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Assessing the Emission Impacts of Current Plans for Constructing and Retrofitting Thermal Power Plants in Japan:

A Study on the Effectiveness of the Policy Mix in the Electricity Sector on Mid- and Long-term CO_2 Emissions

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【Abstract】

Assuming all thermal power plants currently planned for construction and replacement are put into operation, coal-fired and gas-fired power plants need to operate below 56% and 43%, respectively, of their capacity factor in order to achieve Japan's electric power sector's voluntary emissions intensity targets for 2030. However, the voluntary framework together with supporting policy measures pursuant to the Energy Conservation Act and the Law Concerning Sophisticated Methods in their current form cannot guarantee attainment of these voluntary targets. Potential mitigation measures such as carbon capture and storage (CCS) and carbon offsets cannot be fully utilised to reduce all CO_2 emissions from these plants due to technical and institutional constraints. Once plants go online they also "lock-in" high-level carbon emissions for decades to come. A high degree of caution therefore needs to be exercised, not only in light of the 2030 target but also the 2050 80% reduction target. Following the Paris Agreement, preparation in earnest towards a low-carbon transition in electric power is now required. Further, if the 2030 target becomes difficult to achieve by voluntary action, then the government should adopt stricter policy measures—such as emission caps for the electricity sector and an emission intensity/capacity factor-target policy mix.

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1. Background

In the wake of the electric power crisis following the Great East Japan Earthquake and in line with trends toward a liberalised power sector and low fuel costs, Japan's electric power companies are making plans to replace or build new coal-fired power plants. To clarify what environmental and CO_2 impacts this would have, TEPCO held discussions with the directors of the relevant divisions in the Ministry of Economy, Trade, and Industry (METI), and the Ministry of the Environment (MOE), resulting in the "Summary of a meeting by relevant directors on TEPCO's bid for thermal power" (or "Directors' Summary" hereafter). This Summary led to a voluntary framework to reduce CO_2 emissions in the industrial sector.[1]

However, as the voluntary framework put forward by power producers lacked any concrete measures, the coal-fired power plants were not approved. For example, the Minister of the Environment rejected a plan proposed by the Yamaguchi-Ube Power Generation Company, on 12 June 2015. The following month, the Federation of Electric Power Companies, Japan (FEPC) and other power producers responded with the "Action Plan for the Electricity Sector for Achieving a Low-Carbon Society" ("Action Plan" below), which proposed an emission intensity target of 0.37 $kgCO_2/kWh$, and released a summary of the "Voluntary Framework toward Reduction of Greenhouse Gases" (below, "voluntary framework")[2]. However, on 14 August, the Ministry of the Environment (MOE) again rejected a proposal to replace a coal-fired power plant in Taketoyo Town, due to confusion over whether individual power plants need to comply with the national emission reduction target, and thereafter requested further development of a substantial framework, i.e., rules for power producers to mitigate CO_2 emissions in the electricity sector[3].

The industry's response to this took the form of concrete initiatives for a voluntary framework in Feb. 2016, including creation of the Electric Power Council for a Low Carbon Society (ELCS). METI and MOE followed this up with supplemental policy measures (e.g., concerning establishment of emission standards for construction of new facilities and heat efficiency benchmarks pursuant to the Energy Conservation Act; share of non-fossil fuel power sources pursuant to the Law Concerning Sophisticated Methods of Energy Supply Structures; as well as information disclosure and performance reporting on thermal power plants) to ensure the potential effects of the electric power industry's voluntary framework would be realised[4].

This paper provides an overview of the voluntary framework and policy measures and how such plant replacement and renewal plans will affect Japan's 2030 mid-term and 2050 long-term emissions reduction targets. It also discusses the risks associated with such plans.

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[1] METI and MOE, "Summary of a meeting by relevant directors on TEPCO's bid for thermal power" (25 April 2013), in Japanese.

[2] The Federation of Electric Power Companies of Japan (FEPC) et al., On the drafting of the "Action Plan for the Electricity Business for Achieving a Low-Carbon Society", (17 July 2015) , in Japanese, http://www.japc.co.jp/news/press/2015/pdf/270717.pdf

[3] MOE, "On opinions from experts at the hearing on a framework for global warming measures in the electricity sector (mid-term report)" , (27 July 2015), in Japanese

https://www.env.go.jp/earth/ondanka/denryoku/denryoku-d03.html

[4] Statement and declaration by Minister Hayashi, Minister of Economy, Trade and Industry, "Introduction of a Mechanism to Ensure the Effectiveness of the Voluntary Framework in the Electricity Field", 9 February 2016, in Japanese.

2. Voluntary framework and policy measures

2.1 Institutional structure for the voluntary framework

The Electric Power Council's mission of "ensuring that the global warming countermeasures taken by the electricity sector are effective by encouraging and assisting the voluntary and individual action plans of the Council members" sets the agenda of this voluntary framework, (see fig. 1), which is designed to facilitate progress in carrying out the Action Plan for the Electricity Sector for Achieving a Low-Carbon Society. ELCS's task is to monitor member producers and promote the PDCA (plan–do–check–act) cycle to mitigate CO_2 emissions. However, although ELCS can request member producers to revise their action plans if emissions for the electric power sector overall exceed the voluntary targets, how additional targets or remedial steps are assigned or enforced remains undecided.

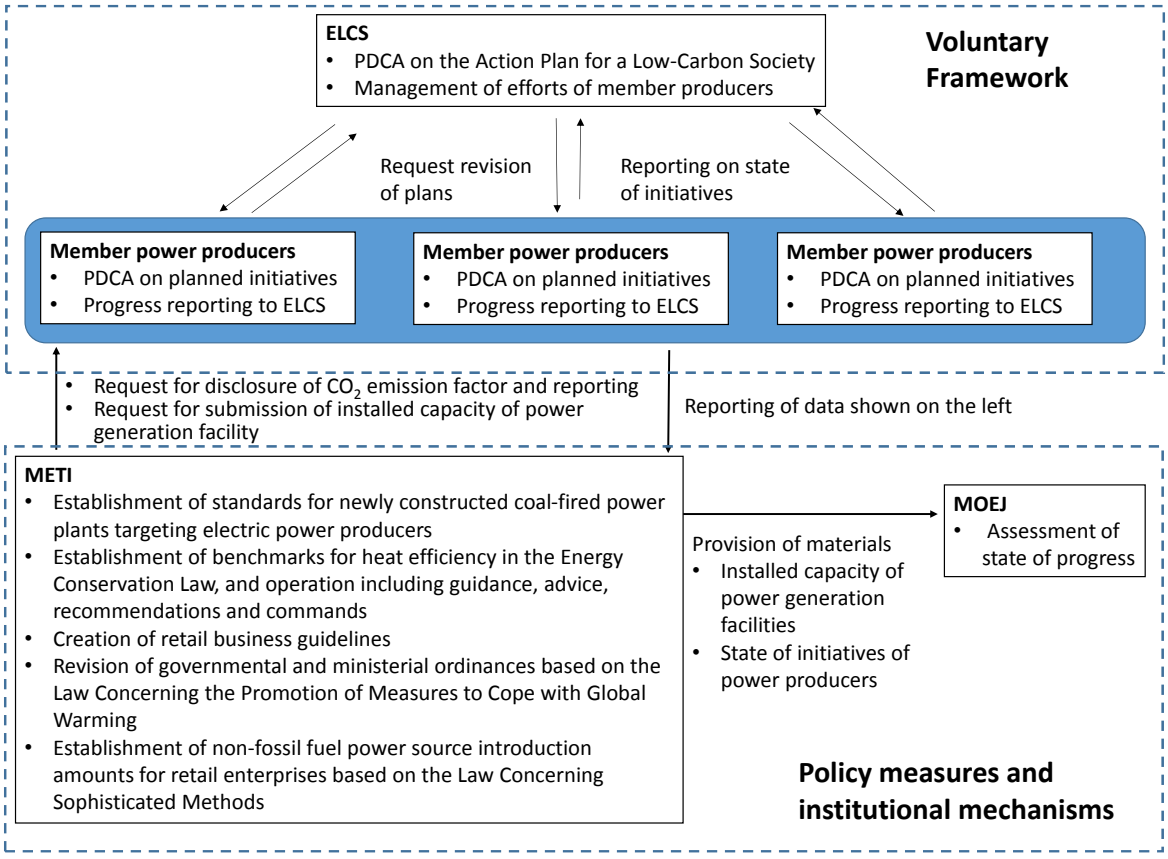

Figure 1: Electric Power Industry's Voluntary Framework and Related Government Policy Measures

Source: Created by author based on materials from the Electric Power Council for a Low Carbon Society (ELCS) and the MOE.

2.2 Supporting policy measures by government ministries (METI and MOE)

METI established emission standards for heat efficiency for both newly constructed and existing power plants pursuant to the Law Concerning the Rational Use of Energy (Energy Conservation Act). Newly constructed coal-fired power plants as well as small-scale plants are required to have a heat efficiency of 42% (corresponding to ultra-supercritical (USC))[5]; for gas-fired power plants this figure is 50.5% (equivalent to gas turbine combined cycle (GTCC) for 1400–1500°C class).

The heat efficiency for existing power plants was determined based on a list of best available technologies to be 41% for coal-fired, 48% for gas-fired, and 39% for oil-fired power plants. In practice, power producers are required to meet both benchmarks—achievement ratio of heat efficiency targets for the group of power plants by each fuel type, and the average heat efficiency for all power generating facilities owned (44.3%). If a company's efforts to meet heat efficiency targets fall short, then METI will direct the company to improve, first through guidance, then advice and recommendations, then a ministerial order, and if these are still not sufficient, then METI will make a public announcement that the company's efforts have fallen short[6].

Moreover, the share of non-fossil fuel power sources should be made consistent with the energy mix pursuant to the Law Concerning Sophisticated Methods of Energy Supply Structures, which in reality means over 44% of electricity should come from non-fossil fuel sources, including renewable energy and nuclear power, for all power retailers generating over 500 million kWh annually.

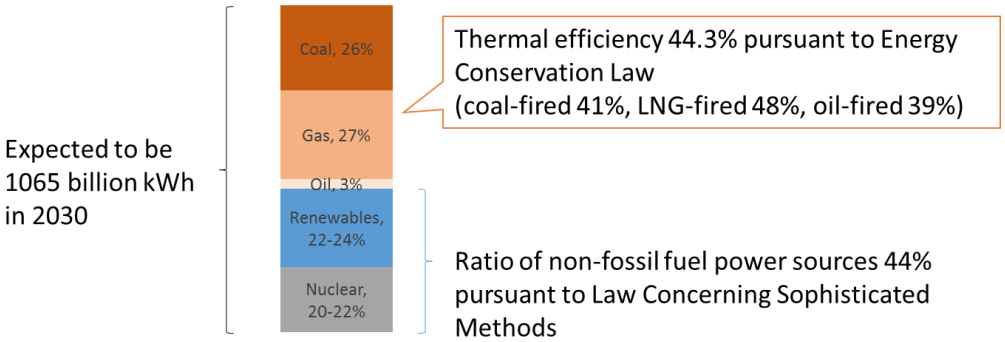

Figure 2: Fuel mix and thermal efficiency based on laws related to the electric power sector

Additionally, all power retailers are required to disclose CO_2 emission intensities of all electricity sold using guidelines for retail business pursuant to the Electric Utilities Industry Law and the Law Concerning the Promotion of Measures to Cope with Global Warming.

[5] Advisory Committee for Natural Resources and Energy, Committee on Energy Conservation and New Energy, Subcommittee on Energy Conservation, Working Group on Evaluation Criteria related to Thermal Power Generation, "Summary (draft)", 9 February 2016, in Japanese.

[6] Statement and declaration by Minister Hayashi, Minister of Economy, Trade and Industry "Introduction of a Mechanism to Ensure the Effectiveness of the Voluntary Framework in the Electricity Field", 9 February 2016, in Japanese.

Every fiscal year, the MOE is required to evaluate progress on the voluntary actions by power producers, including the capacity of power plants and CO_2 emission intensity of generated electricity based on the data delivered by METI.

2.3 Potential effects of the Voluntary Framework and Supporting Policy Measures

In order for the electricity sector to achieve its 0.37 $kgCO_2/kWh$ emission intensity target, electricity producers drafted a voluntary framework in line with the policy measures, such as the Energy Conservation Act, which sets benchmarks for thermal power plant heat efficiencies, the Law Concerning Sophisticated Methods, which determines the share of electricity from non-fossil fuel power plants, and information disclosure.

However, although the voluntary framework sets out how power producers are to develop plans and fulfil actions via PDCA, no details of how individual actions contribute to the overall emission intensity target for the electricity sector are given. Further, although obligations are set out in the policy measures designed to facilitate the voluntary framework (Energy Conservation Act and the Law Concerning Sophisticated Methods), it does not necessarily follow that power producers will comply with them, judging from past experience. As of 2015, only about half of all benchmarks in 10 areas covering six industries (including the electricity supply industry) were achieved[7], and none of the 11 electricity companies had achieved the benchmark as of 2015. Accordingly, if the voluntary emission intensity target cannot be achieved via the voluntary framework with the support of policy measures, then more stringent policy measures will be needed.

3. Impact on Japan's mid- and long-term targets

One of the biggest fears associated with starting up new coal- and gas-fired power plants is the lock-in effect due to the high CO_2 emissions they generate over their several-decade lifespan (30-40 years). Power producers therefore need to account for this when drawing up plans to ensure the 2030 or 2050 targets are not compromised[8]. Further, in light of the Paris Agreement's 2°C/1.5°C goal, which targets net-zero emissions by century's end, all countries are requested to review their nationally determined contributions within five years (the so-called "ratcheting-up mechanism". Thus when Japan renews its INDC it will be expected to reduce the use of coal- and gas- fired power plants in order to decarbonise the electricity sector[9]. This section therefore discusses whether the new power plants on the table would affect Japan's 2030 and 2050 electricity sector emission reduction targets.

[7] Agency for Natural Resources and Energy (2015) "Reported Findings on Benchmarks Pursuant to the Law Concerning the Rational Use of Energy", in Japanese , http://www.enecho.meti.go.jp/category/saving_and_new/benchmark/2014/benchmark26.pdf.

[8] The 2030 target was established in a Global Warming Prevention Headquarters decision on "Japan's INDC" (17 July 2015), and the 2050 target in the Fourth Basic Environment Plan (April 2014 Cabinet Decision), in Japanese.

[9] The IPCC Fifth Assessment Report cites large-scale decarbonisation in the electric power sector by 2050 in combination with phase-out of coal-fired power plants not equipped with CCS technology as an item common to scenarios for low-carbon emissions pathways (IPCC AR5 WGIII Chapter 6 Executive Summary, paragraph 5).

3.1 New and existing capacity of coal- and gas-fired power plants

Current plans for new construction or replacement total 18 GW of coal-fired power plants and 29 GW of natural gas-fired power plants[10], while the total capacity of existing plants is 49 GW and 73 GW, respectively[11]. This section looks at how plans for the intended new and replacement plants would impact the CO_2 emission reduction target under Japan's INDC, under the following assumptions.

- All coal- and gas-fired power plants that exceed their 40-year lifespan in 2030 are retired
- All newly constructed or replaced coal- and gas-fired power plant are installed by 2030
- Heat efficiency is 41% for coal-fired power plants and 48 % for gas-fired power plants
- A capacity factor of 70% is applied if the capacity factor needs to be fixed ex ante

As shown in Figure 3, if all new or replacement coal- and gas-fired power plants are installed by 2030 and operate at a 70% capacity factor—as assumed by a government outlook—CO_2 the resulting emissions will greatly exceed the emission target that can be calculated based on the outlook; in fact, they will surpass the 2030 INDC targets by 5.8 Gt CO_2 and 6.7 Gt CO_2, respectively.

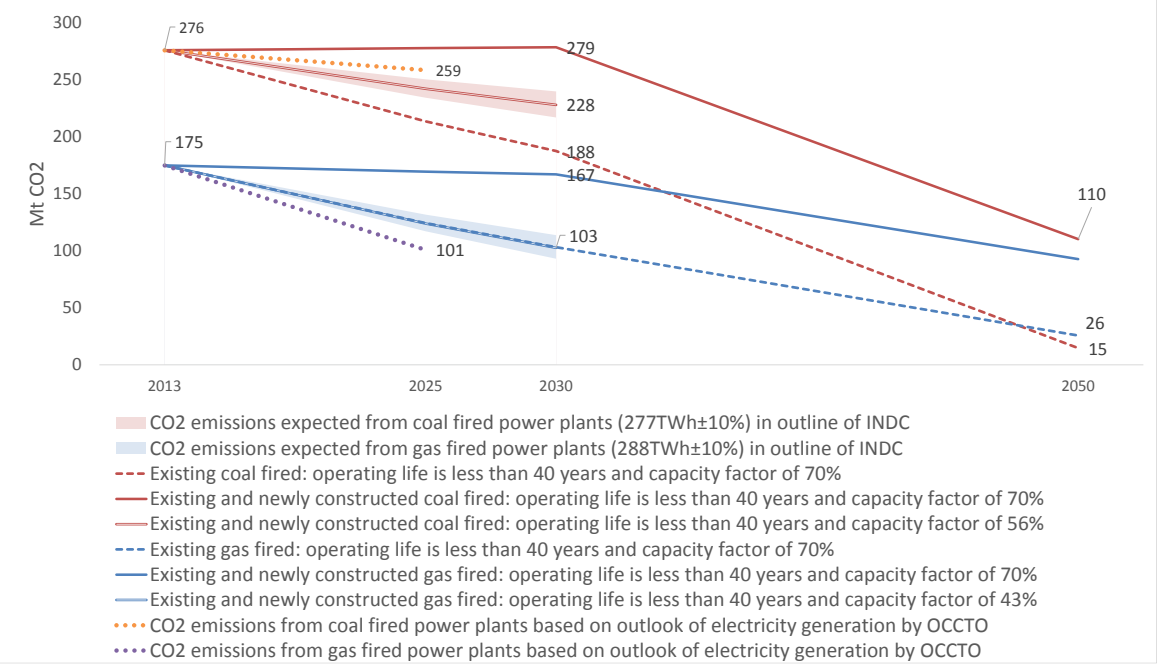

Figure 3 CO_2 emissions from existing and newly constructed coal- and gas- power plants in 2030 and 2050

The Organisation for Cross-regional Coordination of Transmission Operators, Japan (OCCTO)

[10] Agency for Natural Resources and Energy, "Standards for heat efficiency toward high efficiency thermal power plants" (17 November 2015), in Japanese.

[11] MOE, "Towards a large amount of GHG emission reduction in 2050" (11 October 2015), Agency for Natural Resources and Energy, "Standards for heat efficiency toward high efficiency thermal power plants" (17 November 2015) , in Japanese.

estimated the power output potential in 2025 for coal- and gas-fired power plants to be 314 TWh and 281 TWh, respectively. The emissions from coal-fired power plants in 2025 under the OCCTO estimation does not appear to be consistent with the emission pathway under the 2030 INDC target.

Based on the amount of electricity generated by each power source in 2030, assumed under the long-term energy outlook, and target heat efficiencies (under the Energy Conservation Act), CO_2 emissions would be 259 $MtCO_2$ for coal-fired plants, which would exceed the CO_2 emission target, and 101 $MtCO_2$ for gas-fired power plants, which might exceed the target due to the need to add 146 TWh from unidentified electricity supply sources (due to limitations implicit in the OCCTO estimation method), a part of which would likely be generated by coal- and gas-fired power plants.

Moreover, when all the coal- and gas-fired power plants, including all new and existing ones operating for less than 40 years in 2030, are operated, and the CO_2 emissions from these plants are subject to CO_2 emission targets, coal- and gas-fired power plants will have to operate at a capacity factor of 56% and 52%, respectively, to meet the targets.

However, some of the above assumptions are oversimplified. First, in particular for coal-fired power plants that are commonly operated at a capacity factor of 70–80%, lowering the capacity factor is not realistic[12]. Second, since coal- and gas-fired power plants are now more heat-efficient, as shown in Figs. 4 and 5, and the payback period of power plants is generally 15 years, older existing power plants might be retired before 40 years of operation, which would improve CO_2 emission intensity figures. Therefore, section 3.2 discusses four scenarios, based on a range of assumptions about the operating life and capacity factors for such plants.

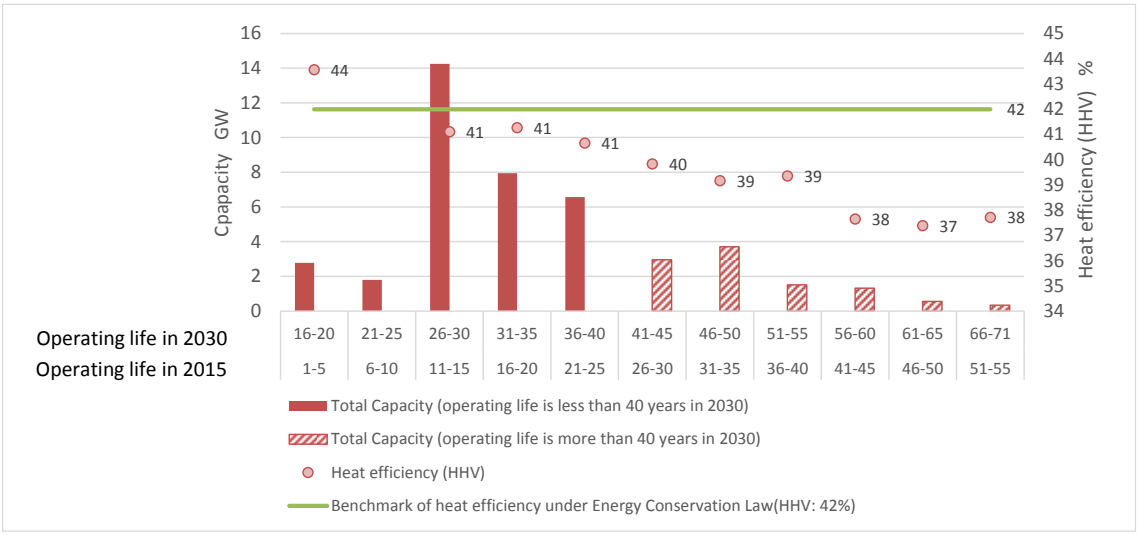

Figure 4 Capacity and heat efficiency (HHV) of existing coal-fired power plants, by year

[12] Agency for Natural Resources and Energy, "Issues in thermal power plants", March 2015, in Japanese.
Actual values released by the Agency for Natural Resources and Energy for 2014 are 78.4%. However, it is conceivable that some electric power producers are estimating low capacity factors in anticipation of large scale adoption of renewable energies.

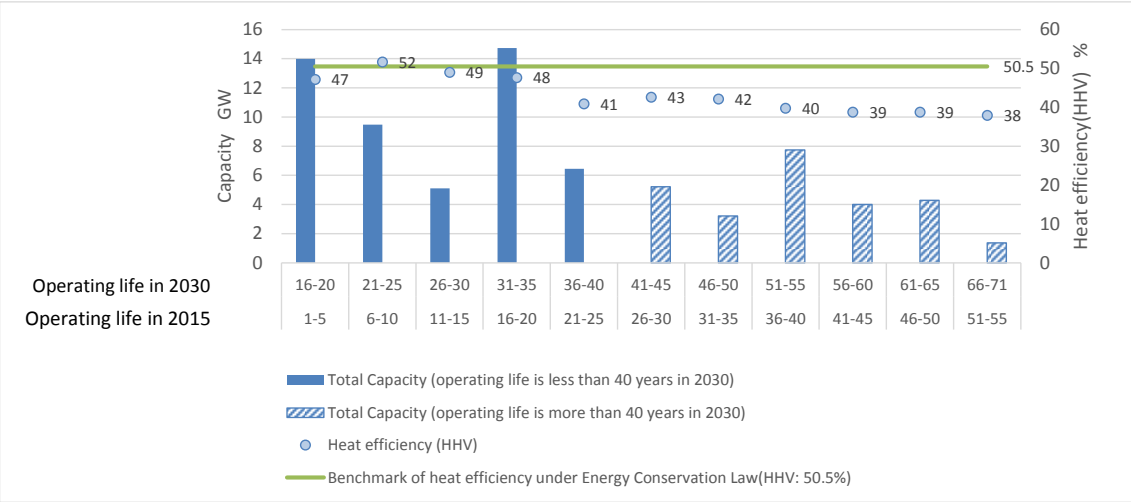

Figure 5 Capacity and heat efficiency (HHV) of existing gas-fired power plants, by year

3.2 Operational scenarios of the impact of coal- and gas-fired power plants on 2030 mid-term and 2050 long-term CO_2 emissions

This section develops four scenarios regarding the operation of coal- and gas-fired power plants and estimates CO_2 emissions in 2030 and 2050 with given amounts of electricity supply based on the government's energy outlook. The four scenarios are described below in order of CO_2 emissions in 2030 (from higher to lower):

- Scenario 1: a 70% capacity factor is applied for newly constructed coal- and gas-fired power plants; for existing ones, a 40-year lifetime period is applied but with the capacity factor adjusted to agree with electricity supply targets under the government's energy outlook.
- Scenario 2: a 70% capacity factor is applied for both newly constructed and existing coal- and gas-fired power plants; and existing older power plants are retired at the 35-year lifetime in order to meet the electricity supply targets under the government's energy outlook.
- Scenario 3: a 70% capacity factor and 40-year operating life are applied for both newly constructed and existing coal- and gas-fired power plants; some of the construction plans for new coal-fired power plants are terminated to meet the electricity supply targets under the government's energy outlook.
- Scenario 4: all plans for newly constructed coal- and gas-fired power plants are terminated; existing ones operate until end of their 45-year lifetime.

Table 1 summarises the conditions for each scenario. In Scenario 1, the capacity factors of newly constructed coal- and gas-fired power plants need to be reduced to 70% and 51%, respectively. In Scenario 2, while the capacity factor of coal-fired power plants with operating lives of less than 40 years is 37 GW, 10 GW of capacity should be retired before the 35th year

of operation. As a result, the heat efficiency of existing coal-fired power plants will be improved by 0.1 percentage points compared with Scenario 1. In Scenario 3, the capacity of newly constructed coal-fired power plants is reduced to 8 GW, which indicates that 10 GW of the planned new construction should be terminated. In Scenario 4, existing power plants should be operated at a 78% capacity factor. Since it is assumed in this scenario that operating lives should be 45 years, the average heat efficiency of all the coal-fired power plants decreases by 0.2 percentage points compared to Scenario 1. It should also be mentioned that all Scenarios can achieve the 0.37 $kgCO_2/kWh$ voluntary emission intensity target in 2030.

Table 1 Capacity and heat efficiency for coal- and gas-fired power plants under scenarios enabling to archive the 2030 emission intensity target

		Operation years	Coal-fired power plant			Gas-fired power plant			Emission factor ($kgCO_2$/kWh)
			Capacity（GW）	Capacity factor	Weighted average of heat efficiency	Capacity（GW）	Capacity factor	Weighted average of heat efficiency	
Scenario1	Existing	40	37	*51%*	*41.3*	47	*27%*	*47.5*	*0.36*
	New	40	18	70%	*43.2*	29	70%	*51.9*	
Scenario 2	Existing	35	*27*	70%	*41.4*	*18*	70%	*48.5*	*0.35*
	New	35	18	70%	*43.2*	29	70%	*51.9*	
Scenario 3	Existing	40	37	70%	*41.3*	47	70%	*47.5*	*0.36*
	New	40	*8*	70%	*43.2*	*0.07*	70%	*51.9*	
Scenario 4	Existing	45	40	*78%*	*41.1*	55	*60%*	*47.0*	*0.37*
	New	—	0	—	—	0	—	—	

Note: Underlined figures are calculation results; those without underlining are based on the assumptions under each scenario.

Figure 6 summarises the CO_2 capacity of coal-fired power plants and CO_2 emissions for each Scenario. In 2030, CO_2 emissions in Scenario 4 are 233 $MtCO_2$, which is 5 Mt higher than Scenario 1 and 2, while CO_2 emissions in all Scenarios would be within 5% of the level obtained by multiplying the target heat efficiency under the Energy Conservation Act by the amount of electricity generation under the government's energy outlook.

When coal- and gas- fired power plants are operated with same conditions under the four scenarios above, CO_2 emissions in 3050 are calculated to be 98 $MtCO_2$ for Scenario 1, 89 $MtCO_2$ for Scenario 2, 53 $MtCO_2$ for Scenario 3 and 15 $MtCO_2$ for Scenario 4 respectively, resulting in much higher CO_2 emissions in Scenarios 1 and 2 than in 3 and 4.

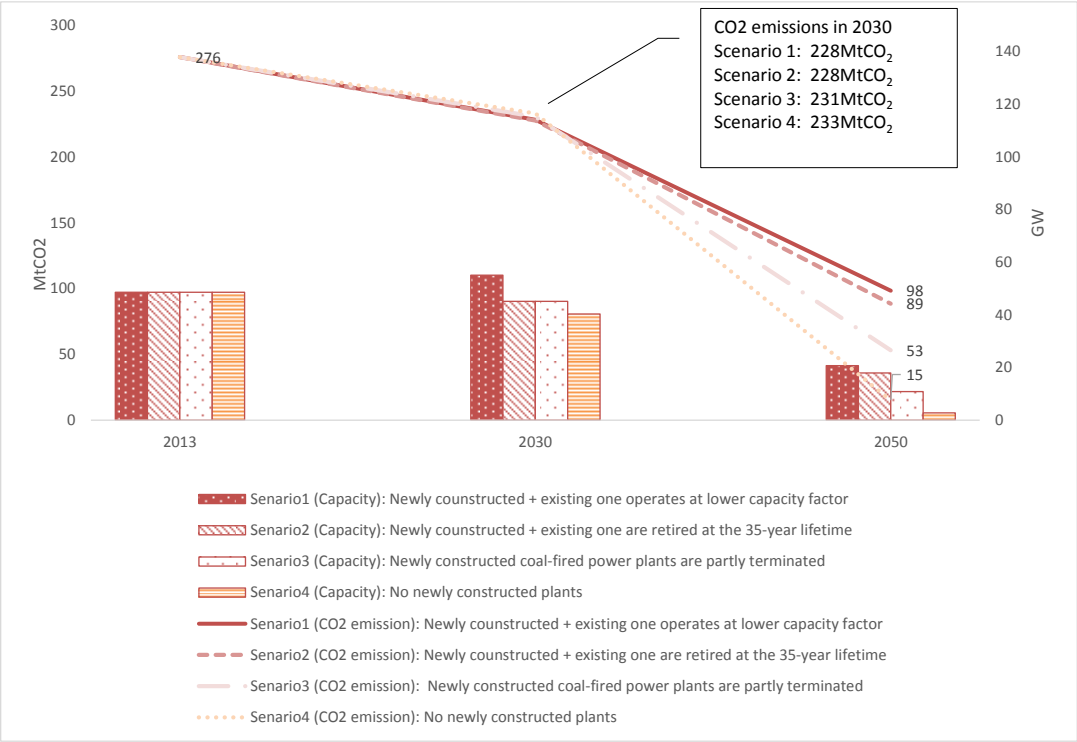

Figure 6 CO_2 emissions and capacity of coal-fired power plants under scenarios enabling to archive the 2030 emission intensity target

Figure 7 summarises the CO_2 emissions and capacity of gas-fired power plants for each Scenario. For gas-fired power plants in Scenario 1, if newly constructed ones are operated at 70%, existing ones would need to be operated at 27% in order to fulfil the emission reduction target that can be calculated based on the government's energy outlook. In Scenario 2, while the capacity factor of gas-fired power plants with operating lives of less than 40 years is 47 GW, 29 GW of capacity should be retired earlier than 35 years of operation. As a result, the heat efficiency of existing coal-fired power plants would be improved by 1 percentage point compared with Scenario 1. In Scenario 3, most plans for newly constructed gas-fired power plants need to be terminated. In Scenario 4, existing power plants should be operated at a capacity factor of 60%. Since existing plants operating for under 45 years in 2030 should be operated, the average heat efficiency of all gas-fired power plants would be lower (i.e., not improved) by 0.5 percentage points compared to Scenario 1. In 2030, CO_2 emissions in Scenario 4 are 116 Mt CO_2, the highest in the four scenarios but just 9 $MtCO_2$ higher than the lowest in Scenario 2. It should be also noted that all four Scenarios can achieve the 0.37 $kgCO_2/kWh$ voluntary emission intensity target in 2030. For 2050, CO_2 emissions calculated under the same conditions for 2030 CO_2 are estimated at 89 $MtCO_2$ for Scenario 1, 78 $MtCO_2$ for Scenario 2, 8 $MtCO_2$ for Scenario 3 and 6 $MtCO_2$ for Scenario 4, resulting in CO_2 emissions in Scenarios 1 and 2 much higher than in Scenarios 3 and 4.

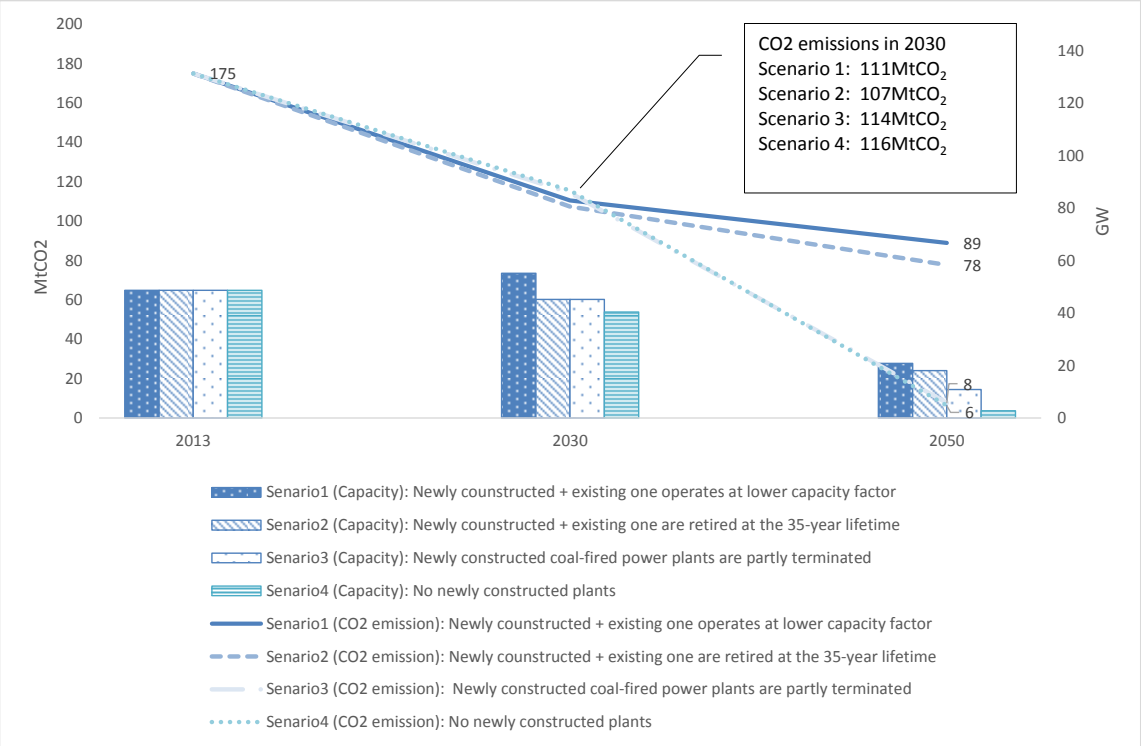

Figure 7 CO_2 emissions and capacity of gas-fired power plants under scenarios enabling to archive the 2030 emission intensity target

From the results above, 2030 CO_2 emissions in the scenarios that implement all plans for newly constructed coal- and gas-fired power plants would be lower than scenarios in which only existing coal- and gas-fired power plants are operated. But in terms of 2050 CO_2 emissions, Scenarios 1 and 2 are higher than Scenarios 3 and 4. Scenario 2 has lower emissions in 2050 than Scenario 1, with 89 and 78 Mt for coal- and gas-fired plants, respectively. In total, 167 Mt CO_2 would be emitted from all of the plants combined, which amounts to 62–68% of the 2050 emission target. This means that new coal- and gas- plants would incur a lock-in effect and compromise Japan's long-term target. Conversely, in order to achieve the long-term target, stringent measures are needed that shorten the operating lives of power plant or lower their capacity factors. Although CO_2 emissions from the plants could in theory be mitigated, for example via CCS and carbon offsets, these measures are risky, as explained in section 4.

4. Risk of mitigation measures to reduce CO_2 emissions from coal- and gas- power plants

4.1 Carbon capture and storage (CCS)

As discussed in the "Directors' Summary", installation of carbon capture and storage (CCS) technology has been studied for mid- to long-term control of CO_2 emissions from coal- and gas- power plants. The Summary states that new plants must be "CCS-ready" so that CCS

technology can actually be introduced. The previous Basic Energy Plan (June 2010) contains proactive wording on CCS, including acceleration of initiatives aimed at CCS commercialisation by around 2020, examination of introduction of CCS-ready new and additional coal-fired power, and examination of installation of CCS in coal-fired power plants by 2030. On the other hand, in the Basic Energy Plan of April 2015, any specific mention of a concrete time period for introduction has disappeared, and discussion of CCS was significantly reduced. The difference in policy on CCS between the two Basic Energy Plans might have resulted from the difference in motivation (recognition of necessity) to reduce emissions even to the extent of introducing CCS, that came about between June 2010 and April 2015 due to Japan's declaration in December 2010 of non-participation in the second commitment period of the Kyoto Protocol and the fact that initiatives became voluntary under the Cancun Agreement. However, this issue is not addressed in the current voluntary framework and policy measures.

Although Japan has started a CCS demonstration project aimed at commercialisation by 2020 and is assessing potential sites, several hurdles remain before it can be widely adopted, namely the high technology cost, regulations on environmental impact assessments and safety measures, lack of legal and institutional frameworks to maintain CCS over the long-term, and unknown level of social acceptability from the viewpoints of fisheries and nearby residents.

Meanwhile, the Paris Agreement's goals of 2°C/1.5°C and global net-zero emissions by the end of the century, which incorporates a ratcheting-up mechanism, will further limit fossil fuel use, which means non-CCS-compatible plants risk becoming stranded assets[13]. Even for coal- and gas- power plants that are CCS-ready, the aforementioned social and technical issues remain.

4.2 Carbon offsets

From 2008 to 2012, Japan's electric power industry transacted 275 million tonnes of Kyoto Units during the Kyoto Protocol's first commitment period (2008–2012) in order to achieve its voluntary action plan[14]. Moreover, according to the "Directors' Summary", during the period leading up to the formation of the voluntary framework, carbon credits from abroad are allowed to offset the difference in real CO_2 emissions of newly constructed coal-fired power plants and emission amounts which gas-fired power plants would emit. However, Japan's INDC plan sets out to achieve the 2030 reduction target based on domestic measures. Therefore, any construction and replacement plans that take into account overseas credit-based offsets would be inconsistent with the assumptions of Japan's INDC[15]. The INDC also states that "the Joint Crediting Mechanism (JCM) is not included as a basis of the bottom-up calculation of Japan's emission reduction target", but will be further elaborated to read, "but the amount of emission reductions and removals acquired by Japan under the JCM will be appropriately counted as Japan's reduction".

[13] Caldecott, B. et al., (2016) "Stranded Assets and Thermal Coal: An Analysis of Environment-related Risk Exposure" Stranded Assets Programme, Smith School of Enterprise and the Environment, University of Oxford.

[14] Keidanren (2013) Results of Fiscal 2013 Follow-up Survey of Voluntary Action Plan on the Environment, in Japanese.

[15] In the "Directors' Summary", utilisation of overseas credits is conditionally assumed for the "period leading up to framework formation". The current voluntary framework is not explicit on this fact, thus the potential for utilisation of overseas credits cannot be disaffirmed.

If overseas credits are unintentionally required to make up for a shortfall in the contribution of voluntary actions to the emission reduction targets, then the credits must be carefully scrutinized from the perspective of environmental integrity and accounting rules for credits (CERs) from Clean Development Mechanism (CDM) projects[16].

As of December 2015, over 7,500 CDM projects had been registered and over 30 million tCO_2 of credits issued for the second commitment period (2013-2020)[17]. Currently, global demand for credits is low, and how CERs would be actually issued is still undetermined. But once demand for credits increases, 800 million tCO_2 of CERs could potentially be issued[18]. This means that power producers could purchase CERs in bulk to reduce the emission intensity of their generated electricity. However, several issues remain in using CERs to lower electric power intensity levels. First, as noted above, the 2030 targets are based upon the assumption that the domestic measures will be implemented, and offsets based on CERs should not be factored in at the power plant planning stage. Second, the accounting and environmental integrity of using some CERs is problematic, as CERs were originally intended to be used to achieve targets under Kyoto Protocol rules. International rules, however, have yet to be set regarding the utilisation of CERs for reduction targets outside of the Kyoto framework—such as the voluntary targets leading up to 2020 of the Cancun Agreement and the post-2020 reduction targets under the Paris Agreement. Accordingly, Japan, with no emission reduction target under the second commitment period of the Kyoto Protocol, must proceed with caution in applying these credits toward a specific reduction target[19]. Third, of all registered projects, many involve concerns over additionality and do not contribute to sustainable development, issues which were also raised in the CDM policy dialogue held in 2012[20]. Moreover, it has also been pointed out that in the worst case the total volume of such credits is only about 15% of total issued CERs[21]. In terms of environmental integrity, and in view of possible international criticism, Japan needs to adopt a cautious stance similar to Switzerland on the quality of carbon credits used to achieve its reduction target.

Currently, 300,000 tCO_2 of domestic J-Credits (including 200,000 tCO_2 from solar power generation projects) are available for use in the Action Plan for Achieving a Low-Carbon Society. Reductions in CO_2 for solar power projects are calculated based on the concept that they indirectly reduce CO_2 emissions by substituting a certain amount of power generated by thermal power plants. Thus, from the perspective of double-counting, it is inappropriate to use such credits by installing solar power projects to offset the CO_2 emissions of thermal power plants. Further, it has been pointed out that carbon credits from forest absorption measures is problematic in terms of double-counting with reduction targets of different sectors, as well as consistency with internationally calculated and reported forest absorption

[16] Moreover, although Japan is not participating in the second commitment period of the Kyoto Protocol, it is possible for Japan to directly become a project participant and acquire primary CERs.

[17] See the IGES CDM Project Database. http://pub.iges.or.jp/modules/envirolib/view.php?docid=968.

[18] The necessary data for issuance of credits, such as power volume for power plant projects, is thought to have been continually recorded, making it possible to verify the data and issue credits at a later stage if the price of credits rises.

[19] For instance, there are credits used for the first commitment period of the Kyoto Protocol (CP1) as well as those used for the second commitment period (CP2). A variety of accounting rules exist to promote compliance with reduction targets, including the possibility for countries that have reduction targets under the Kyoto Protocol during CP2 to carry over unredeemed CP1 credits as CP2 credits.

[20] See Spalding-Fecher et al. (2012), Assessing the Impact of the Clean Development Mechanism, CDM Policy Dialogue.

[21] See Kuriyama and Koakutsu (2016), "Calculating credit amounts for CDM projects with concerns over additionality", IGES Working Paper No. 1508.

amounts[22]. While carbon credits generated from biomass boiler projects could be used, volumes are low.

5. Conclusion

According to all plans for new construction or replacement released to date, coal-fired and natural gas-fired power plants have total respective capacities of 18 and 29 GW. With older facilities (over 40 years old) being gradually phased out, if current plans for new and replacement coal-fired power plants are carried out, this paper concludes that they will need to be operated at 56% capacity factor in order to satisfy the emission target based on Japan's INDC electricity mix for 2030. The case for gas is similar, and gas plants will need to operate at 43% capacity factor. However, these figures are much lower than the 70% capacity factor assumed under the long-term energy outlook (electricity mix in 2030; METI). This means all newly constructed coal- and gas-fired power plants would exceed CO_2 emission estimates for the electricity sector under Japan's INDC.

On the other hand, regarding long-term targets (2050 targets), if existing and currently planned coal- and gas-fired power plants operate under the same conditions to achieve the 2030 mid-term target without installation of carbon capture and storage (CCS) equipment, emissions in 2050 would be 89 million tCO_2 from coal-fired power plants and 78 million tCO_2 from gas-fired power plants, equal to 62–68% of maximum emissions in the 2050 80% reduction target. Thus, measures to achieve the 2050 target would need to be more stringent than those needed for the 2030 target, and this, in turn, means that the operating lives and capacity factors would need to be reduced.

Regarding the installation of carbon capture and storage (CCS) equipment for mid- to long-term control of CO_2 emissions from thermal power plants, implementation risks remain. At a minimum, power plants must be built CCS-ready so that the technology can actually be introduced if it becomes available. However, the current voluntary framework and policy measures do not address CCS in detail, which leaves it in an awkward position, technologically, legally and socially, and raises concerns as to whether it can actually be implemented in a timely manner. Offsetting thermal power plant emissions using carbon credits was permitted during the first commitment period of the Kyoto (2008-2012), but Japan's INDC is premised on achieving the 2030 reduction target solely based on domestic measures. This means that using foreign carbon credits to offset the construction of new and replacement plants would contradict Japan's INDC policy, so if overseas credits are required to reach reduction targets, prudence will be necessary in order to avoid jeopardizing the environmental integrity of overseas credits and accounting rules.

Therefore, in order to operate all currently planned coal- and gas- power plants, while at the same time limiting CO_2 emission levels from the electricity sector as assumed in the INDC, these plants would need to operate at a low capacity factor, which would reduce their profitability. The Paris Agreement's goals of 2°C/1.5°C and net-zero emissions by century's end add additional pressures, as will the 5-yearly hikes in nationally determined

[22] METI (2012) "Direction of the New Credit System" (draft outline), in Japanese.

contributions—or "ratcheting-up mechanism". All these factors combined will put further pressure on the use of fossil fuels. If this pressure intensifies, it could result in coal- and gas-power plants incompatible with CCS becoming stranded assets.

The Energy Conservation Act, Law Concerning Sophisticated Methods and Retail Business Guideline requires that replacement and retirement of older power plants should result in improved heat efficiency and lower emission factors, but it does not regulate the retirement of older power plants or the operation of coal- and gas- power plants at lower capacity factors. In addition, if power producers build new coal-fired power plants, then they would have a strong incentive to operate them at the highest capacity. Therefore, the status of producers' voluntary action plans must be closely monitored in order to evaluate weather this voluntary framework is effective or not.

In conclusion, Japan's power producers are requested to develop individual action plans that satisfy the 2030 emission intensity targets under the voluntary framework supported by the policy measures (such as operating at lower capacity factors and early retirement of older plants). In addition, power producers should also aim to contribute to the 2050 long-term target, including partial termination of current plans for new construction and replacement. If these voluntary actions appear unlikely to achieve the 2030 target, the government may need to resort to stronger legal measures—such as emission caps for the electricity sector or a policy mix consisting of emission intensity and capacity factor targets.

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