自然エネルギー財団
RENEWABLE ENERGY INSTITUTE

Summary

Proposal for the 2035 Energy Mix (First Edition)

Toward Decarbonizing Electricity with Renewable Energy

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Chapter 1: Accelerating the energy transformation to overcome the climate and energy crises

The 2022 G7 leaders' communiqué agreed “to commit to achieving a fully or predominantly decarbonized power sector by 2035”. A review of national policies and development trends shows that, with the exception of France, five countries have set a target of supplying 70% or 80% of their electricity from renewables by 2035, or are taking measures in this direction.

The Green Transformation (GX) Basic Policy, decided by the Japanese Government in February 2023, does not raise the target of 36%–38% renewables by FY2030 nor does it mention about decarbonization pathway target for 2035. The Kishida Government's emphasis in the GX Basic Policy is on the use of nuclear power and 'zero-emission thermal power', neither of which are expected to generate significant supplies in the 2030s, nor are they sustainable sources of generation. It is not a rational choice in terms of cost.

Considering the GX Basic Policy, the only way to achieve an electricity mix in 2035 in line with the IPCC 1.5-degree decarbonization pathway is to further accelerate the introduction of renewable energy sources, which are becoming increasingly cost-effective in Japan. If Japan fails to expand renewable energy, it will not be able to achieve the emission reductions proposed by the IPCC by 2035. In addition, Japan's dependence on fossil fuels and the high emission factor of electricity will make it an unsuitable location for businesses. While the delays and distortions in national policy are serious, Japan inherently has abundant renewable energy potential, and companies, local governments, and communities are taking various progressive steps to utilize this potential. If national energy policy can be transformed by accelerating the movement of these non-state actors, it is entirely possible for Japan to achieve a 2035 decarbonization pathway electricity mix in which the vast majority of electricity will be supplied by renewables.

Chapter 2: Solar PV development potential

Since the introduction of the FIT system in 2012, solar power generation has increased, reaching 79.2 GW by the end of FY2021. The cost of power generation in Japan, which was relatively high compared to international standards, has been declining and is estimated to reach 5 JPY/kWh by 2030. Up to now, the introduction of ground-mounted large-scale solar power generation has been the driving force. However, the biggest driver towards 2035 will be solar installed on building rooftops. The introduction of solar PV not only in new buildings but also in existing buildings is increasing due to the fact that solar PV is now cheaper than grid electricity and the development of lightweight, space-saving solar panels. By accelerating this trend through the introduction of appropriate regulation and guidance measures, it is possible to increase this fivefold from 31.6 GW at the end of FY2021 to 159 GW by the end of FY2035. In the case of ground-mounted systems, solar sharing coexisting with agricultural operations and the use of abandoned land are progressing, and installation has also started in parking lots, on infrastructure lands such as roads, airports, and railways, and on water surfaces. Together, these could increase by 2.5 times from 47.6 GW at the end of FY2021 to 121.2 GW by the end of FY2035. Combined with rooftop and ground installations, 280.2 GW of solar PV could be installed by the end of FY2035, generating 343.7 TWh of electricity.

Chapter 3: Wind power development potential

The introduction of wind power in Japan has lagged far behind, standing at 4.6 GW at the end of FY2021. Offshore wind power was only 135 MW. This delay is due to the restriction to connecting to the grid and lengthy environmental assessment procedures. On the other hand, Japan has great potential for wind power generation, which according to a survey by the Ministry of the Environment amounts to 264 GW onshore and 392 GW offshore, for a total of 656 GW. For onshore wind power, the total installed capacity of projects currently undergoing environmental assessment procedures is 29.7 GW. Based on an assumption of the extent to which projects are scaled down or cancelled due to environmental conservation considerations and other factors at each stage of the assessment procedure, and after examining the status of applications for connection contracts to the power grid, it was estimated that 34.4 GW could be installed by 2035 if various regulations are relaxed and environmental assessments are accelerated.

In offshore wind, the total installed capacity of projects undergoing environmental assessment procedures is 18.6 GW, if overlaps in the same sea area are excluded. Taking into account the status of procedures under the Renewable Energy Sea Area Utilization Act, it is estimated that 14.3 GW will be in operation by 2035. In addition to this, the introduction of new projects, including floating projects, could be expanded to a total of 25.4 GW by accelerating the formation of new projects and the designation of promotion areas. As a result, the total installed capacity of onshore and offshore wind power generation is estimated to reach 59.8 GW, with an estimated generation of 174 TWh.

Chapter 4: Potential for non-variable renewables

The introduction of bioenergy power generation has increased due to the FIT scheme, with 6.4 GW in operation at the end of June 2022. Outside of the FIT scheme, it can be assumed that the existing coal-fired power used for on-site industrial power generation will be converted to 100% biomass as an emission reduction measure. Based on this situation, the installed capacity of bioenergy power generation is estimated to be 9.2 GW in 2035, with a generation capacity of 85.7 TWh.

The total installed capacity of hydropower (excluding pumped storage) at the end of FY2021 was 22.5 GW, of which 9.8 GW was small and medium hydro of less than 30 MW in size. The amount of electricity generated is 77.8 TWh. For large hydropower, a certain increase in electricity generation is expected due to the refurbishment of facilities. Small and medium hydropower is estimated to increase by 2 GW in the future, based on the introduction trends to date. Based on the above, hydropower generation is projected to be 99.6 TWh in 2035.

Japan's geothermal power potential is estimated to be around 23 GW, the third largest in the world. However, as of FY2021, only 0.54 GW of installed capacity was in operation and only about 2.3% of geothermal resources were being utilized. The development of geothermal power generation requires a resource survey, a grid connection to the area where the power plant is to be installed, and the formation of an agreement with the surrounding hot spring operators. The current lead time for geothermal development is more than seven years. Fundamental institutional reforms are needed to utilize the great potential of geothermal power generation. By implementing these institutional reforms promptly, it is assumed that the installed capacity will increase by 1 GW by 2035, with an annual electricity generation capacity of 11.5 TWh.

Chapter 5: Electricity supply mix in 2035

Electricity demand outlook in 2035

In order to achieve the emission reductions by 2035 proposed by the IPCC, it is necessary to thoroughly promote energy efficiency and electrification on the demand side as well as decarbonization on the supply side. In particular, it is important to reduce energy consumption by shifting to a circular economy in the future. While electrification increases electricity demand, it also increases energy efficiency, as exemplified by heat pump equipment, which can limit the increase in electricity demand.

Based on this consideration, final energy consumption and electricity demand in 2035 were estimated for the industrial, commercial, residential, and transport sectors. The industrial sector, particularly the steel industry, which accounts for nearly half of the industrial emissions, is expected to convert 15% of blast furnaces that will reach the end of their lifetime by 2035 are expected to be converted to electric furnaces. In the transportation sector, we assumed a policy shift from the use of hybrid passenger cars to the promotion of EVs. In the commercial and residential sectors, efficiency improvements through equipment upgrades, the use of heat pumps for air conditioning and hot water supply, and improvements in building insulation and heat shielding performance can be expected. Through the promotion of these measures, final energy consumption in FY2035 was estimated to be 24% lower than in FY2019, and electricity demand was estimated to be 850 TWh, 8% lower than in FY2019, even with the promotion of electrification.

Projected supply potential of each power source

Renewable energy generation

When the potential deployment of each of the renewable sources estimated in Chapters 2 to 4 is added together, it is assumed that the amount of electricity generated from renewables in 2035 can be expanded to 714.5 TWh. This is more than three times the current level and more than twice the government target of 353 TWh for FY2030. Solar PV deployment needs to increase to 3.5 times the current level by 2035, while the European REPowerEUPlan aims for a fourfold increase by 2030. Wind power will need to increase by a factor of 13 by 2035, which is a more rapid expansion than solar power. However, this is a lagging result of the current installed capacity of only 4.6 GW and only 135 MW of offshore wind power. Based on the experience of the countries that have led the way, it is entirely possible to achieve this high target by taking the measures and regulatory reforms proposed in Chapter 6. In addition, decreasing costs, technological development, and progress in regulatory reform may make it possible to introduce more than this time envisioned.

Nuclear power generation

The roadmap in the GX Basic Policy does not envisage the operation of new reactors as of 2035. As of March 2023, only 10 (10 GW) of the 33 (33 GW) reactors in Japan were in operation, and of these, only two will be operational in 2035. If we add to this the two reactors that are not in operation at the moment but have passed the new regulatory standards and have a scheduled start-up date, a total of four reactors will be able to supply approximately 17 TWh of electricity, which is only 2% of the forecast demand in 2035. A maximum of 16 reactors would operate and may supply 11% of power in FY 2035 if all the following assumptions are realized, which would be extremely difficult to achieve: (i) all reactors under review will restart, (ii) all the reactors that have applied for 60-year operation are granted an extension, and (iii) the two reactors under construction go into operation. This estimate assumes a capacity factor of 70%, but existing nuclear power

plants are not immune from the effects of aging, and the operating rate is expected to decline due to frequent problems. Furthermore, half of the 14 existing reactors, seven reactors will cease operation by 2038.

Fossil fuel power generation

At the end of FY2021, there were 50.4 GW of coal, 79.1 GW of natural gas, and 22.7 GW of oil-fired power generation capacity in Japan. In terms of generation share, coal accounted for 31%, natural gas 34.4%, and oil and waste 7.4%, with fossil fuels accounting for 72.8% of total electricity generation in FY2021. The government intends to continue using coal-fired power generation beyond the 2030s through ammonia co-firing and the use of CCS, but cutting emissions of thermal power generation in this way is not a reasonable option in terms of both emission reduction effectiveness and cost. The government's CCS strategy also aims to export and store carbon dioxide emitted domestically to Southeast Asia and elsewhere. Coal-fired power generation needs to be phased out by 2030.

Natural gas-fired power generation needs to be phased out as well, as soon as possible, but it will supply the part that renewables cannot supply until achieving 100% renewables. If we assume the 79 GW of existing facilities will be shut down after 40 years of operation and even if the construction of 2.3 GW of facilities that are planned but not yet built are suspended, there will still be approximately 58 GW of natural gas-fired capacity in 2035. Assuming that these generating facilities operate at 70% of capacity, a supply of 356 TWh would be possible. This corresponds to 42% of the electricity demand assumed earlier.

The shape of the 2035 electricity mix toward decarbonization

Renewable energy sources, mainly solar PV and wind power will supply 714.5 TWh, or 80.3% of the total power supply requirement of 890 TWh (850 TWh of electricity demand plus transmission losses) envisaged for 2035. The remaining 175.5 TWh will be supplied by natural gas. Coal-fired power generation is not envisaged to be used. Nuclear power generation is not assumed to be used, as it cannot be assessed as a sustainable power source, although it could supply up to 11% of the electricity in 2035, according to our calculations.

This decarbonization pathway electricity mix would reduce carbon dioxide emissions from the power generation sector by 73.2%. The overseas fossil fuels import cost required for thermal power generation can be significantly reduced by JPY 4.209 trillion, from JPY 5.368 trillion to JPY 1.159 trillion annually. As 80% of electricity would be generated from domestic renewable energy resources, this would contribute to increased energy self-sufficiency and strengthen energy security.

Decarbonization Pathway Electricity Mix in 2035

Source of Electricity		Generation (TWh)	Share (%)
Renewable Energy	Solar	343.7	38.6
	Wind	174.0	19.6
	Geothermal	11.5	1.3
	Biomass	85.7	9.6
	Hydro	99.6	11.2
	Subtotal	714.5	80.3
Fossil Fuel	Natural Gas	175.5	19.7
Total		890.0	100

Source: Renewable Energy Institute

Chapter 6: Proposals for 2035 decarbonization pathway electricity mix

1. Promptly revise the Strategic Energy Plan, with a 2035 renewable energy target of 80%

As a first step towards decarbonizing power sources as of 2035, the current Strategic Energy Plan renewable energy target needs to be revised to at least 80% in 2035 as the cornerstone of national energy policy. In conjunction with this, the annual roadmap for the introduction of solar power, wind power, etc. will be presented to enhance the predictability of investment. This will also support the formation of a domestic supply chain to supply renewable energy generation facilities.

In the Strategic Energy Plan, which was first revised in 2014 after the Great East Japan Earthquake and Fukushima Daiichi Nuclear incident, the government set the 2030 renewables target at a low level of 22-24% and left it unchanged in the 2018 revision. This should not be repeated in the next revision.

2. Implement regulatory reforms to significantly accelerate the introduction of wind and solar power

Wind power development in Japan remains significantly lower than in Europe, the U.S., and China, and acceleration of deployment is the most important issue to achieve power source decarbonization by 2035. What is needed to accelerate the deployment of wind power is to speed up the permitting process, accelerate the development impact assessment process, and improve the process for coexistence with local communities. In particular, in terms of speeding up licensing procedures, it is necessary to centralize procedures that span multiple administrative agencies and shorten the time required to review safety standards for power generation facilities.

To accelerate the deployment of solar PV, the installation of PV systems in new buildings, including residences, should be made mandatory nationwide, as Tokyo metropolitan government and Kawasaki city have done in the past. In addition, for existing buildings, it is necessary to promote 100% installation in public buildings by 2035 and to work on the diffusion of lightweight PV systems.

3. Reform of the electricity system with a focus on the separation of ownership

Since 2022, there have been revelations of acts in breach of the Anti-Monopoly Act and the Electricity Business Act, including alleged collusion by major power companies, leaks and unauthorized access to customer information of new power companies, and unauthorized access to METI's renewable energy management system by those incumbent utilities. As former monopolies, the major power companies still have overwhelming market dominance and monopolize the power transmission and distribution networks. If the transmission and distribution business is not independent, grid connection will be difficult for renewable energy generators, many of whom are new entrants. As the legal separation of the transmission and distribution business implemented in 2020 has proved inadequate, separation of ownership is necessary. Under a transmission and distribution utility that is also independent in terms of capital, priority connection, and supply of renewables to the grid; wide-area and rational supply-demand coordination; and transmission network reinforcement must be accelerated.

4. Start of grid reinforcement for decarbonization through renewables

In the decarbonization pathway electricity mix presented here, 58% of the 890 TWh of electricity generated in 2035 will be supplied by variable sources: solar PV and wind power. In parallel with the study of the 2035 energy mix, Renewable Energy Institute conducted a study and published a report on how the power grid can be decarbonized with renewables. Based on the results of this study, the transmission network development required to realize a decarbonized electricity mix was examined, and it is considered that 4 GW of transmission network reinforcement is needed between Hokkaido and Honshu. Currently, 2 GW of grid reinforcement between Hokkaido and Tokyo transmission system operators is underway in Japan. Since it will take a long time to build the grid, it is necessary to reach a consensus on the 2035 energy mix that will decarbonize Japan by 2050 and start the planned grid development.

5. Early introduction of carbon pricing to attract global decarbonization investment to Japan

The carbon pricing concept set out in the GX Basic Policy is a voluntary system under which companies that do not want to participate are not required to do so. The transition to a mandatory system and the start of paid auctioning of emission allowances will take place 10 years later, in FY2033, and is limited to power generators only. The level of the carbon tax will be as low as one-tenth of the $130 in 2030 required of developed countries estimated by the IEA. In addition, GX Transition Bonds, which will be issued with revenues from carbon pricing as a reimbursement source, will also include the development and use of grey hydrogen and grey ammonia. In order to attract global decarbonization investment to Japan and achieve an energy transition, carbon pricing must be introduced as soon as possible as a global standard, and an effective carbon price for emission reductions must be achieved.

6. Acceleration of corporate PPAs

A comparison of country-specific renewable electricity utilization rates among RE100 member companies shows that in Japan, the rate is only 15%, compared to 68% in the USA, 99% in the UK, and 85% in Germany. The first reason for this is the low share of renewables in the country's overall electricity in Japan, while the second is the slow utilization of corporate PPAs. Corporate PPAs are increasing in Japan, but the scale of power generation is small, totalling less than 1% of the global contracted amount. In order to further dramatically increase the number of contracts in the future, it is necessary to provide economic incentives, such as tax credits, to accelerate corporate initiatives.

7. Strengthening the responsibilities and implementation capacity of municipalities in renewable energy development

The most fundamental responsibility of local authorities is to protect the safety, lives, and property of their residents. At a time when the climate crisis threatens this, it is the responsibility of the state as well as local governments to reduce greenhouse gases, and the expansion of renewable energy, the most important means of fulfilling this, as well as energy efficiency, is a responsibility that local governments should take on. The ordinances enacted successively by the Tokyo Metropolitan Government and Kawasaki City requiring housing manufacturers to install solar PV generation in new homes are a recognition of the role that local authorities should play in the climate and energy crises. In order for local governments to be able to play a greater role in expanding renewable energy, it is essential that, in addition to strengthening their responsibilities, they also strengthen their financial base, secure human resources, and otherwise enhance their ability to implement.

Conclusion

In light of the IPCC's 6th Assessment Report target of a 65% reduction in CO2 emissions by 2035 compared to 2019 levels, Japan must aim to supply at least 80% of its electricity from renewable energy sources by 2035 as a minimum requirement. What is needed now is a complete break from the stereotype that Japan must remain forever dependent on fossil fuels and nuclear power. It should move forward with a new, decarbonized, sustainable, and globally compatible energy system that relies almost entirely on domestically produced renewables.