U.S. Energy Information Administration

Japan

International energy data and analysis

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full report

Overview

Japan is the world's largest liquefied natural gas importer, second-largest coal importer, and third-largest net importer of crude oil and oil products.

Japan has limited domestic energy resources that have met less than 9% of the country's total primary energy use since 2012, compared with about 20% before the removal of nuclear power following the Fukushima plant accident.[1] It is the third largest oil consumer and net importer in the world behind the United States and China. Furthermore, it ranks as the world's largest importer of liquefied natural gas (LNG) and second-largest importer of coal behind China.

In light of the country's lack of sufficient domestic hydrocarbon resources, Japanese energy companies have actively pursued participation in upstream oil and natural gas projects overseas, providing engineering, construction, financial, and project management services for energy projects around the world. Japan is one of the major exporters of energy-sector capital equipment and has a strong energy research and development (R&D) program supported by the government. This program pursues energy efficiency measures domestically to increase the country's energy security and to reduce carbon dioxide (CO_2) emissions.

In March 2011, a 9.0 magnitude earthquake struck off the coast of Sendai, Japan, triggering a large tsunami and serious nuclear damage at the Fukushima-Daiichi reactors. The damage to Japan's energy infrastructure resulted in an immediate shutdown of about 10 gigawatts (GW) of nuclear electric generating capacity. The plants that were not immediately damaged were gradually shut down as a result of scheduled maintenance and lack of government approvals to return to operation. Two nuclear reactors, Kansai Electric's Ohi reactors 3 and 4, were restarted in July 2012 and represented the only source of nuclear power in the country for more than a year. However, these two reactors were shut down again in September 2013, suspending all of Japan's nuclear power generation for a second time in more than 40 years.[2]

Nuclear generation in Japan represented about 27% of the power generation prior to the 2011 earthquake and was one of the country's least expensive sources of electric power. Japan replaced the significant loss of nuclear power with generation from imported natural gas, low-sulfur crude oil, fuel oil, and coal. This substitution of more expensive fossil fuels led to higher electricity prices for consumers, higher government debt levels, and revenue losses for electric utilities.

Japan imports virtually all its fossil fuels, whereas very little fuel is needed for nuclear energy generation. Japan spent about $270 billion, or around 58% more, for fossil fuel imports in the

three years following the Fukushima accident.[3] Despite some strength in export markets, the yen's depreciation and soaring natural gas and oil import costs from a greater reliance on fossil fuels and sustained high international oil prices through the first half of 2014 continued to deepen Japan's recent trade deficit. The trade balance reversed from a 30-year trade surplus, which was $65 billion in 2010 to a deficit that reached $112 billion in 2013.[4] The recent drop in oil prices in the latter part of 2014 is likely to ease the trade deficit and provide some relief to Japanese utilities.

Japan's current government intends to resume using nuclear energy as a baseload power source with necessary safety measures. The government believes that the use of nuclear energy is necessary to help reduce current energy supply strains and high energy prices faced by Japan's industries and end users. The government's new energy policy issued in 2014 emphasizes energy security, economic efficiency, and emissions reduction. Key goals and plans to balance the country's fuel portfolio include strengthening the share of renewable and alternative energy sources, diversifying away from oil to reduce dependency in the transportation sector, and developing the most advanced generation technologies using fossil fuels. These efforts occur in the context of the government's goal to reverse two decades of economic stagnation in Japan and to provide economic revitalization through public infrastructure spending, monetary easing, labor market reform, and business investment.

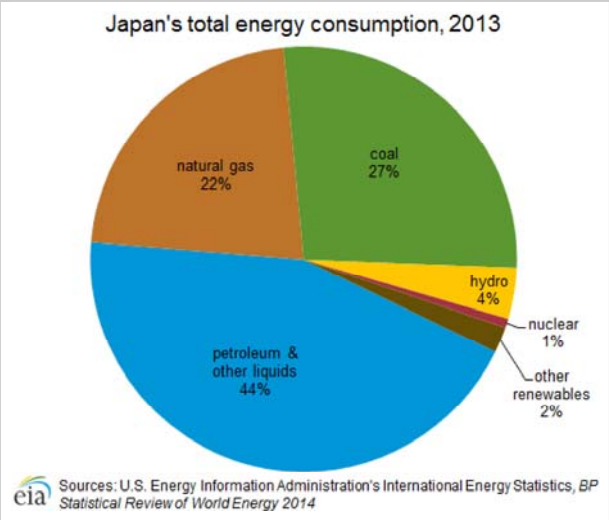
Source: Central Intelligence Agency, The World Factbook

Total primary energy consumption

In the wake of the Fukushima nuclear incident, Japan's energy fuel mix shifted as natural gas, oil, and renewable energy now provide larger shares and supplant some of the nuclear fuel. Oil remains the largest source of primary energy in Japan, although its share of total energy consumption has declined from about 80% in the 1970s to 44% in 2013. The decline in oil use occurred as a result of increased energy efficiency and the increased use of other fuels. Coal continues to account for a significant share of total energy consumption, although natural gas is increasingly important as a fuel source and is currently the preferred fuel of choice to replace the nuclear shortfall. Natural gas rose from 19% in 2010 to 22% of total primary consumption in 2013, according to *BP Statistical Review of World Energy*, 2014 and EIA estimates. Before the 2011 earthquake, Japan was the third-largest consumer of nuclear

power in the world, after the United States and France, and nuclear power accounted for about 13% of the country's total energy in 2010. By 2012 and 2013, the nuclear energy share had fallen to less than 1% of total energy consumption. Hydroelectric power and other renewable energy sources comprise a relatively small percentage of total energy consumption in the country, although renewable energy is slowly growing as an alternative fuel source.

The Japanese government's policy has emphasized increased energy conservation and efficiency and a lower dependency on oil imports. The government generally aims to reduce the share of oil consumed in its primary energy mix. Among the large developed world economies, Japan has one of the lowest energy intensities, as high levels of investment in R&D of energy technology since the 1970s have substantially increased energy efficiency.



Petroleum and other liquids

Japan is the third-largest petroleum consumer in the world. The country relies almost solely on imports to meet its oil consumption needs because Japan's oil resources are very limited.

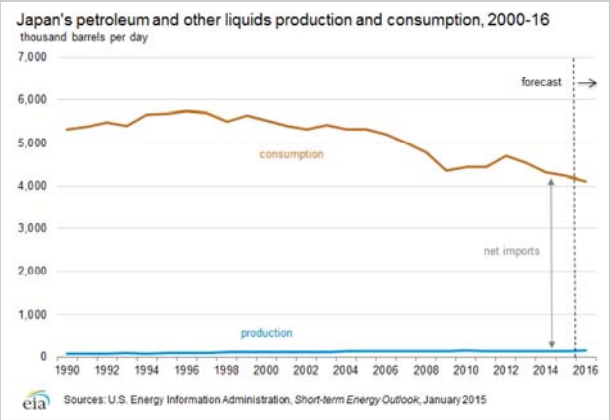
Japan has very limited domestic proved oil reserves, amounting to 44 million barrels as of January 2015, according to the *Oil & Gas Journal* (*OGJ*).[5] Japan's domestic oil reserves are concentrated primarily along the country's western coastline. Offshore areas surrounding Japan, such as the East China Sea (ECS), also contain oil and natural gas deposits. However, development of these zones is held up by competing territorial claims with China. The two countries reached an accord in 2008 to jointly explore four natural gas fields and equally invest in the development of two fields–Chunxiao/Shirakaba and Longjing/Asunaro. Since the agreement was signed, the countries have continued unilateral actions in attempts to develop the gas fields. Tensions escalated with territorial claims by Japan in 2012, with China's installation of a production platform in the contested area, and after China's unilateral declaration of an air defense zone covering much of the ECS in 2013 (see East China Sea analysis brief).[6]

Consequently, Japan relies almost solely on imports to meet its oil consumption needs. Japan maintains government-controlled oil stocks to ensure against a supply interruption. According to the International Energy Agency, total strategic crude oil stocks in Japan were more than 420 million barrels as of October 2014, where 73% of those were government stocks and 27% were commercial stocks.[7] Also, Japan has signed agreements with oil-producing countries such as Saudi Arabia and United Arab Emirates in recent years that involve Japan leasing crude oil storage for these countries, with Japan having a priority to

purchase the oil in the event of a serious supply disruption. Japan has a three-year lease to store 6.3 million barrels for each of these producers.[8]

Japan consumed an estimated 4.3 million barrels of oil per day (bbl/d) in 2014, making it the third-largest petroleum consumer in the world, behind the United States and China. However, oil demand in Japan has declined by 22% overall since 2000. This decline stems from structural factors, such as fuel substitution, a declining population, and government-mandated energy efficiency targets. Japan consumes most of its oil in the transportation and industrial sectors (about 41% and 29% of petroleum products, respectively), and it is also highly dependent on naphtha and low-sulfur fuel oil imports.[9] Demand for naphtha has fallen as ethylene production is gradually being displaced by petrochemical production in other Asian countries. In addition to the shift to natural gas in the industrial sector, fuel substitution is occurring in the residential sector as high prices have decreased demand for kerosene in home heating.

Japan's oil consumption rose by 255,000 bbl/d in 2012 from the 2011 level, the first significant annual jump in nearly two decades. Demand for low-sulfur fuel oil and direct use of crude oil rose substantially in 2012 as these fuels replaced some nuclear electric power generation and supported the post-disaster reconstruction works. However, oil consumption in the power sector began declining in 2013 as Japan relied more on natural gas and coal as nuclear power substitutes, and energy conservation measures were enforced for larger businesses and highly encouraged for smaller consumers. In addition, a consumption tax hike implemented in April 2014, the first in 17 years, and the yen's devaluation, which lowers purchasing power for imported products, have put downward pressure on oil consumption. EIA assumes that Japan's oil consumption will continue declining through 2015 as nuclear capacity comes back online.



Sector organization

Although Japan is a minor oil-producing country, it has a robust oil sector comprised of various state-run, private, and foreign companies. Until 2004, Japan's oil sector was dominated by the Japan National Oil Corporation (JNOC), which was formed by the Japanese government in 1967 and was charged with promoting oil exploration and production domestically and overseas. In 2004, JNOC's profitable business units were spun off into new companies to introduce greater competition into Japan's energy sector. Many of JNOC's activities were taken over by the Japan Oil, Gas and Metals National Corporation (JOGMEC), a state-run enterprise charged with aiding Japanese companies involved in exploration and production overseas and in the promotion of commodity stockpiling domestically. New companies were formed, of which the two largest are Inpex, now Japan's largest oil and gas company, and the Japan Petroleum Exploration Company (Japex).

Private Japanese firms dominate the country's large and competitive downstream sector, as foreign companies have historically faced regulatory restrictions. But over the past several

years, these regulations have been eased, which has led to increased competition in the petroleum-refining sector. Chevron, BP, Shell, and BHP Billiton are among the foreign energy companies involved in providing products and services to the Japanese market as well as being joint venture (JV) partners in many of Japan's overseas projects.

Domestic exploration and supply

In 2014, Japan's production of petroleum and other liquids was an estimated 136,000 bbl/d, of which only 18,000 bbl/d was from crude oil and natural gas liquids. The vast majority of Japan's domestic oil supply comes in the form of refinery gain, resulting from the country's large petroleum refining sector. Japan has 148 producing oil wells in more than a dozen fields, according to the *OGJ*.[10]

Overseas exploration and production

The government's energy strategy plan encourages Japanese companies to increase energy exploration and development projects around the world to secure a stable supply of oil and natural gas.

Japanese oil companies have sought participation in exploration and production projects overseas with government backing because of the country's lack of domestic oil resources. The government's energy strategy plan encourages Japanese companies to increase energy exploration and development projects around the world to secure a stable supply of oil and natural gas. The Japan Bank for International Cooperation supports upstream companies by offering loans at favorable rates, thereby allowing Japanese companies to bid effectively for projects in key hydrocarbon-producing countries. Such financial support helps Japanese companies purchase stakes in oil and gas fields around the world, reinforcing national energy security while guaranteeing their own financial stability.

The government set out in 2010 to double Japan's ratio of independently-developed fossil fuels (domestic and overseas) by 2030, up from an estimated 22% through JOGMEC's investments in production assets abroad. Following Fukushima, the government has not established a new self-sufficiency target. As a result of the 2011 earthquake and a pressing need to secure energy supplies, Japan is promoting even more investment in overseas oil and natural gas operations. Japanese companies participate in about 140 oil and gas projects worldwide that are in various stages of development, including about half that are in the production phase as of 2014, as well as technology exchanges with various countries.[11]

Japan's overseas oil projects are primarily located in the Middle East and Southeast Asia, although companies have recently invested in shale oil and oil sands projects in North America. Japanese oil companies involved in exploration and production projects overseas include: Inpex, Cosmo Oil, Idemitsu Kosan Company, Japan Energy Development Corporation, Japex, Mitsubishi, Mitsui, Nippon Oil, and others. Many of these companies are involved in small-scale projects that were originally set up by JNOC. However, several have invested in high-profile overseas upstream projects in recent years.

Oil imports

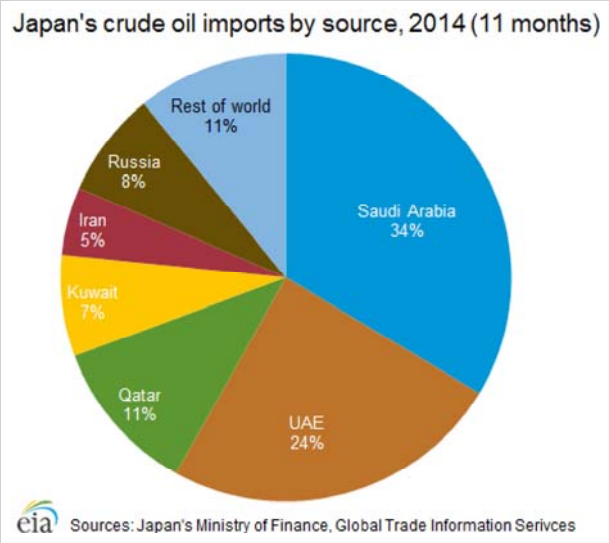
Japan, the third-largest global net oil importer, is highly dependent on the Middle East for most of its supply. The country is seeking to diversify its supply sources in Russia, Southeast Asia, and West Africa.

Japan was the third-largest net importer of total crude oil and petroleum products in the world after the United States and China in 2014. Net imports of total liquids (crude oil and petroleum product consumption less production) were 4.4 million bbl/d. After the Fukushima incident, Japan has increased imports of crude oil for direct burn in power plants. The country is primarily dependent on the Middle East for its crude oil imports, as roughly 84% of Japanese crude oil imports originated from this region in 2014, up from 70% in the mid-

1980s. Saudi Arabia is the largest source of imports, making up 34% of the import portfolio, or more than 1.1 million bbl/d of crude oil in the first 11 months of 2014. The UAE, Qatar, Kuwait, Russia, and Iran are other sizeable sources of oil to Japan.[12]

Japan's imports of crude oil and condensate from Iran have decreased since mid-2012 as a result of the latest rounds of U.S. and European Union sanctions targeting Iran's oil exports. Japanese refiners have replaced Iranian oil with other Middle Eastern supplies. Japanese imports from Iran were more than 166,000 bbl/d in 2014, down from about 314,000 bbl/d in 2011, and Iran represented only 5% of Japanese crude oil imports in 2014 compared to nearly 9% in 2011. Japan is leveraging its nuclear capabilities to secure nuclear cooperation and technology transfer deals and to strengthen ties with Middle Eastern countries in exchange for long-term crude oil supplies and upstream contracts. It signed a technology transfer deal with the UAE in 2013.[13]

Also, Japan is currently looking towards Russia, Southeast Asia, and Africa to geographically diversify its oil imports. As of mid-2011, Japan replaced some of the lost nuclear power generation with low-sulfur, heavy crudes from sources in West Africa (Gabon, Angola, and Nigeria) and Southeast Asia (Vietnam, Indonesia, and Malaysia). However, when some crude oil burn for power began declining in 2013 as power utilities favored natural gas and coal as feedstock, some of these imports dwindled as well. After the U.S. began allowing ultra-light crude oil (condensate) to be exported in 2014, Japan became one of the first countries to import U.S. crude oil cargoes through private company Cosmo Oil's purchase in late 2014.[14]



Pipelines

For a country of its size, Japan has a relatively limited domestic oil pipeline transmission system. Crude oil and petroleum products are delivered to consumers mainly by coastal tankers and tank trucks, and, to a lesser degree, by railroad tankers and pipelines.

Russia's Eastern Siberia-Pacific Ocean pipeline (ESPO), a 2,900-mile pipeline running from Taishet, Siberia, to the Kozmino Bay Oil Terminal on the Pacific Ocean, began sending crude oil to Japan in 2009. Since then, Japan significantly raised crude oil imports from Russia, which now accounts for about 7% of Japan's total crude oil imports.

Refining

According to the Petroleum Association of Japan (PAJ), Japan had 3.9 million bbl/d of crude oil refining capacity at 23 facilities as of October 2014, although some sources such as *OGJ* report a higher capacity of 4.4 million bbl/d.[15] It has the third-largest refining capacity in the Asia-Pacific region, surpassed by China and India. JX Nippon is the largest oil refinery company in Japan and operates five refineries with about 1.1 million bbl/d of capacity. Other key operators include Idemitsu Kosan, Cosmo Oil, and TonenGeneral Sekiyu. In recent years, the refining sector in Japan has encountered excess capacity because domestic petroleum product consumption has declined as a result of the contraction of industrial output and the mandatory blending of ethanol into transportation fuels. In addition to declining domestic demand for oil products, Japanese refiners now must compete with new state-of-the-art refineries in emerging Asian markets. Currently, private refiners in Japan are required to maintain petroleum product stocks equivalent to at least 70 days of consumption, which imposes large additional costs to these companies. This regulation was relaxed to 67 days after the Fukushima incident.

The Japanese government seeks to promote operational efficiency in the refining sector, including increasing refinery competitiveness, which may lead to further refinery closures in the future. As a result, Japan has scaled back refining capacity from around 4.8 million bbl/d a decade ago, according to the International Energy Agency (IEA).[16] In 2010, METI announced an ordinance that would raise refiners' mandatory cracking-to-crude distillation capacity ratio from 10% to 13% or higher by March 2014. To adhere to METI's directive, some refiners reduced capacity by nearly 20% between April 2010 and April 2014 by closing plants entirely or by consolidating facilities. METI initiated a second phase of refining restructuring, which involves improving the overall processing capacity to 50% from a current 45% and includes a broader range of processing units. The government calls for this phase to be implemented by March 2017, and it is likely that another 400,000 bbl/d of capacity will be curtailed through further reductions in refining operations and facility closures.[17] Refiners such as Cosmo Oil and TonenGeneral have announced plans to form a joint venture in 2015 to reduce their combined refinery capacity in the Chiba area and to share infrastructure.[18]

Some industry analysts expect METI will issue a third phase to further consolidate the number of refiners and the total capacity by 2021.[19] These capacity reductions come at a time when the country's oil demand continues to decline as a result of an aging population, energy conservation measures, expectations of nuclear facilities returning to serve the power sector, and financial burdens of companies having to upgrade and maintain Japan's old refining plants.

Natural gas

Japan relies on LNG imports for virtually all of its natural gas supply and ranks as the world's largest LNG importer.

According to the OGJ, Japan had 738 billion cubic feet (Bcf) of proved natural gas reserves as of January 2015. Natural gas proved reserves have declined since 2007, when they measured 1.4 trillion cubic feet (Tcf). Most of Japan's natural gas fields are located along the western coastline.

Sector organization

Similar to Japan's oil sector, Inpex and other companies created from the former Japan National Oil Company are the primary actors in Japan's domestic natural gas sector. Inpex, Mitsubishi, Mitsui, and various other Japanese companies are actively involved in domestic as well as overseas natural gas exploration and production. Osaka Gas, Tokyo Gas, and Toho Gas are Japan's largest retail natural gas companies, with a combined share of more than 70% of the retail market.[20] Japanese retail gas and electric companies are participating

directly in overseas upstream liquefied natural gas (LNG) projects to assure reliability of supply.

Although Japan is a large natural gas consumer, it has a relatively limited domestic natural gas pipeline transmission system for a consumer of its size. This limited pipeline system is partly due to geographical constraints posed by the country's mountainous terrain, but it is also the result of previous regulations that limited investment in the sector. Reforms in 1995 and 1999 helped open the sector to greater competition. A number of new private companies entered the industry since the reforms were enacted. Japanese companies have been constructing short pipelines to further integrate the country's gas infrastructure.

Exploration and production

Japan's natural gas production has been low and flat for more than a decade as a result of declining reserves. In 2013, production was 161 Bcf, down from an average of 182 Bcf over the past 10 years (2003-2012). Japan's largest natural gas field is the Minami-Nagaoka on the western coast of Honshu, which produces about 40% of Japan's domestic gas. Exploration and development are still ongoing at that field, which Inpex discovered in 1979. The gas produced is transported via an 840-mile pipeline network that stretches across the region surrounding the Tokyo metropolitan area.[21] In 2013, Inpex installed an LNG terminal with a 73 Bcf/y capacity at Naoetsu port in Joetsu City, which connects to this domestic pipeline network and supplements the domestic gas supply with imports. Japex has been involved in locating new domestic reserves in the Niigata, Akita, and Hokkaido regions of Japan, targeting areas near existing oil and gas fields.

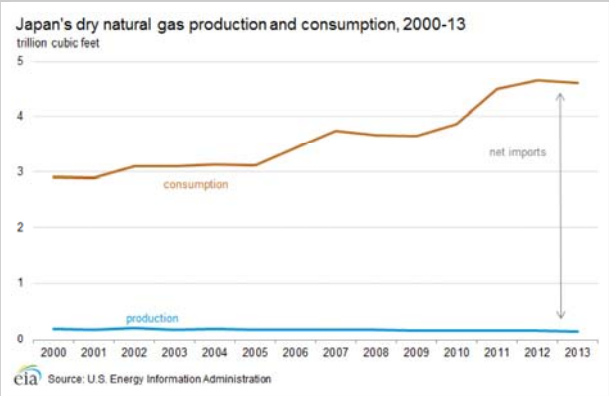
Japanese companies are using innovative methods to produce hydrocarbons and have discovered methane hydrates—natural gas deposits trapped within crystalized ice structures— off the country's east coast. In March 2013, JOGMEC conducted the first successful testing of methane hydrates offshore and confirmed Japan's estimates of 40 Tcf of methane hydrates in the Nankai Trough on the southeast coast of the country.[22] Japan hopes to begin production by 2018, and a joint venture of eleven Japanese companies formed in late 2014 to advance the production and commercialization of methane hydrates.[23] However, the high cost of such developments could push back production plans.

Consumption

In 2013, Japan consumed 4.6 Tcf of natural gas, rising about 58% from the 2000 level. Virtually all of the gas demand is met by LNG imports with the exception of a very small portion of domestic production. As a result of the March 2011 earthquake, Japan's overall LNG imports rose by more than 25% between 2010 and 2013, from 3.3 trillion feet of natural gas per year (Tcf/y) to 4.2 Tcf/y, according to BP Statistical Review. In 2013, LNG import growth slowed for the first time since the Fukushima accident as most of the fuel substitution for the lost nuclear power occurred in 2012. The power sector is the largest consumer of gas, with about 68% of the mix, followed by the industrial sector (17%), residential (8%), commercial (4%), and other sectors (3%) in 2013, according to Federation of Electric Power Companies of Japan (FEPC) and the Japan Gas Association.[24] The share of power generation grew as the sector significantly increased its imports of natural gas following the loss of nuclear power capacity more than three years ago.

Tokyo Electric Power Company (TEPCO) is Japan's largest electric utility and gas importer, holding 24% of the power generation market, according to the FEPC. The company purchased an estimated 1.2 Tcf/y, or 28% of Japan's LNG imports, in 2013. Tepco and Chubu Electric formed a joint venture to purchase LNG and make upstream gas and downstream power plant investments beginning in 2015. The companies are seeking to leverage their combined market power to lower import prices and create more market

efficiencies.[25] Other firms such as Tokyo Gas, the country's largest gas supplier, and Osaka Gas have expressed interest in becoming additional partners.



Liquefied natural gas imports

Japan have accounted for about 37% of global LNG purchases since 2012, as the Fukushima disaster spurred greater demand for LNG in the power sector. Nearly a third of the country's LNG imports are from Southeast Asia, but Japan has a diverse portfolio of supply sources.

Because of its limited natural gas resources, Japan must rely on imports to meet nearly all of its natural gas needs. Japan, the world's largest LNG importer, accounted for 37% of the global market share of LNG demand from 2012 through most of 2014, rising from 31% in 2010, the lowest share in four decades.[26] Japan began importing LNG from Alaska in 1969, making it a pioneer in the global LNG trade. Because of environmental concerns, the Japanese government has encouraged natural gas consumption in the country. The government has chosen LNG as its first fuel-of-choice for power generation to substitute for the lost nuclear generation following Fukushima.

According to IGU, Japan operated 23 major LNG import terminals, including expansions and satellite terminals, with a total gas send-out capacity of 9 Tcf/y in 2014, which is well in excess of demand.[27] However, Japan is still constrained on how much LNG it can receive based on berthing, ship size, and other infrastructure limitations. Japan also has the largest regasification storage capacity in the world, holding 551 MMcf, which serves as a buffer during seasons of higher LNG demand. Most of the LNG terminals are located in the main population centers of Tokyo, Osaka, and Nagoya, near major urban and manufacturing hubs, and are owned by local power companies, either alone or in partnership with gas companies. These same companies own much of Japan's LNG tanker fleet. Three terminals now under construction or undergoing trial operations are anticipated to come online by 2016, adding at least 145 Bcf/y of capacity, and other projects are proposed for construction by 2020.

Several factors have favored the use of LNG over other fossil fuels and other sources to replace nuclear energy after the 2011 earthquake. Current government carbon-abatement policies and the government's pledge to lower greenhouse gas emissions support natural gas as the cleanest fossil fuel to replace lost nuclear capacity. Also, natural gas was less expensive than international oil prices initially. However, natural gas import prices quickly escalated to levels on par with international crude oil prices at the end of 2012. Destruction of coal-fired electric capacity was widespread in the area affected by the earthquake, restricting its use for two years following Fukushima. More coal-fired plants came online in 2013. After the Fukushima incident, Japan replaced lost nuclear capacity with natural gas-fired power from short-term and spot purchases of LNG. Subsequently, Japanese companies signed several medium- and long-term LNG purchase agreements with both existing and new suppliers to hedge against higher rates. In the long run, reliance on the higher levels of LNG

is contingent on how many nuclear facilities are able to return to operation in the next few years.

Asian LNG prices traditionally have been linked to international crude oil prices, which rose sharply between 2008 and 2014. Japan's higher natural gas demand for power, a tighter LNG global supply market over the past few years, and higher oil prices have led to a significant increase in Asian spot LNG import prices, climbing from an average of $10/MMBtu before the Fukushima crisis to around $18/MMBtu in mid-2012.[28] Japan has been negotiating lower prices for long-term LNG contracts that historically have been linked to international crude oil prices. Oil prices in the past few years have remained at all-time high levels for Asian buyers until the last few months of 2014, causing Japanese utilities, particularly those affected by the Fukushima accident, to incur serious costs from higher gas and oil purchases, resulting in net revenue losses. In response to the rising fuel acquisition costs and attendant power price increases, Japanese companies have signed some LNG contracts that are based on U.S. gas market prices, which are lower, rather than being tightly linked to crude oil prices. The recent decline in international oil prices at the end of 2014 will likely provide some relief for Japanese customers purchasing LNG for delivery in 2015.

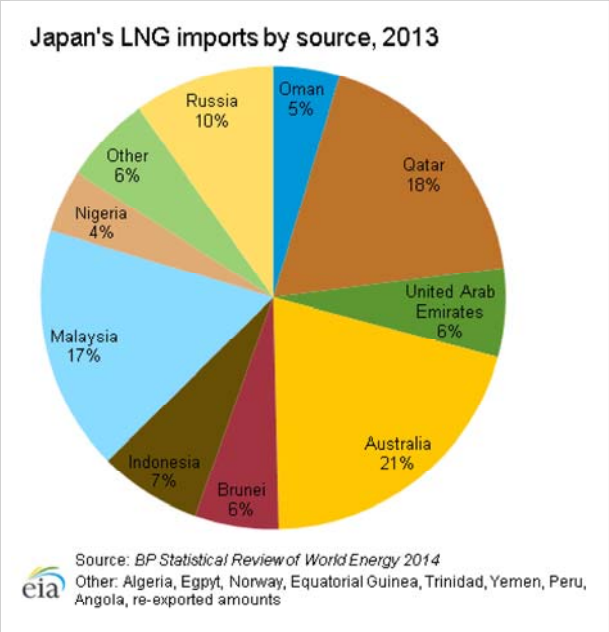
Japanese regulations permit individual utilities and natural gas distribution companies to sign LNG supply contracts with foreign sources and re-sell the cargoes, in addition to directly importing LNG volumes. The largest LNG supply agreements are held by Tokyo Gas, Osaka Gas, Chubu Electric, TEPCO, Kansai Electric, Kyushu Electric, and Tohoku Electric, primarily with countries in Southeast Asia and the Middle East. Many of Japan's existing LNG contracts that date from the 1970s and 1980s have expired in recent years, forcing Japan to renegotiate term contracts or locate other supply sources. Japan's interest in securing natural gas imports over the long term at a reasonable price has been an impetus for its companies to acquire equity stakes in foreign liquefaction projects such as those in Australia and North America.

About 30% of Japan's LNG imports originate from regional suppliers in Southeast Asia, although the country has a fairly balanced portfolio with supplies coming from other regions.[29] After the March 2011 disaster, several suppliers from Qatar, Russia, Malaysia, and Indonesia exported cargoes to Japan through swaps, diverted cargoes, and short-term arrangements to quickly provide natural gas to power facilities. Qatar, the world's largest supplier of LNG, overtook Indonesia and Malaysia to become Japan's second largest supplier, behind Australia, since 2012. Japanese utility companies signed long-term agreements with Qatargas at the end of 2011.

LNG supplies from traditional suppliers Malaysia and Indonesia are becoming more constrained, and Japan is seeking to diversify its contracts and investments in other LNG ventures. Australia surpassed Malaysia to become Japan's largest LNG supplier in 2012, and Japanese companies are investing in small-equity stakes in Australia's liquefaction projects. Japanese electric and gas companies and trading houses have signed supply contracts with various large LNG projects in Australia, most notably the Chevron-led Gorgon project, Wheatstone LNG, and Ichthys LNG, all of which are slated to come online by 2017. Japan began importing LNG from Russia's Sakhalin terminal in 2009, and the two countries are discussing ways to increase gas imports to Japan via a proposed pipeline or more LNG shipments.

Additional LNG supplies over the medium and long term are likely to come from new projects in North America. Japan is in discussions with U.S. exporters for more natural gas supply, although negotiations depend on approval of export licenses by the United States. In May 2013, the U.S. Department of Energy gave approval for its Freeport LNG terminal in the Gulf of Mexico to ship LNG to countries that do not hold free trade agreements (FTAs) with the United States. This decision allows Japanese utilities to formalize deals for LNG supply from the terminal's operator. Japan's Chubu Electric and Osaka Gas signed preliminary agreements to import more than 100 Bcf/y each for 20 years from Freeport LNG starting in

2017, marking a potential reduction in the high LNG prices that Japan currently pays. The companies also plan acquire half of the assets of Freeport LNG's first train.[30] Sumitomo, Japan's third-largest trading house, holds an agreement to buy 110 Bcf/y for 20 years from Cove Point LNG located on the U.S. East Coast and which received approval to export to non-FTA countries in September 2013. Sumitomo intends to sell the cargoes to Japanese utilities Tokyo Gas and Kansai Electric. In May 2013, Mitsubishi and Mitsui, Japan's two largest trading companies, first ventured into the U.S. shale gas export market by purchasing a combined 33% equity share Cameron LNG project located in the Gulf of Mexico. The companies have agreements to purchase 384 Bcf/y, or two-thirds of the terminal's export capacity that is expected to come online by 2017. Altogether, Japanese companies have secured about 1,000 Bcf/y in long-term volumes from the new U.S. terminals coming online by 2020.



Overseas exploration and production

Japanese companies, especially JX Nippon Group, Inpex, and Mitsubishi, have actively sought participation in overseas natural gas exploration and production projects that are typically linked to export facilities. The Japanese trading company, Mitsubishi, a key supplier to Japanese utilities, has owned capacity in liquefaction terminals, mostly in Southeast Asia, Australia, and Oman, for four decades. JX Nippon and Inpex are developing several production and export projects throughout Southeast Asia, Australia, and the UAE, and more recently, in North America. In the past few years, Japanese utilities have also acquired small stakes in the upstream supply and operations of LNG projects in attempts to secure LNG contracts from emerging and growing LNG markets such as Australia, the United States, Canada, and Russia.

The recent opening of North American shale gas production and anticipated gas exports have attracted investment by Japanese companies in North American gas developments linked to planned LNG projects. Also, JOGMEC has been guaranteeing loans to back such projects that could help Japan diversify its gas sources and secure supply at lower prices. Mitsubishi and Mitsui's recent purchase of capacity in Cameron LNG cost $10 billion and will hold 16.6% each of equity shares in the joint venture with Sempra Energy. Mitsubishi and Inpex are also participating in upstream ventures in the oil and shale gas developments in western Canada. Mitsui and Sumitomo are involved in large upstream shale gas ventures in the United States.

JOGMEC announced in 2013 that it will guarantee 75% of the bank loans to Japanese companies involved in developing LNG projects that help reduce Japan's import fuel cost. The projects must demonstrate lower rates compared to Japan's average LNG import costs from the previous year.

Electricity

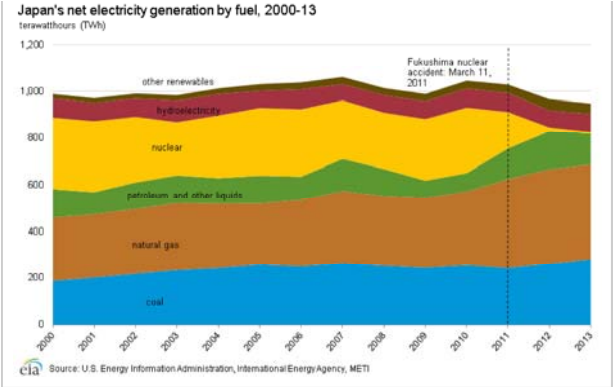
Japan was the world's third-largest producer of nuclear power, after the United States and France, before the Fukushima Daiichi nuclear power plant accident in March 2011. After the Fukushima disaster, the composition of fuel used for power generation shifted to fossil fuels, particularly LNG, which became the primary substitutes for nuclear power.

Japan had 293 gigawatts (GW) of total installed electricity generating capacity in 2012. Fossil fuel-fired plants made up a bulk of this capacity, with 189 GW (64%) of the total capacity. Nuclear capacity was 44 GW in 2012, constituting 15% of the capacity, although installed capacity fell to 42 GW by 2014 after the last two of the six Fukushima-Daiichi reactors were decommissioned, according to Japan Electric Power Information Center, Incorporated (JEPIC) and the International Atomic Energy Agency (IAEA). Hydroelectric facilities held 17% of the capacity and have been a steady source of power supply for Japan for several years. The remaining capacity came from wind, solar, geothermal, and small biomass-fired plants.[31]

Although Japan has the second highest demand for electricity in Asia, it has one of the lowest electricity demand growth rates in the region. Net electricity generation, which has hovered around 1,000 Terawatthour (TWh) for more than a decade, was estimated at around 950 TWh in 2013. Because Japan depends heavily on fuel imports to meet its generation needs, the country seeks to ensure an optimal combination of sources based on cost efficiency, energy security, and environmental stability. Before most nuclear power generation was removed from service after 2011, Japan had one of the most balanced portfolios of fuels used for power generation of the world's major power consumers.[32]

Prior to the Fukushima disaster and the displacement of much of the nuclear-generated power, Japan was not reliant on any particular fuel source for more than one-third of its total generation. However, nuclear generation played a pivotal role in Japan's electricity generation mix and represented 27% of net generation in the two years prior to Fukushima. Natural gas and coal were the primary fossil fuels used in Japan's electricity portfolio and constituted about 30% and 24%, respectively, in 2010. Oil, which was expensive and one of the least clean fuels to burn, played a more minor role and accounted for just 7% of power generation in 2010. Renewable energy made up about 11%, mostly from hydroelectricity. Once Japan removed its nuclear generation capacity from operation starting in 2011, other fuels such as LNG, oil, and coal displaced it. This shift has markedly altered the generation portfolio. METI and IEA report that LNG, oil, and coal shares rose to 43%, 14%, and 30%, respectively, in 2013.[33]

The Japanese government and electric utilities have taken several steps to ensure power supply meets demand following the Fukushima crisis. Some of these measures for power plants using fossil fuels included relaxing regulations on inspections and restarting mothballed oil-fired generation units. Also, the government promoted power restrictions for consumers, particularly in the disaster-affected areas, and encouraged other demand-side measures especially during the peak summer and winter seasons. The government continues to encourage some level of electricity rationing because energy costs have increased as a result of higher fossil fuel purchases.



Sector organization

Japan's electricity industry is dominated by 10 privately-owned, integrated power companies that act as regional monopolies, accounting for about 80% of the country's total installed generating capacity. The remaining electricity is generated by industrial facilities or independent power producers. The largest power company is TEPCO, which accounted for 22% of total power generation in the country in 2012.[34] These companies also control the country's regional transmission and distribution infrastructure. Japan's electricity policies are managed by the Agency for Natural Resources and Environment, part of METI. Japan has two power grids with virtually no interconnections and two different power line frequencies.

Other significant operators in the electricity market are the Japan Atomic Power Company, the first Japanese company to build a nuclear reactor in 1960, and the Electric Power Development Company (J-Power), formerly a state-owned enterprise that was privatized in 2004. The Japan Atomic Power Company operates four nuclear power plants with 2.6 GW total and sells electricity to the local power companies. J-Power operates 16 GW of hydroelectric and fossil fuel-fired power plants. It has also been involved in consulting services for electricity production and environmental protection in 63 countries, mainly in the developing world, since 1960.

Electricity price reform

Deregulation of Japan's electricity sector began in 1995, although the country has been slow to fully deregulate its regional generation, transmission and distribution sectors from the same companies. The government's goal of the current electricity reforms are for end-users to be able to choose their power generation suppliers by 2020. Essentially, the electricity reforms aim for greater competition and lower electricity prices for consumers based on more efficient power sector operations and investments. The first phase involves establishing a national grid that will enhance supply security in 2015. Japan currently has two electricity frequencies (50 hertz and 60 hertz) that are not compatible and that allow only 1.2 GW of electricity to be connected or transferred between the frequencies, posing problems in implementing a completely interconnected system. The second phase includes a full deregulation of the retail sector in 2016, and the third phase involves the divesting of transmission and distribution divisions from generating companies by 2020.

Because of the soaring fossil fuel costs, Japan's electric utilities have sought to increase the electricity tariffs paid by end users to help cover the companies' losses. Between 2010 and 2013, electricity prices rose nearly 20% and 30% for residential and industrial customers, respectively.[35] Since July 2012, METI has approved tariff increases for several utilities such as TEPCO, Kansai Electric, Kyushu Electric, Hokkaido Electric, Shikoku Electric, and Tohoku Electric.

Electricity generation

As of the second half of 2013, all of Japan's nuclear power generation capacity was removed from service. Oil and natural gas replaced all of the lost nuclear generation in 2011 and 2012, and coal supplanted some in 2013. As nuclear capacity resumes operation following government approval of facilities, Japan anticipates reducing the current share of fossil fuel generation.

Fossil fuels

Japan had about 189 GW of installed fossil fuel-fired electric generating capacity in 2012, or about 64% of the total capacity. Net electricity generation of fossil fuels accounted for an estimated 820 TWh in 2013, representing more than 86% of the total generation, up from about 62% in 2010. This was the highest share of fossil-fuel-powered generation in several decades in the wake of the Fukushima disaster when electric utilities turned to hydrocarbons as substitutes for the lost nuclear power generation.

According to Japan Electric Power Information Center, there are currently more than 60 major thermal power plants owned by the top 10 electric utilities and JEPCO. Several combined-cycle LNG-fired or coal-fired plants are under construction or in the planning stages. The country's aging oil-fired power plants are used primarily to meet peak demand. Some facilities have dual-fuel (coal/oil or natural gas/oil) capabilities to provide more flexibility of supply that have been particularly useful during the loss of nuclear generation capacity.

Coal, typically used as a baseload source for power generation, remains an important fuel source. Domestic coal production ended by 2002, and Japan began importing all of its coal, primarily from Australia. Japan imported nearly 211 million short tons of coal in 2013, up from 204 million short tons in 2012, after more coal capacity came online.[36] Japan had been the largest global coal importer for three decades until 2012 when China surpassed Japan by a wide margin according to World Coal Association estimates.[37]

Coal consumption has hovered around 200 million short tons since 2004. Some coal-fired plants experienced significant damage following the 2011 earthquake because they were located near the earthquake epicenter off the coast of Fukushima. Therefore, coal use declined slightly in 2011 while the country heavily relied on natural gas and oil for power generation to quickly replace lost nuclear capacity. Two new coal-fired power plants with a combined capacity of 1.6 GW came online in northern Japan in the first part of 2013. Also, 2 GW of capacity at the Haramachi plant came back online in 2013 after being decommissioned following damage in the 2011 earthquake. These plants boosted coal import levels in 2013 to 211 million short tons.[38]

Japan's government loosened the environmental regulations for the construction of coal-fired capacity and use in the aftermath of the earthquake as emergency measures to ensure electricity supply. At the same time, new, clean coal plant technologies, such as ultra-supercritical units or integrated gasification combined-cycle technology, are being pursued by utilities to meet environmental targets and replace some of the decades-old coal plants. Utilization rates of Japan's coal-fired power plants are greater than 80%, and the country would need to expand capacity before coal use for power can be substantially increased.[39] Although no significant coal-fired capacity is expected online before 2020, some sources report that Japan could add up to 10 GW after 2020. Coal is expected to displace some of the expensive oil-fired power generation, but the extent of build-out will depend on how many nuclear units can return to service.

Natural gas plays a significant role in the power sector and made up 30% of the electric generation in 2010 before the Fukushima disaster, according to METI. Post-Fukushima, natural gas-fired power is utilities'first choice of nuclear substitution as a result of natural gas being a cleaner-burning fossil fuel, and the share of natural gas in the power sector rose to 43% in 2013. Japan is ramping up the number of natural gas-fired power stations under

construction, and utilities installed an estimated 10 GW of new natural gas-fired capacity between 2011 and 2014. Some of this capacity replaces older, less efficient units. The government has plans to construct more gas-fired power generators, and currently, there are three proposed gas-fired power plants with a total of 3.4 GW of capacity scheduled to come online by 2016.[40] The lead time on greenfield plants is generally 7 to 10 years, mainly because of environmental permitting requirements. However, TEPCO and Tohoku Electric Power, utilities that suffered damage to their gas-fired plants in the earthquake zone, were temporarily exempted from these environmental requirements. The expected return to operation of some nuclear reactors in 2015 could put some downward pressure on LNG imports and natural gas use in the power sector.

Before the 2011 earthquake, Japanese utilities began removing oil-fired generation capacity because of the higher operational costs, aging units, and environmental downsides of the fuel. Capacity utilization at oil-fired facilities was around 30% in 2009.[41] Power companies have plenty of room to increase burn of crude oil and fuel oil, and some utilities have brought back mothballed facilities to compensate for lost nuclear power. Direct crude oil burned for power skyrocketed from 70,000 bbl/d in 2010 to 256,000 bbl/d in 2012, a 266% increase, according to Japan's FEPC. Subsequently, direct crude use fell back to 192,000 bbl/d in 2013 as power consumption declined and as expensive oil imports used for power were replaced by LNG and coal. Likewise, power demand for heavy fuel oil grew from 100,000 bbl/d in 2010 to 280,000 bbl/d in 2012, an increase of 180%. Heavy fuel oil used to generate power also fell back to 222,000 bbl/d by 2013.[42] Total oil demand for power continued declining through most of 2014. Lower overall power demand and the new coal facilities installed in 2013 are allowing utilities to reduce their oil consumption and generating costs.

Nuclear

Before the Fukushima accident, Japan ranked as the third-largest nuclear power generator in the world behind the United States and France. However, the country has lost all of its nuclear generation capacity as its facilities have been removed from service over the past three years because of earthquake damage or for regular maintenance. Japan currently has 48 operable nuclear reactors at 16 power plants with a total installed generating capacity of more than 42 GW, down from 54 reactors with about 47 GW of capacity in 2010.[43] More than 10 GW of nuclear capacity at the Fukushima, Onagawa, and Tokai facilities ceased operations immediately following the earthquake and tsunami, and some of the reactors are permanently damaged from emergency seawater pumping efforts and not scheduled to return to service. The government officially decommissioned the 6 reactors at the Fukushima Daiichi nuclear plant, which had a combined capacity of 4.6 GW.[44]

General maintenance standards in Japan require facilities to come offline every 13 months for inspections. Following the Fukushima disaster, the Japanese government required facilities to pass stress tests as well as local government approval. As reactors were removed from operation, they remained offline. By May 2012, Japan had no nuclear generation for the first time in more than 40 years. The government returned two reactors, Kansai Electric's Ohi 3 and Ohi 4, to service in July 2012, leaving Japan with only 2.4 GW of capacity for slightly more than a year. These two reactors were again removed from service in September 2013, leaving Japan with no operational nuclear capacity for a second time. METI and FEPC estimate that Japan produced less than 10 TWh of nuclear-generated electricity in fiscal year 2013 (April 2012–March 2013), down from about 288 TWh in FY 2010.[45]

Japan's 2010 Energy Plan called for at least a dozen new nuclear reactors to be constructed by 2020 and for the share of nuclear-fired electric generation to increase to 50% by 2030 as the country attempts to reduce greenhouse gas emissions. However, the Fukushima catastrophe created greater public concerns and revealed potential dangers of an aggressive nuclear policy. The previous government led by former Prime Minister Noda in 2012 pledged a no-nuclear policy that encountered push-back from the business sector. The current administration headed by Prime Minister Abe supports nuclear power providing at least 15%

of power generation. Prime Minister Abe and industrial interests in Japan favor re-commissioning nuclear power to lower energy costs. However, they are considering safety concerns and resistance from anti-nuclear government factions and the public. Japan's most recent 2014 Strategic Energy Plan expressed the view that nuclear power is an important source of baseload power, but that dependence on nuclear generation will be offset as much as possible by improved efficiency and the acceleration of renewable energy supplies. While supporting the restart of reactors, the Strategic Energy Plan recognizes the need for the "untiring pursuit of safety and establishment of [a] stable environment for nuclear operations."[46]

Japan established the Nuclear Regulatory Authority (NRA) in September 2012 to replace two other nuclear agencies–the Nuclear Safety Commission and METI's Nuclear and Industrial Safety Agency. The NRA was established to provide a more independent assessment of nuclear safety. The NRA adopted more stringent nuclear safety guidelines and procedures in July 2013 and is in charge of their enforcement. All nuclear facilities must submit applications to restart operations to the NRA, and the government estimates taking up to six months to review each application.

These safety guidelines are to ensure facilities can withstand all natural disasters and require reactors to be located away from active earthquake fault lines. The guidelines require installation of larger seawalls, air vents, and safety control rooms. Also, the new standards include decommissioning any reactors older than 40 years, with a possible 20-year extension, to improve safety. Ultimately, this standard will result in a long-term decline in nuclear capacity unless new reactors are constructed.

As of January 2015, restart applications for 20 reactors and an application for the new Ohma plant, representing nearly half of Japan's remaining operable capacity, had been filed with the NRA.[47] Kyushu Electric's Sendai 1 and 2 units in southwestern Japan have received approvals from the NRA and local authorities as of November 2014 and may restart in May 2015.[48] The NRA also approved Kansai Electric's Takahama Units 3 and 4 at the end of 2014, although these facilities are waiting on authorization from the local government. Two nuclear reactors (Ohma Unit 1 and Shimane Unit 3) with a combined capacity of 2.7 GW are under construction, but work was suspended on these plants following Fukushima. Both units were originally scheduled to come online by 2014, although they must be approved under the new standards before they can begin operations. The timeline for restarting many of these reactors is uncertain, because of the need to meet more stringent regulations and overcome political opposition in some provinces.

Japan has a full nuclear fuel cycle, including enrichment and reprocessing of used fuel. Japan has promoted nuclear electricity over the years as a means of diversifying its energy sources and reducing carbon emissions, emphasizing safety and reliability. According to the FEPC, nuclear power has made a great contribution to Japan's energy security by reducing its energy imports and CO_2 emissions. Before nuclear power was disrupted, the intensity of Japan's CO_2 emissions (emission per unit of electricity consumption) decreased by about 18% from 1970 levels. Japan had a goal to reduce carbon intensity by 20% from 1990 levels by 2012. However, the surge in fossil fuel use after Fukushima caused CO_2 emissions intensity to increase by 17% from 1990 levels.[49]

Hydroelectricity and other renewables

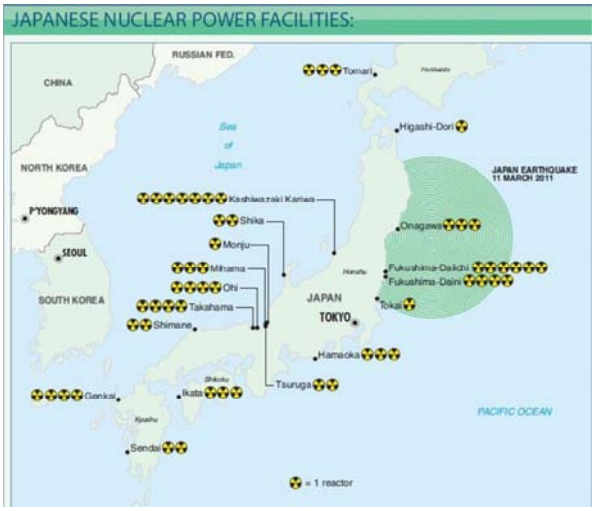
Japan's installed hydroelectric generating capacity was 49 GW in 2012, accounting for about 17% of total electricity capacity. About half of the installed capacity consists of large plants. One of TEPCO's facilities at the Kannagawa plant came online in 2012, and another 3.3 GW is expected to be online by 2022. Like nuclear power, hydropower is a source for baseload generation in Japan because of the low generation costs and a relatively stable supply. Hydroelectric generation was 76 TWh in 2013, making up about 8% of total net generation mix. The Japanese government has been investing in small hydropower projects to serve local communities, although the potential for growth of hydroelectricity in Japan is limited.

As part of the revised energy policy plan, Japan is trying to encourage a greater use of renewable energy, from sources such as solar, wind, geothermal, and biomass for power generation. Renewable energy apart from hydroelectricity made up about 2% of Japan's total energy consumption and less than 4%, or 42 TWh, of the country's total electricity generation in 2013.[50] The Japanese legislature approved generous feed-in tariffs for renewable sources in July 2012, compelling electric utilities to purchase electricity generated by renewable fuel sources, except for nuclear, at fixed prices. The costs are shared by government subsidies and the end users.

The feed-in tariffs spurred the installation of more than 8 GW of renewable energy capacity since July 2012, mostly from solar.[51] Biomass made up the largest portion (estimated 55%) of generation from other renewable sources in 2013, according to BP Statistics and EIA. Wind, solar, and tidal power are being actively pursued in the country and installed capacity from these sources increased in recent years as a result of the feed-in tariffs incentives. However, these sources continue to account for a relatively small share of generation at this time. Most renewable capacity growth since 2012 has occurred in solar energy as a result of heavy investment for large-scale PV units. Although renewable capacity climbed sharply in the past two years, many projects are encountering problems connecting to the grid and selling the electricity to the regional utility firms, slowing the process for actual generation increases.[52]

The potential for geothermal power is significant, and many of the strict regulations have kept geothermal power from growing in Japan. Following Fukushima and the need for cleaner energy alternatives, METI is considering 36 additional geothermal projects in addition to the 537 MW of capacity at 17 facilities that currently exist. Japan aims to increase geothermal capacity by another 50 MW by 2020.[53]

Japan's key nuclear power plants in relation to the Fukushima earthquake



Source: Financial Times via Petroleum Economist.

Notes

- Data presented in the text are the most recent available as of January 30, 2015.
- Data are EIA estimates unless otherwise noted.

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