Japan's likely 2030 energy mix: more gas and solar

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The Japanese government released the draft of its long-term energy outlook at the end of April and reaffirmed it on 1 June 2015. There are significant differences between the government's future scenarios and Bloomberg New Energy Finance's analysis, which shows a larger share of renewables and gas generation and a smaller contribution from nuclear and coal. This report details those differences and the underlying causes.

- **Nuclear:** the government projects nuclear generation will account for 20% to 22% of electricity supplied (213-234TWh) in 2030, thus requiring at least 38GW of capacity. Our analysis shows that by 2030, only 26GW of capacity would be operational even under the most optimistic restart scenario. Taking into account the costs and additional regulatory burden associated with extending the lifetime of reactors beyond 40 years, we do not expect nuclear to supply more than 10% of Japan's electricity in 2030 unless there are significant changes to current policy.
- **Thermal generation:** the government projects thermal sources will account for 56% of electricity supplied in 2030, down significantly from the 87% share in 2013. Our analysis forecasts thermal generators will account for 65% of electricity supplied. The biggest difference lies in the role of gas. The government forecasts almost equal contribution from coal and gas at 26% and 27% respectively, and oil at 3%. We project 23% from coal, 42% from gas and zero contribution from oil in 2030.
- **Renewables:** the government's projections for renewables are based on the implicit assumption that renewable projects cannot be economical without support mechanisms such as feed-in tariffs. As a result, the government's projects solar PV contribution to electricity supplied in 2030 at 7%. We expect solar PV contribution to electricity to reach 12%.
- **Emissions:** the government projects overall CO_2 emission reduction of 26% in 2030 compared to 2013. We have not modelled emissions outside of the electricity sector. However, our projected electricity generation mix would result in 28% lower emissions in 2030 compared to 2013. While we appear to be in agreement with the government's outlook, our projections are based on a higher percentage of renewables and gas, whereas the government's projection primarily relies on achieving its highly ambitious nuclear target.
- **Verdict:** our outlook is based on current policies, market trends as well as economics. The government's outlook appears to be an attempt at reconciling competing political goals of achieving a lower emission generation mix while at the same time protecting politically favoured technologies of coal and nuclear.

1. INTRODUCTION

Prior to the 11 March 2011 earthquake, tsunami and resulting Fukushima nuclear disaster, Japan planned to increase the share of its nuclear generation to 50% by 2030 from 30% in 2010 to reduce emissions from the power sector while ensuring cheap and secure electricity supply. Since then, the long-term energy outlook has been in a flux due to continued public wariness to nuclear power, industry concerns on rising energy costs as well as the hesitance of vertically integrated utilities towards renewables and the electricity market reform process. The change of government

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at the end of 2013, with power moving from the Democratic Party of Japan (DPJ) to the Liberal Democratic Party (LDP), further delayed a cohesive long-term vision.

The first "Energy Basic Plan" issued after the disaster – approved by the LDP-led Cabinet on 11 April 2014 – did not include any specific numerical targets. It rather called for nuclear and coal to be treated as important sources of base-load supply, in line with LDP's support for coal and nuclear. For the role of renewables (including hydro), it included a footnote: "Japan will aim to achieve higher level of contribution by renewables compared to prior targets", referring to the targets in the last Basic Energy Plan from June 2010: 13.5% by 2020 and 20% by 2030.

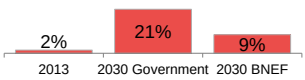
With the LDP government confident that the newly formed independent Nuclear Regulation Authority will be able to usher in restarts of nuclear power-plants, a "long-term energy supply-demand outlook subcommittee" under the Ministry of Economy, Trade and Industry's Advisory Committee on Energy and Natural Resources, started convening meetings earlier this year to draft a long-term outlook on energy mix. While no specific deadlines had been set, the goal was to ensure a draft was in place in time for the Japanese government to submit its emission reduction targets – Intended Nationally Determined Contributions (INDC) in the UN terminology – at the Bonn Climate Change Conference in June in preparation for the COP21 negotiations in Paris at the end of the year. On 28 April, the subcommittee released its draft 2030 energy outlook; the draft was reaffirmed on 1 June.

The committee's draft outlooks appears to be an attempt at reconciling competing goals of achieving a lower-emission generation mix while at the same time protecting politically favoured technologies of coal and nuclear. However the reasoning provided within the outlook remains inconsistent with current market trends and policies in place. We highlight the key issues.

2. GENERATION MIX

Fundamentally our approach and the government's approach to projecting generation mix differs: the government appears to assume that all existing nuclear assets can be restarted, and for other technologies, the existing project pipeline will be commissioned. All along it has stated that its goal is to ensure spending on electricity is reduced from the 9.7 trillion yen in 2013 to below 9.4 trillion yen in 2030. In our approach, we have first forecasted demand, and then projected what portion of existing assets (nuclear, thermal and renewables) will remain active based on regulations and economics. Next, we have projected how the supply shortfall will be met by looking at the existing announced project pipeline as well as the economics of yet-to-be announced projects.

Figure 1: Comparison of nuclear's share of electricity generated (TWh, normalised %)



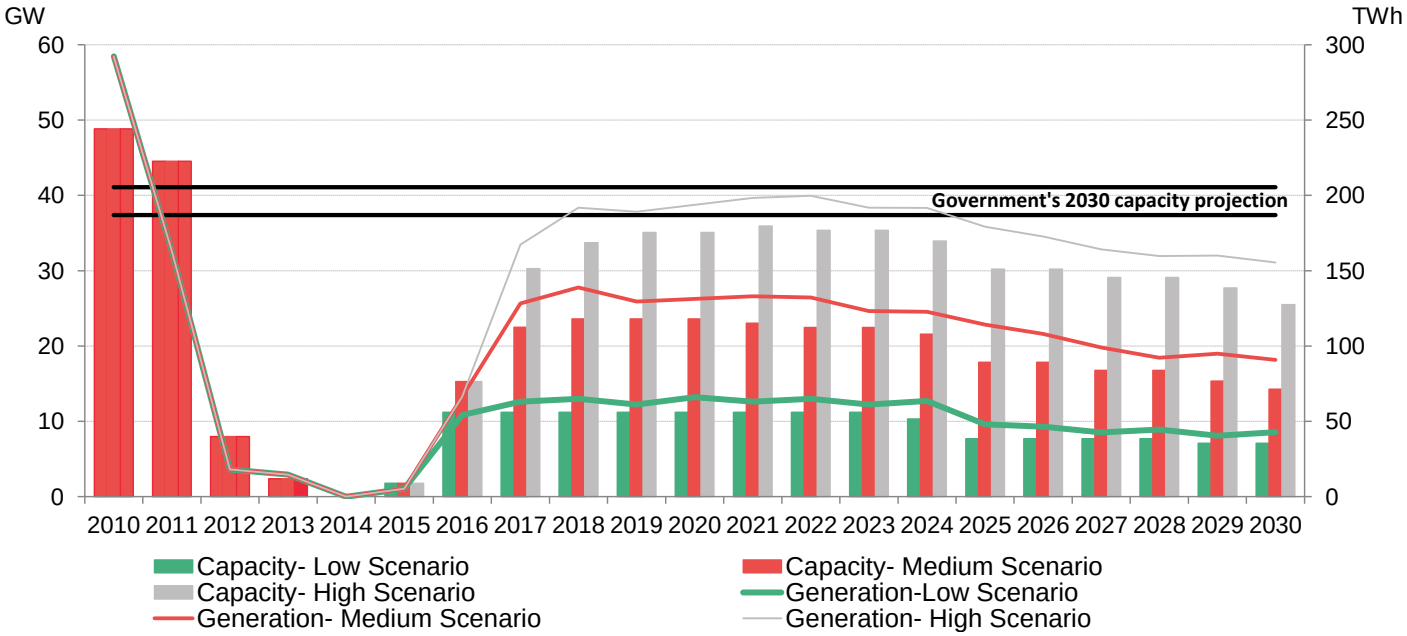
Source: Bloomberg New Energy Finance, Japan's Ministry of Economy, Trade and Industry

2.1. Nuclear

The government projects nuclear generation will account for 20% to 22% of electricity supplied in 2030 ie, 213-234TWh based on their absolute electricity generation projection. To generate 213-234TWh, we estimate 37.4GW to 41.1GW of nuclear capacity would be required ie, 11.9GW to 15.6GW more than our most optimistic "high" restart scenario forecast (Figure 2). This suggests the Japanese government intends to extend the lifetime of at least 13 reactors beyond 40 years, with the likely candidates being: TEPCO's Kashiwazaki Kariwa 1, 2, 3&5, Chubu Electric's Hamaoka 3&4, Kansai Electric's Ohi 3&4, Takahama 3&4, Chugoku Electric's Shimane 2 and Kyushu Electric's Sendai 1&2. However, extending the lifetime of all these reactors would be challenging due to continued anti-nuclear-power public sentiment. It may also not be economical to extend all these reactors due to additional costs involved in meeting the safety measures required to receive extension approval. Alternatively new nuclear capacity could be built.

However, the government's stated official policy is no new nuclear-build. For more information on our nuclear forecast, please refer to the appendix.

Figure 2: Bloomberg New Energy Finance's forecast for nuclear capacity and generation



Source: Bloomberg New Energy Finance, Japan's Ministry of Economy Trade and Industry.

2.2. Fossil fuel generation

The government projects thermal sources will account for 56% of electricity supplied in 2030 down significantly from the 87% share in 2013. Our analysis forecasts thermal generators will account for 65% of electricity supplied. The biggest difference lies in the role of gas generators. The government forecasts almost equal contribution from coal and gas at 26% and 27% respectively, and oil at 3%. We project 23% from coal, 42% from gas and zero contribution from oil in 2030. The government cites commitment to adoption of "efficient" coal technologies such as ultra-supercritical for its reasoning. We forecast a higher role for gas based on utilities' existing assets and project pipeline, as well as the ramping flexibility offered by gas turbines, which is needed to accommodate the increasing uptake of renewables such as solar PV.

Figure 3: Comparison of renewables share of electricity generated (TWh normalised, %)

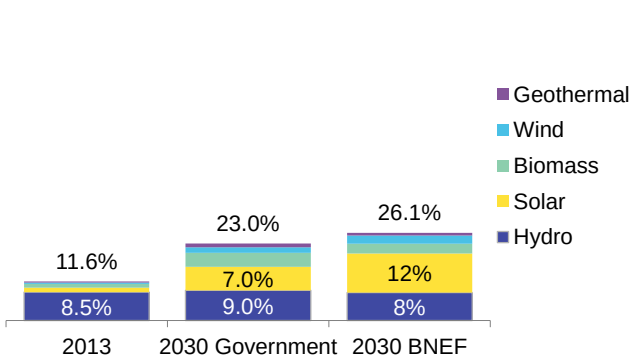
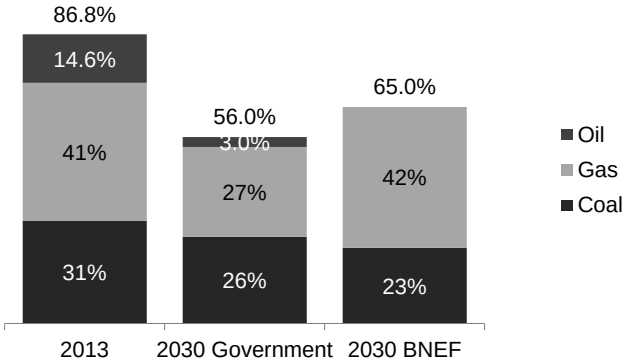


Figure 4: Comparison of fossil fuel powered generators share of electricity generated (TWh normalised, %)



Source: Bloomberg New Energy Finance, Ministry of Economy, Trade and Industry

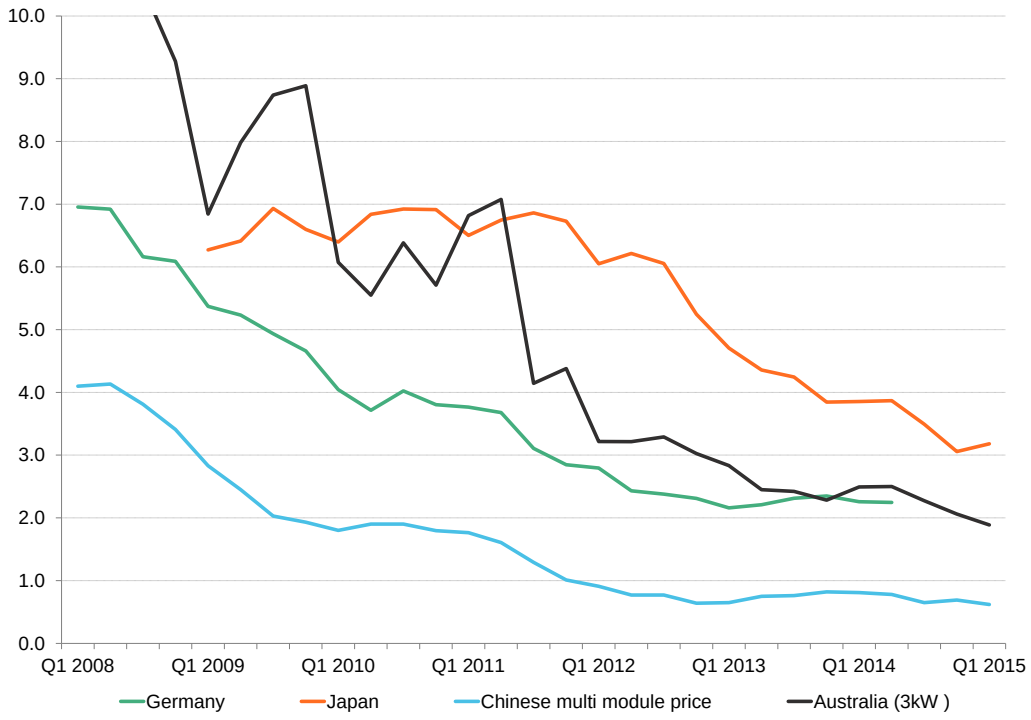
2.3. Renewables

The government appears to implicitly assume that no renewables would be built without feed-in tariff (FiT) support. Additionally its projections are primarily based on the existing feed-in tariff application approvals (and environmental impact assessment applications in the case of wind), even though new applications can still be approved and existing approved applications can be revoked. The biggest difference between the government's projections and our projections are for the solar sector.

Solar

The government has assumed 64GW of solar PV will be commissioned by 2030 – 9GW of residential and 55GW of non-residential. 61GW out of 64GW is based on the existing commissioned capacity (25GW) and existing approved feed-in tariff applications. The additional 3GW is estimated based on future feed-in tariff spending the government has proposed in its outlook. The government is implicitly assuming no solar PV would be built without support mechanisms despite the fact rooftop solar PV has proven to be economical without incentives in many countries already. Currently, residential rooftop PV systems (Figure 5) in Japan, on average, cost over 50% more than in Germany and Australia, both markets that experienced PV system price reductions once support schemes such as feed-in tariff were reduced. The rooftop PV market in Germany and Australia is now fully competitive with electricity retail rates. There is no fundamental reason to assume Japan will not follow a similar trajectory, unless additional regulatory burdens are applied to prevent uptake of rooftop solar PV.

Figure 5: Average residential PV system capex, $/W (DC)



Source: Bloomberg New Energy Finance, Solarchoice, J-PEC, BSW-Solar

In our analysis, we take into account the probability of cancellation of existing approved FiT applications, and also analyse the economics of rooftop installations that will be driven purely by

electricity retail rates. We therefore forecast 95.3GW of capacity by 2030, with installations under 1MW – primarily rooftop – accounting for 82%.

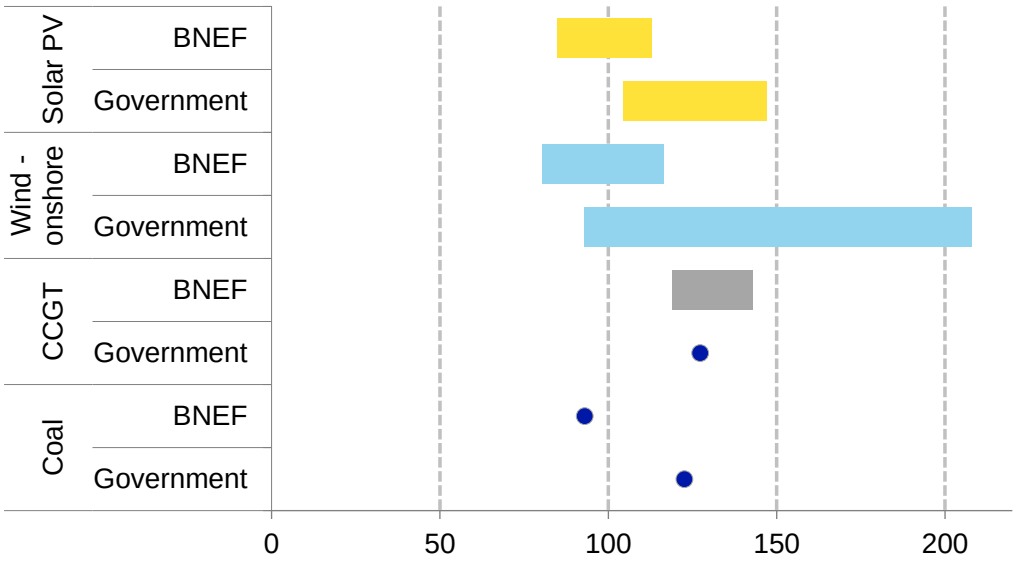
Wind

Our 2030 projections for wind (11.1GW) are fairly close the government's (10GW) albeit we differ on the details. The government projects 9.18GW of onshore and 0.82GW of offshore installations whereas we project 8GW of onshore and 3.1GW of offshore. The government's projections are on the basis of existing commissioned capacity (2.7GW), and projects currently going through environment impact assessment (5.2GW). It also expects an additional 2.1GW of yet-to-be announced projects as a result of enhancement to rules as well as the physical structure of the transmission network. The government's low offshore projection is rather surprising given its own stated policy of supporting that sector. In 2014 it launched the world's highest feed-in tariff rate for offshore wind, additionally the Ministry of Economy Trade and Industry has provided significant technology development funding: JPY4.9bn and JPY7.93bn in 2014 and 2015 respectively. In its projections the government has not addressed the number one concern raised by onshore wind developers: the far more stringent environmental impact assessment process that wind projects face compared to other generation technologies. Currently it is easier to develop a coal plant under 112.5MW than a wind project of a similar size.

3. COST OF NEW PLANTS

When it comes to projections for levelised cost of electricity (LCOE) associated with different technologies, our projections for renewables are lower than the government's projections (Figure 6). For thermal sources on the other hand we are consistent with regards to gas, while our projection is lower on coal compared to the government's forecast.

Figure 6: Comparison of 2030 forecast for levelised cost of electricity for new-built utility-scale projects ($/MWh)



Source: Bloomberg New Energy Finance, Ministry of Economy, Trade and Industry. Note: For converting the government's LCOE values, we have used the exchange rate disclosed by the government in its 2030 calculation: JPY 105.24 = $1

For coal, our fuel price assumption and the government's is very close: we forecast $129/t whereas the government uses $133/t. However the government appears to have calculated the LCOE based on the assumption that the plants would be ultra-supercritical, whereas we have considered the technology cost of the majority of current announced coal projects: supercritical and subcritical. Currently there is no regulation mandating usage of ultra-supercritical technology. Additionally coal plants under 112.5MW are not subject to environmental impact assessment by the Ministry of Environment. As a result, the majority of plants in this category are subcritical, as they are cheaper.

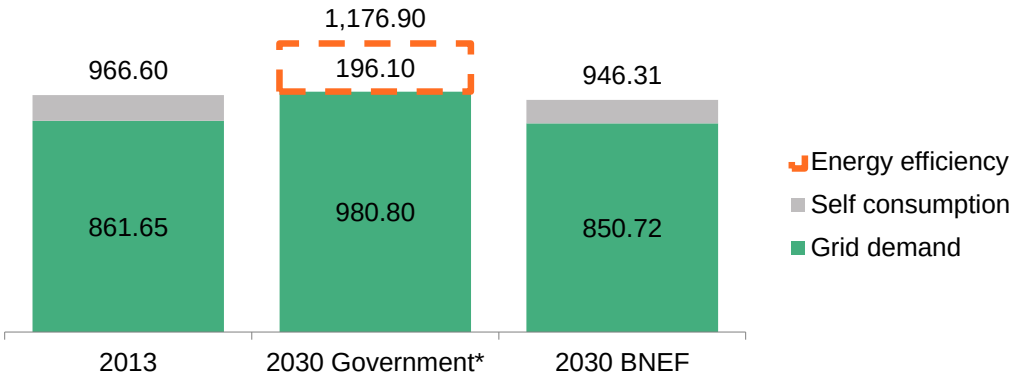
For nuclear, we do not have any projections specifically for Japan. The government's LCOE of JPY 8.8-10.1/kWh appears in-line with the last nuclear plants that were built in Japan. However, given the experience of recent projects in Western countries eg, Hinckley C in UK (GBP 92.5/MWh ie, JPY 17.96/kWh) it is unlikely that the government's range is realistic.

For solar, in its projections, the government also assumes cost reduction for equipment (modules and inverters) based on the solar PV technology experience curves. However, it assumes construction cost will remain constant at JPY 85,000/kW (10kW+) (JPY 58,000/kW for <10kW) through 2030. Its reasoning for this assumption is the expectation that labour cost increases will cancel out any productivity benefits from increased experience. In its calculation, the government also adds 5% of CAPEX as decommissioning costs. In our analysis, based on experience of mature markets such as Germany, we assume the experience curve applies to total capex, including labour, and not just equipment.

4. DEMAND OUTLOOK

The draft projections by the government see electricity demand increasing to 1,176TWh by 2030 ie, an increase of 21% compared to 2013 (967TWh) based on an average annual economic growth rate of 1.7%. Over the last 15 years, Japan's average annual GDP growth rate has been 0.67%. The report does not outline the basis of its high economic growth assumption; it appears to be an attempt to ensure consistency with the Bank of Japan's target inflation rate of 2%. In our demand analysis we have relied on economic outlook provided by the World Bank/IMF and have utilised an average nominal economic growth rate of 1%.

Figure 7: Electricity demand projections (TWh)



Source: Japan's Ministry of Economy, Trade and Industry, Bloomberg New Energy Finance. Note: in the government's draft outlook, electricity demand from the grid has not been distinguished*

Taking into account deployment of technologies such as smart meters, home/building energy management systems, demand response and residential fuel cell co-generation systems, the

government's demand projection for 2030 is reduced by 17% to 981 TWh closer to our projection of 946TWh (851 TWh excluding industrial self-consumption.). Still our projection of demand is below 2013 (by 2%) whereas the government's is above 2013 (by 1.5%). Given that the government's own projection shows population declining by 8% from 127m in 2013 to 117m in 2030, our demand projection and the government's may both prove to be too optimistic.

5. CONCLUSION

It is certainly very plausible that our projections may not be realised due to changing circumstances, for example, a significant spike in natural gas prices as a result of geopolitical conflict. As an independent third-party however, we try to ensure our projections are consistent with the best available data as well as fundamental market understanding. For governments' on the other hand, outlook projections can certainly become influenced by political preference as it appears to be in this case. It would be unrealistic to expect a subcommittee under the Ministry of Economy Trade and Industry's Agency for Energy and Natural Resources ie, an entity both with executive as well as regulatory powers, to produce an outlook free of political considerations. Some countries try to get around this challenge by assigning these types of analysis to an arm's length agency without any executive or legislative powers such as the Department of Energy's Energy Information Administration. Japan may very well want to consider such an approach in the future.

Table 1: Comparison of generation mix forecasts

Technology	2030 Government	2030 BNEF
Coal	26%	22.8%
Gas	27%	42.2%
Oil	3%	0%
Nuclear	20 ~ 22 %	8.9%
Hydro	8.8 ~ 9.2 %	8.4%
Geothermal	1.0 ~ 1.1%	0.8%
Biomass	3.7 ~ 4.6%	2.9%
Wind	1.7%	2.4%
Solar	7%	11.6%
Renewables subtotal	22 ~ 24%	26.1%
Zero-emission subtotal	42 ~ 46%	35%
Thermal subtotal	54 ~ 58%	65%

Source: Bloomberg New Energy Finance, Japan's Ministry of Economy Trade and Industry. The nuclear value in 2030 BNEF refers to our medium scenario.

Appendices

Appendix A: Nuclear restarts scenario details

The details of our new restart estimates are provided in Table 2. We have reviewed the status of each of the reactors:

- **Low scenario:** 12 reactors (totalling 11.2GW) will resume operation over the next two years with Kyushu's Sendai 1&2 restarting in August and September 2015, respectively. The low scenario assumes that only 12 pressurised water reactors (PWR) for which review applications have already been submitted will restart – namely, Kyushu's Sendai 1&2 and Genkai 3&4 and Kansai's Takahama 3&4 and Ohi 3&4, Shikoku's Ikata 3 and Hokkaido's Tomari 1-3.
- **Medium scenario (base case):** we project 26 reactors (totalling 24.4GW) will come back online over the next three years. In addition to the 12 reactors under the low scenario, we include
  - Six boiling water reactors (BWR) for which safety review applications have been submitted (TEPCO's Kashiwazaki Kariwa 1, 6&7, Chugoku's Shimane 2, Chubu's Hamaoka 4 and Tohoku's Onagawa 2)
  - Five reactors for which safety review application have not yet been submitted but additional safety measures are under construction. For example, Kashiwazaki Kariwa 5, Hamaoka 3 and Onagawa 3.
  - Takahama 1&2 and Mihama 3, for which Kansai has submitted a 20-year lifetime extension application.
- **High scenario:** in this case, 37 reactors (totalling 35.9GW) will restart including the two reactors currently under construction – ie, Chugoku's Shimane 3 (93.7% complete as of March 2011) and J Power's Ohma (construction planned to be completed in December 2021). In addition, we assume the 20-year extension will be granted to Ohi 1&2, which are relatively large (total 2.35GW) PWR reactors with other reactors in the same site already under safety review. In this scenario all reactors will eventually restart *except:*
  - Eight old reactors built before 1978 (ie, reaching the end of their 40-year lifetime within four years - Kansai's Mihama 1&2, Chugoku's Shimane 1, Shikoku's Ikata 1, Kyushu's Genkai 1 and Japan Atomic Power's Tsuruga 1 & Tokai 2) for which utilities have decided not to apply for an extension because of the high cost of meeting new safety requirements. Exceptions are Takahama 1&2 and Mihama 3 (built in 1974, 1975 and 1976), as described above.
  - Four located in Fukushima prefecture (TEPCO's Fukushima Daini 1-4)
  - Five reactors that the NRA has concluded are close to active fault lines (Japan Atomic Power's Tsuruga 2, Tohoku's Higashidori 1 & 2, and TEPCO's Higashidori 1 & 2)

Table 2: Nuclear restart scenarios

Scenario	Reactor	Type	Restart date estimate (CY)	Current status	Capacity (MW)	40-yr lifetime
Low	Kyushu- Sendai1,2	PWR	Q3 2015	NRA approved for all the three steps. Local consent given. Sendai 1 likely to restart in August and Sendai 2 in September.	890 890	2024 2025
	Kansai-Takahama 3,4	PWR	Q1 2016	NRA approved the first report. Utility has submitted the second report: plan for construction works.	870 870	2025 2025
	Shikoku- Ikata 3	PWR	Q1 2016	NRA likely to approve the first report in June. Utility plans to restart within 2015. Local consent yet to be given.	890	2034
	Kyushu-Genkai 3,4	PWR	Q1 2016	Under safety review, Earthquake assumptions approved by NRA	1,180 1,180	2034 2037
	Kansai- Ohi 3, 4	PWR	Q3 2016	Under safety review, earthquake assumption approved, seismic strengthening under way.	1,180 1,180	2031 2033
	Hokkaido-Tomari 1,2,3	PWR	Q3 2016 Q1 2017,Q3 2016	Under safety and earthquake assumption review. Utility decided to invest five times more in safety measures.	579 579 912	2029 2031 2049
Low Scenario total capacity: 11.2GW (12 reactors)						
Medium (including 'Low')	TEPCO- Kashiwazaki Kariwa 6, 7	BWR, ABWR	H2 2016	Under safety review. Safety facilities in final phase, geological survey under way.	1,356 1,356	2036 2037
	Chugoku- Shimane 2	BWR	H2 2016	Vent and other safety facilities under review.	820	2029
	Kyushu- Genkai 2	PWR	H2 2016	Safety review application not yet submitted, but we expect a restart after Genkai 3,4	559	2021
	Shikoku- Ikata 2	PWR	H1 2017	Safety review application not yet submitted, but we expect a restart after Ikata 3	566	2022
	TEPCO- Kashiwazaki Kariwa 1,5	BWR, ABWR	H1 2017	Reactor 1 is under safety review. For reactor 5, review application not yet submitted but safety facilities under construction	1,100 1,100	2025 2030
	Kansai- Takahama 1&2	PWR	H1 2017	Utility submitted life time extension application as well as safety review for restart.	826 826	2014+20 2015+20
	Kansai – Mihama 3	PWR	H1 2017	Submission for life time extension to METI and safety review to NRA, under review. Under NRA's active fault inspection.	826	2016+20
	Tohoku- Onagawa 2, 3	BWR	H1, H2 2017	Reactor 2 under safety review. Vent to complete in 2015, higher tsunami wall in Mar 2016	825 825	2035 2042
	Chubu- Hamaoka 4	BWR	2017	Under safety review. Additional safety measures to complete in Sep 2016	1,137	2033
	Chubu-Hamaoka 3	BWR	2018	Additional safety measures to complete in Sep 2017	1,100	2027
Medium Scenario total capacity: 24.4GW (26 reactors)						
High (including 'Low' & 'Medium')	Hokuriku- Shika 1,2	BWR ABWR	2017	Reactor 2 under safety review. Both under NRA's active fault inspection	540 1,206	2033 2046
	Chugoku- Shimane 3	ABWR	2017 (start)	93.6% complete as of Apr 2011 (utility is not providing the further updates)	1,373	2057e
	Tohoku- Onagawa 1	BWR	2017	Higher tsunami wall to be completed by Mar 2016	524	2024
	TEPCO- Kashiwazaki Kariwa 2,3,4	BWR	2017	Vent and other safety facilities construction under consideration by the company	1,100 1,100 1,100	2030 2033 2034
	Kansai- Ohi 1,2	PWR	2018	We expect Kansai to apply for life extension	1,175 1,175	2019+20 2019+20
	Chubu- Hamaoka 5	ABWR	2019	Construction of additional safety measures under consideration by the company	1,380	2045
	J Power- Ohma	ABWR	2021 (start)	Under construction, J-Power announced additional construction to be completed in 2020	1,383	2061e
High Scenario total capacity: 35.9GW (37 reactors)						

Source: Nuclear Regulatory Authority, Bloomberg New Energy Finance. Note: ABWR, BWR and PWR stand for advanced boiling water reactor, boiling water reactor and pressurised water reactor respectively.

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