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Why is METI Aiming to Limit Renewable Energy Generation to 50-60% of Total Output?

—Questioning the 53.4 yen/kWh Estimate for a 100% Renewable Energy Scenario—

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Renewable Energy Institute

In October last year, the Japanese government declared a new target of achieving carbon neutrality by 2050, followed in April this year by the announcement of a planned 46-50% reduction in greenhouse gases by 2030. In order to achieve these targets, Prime Minister Yoshihide Suga has stated his intention to push for the maximum introduction of renewable energy.

Against this backdrop, the Ministry of Economy, Trade and Industry (METI), which oversees the government's energy policy, has embarked on a series of proactive initiatives aimed at expanding renewable energy. However, since last year METI has presented a proposal[1] that the share of renewable electricity in the electricity supply in 2050 be limited to 50-60% of total generation, and at the Strategic Policy Committee meeting on May 13 of this year, the Research Institute of Innovative Technology for the Earth (RITE), at the request of METI, presented an estimate that in a scenario with 100% renewable energy "the cost of electricity would be 53.4 yen/kWh due to increased system integration costs."

This estimate has led to media coverage such as "increasing the renewable energy share to 100% will almost quadruple (generation) costs," and this assumption has sparked debate the full adoption of renewable energy will cause the domestic manufacturing industry to disappear.

The Net Zero by 2050 report[2] released in May this year by the International Energy Agency (IEA) assumes that renewable energy, primarily solar and wind power, will supply close to 90% of the world's electricity in 2050. It goes without saying that the reason for this increase is the dramatic decline in the price of renewable energy. Both the European Union and the UK Committee on Climate Change have unveiled strategies or scenarios that involve supplying between 80% and 90% of their electricity from renewable energy sources by 2050[3]. The views being put forward by METI and RITE are strikingly at odds with these global trends.

It is difficult to tell from the materials presented at the Strategic Policy Committee meeting on what assumptions and rationale RITE's estimated cost of 53.4 yen/kWh is based. Despite a lack of clear rationale, the headline figure of 53.4 yen/kWh has already taken on a life of its own in media reports. This situation, if it continues, could hinder constructive discussions on Japan's energy policy. In addition to requesting that the grounds for this estimate are clearly made available at the earliest opportunity, given the magnitude of the report's impact we would like to raise the following concerns as far as we can ascertain from the materials that are publicly available.

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[1] The Japanese government's "Green Growth Strategy Through Achieving Carbon Neutrality in 2050" (December 25, 2020) indicates "reference values" of 50-60% for renewable energy, 30-40% for nuclear power and coal-fired power equipped with carbon capture systems, and 10% for hydrogen and ammonia power. In the draft revision released on June 2, 2021, the composition of these power sources was described in the past tense as "reference values for further discussion," and the percentages of the respective power sources were removed from the diagram in the paper. The intention behind this revision is unclear.

[2] IEA "Net Zero by 2050 A Roadmap for the Global Energy Sector," May 2021

[3] For more on the European Union's decarbonization strategy, refer to "The Quest to Decarbonize Europe: 2020 Strategies towards 2050," (December 2020, p. 9.) published by Renewable Energy Institute. In the UK, "The Sixth Carbon Budget: The UK's Path to Net Zero," (December 2020) a report by the Climate Change Committee, sets the percentage of electricity from variable renewable energy sources in 2050 at 80%, with alternative scenarios of 85%t and 90% also presented.

■Doubts regarding the 53.4 yen/kWh estimate for 100% renewable energy

1 Why is the cost more than double that of other studies that also take into account “cloudy and windless periods” ?

The cost of 53.4 yen/kWh can be broadly divided into the generation cost related to the installation of solar or wind power equipment, and the integration cost required to connect this power to the power grid and maintain a stable power supply. As we will outline below, RITE's estimate of the generation cost for renewable energy itself is high, and in addition, estimates for the integration cost are particularly high.

The first question that arises is why RITE's estimated cost is more than double that of other studies that have also calculated the integration cost assuming 100% renewable energy.

RITE's explanatory materials clearly state that the analysis of the integration cost of the power system in this estimate was conducted through cooperation with the Institute of Energy Economics, Japan (IEEJ). The IEEJ's report[4] to the Strategic Policy Committee on December 14 last year, showed that the cost of power generation under a scenario of 100% renewable energy would be 25 yen/kWh, including integration costs. Both the RITE and IEEJ estimates assume that so-called "cloudy and windless periods" will occur. A "cloudy and windless period" in this context refers to a period of time, which may occur once or twice a year, where very little solar or wind power can be generated.

Although, as we will outline later, Renewable Energy Institute believes that generation costs will not approach the 25 yen/kWh level even if "cloudy and windless periods" are taken into account, RITE's cost estimate is still more than twice that estimated by the IEEJ. No reason was stated as to why these results differ so significantly from those compiled by the aforementioned collaborators.

One possibility is that whereas the IEEJ estimate represents the average annual cost of electricity, RITE's figure of 53.4 yen/kWh may represent the long-term marginal cost of some sort of power generation used in response to the exceptional circumstances of "cloudy and windless periods" during which little or no solar or wind power is generated across Japan. Even if this were the case, whether or not the long-term marginal cost equals the cost of power depends on the design of the system. The argument that the cost of electricity is equivalent to the long-term marginal cost is misleading.

In any case, the definition of what "integration cost" constitutes has not yet been definitively established. A report issued by IEEJ last December attempted to clarify integration costs into four categories: balancing costs, grid-related costs, profile costs, and other costs. However, figures for each of these categories have not been published. Not only does RITE's estimate fail to clarify the figures for each category, but it also neglects to specify what type of components are included in integration costs.

We hope that RITE will clearly explain these points in order to allow a constructive discussion on decarbonization scenarios.

2 Does dealing with "cloudy and windless periods" necessarily incur a high cost?

Our second question is whether dealing with the "cloudy and windless periods" assumed in RITE's estimates really requires huge additional costs in the first place. In their estimate, RITE did not provide data on the assumptions made in order to calculate related costs, namely how long these "cloudy and windless periods" were assumed to last, how much electricity would need to be supplied to deal with these periods, and by what methods alternative generation would occur.

[4] Yuji Matsuo, The Institute of Energy Economics, Japan, “Investigating the economics of the power sector under high penetration of variable renewable energies.”

Based on weather data to date, there will certainly be periods when the amount of electricity generated by solar and wind power will decrease simultaneously, and under a 100% renewable energy scenario there is no doubt that we need to consider contingencies for such a situation.

“Renewable Pathways: The Strategies to 100% RE for a Carbon-neutral Japan[5],” published by Renewable Energy Institute in March this year, presents the following findings: "Study of the wind and solar power generation profiles across Japan in 2018 and 2019 found that wind power output remained below 10 % of its rating for a maximum of 96 hours. However, the combined output of solar and wind remained below 10%for a maximum of 18 hours."

The 100% scenario proposed by Renewable Energy Institute is based on studies conducted in collaboration with the German think-tank Agora Energiewende and LUT University in Finland[6]. As part of these studies, hourly simulations of electricity supply and demand have been conducted across Japan (excluding Okinawa), separated into nine regions, for 8,760 hours per year. This research has found that it is possible to secure a balance between power supply and demand, including dealing with "cloudy and windless periods," through a combination of (1) flexible utilization of demand that can be adjusted according to the amount of variable power generation, (2) power generation that is not influenced by weather conditions, and (3) battery storage.

A typical example of flexible demand is the power demand of the electrolyser used to produce green hydrogen. There is also significant potential for response on the demand side, such as shifting the charging time for EV batteries. This will reduce the amount of power demand that needs to be supplied. On the power generation side, our assumptions include 22GW of hydroelectric power, 52GW of power generation /cogeneration facilities using biogas and green synthetic fuel (methane), and 5GW of biomass power generation. Furthermore, even when wind conditions are poor, wind power is still being generated somewhere in the country—at the very least 5GW. This brings the total amount generated to 84GW. Regarding energy storage facilities, in addition to 87GW of batteries (including prosumer-type facilities installed in the industrial and residential sectors that also serve as captive consumption) and 30GW of pumped-storage hydroelectricity, we assume that EV batteries will also be used for electricity storage.

As these facilities do not need to be newly added to cope with "cloudy and windless periods," they therefore do not incur any additional cost. "Cloudy and windless periods" do not make a 100% renewable energy scenario infeasible, nor do they lead to an extraordinary rise in costs.

3 Why are the assumed costs for solar and other power generation higher than METI estimates?

RITE's estimates also set the cost of solar and wind power themselves at a considerably high level. According to materials released by RITE, in the "reference value case" that serves as a basis, solar power is assumed to cost 10-17 yen/kWh and wind power 11-20 yen/kWh in 2050.

METI has set price targets for solar power of 7 yen/kWh in 2025 and for wind power of 8-9 yen/kWh in 2030. In actuality, low-cost solar power projects operating at the 6-7 yen/kWh level were achieved in Japan during the second half of last year[7].

RITE's estimate explains that the cost of solar and wind power is calculated as "the average cost of the stock of facilities installed at each point in time, and is not limited to the cost of new facilities installed at the time in question." Even if this were the case, with METI already forecasting costs for solar and wind power to be below 10 yen/kWh in 2025 and 2030 respectively, it is not rational to suggest that the average cost will be 10-17 yen/kWh or 11-20 yen/kWh in 2050—more than 20 years later.

[5] "Renewable Pathways: The Strategies to 100% RE for a Carbon-neutral Japan," March 2021 (in Japanese)

[6] "Renewable pathways to climate-neutral Japan," March 2021

[7] "Bloomberg NEF, Levelized Cost of Electricity 2020 2H (December 2020) (subscription required)"

RITE's estimate also assumes a total supply cap of 1,050TWh for solar and wind power due to constraints posed by land use and natural conditions, and that the generation costs will rise sharply as deployment progresses. However, the installation potential study conducted by the Ministry of the Environment (MOE)[8], studies conducted by private research institutes in Japan[9], and IEA reports[10], all estimate that the potential for installation of solar and wind power generation significantly exceeds the upper supply limit used as a basis by RITE. The reality occurring around the world is that as more facilities are installed, the cost of generating renewable energy is dropping dramatically due to the learning effect and other factors. If the authors of the study believe that generation costs will rise sharply, they should provide the grounds for their assumptions regarding the supply curve and upper limit of supply, along with the relevant data.

In addition to the three issues raised above, as the integration costs are provided exogenously in this estimate, there is also the question of whether the time-based generation profiles of solar and wind power were directly accounted for during the simulation in the DNE21+ model used. In RITE's simulation, the integration costs were simulated via analysis using the University of Tokyo and IEEJ electricity dispatch model, including time variance, and the corresponding increase in power system costs was used in the DNE21+ model. This means that an analysis using time-based power generation profiles (e.g., hourly) was not conducted in the DNE21+ model itself, which raises doubts about its validity as a tool for discussing energy systems with variable renewable energy as main sources.

Regarding this point, RITE states that the characteristics of the DNE21+ model are that "it has the capacity to conduct evaluations on a global scale while maintaining consistency in the quantities and prices of energy imports and exports," while also noting that "a more detailed analysis needs to be conducted separately in Japan, taking into account the specific constraints in greater detail." Surely it is not reasonable to discuss Japan's basic energy plan in an era where renewable energy is mainstream solely based on the simulation results obtained through the DNE21+ model.

■Is 30-40% supply by nuclear power and CCS-equipped coal-fired power realistic?

While explaining that "50-60% is a reference value" and that "the results of estimates vary depending on the assumptions taken," METI, in the revised draft of its Green Growth Strategy[11] released on June 3, used RITE's estimate as grounds to rationalize the continued use of nuclear power and CCS-equipped coal-fired power, stating that "the report indicates the importance of exploring all options for decarbonization without narrowing policy options. In addition to renewable energy, which will be deployed to the maximum extent possible, it is also important to consider nuclear power, hydrogen/ammonia, and CCUS/carbon recycling, etc." However, is a scenario in which nuclear power and CCS-equipped coal-fired power supply 30-40% of Japan's electricity in 2050 realistic?

■Is it possible to build 10-20 GW of new nuclear power capacity?

RITE's scenario assumes that nuclear power will contribute to Japan's decarbonization, with as much as 10% (5 scenarios with reference values, etc.) or 20% (under a nuclear power utilization scenario) of the nation's electricity provided by nuclear power[12]. Needless to say, the nation's electricity scenario for 2050 should not be one that is possible in 2050, but not viable ten years later.

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[8] Ministry of the Environment, "Entrusted Work Concerning the Development and Disclosure of Basic Zoning Information Concerning Renewable Energies (FY2019)," 2020

[9] RTS Corporation "Forecasting PV Installed Capacity in Japan toward FY 2030/2050 (2019 Edition)"

[10] IEA, "Offshore Wind Outlook 2019"

[11] "Green Growth Strategy Through Achieving Carbon Neutrality in 2050 (Draft)," June 2, 2021

[12] The IEA's "Net Zero by 2050" report states that the global share of nuclear power will decline from 18% in 2020 to 10% in 2050. It is assumed that most new nuclear power generation will be in developing countries.

According to data from METI[13], even with three extreme assumptions that (1) all existing nuclear power plants are restarted, other than those that have been selected for decommissioning, (2) all nuclear power plants are in operation for 60 years, a case which is supposed to be an exception, and (3) all three new nuclear power plants, whose construction has been suspended or barely started, are completed, total nuclear power generation capacity will fall to 23.74GW in 2050, and further to 9.56GW in 2060 as decommissioning continues through the 2050s. Even with a high capacity utilization rate of 80%[14], which is much higher than the past record assumed by METI (67.8% average from 2001 to 2010), it will only be sufficient to supply around 5% of total electricity demand in 2060. Removing these unrealistic assumptions, the actual supply available is likely to be only 2-3% at best.

To achieve 10% or 20% supply in 2050 and beyond, Japan would need to build 10-20GW of new nuclear power generation capacity. After experiencing the tragic accident that occurred at the TEPCO Fukushima Daiichi Nuclear Power Plant and with many of the problems caused by the accident still unresolved, it is difficult to conceive that the Japanese public would consent to the construction of new nuclear power plants as described above. Furthermore, the issue of high generation costs, which even at present are more than four times that of solar and wind power, cannot be avoided[15].

■Can Japan export more than 200 million tons of CO_2 overseas each year?

In addition, RITE's estimate assumes that CCS-equipped coal-fired power will provide as much as 20 to 35% of the total power supply. CCS will also be required in the industrial sector due to the assumed use of fossil fuels, resulting in the massive volume of 230-280 million tons of carbon dioxide per year being exported overseas. Similarly, although it is envisioned that 90-270 million tons of CO_2 will be stored in Japan, the question of where this will be conducted is completely unanswered, making the feasibility of this plan uncertain. It is questionable whether METI, as well as the ministries listed in the Green Growth Strategy, have seriously discussed whether Japan, as an advanced nation, will be able to obtain international understanding for its strategy of exporting CO_2 to other countries due to being unable to handle it domestically, at a time when the world as a whole, including Southeast Asian countries, is being called upon to decarbonize.

The problems with CCS are not limited to the practicalities of securing storage sites. METI estimates the current generation cost of CCS-equipped coal-fired power to be 16-18 yen/kWh, with the goal of reducing this to 13-15 yen/kWh in the future (RITE's estimate assumes a cost of 13-16 yen). Unlike renewable energy sources, which are already operating at low generation costs throughout the world, the reality is that there is currently only one CCS-equipped coal-fired power plant in operation in the world today, a small-scale (115MW) coal-fired power plant in Canada. Although it is unclear whether the cost targets set by METI are realistic, even if cost reductions are achieved, it is certain that costs for CCS will be added on top of current coal-fired power generation costs, making it a comparatively expensive power source.

In addition to this, there is a problem in that while CCS-equipped coal-fired power generators are fitted with CO_2 capture systems, they are not capable of capturing all emissions and are therefore not a complete decarbonization technology. A report by the IEA states that CCS-equipped coal-fired power emits about 100-140 g/kWh of CO_2[16]. In the taxonomy set by the EU as a standard for sustainable investment, power generation is only permitted as a "sustainable economic activity" if it has an emission factor of 100 gCO_2eq/kWh or lower[17]. Furthermore, this emissions factor will be reviewed every five years and reduced to 0 gCO_2eq/kWh by 2050.

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[13] METI, "Study Toward the Realization of Carbon Neutrality in 2050," December 21, 2020

[14] It is possible that the 80% capacity utilization rate is based on the latest utilization rate of the nine reactivated reactors. However, the assumption made by METI in the document is that aging nuclear power plants whose operation has been extended to 60 years will operate long-term, until 2050 or later. In such a case, it will be difficult to maintain a high utilization rate.

[15] It has been argued that small modular reactors (SMRs) could be the future of nuclear power, but at present they are technically unproven and do not resolve the problem of high cost. For example, refer to “Small Modular Nuclear Reactors Are Mostly Bad Policy”, by Michael Barnard (May 2021).

[16] IEA "Energy Technology Perspectives 2017"

[17] Technical expert group on sustainable finance (TEG) “Taxonomy: Final report of the Technical Expert Group on Sustainable Finance” and “Taxonomy Report Technical Annex Updated methodology & Updated Technical Screening Criteria”

The IEA's Net Zero by 2050 report estimates that CCS-equipped coal-fired power will comprise only 3% of total power generated in 2050. Although it may be necessary to use CCS to a certain extent in the industrial sector where high temperatures are required, it is not plausible to expect such wide-scale use that it comprises 20% to 30% of the power generation sector.

■Can Japan maintain industrial competitiveness by relying on nuclear power and CCS-equipped coal-fired power while the rest of the world embraces low-cost renewable energy?

The Japan Federation of Economic Organizations (Keidanren) and other Japanese business groups have repeatedly stressed the need to keep electricity prices low in order to maintain Japan's industrial competitiveness. The IEA's Net Zero by 2050 report includes at its end estimates of the cost of electricity generation (LCOE) in 2030 and 2050 in the United States, Europe, China, and India. Although the cost varies slightly between the four regions, the overall cost of solar power, onshore wind power, and offshore wind power in 2050 is estimated to range from 1.5 cents to 4.5 cents per kilowatt hour. IEA's image of 2050 is a world in which nearly 90% of electricity in the United States, Europe, China, and India is supplied by these types of low-cost renewable energies.

If Japan is only able to supply 50-60% of its electricity from renewable energy at this time—and moreover this cost is still many times higher than international prices—and if 30-40% of its electricity must be supplied by CCS-equipped coal-fired power and nuclear power, which are five to ten times more expensive than global levels for renewable energy—how can the nation possibly expect to maintain its industrial competitiveness?

Why does METI wish to limit renewable energy to 50-60% of the total supply? Naturally, there are problems that must be solved in order to supply 100% of the nation's electricity from renewable energy sources, as Renewable Energy Institute proposes, or even the 90% figure advocated by the IEA. However, the answers to most of these challenges are already apparent from the experience of countries and regions that have pioneered the use of renewable electricity.

It is a fact that sincere efforts are being made within METI to expand the use of renewable energy. Unfortunately, however, looking at materials released under METI authority, one can only conclude that the dominant policy is to continue using fossil fuels, such as coal-fired power, and nuclear power. We hope for and urge a shift to an appropriate energy policy that allows Japan to realize a decarbonized society while maintaining and advancing the competitiveness of the nation's industry.