Consideration of the Power Generation Mix from Perspective of Regulations

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In order to achieve the power generation mix in FY 2030, the government is promoting voluntary efforts for global warming by electric utilities combined with regulations. This paper, based on the latest data, clarified the status of progress and future outlook of non-fossil fuel based power ratio and benchmark target. In addition, it considered challenges focusing on the probability of achieving the power generation mix in FY 2030. The result of estimates showed that non-fossil fuel based power ratio in FY 2026 would approach 44%. For benchmark target in FY 2016, Index-A was not achieved, while Index-B was achieved. Needles to say, achieving the power generation mix in FY 2030 is important. But more than that, the power generation mix need to be considered and discussed from long-term perspective, from the view point of 2050, since energy situation in the world is rapidly changing and uncertain, such as declining oil price, progress of renewable energy and innovation etc.

Keywords : Power generation mix, Non-fossil fuel based power ratio, Benchmark

1. Introduction

In order to achieve the optimum composition of power generation (hereinafter the "power generation mix") for FY2030 as given by the Long-Term Energy Supply and Demand Outlook, the government is taking steps to ensure the effectiveness of voluntary efforts to combat global warming by the electric utilities, through the "Act on the Promotion of the Use of Non-fossil Energy Sources and Effective Use of Fossil Energy Materials by Energy Suppliers" (hereinafter the "Sophisticated Methods Act") and the "Act on the Rational Use of Energy" (hereinafter the "Energy Saving Act"). In this paper, we clarify the progress status and future prospects of benchmark indicators set out in the Energy Saving Act and non-fossil fuel-based power ratio set out in the Sophisticated Methods Act, based on the most recent published data, and have considered the various challenges to achieving power generation mix.

2. Voluntary efforts by the electric utilities and regulations by government

In April 2014, the government gave cabinet approval to the "Basic Energy Plan" which gives guidelines for medium and long-term energy policies, and in July 2015, it decided on the power generation mix in FY2030, as shown in Figure 1 based on this Plan. Based on the power generation

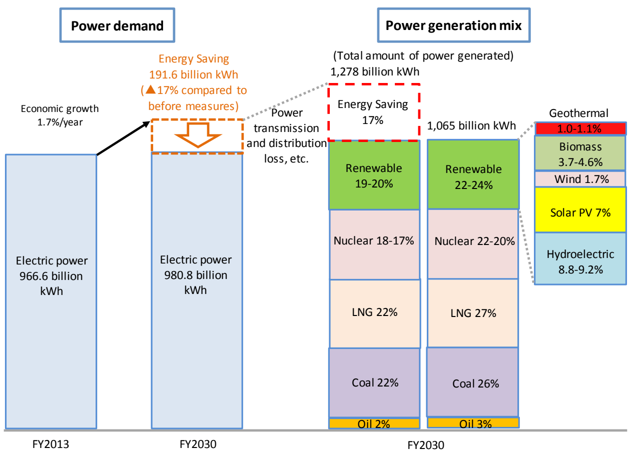

Figure 1. Power generation mix (FY2030)[1)]

mix, 12 electric utility companies and 23 new power companies set out "The commitment to a low carbon society for electric utilities" under the Keidanren's global warming countermeasures, and set as a target "to aim for emission factor of around 0.37kg-CO_2 /kWh (usage end) in FY2030". However, the emission factor target raised here (around 0.37kg-CO_2/kWh) is a target that should be aimed for by the electric utilities industry as a whole, calculated[2)] from the CO_2 emissions from electricity (0.36 billion t-CO_2) and the expected demand (980.8 billion kWh) for FY2030 indicated in the Long-Term Energy Supply and Demand Outlook, and the effectiveness of attaining this target by the electric utilities has been highlighted as an issue[3)]. In order to deal with this issue, 12 electric utility companies and 24 new power companies established "The Electric Power

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Council for a Low Carbon Society"[1] (hereinafter "ELCS") in February 2016. The ELCS have positioned the emission factor target (around 0.37kg-CO_2/kWh) as a target for the entire ELCS, and is pursuing efforts that correspond with the business circumstances of each member company, through the PDCA cycle within the organization.

Meanwhile, in order to raise the probability of achieving the power generation mix, the government has also reviewed regulatory measures under the Sophisticated Methods and Energy Saving Acts. Under the former, it has set the non-fossil fuel based power ratio for FY2030 at 44% or higher for retail electric utilities, as per Table 1. Under the latter, it has reviewed standards for new thermal power plant and provided new power generation efficiency standards per fuel type (coal: 42%, LNG: 50.5%, oil: 39%). Furthermore, it has also reviewed the benchmark indicators for existing thermal power plant that power generating companies should achieve over the medium and long-term, and provided target values for generation efficiency per fuel type (coal: 41%, LNG: 48%, oil: 39%). It has set out Indicator A that specifies the target attainment rate for actual performance with respect to the target values per fuel type (Figure 2), and Indicator B to encourage an increase in the overall power generation efficiency itself (Figure 3).

Table 1. Regulation under the Sophisticated Methods Act

	After revision	Before revision
	Retail electric utilities etc.	General electric utilities New power companies
Non-fossil fuel-based Power ratio	44% or higher	General electric utilities: 50% or higher New power companies: 2% or higher
Target year	FY2030	FY2020

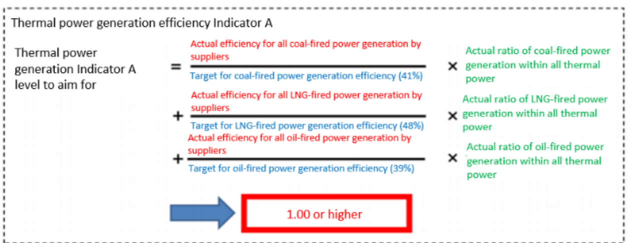

Figure 2. Thermal power generation efficiency Indicator A[5)]

[1] As of October FY2017, ELCS with 42 companies covers 98.1% of total electric power sales (FY2016 performance.)

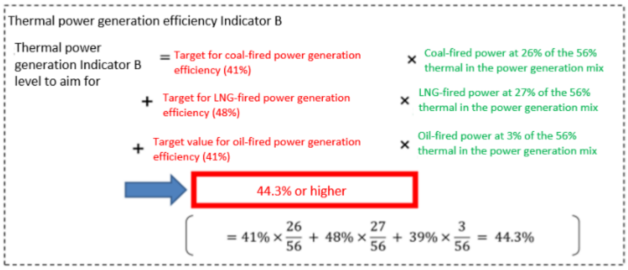

Figure 3. Thermal power generation efficiency Indicator B [5)]

3. Verification and consideration of the power generation mix

3.1 Methodology

From the perspective of the Sophisticated Methods Act, we carried out trial calculations of the non-fossil fuel-based power ratio in the future (FY2026) based on the Aggregation of Electricity Supply Plans for FY2017 (hereinafter, the "Supply Plans"). From the perspective of the Energy Saving Act, we carried out trial calculations of the benchmark indicators for Japan as a whole for its most recent performance (FY2016), based on the Surveys and Statistics of Electricity for FY2017.

3.2 Sophisticated Methods Act perspective (non-fossil fuel-based power ratio 44%)

The composition amount of power generated in Japan is as shown in Figure 4. The non-fossil fuel-based power ratio for FY2016 (actual results) and FY2026 (forecast) are respectively, 16.3% for FY2016 and 21.5% for FY2026. Under the feed-in tariff system (hereinafter, the "FIT"), there will be a large increase in the amount of renewable power generation, primarily through solar power generation; the renewable energy ratio will increase by around 1.5 times, from 14.4% in FY2016 to 20.8% in FY2026, which draws very close to the target renewable energy ratio in the power generation mix, of 22 to 24%. As for nuclear power meanwhile, although Sendai No. 1 and No. 2, Takahama reactors No. 3 and No. 4 and Ikata reactor No. 3 were restarted in FY2016, the ratio remained at just 1.9%. The nuclear power ratio for FY2026 will be 0.7%, below that of FY2016, but this is because it was calculated as zero in the Supply Plans, since power companies submitted the amount for power generation from nuclear as "yet to be decided."

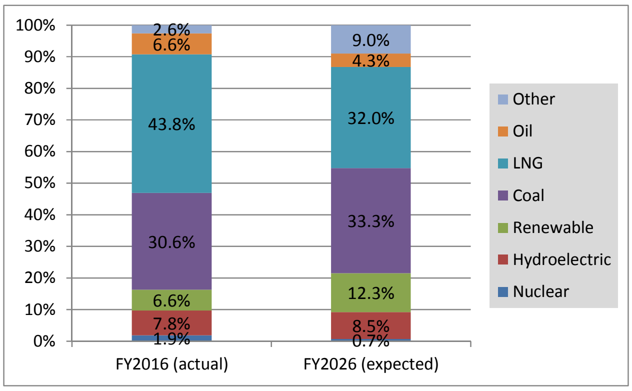

Figure 4. Power generation composition in Japan[6)]

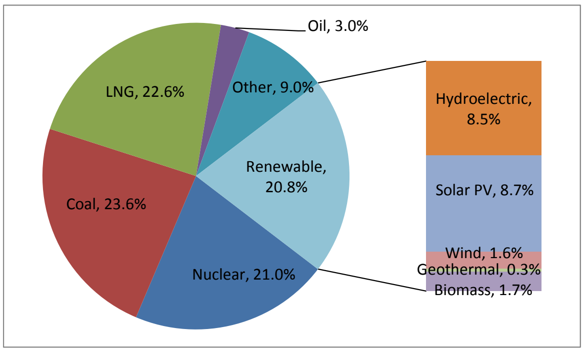

Figure 5. Power generation mix for FY2026 (nuclear power fixed at 21%) [6)]

Figure 5 shows the power generation mix if we fix ratio of nuclear power at 21% (the median in the range 22 to 20%)t to total power generation in FY2026 of under the Supply Plans, as demanded by the power generation mix. The increase in nuclear power is offset by decreasing the proportion of thermal power generation, without altering the total amount of power generated. As a result, we find that non-fossil fuel-based power ratio in FY2026 is 41.8%, which is a level that almost attains the 44% demanded by the Sophisticated Methods Act. In order to achieve the nuclear power ratio of 21% in Figure 5, power generation output of 1,966 hundred millions kWh will be required. We calculated below, the scale of restarting nuclear power plants necessary for this, and used in our calculation, the suitability review status for new regulatory standards for nuclear power plants as per Table 2. As of October 27, 2017, there are 5 reactors in operation, 7 which have passed review, 14 currently under review, 19 not yet applied for and 15 which will be decommissioned.

Table 2. Review status for new regulation suitability

In operation (5 reactors)	Sendai No. 1, 2, Takahama No. 3, 4, Ikata No. 3
Passed review (7 reactors)	Takahama No. 1, 2, Mihama No. 3, Oi No. 3, 4, Genkai No. 3, 4
Under review (14 reactors)	Tomari No. 1, 2, 3, Higashidori No. 1, Onagawa No. 2, Kashiwazaki-Kariwa No. 6, 7, Hamaoka No. 3, 4, Shika No. 2, Shimane No. 2, Tokai Daini, Tsuruga No. 2, Oma
Not yet applied for (19 reactors)	Oi No. 1, 2, Ikata No. 2, Genkai No. 2, Onagawa No. 1, 3, Fukushima Daini No. 1, 2, 3, 4, Kashiwazaki-Kariwa No. 1, 2, 3, 4, 5, Hamaoka No. 5, Shika No. 1, Shimane No. 3, Higashidori No. 1
To be decommissioned (15 reactors)	Tokai, Hamaoka No. 1, 2, Fukushima Daiichi No. 1, 2, 3, 4, 5, 6, Mihama No. 1, 2, Genkai No. 1, Shimane No. 1, Tsuruga No. 1, Ikata No. 1

If we were to operate all of the 26 reactors, which are in operation, reviewed and under review as of October 27, 2017 (hereinafter “applied for”) at a utilization rate of 70%, it would result in 1,608 hundred millions kWh, which does not reach the 1,966 hundred millions kWh required to achieve and nuclear power ratio of 21%. However, if we could start up all 45 reactors (45,623MW) including those for which an application has not yet been made (hereinafter, “all including not yet applied”) at a 70% utilization rate, this would bring 2,798 hundred millions kWh (nuclear power ratio of 30%). This is clearly at a level which adequately satisfies the 21% nuclear power ratio (see Figure 6).

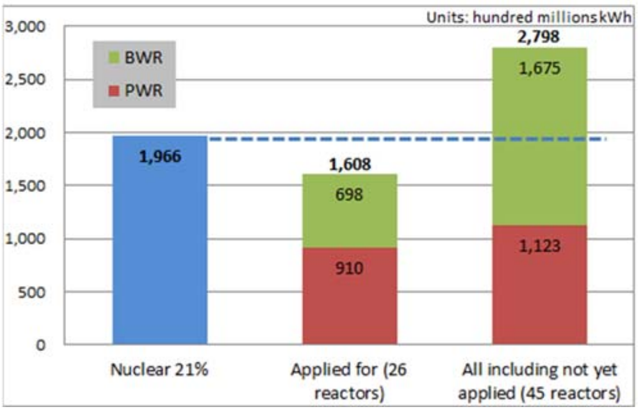

Figure 6. Scale of 21% nuclear power ratio (FY2026)

If we look at the situation in terms of years of operation by 2030, for those not yet applied for (26 reactors), only 12 will have exceeded 40 years, which is not even 50% of the reactors; if we consider all including not yet applied (45 reactors) however, then the 50% mark is surpassed, at 24 reactors. Consequently, in order to attain the 22 to 20% nuclear power ratio demanded in the power generation mix, it will be necessary for the reactors with at least 40 years of nuclear power generation, which means all including not yet applied (45 reactors), to be approved for an extended period of operation to 60 years, and used accordingly. At present (as of October 27, 2017), only three reactors have received approval from the nuclear regulation authority for an extended period of operation to 60 years, namely Takahama No. 1 and No, 2 and Mihama No. 3. For other reactors, operators taking comprehensive account of various factors such as cost effectiveness, are likely to decide going forward, on whether or not to apply for review process by Nuclear Regulation Authority to extend reactor operating periods. From the perspective not only of achieving the power generation mix, but also of improving the business environment for nuclear power over the long term, it will be necessary in any new Basic Energy Plan set out in the future, to clearly set out the importance of extended operating periods, replacement and new establishment of nuclear power plant.

3.3 Energy Saving Act perspective (benchmark indicators)

Table 3 shows the results of trial calculations for benchmark indicators for the whole of Japan in FY2016. While the performance of Indicator A was 0.981, which failed to reach the target value of at least 1.00, Indicator B achieved 44.7% against a target of 44.3%. Figure 7 shows the results of comparisons between the target and actual values per fuel type. Although coal and oil-fired power did not reach the target values, LNG-fired power surpassed its target at 48.96%. From these results, we see that if we focus on supplier efforts, then higher efficiency is required for coal-fired power generation in particular, in order to achieve Indicator A. Meanwhile, for Indicator B, it will be possible to increase the overall power generation efficiency substantially through the use of LNG-fired power, for which the absolute target value is high. In practical terms, this is an indicator which relies heavily on the power source composition used by suppliers.

Table 3. Attainment status of benchmark indicators (FY2016)[7)]

	FY2016	Target value
Indicator A	0.981	1.00 or higher
Indicator B	44.7%	44.3% or higher

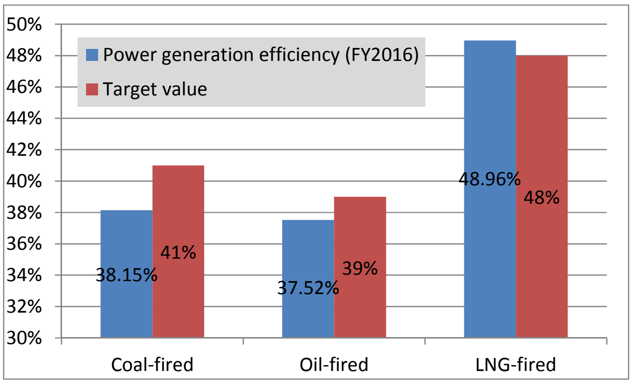

Figure 7. Power generation efficiency results per fuel type (FY2016)[7)]

Figure 8 shows power generation capacity per number of years of operation. Coal-fired power generation in Japan was replaced new one (17,171MW) using imported coal from the late 1990's to the early 2000's affected by the first and second oil crises. The replacement of old facilities resulted in a relative decrease in capacity after 40 years operation, at 3,839MW (9%). For LNG power generation, the largest ratio is accounted for by less than 10 years of operation, at 18,820MW (26%). Thanks to a great deal of investment in state-of-the-art LNG over the past 10 years, it appears that LNG made a substantial contribution to the attainment of Indicator A (see **Figure 7**). What's more, since the capacity of LNG generation at over 40 years, 15,345MW (21%), is greater than that for coal-fired generation, one may say that there is adequate potential to raise both Indicator A and Indicator B together.

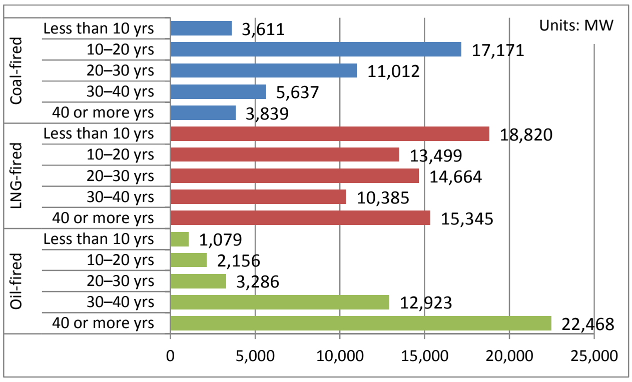

Figure 8. Capacity per years of operation[8)]

In calculation of the power generation efficiency for the benchmark indicators, the three factors of byproducts such as blast furnace gas and solid waste fuel, cogeneration and mixed biomass firing are treated favorably by the calculation method shown in **Figure 9**. Specifically, for power generation that uses byproducts, and mixed biomass firing, we can subtract the amount of energy of the byproducts and biomass fuel introduced, from the invested energy amount, while for cogeneration, the thermal energy obtained from power plant, which is then used as heat was calculated and evaluated favorably.

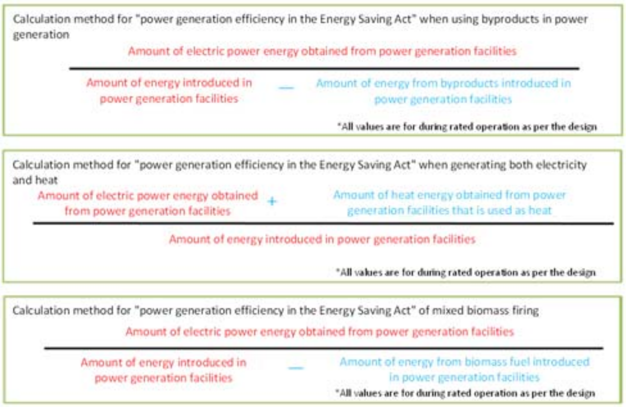

Figure 9. Calculation method for mixed biomass

At the Working Group for Evaluation Criteria for Thermal Power Generation FY2017, held in October 2017, the attainment status for the benchmark indicators was revealed. The results showed that, of 54 target suppliers, 19 achieved both Indicator A and Indicator B, 21 did not achieve either, 6 achieved Indicator A only and 9 achieved Indicator B only. **Figure 10** shows the benchmark indicator of attainment status as viewed with respect to capacities of suppliers. The attainment rate for both Indicator A and Indicator B, among medium and small-scale suppliers less than 1.5 GW, exceeded 50%. The attainment rate was much lower however, for large-scale suppliers producing over 1.5 GW. Of the small-scale suppliers, less than 500MW, the 6 that achieved both Indicator A and Indicator B achieved a considerable increase in power generation efficiency from mixed firing, of biomass, byproduct gas, and so forth (Indicator A: 2.00 or higher, Indicator B: 100% or higher). One may assume that the smaller the scale of the supplier, the greater are the effects of power generation from mixed firing of biomass, byproduct gas, and so forth.

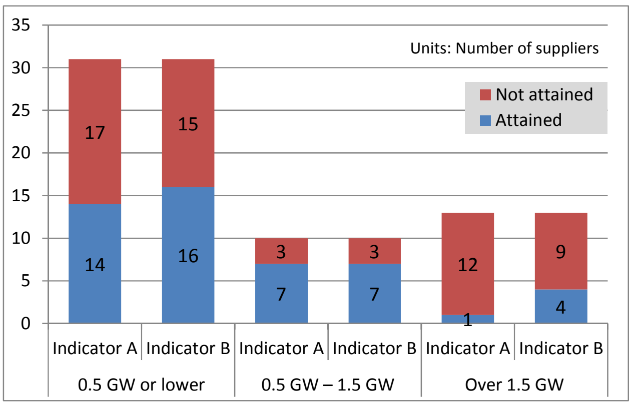

Figure 10. Attainment status for benchmark indicators per capacity[9)]

The benchmark indicators must function in close connection with the Sophisticated Methods Act, as complementary steps to ensure the effectiveness of voluntary efforts by electric utilities to combat global warming, toward achieving the power generation mix for FY2030. We must avoid situations wherein favorable policies toward mixed biomass firing cause significant damage to incentives to replace thermal power generation facilities based on these indicators. As a countermeasure to this, it is necessary to discuss matters such as setting upper limits for power generation efficiency, and to focus on the direction of future discussion.

3.4 Drastically increasing biomass power generation

It is extremely important for us to strike a balance between enlarged introduction of renewable energy and control of the burden on citizens, as evidenced by the fact that it is also mentioned in the Long-Term Energy Supply and Demand Outlook. From the perspective not only of the power generation mix, but also of controlling the citizen burden, we must ascertain the situation regarding the drastically increasing generation of power from biomass. Changes (cumulative) in biomass power facilities which have received approval to install the FIT are shown in **Figure 11.** Approved facilities achieved 12,420MW by the end of FY2016, reaching a level twice that envisioned under the power generation mix, of 6,020 to 7,280MW. If we look at a breakdown of the approved facilities, then Wood and agricultural residues (imported materials, palm kernel shells, etc.) account for 90% or more of total at 11,470MW, exceeding 3 to 4 times that envisioned under the power generation mix, of 2,740 to 4,000MW.

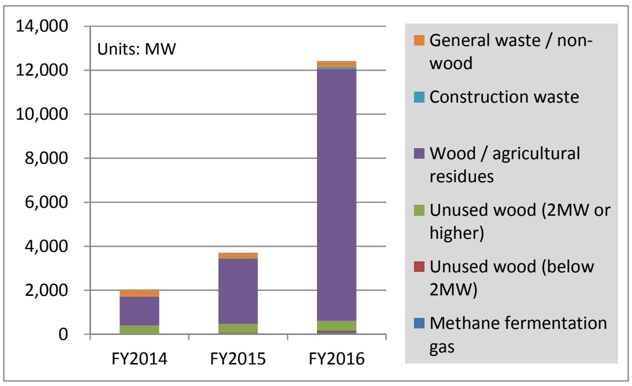

Figure 11. Changes in approved biomass power generation facilities (cumulative)[10)]

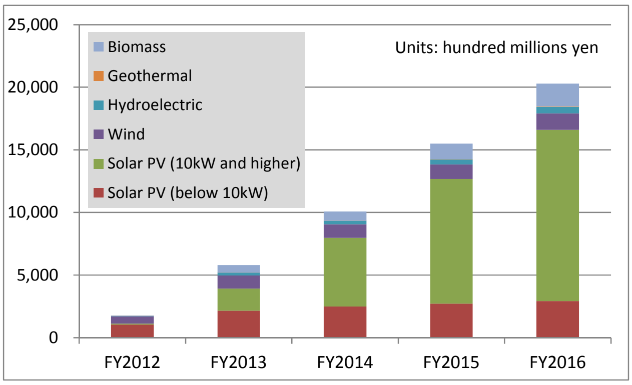

Figure 12. Status of FIT purchase costs (single year)[10)]

Next, changes in the FIT purchase cost are shown in **Figure 12**. Although it was 178.2 billion yen in the starting year of the FIT system, FY2012, amount exceeded 2 trillion yen in FY2016, and reached a cumulative level surpassing 5 trillion yen. The amount of the purchase price accounted for by biomass generation was 441.2 billion yen, which remains only a small proportion of the whole, but as shown in **Figure 11**, for Wood and agricultural residue, approximately 8,500MW of facilities were approved in the one year of FY2016 alone. With just this, the FIT purchase cost is at a level exceeding 1 trillion yen[2] annually.

Compared with other FIT sources, biomass power generation is a source with high marginal costs, which requires fuel for generation. Wood and agricultural residue, which account for over 90% of the total approved facilities rely primarily on imports from overseas. Furthermore, because fuel costs make up the majority of the expenses associated with biomass power generation, it is possible that the majority of the renewable energy levees, imposed on users according to their usage in order to help spread biomass generation, are spent for the import of bio-fuel, resulting in an outward flow of our national wealth abroad. Urgent measures are demanded to address this issue.[3]

4. Conclusion

4.1 Effectiveness of regulatory measures under the Sophisticated Methods Act and Energy Saving Act

Based on verification and discussion of the power generation mix in 3., we have organized the various challenges to be addressed in order to raise the probability of achieving the power generation mix through regulatory measures under the Sophisticated Methods Act and Energy Saving Act.

(1) Sophisticated Methods Act (non-fossil fuel-based power ratio 44%)

As per **Figure 5**, we learned that a non-fossil fuel-based power ratio of 41.8% can be reached in Japan, if nuclear power generation can be operated at 21% in FY2026, which is a level that almost attains the 44% demanded under the Sophisticated Methods Act. If steady progress can be made in the restarting of nuclear power plants, including those running for over 40 years, then there is a high probability that a non-fossil fuel-based power ratio of 44% can be achieved.

However, we should keep in mind that based on the Sophisticated Methods Act, a non-fossil fuel-based power ratio of 44% is demanded on a retailer unit basis. In terms of access to non-fossil sources, there is a sizable gap between former general electric utility and new power companies. As a measure for dealing with this gap, government is currently discussing the market output of the base load sources such as nuclear, hydroelectric and coal-fired, and the creation of a non-fossil value trading market. This non-fossil value trading market, in particular, will separate actual electricity value and non-fossil value, and allow transactions through the certification of non-fossil values. Retail electricity businesses will be able to use this certification in order to attain non-fossil fuel-based power ratio targets. As for FIT sources, FIT electricity generated in FY2017 is subject to trade, and even non-FIT sources are being considered as subject for trade, with a view toward FY2019.

In order to have the non-fossil value trading market function by 2030, an adequate amount of certificated non-fossil value will be necessary. If we were to assume that all of the power generated from nuclear is supplied to the market, and that the operation rate is 21% based on the data in **Figure 6**, then similarly, 21% (196.6 billion kWh) of the non-fossil value certification will be issued. From the perspective of amounts, the importance accounted for by nuclear is clear, even among various non-fossil sources.

(2) Energy Saving Act (benchmark indicators)

As **Table 3** shows, Indicator A was not achieved across Japan as a whole, at 0.981 in FY2016, but Indicator B reached its target value, at 44.7%. However, we must be cautious over the fact that the benchmark indicators demand achievement of individual suppliers, and that generally benchmark targets applied to other industries under the Energy Saving Act are indicators of a level that approximately 10 to 20% of all suppliers reach in every industry. The government is required to carefully check the progress status of supplying efforts.

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2 Calculated as: output of approved facilities: 8,500 MW; utilization rate: 70%; FIT price: 24 yen.

3 Under discussion and consideration by the Procurement Price Calculation Committee.

It will be difficult to improve power generation efficiency, unless there is increase in utilization rates for thermal power plants, introduction of cutting-edge high-efficiency plant, or decommissioning of old thermal power plants. From the standpoint of increase utilization rates, it is predicted that over the medium to long term, there will be a decrease in the utilization of thermal power generation, due to large influx of variable sources such as solar PV and wind power into the grid. With regard to investment in state-of-the-art, high-efficiency sources, because of factors such as the changing supply and demand structure, as well as intense competition resulting from electricity deregulation, it is not easy to reach the starting point of this.

So, what should we do? What incentives would help us to achieve these targets? One measure would be to improve the assessment system that divides suppliers into classes (SABC system) in response to accomplishment level under Energy Saving Act. In reality however, suppliers that reach the benchmarks are only listed on the METI website, as superior suppliers. Naturally, business decisions by suppliers which pertain to investment in energy saving are largely predicated on economic matters. Simply being assessed as a superior supplier, in and of itself, is not an incentive. The government has taken steps aimed at encouraging investment in energy saving, such as providing support grants; however, it is difficult to make use of these grants if limited to the benchmark indicators in the electricity supply industry.

Despite facing these challenges, in order to ensure that the attainment of indicators toward 2030, suppliers must improve the mechanisms by which their efforts can be evaluated as appropriate. In particular, from the perspective of an equal footing, it is necessary to review the steps that favor mixed biomass firing. Furthermore, while it is necessary to have efforts evaluated, through measures that should be in place, to improve utilization rates for power plants, invest in state-of-the-art, high-efficiency power generation and decommission old facilities, it is also required that systems are reviewed, in a form that gives consideration to the large differences in power source composition and scale between suppliers, and to the large difference in effort and burdens for the purpose of achieving targets.[4]

4 On this point, Nagano has pointed out that Indicator B (44.3%) would be a good target value for Japan as a whole if it can be achieved, and that assigning this to an individual company would be slightly illogical.

4.2 How should the power generation mix be?

More than 3 years have passed since the establishment of the Energy Basic Plan in April 2014, and now, we have entered the period of consideration for the new Energy Basic Plan, as set out in the Basic Act on Energy Policy. While the above discussion is ongoing in the Strategic Policy Committee, In order to consider the direction for long-term energy policy, the Round Table for Studying Energy Situation was newly set up. Meanwhile, the Paris Agreement was adopted and ratified as an international mechanism to address global warming in 2020 and beyond; in Japan, the government gave cabinet approval to the “Global Warming Countermeasures Plan”, and a course was set out toward the realization of domestic emissions reduction targets. An 80% reduction by 2050 was specified as a long-term target.

Based on this situation, what should our power generation mix look like? From the perspective of the basis of Japanese energy policy, “3E+S”[5], it is thought that we should discuss the power generation mix with a long-term view point of 2050, rather than a single cross section of 2030. Setting out the direction for energy policy with a view towards 2050 is a pillar to the consideration undertaken in the Round Table for Studying Energy Situation. There is a strong certainty that the importance of electricity as infrastructure will rise over the long term in France and the United Kingdom. These countries indicate policies that prohibit the sale of gasoline and diesel vehicles by 2040, with a change to EV. Trends like this have resulted in increasing social demand for the low-carbonization of supplied electricity, from the perspective of environmental adaptability in particular. This will surely result in an increasing role to be played by nuclear power generation in the mix.

According to the Long-term Climate Change Policy Platform Report, an 80% reduction by 2050 is a level that cannot be achieved even if we introduce all technology that is possible at present and in the near future, which is to say 100% non-carbonization of electricity through renewable energy, nuclear power and thermal power generation with CCS. It has been pointed out that there is a limit to what we can face with our existing measures[12)]. In other words, the necessity of further innovation has been highlighted, with low carbonization of electricity supply through the maximum use of both renewable energy and nuclear power to be regarded not as a target, but as a given premise. Hence, it is important to create an environment where discussion can be actively undertaken, regarding new nuclear power plants, the replacement of old plants, and so forth.

5 Energy Security, Economic Efficiency, Environment, Safety

This shall include review of nuclear policy with a view towards 2050, rather than limit consideration to the power generation mix for 2030.

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