April 2024

The role of LNG in the North Asian energy transition: lagging renewables means more LNG for longer?

1. Summary

Japan, Korea and Taiwan are all struggling to meet their emissions reduction targets as they work to decarbonize their energy systems. Failures to grow renewables in the power sector fast enough to meet end-of-decade emission targets mean that there will inevitably be recourse to LNG and even coal imports at higher volumes for longer.

The three countries, all top ten LNG importers, have varied political approaches and energy circumstances. However major commonalities exist in the strategic challenge to decarbonize energy systems. In terms of renewables, the most obvious is that while some growth is evident in solar power, wind power growth has lagged behind targets badly. Nuclear restarts in Japan remain a vexed political topic and are therefore uncertain while, on the other hand, Korea's plans to sustain recent strong growth look reasonable given new nuclear plants under construction. Taiwan's commitment to winding down nuclear by next year means more LNG as its growth in renewables falls short.

Setting aside the macro drivers for energy demand growth that will impact all supply sources, other things being equal we expect LNG is likely to maintain a stronger profile in the energy mix – closer to the OIES Declared Policy Scenarios (DPS) than the IEA or even some government targets – all of which is explained in depth below. Government reality checks on energy strategy that may include relaxation of medium and long-term emissions targets, would reinforce that expectation. Whatever their targets, it is clear that in all three countries, whether through infrastructure investment or the push to renew long-term contracts, preparations are underway to retain more LNG as part of the energy mix for longer, despite aggressive emissions targets.

The gap between emission reduction targets and reality was the focus of the March 2024 message from Mr Tatsuya Terazawa, Chairman and CEO of the Japan Institute of Energy Economics who gave his message the provocative title of, "The gap between aspiration and reality: the need for Plan B"[1]. As he noted, G7 members' greenhouse gas emissions reductions are off-track from their Nationally Determined Contributions (NDCs) and carbon neutrality paths. The gap between aspiration and reality necessitates Plan B.

Mr Terazawa's comments are particularly relevant to Japan, Korea and Taiwan, the subject of this Energy Insight. Realistically Plan B is likely to require more LNG but if not, more coal.

[1] https://eneken.ieej.or.jp/en/chairmans-message/index.html

Graeme Bethune, Senior Visiting Research Fellow, OIES

Japan – LNG and coal needed to offset lags in renewables and nuclear restarts

As of 2022 Japan's emissions from energy usage were down by 20.2% from 2013 but with a long way to go to reduce emissions by the target of 46% by 2030.

Reducing emissions requires a significant change in the fuel mix for electricity generation. In Japan 65% of electricity was generated from fossil fuels in 2022, 30% from coal, 31% from gas and 4% from oil. Renewables contributed 15%, hydro 7% and nuclear 5%.

Around two-thirds of gas supply is used for electricity generation with the remainder evenly spread between industry, residential and commercial use. The outlook for gas in Japan depends particularly on gas use for generation.

As part of its commitment to net zero by 2050, Japan plans to reduce the LNG share of power generation to 20% and coal to 19% by 2030, to be largely replaced by increased renewables and nuclear. This would imply LNG imports dropping from 72 Mt in 2022 to 47 Mt by 2030.

Japan has made significant progress in solar. In 2020 Japan ranked 6th in the world among major nations in renewable energy generation capacity and 3rd in solar capacity[2]. However, there has been much less progress with wind, particularly offshore wind. Nuclear generation also needs to more than double by 2030 but in 2022 was down by 21% from its most recent peak in 2019.

Japanese renewables and nuclear are not growing fast enough to offset the proposed reduction in fossil fuels, with coal and/or gas needing to make up the generation gap. In terms of emissions, maintaining the role of LNG with CCS would be preferable to coal but to date, gas has lost out to coal, with higher emissions as a result. Since peaking in 2014, the use of both coal and gas for power generation has fallen but gas has been the biggest loser. In 2021 gas use was 23.2% down from 2014 whereas coal use was down by 9.3%. Maintaining the role of LNG is likely to need a realistic carbon price or direct government action.

Korea – LNG likely to defy reduction targets amid renewables shortfall

Korea is planning to reduce its emissions by 40% below 2018 levels by 2030 but by 2022 emissions from energy were only down by 9.3%. In recent years there has been a reduction in coal use for power generation, with increases in gas and nuclear. Coal's share of power generation has fallen from 45% in 2012 to 34% in 2022 while gas has increased significantly, from 21% to 29%. The share of nuclear has been steady over the same period. The share of renewables has increased from 2% to 8%.

Like Japan Korea aims to achieve its emission reduction targets with renewable energy and nuclear increasing steeply while coal and LNG decline. The use of LNG for power generation is targeted to decline from 29 Mt in 2021 to 22 Mt in 2030 to 10 Mt in 2036. Assuming LNG for other purposes remains constant, total LNG imports would decline from 47 Mt in 2022 to 38 Mt in 2030 and 26 Mt in 2036, the same as in 2007. The capacity of renewable energy in 2030 is expected to be 72.7 GW. This requires an additional 39.9 GW above existing capacity. Nuclear generation has been growing strongly in Korea (up by 21% between 2019 and 2022) and construction of two new nuclear reactors is resuming after being halted in 2017.

As in Japan, Korea's plans to reduce emissions also rely heavily on growth in renewables. Solar capacity is growing relatively quickly at about 2 GW per annum. However, in 2022 solar only contributed 4.3% of total generation. There has been even less progress with wind. Onshore wind capacity at the end of 2022 was only 1,658 MW and offshore capacity was only 142 MW (i.e. 1.8 GW in total)[3]. Wind contributed less than 1% of total generation. The Korean government is targeting 34 GW of installed wind capacity by 2036.

Notwithstanding the targeted reduction in LNG, substantial investment is currently underway and proposed in Korean LNG infrastructure, regasification terminals and storage. Korean LNG buyers have

[2] https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2022.pdf

[3] https://gwec.net/globalwindreport2023/

been active in securing new long-term LNG contracts. This suggests that companies believe Korean LNG imports will need to grow, not decline.

Taiwan – LNG wins as nuclear winds down

Taiwan is also committed to net zero by 2050 but is aiming to phase out nuclear by 2025 and increase the use of gas.

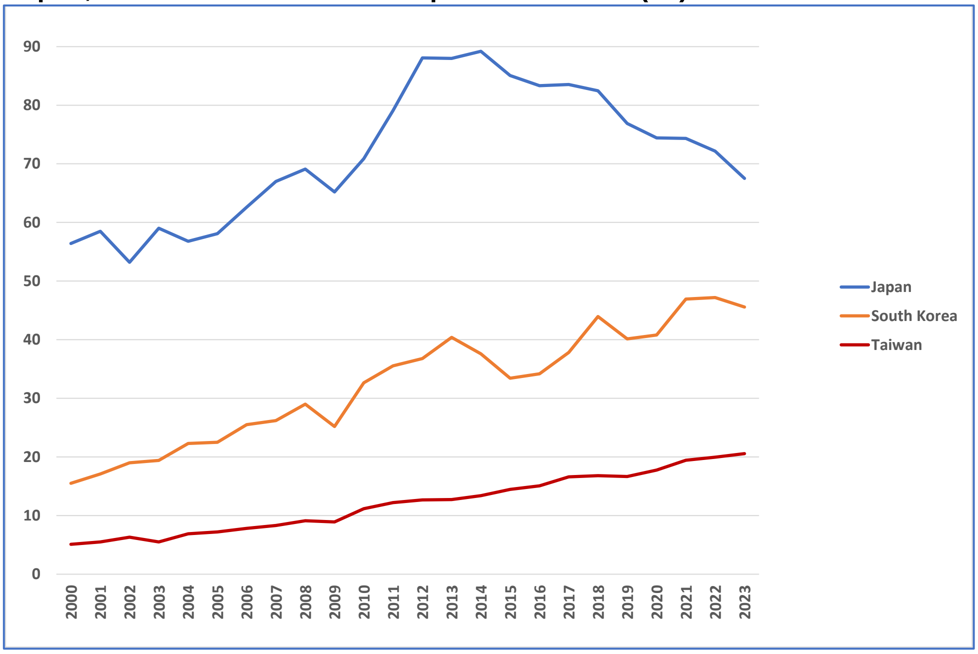
Coal-fired power generation accounted for 42% of its power mix in 2022, gas was 39%, renewables around 5%, nuclear 8% and the remainder was accounted for by other sources including hydro. By 2025, the share of coal has to come down to 30%, gas has to reach 50%, renewables have to reach 15% and nuclear has to go to zero[4]. Taiwan is proposing a higher share for LNG to offset the impact of the final nuclear phase-out. These emissions will also need to be abated. Increasing the gas share of power generation to 50% would require an additional 3 Mtpa of LNG imports.

As in Japan and Korea renewables are growing. Solar has been growing but as of 2022 had only achieved half of the 2025 target and less than one-third of the wind target. Achieving 50% gas-fired power generation in Taiwan's power mix by 2025 requires accelerated development of both gas-fired power plants and LNG receiving terminals, but projects have been bogged down by environmental delays.

2. Introduction

Japan, Korea and Taiwan are three of the world's most important buyers of LNG. In 2022 Japan was the world's largest buyer, Korea was the third largest and Taiwan was the fifth largest[5]. Japanese demand gradually increased through the early 2000s and then surged following the Fukushima Earthquake in 2011, reaching nearly 90 million tonnes (Mt) in 2014 (Figure 1). However, this surge was temporary and by 2022 Japanese demand was down close to the pre-Fukushima level. Meanwhile, LNG demand has been continually increasing in Korea and Taiwan. Figure 1 shows LNG imports in each of the three countries since 2000.

Figure 1: Japan, Korea and Taiwan LNG imports 2000-2023 (Mt)



Source: GIIGNL/BP/Kpler

[4] https://www.moea.gov.tw/MNS/english/Policy/Policy.aspx?menu_id=32904&policy_id=19
[5] https://giignl.org/wp-content/uploads/2023/07/GIIGNL-2023-Annual-Report-July20.pdf

The purpose of this Energy Insight is to consider the outlook for LNG in each of these countries. This is an ambitious task. Future LNG demand is a subset of future energy demand, which depends on population growth, GDP growth and the energy intensity of GDP[6]. The market share of LNG further depends on competition from other traditional fuels (coal, oil and nuclear) and renewables, with governments pledging to achieve net zero greenhouse emissions by 2050 (i.e. net zero carbon intensity).

All three countries have committed to achieving net zero greenhouse emissions by 2050.

The pledges by Japan and Korea in October 2020 appear to have been in reaction to China's commitment to net zero by 2060 in September 2020. Taiwan followed in April 2021. Japan and Korea are both parties to the Paris Agreement on greenhouse emissions reduction and submit their plans to the United Nations every five years. Japan is an Annex 1 party but Korea is still categorised as a developing country and Taiwan is not a member of the UN.

The three countries not only have long-term emission reduction targets for 2050 but also ambitious interim targets for 2030 with a reduced role for LNG in Japan and Korea. LNG demand is already falling in Japan, as is energy demand generally. Japan aims to reduce its emissions in 2030 by 46% compared with 2013 by boosting renewable energy and nuclear power and reducing the share of natural gas (LNG), coal and oil[7]. Renewables (including hydro) are targeted to grow from 20% of generation in 2021 to 36-38% by 2030 while LNG is targeted to fall from 34% to 20%.

OIES Energy Insight 104, by Martin Lambert published in November 2021[8], provided a detailed analysis of the energy transition in Japan and the implications for gas consumption. It concluded that future Japanese demand for LNG will be much more uncertain than has been the case in the past. This continues to be the case.

It is a similar story in Korea, which aims to reduce its 2018 emissions by 40% by 2030 by increasing the share of nuclear and renewables in power generation to the detriment of LNG and coal. The share of renewables in power generation is targeted to increase from 6.2% in 2021 to 21.6% in 2030 while the share of LNG is targeted to fall from 31.8% to 22.9%.

Taken at face value, these interim targets undermine the case for gas as a partner in decarbonisation.

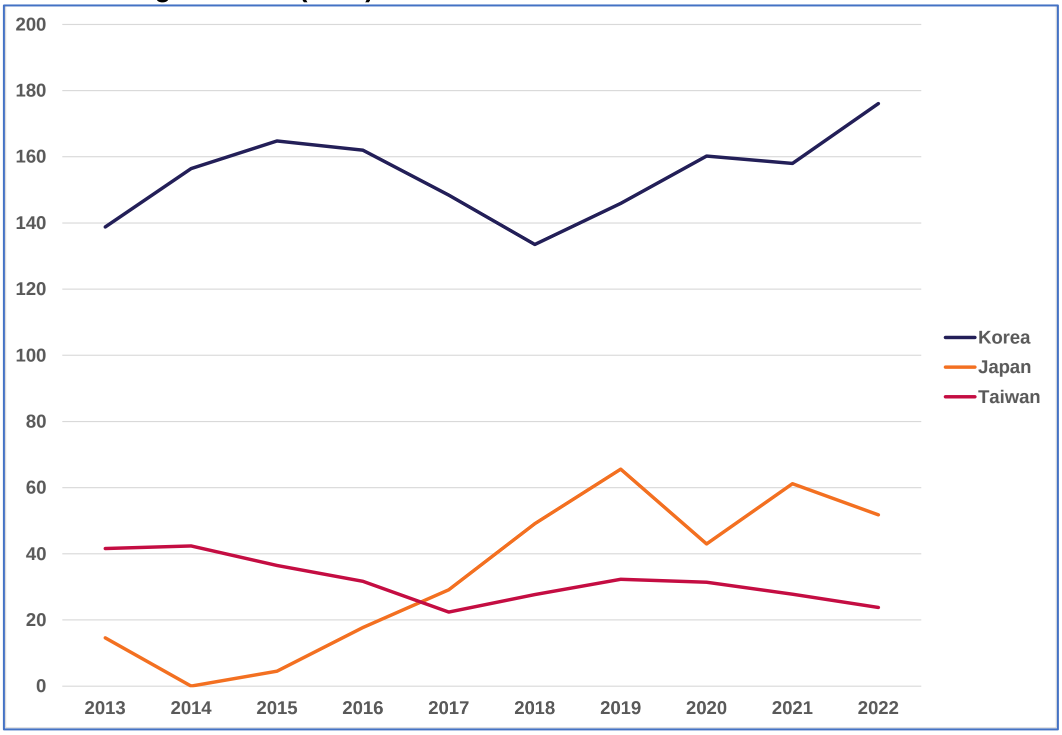
Only in Taiwan is there a target to increase LNG, from 39% of power generation in 2022 to 50% by 2025 (next year) but this is to offset a phase-out of nuclear, which would increase emissions.

However, all three countries are highly dependent on imported fossil fuels and have challenges in quickly expanding cleaner alternatives. While renewables are growing, fossil fuels still supplied 80% of primary energy in Korea in 2022, 87% in Japan and 91% in Taiwan. Quickly replacing fossil fuels with renewables is challenging. Development of renewables onshore is limited by high population densities, with 328 people per square kilometre in Japan, 521 in Korea and 667 in Taiwan. By way of comparison, population density in the United Kingdom is 279 people per square kilometre. Solar capacity has been growing, reaching nearly 10% of Japanese generation in 2022 but it was still less than 5% in Korea and Taiwan. Wind capacity has lagged far behind solar. Of the three countries wind made the greatest contribution in 2022 in Taiwan and that was only 1.2% of generation.

Attitudes to nuclear are softening in Japan and Korea but it remains controversial but Taiwan aims to completely phase out nuclear next year. Nuclear generation is increasing in Korea and contributed 28% of power generation in 2022, but has been flat in recent years in Japan (contributing only 5% in 2022) and declining in Taiwan (with only an 8% share in 2022) (Figure 2).

[6] As per the Kaya identity.
[7] https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2022.pdf
[8] https://www.oxfordenergy.org/publications/energy-transition-in-japan-and-implications-for-gas/

Figure 2: Nuclear generation (TWh)



Source: Energy Institute

With only eight years to go to 2030, Japan had only reduced its emissions from energy by 20.2% below 2013 levels in 2022, Korea had only reduced its emissions by 9.3% below 2018 and Taiwan's emissions were 3.1% higher than in their selected base year of 2005.

If, as is likely, renewables do not grow quickly enough for Japan or Korea to meet their 2030 emission reduction targets, the difference will inevitably be met by gas and/or coal. With a realistic carbon price gas would be likely to be called upon as a backup option, still enabling an overall reduction in emissions. Reaching emissions reduction targets however would require substantial Carbon Capture and Storage (CCS) and /or some other offsets or abatement.

In the absence of a meaningful carbon price, coal is likely to be called upon, marginalising gas and increasing emissions.

In Taiwan, the outcome depends on how quickly nuclear is phased out and the degree to which this is offset by gas or coal.

Moreover, reducing emissions is not the only energy challenge facing these countries. Some of their major exports are vulnerable to the energy transition. Motor vehicles are major exports for both Japan and Korea, with the issue of the future of internal combustion engines and whether the future vehicle mix will be dominated by electric vehicles, hybrids or hydrogen. Although none of the countries produce crude oil, they are major exporters of refined petroleum and petrochemicals. The future of petroleum refining in the energy transition is also an important issue they must face while reducing emissions.

As can be seen, considering the future of LNG demand by these three countries raises myriad issues well beyond the scope of any single Energy Insight. Any forecast for LNG demand in 2050 or even 2030 is uncertain. However, this report aims to provide an update on the current energy mix of each of the three countries and their energy policies, together with pointers to the future.

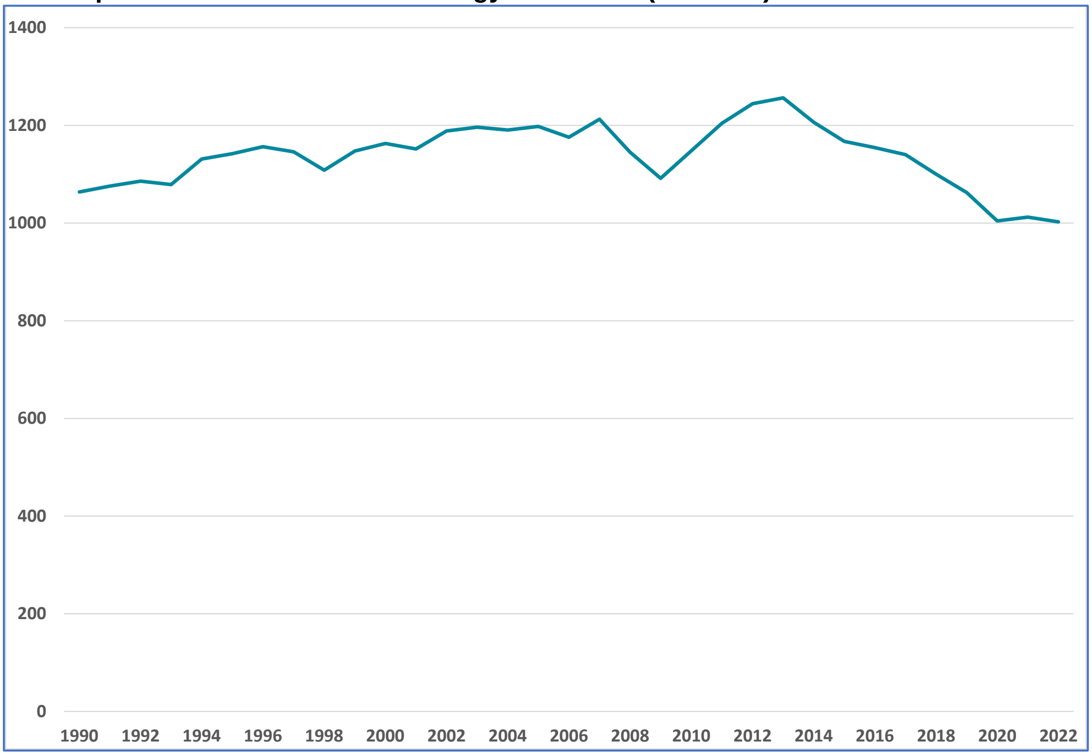
3. Japan

Energy background

Japan is the world's fifth largest energy consumer and one of the world's major consumers of fossil fuels, ranking 4th largest for coal, 6th largest for oil and 7th largest for gas in 2022 according to the Energy Institute[9]. Japan was the world's largest LNG importer in 2022, importing 72.2 million tonnes (Mt), representing 18.5% of the global LNG market[10]. Natural gas comprised 21% of total Japanese energy supply[11]. Oil comprised 39% and coal 27%, giving fossil fuels a total 87% market share in 2022.

Japan is highly reliant on imported energy, primarily fossil fuels. In 2020 Japan's energy self-sufficiency ratio was only 11.3%, lower than those of all other OECD countries. Japan depends on the Middle East for around 90% of its crude oil imports. For LNG and coal dependence on the Middle East is low, Japan relies on imports from Oceania (Australia), Asia and other overseas sources[12].

Figure 3: Japan CO2 emissions from energy 1990-2022 (Mt CO2e)



Source: IEA

Reflecting the importance of fossil fuels, Japan had the world's fourth largest CO2 emissions from energy in 2022, after China, the US and India[13]. Emissions peaked in 2013 at 1,257 Mt CO2e (Figure 3).

By 2022 emissions were down by 20.2% to 1,003 Mt CO2e but with a long way to go to reduce emissions by the target of 46% by 2030. In Japan, the largest source of overall greenhouse gas emissions is CO2 emissions from fuel combustion, which accounts for around 86% of the annual total. These emissions have been decreasing since 2013 (due to increasing nuclear and renewables) and have been the major cause of overall emissions reductions since. In 2021, the power generation sector

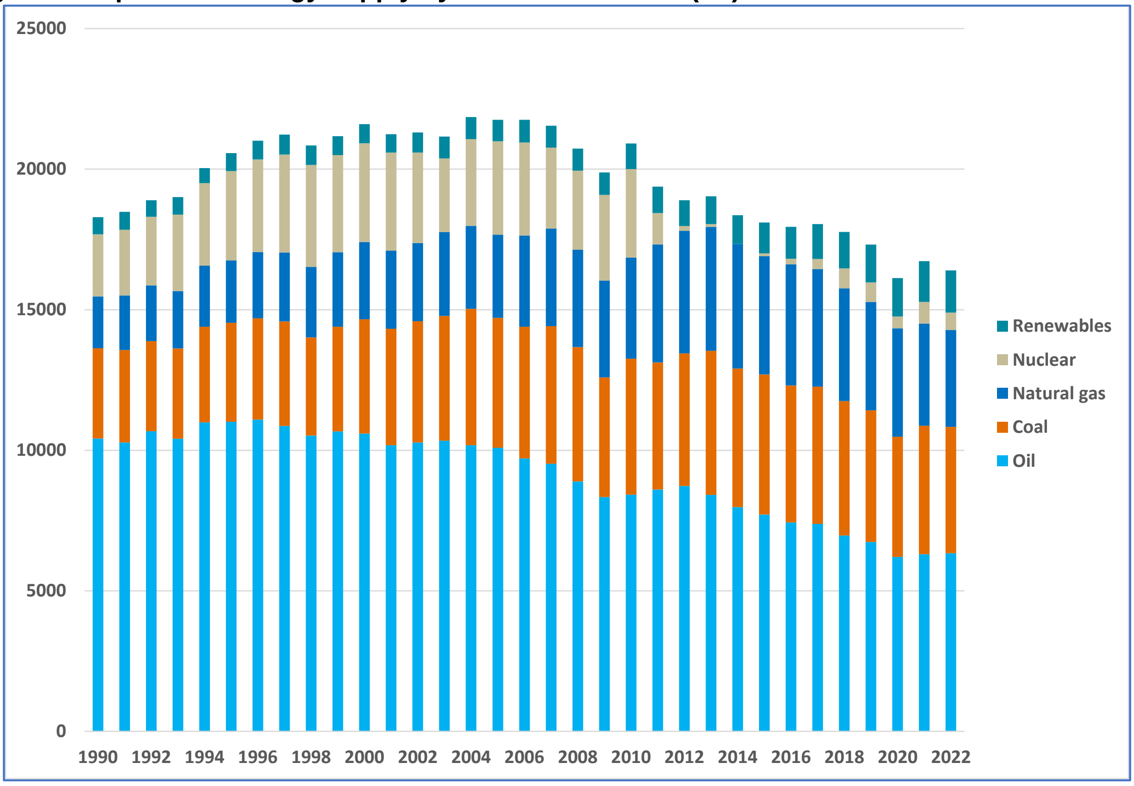
---

[9] https://www.energyinst.org/statistical-review
[10] https://giignl.org/wp-content/uploads/2023/07/GIIGNL-2023-Annual-Report-July20.pdf
[11] https://www.iea.org/data-and-statistics/data-product/world-energy-balances-highlights
[12] https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2022.pdf
[13] https://www.iea.org/data-and-statistics/data-product/greenhouse-gas-emissions-from-energy-highlights

was the largest contributor to CO2 emissions from fuel combustion, with a 41% share, followed by industry and transport, with 27% and 18%, respectively[14].

Figure 4 shows the trends in Japan's total energy supply by source since 1990. Total energy supply peaked in 2005 and has since been declining, and by 2022 was down by 25% from its peak. Final energy consumption also peaked in 2005 and was down by 21% by 2021.

Figure 4: Japan total energy supply by source 1990-2022 (PJ)



Source: IEA

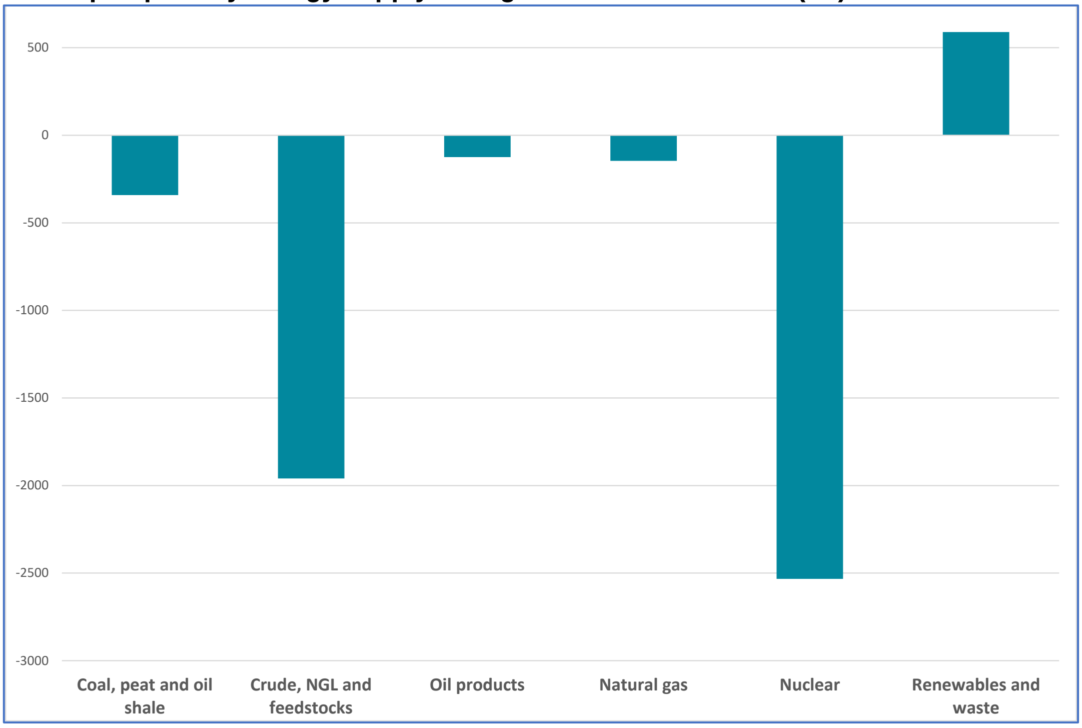
Japan's energy supply was severely impacted by the Fukushima earthquake in 2011 which led to the closure of most of the country's nuclear generation. Nuclear had been supplying up to 15% of total energy but was shut in virtually overnight.

Gas demand increased steadily from 1990 and grew further following the earthquake reaching 4,409 PJ in 2014, which was 23% of primary energy supply. Gas demand has since fallen by 21.6% to 3,455 PJ in 2022 with a slight fall in share of primary energy supply to 21%. The fall in gas demand is partly attributable to nuclear restarts and the growth of renewables. However, as of 2022 Japan was still the world's seventh largest gas consumer. Coal demand has also fallen but by a lesser 8.9% and in 2022 Japan was the world's fourth largest coal consumer.

Figure 5 shows the changes in energy mix since 2010, a period over which total primary energy supply fell by 21.5%. The decline in nuclear was partly offset by the growth in renewables but also by the decline in oil-use reflecting the declining and ageing population.

[14] https://www.climate-transparency.org/wp-content/uploads/2022/10/CT2022-Japan-Web.pdf

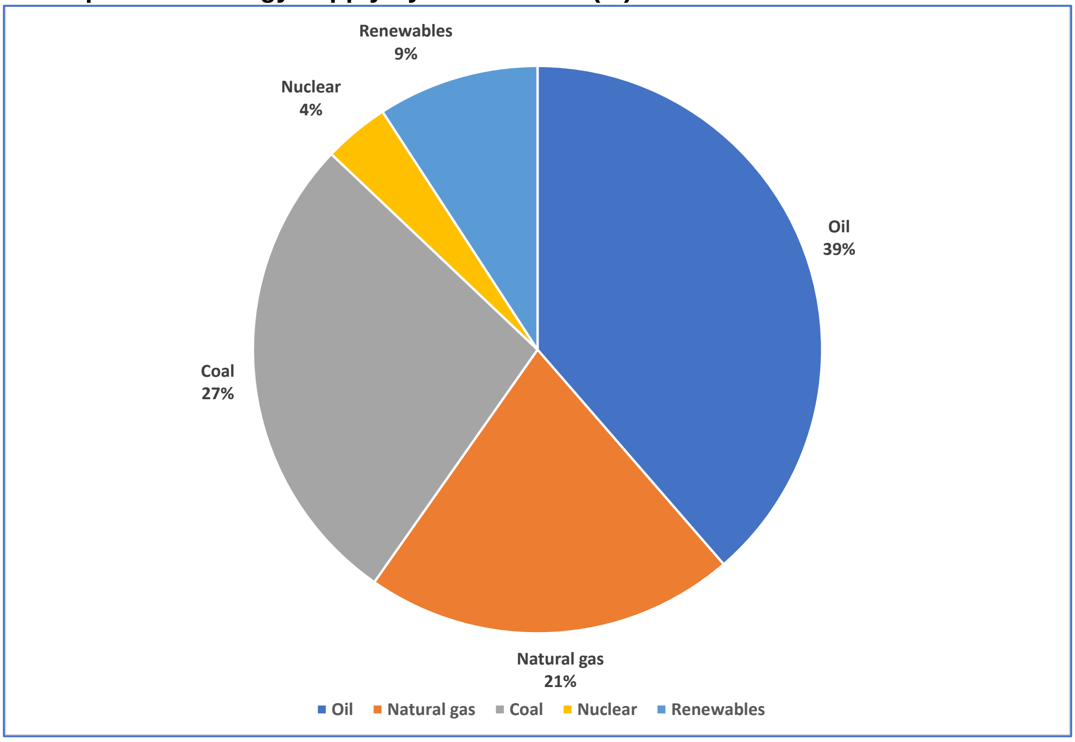
Figure 5: Japan primary energy supply change in 2022 versus 2010 (PJ)



Source: IEA

Notwithstanding these changes, oil was still the biggest component of primary energy consumption in 2022 (Figure 6), followed by coal and gas, with non-fossil fuels only making up 13% of primary energy supply. Renewables have doubled since 2010 but only had a 9% share in 2022.

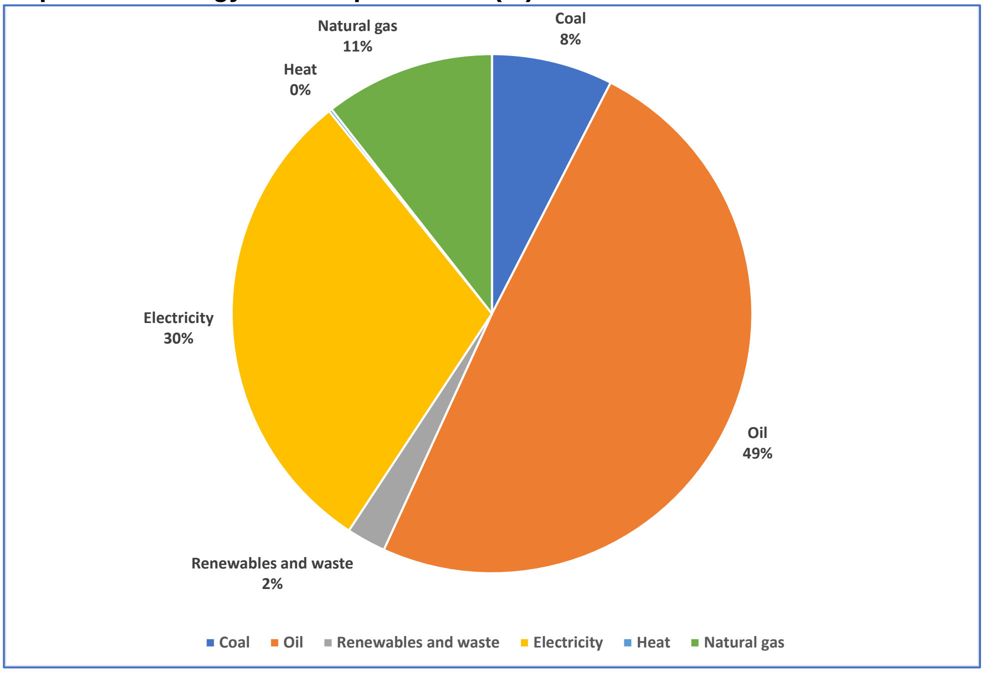
Figure 6: Japan total energy supply by source 2022 (%)



Source: IEA

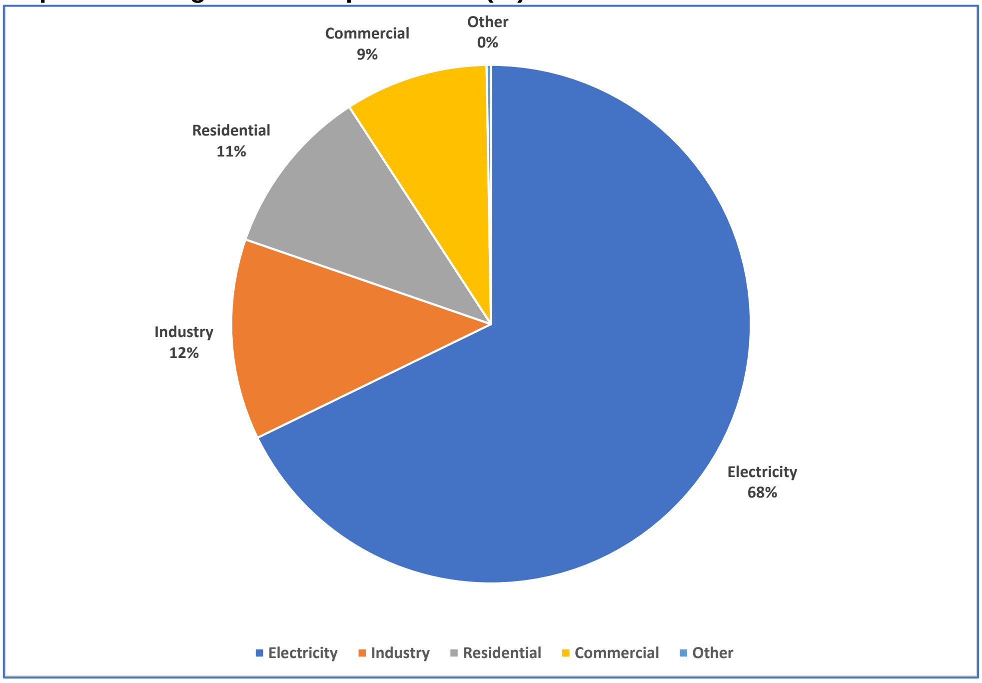
Japan's final energy consumption is dominated by oil and electricity (Figure 7). Japan is already heavily electrified. In 2019 it was the world's fourth-highest electricity-consuming country[15]. Notwithstanding the fall in oil consumption, it was also the sixth-largest oil consumer[16].

Figure 7: Japan final energy consumption 2021 (%)



Source: IEA

Figure 8: Japan natural gas consumption 2021 (%)



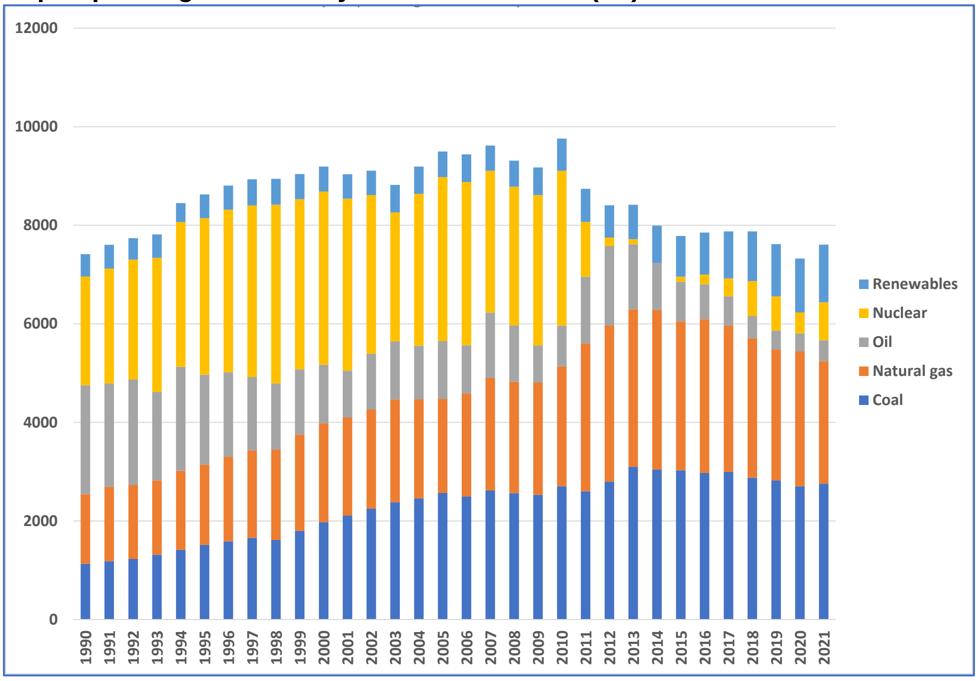
Source: IEA

[15] https://www.iea.org/reports/electricity-information-overview/electricity-consumption
[16] https://www.energyinst.org/statistical-review

Around two-thirds of gas supply is used for electricity generation with the remainder fairly evenly spread between industry, residential and commercial use (Figure 8). The outlook for gas in Japan depends particularly on gas-to-power.

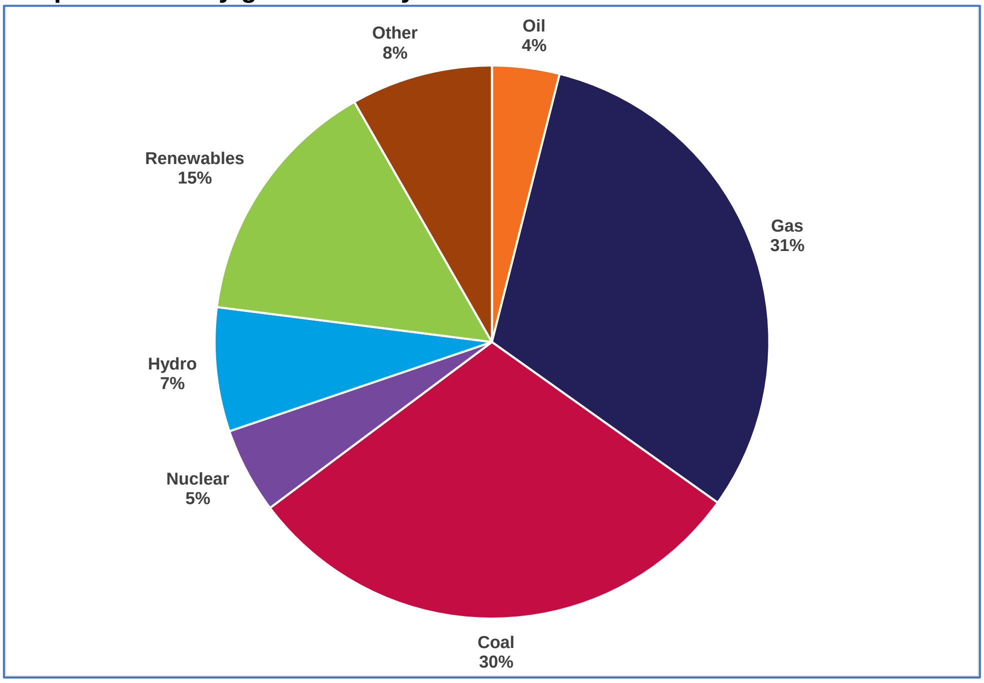
Since peaking in 2014, the use of coal and gas for power generation has fallen but gas has been the biggest loser. In 2021 gas use was 23.2% down on 2014 whereas coal use was down by 9.3%, renewables reached 15% of power generation (up from 9%) and nuclear rebounded to 10% from virtually zero.

Figure 9: Japan power generation by source 1990-2021 (PJ)



Source: IEA

Figure 10: Japan electricity generation by fuel 2022



Source: Energy Institute

As of 2022 gas supplied 31% of electricity generation and coal supplied 30% (Figure 10).

Gas consumption in the industrial, residential and services sectors has been relatively flat since 2014.

Japanese energy policy

The Japanese government's basic energy policy reflects the fact that Japan is a country with limited natural resources and prone to natural disasters. There is no one source of energy that is superior in every way, so Japan has a multi-layered energy supply structure. Safety is the major premise, followed by increasing energy security (aiming to reach approximately 30% indigenous supply by 2030), reducing electricity prices (which have been rising since Fukushima, affected by oil prices) and reducing greenhouse gas emissions. Pre-tax electricity prices for both households and industry are higher than in the US and Europe[17].

Following net zero pledges by several other countries, including China, Japan announced in October 2020 a target of net zero emissions by 2050. This was followed by the 6th Strategic Energy Plan in October 2021 and the Green Transformation Policy (GX) in December 2022.

As the IEA points out in the 2023 World Energy Outlook, it remains challenging to decarbonise large industrial economies like Japan (and Korea) that have historically relied heavily on imported fossil fuels[18]. Reflecting the immensity of the challenge the Strategic Energy Plan describes the target of net zero by 2050 as a "lofty goal".

The fundamental drivers of a country's greenhouse emissions are population, GDP per capita, the energy intensity of the economy and the carbon intensity of the energy system. Japan's population, peaked at 128.1 million in 2008 and is now falling, to 123.7 million in 2023 and expected to fall below 100 million by 2050. While a falling population may put downwards pressure on emissions, a falling population creates numerous economic and social challenges[19].

Japan is falling behind economically. It was the second-largest economy after the US until 2010 but was then overtaken by China and is now the world's fourth-largest economy, set to be overtaken by India. Japan only ranks 47th globally in GDP per capita[20]. The government is seeking to reverse this relative decline.

The Japanese economy is energy-efficient but carbon-intensive. The energy intensity of the Japanese economy is below the average of IEA countries in per capita terms: 143.9 GJ per head in Japan in 2022 compared with an OECD average of 169.9 GJ per head according to the Energy Institute. The energy intensity of Japan's GDP is also below average. However, Japan's CO2 emissions intensity in relation to GDP is similar to the IEA average[21] and at 7.91 tonnes of CO2 emissions per head in 2022 was above the OECD average of 7.70[22].

The 6th Strategic Energy Plan set out detailed goals to reduce emissions by 2030 by 46% compared with 2013. In the electricity sector the targets are for renewable energy to increase to 36%-38% (20% in 2021), with hydro targeted to increase to 11% (7.5% in 2021), solar to 14-16% (8.3%), wind to 5% (0.9%), geothermal to 1% (0.3%) and biomass to 5% (3.2%), Nuclear power is targeted to increase to 20%-22% (7% in 2021) and hydrogen/ammonia to increase to 1% from zero. The share of natural gas (LNG) is set to fall from 34% to 20%, coal from 31% to 19% and oil from 7% to 2%[23]. No detailed targets have been released for the energy mix in 2050.

---

[17] https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2022.pdf

[18] https://iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2a-edf61467e070/WorldEnergyOutlook2023.pdf

[19] https://oecdecoscope.blog/2024/01/11/addressing-the-challenges-of-high-government-debt-and-population-ageing-in-japan/

[20] https://www.cia.gov/the-world-factbook/field/real-gdp-per-capita/country-comparison

[21] https://www.iea.org/reports/japan-2021

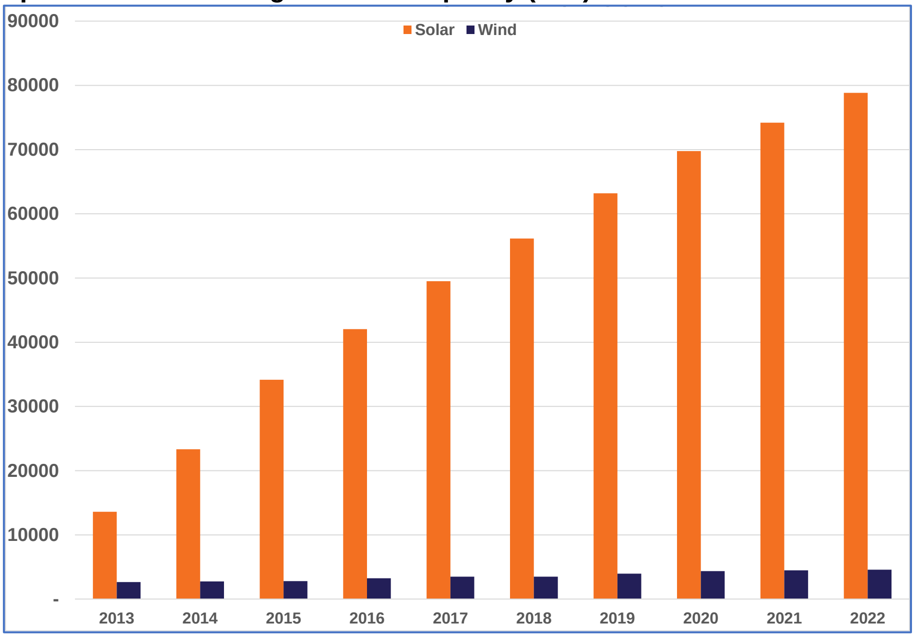
[22] https://www.iea.org/data-and-statistics/data-product/greenhouse-gas-emissions-from-energy-highlights

[23] https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2022.pdf

The Green Transformation Policy (GX) provides further detail including enhanced energy efficiency measures, expansions to the power grid system and requirements to strengthen community consultation for renewable energy projects.

Notwithstanding the relatively small share of renewables in the overall energy mix, Japan has made significant progress in solar. In 2020 Japan ranked 6th in the world among major nations in renewable energy generation capacity and 3rd in solar capacity[24]. Based on the generous feed-in-tariff (FIT) introduced after the Fukushima earthquake, solar PV has grown quickly such that Japan now has the highest deployment of flat land PV in the world[25]. Over the 10 years to 2022 solar grew from 1.2% of power generation to 9.9%[26]. However, the cost of the FIT scheme increased to around US$28 billion by 2022, almost double the cost in 2016. Reflecting the increasing cost pressure METI says it is "working to expand the introduction of renewable energy sources in a cost-efficient manner in order to maximise the use of renewable energy while decreasing the financial burden of doing so"[27]

Figure 11: Japan solar and wind generation capacity (MW)



Source: Energy Institute

Figure 11 contrasts the recent growth in solar capacity compared with wind. Solar capacity is growing at about 5 GW per annum. Wind capacity only grew by 210 MW between 2020 and 2022. According to the Global Wind Energy Council onshore wind capacity at the end of 2022 was only 4,668 MW and offshore capacity only 136 MW[28]. According to the GWEC there were high hopes for Japan following the launch of its First Vision for the Offshore Wind Power Industry in 2020. It has since started designating sea areas that will be dedicated for general auction. However, concerns have been raised about the transparency of the selection criteria for the offshore tender, compounded by lengthy Environmental Impact Assessment (EIA) timelines, largely stemming from local fishing community resistance.

There is much disagreement about Japan's renewable energy capacity. A recent study by the US government Berkeley Lab on Japanese decarbonisation finds that in its Clean Energy Scenario, renewable energy generated mainly from solar PV and wind sources could total 70% of annual

[24] https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2022.pdf
[25] Progress Report on Japan's GX Strategy. IEEJ podcast, 2 February 2024.
[26] https://www.energyinst.org/statistical-review
[27] https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2022.pdf
[28] https://gwec.net/globalwindreport2023/

Japanese electricity generation by 2035[29]. This is based on a detailed assessment of possible solar PV and wind potential. However, the IEA cautions that while offshore wind has major potential it has been limited by cost and a lack of transmission capacity. Also, the sea surrounding Japan is more than 50 metres deep in many places and has steep slopes which make it impossible to deploy traditional seabed-mounted offshore wind installations[30]. The GX Policy includes measures to increase the deployment of offshore wind.

In addition to challenges in renewable energy development, another important issue for Japan will be that its power system is not well suited to growing intermittent renewables, which require firming capacity such as that supplied by open cycle gas, pumped hydro and batteries. Combined cycle gas, nuclear and base-load coal stations are not well suited to provide the firming required by growing intermittent renewables. Also solar typically requires more firming than wind. Another challenge is that Japan's electricity grid is fragmented and there is limited capacity between regions[31].

GX also includes extensions to the life of nuclear power plants beyond 60 years. At the end of 2023 12 nuclear reactors were back online, two brought on in 2023 and more scheduled for 2024. However, 27 of the 36 available reactors need to return to full operation in order for Japan to achieve the goal of raising the contribution of nuclear to 20-22% as envisioned under the 6th Strategic Energy Plan. Five plants are preparing for restart (subject to local safety approvals), 10 are under review and nine have not yet filed applications to restart[32]. The restart process is very slow as reactors have to complete a complex approval process. There are also issues of disposal of nuclear waste.

The new GX nuclear policy marks a major change. The Nikkei newspaper describes the shift in policy as drastic[33]. "Since the Fukushima nuclear disaster of 2011, Japan has avoided all talk of constructing new nuclear plants or expanding existing ones. The government should be commended for squarely facing reality and taking the first step toward building new facilities. But the process seems rushed. The government needs to carefully explain the reasons for its change to the public and win a broad nod of approval in moving forward with the policy."

Concerning LNG, the Policy says that existing interests in international projects such as Sakhalin in Russia will be maintained for the time being for energy security. It also notes that in light of the growing uncertainty in the global LNG market, Japan will build a mechanism to strategically secure buffer LNG. Starting in December 2023 Japan began operating "Strategic Buffer LNG," or SBL, cargoes in order to be prepared for any supply issues, starting with a minimum of one LNG cargo a month during the country's peak winter demand months from December 2023 to February 2024[34].

The only specific policy announcement on the future of coal-fired generation has been Prime Minister Kishida's statement at COP 28, "In line with its pathway to net zero, Japan will end new construction of domestic unabated coal power plants, while securing a stable energy supply"[35].

The GX Policy is technology-focussed, with the development and deployment of technologies to achieve carbon neutrality by 2050. The effort will be funded by GX Economic Transition Bonds ("Transition to a Decarbonized Growth-Oriented Industrial Structure Bonds") to be issued over the coming decade to the tune of some ¥20 trillion. To secure the transition bonds' principal, Japan has said it will begin full-scale implementation of a voluntary emissions trading scheme in fiscal year 2026, before instituting fossil fuel (i.e., carbon) levies in 2028 and then auctioning carbon-emission allowances to power generators in 2033[36].

---

[29] https://emp.lbl.gov/publications/2035-japan-report-plummeting-costs
[30]https://iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2a-edf61467e070/WorldEnergyOutlook2023.pdf
[31] https://www.iea.org/reports/japan-2021
[32] https://www.jepic.or.jp/pub/pdf/epijJepic2023.pdf
[33] https://asia.nikkei.com/Opinion/The-Nikkei-View/Japan-must-clearly-explain-its-energy-policy-switch
[34]https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/lng/112723-interview-japan-aims-to-quadruple-strategic-buffer-lng-by-mid-2020s#:~:text=With%20Japan%20set%20to%20launch,by%20the%20mid%2D2020s%2C%20a
[35]https://japan.kantei.go.jp/101_kishida/statement/202312/01statement.html#:~:text=Statement%20by%20Prime%20Minister%20KISHIDA%20Fumio%20at%20COP28%20World%20Climate%20Action%20Summit,-December%201%2C%202023&text=At%20COP28%2C%20we%20will%20conclude,action%20until%202030%20is%20critical.
[36] https://www.mri.co.jp/en/knowledge/mreview/2023062.html

LNG demand outlook

What does all this mean for Japan's future LNG imports?

In his 2021 paper Martin Lambert concluded that future Japanese demand for LNG will be much more uncertain than has been the case in the past. This continues to be the situation.

With nearly 70% of gas used for power generation and gas demand in other sectors relatively flat, future Japanese LNG demand depends primarily on natural gas use for power generation. Table 1 shows Japan's power development plans to 2030 as of 2022 as published by the Japan Electric Power Information Centre. (Solar refers to corporate investments in solar by energy companies and does not include individual investments.) These plans pre-date the GX policy announcement and are subject to revision. In addition to growth in renewables (including wind) the plans also propose continuing growth in coal. As the IEA notes, Japan ranks among the few advanced economies to anticipate new coal generation capacity, which, if unabated by CCS, would place additional pressure on meeting its 2030 and 2050 climate goals.

Moreover, even if all new coal stations are required to abate their emissions, Japan already has 54.6 GW of existing coal stations as of July 2023 [37] with relatively modest future retirements notwithstanding the announcement in July 2020 that inefficient coal-fired power plants will be phased out by 2030. About half of the installed capacity has been built within the past 20 years and, according to the IEA, Japan's coal power generation fleet already ranks among the most efficient in the world[38].

Therefore, the issue for gas in power generation is that it will still be competing with largely unabated coal plus growing renewables and nuclear. As a sign of likely things to come, Bloomberg reported on 2 February 2024 that Japan's LNG imports in January fell to the lowest level for that month since 2009, curbed by nuclear restarts, higher renewables output and energy savings efforts [39]. On the other hand, Japan's imports of seaborne thermal coal climbed from December's 9.99 million to 11.24 million tons in January, the strongest month since January 2023's 11.54 million[40].

Table 1: Japan power development plans up to FY 2030

Power source		New installation plan		Updating/derating plan		Retirement plan		Total
		Output (MW)	Sites	Output (MW)	Sites	Output (MW)	Sites	Output (MW)
Hydro	Conventional	391	61	60	36	-183	33	268
	Pumped storage	0	0	0	0	0	0	0
	Total	391	61	60	36	-183	33	268
Thermal	Coal	4,413	6	0	0	-518	3	3,895
	LNG	7,174	15	0	0	-4,326	12	2,848
	Oil	51	9	0	0	-1,759	20	-1,708
	Total	11,638	30	0	0	-6,603	35	5,035
Nuclear		10,180	7	152	1	0	0	10,332
Renewables	Wind	1,566	54	0	0	-474	52	1,092
	Solar	3,323	168	0	0	-2	1	3,321
	Geothermal	44	3	0	0	-24	1	20
	Biomass	968	20	0	0	-75	5	893
	Waste	52	5	2	1	-75	7	-21
	Total	5,953	250	2	1	-650	66	5,305
Total		28,162	348	214	38	-7,436	134	20,940

Source: The Electric Power Industry in Japan 2022, Japan Electric Power Information Centre.

[37] https://www.statista.com/statistics/530569/installed-capacity-of-coal-power-plants-in-selected-countries/
[38] https://www.iea.org/reports/japan-2021
[39] https://www.bloomberg.com/news/articles/2024-02-02/japan-s-january-lng-imports-fall-to-lowest-for-month-since-2009
[40]https://www.reuters.com/markets/commodities/asias-thermal-coal-imports-slip-record-winter-demand-eases-russell-2024-02-13/

As noted above, Japanese gas use in power generation in 2021 was 23.2% down on 2014 whereas coal use was down by 9.3%, renewables reached 15% of power generation (up from 9%) and nuclear rebounded to 10% from virtually zero. According to the Energy Institute, renewable generation grew by a further 11.5% in 2022, compared with 2021, while coal increased by 2.4% but gas volumes declined by a further 2.0%.

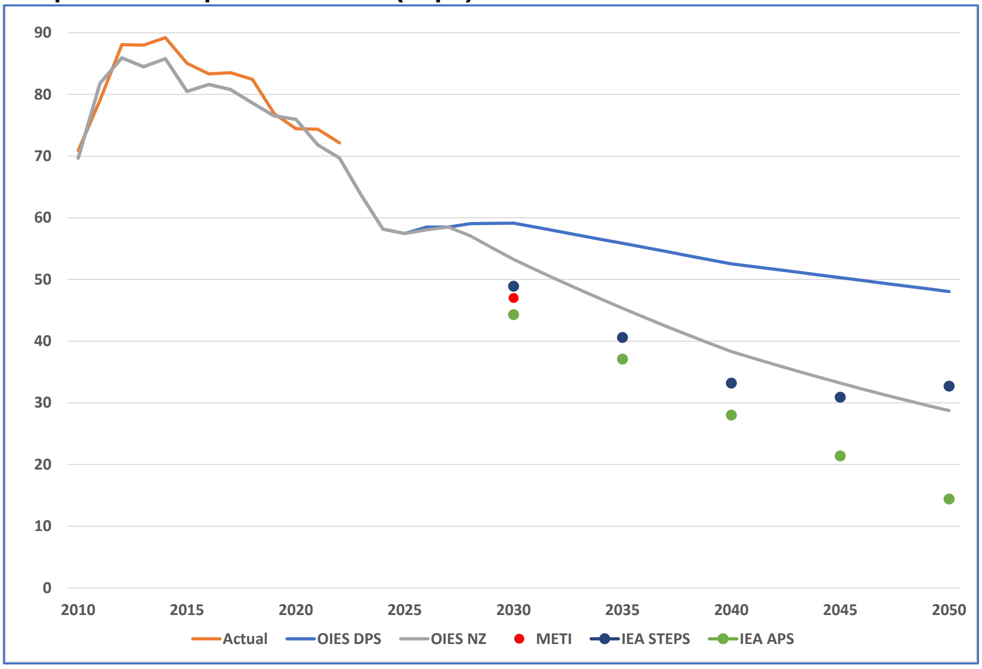
Under the targets in the Strategic Energy Plan Japanese LNG demand would fall significantly as the economy transitions to its 2030 and 2050 decarbonisation goals.

Under the IEA Announced Policies Scenario LNG volumes for power generation are expected to fall from around 45 Mt in 2022 to 27 Mt by 2030 and 12 Mt by 2050[41].

METI expects that volumes will need to fall even further to meet the country's net zero targets. A target for natural gas to meet 20% of power needs in 2030 implies LNG imports of only 23 Mt[42]. (METI forecasts lower overall power generation than the IEA.) METI forecasts overall LNG demand of 47 Mt in 2030, down from 72 Mt in 2021 and implying around 24 Mt of gas used for non-power generation in 2030 , essentially flat with 2021[43].

This is significantly lower than Wood Mackenzie, which forecasts that LNG only falls below 55 Mtpa by 2040[44]. It is also significantly lower than the OIES scenarios, which are shown in Figure 12. DPS is a Declared Policies scenario, similar conceptually to the IEA STEPS scenario but significantly above the STEPS scenario for LNG imports and close to the Wood Mackenzie forecast. NZ is the OIES Net Zero scenario which assumes significant CCS. This is higher than the IEA Announced Policies scenario (APS). (The IEA does not provide a breakdown of its NZ scenario by country but would imply even lower LNG imports than the APS scenario.) The OIES scenarios imply Japanese LNG imports of 30-50 Mt by 2050.

Figure 12: Japan LNG import scenarios (Mtpa)



Source: OIES

[41] https://iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2a-edf61467e070/WorldEnergyOutlook2023.pdf
[42] Assuming a heat rate of 8.
[43] https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2022.pdf
[44] https://www.woodmac.com/reports/lng-japan-lng-market-report-529072/?_t_id=1B2M2Y8AsgTpgAmY7PhCfg%3D%3D&_t_q=Press+Note+++Industry+slashes+spending+as+price+rout+deepens:+Can+companies+cope%3F++&_t_tags=language:en&_t_ip=66.249.65.46&_t_hit.id=WoodMac_Site_Features_Product_Core_Models_ReportProduct/CatalogContent_1ffc373c-5e78-4c17-b33d-c40c77f3d15b_en&_t_hit.pos=191

Future LNG demand depends not only on the competitive position of different energy sources but also on overall energy demand. Japanese total energy demand fell by 11% in the nine years to 2021 and METI is expecting a further reduction of 10% in the nine years from 2021 to 2030. A falling population is one of the drivers of falling energy demand but the level of the fall in demand also depends on GDP growth, and the Japanese government is keen to stimulate stronger growth. This is more about macroeconomics than energy policy and long-term Japanese economic forecasts are well beyond the scope of this report. However, the strength or not of the Japanese economy will be an important factor for Japanese energy demand as well as for global energy markets.

In terms of energy mix, Table 2 shows actual 2021 Japanese power generation by source. Total generation was 1,033 TWh. The table also shows the METI targets for 2030. METI is assuming lower generation of around 933 TWh in 2030 and the table shows this broken down by energy source in line with METI's decarbonisation targets. LNG imports for power generation would be 23 Mt in 2030, with overall LNG imports of 47 Mt, which compares with 53.2 Mt in the OIES net zero scenario shown in Figure 12.

Table 2: Japan electricity generation to 2030

TWh	2021 Actual	2030 METI
Solar generation	86	149
Wind generation	9	47
Hydro	77	103
Geothermal	3	1
Biomass	33	47
Nuclear	72	196
Gas	351	187
Coal	328	185
Oil	72	19
Total	1033	933
Natural gas %	34%	20%
LNG Mtpa	44	23
CO2 emissions (Mt)		
Gas	176	93
Coal	328	185
Oil	58	15
Total	**606**	**317**

Source: Author's analysis/METI

Table 2 also shows estimates of CO_2 emissions, assuming that coal generation produces emissions of 1 tonne/MWh, oil generation 0.8 tonnes/MWh, gas 0.5 tonnes/MWh and that other fuel sources are emission free. Lower power consumption and a cleaner energy mix reduce emissions from generation by 48% below the 2021level.

METI acknowledges that meeting these targets by 2030 will be challenging. In the case of solar and wind new investments are beset by problems of cost increases and community acceptance, as well as the need for massive investment in transmission infrastructure. Ramping up nuclear also has challenges of a lengthy regulatory process and community acceptance. This raises the question of what the path to 2030 might look like in the case of delays in clean energy investment resulting in a disorderly energy transition. For example, what might the energy mix in 2030 look like if total power demand is still 933 TWh but only half of the increased investment in renewables and half the increased nuclear generation are achievable by 2030? To be clear, this is a scenario or stress test, not a forecast.

Table 3: Japan electricity generation 2030- coal scenario

TWh	2021 Actual	2030
Solar generation	86	117
Wind generation	9	28
Hydro	77	90
Geothermal	3	1
Biomass	33	40
Nuclear	72	134
Gas	351	187
Coal	328	318
Oil	72	19
Total	1033	933
Natural gas %	34%	20%
LNG Mtpa	44	23
CO2 emissions (Mt)		
Gas	176	93
Coal	328	318
Oil	58	15
Total	**606**	**450**

Source: Author's analysis/METI

Table 3 shows the reduced clean energy output scenario with growth reduced by 50%. Growth in clean energy is still substantial compared with 2021. Solar is 36% higher, wind is over 200% higher and nuclear is 17% higher. However, this leaves a gap of 133 TWh. One possible outcome in such a situation, shown in Table 3, is that coal generation fills the gap. As we are already seeing, renewables grow (as does nuclear), coal-fired generation is steady with 2021 and gas falls by 47%. Instead of falling to just over 300 Mt, emissions are 450 Mt, a reduction of only 26% from 2021 (requiring substantial CCS). LNG imports for power generation are only 23 Mt, with commensurately higher thermal coal imports.

Table 4: Japan electricity generation 2030- gas scenario

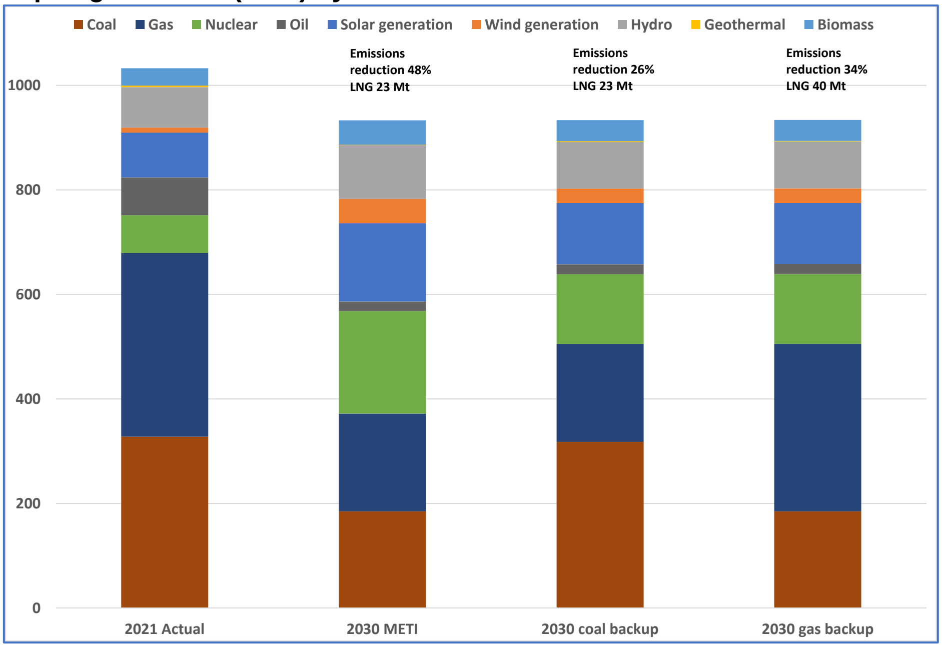
TWh	2021 Actual	2030
Solar generation	86	117
Wind generation	9	28
Hydro	77	90
Geothermal	3	1
Biomass	33	40
Nuclear	72	134
Gas	351	320
Coal	328	185
Oil	72	19
Total	1033	934
Natural gas %	34%	34%
LNG Mtpa	44	40
CO2 emissions (Mt)		
Gas	176	160
Coal	328	185
Oil	58	15
Total	**606**	**400**

Source: Author's analysis/METI

The scenario in Table 4 makes the same assumptions about renewable and nuclear output as in Table 3 but assumes that gas rather than coal fills the generation gap. The natural gas share of 2030 generation is 34% rather than 20% and LNG imports for power generation are 40 Mt. The key difference however is a bigger reduction in emissions from power generation, down by 34% compared with 26% in the coal scenario and requiring less CCS.

Figure 13 summarises the differences between the scenarios and Figure 14 shows total LNG imports under the different scenarios. Under the METI scenario, and a coal backup scenario, LNG imports in 2030 are only 47 Mt, below even the OIES NZ scenario. However, under the gas backup scenario, total LNG imports are 64 Mt, slightly higher than the OIES DPS scenario.

Figure 13: Japan generation (TWh) by source and scenario



Source: Author's analysis/METI

Figure 14: Japan 2030 LNG import scenarios (Mt)

Source: Author's analysis/METI

It seems likely that Japan's transition will be disorderly, as is the case in most countries. In these circumstances the gap is typically filled by fossil fuels, either coal or gas. Which fossil fuel is used depends on carbon pricing and in Japan carbon prices are modest and slow to implement.

As the IEA notes[45], Japan introduced a climate change mitigation tax as a direct carbon tax in October 2012 and increased its level in 2014 and 2016 but to reach a rate of only JPY 289 (USD 2.65) per tonne of CO2. The tax is applied as an add-on to the petroleum and coal tax and is thus levied on crude oil and oil products, natural gas, and coal. Japan does not have a national emissions trading system (ETS). Japan has the eighth highest "carbon pricing gap" among OECD countries, which measures how much countries fall short of pricing CO2 emissions in line with a EUR 30 benchmark value. At the same time, despite low taxation levels, Japan's energy prices are high by international comparisons.

In April 2023 Japan announced the commencement of a more meaningful carbon pricing system. The scheme, based on METI proposals and approved by the cabinet, consists of emissions trading and a carbon levy.

As a first step, Japan's version of an emissions trading system (ETS), will begin in the 2023/24 fiscal year on a voluntary basis, followed by full-scale operation from around 2026/27. Participants - about 680 companies accounting for more than 40% of Japan's emissions as of the end of January - would be required to pledge and disclose emission-cut targets. If the target is not met, they will trade emissions through the market. Trading will likely be done at the Tokyo Stock Exchange, which conducted a trial from last September to January 2024.

By 2026/27, Japan will set guidelines for the ETS and introduce a mechanism for third-party certification of companies' targets. From around 2033/34, auctions for emission allowances for the power generation sector will begin.

Details including the price of carbon, the scope of coverage and whether it is mandatory are still being discussed.

The carbon levy will be introduced from around 2028/29 on fossil fuel importers such as refiners, trading houses and electricity utilities. The initial levy will be set low but will gradually rise.[46]

The carbon levy and the allocation of emission allowances to power companies will start too late to help the country meet the 2030 goal of cutting emissions by 46% on 2013 levels. The measures will help secure funding for the government's green investments, but they may not be ambitious enough to alter private sector behaviour.

Japanese LNG buyers active in signing deals

Notwithstanding its targets for reduced LNG imports, METI is reported to have been meeting with Japanese buyers and overseas suppliers, to urge the signing of more long-term LNG contracts to ensure that power producers and industry have enough gas amid the transition to cleaner sources. Annual long-term LNG supply contracted by Japanese buyers will decrease by 30% from 2022 levels to 55 Mt by 2030[47].

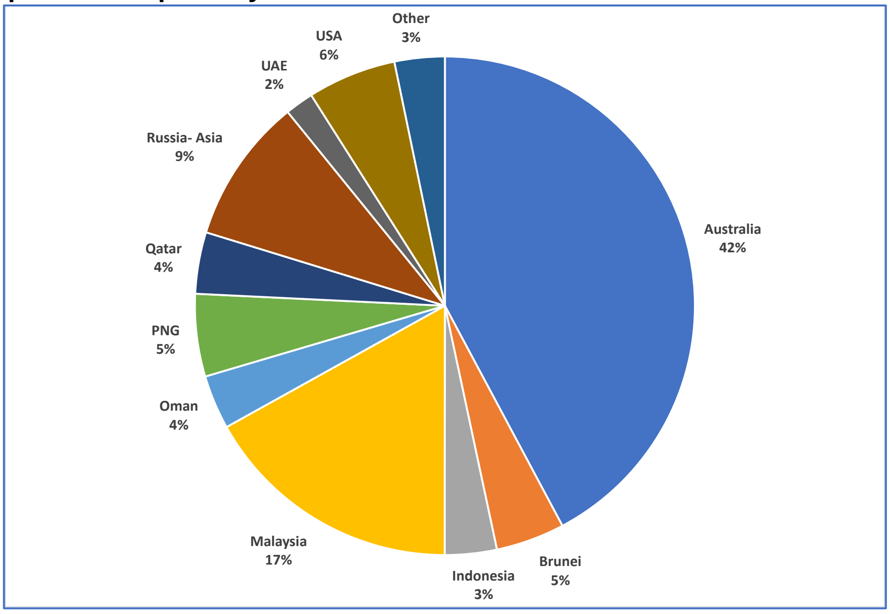
Australia is currently the largest LNG supplier to Japan (Figure 15). LNG Japan and JERA have recently bought stakes in Woodside's Scarborough LNG project[48] [49], with offtake agreements (albeit unbinding at this stage). However, as discussed in OIES Energy Insight 130, (Is Australia Quietly Quitting the LNG Business)[50], Australian LNG exports have peaked. Notwithstanding Australian Government assurances to trading partners such as Japan, heavy-handed government regulation of the gas sector and

[45] https://www.iea.org/reports/japan-2021
[46] https://www.reuters.com/markets/carbon/japans-carbon-pricing-scheme-being-launched-april-2023-03-30/
[47] https://www.bloomberg.com/news/articles/2023-11-21/japan-urges-lng-buyers-to-sign-long-term-deals-for-fuel-security
[48] https://www.woodside.com/docs/default-source/asx-announcements/2023-asx/woodside-to-sell-10-scarborough-interest-to-lng-japan.pdf?sfvrsn=caa9b47f_3
[49] https://www.woodside.com/docs/default-source/asx-announcements/2024/woodside-to-sell-15.1-scarborough-interest-to-jera.pdf?sfvrsn=ffb86761_3
[50] https://www.oxfordenergy.org/publications/is-australia-quietly-quitting-the-lng-business/

continuing aggressive campaigns against gas projects by environmental activists means that Japan will increasingly need to look elsewhere for new LNG contracts.

Qatar is one of the world's largest LNG suppliers and is in the process of increasing its capacity from 77 Mtpa to 142 Mtpa. Qatar has only been a minor supplier to Japan (Figure 15) but is reported to be in discussions with a range of Japanese companies about future LNG contracts[51].

Figure 15: Japan LNG imports by source 2022



Source: GIIGNL

Mitsubishi is expecting expansion of the Cameron LNG project in the United States[52], Kyushu Electric is considering investment in the Lake Charles LNG project[53] and Japanese company INPEX is set to hasten development of its Abadi LNG project in Indonesia[54].

That is not to say that new investments and volumes contracted will necessarily go to Japan[55]. According to figures from the Japan Oil, Gas and Metals National Corporation (JOGMEC), LNG sales by Japanese companies to third countries have increased 2.5 times since FY2018, from 14.97 Mt to 38 Mt in FY2021. Although domestic sales have declined, the volume of LNG transacted by Japanese companies increased over that timeframe. Today, the volume of LNG sold abroad is nearly 50% of the volumes consumed domestically. Given the uncertainties of Japanese demand, Japanese companies are wise to have the option of selling into other markets.

Gas decarbonisation

In the event that renewables and/or nuclear fail to meet their expansion targets, it will be necessary to abate or offset emissions from LNG consumption. Japan has a number of CCS demonstration projects, the oldest of which is the Tomakomai CCS Demonstration Project[56], Japan's first full-chain CCS project,

[51] https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/lng/100223-qatari-energy-ministers-japan-visit-signals-lng-deals-on-the-cards

[52]https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/lng/111623-mitsubishis-dgi-expects-cameron-lng-expansion-fid-and-lng-canada-startup-in-2024#:~:text=Mitsubishi's%20DGI%20expects%20Cameron%20LNG%20expansion%20FID%20and%20LNG%20Canada%20startup%20in%202024,-Author%20Eric%20Yep&text=Diamond%20Gas%20International%20Pte.

[53] https://www.reuters.com/business/energy/japans-kyushu-electric-wait-us-lng-policy-clarity-lake-charles-2024-02-20/#:~:text=TOKYO%2C%20Feb%2020%20(Reuters),Charles%20project%2C%20an%20executive%20said.

[54] https://www.reuters.com/business/energy/inpex-set-hasten-development-indonesias-abadi-lng-project-2024-01-18/

[55] https://ieefa.org/resources/japans-largest-lng-buyers-have-surplus-problem

[56] https://www.iea.org/reports/ccus-around-the-world-in-2021/tomakomai-ccs-demonstration-project

which captured and stored CO_2 from a coastal oil refinery on Hokkaido Island in Japan from 2016-2019. The refinery's hydrogen production unit produces offgas containing about 50% CO_2, which was captured in an active amine process. The project captured around 0.1 Mt of CO_2 during each year of operation for injection into two nearby offshore saline aquifers for storage and monitoring. In late 2019, the project achieved its demonstration target of 0.3 Mt of CO_2 captured and ceased injection as planned. Monitoring of the stored CO_2 will continue.

METI announced in June 2023 that it had chosen to back seven CCS projects currently under development — five in Japan and two abroad — that would help Japan store 13 Mtpa of CO_2 by 2030[57]. Success at this early stage will determine whether Japan can hit its target of storing 120-240 Mtpa of CO_2 by 2050.

The domestic projects are located in Hokkaido, Sea of Japan, Greater Tokyo, Chubu and Kyushu. One of the overseas projects is in Malaysia, while the last project's location is still to be decided but will be in either Malaysia, Indonesia or Australia.

These projects are looking to build on the success of the Tomakomai pilot project, but while it may have hit its targets and convinced the government and industry of CCS' potential, ramping up to a commercial scale requires more than technical considerations, including financing, environmental-linked insurance costs, operational economics and delivery schedule flexibility.

An alternative to decarbonisation through CCS is carbon neutral e-methane, produced from green hydrogen, generated through water electrolysis powered by renewable energy, and CO_2, which instead of being emitted into the atmosphere, is captured at industrial sites or by Direct Air Capture technology[58]. The advantage of e-methane is that it overcomes the challenges associated with the transport and export of hydrogen by allowing the use of existing transport, liquefaction and end user infrastructure providing a neutral Scope 1, 2 and 3 outcome. INPEX, Osaka Gas, Tokyo Gas and other Japanese companies are currently working to develop e-methane demonstration projects.

4. Korea[59]

Energy background

Korea has a population of 52 million, ranking 28th globally but expected to fall gradually to around 47 million by 2050. It is the world's 14th largest economy. GDP growth in Q4 2023 was 2.2%, compared with only 1.0% for Japan[60].

Korean GDP is energy intensive and its energy is carbon intensive. It is the world's eighth largest energy consumer, a large fossil fuel consumer by world standards and has a carbon intensive economy. It is the world's 7th largest oil and coal consumer and the world's12th largest gas consumer. In 2022 primary energy consumption was 245 GJ per head, well above the OECD average of 170 GJ/head[61]. Carbon intensity, measured as kg of CO_2/GDP, was 0.24 compared with an OECD average of 0.18[62].

Like Japan, Korean energy supply is dominated by fossil fuels, by oil (36% in 2022), coal (26%) and gas (18%) all of which are imported. Korea was the world's third-largest LNG importer in 2022[63]. Nuclear also has a significant 16% share. According to the IEA Korea has one of the largest shares of industrial energy use among IEA countries[64]. In 2022 renewables, including hydro, were a modest 4% of primary energy supply (Figure 16).

[57] https://www.energynewsbulletin.net/energy-transition/news/4172823/japan-fleshes-ccs-rules-regulations

[58] https://www.reuters.com/business/sustainable-business/tokyo-gas-begins-synthetic-methane-trial-using-green-hydrogen-2022-06-24/ https://www.osakagas.co.jp/en/whatsnew/__icsFiles/afieldfile/2023/09/01/230904.pdf

[59] References to Korea are to the Republic of South Korea.

[60] The Economist 16 February 2024.

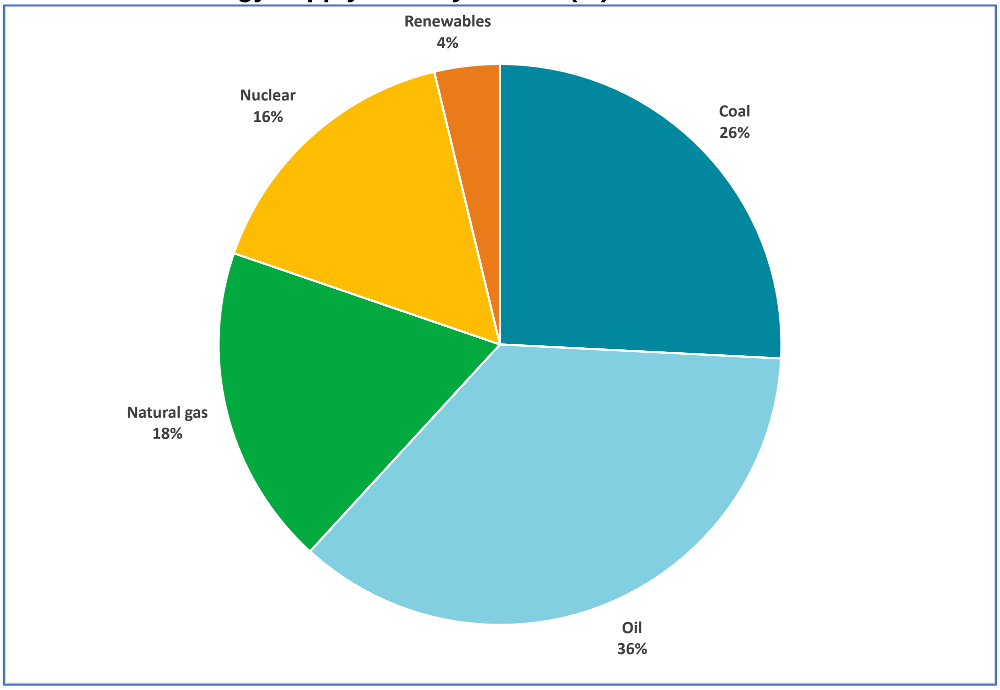
[61] https://www.energyinst.org/statistical-review

[62] https://www.iea.org/data-and-statistics/data-product/greenhouse-gas-emissions-from-energy-highlights

[63] https://giignl.org/wp-content/uploads/2023/07/GIIGNL-2023-Annual-Report-July20.pdf

[64] www.iea.org/countries/korea

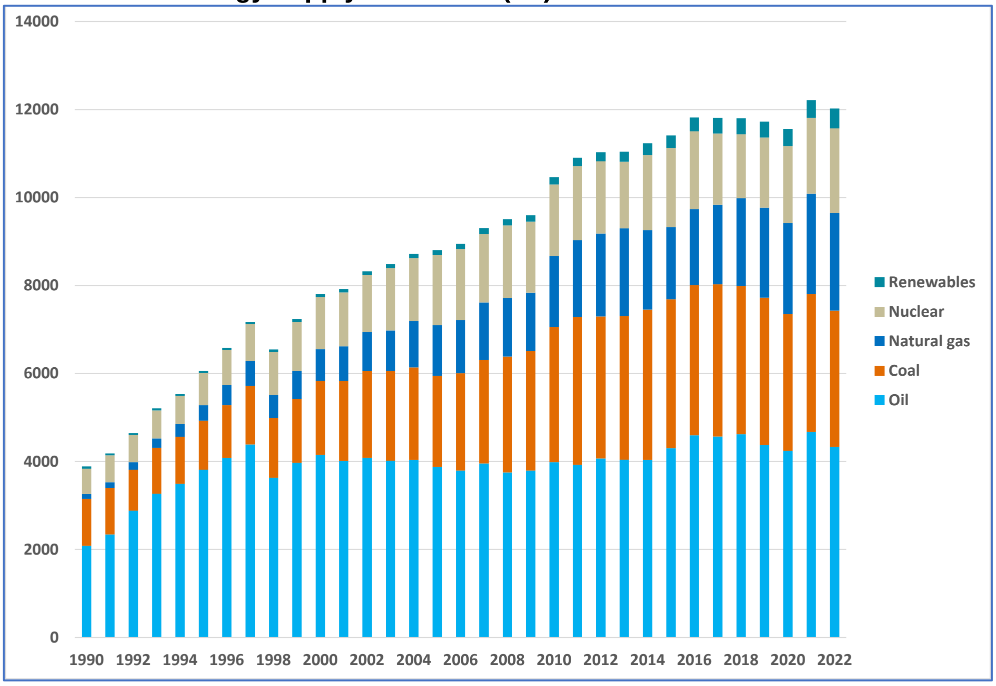
Figure 16: Korea total energy supply 2022 by source (%)



Source: IEA

Unlike Japan, Korean primary energy supply has experienced continuing growth (Figure 17). Between 2012 and 2022 primary energy consumption in Korea grew at an average rate of 0.9% per annum while in Japan it fell at an average 1.1% per annum[65].

Figure 17: Korea total energy supply 1990-2022 (PJ)

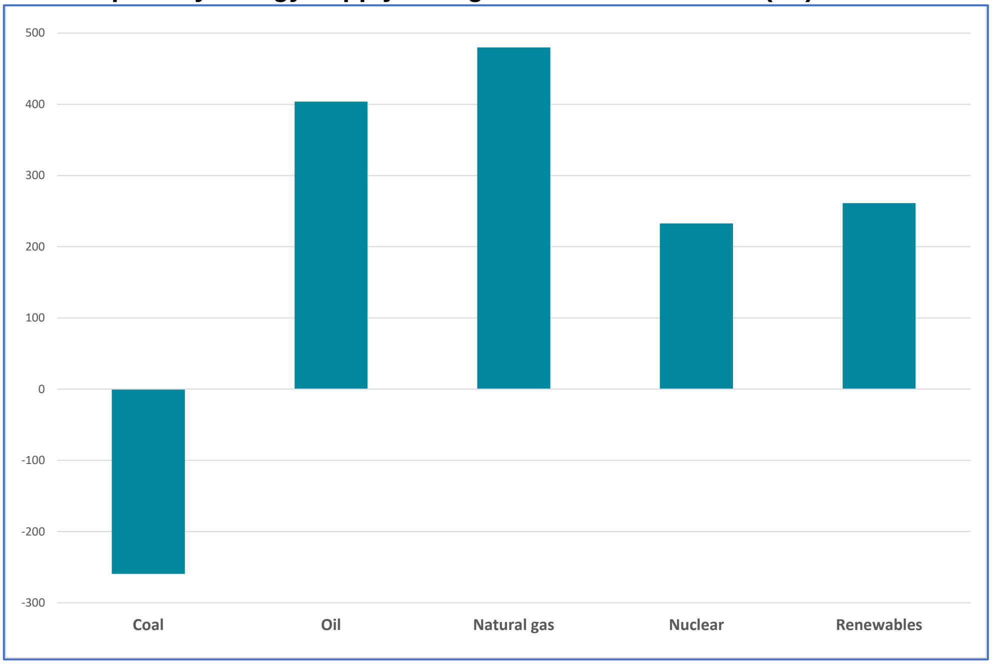


Source: IEA

[65] https://www.energyinst.org/statistical-review

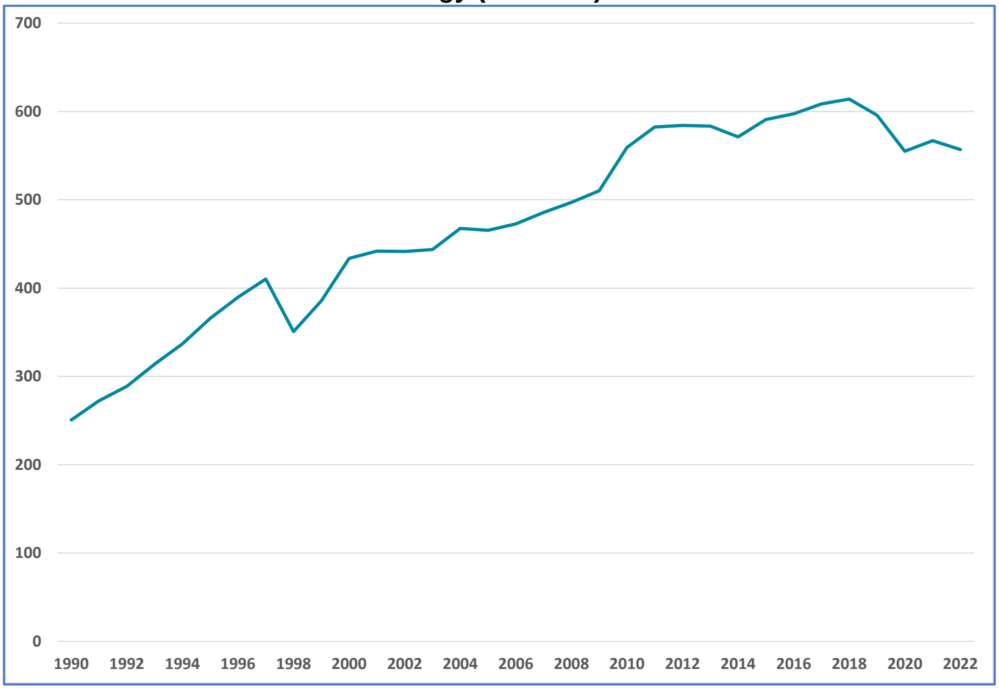
Over the last decade the biggest growth in energy supply has been in LNG. Between 2011 and 2022 LNG imports grew by 32.7% while in Japan imports have been falling since the temporary surge following Fukushima. Korea has also experienced growth in oil, nuclear and renewables and a modest fall in coal use (Figure 18).

Figure 18: Korea primary energy supply change in 2022 versus 2011 (PJ)



Source: IEA

Figure 19: Korea CO2 emissions from energy (Mt CO2e)

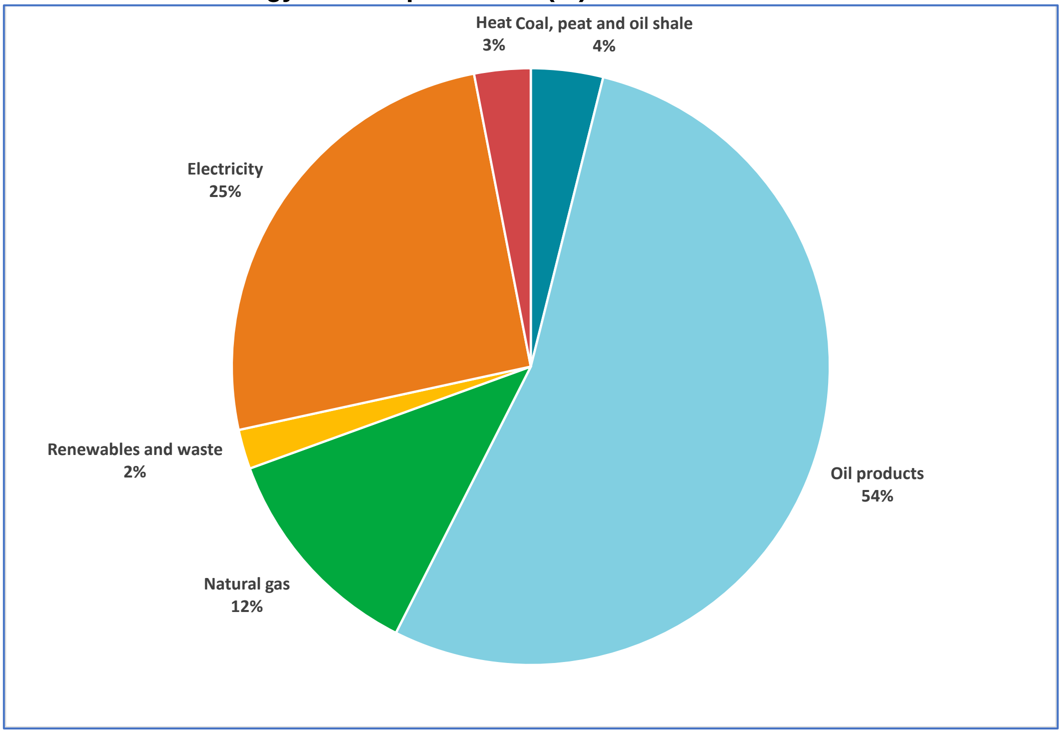


Source: IEA

Reflecting the importance of fossil fuels, Korean CO2 emissions from energy steadily increased until 2018, but fell by 9.3% by 2022, reflecting a reduction in the use of coal and increased use of gas and nuclear (Figure 19).

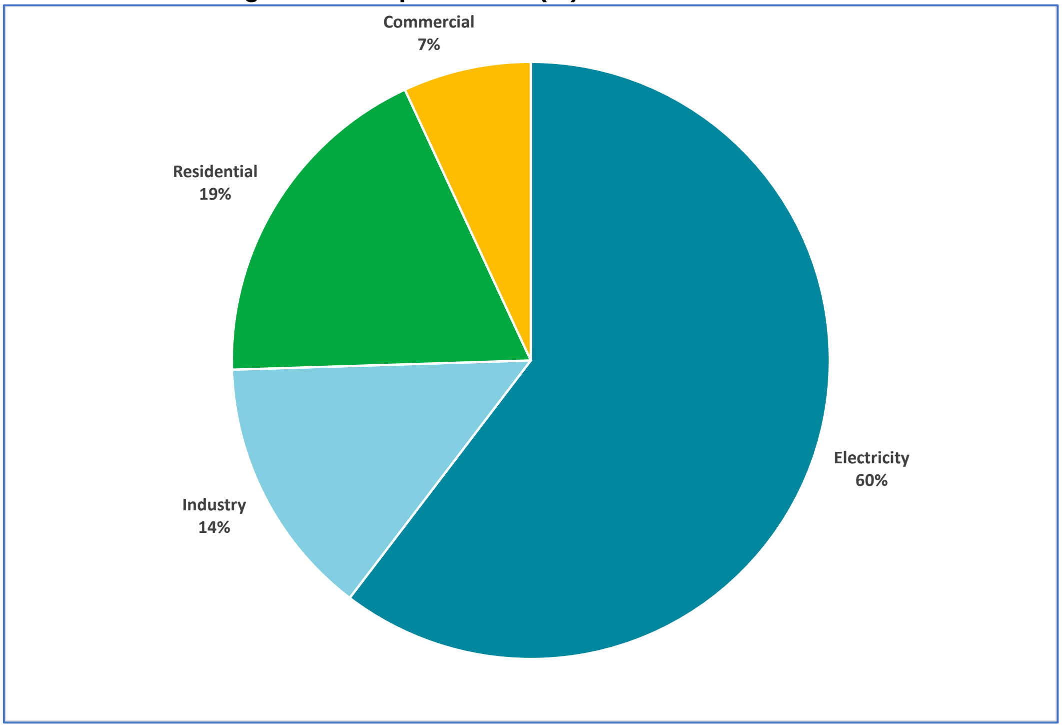
Like Japan, Korean final energy consumption is dominated by oil and electricity (Figure 20). In 2022 Korea was the world's eighth largest electricity consumer. As is the case in Japan, the biggest use of gas in Korea is for power generation, followed by residential, industrial and commercial use (Figure 21).

Figure 20: Korea final energy consumption 2021 (%)



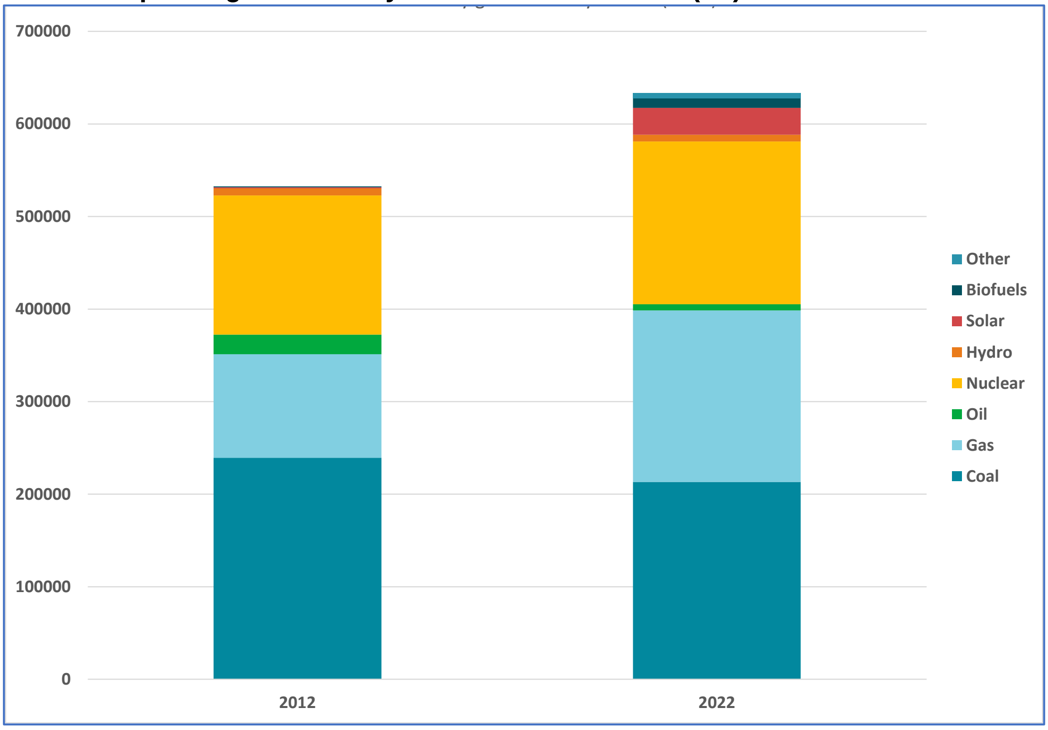
Source:IEA

Figure 21: Korea natural gas consumption 2021 (%)



Source: IEA

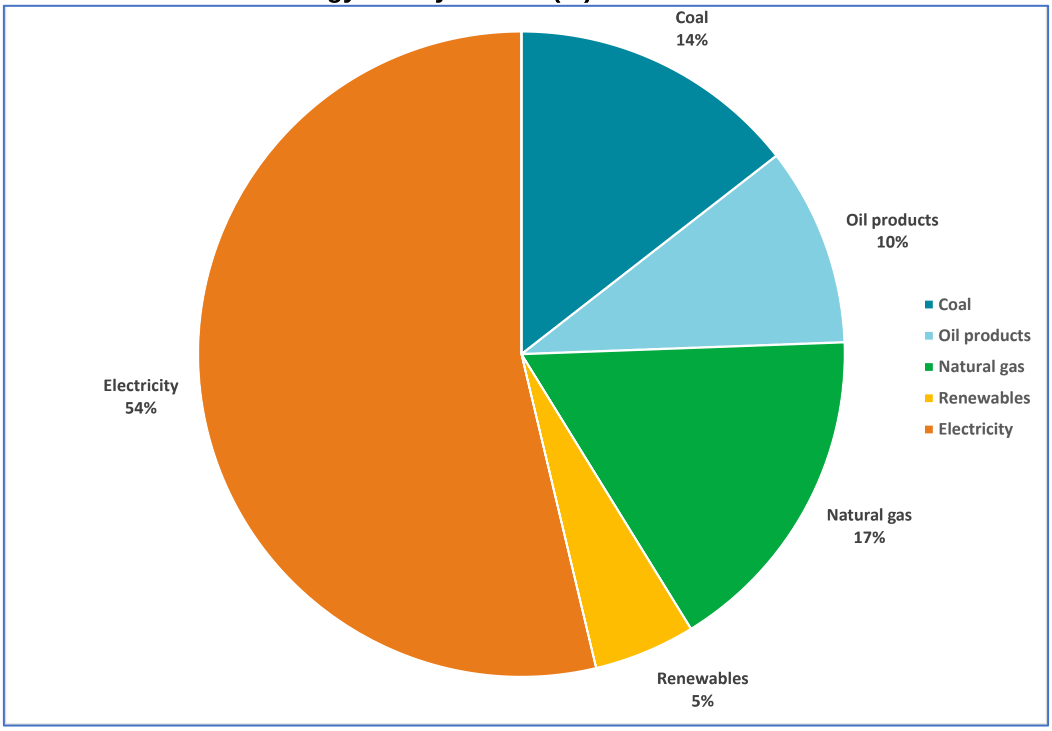
Figure 22: Korea power generation by source 2012 and 2022 (PJ)



Source: IEA

In recent years there has been a reduction in coal use for power generation, with increases in gas and nuclear (Figure 22). Coal's share of power generation has fallen from 45% in 2012 to 34% in 2022 while gas has increased significantly, from 21% to 29%. The share of nuclear has been steady over the same period. The share of renewables has increased from 2% to 8%.

Figure 23: Korea industrial energy use by source (%)



Source: IEA

As well as being important for electricity generation, gas is also an important feedstock for industry (Figure 23).

Korean energy policy

Korea updated its emissions reduction target in December 2021. By 2030 Korea is aiming for a 40% reduction in emissions below the 2018 level and for net zero by 2050[66]. The election of a new government in March 2022 marked a shift in the emissions reduction pathway, with a swing back towards nuclear, which the previous government had aimed to phase out following the Fukushima accident in 2011[67]. The construction of Shin-Hanul No. 3 and No. 4 nuclear reactors (halted in October 2017) is to resume to expand the nuclear energy share of power generation to a minimum of 32.4% by 2030 and 34.6% by 2036 (27.4% in 2022). In December 2023 a consortium led by Hyundai Engineering & Construction was selected by Korea Hydro & Nuclear Power as the contractor for the construction of the main facilities at units 3 and 4[68]. Korea is also aiming to export 10 nuclear plants by 2030.

Table 5 shows the generation mix targets in the 10th Basic Plan on Electricity Supply and Demand released in January 2023[69].

In terms of, renewable energy and nuclear are targeted to increase steeply while coal and LNG decline. Use of LNG for power generation is targeted to decline from 29 Mt in 2021 to 22 Mt in 2030 to 10 Mt in 2036. Assuming LNG for other purposes remains constant, total LNG imports would decline from 47 Mt in 2021 to 38 Mt in 2030 to 26 Mt in 2036, the same as in 2007. The capacity of renewable energy in 2030 is expected to be 72.7 GW. This requires an additional 39.9 GW above existing capacity. The renewable target for 2030 is nine percentage points lower than the previous government and therefore probably more realistic but with criticism from environmental groups[70]. Climate Transparency is one of many NGOs that rate Korea's emissions reduction plans as inadequate for a 1.5-degree world[71].

Table 5: South Korea electricity generation mix targets

Year	Category	Nuclear	Coal	LNG	Renewable	Hydrogen/ Ammonia	Other	Total
2021	Generation (TWh)	158.0	208.3	190.2	37.4	0	4.7	598.6
	% share	26.4%	34.8%	31.8%	6.2%	0.0%	0.8%	100.0%
2030	Generation (TWh)	201.7	122.5	142.4	134.1	13	8.1	621.8
	% share	32.4%	19.7%	22.9%	21.6%	2.1%	1.3%	100.0%
2036	Generation (TWh)	230.7	95.9	62.3	204.4	47.4	26.6	667.3
	% share	34.6%	14.4%	9.3%	30.6%	7.1%	4.0%	100.0%

Source: Korea 10th Basic Plan on Electricity Supply and Demand

As in Japan, Korea's plans to reduce emissions rely heavily on growth in renewables. Solar capacity is growing relatively quickly at about 2 GW per annum (Figure 24). However, in 2022 solar only contributed 4.3% of total generation. There has been even less progress with wind. Wind capacity only grew by 300 MW between 2020 and 2022. According to the Global Wind Energy Council (GWEC) onshore wind capacity at the end of 2022 was only 1,658 MW and offshore capacity only 142 MW (i.e. 1.8 GW in total)[72]. Wind contributed less than 1% of total generation. According to the GWEC the Korean government is targeting 34 GW of installed wind capacity by 2036.

[66] https://unfccc.int/sites/default/files/NDC/2022-06/211223_The%20Republic%20of%20Korea%27s%20Enhanced%20Update%20of%20its%20First%20Nationally%20Determined%20Contribution_211227_editorial%20change.pdf

[67] https://www.korea.net/Government/Briefing-Room/Press-Releases/view?articleId=6497&type=O

[68] https://world-nuclear-news.org/Articles/Contract-awarded-for-construction-of-Shin-Hanul-3

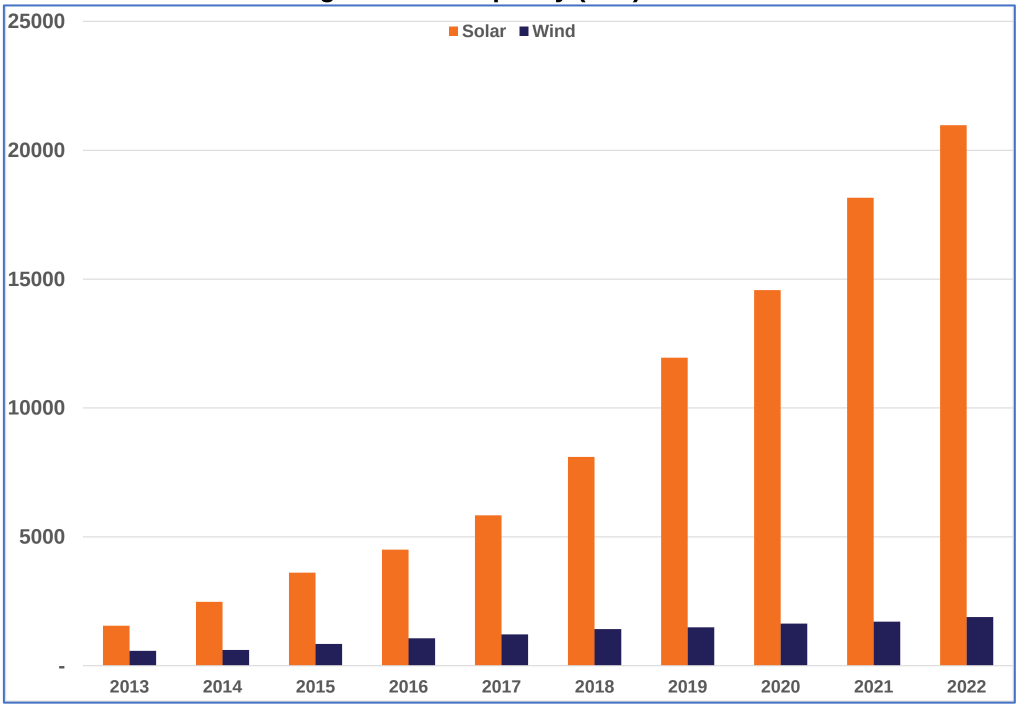
[69] https://www.kimchang.com/en/insights/detail.kc?sch_section=4&idx=26720

[70] https://climateanalytics.org/publications/no-room-for-new-gas-in-south-korea https://energytracker.asia/south-koreas-energy-mix-and-its-10th-basic-energy-plan/

[71] https://www.climate-transparency.org/wp-content/uploads/2022/10/CT2022-South-Korea-Web.pdf

[72] https://gwec.net/globalwindreport2023/

Figure 24: Korea solar and wind generation capacity (MW)



Source: Energy Institute

LNG demand outlook

As noted above, Korean LNG imports have been growing quickly. Between 2011 and 2022 LNG imports grew by 32.7% while coal use declined.

One significant difference from Japan is the role of majority government-owned companies in the Korean energy sector. The Korean Electric Power Corporation[73] generates most of Korea's electricity and KOGAS[74] is the world's largest LNG importer. This gives the government significant influence over the energy mix.

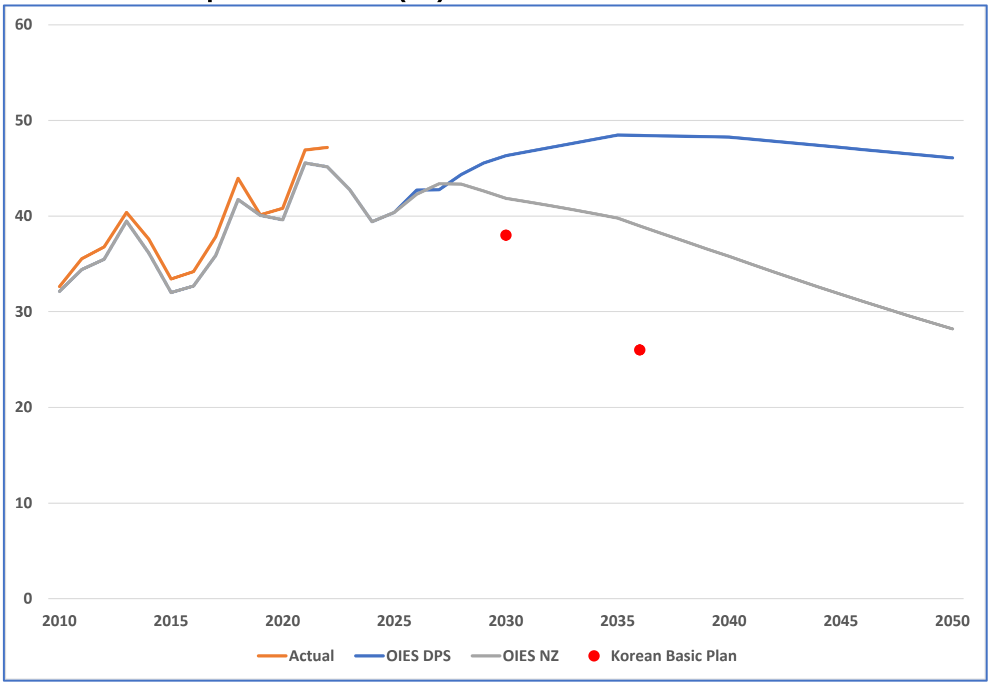
The emissions reduction targets suggest that the growth in LNG imports should reverse. However, there is currently substantial investment underway and proposed in Korean LNG infrastructure. Korea currently has seven LNG regasification and storage terminals, five owned by KOGAS and one each by POSCO and GS Energy, with a combined storage capacity of 6.29 Mt and regasification capacity of 152.95 Mtpa.[75] According to the IEEFA there are another 13 projects under construction with combined storage of 1.29 Mt and regasification capacity of 37.49 Mtpa. The developers include KOGAS, GS Energy, POSCO and SK Gas, a mix of government and private organisations. The IEEF attributes this development to the need for greater energy security in the light of the Russia-Ukraine war, increased competition in the domestic gas market and the development of new LNG applications such as blue hydrogen. An additional explanation is that LNG usage is expected to continue growing, notwithstanding the reduction implied by the emission targets.

Notwithstanding the target for reduced LNG imports, Korean LNG buyers have been active in securing new long-term LNG contracts. In 2022 KOGAS contracted 1.58 Mtpa of US LNG from BP, to commence in 2025 with a term of 18 years. SK Gas Trading contracted for 0.4 Mtpa of US LNG from Energy Transfer for 18 years commencing in 2027. In 2024 KOGAS contracted with Woodside for 0.5 Mtpa for 10.5 years starting in 2026.

[73] https://home.kepco.co.kr/kepco/EN/A/htmlView/ENAAHP001.do?menuCd=EN010101
[74] https://www.kogas.or.kr/site/eng/main
[75] https://ieefa.org/sites/default/files/2023-11/South%20Korea%27s%20LNG%20Overbuild_Nov23_MK_reviewed_112323_clean.pdf

The OIES LNG scenarios are shown in Figure 25. Under the DPS scenario LNG imports remain essentially flat. This is conservative in the light of growth in Korean LNG imports. Imports decline under the NZscenario but not to the levels implied by the Basic Energy Plan (shown as the red dots in Figure 25).

Figure 25: Korea LNG import scenarios (Mt)



Source: OIES

If LNG imports are higher than in the Basic Plan, there will need to be increased emphasis on CCS, including exporting CO2 offshore. In November 2023 Korean company SK E&S and Australian company Santos signed a Memorandum of Understanding to collaborate on cross border CCS[76].

5. Taiwan

Energy background

Taiwan, also known as Chinese Taipei, has a population of 23.4 million, ranking 57th globally. According to current projections, Taiwan's population will continue to grow over the next decade or so until reaching its peak population of 24.01 million people in 2029. After 2030, the population is expected to decline slowly[77].

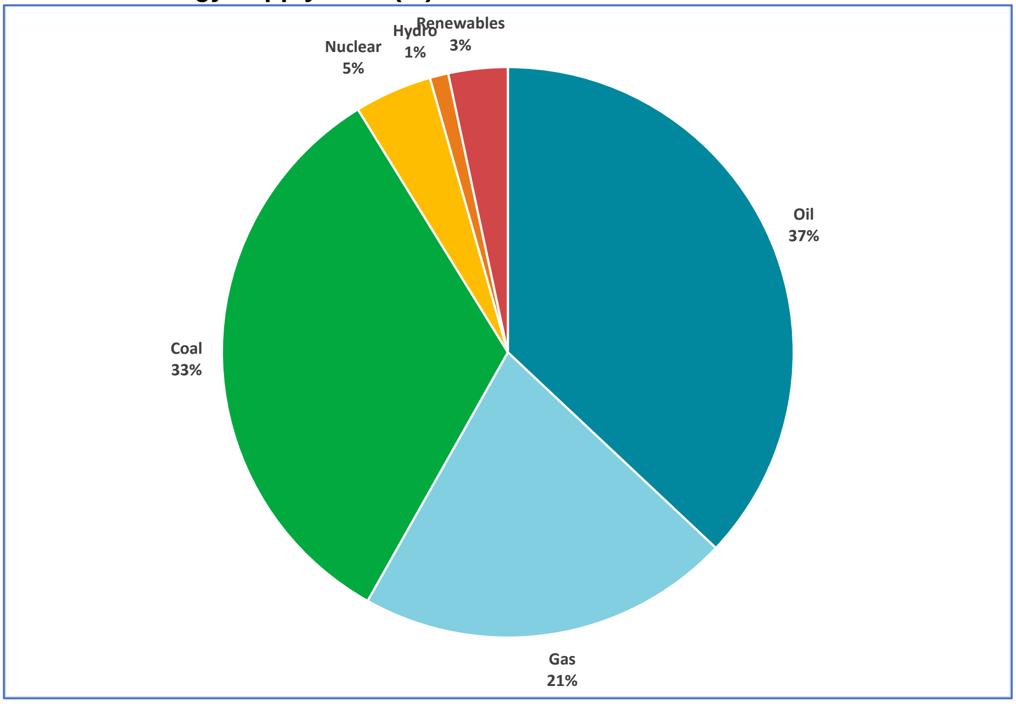
The country is the world's 24th-largest economy. GDP growth in Q4 2023 was 5.1%, compared with only 1.0% for Japan[78].

In 2022 it was the world's 18th largest energy consumer, a large fossil fuel consumer by world standards and has a carbon-intensive economy. It is the world's 21st-largest oil consumer and13th largest coal consumer. It ranks 31 globally in gas consumption and in 2022 was the 5th largest LNG importer, just ahead of India. In 2022 primary energy consumption per head was 200 GJ/head, well above the OECD average of 170 GJ/head[79]. Carbon intensity, measured as tonnes of CO2/head, was 12.07 in 2021 compared with an OECD average of 7.9[80].

76 https://www.santos.com/news/santos-and-sk-es-to-collaborate-on-cross-border-carbon-capture-and-storage/
77 https://worldpopulationreview.com/countries/taiwan-population
78 The Economist 16 February 2024.
79 https://www.energyinst.org/statistical-review
80 https://www.iea.org/data-and-statistics/data-product/greenhouse-gas-emissions-from-energy-highlights

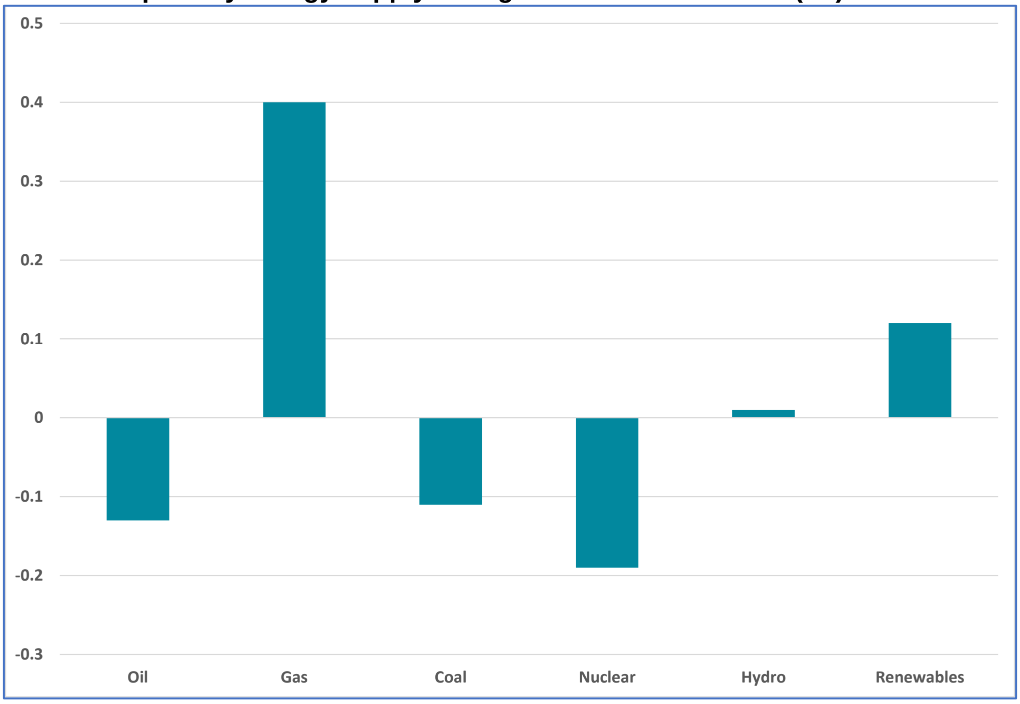
Fossil fuels (all imported) constituted just over 90% of total energy supply in 2022 (Figure 26). The share of nuclear was similar to Japan and the share of renewables similar to Korea. Total primary energy demand has declined slightly since 2018. The share of fossil fuels has been steady at around 90% over the last decade but with the share of gas increasing from 14% to 21%, offset by falls in oil, nuclear and coal (Figure 27). The share of renewables has grown but remains modest while the share of nuclear has fallen from 8% in 2012 to 4% in 2022 (Figure 28).

Figure 26: Taiwan energy supply 2022 (%)



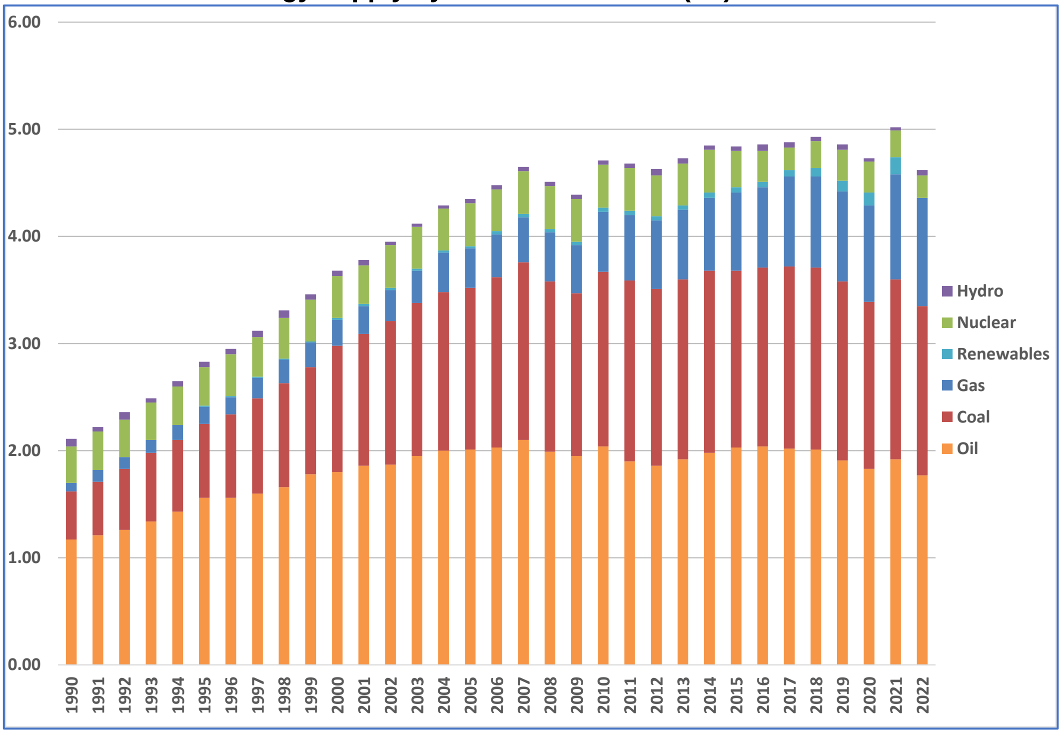
Source: Energy Institute

Figure 27: Taiwan primary energy supply change in 2022 versus 2011 (EJ)



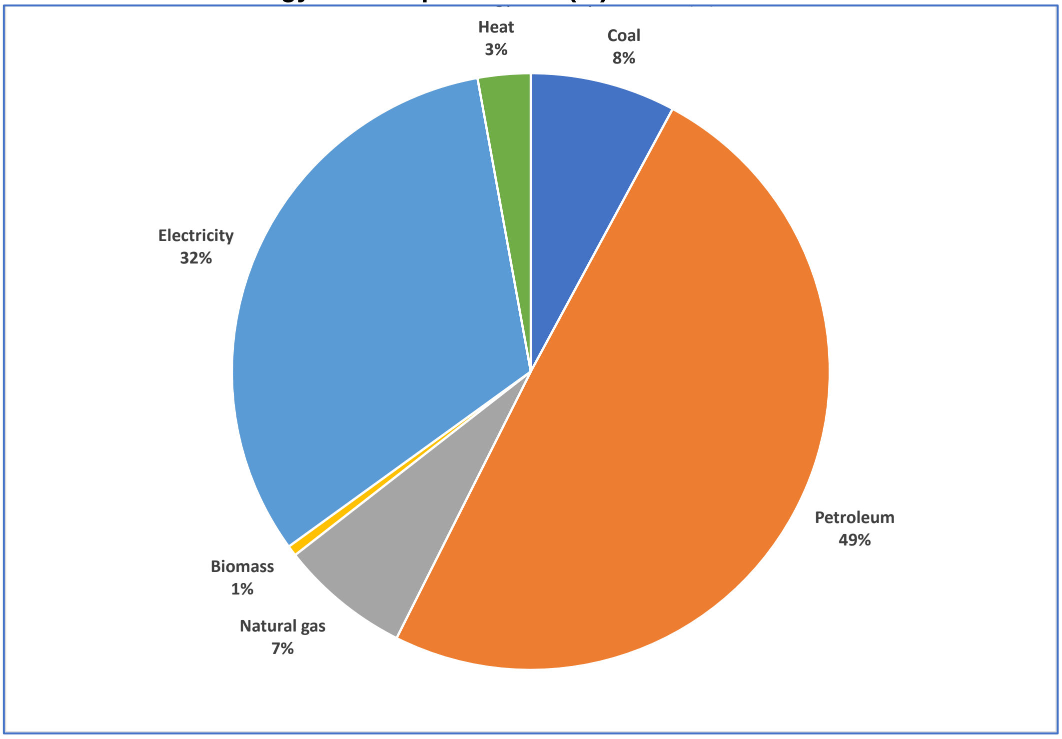
Source: Energy Institute

Figure 28: Taiwan total energy supply by source 1990-2022 (EJ)



Source: Energy Institute

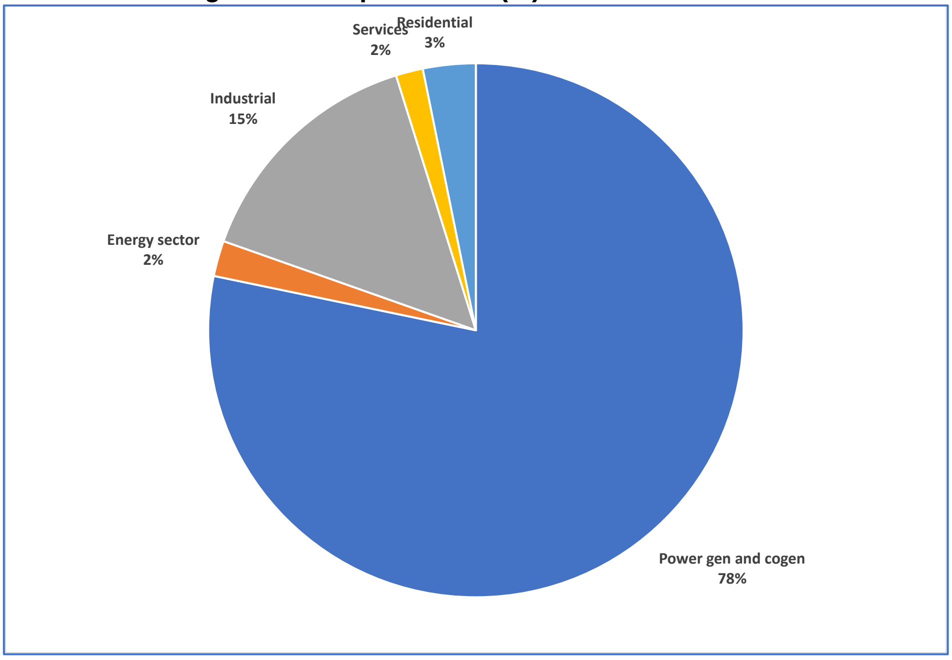
Figure 29: Taiwan final energy consumption 2022 (%)



Source: 2022 Taiwan Energy Statistics Handbook

Like Japan and Korea, Taiwan final energy consumption is dominated by oil and electricity (Figure 29).

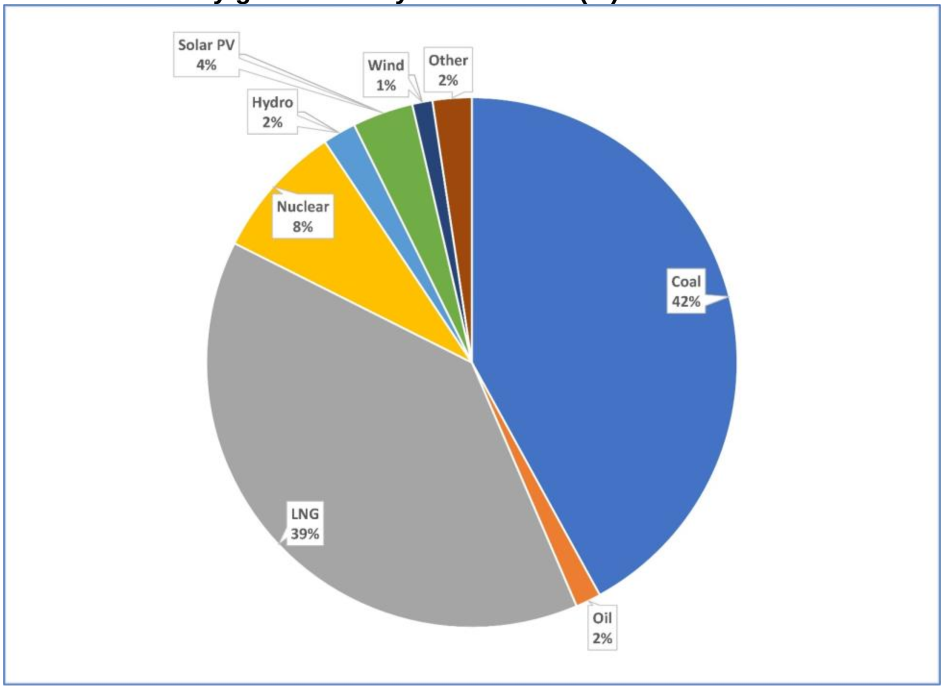
Figure 30: Taiwan natural gas consumption 2022 (%)



Source: 2022 Taiwan Energy Statistics Handbook[81]

Nearly 80% of gas is used for power generation and most of the remainder is used for industry (Figure 30). Taiwan has suffered major power blackouts in recent years[82].

Figure 31: Taiwan electricity generation by source 2022 (%)



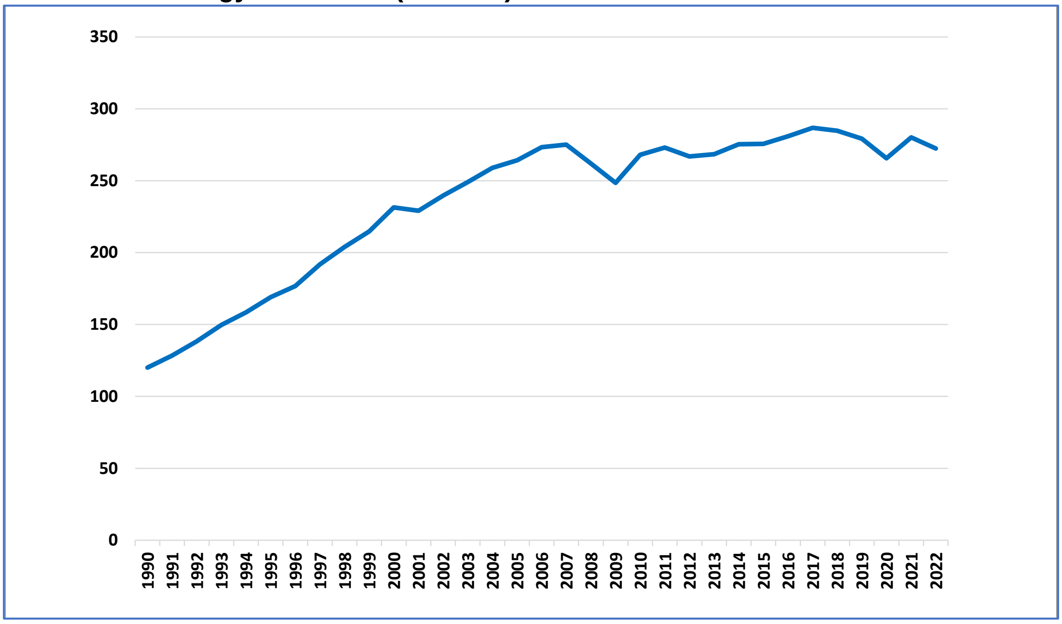
Source: 2022 Taiwan Energy Statistics Handbook

[81] https://www.moeaea.gov.tw/ECW_WEBPAGE/FlipBook/2022EnergyStaHandBook/index.html#p=24
[82] https://globaltaiwan.org/2023/06/taiwans-electrical-grid-and-the-need-for-greater-system-resilience/
https://asia.nikkei.com/Business/Technology/Taiwan-s-frequent-blackouts-expose-vulnerability-of-tech-economy

Although Taiwan has small volumes of power generation from wind, solar, and hydro, the biggest energy sources for power generation are coal, gas and nuclear (Figure 31).

Total emissions from energy grew quickly in the late 1990s and early 2000s, with a fall at the time of the Global Financial Crisis in 2008. Emissions have increased slowly since then, with a small reduction in 2020 due to the pandemic (Figure 32).

Figure 32: Taiwan energy emissions (MtCO2e)



Source: Energy Institute

Taiwan energy policy

According to the EIA [83], Taiwan's electricity policy is focusing on replacing older fossil fuel units with more efficient power plants and increasing its installed capacity and generation from renewable sources to diversify fuel sources. As a result, Taiwan passed the Renewable Energy Development Act in 2009 including a system for feed-in tariffs for solar and wind power.

Taiwan currently has three nuclear plants with about 5.1 gigwatts (GW) of capacity in operation. At one point nuclear energy from all six reactors provided more than half of heavily industrialised Taiwan's electricity. However, the island's three existing plants, Chinashan, Kuosheng, and Maanshan, are reaching the retirement age of 40 years. Chinshan-1 was shut down in 2018, Chinshan-2 in 2019 and Kuosheng-1 in 2021.The closure of Kuosheng-2 leaves two units in operation at the Maanshan nuclear power station, but both are scheduled to be shut down in the next two years, fulfilling the ruling Democratic Progressive Party's promise of a "nuclear-free homeland" by 2025[84].

Although construction of Taiwan's fourth nuclear facility, with a capacity of 2.6 GW, was nearly complete, public protests over safety concerns led to suspended construction of the facility in early 2014. The plant was mothballed after safety inspections finished \in 2015. The Taiwanese government is discussing various plans for this plant including converting it to accept other fuels such as natural gas or coal.

The operating licenses for Taiwan's last remaining reactors expire in 2024 and 2025, which means the government would need to bend its rules to allow for a lifetime extension.

[83] https://www.eia.gov/international/analysis/country/TWN
[84] https://www.nucnet.org/news/latest-reactor-shutdown-leaves-island-in-precarious-position-3-4-2023

The government has been seeking more natural gas and renewable sources to feed power supply and replace any loss of nuclear power generation.

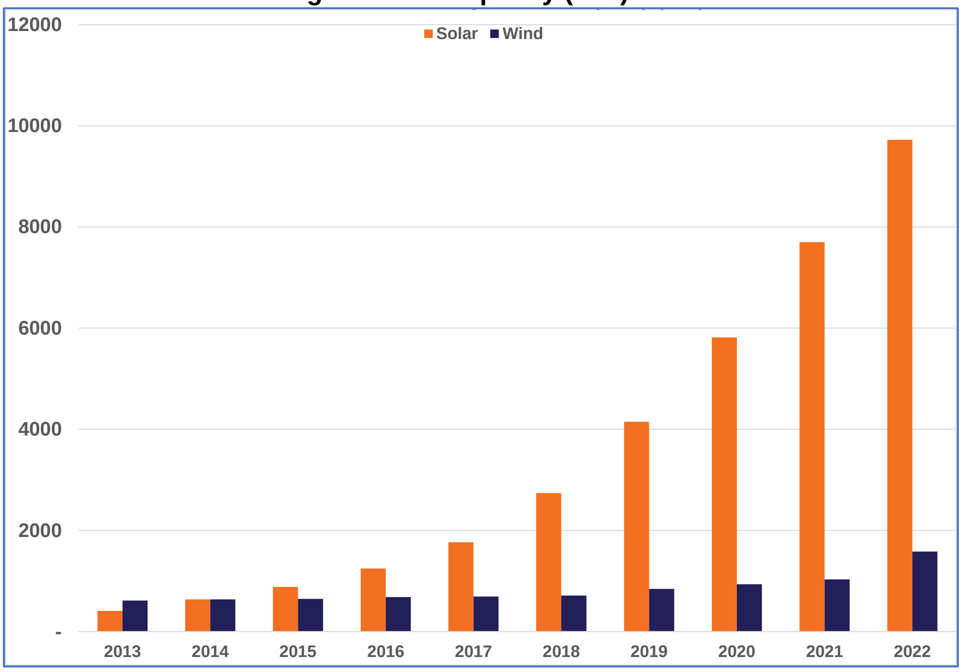
Currently, the security stockpile for natural gas is only 8 days. In 2025, when 50% of electricity is targeted to come from LNG, if there should be a 10-day-long blockade, Taiwan will suffer a power crunch[85].

Taiwan's latest election was held on 13 January, and was won by the ruling Democratic Progressive Party (DPP), which is expected to maintain continuity in energy policy[86]. According to S&P Global the result carries over uncertainty around long-term decarbonization plans to meet its net zero goals and achieve its near-term 2025 renewables target.

Under the previous administration, Taiwan was pursuing a policy of decommissioning its nuclear-powered generation fleet by 2025, and cutting coal-fired power generation, while ramping up renewables and gas-fired power generation. As shown in Figure 31, coal-fired power generation accounted for 42% of the power mix in 2022, gas was 39%, renewables around 5%, nuclear 8% and the remainder was accounted for by other sources including hydro. By 2025, the share of coal is planned to fall to 30%, gas has to reach 50%, renewables have to reach around 20% (subsequently revised down to 15%) and nuclear has to fall to zero[87]. Increasing gas share of power generation to 50% would require an additional 3 Mtpa of LNG imports.

On Earth Day 2021 Taiwan announced its goal of achieving net zero emissions by 2050 and in March 2022, Taiwan's National Development Council (NDC) released its 2050 net-zero roadmap, which set ambitious renewables targets to build 40-80 GW of solar PV and 40-55 GW of offshore wind generation capacity by 2050. The government expects to build 20 GW of solar PV and 5.7 GW of offshore wind generation capacity by 2025. As in Japan and Korea solar has been growing, but as of 2022 had only achieved half of the 2025 solar target and less than one-third of the wind target (Figure 33).

Figure 33: Taiwan solar and wind generation capacity (MW)



Source: Energy Institute

[85] https://hk.boell.org/en/2023/04/14/charged-debate-taiwans-nuclear-energy-conundrum
[86] https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/020124-taiwan-government-faces-energy-climate-policy-challenge-after-elections
[87] https://www.moea.gov.tw/MNS/english/Policy/Policy.aspx?menu_id=32904&policy_id=19

Increasing solar generation capacity is challenging as rooftop capacities that are most suitable for solar panel installation have been almost all developed, and many possible sites for utility-scale solar PV are inaccessible. With a population density ranking 17th in the world, it is challenging for solar developers to get approval for land. For example, the 157 MW solar project in eastern Taiwan proposed by the Singapore-based Vena Energy had to be withdrawn after three years as a result of strong opposition from the indigenous community. Solar PV projects also compete with land resources in agricultural or fishery sectors.

Taiwan is expected to miss the 5.7 GW offshore wind target under the current engineering schedule due to project cancellations and delays in environmental approvals. Offshore wind requires opening up areas that are restricted for environmental concerns or maritime boundary concerns with China. It took Europe 20 years to reach similar installed capacity. Adding to the challenge is the Ministry of Economic Affairs' ambition to build up Taiwan's offshore wind supply chain, requiring that the wind farms use a certain percentage of locally sourced parts, such as jackets and towers. Lack of manufacturing expertise, combined with the COVID-19 pandemic, has resulted in delays and gross cost overruns of major projects.

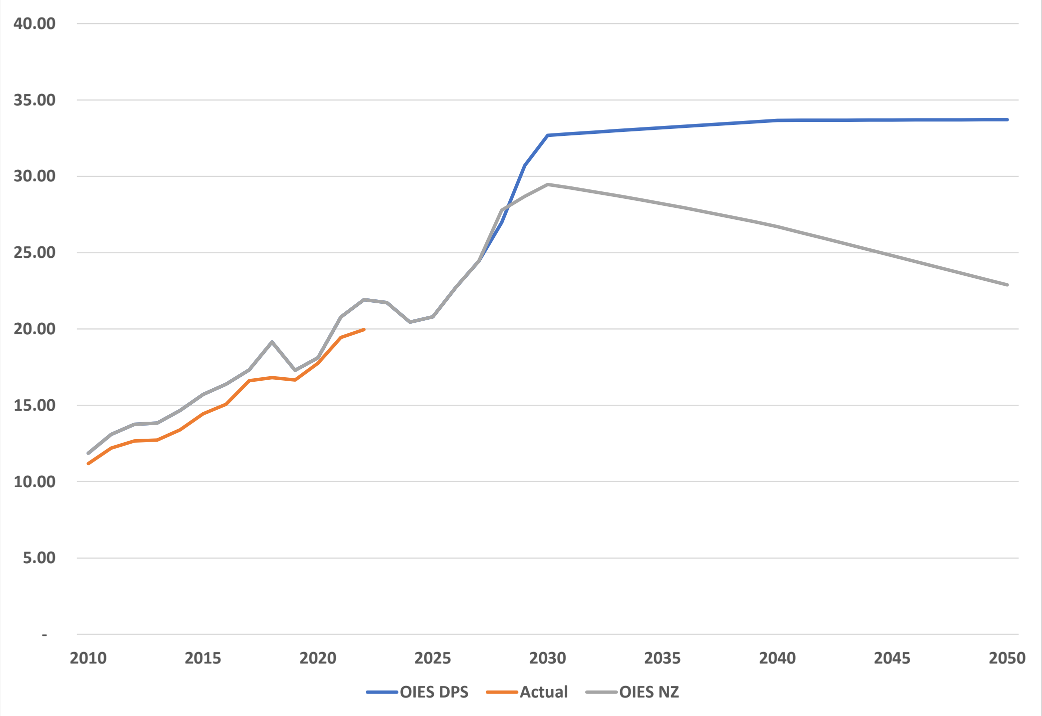
The DPP government has also been cutting dependency on equipment supply chains from China for low-cost solar PV products and wind turbines, forcing companies to import from markets such as the EU or build domestic capacity at significantly higher costs.

Achieving 50% gas-fired power generation in Taiwan's power mix by 2025 requires accelerated development of both gas-fired power plants and LNG receiving terminals, but projects have been bogged down by environmental delays. Currently, Taiwan has only two LNG receiving terminals -- CPC's 12 million Mtpa Yung-An LNG terminal and the 6.5 Mtpa Taichung LNG terminal. Taiwan plans to add three more LNG receiving terminals -- CPC's third LNG terminal with a capacity of 3 Mtpa, Taipower's 1.8 Mtpa Hsieh-ho LNG terminal and the 3 Mtpa Taichung LNG terminal.

LNG demand outlook

Figure 34 shows the OIES scenarios for Taiwan LNG imports. Under the DPS scenario imports grow from 20 Mt in 2022 to 33 Mt in 2030. They also grow in the Net Zero scenario to 30 Mt in 2030, after which they begin to decline. These increases rely on expansion of LNG import capacity.

Figure 34: Taiwan LNG import scenarios (Mt)



Source: OIES

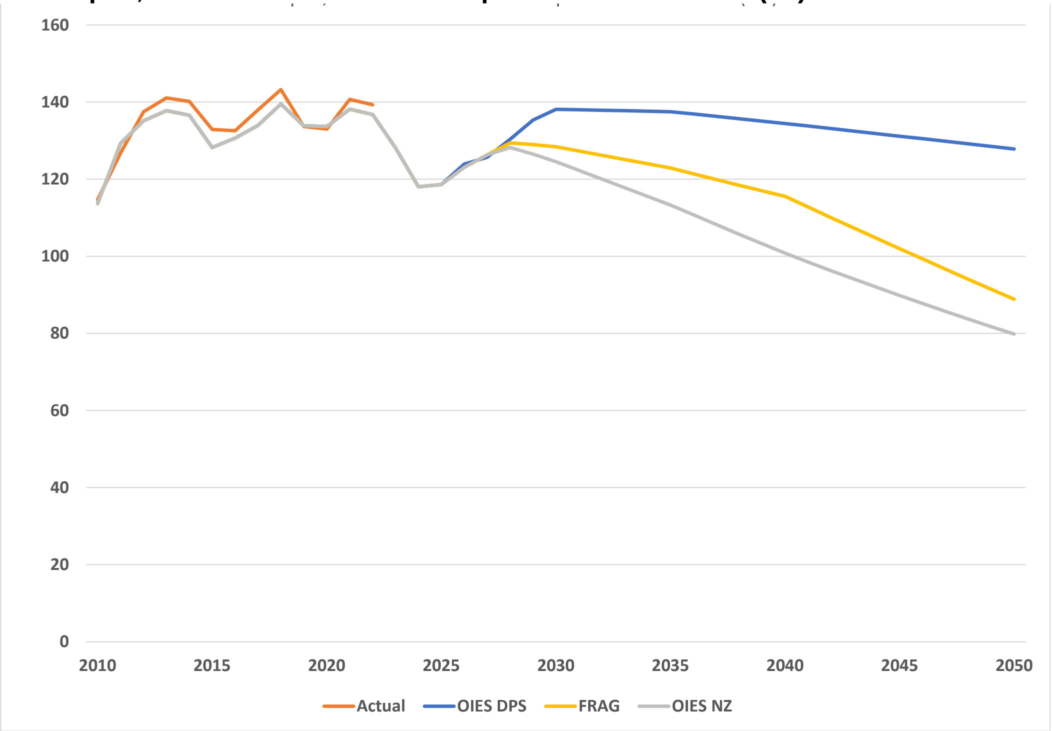
Australia was the largest LNG supplier to Taiwan in 2022, followed by Qatar. In 2021, CPC Corporation, Taiwan and Qatar Petroleum signed a 15-year LNG contract for 1.25 Mtpa starting in 2022.

Taiwan is developing CCS to offset its growing emissions. According to Schlumberger[88], CPC aims to commence commercial CCS operations in 2030. The goal is to inject 5 Mtpa of CO_2 into selected sites and gradually build up to 14 Mtpa. Schlumberger has been contracted to conduct a feasibility study for subsurface carbon storage. To do this, a preliminary field development plan was created which included injection and monitoring well placement and design, risk management strategies, and a monitoring scheme.

6. Regional LNG outlook

Figure 35 shows the long-term OIES LNG demand scenarios for the total JKT region. In addition to the DPS and NZ scenarios it has a third scenario for fragmented decarbonisation (FRAG). In a more fragmented world different countries and regions move at different paces and with different methods of decarbonising. It has a higher temperature target with higher CO_2 emissions by 2050. The range of import scenarios for 2050 is from 80 Mt in the NZ scenario to 128 Mt in the DPS scenario, a reduction of between 41% (NZ) and 6% (DPS) from 2022. This is a wide range but even under the most aggressive decarbonisation scenario the region remains a significant LNG importer.

Figure 35: Japan, Korea and Taiwan LNG imports OIES scenarios (Mt)

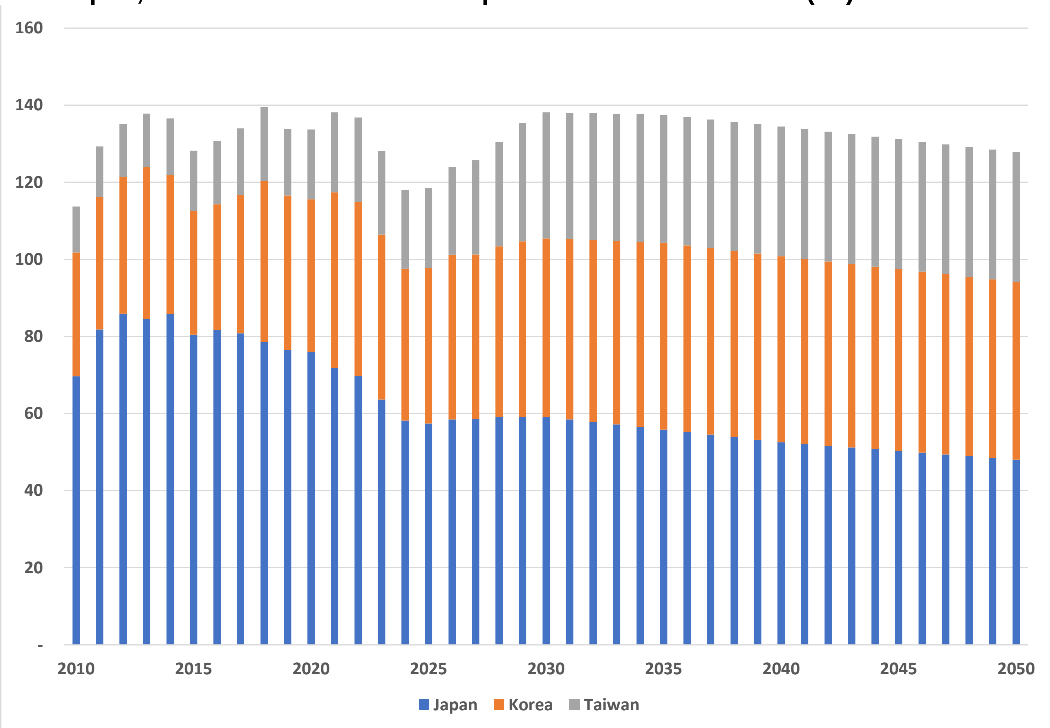


Source: OIES

In the DPS scenario Japanese imports fall from 70 Mt in 2022 to 48 Mt in 2050 but Korean imports are flat and Taiwan's imports increase from 22 Mt to 34 Mt (Figure 36). In the FRAG scenario Japanese imports fall to 32 Mt and Korean to 31 Mt but Taiwan imports still increase, to 26 Mt (Figure 37). In the NZ scenario Japanese imports fall to 29 Mt, Korean imports fall to 28 Mt and Taiwan's imports are flat (Figure 38).

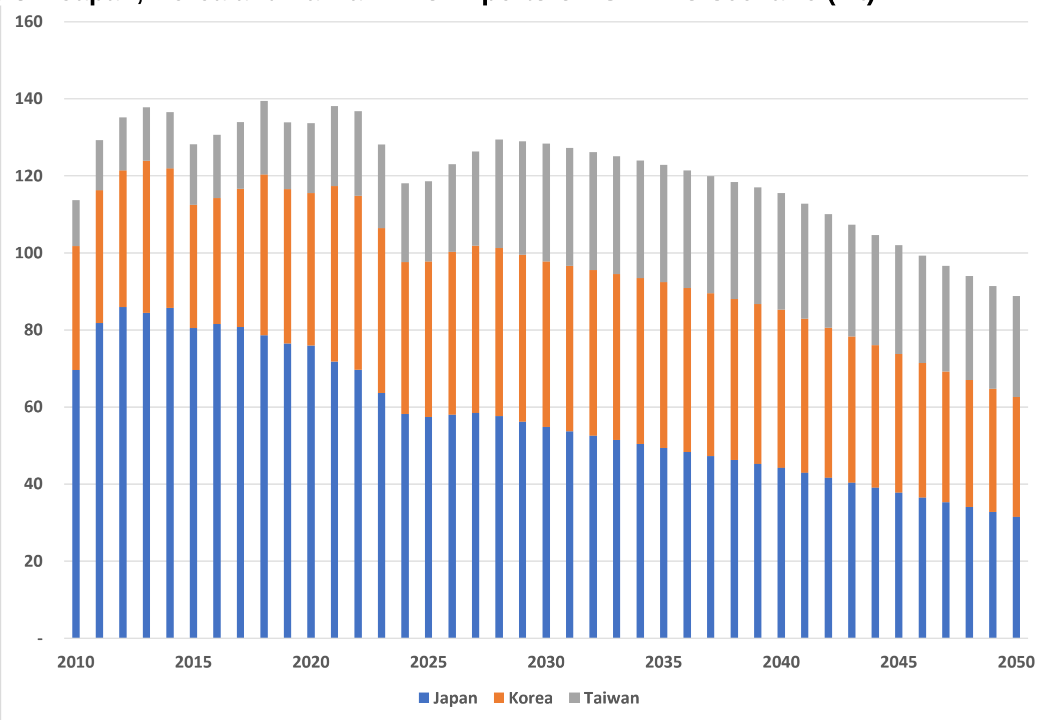
[88] https://www.slb.com/resource-library/case-study-with-navigation/sne/ccs-cpc-taiwan-cs

Figure 36: Japan, Korea and Taiwan LNG imports OIES DPS scenario (Mt)



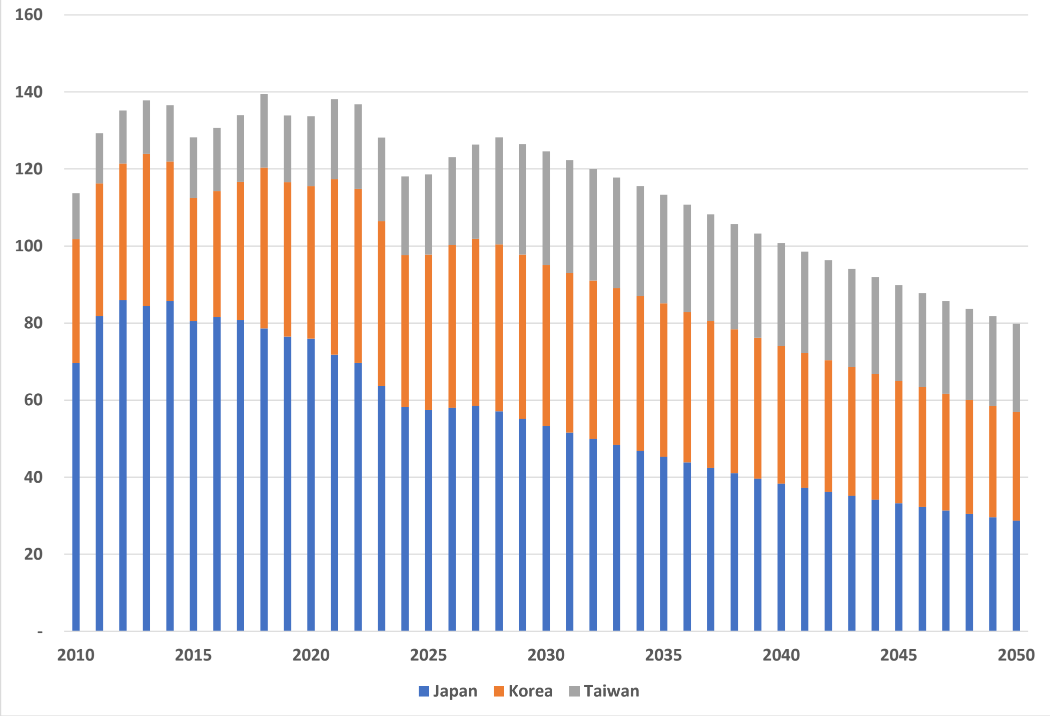
Source: OIES

Figure 37: Japan, Korea and Taiwan LNG imports OIES FRAG scenario (Mt)



Source: OIES

Figure 38: Japan, Korea and Taiwan LNG imports OIES NZ scenario (Mt)



Source: OIES

7. Conclusion

This insight has only been able to provide a high-level review of issues affecting the future role of LNG in Japan, Korea and Taiwan. The three countries have ambitious targets to reach net zero emissions, which at least for Japan and Korea envisage a declining role for LNG. Taiwan is aiming to increase LNG but to do so would require significant investment in import infrastructure. The scale-up of renewables and increase in nuclear are proving challenging. In these circumstances there is also the risk of a reversion to unabated coal in the absence of realistic carbon prices. Game changers for the future of LNG in these countries include:

- Carbon price implementation.
- Electricity market infrastructure investment.
- Nuclear increase or phase out.
- Renewable energy progress.
- Carbon capture and storage.
- Offshore wind development.
- Solar development.
- Progress on decarbonised gases such as green hydrogen and e-methane.