The Potential & Challenges of Renewable Energy Deployment in Japan

By Hiroko Nakamura

Author
Hiroko Nakamura

In fiscal 2020, Japan's total power generation was 1,001 terawatt-hours (TWh), with 19.8% of the electric power supply generated from renewable energy (hereafter "renewable power"), including large scale hydropower. The share of renewable power has almost doubled from fiscal 2011 levels (10.4%). The Feed-in-Tariff (FIT) scheme introduced in July 2012 has contributed greatly to this massive increase. However, given the high surcharges under the FIT scheme shouldered by consumers, amounting to a total of around 2.7 trillion yen in fiscal 2021, an auction scheme was introduced for larger projects in 2017. In April 2022, a Feed-in-Premium (FIP) scheme will be introduced with the intention of encouraging power generators to act more in line with market trends.

With Cabinet approval of the Sixth Strategic Energy Plan, Japan has welcomed the new year with a new renewable deployment target for the electric power mix in 2030. This paper will examine current trends and challenges of renewable energy deployment in Japan.

How Challenging Are Japan's Renewable Energy Targets?

The Sixth Strategic Energy Plan, approved by the Cabinet in October 2021, renewed Japan's renewable energy targets. The new overall target aims to have an "ambitious" renewable power mix of 36-38% in 2030 compared to the previous target of 22-24% set out in the Strategic Energy Plan published in 2018. This amounts to a total of 336-353 TWh of renewable power, calling for installed capacity of 103.5-117.6 gigawatts (GW) of solar power, 23.6 GW of wind power (17.9 GW onshore, 5.7 GW offshore), 1.5 GW of geothermal power, 50.7 GW of hydropower, and 8 GW of biomass.

How does this compare to previous targets? The renewed targets do not call for significant increases in hydropower and geothermal power, but require efforts to upscale solar power, wind power, and biomass for which previous targets were 64 GW and 10 GW, and 6.02-7.28GW, respectively *(Chart 1)*. The installed capacity of these sources stood at 62.4 GW, 4.6 GW and 5.4 GW, respectively, as of June 2021. Taking into consideration the capacity of facilities already approved under the FIT scheme yet to be commissioned, an additional 22.6-36.7 GW will be needed to meet the renewed target for solar power, and an additional 7.7 GW for wind power. However, even the offshore wind projects for which winning bidders were recently selected will only come online in 2028 at the earliest.

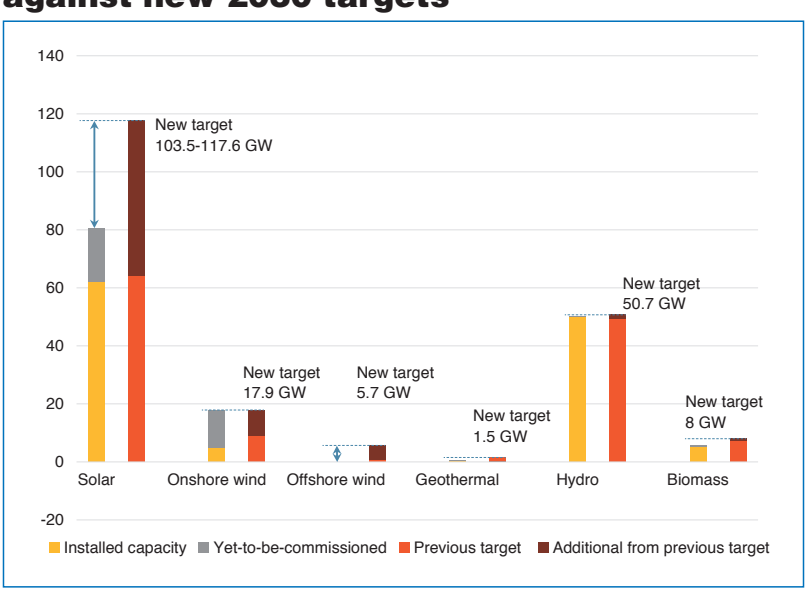
This paper will focus on the three sources that require significant efforts in increased deployment: solar power, wind power and biomass.

Solar Power – Main Driver of Renewable Energy Deployment

Solar power has been the main driver of renewable energy deployment in Japan *(Chart 2)*. Japan's increases in renewable energy will need to continue to rely on solar power in the short term, due to the shorter lead time required to install solar power generation facilities and the cost reductions already achieved for this technology. In order to achieve the renewed 2030 target, Japan will

CHART 1

Status quo of renewable energy deployment against new 2030 targets

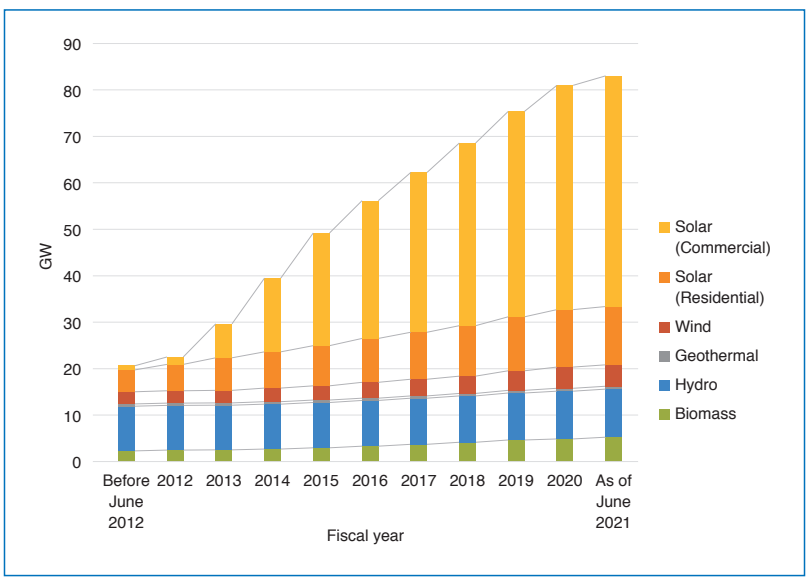


Source: Compiled by the Institute of Energy Economics, Japan based on published METI data

have to deploy 4-5.5 GW every year during the coming decade. However, with a FIP scheme to be newly introduced this year, a wait-and-see mood is expected to prevail in solar investments this year.

CHART 2

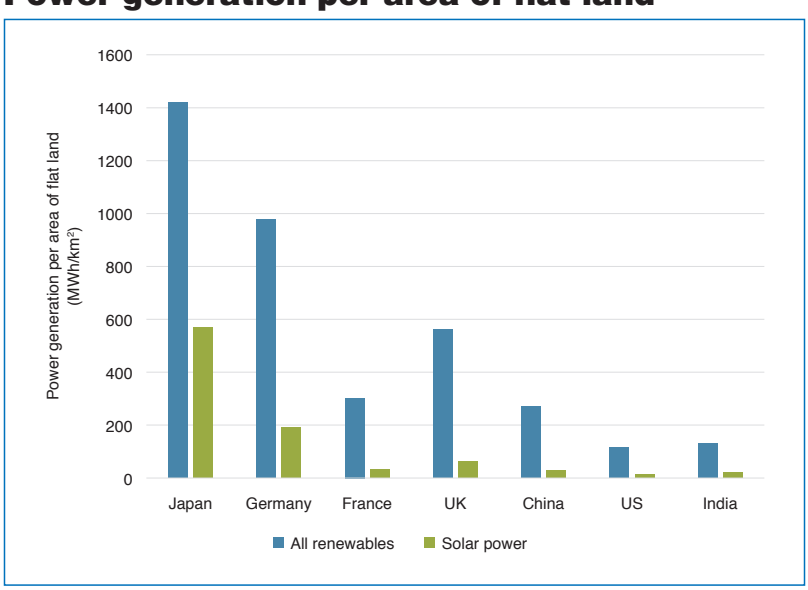
Renewable energy increases in Japan under the FIT scheme



Source: Compiled by the Institute of Energy Economics, Japan based on published METI data

CHART 3

Power generation per area of flat land



Source: Compiled by Institute of Energy Economics, Japan based on published METI data and IEA (2021) Renewables 2020

Overcoming land restrictions

Further increases in solar power entail many challenges. Japan already has the third-largest installed capacity of solar power in the world, only after the United States and China. The amount of solar power generated per area of flat land tops all other countries with 570 MWh/km^2. Germany follows with 190 MWh/km^2, or only one-third the figure for Japan *(Chart 3)*. This indicates the limits faced by Japan in increasing solar power generation.

Social acceptance has become another challenge. Natural disaster-induced accidents and landscape conservation issues have aroused local resistance against utility-scale solar power projects. This has led to a recent increase in the number of local ordinances that regulate the siting of solar power facilities. Therefore, in addition to the objective judgment of whether an accident is really attributable to the siting or if there were problems with the construction, there is a growing need for fostering good relations with the local community, which often have a sense of ownership of local natural resources or the landscape and ecosystem that it is a part of. Developers should make efforts to foster a win-win relationship with local communities, for example by demonstrating how the facility can be counted on for disaster relief. Local governments can play a key role in representing local values and ethics. To this end, the government seeks to initiate positive zoning measures and support local development plans for renewable energy.

In 2021, the Ministry of Agriculture, Forestry and Fisheries eased a requirement for farmers who install solar panels on abandoned farmland to produce 80% or more crops per square meter compared with the regional average. This will help promote agrophotovoltaics, which have become mainstream in many parts of Europe where such projects now represent a large share of winning bids in renewable power auctions. The Cabinet has recently approved a bill to facilitate the utilization of land plots with unknown owners. When this bill becomes law, more land area will be available for the installation of renewable power facilities.

Future applications

With the end of the FIT scheme for projects exceeding 1MW, onsite power purchase agreements (PPAs) are expected to continue to increase in the short term, mainly for self-

TABLE

Results of 2021 offshore wind power auctions

Area (capacity)	Goto (16.8 MW)			Akita Noshiro Mitane Oga (478.8 MW)			Akita Yurihonjo (819 MW)			Choshi (390.6 MW)		
Winning bidder	**Toda Corp-led consortium**			**Mitsubishi Corp-led consortium**			**Mitsubishi Corp-led consortium**			**Mitsubishi Corp-led consortium**		
Bidders	**T**	**P**	**F**	**T**	**P**	**F**	**T**	**P**	**F**	**T**	**P**	**F**
1)	**207**	**120**	**87**	**208**	**120 (13.26)**	**88**	**202**	**120 (11.99)**	**82**	**211**	**120 (16.49)**	**91**
2)	–			161.52	87.52 (18.18)	73	156.65	83.65 (17.00)	73	185.6	87.60 (22.59)	98
3)	–			157.77	93.8 (16.97)	64	149.7	58.73 (24.50)	91	–		
4)	–			149.35	71.4 (22.30)	78	144.73	78.2 (18.40)	66	–		
5)	–			127.04	69.0 (27.00)	68	140.20	62.58 (23.00)	78	–		

Notes: 1) – 5) indicate the ranking of bids. T stands for total; P for price score (total 120 points); F for feasibility score (total 120 points). Prices (yen/kWh) are provided in brackets for each bidder, calculated based on the price score, which represents the ratio to the winning bid.
Source: Compiled by the Institute of Energy Economics, Japan based on the joint press release by the Ministry of Economy, Trade and Industry (METI) and the Ministry of Land, Infrastructure and Transport (MLIT) dated Dec. 24, 2021

consumption in the industrial and commercial sectors. PPAs, which do not require upfront capital costs, will be an attractive option for public buildings, for which the government seeks to make the installation of solar panels mandatory by 2040. In the residential sector as well, a real estate developer has announced that it will install solar panels on all new residential buildings, using a PPA model.

Promising future applications for solar power are building facades, automobiles, roads and greenhouses. Innovative solar photovoltaic technologies can enable the application of solar modules to places that we could never imagine before due to their lightweight and flexible features. At the end of last year, a national research and development agency, the New Energy and Industrial Technology Development Organization (NEDO), announced plans to allocate 20 billion yen for the development of perovskite photovoltaic technologies, for which Japanese companies have demonstrated world-leading power conversion efficiency levels and innovating coating methods that greatly reduce production time and costs.

Offshore Wind Momentum

Japan initially introduced onshore wind power in the 2000s, but its deployment has been slow, accounting for only 0.9% of total power generation in fiscal 2020. According to the Japan Wind Power Association (JWPA), Japan bears the potential for around 128 GW of fixed offshore wind power in shallow ocean areas 10-50 meters deep and around 424 GW of floating wind power in areas 100-300 meters deep. Most of these areas are located in the regions of Hokkaido, Tohoku and Kyushu.

The year 2021 was a landmark year for offshore wind power, a promising technology for Japan, given its limited flat land area with optimal wind conditions. The government held the first round of auctions for offshore wind projects in sites designated as promotion zones under the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities. The first auction was held for a project off the coast of Goto city in Nagasaki Prefecture. Only one bidder responded to the call and the result was finalized in June. Auctions were also held for three projects in the sea area offshore Noshiro city, Mitane town and Oga city, all in Akita Prefecture; the sea area offshore Yurihonjo city in Akita (northern and southern sides of the prefecture); and the sea area offshore Choshi city in Chiba Prefecture. The winning bidders for all three projects were announced on Dec. 24, 2021 *(Table)*.

The auction results for the three projects aroused both optimism and concerns for the future of offshore wind power development in Japan. The price target for offshore wind power in 2030-35 has been set at 8-9 yen/kWh. This had been considered an ambitious target compared to the FIT price of 36 yen/kWh for fixed-bottom offshore wind power initially determined in fiscal 2014. The winning bid for the Akita Yurihonjo project (11.99 yen/kWh) was less than half of the bid cap (29 yen/kWh) and offered reality to the feasibility of the 2030-2035 target.

Hopefully, the fact that consortiums led by the same corporate group won all three auctions with an outstandingly competitive price will not discourage future bidders from working closely with local stakeholders to foster good relations. A significant feature of the current Japanese auction scheme is that once a promising area for offshore wind projects is selected, a council comprising interested

parties, including local government and fishery cooperatives, is assembled to discuss the designation of a promotion zone and aspects the auctions should consider. The price score and feasibility score, which includes local considerations, are equally allocated 120 points. As aforementioned, fostering local understanding is essential for successful renewable power projects. While we have yet to see how these projects will play out, hopefully the Japanese auction model will set a promising example for other Asia-Pacific countries sharing similar circumstances, including those pertaining to local resource management.

Commenting on the auction results, Minister of Economy, Trade and Industry Koichi Hagiuda mentioned his idea to consider a scheme that would facilitate the participation of other players. The large-scale deployment of offshore wind power, which requires as many as 10,000-20,000 components, promises to have positive impacts on domestic industry. As turbines get larger, suppliers will have a larger incentive to develop and enhance local supply chains to reduce transportation costs. A wider range of project operators would allow for the diversification of the supply chain. However, the recent auction results could be a sign of early market consolidation in Japan.

Revisiting the Value of Domestic Biomass Resources

Biomass power generation accounted for 2.9% of Japan's total electric power generation in fiscal 2020. It used to have the largest renewable share in Japan's electric power mix before it was surpassed by solar power in fiscal 2014. The government has promoted the deployment of biomass power generation through the FIT scheme, but biomass power generation facilities of 10 MW and more will be covered by the FIP scheme from April 2022. "Locally integrated" projects contributing to enhancing local resilience and/or promoting the consumption of local products will remain eligible for the FIT scheme.

Japan faces several challenges in increasing biomass power generation, which requires a stable fuel supply. Many large-scale biomass-fired power plants currently rely on imported palm kernel shell (PKS) and wood pellets that can be procured stably. However, not only are these imports expensive, the use of PKS, in particular, is internationally debated from the perspective of socially and environmentally ethical supply chains.

With around two-thirds of its land covered with forest, Japan is home to a promising source of domestic woody biomass. Using domestic resources will increase the energy self-sufficiency rate, improve its resilience against natural disasters and contribute to the management and utilization of domestic forests, much of which have been left unmanaged for many years. Biomass power generation therefore promises to bring enormous local economic benefits, including employment. Government efforts to promote the use of forest residue and thinned wood have led to their increased use. However, fuel costs, which account for 70% of biomass power generation costs, still need to be reduced to ensure continued operation after the FIT expires.

The current forestry system has been developed mainly for high-value building materials, mostly made of conifers. Much domestic woody biomass for energy use is produced from thinning residues and other material that could not be used for building purposes. Because woody biomass for fuel use is a byproduct, it is difficult to forecast supply. Furthermore, the collection and transport system has been tailored to the needs of bulky lumber and should be made more cost-efficient for woody biomass for fuel use. This has disincentivized many biomass power generators from using domestic biomass and instead rely on more stable imported supplies.

Broadleaf trees, which comprise around 30% of forest accumulation in Japan, are not widely used for construction because they tend to grow crookedly. Therefore, systems to transport woody resources out of broadleaf forests are underdeveloped in many parts of Japan. We have yet to seek ways to harness these abundant domestic resources in a sustainable way. Thinning unmanaged forests will contribute to sustainable forest management and thus local water management. Securing demand would also contribute to the stable development of the local forestry industry. Domestic hardwood pulp materials may also be used in the pulp and paper industry, which also relies heavily on imported resources.

Planting fast-growing trees exclusively for fuel use can also save time and costs. The commercial use of fast-growing trees will lead to increased revenue for local forestry workers. Local procurement of woody biomass for power generation can create a sustainable win-win relationship between the forestry and power sectors.

Challenges pertaining to the use of woody biomass in power generation include retaining the quality of woody biomass resources, such as the moisture content which can affect the capacity factor. Local providers of biomass may develop drying processes or secure storage facilities to increase the value of their woody biomass products. Yet there is no standardization scheme in place to evaluate the quality of these products.

It will also be important to verify lifecycle GHG emissions, as well as to certify that woody biomass products are from sustainably managed forests. While biomass is considered a carbon neutral energy source, it should be kept in mind that if large amounts of fossil fuels are used along the supply chain, its CO_2 emissions could exceed the amount absorbed during photosynthesis. The government has been addressing such supply chain issues. Currently, there is limited information on the availability and distribution of woody biomass products. A transparent system visualizing supply and demand, tracing the origin of resources and tracking GHG emissions will be called for as more biomass is used in the power sector.

Other Challenges & Potential Solutions

Increasing renewable energy – especially variable renewable energy – in the power grid entails various challenges, including those associated with power transmission, supply-demand balancing and energy storage.

As aforementioned, offshore wind power is found in the Hokkaido, Tohoku and Kyushu regions, located far from the major urban electric power consumption areas. A masterplan for a transmission network based on the Sixth Strategic Energy Plan and the potential project areas is being discussed under METI. Related cost allocation is another topic of ongoing discussions.

Energy storage is also an issue to be highlighted in the massive integration of variable renewable energy in the power grid. Pumped storage and battery technologies are key solutions to providing flexibility to the grid. Grid-scale battery energy storage systems (BESS) can smooth out output fluctuation and thus contribute to accommodating high shares of renewable energy. Japan is a global leader in the development of various battery technologies but further cost reductions are called for.

Surplus renewable power can also be used to produce hydrogen, which can be stored for longer periods of time in fuel cells. A power-to-gas (P2G) system using a water electrolysis process to use electricity to split water into hydrogen and oxygen can provide grid balancing services and demand management. A hydrogen utilization business model that optimizes the exploitation of hydrogen both as a commercial commodity and an energy source for balancing the supply and demand of the electricity grid is currently being demonstrated at Fukushima Hydrogen Energy Research Field (FH2R), which only recently supplied fuel for the relay torch and hydrogen-powered vehicles used at the Tokyo Olympics and Paralympics Games. Since hydrogen can be used in sectors other than power generation, the P2G model is an optimal solution for energy system integration, or sector coupling.

Another issue often overlooked is the secure procurement of metals that will be required in large quantities as the world shifts to low carbon forms of energy and to the massive deployment of renewable energy. In addition to the rare earth and rare metals required for various battery and fuel cell technologies, metals such as copper will be required in greater amounts not only for electric mobility but also for wind and solar power facilities.

New Frameworks for Promoting Renewable Energy

The year 2021 saw many demand-driven changes in the market framework of renewable power procurement. Amid the growing momentum for achieving carbon neutrality, this trend was largely led by major companies seeking to procure large amounts of renewable power with “additionality” in Japan.

Japan’s Renewable Energy Value Trading Market held its first auction in November 2021. Renewable energy value had been traded in the Non-fossil-Value Trading Market, open only to electricity retailers, who purchase credits to fulfill their obligation under the Act on Sophisticated Methods of Energy Supply Structures to achieve a non-fossil electricity ratio of at least 44% in their electricity sales by 2030. The newly launched market, which was detached from the Non-fossil-Value Trading Market, allows consumers to directly purchase renewable energy value certificates.

Some key discussion points in launching the Renewable Energy Value Trading Market were the nature of the FIT certificates – whether they would simply guarantee renewable energy sources or if they would function as a guarantee of origin – and price levels. The development of a permanent tracking scheme for certificates is underway.

Japan saw a significant increase in onsite and physical (offsite) PPAs in 2021. A number of milestone physical PPAs between developers and consumers were signed with registered retailers under the Electricity Business Act. METI changed the rule in November 2021 so that corporate consumers can use the self-wheeling program for electricity generated at new sites owned by other companies. The benefits of the self-wheeling program, which include a smaller wheeling fee and exemption from surcharges, could previously only be enjoyed for transferring self-generated electricity to other locations through the grid. Sometime in the near future, a deregulation of Non-fossil Value Credits market rules may allow direct virtual PPA contracts between developers and consumers.

Conclusions

It is often speculated whether or not the ambitious goals set out in the new Strategic Energy Plan can be met. However, in our drive toward a decarbonized society, the question is how we can achieve it. Despite the various challenges associated with massive deployment and integration of renewable energy, there is still much unlocked potential. Creative market and business models, as well as innovative technologies, will help harness our renewable resources in a sustainable way. JS

Hiroko Nakamura is a senior researcher at the Institute of Energy Economics, Japan. She has a Master’s degree in Education from Kagawa University and a B.A. in Law from Keio University. Her expertise is in climate policy, renewable energy and hydrogen policy, and participative democracy in energy policy.