by 2030 has been slightly increased, to 49 GW by 2020 and 102 GW by 2030. In March 2015, JPEA announced "steady progress toward 2030 – aiming for smart country Japan" and showed a scenario up to 2030 based on the rapid growth of solar PV as a result of the FIT system. Forecasting from the current situation for certified solar PV under the FIT scheme, JPEA aimed for 100 GW in 2030. In 2017, JPEA proposed a solar PV outlook for 2050, "Towards realization of a decarbonized and sustainable society", which targets a solar PV capacity of 200 GW by 2050 in Japan.[23]

The Japan Wind Power Association (JWPA) has updated and announced its introductory target and roadmap, following the establishment of a long-term installation target in FY 2007, along with calculations of potential viability. In 2013, the long-term implementation target was calculated on the premise of a wide-area operation of the electric power system and recent trends such as electric power system reform, new extensions of local transmission lines, and offshore wind power demonstration projects. Based on the results of the latest potential survey, this study found that the long-term installation target capacity could be 75 GW in 2050, supplying 20% or more of electricity demand.[24]

4.4 Indicators of the sustainability of a 100% renewable energy region

By evaluating the installation status of renewable energy for each region, prefecture, and municipality, several regions have been identified that supply more than 100% renewable energy as a contribution towards the region's sustainability. For this evaluation, the "Sustainable Zone Study Group" (a collaboration between Chiba University's Kurasaka laboratory and ISEP) has announced the current state and future trend of renewable energy supply by region every year since 2007.[25] The share of renewable energy in the region is used as an indicator of the sustainability of the region, and shows the amount of renewable energies being deployed. By evaluating renewable energy performance as an indicator, it is possible to evaluate the sustainability of the region in a way that could not be achieved, for example, by the application of economic indicators. The "Sustainable Zone FY2016 Report" published in March 2017 shows the supply ratio of renewable energy by region.[26]

The five prefectures with the highest proportions of renewable energy in FY 2015 were Oita, Kagoshima, Akita, Miyazaki and Toyama, as shown in Fig. 19. In each of these prefectures, the proportion of renewable energy supply compared to the electricity demand of the building (home and business), agriculture, forestry, and fishery sectors exceeded 20%. There are differing characteristics in these prefectures; in Oita and Kagoshima prefectures in the Kyushu district, solar power generation, in addition to geothermal power generation, accounts for a large proportion of the electricity mix, whereas in Akita Prefecture, in addition to geothermal power generation and small hydropower generation, the ratio of wind power generation is also high. Miyazaki Prefecture, also in the Kyushu district, has a large proportion of solar PV power generation and biomass power generation. Small hydro power generation is abundant in Toyama Prefecture because of its abundant hydro power resources. Besides the use of solar heat spreading, geothermal use, such as hot spring heat, and thermal utilization of woody biomass are being implemented in each region.

Based on the study, it was estimated that in 71 municipalities in FY 2015 the share of renewable energy supply was already more than 100% of annual energy demand, excluding industrial energy. Furthermore, in 111 municipalities, it is estimated that more than 100% of the electricity demand was supplied by renewable energy. In 19 municipalities, annual power generation by wind power reached more than 100% of annual energy demand in the region. And in five municipalities, annual power generation by geothermal means reached more than 100% of demand. Furthermore, in 58 municipalities, annual power generation by small hydro reached more than 100% of the electricity demand in the region. Since the FIT system began in 2012, the installation of solar PV has advanced rapidly, and in seven municipalities, annual power generation by solar PV reached more than 100% of annual electricity demand in FY 2015. Most of these large-scale solar PV facilities are owned and operated by large companies outside the region, and efforts are required for communities to utilize local energy resources. Also, full-scale efforts are necessary to utilize renewable heat energy (solar heat, biomass, geothermal), which has previously been neglected.

In large cities such as Tokyo and Osaka prefectures, huge amounts of energy are being consumed, so despite a certain capacity of solar PV, the share of renewable energy supply is only a few percent or less. In order to increase the share of renewable energy supply in urban areas, it will be necessary to collaborate with regions and places where renewable energy resources are abundant and can be supplied to urban areas through liberalization of electricity and trading the environmental value of renewable energy.

To estimate the share of renewable energy, this "Sustainable Zone" study simply compares the annual amount of renewable energy supply with the amount of energy demand in the region, and indexes it. The installation potential of renewable energy in the specific region or the installation targets have not been evaluated. Meanwhile, in the evaluation method of 100% renewable energy regions in Germany, the target values decided politically by the municipality in the region and the contents of the master plan for the introduction of renewable energy are multilaterally evaluated. It is characterized not only by the areas that have already achieved 100% renewable energy, but also by the regions that are working towards 100% renewable energy. In Japan as well, it is considered necessary to incorporate these evaluation methods and to evaluate and support local governments and regions actively working towards 100% renewable energy.

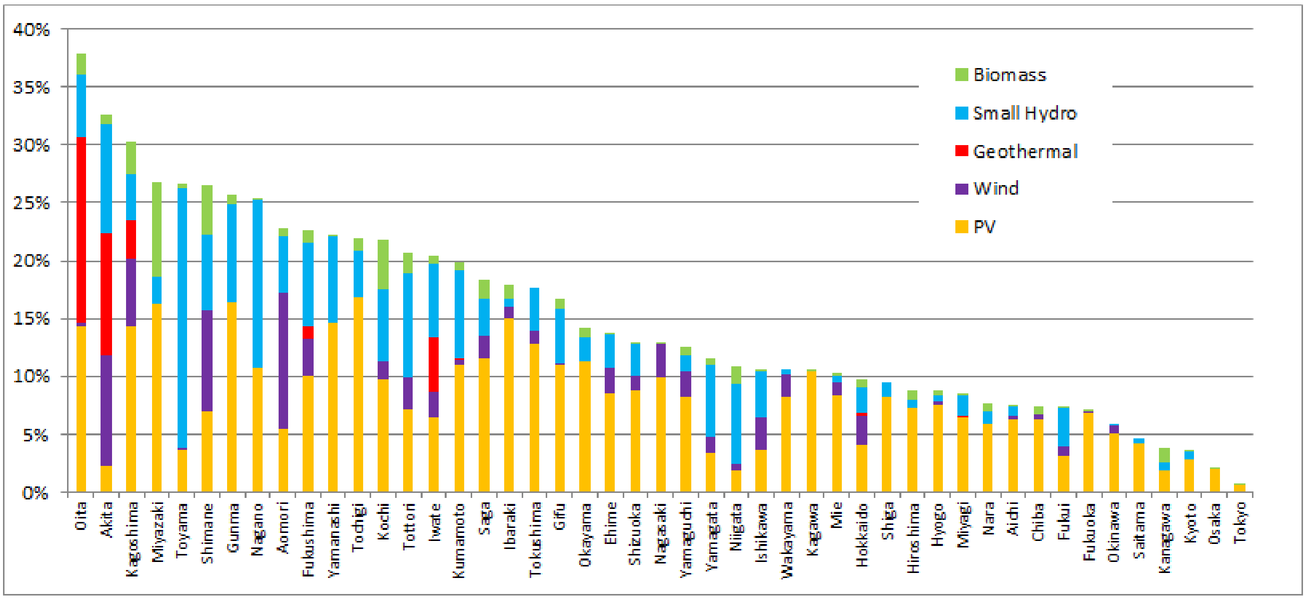

Fig. 19. Ranking of prefectures in electricity share of renewable energy in Japan
(Source: Sustainable Zone study group)

5. Country-specific topics

5.1 Community power in Japan

The first World Community Power Conference was held in Fukushima City in November 2016, the year of the fifth commemoration of the Fukushima disaster and one year after the Paris Climate Agreement. More than 600 people from over 30 countries participated in the conference and discussed the role which community power can play in the global shift towards 100% renewable energy. The participants agreed to the "Fukushima Community Power Declaration", which was expected to become the starting point for a global community power reflection.[27]

Inspired by developments in Denmark and Germany, community power projects started to appear in Japan in the early 2000s, especially after the Fukushima nuclear disaster. This event had a huge impact on people's awareness of community power produced from regional renewable resources in Japan. After the disaster, the population started to take initiatives to work on community-based renewable energy planning and development. 2011 was also the year when the MoE set up a support program for communities to start up renewable energy projects. After FIT was introduced in July 2012, these community power plans flourished. Hotoku Energy in Odawara City, Shizuoka Mirai Energy in Shizuoka City, Tokushima Regional Energy in Tokushima prefecture, and Obama Onsen Energy in Nagasaki prefecture are just some examples. The government and regional agencies then started various support programs for community-based renewable energy. By the end of 2016, nearly 200 community power enterprises had emerged. One of the outstanding characteristics of this community power movement is its diversity of people. Before Fukushima, the projects were often motivated and organized by engaged activists, but after the disaster, people from a broader spectrum joined the renewable energy movement.[28]

5.2 Status of credit system specific to Japan

The Green Energy Certificate, a Japanese non-governmental environmental benefit trading system, makes use of the environmental benefits of renewable energy to tackle climate change. The Green Energy Certification Center (GECCJ) is an independent organization managing the Green Power and Green Heat certification standards.[29] GECCJ certifies renewable energy facilities and also green power or heat generation for the providers of Green Energy Certificates. The providers issue the certificates to the users in need of the environmental value of the certificates. The value includes reducing GHG emissions in Japan, limiting radioactive waste, regional activation, improving energy self-sufficiency, and fostering new industries in the regions. By using the Green Energy Certificates, users can choose to pursue domestic renewable energy and encourage its expansion. In addition to individuals, companies, organizations, local governments, etc., can actively and continuously purchase Green Power Certificates as part of their corporate social responsibility (CSR) activities.

In the green electricity certificate system, electric power is not necessarily delivered to the buyers of the certificates. Instead, certificates can be purchased from issuing organizations while voluntarily paying for a certain amount of renewable electricity to be added to the grid, even if none of that electricity was delivered to the buyer. The certificate-issuing organization entrusts power generation to renewable energy facilities and it certifies that environmental value from renewable energy was added, based on the actual renewable power generation.

Until June 2012, most independent power producers (IPPs) of renewable energy power sold electricity and other environmental value to major power utilities based on the Renewable Portfolio Standard (RPS) law. Under the RPS system, the environmental value of renewable energy production mainly for self-consumption remained in the hands of the power producers. The power producers were able to gain additional revenue by selling the environmental value for green power certificates. Power producers were expected to use the sales revenues of this green power to introduce and maintain new power generation facilities and so lead the further spread of renewable energy. However, as the Fukushima nuclear accident changed citizens' and companies' perceptions about renewable energy from a so-called environmental problem to a more drastic energy problem, and as the FIT system started to put more emphasis on businesses, new IPPs tended to sell electricity under the FIT system. As a result, efforts to sell environmental value as a green electricity certificate became very difficult. However, since the environmental value of self-consumption of existing power stations can be sold as a green power certificate, the market size of green power certificates continues to decrease; a shift is occurring from the RPS system to the FIT system.

Furthermore, after FY 2018, under the FIT system's "non-fossil value trading market", it will be possible to deal with electricity by separating environmental value from electricity with a "non-fossil certificate". In FY 2018 this non-fossil fuel value market will begin an auction and start trading the value of only renewable energy from FIT scheme electricity, without any tracking system of the origin, despite traceability of the origin being very important for the environmental value of renewable energy. It seems that it will be necessary to coordinate this new market with the existing credit scheme, such as green power certificates. Since the full liberalization of the electricity retail market, the number of users seeking electricity with 100% renewable energy and zero CO_2 emissions has increased steadily, and some retail electricity companies have started selling such electricity using green electricity certificates and J-Credits for CO_2 reduction from energy-saving projects, forestry certification, and fuel conversion from fossil fuel to renewable energy. A group of NGOs started the Power shift campaign in 2016 after full retail liberalization of electricity, to promote the supply of renewable- based electricity to a large number of corporate and non-corporate consumers.[30]

6. Policy Recommendations

It is very important to fundamentally transform the existing fossil fuels-based energy system in order to reduce GHG emissions which contribute to global warming. It is necessary to develop renewable energy as the leading countermeasure against climate change. Renewable energy from sources such as solar energy, wind power, geothermal, small hydro power and biomass can provide economic benefits and energy independence for Japan. Thus, efforts should be made towards its fast expansion.

Despite being considered as a climate change countermeasure by some politicians, scientists and economists, nuclear power generation bears serious risks, including the possibility of severe accidents, the problem of nuclear waste storage, and nuclear proliferation. These risks were made evident by the March 11th Fukushima Daiichi nuclear accident. Another proposed climate change countermeasure is carbon dioxide capture and storage (CCS). Since this technology is still difficult to implement, more resources have to be directed towards investigation and further development. Coal-fired power plants should not be constructed anymore. Coal-based technologies clearly undermine the goals of climate change policy.

The FIT system is supposed to maximize the integration of renewable energy. However, nuclear power plants are prioritized without considering the “priority dispatch” necessary for the full-scale introduction of renewable energy. Additionally, major utilities and heavy industries have been successful in lobbying for the elimination of the “priority access” law, which is a serious obstacle to renewable energies. It is essential to reexamine the operation of the FIT system and to give top priority to renewable energy for the sake of sustainability. Furthermore, in order to maximize the installation of renewable energy power generation plants in the future, and to aim for an ambitious national target of renewable energy, it is imperative to first implement reform of the existing electricity system and market such that it can steadily enact these measures. If the current lackluster target remains unchanged, renewable energy that should be given the highest priority will be neglected. Reforms of the existing electricity system and market could put pressure on increased integration. A higher target value for renewable energy in the medium to long-term after 2030 would contribute to achieving a “decarbonized society” by reducing the emission of GHGs to almost zero, including artificial absorption, as indicated by the Paris Agreement adopted at COP 21. To combat climate change, the country’s target value for GHG emission reduction should also be increased as compared to Japan’s INDC, for example in the context of the long-term strategy on climate change which Japan is supposed to submit to the UNFCCC in the near future.

The Organization for Cross-regional Coordination of Transmission Operators (OCCTO) and the Electricity and Gas Market Surveillance Commission (EGC) play a substantial role in Japan, ensuring the neutrality and fairness of transmission and distribution between business operators and the transparency of wholesale power transactions. In order to ensure fairness in the use of the electric power system, an important part of public infrastructure, it is necessary to keep account of connections for local projects and optimize the rules of connection cost sharing. Setting a time limit between the connection contract and actual equipment certification would help to prevent large-scale power generation companies from maintaining empty holds on the system, but this could also make the connection procedure difficult for small and medium-sized companies. Therefore, it is necessary to develop a policy that combines a fast-track procedure for grid connection and “priority access”. Regarding the financial burden of connecting to the electric grid, it is necessary to minimize the burden on the specific power producer. The government must systematically improve the electric power transmission and distribution network. Since this network is infrastructure that serves the whole society, the financial burden should be spread more equally among all parts of the system.

Originally, the idea of an “allowable connection amount” to the electric power system for solar and wind power generation was rather meaningless in Japan, because there was so little renewable energy compared to levels in Europe. Now, however, Japan has an increasingly large share of renewable energy in its system. Yet major utilities have argued for the placing of limitations on variable renewable energy such as solar PV and wind power, arguing that doing so is necessary for the stability of the transmission system. These claims are exaggerated. Japan should be able to respond adequately to renewable energy supply through weather forecasting, the utilization of interconnecting lines between electric power companies, and a decentralized market. The limitation of the connection amount should not be arbitrarily set by METI and the power utility companies. Government and major utilities should steadily prepare for the full use of renewable energy. There should be reforms such as the expansion of a new wholesale electricity market, full liberalization of electricity retailing, and the separation of electricity from power transmission.

In the design and operation of the FIT system, priority should be placed on social acceptance and support for community-led projects for revitalization of the region, and priority connection to the electric power system. In order to avoid troubles in the development of large-scale renewable energy projects such as solar PV in terms of the accreditation requirements for power generation project plans, the social acceptance process should actively disclose information and encourage the participation of local stakeholders.[31] The sustainable development of renewable energy projects requires a considerable degree of consensus to avoid conflict with nature conservation efforts, scenery preservation, and so forth.[32] Furthermore, it is necessary to understand the current problems of regionally dispersed small-scale facilities of less than 1 MW and to provide sufficient support to them, not only through matching the purchase price to the size of the project, but also with procedures such as capacity building and financing.

The purchase price of biomass power generation should take into consideration the type of fuel, equipment size, sustainability of fuel, and presence of heat supply. Detailed conditions have to be set, such as the scale and type of fuel, and it is necessary to set the certification conditions and purchase prices for each. In particular, with regard to woody biomass, it is necessary to set an upper limit of the power generation scale (for example, about 20 MW) based on operating expenses, including equipment costs and fuel procurement costs. It is also necessary to ensure the traceability and sustainability of fuel procurement and to determine the procurement price according to the scale of power generation. Especially for imported materials targeted for general timber, standards for certification and procurement should be set with reference to EU and ISO sustainability standards for solid biomass.

For the utilization of renewable energy in the thermal field, it is important to develop boilers for heat utilization and an infrastructure for heat supply. Up to now, three types of renewable energy have been used extensively in the thermal field in Japan. The most popular is solar heat, followed by geothermal heat (the energy that heats hot springs) and biomass heat that uses forest resources. However, in view of the widespread use of relatively inexpensive heat-utilizing equipment that harnesses fossil fuels, there are various problems in the dissemination of renewable heat energy. As the price of fossil fuels rises, the effectiveness of heat utilization as an alternative renewable energy has been pointed out, but full-scale dissemination has not progressed in Japan. To improve this, it is necessary to develop infrastructure such as a regional heat supply for heat utilization, like in Europe.

Regarding the use of solar heat, solar water heaters were widely used in the 1980s after the oil shock, but their quality was not high and they were not very reliable. As a result, their sales have been sluggish since then. Because solar system equipment can be combined with other heat sources, dissemination in various combinations could be promoted for households and businesses. The use of geothermal heat is well known in hot springs for bathing. This heating value has been used to offset the need to burn fossil fuels. In addition, by utilizing the stable temperature in the ground, geothermal heat can be used to increase the energy efficiency of cooling, heating, and hot water supply. Heat utilization of forest-based biomass includes large-scale biomass boilers attached to paper mills and sawmills that use wood chips and pellets. High-performance woody biomass boilers have been developed, mainly in European countries since the oil shock of the 1970s. As in Europe, modern boilers capable of automatic operations are expected to play a major role in the supply of renewable energy heat, because a combustion efficiency of more than 90% is possible, there is less soot, and automatic operation is possible.

Realizing 100% renewable energy regions is important not only for climate change mitigation but also for the independence of regional economies. But so far, even in those regions of Japan that are rich in renewable energy resources, most of the energy supply comes from outside the region. This is one of the reasons why achieving independence of regional economies is difficult. If a region is able to self-sufficiently run on renewable energy, it can export surplus energy outside the region as value-added energy. The economic effects of 100% renewable energy scenarios will endure for the long-term. The energy infrastructure can then be handed down to the next generation. Considering this, it is necessary for local governments and related enterprises to establish long-term targets for 100% renewable energy and to formulate a basic plan for realizing this goal with local energy policies. Additionally, it is important to create a foundation for stakeholders in the region to collaborate on projects. As for building infrastructure, there are various issues such as human resources development, the creation of bases, the scheme of commercialization, the formation of business entities, the financial scheme, etc. The national government, prefectures, and intermediate support organizations need to build up a support system for this infrastructure.

To tackle climate change, support of activities should be focused on projects aimed at 100% renewable energy regions, and their connection in order to share best practice. Thereby, it is worth putting the focus on activities such as the "Global 100% Renewable Energy Campaign".[33] In these activities, bottom-up engagement by local communities and the participation of citizens is especially important.

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List of Abbreviations

AC	alternating current
ANRE	Agency for Renewable Resources and Energy
BNEF	Bloomberg New Energy Finance
CCS	carbon dioxide capture and storage
CDM	Clean Development Mechanism
CSR	corporate social responsibility
EEG	German Renewable Energy Sources Act
EGC	Electricity and Gas Market Surveillance Commission
EIA	environmental impact assessment
EPCO	electric power company
FIT	feed-in-tariff
FY	fiscal year
GDP	Gross Domestic Product
GECCJ	Green Energy Certification Center
GHG	greenhouse gases
INDC	Intended Nationally Determined Contribution

IPP	independent power producer
IRENA	International Renewable Energy Agency
ISEP	Institute for Sustainable Energy Policies
JAPC	Japan Atomic Power Company
JEPX	Japan Electric Power Exchange
JNFL	Japan Nuclear Fuel Limited
JPEA	Japan Photovoltaic Energy Association
JWPA	Japan Wind Power Association
KEPCO	Kansai Electric Power Company
LNG	liquid natural gas
METI	Ministry of Economy, Trade and Industry
MoE	Ministry of Environment
NDC	Nationally Determined Contribution
NPP	Nuclear Power Plant
NRA	Nuclear Regulation Authority
OCCTO	Organization for Cross-regional Coordination of Transmission Operators
PKS	palm kernel shells
PPS	power producer and supplier
PV	photovoltaic
RE	renewable energy
RPS	Renewable Portfolio Standard
T/D	transmission & distribution
TEPCO	Tokyo Electric Power Company
TSO	transmission system operator
UNEP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
VRE	variable renewable energy
WG	working group

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