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Overview

Japan relies heavily on energy imports to meet its demand requirements, especially after nuclear facilities were removed from service following the Fukushima accident. Japan is the world's largest liquefied natural gas importer and ranks in the top five countries for the highest coal imports, crude oil imports, and consumption of crude oil and petroleum products.

Japan has limited domestic energy resources that have met less than 13% of the country's total primary energy use each year since 2012. Before the Fukushima nuclear plant accident in 2011 and the removal of the country's nuclear power, Japan's domestic energy resources met nearly 20% of the country's total primary energy use.[1] Japan's lack of sufficient domestic hydrocarbon resources has led Japanese energy companies to actively participate in upstream oil and natural gas projects around the world by providing engineering, construction, financial, and project management services for energy projects. Japan is a major exporter of energy sector capital equipment and has a strong energy research and development (R&D) program supported by the government that pursues domestic energy efficiency measures to increase the country's energy security and to reduce carbon dioxide emissions.

In March 2011, a 9.0 magnitude earthquake struck off the coast of Sendai, Japan, triggering a tsunami and causing serious damage at the Fukushima Daiichi nuclear 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 approval to return to operation. For nearly two years, from mid-2013 and mid-2015, Japan suspended nuclear power generation for the first time in more than 40 years. At the end of 2015, electric utilities received approval to recommission a few reactors. Public opposition to nuclear power after the Fukushima accident and delays in the approval process have created uncertainty about the timing and degree to which Japan can revive its nuclear sector and about the role nuclear power generation will play in the long-term future of the country.[2]

Nuclear power generation in Japan represented about 27% of the power generation before the 2011 earthquake, and it 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. Using more expensive fossil fuels led to higher electricity prices for consumers, higher government debt, and revenue losses for electric utilities.

Japan imports virtually all of its fossil fuels, and in the three years following the Fukushima accident, Japan's annual average spending on fossil fuel imports increased about $30 billion. Japan's trade deficit continued to deepen through the first half of 2014 because of the Japanese yen's depreciation against the U.S. dollar and because natural gas and oil import costs increased significantly as a result of Japan's greater reliance on fossil fuels and sustained high international oil prices. The trade balance reversed from a 30-year trade surplus, which was $65 billion in 2010, to a deficit that reached a record $116 billion (12.8 trillion yen) in 2014. The decreasing oil and natural gas prices after mid-2014 improved Japan's trade balance, which was in a surplus in 2016 and 2017 and provided some financial relief for Japanese utilities.[3]

Japan's current government intends to resume using nuclear energy as a baseload power source once safety measures have been implemented. The government believes nuclear energy is necessary to reduce current energy supply strains and high energy prices faced by Japan's industries and end users. The government's latest energy plan, issued in July 2018, emphasizes energy security, economic efficiency, emissions reduction, and the safe use of nuclear power, which are similar to the objectives of the previous basic energy plan published in 2014. Key goals to balance the country's fuel portfolio include strengthening the share of renewable and alternative energy sources, diversifying its electricity and transportation energy sources to reduce dependence on imported oil, and developing advanced and efficient generation technologies for fossil fuel use.[4] These efforts align with the government's goal to reverse more than two decades of economic stagnation in Japan and to provide economic revitalization through public infrastructure spending, monetary easing, labor market reform, and business investment.[5]

The Japanese government's policy has emphasized increased energy conservation and efficiency and decreased dependence on fossil fuel 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 because high levels of investment in R&D of energy technology since the 1970s have substantially increased energy efficiency.

Figure 1. Map of Japan

Source: Central Intelligence Agency, *The World Factbook*

Petroleum and other liquids

Japan relies almost solely on imports to meet its oil consumption needs because Japan's oil resources are limited.

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 developing two fields—Chunxiao/Shirakaba and Longjing/Asunaro. Since the agreement was signed, the countries have attempted to develop the natural gas fields separately.

Tensions escalated in 2012 because Chinese ships entered the contested area and because China declared an air defense zone that covered much of the ECS in 2013 (see East China Sea analysis brief). These disputes have continued through 2020 as China has increased the number of vessels in Japanese-claimed waters and Japan has formally complained to China about China's recent unilateral activities.[6]

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 responsible for aiding Japanese companies involved in oil and natural gas exploration and production overseas and in promoting domestic stockpiling. The largest of the new companies formed were Inpex and the Japan Petroleum Exploration Company (Japex).

Private Japanese firms dominate the country's large and competitive downstream sector because foreign companies have historically faced regulatory restrictions. However, during 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 that have been involved in providing products and services to the Japanese market.

Overseas exploration and production

Because of Japan's lack of domestic oil resources, the government's energy policy encourages Japanese companies to increase overseas energy exploration and development projects to secure a stable supply of oil and natural gas. The 2011 earthquake and Fukushima nuclear accident prompted more energy investment by Japanese firms abroad. The Japan Bank for International Cooperation supports upstream companies by offering loans at favorable rates, which allows Japanese companies to bid competitively for projects in key hydrocarbon-producing countries. Such financial support helps Japanese companies purchase stakes in oil and natural gas fields around the world, reinforcing national energy security while also guaranteeing their own financial stability. JOGMEC also supports Japanese companies with financial assistance, acquisition of foreign upstream companies, research, and technology development.[7]

As part of the country's focus on energy security, Japan has established a target ratio of global oil and natural gas equity development by Japanese companies as a part of the total amount the country supplies through imports and domestic production. Although Japan has changed these independent development ratio targets during the past few decades, historically, the country has not met its ratio targets. By 2019, the development ratio for Japanese-produced oil and natural gas abroad reached nearly 35%, which was 5.3% higher than the 2018 ratio, and Japan set a goal to increase the ratio to more than 40% by 2030.[8]

Japanese companies have participated in more than 140 oil and natural gas projects worldwide in various stages of development; as of 2014, about half were in the production phase. Japan also participates in technology exchanges with numerous countries.[9]

Japan's overseas oil projects are located primarily in the Middle East, Southeast Asia, and Australia, although companies have recently invested in shale oil and oil sands projects in North America. The following are some of the Japanese oil companies that are involved in exploration and production projects overseas:

- Inpex
- Cosmo Oil
- Idemitsu Kosan Company
- Japan Energy Development Corporation
- Japex
- Mitsubishi

- Mitsui
- Nippon Oil

Many of these companies have participated in small-scale projects that JNOC originally set up. However, several companies have invested in high-profile overseas upstream projects in recent years.
Japan also maintains government-controlled oil stocks to guard against a supply interruption. As part of its international stockpiling program, Japan has signed agreements with oil-producing countries, including Saudi Arabia and the United Arab Emirates, in recent years that involve Japan lending crude oil storage to these countries. Japan has the right to purchase the oil in the event of a serious supply disruption.

Consumption

Structural factors, such as a declining and aging population, energy efficiency measures, and a high penetration of alternative vehicles in the transportation sector are overriding factors that have been reducing Japan's oil consumption rate during the last two decades. Japan's oil consumption rose by almost 300,000 barrels per day (b/d) between 2011 and 2012, the first significant annual jump in nearly two decades. Demand for low-sulfur fuel oil and the direct use of crude oil rose substantially in 2012 because these fuels replaced some nuclear electric power generation and supported disaster reconstruction after the Fukushima accident. However, oil consumption in the power sector began declining in 2013 because Japan was relying on more natural gas and coal for nuclear power substitutes, few nuclear reactors returned to service, and electricity demand declined overall. A general consumption tax hike implemented in April 2014, the first one in 17 years, also placed downward pressure on oil consumption.[10]

Gasoline and diesel use for transportation have steadily declined during the past decade. Japan is highly dependent on naphtha and liquefied petroleum gas (LPG) imports for its petrochemical sector and some residential use of LPG. However, demand for naphtha has fallen because ethylene production is gradually being displaced by petrochemical production in other Asian countries. Japan has imported more LPG from the United States in the past few years to diversify its supply sources, and consumption will remain strong as the country blends LPG with lean LNG (liquefied natural gas with a lower heating value and higher methane content than rich natural gas) from the United States and Australia. In addition to the shift to natural gas in the industrial sector, fuel substitution is occurring in the residential sector, where kerosene is being replaced by electric home heating.[11]

Refining

ENEOS Holdings (formerly JXTG Group) is the largest refinery owner in Japan, and other key operators include Idemitsu Kosan, Cosmo Oil, and Taiyo Oil. In the past decade, the refining sector in Japan has encountered excess capacity because domestic petroleum product consumption has declined as a result of the overall contraction of industrial output, mandatory blending of ethanol into transportation fuels, more fuel-efficient vehicles, and shifting demographics leading to less driving each year. In addition to declining domestic demand for oil products, Japanese refiners must compete with new, sophisticated refineries in other Asian markets, which affects its export competitiveness. Refinery companies face the financial burdens of upgrading and maintaining Japan's old refining plants.

The Japanese government is promoting operational efficiency in the refining sector, including increasing refinery competitiveness. As a result, Japan has significantly scaled back refining capacity from about 4.6 million b/d in 2009.[12] In 2010, Japan's Ministry of Economy, Trade and Industry (METI) announced an ordinance that would raise refiners' mandatory cracking-to-crude oil 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's goal is to optimize Japan's refining sector and to produce greater amounts of higher quality fuels. METI initiated a second phase of refinery restructuring, which involved improving the overall processing capacity from 45% to 50% and affected a broader range of processing units. Refining companies had to adhere to this phase of the directive by March 2017, and refiners curtailed about 450,000 b/d of nameplate capacity and upgraded some facilities.[13]

Recently, two large mergers of refining corporations occurred in Japan: one between JX Holdings (ENEOS Holdings as of June 2020) and TonenGeneral and the other between Idemitsu Kosan and Showa Shell Group. JX Holdings and TonenGeneral reduced their combined refinery capacity, began to share infrastructure, and gained a majority share of the country's gasoline retail market.[14] The companies completed the merger in April 2017 and renamed themselves the JXTG Group. The Idemitsu founding family had stalled the Idemitsu/Showa Shell merger because they claimed that the two companies had different corporate cultures.[15] However, the companies struck a deal in mid-2018 and completed the merger in April 2019.[16] These mergers have improved Japanese refiners' downstream revenue margins in a highly competitive environment.[17]

Natural gas

Japan relies on liquefied natural gas (LNG) imports for nearly all of its natural gas supply because domestic production meets only a small fraction of the country's consumption.

Natural gas sector organization

Inpex and other companies created from JNOC in 2004 are the primary participants in Japan's domestic natural gas sector. Inpex, Mitsubishi, Mitsui, and other Japanese companies are actively involved in domestic and overseas natural gas exploration and production.

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 limitation is partly a result of geographical constraints caused by the country's mountainous terrain and partly the result of previous regulations that restrained investment in the natural gas pipeline network.

Osaka Gas, Tokyo Gas, and Toho Gas are Japan's largest retail natural gas companies and own more than half of the country's city gas pipeline network.[18] Japanese retail natural gas and electric companies participate directly in overseas upstream liquefied natural gas (LNG) projects to assure reliability of supply. Japan imports LNG through a number of regasification terminals that are owned by both natural gas and electric utilities.

Japanese utilities have been forming partnerships and alliances to negotiate LNG contract terms and prices as a result of new, more flexible contracts. In addition, in the face of natural gas and electricity sector deregulations, domestic natural gas and electric companies are attempting to increase market shares and remain competitive in downstream energy sales by optimizing their competitive advantage and entering other markets. In 2015, Tokyo Electric Power Company (TEPCO) and Chubu Electric formed a joint venture (JERA Company) to purchase LNG and to make upstream natural gas and downstream power plant investments. JERA became the world's largest LNG importing company in 2016.[19] TEPCO and Chubu Electric are looking to leverage their combined market power to lower import prices, improve contract flexibility, share technology, and create more market efficiencies. Other firms such as Tokyo Gas (the country's largest natural gas supplier) and Kansai Electric as well as Tokyo Gas and Kyushu Electric have formed partnerships to cooperate on LNG procurement and technological expertise.[20] Since 2016, Japanese natural gas utilities, such as JERA, Tokyo Gas, and Osaka Gas, have pursued partnerships with European companies for LNG procurement, allowing the Japanese companies access to European natural gas markets for excess imports.[21]

Natural gas sector reform

Reforms that began in 1995 helped to open the natural gas sector to greater competition for larger customers. Several new private companies entered the natural gas industry after the reforms were enacted. After three more rounds of reforms, the government fully deregulated the natural gas retail sector for smaller commercial and residential customers in April 2017. This reform allowed all customers to choose their natural gas suppliers. The final phase of natural gas market reform includes the unbundling of pipeline operations (separation of each company's transmission sector from the generation and distribution sectors) and lifting the tariff regulations on the top three natural gas utilities by 2022. The reforms are intended to allow more access for third-party suppliers to pipelines and LNG terminals. However, logistical hurdles still exist, including an insufficient pipeline network, a lack of a natural gas wholesale market (which creates a challenge for new retailers), and a lack of competitors.

Domestic exploration and production

Most of Japan's natural gas fields are located along the western coastline. The Minami-Nagaoka natural gas field, operated by Inpex, on the western coast of Japan's main island, is one of the country's largest natural gas fields. The natural gas produced from this field is transported through a 930-mile pipeline network that goes to the Tokyo metropolitan area.[22] Japex, Japan's other major upstream oil and natural gas company, has explored for new domestic reserves in the Niigata, Akita, and Hokkaido regions of Japan, targeting areas near existing oil and natural gas fields.[23]

Japanese companies are using innovative methods to produce hydrocarbons and have discovered methane hydrates (natural gas deposits trapped within crystalized ice structures). In 2013 and 2017, Japanese upstream companies conducted two successful production tests of offshore methane hydrates in the Nankai Trough on the southeast coast. Several Japanese companies formed a joint venture in late 2014 to advance production and commercialization of methane hydrates. The companies planned to begin commercial production after 2023.[24] However, the high cost of these developments could delay production plans.

Overseas exploration and development

Japanese companies, especially JX Nippon Group, Inpex, and Mitsubishi, have actively pursued overseas natural gas exploration and production projects that are typically linked to export facilities. The Japanese trading company Mitsubishi, a key natural gas 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, the United Arab Emirates, and North America. In the past few years, Japanese utilities have also acquired small stakes in the upstream supply and operations of LNG projects to secure contracts in emerging and growing LNG markets such as Australia, the United States, Canada, and Russia.[25]

The advent of North American shale gas production and anticipated natural gas exports attracted investment by Japanese companies in North American natural gas developments linked to planned LNG projects. 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 in the Cameron LNG project in the Gulf of Mexico. The companies have agreements to purchase two-thirds of the terminal's export capacity, which came online in 2019.[26] Mitsubishi and Inpex are also participating in upstream ventures in oil and shale gas developments in western Canada.[27] Sumitomo, another large Japanese trading company, and Mitsui are involved in large upstream shale gas ventures in the United States.[28]

Consumption

The Japanese government has encouraged natural gas consumption during the past several decades because natural gas is lower in carbon emissions than other fossil fuels. Japan's natural gas demand rose dramatically between 2009 and 2012 as a result of the economic recovery following the 2008 global financial crisis and the March 2011 earthquake and ensuing nuclear outages. After 2012, economic and electricity demand weakened, coal prices dropped, and renewable energy production rose, which caused natural gas demand to plateau for a few years before falling in 2015. In addition, in 2015, nuclear facilities gradually returned to operation, halting natural gas demand growth in the power sector.

Liquefied natural gas

Most of the LNG terminals, which are located in the main population centers and manufacturing hubs of Tokyo, Osaka, and Nagoya, are owned primarily by local power utilities and city natural gas companies. Japan lacks extensive natural gas pipeline infrastructure, and it relies on LNG imports in many coastal demand centers and uses LPG in other areas.[29]

Japan's global LNG purchases reached record-high import levels in 2014 when the Fukushima disaster spurred higher demand for LNG in the power sector. The government chose LNG as its primary fuel of choice for power generation to substitute for the lost nuclear generation immediately following the Fukushima nuclear accident. Government carbon abatement policies and the government's pledge to lower greenhouse gas emissions in 2030 by 26% from 2013 levels support natural gas as the cleanest fossil fuel to replace lost nuclear capacity.[30] However, the higher cost of LNG, particularly in Asia compared with other regions, makes coal the more cost-competitive fuel. In 2013 and 2014, high LNG prices in Asia, which are linked to international crude oil prices, caused Japan's electric utilities to replace some of the lost nuclear generation with coal-fired power. However, according to Japan's latest energy plan, published in 2018, LNG is likely to remain a significant fuel source for the power sector through 2030.[31]

Immediately after the Fukushima accident, Japan procured LNG with short-term and spot purchases. Subsequently, Japanese companies signed several medium- and long-term LNG purchase agreements with existing and new suppliers to hedge against higher prices. Japanese LNG buyers began negotiating for lower prices and greater flexibility in LNG contracts. All of Japan's previous long-term LNG contracts were tightly linked to crude oil prices. Oil prices remained at high levels through mid-2014, causing Japanese utilities, particularly those affected by the Fukushima accident, to incur serious costs from higher natural gas and oil purchases. In response to the higher fuel acquisition costs and attendant power price increases, Japanese companies sought out LNG contracts that were based on lower U.S.-based natural gas market prices and that provided greater flexibility with the resale of LNG cargoes. In 2017, the Japanese government's anti-trust regulator issued a report claiming that destination restrictions in LNG contracts potentially violated Japan's competition laws and that new contracts or renegotiated contracts could not restrict Japanese companies from reselling LNG. During the past few years, Japanese utilities have signed agreements that provide greater flexibility with the destination of cargoes, timelines, quantities, and price structure.[32]

Japanese utilities signed several long-term contracts a few years ago for LNG supply from new terminals in the United States and Australia, which have flexible destination clauses.[33] Japanese electric and natural gas companies and trading houses signed long-term supply contracts with various large LNG projects in Australia, most notably the Chevron-led Gorgon project, Wheatstone LNG, Ichthys LNG, and Prelude LNG. All of these projects were operational by 2019. Australia is expected to remain a key source of LNG supply to Japan during the next decade.

Japan still faces long-term uncertainties regarding the pace of nuclear reactors returning to operations, market changes resulting from natural gas deregulation, and the declining rate of energy demand as Japan's population declines.

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 heavily to fossil fuels, particularly LNG, which became the primary substitute for nuclear power.

Although Japan has one of the highest demand levels for electricity in Asia, it has one of the lowest electricity demand growth rates in the region. Net electricity generation has remained, on average, slightly higher than 1,000 terawatthours (TWh) per year for two decades. Because Japan depends heavily on fuel imports to meet its generation needs, the country is working toward the 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 among the world's major power consumers.[34]

Before the Fukushima disaster occurred and much of the nuclear-generated power was displaced, Japan did not rely on any 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 accounted for 26% of net generation in the two years before Fukushima. In 2010, natural gas and coal were the primary fossil fuels used in Japan's electricity portfolio, and they accounted for about 27% and 26%, respectively. Oil, which was expensive and produced high levels of carbon dioxide emissions, accounted for just 8% of power generation in 2010. Renewable energy, mostly from hydroelectricity, accounted for the remaining 12%.[35]

Once Japan began to remove its nuclear generation capacity from operation in 2011, other fuels such as LNG, oil, and coal displaced it. Financial incentives for clean energy projects prompted renewable energy growth. This shift has markedly altered the power generation portfolio. Despite the uncertainty about the role nuclear fuel will play in Japan's future energy landscape, the government intends to include it in the fuel mix to balance economic costs, environmental concerns, and safety measures.[36] Current targets for fuel use in the electricity mix, based on Japan's 2018 *Fifth Basic Energy Plan*, have LNG at 27%, coal at 26%, renewable energy at 22%–24%, nuclear at 20%–22%, and oil at 3% by 2030.[37]

Electricity sector organization

Japan's electricity industry has been controlled by 10 privately owned, integrated power companies that were regional monopolies, accounting for about two-thirds of the country's total power generation and more than 80% of power consumption in 2016. Other electric utilities, industrial facilities, or independent power producers generated the remaining electricity. TEPCO, Japan's largest power company, accounted for 20% of total power generation and 25% of power consumption in the country in 2016.[38] The large companies also controlled the country's regional transmission and distribution infrastructure. However, the electricity landscape began to change after Japan's electricity sector fully deregulated in 2020 and electric utilities were forced to compete with other new market entrants and separate their transmission sector into distinct companies. Japan's electricity policies are managed by the Agency for Natural Resources and Environment, which is 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 include 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 a combined capacity of 2.6 gigawatts (GW), and sells electricity to the local power companies. J-Power operates several hydroelectric and fossil fuel-fired power plants. J-Power has also been involved in consulting services for electricity production and environmental protection in 63 countries, mainly in the developing world, since 1960.

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 adopted more stringent nuclear safety guidelines and procedures in July 2013 after the Fukushima accident. All nuclear facilities must submit applications to restart operations to the NRA, which is in charge of enforcing the new safety guidelines.

The safety guidelines ensure facilities can withstand all natural disasters, require reactors to be located far from active earthquake fault lines, and compel reactors to install larger seawalls, air vents, and safety control rooms. In addition, the new standards require the decommissioning of any reactor older than 40 years. A 20-year extension is possible, but the NRA must approve it in a separate application. Ultimately, the new standards will result in a long-term decline in Japan's nuclear capacity unless new reactors are constructed.

Electricity sector reform

Deregulation of Japan's electricity sector began in 1995 when industrial and commercial customers were given a choice of electric suppliers, although the country has been slow to fully separate its generation, transmission, and distribution sectors from the regional companies. Following the Fukushima incident, Japan encountered power supply shortages because the regional monopolies could not transmit electricity outside of their regions, and power costs rose following the loss of nuclear generation.

Recent electricity reforms aim to achieve greater competition and lower electricity prices for consumers based on more efficient power sector operations and investments. The government designed its current electricity reforms to allow end users to choose their power generation suppliers and to unbundle the regional monopolies that are vertically integrated. The first phase, implemented in 2015, involved establishing the Organization for Cross-Regional Coordination of Transmission Operators (OCCTO) to manage electricity flows across Japan's regions and to enhance supply security by strengthening overall transmission capacity on the national grid during normal and emergency circumstances. Japan's two electricity frequencies (50 hertz and 60 hertz) are not compatible, so only 1.2 GW of electricity can be connected or transferred between the frequencies. This incompatibility of electricity frequencies complicates moving to a fully interconnected system.

The second phase, which began in April 2016, included a full deregulation of electricity to the retail sector and opened the residential sector to competition. As of July 2020, nearly 30% of households in Japan had chosen different utilities, and that percentage has been rising rapidly since 2016.[39] The third phase involved divesting of transmission and distribution divisions from generating companies and replacing a fuel cost-recovery scheme with a market-based pricing system by April 2020.[40]

Generation

All of Japan's nuclear power generation capacity was removed from service between September 2013 and August 2015 as a result of new, stringent safety inspections and several levels of regulatory approval required to restart facilities. Oil and natural gas-fired generation replaced all of the lost nuclear generation immediately after the Fukushima accident, and coal-fired production began to replace oil-fired power generation after 2013. As nuclear capacity gradually resumes operation following government approvals, Japan anticipates reducing the current share of fossil fuel generation.

Fossil fuels

The share of fossil fuel-fired generation rose substantially for the first time in several decades in the wake of the Fukushima disaster, when electric utilities turned to hydrocarbons as substitutes for the lost nuclear power generation. However, after 2013, growth in renewable energy and the return of small amounts of nuclear power have eroded the share of fossil fuels from a high of 85%.

According to the Japan Electric Power Information Center, the major electric utilities and J-Power owned about 40 major thermal power plants in 2016. Several combined-cycle LNG-fired or coal-fired plants are under construction or are in the planning stages.[41] 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 in fuel sources that have been useful during the loss of nuclear generation capacity.

Some coal-fired power plants near the earthquake epicenter off the coast of Fukushima experienced significant damage following the 2011 earthquake. As a result, coal-fired generation declined slightly in 2011 when the country relied heavily on natural gas and oil for power generation to replace lost nuclear capacity. Once new coal-fired capacity was commissioned in 2013 and international coal prices fell, electric utilities increased coal purchases for power generation.

Japan has the highest efficiency rate of coal-fired technology in the world. The country is installing new, clean coal plant technologies, such as ultra-supercritical units or integrated gasification combined-cycle technology, to meet environmental targets and to replace some of the decades-old coal power plants. Japan intends for coal to remain a baseload power source, and the new energy plan reduces the coal share slightly to 26% of the electricity portfolio by 2030.[42] Several highly efficient coal-fired capacity additions are under construction, and almost three dozen other projects with 17 GW of capacity are in the planning phase. However, starting in 2017, developers and investors converted to biomass or canceled five projects as a result of lower-than-expected electricity consumption, the rapid expansion of renewable energy production, and a commitment by the industry to reduce environmental emissions following Japan’s adoption of the Paris Agreement at the end of 2015.[43]

The pace of development depends on how many nuclear units return to service and whether or not the government will grant environmental approvals to each coal-fired power plant in light of Japan’s commitment to reduce its greenhouse gas emission levels by 2030.[44]

Immediately following Fukushima, natural gas was the first choice of nuclear fuel substitution for utilities because of the cleaner-burning nature of natural gas compared with other fossil fuels. Japan has been replacing many of its older, less efficient natural gas-fired power plants with more efficient combined-cycle units during the past few years. However, the return to operation of some nuclear reactors, the growing role of renewable energy in the country’s energy portfolio, and lower-than-expected electricity consumption growth are likely to reduce LNG imports and natural gas use in the power sector.[45] By 2030, Japan expects LNG to slightly decrease its share to 27% of the country’s power generation, which will still be a significant source of electricity load.[46]

Before the 2011 earthquake, Japanese utilities began removing oil-fired generation capacity because of the higher operational costs, aging units, and environmental downsides. Some utilities brought back mothballed oil-fired generation facilities to compensate for lost nuclear power. Total oil demand for power, primarily from residual fuel oil and direct crude oil burn, climbed sharply from an estimated 175,000 barrels per day (b/d) in 2010 to 590,000 b/d in 2012, when oil produced 17% of power generation. Overall Japanese power consumption declined, and the other less-expensive fuels began to fill the gap. Oil use in the power sector fell to 270,000 b/d by 2015.[47] Any nuclear power generation that returns to service will continue to replace oil supply for electricity in Japan, and some oil-fired facilities have been mothballed. In its long-term energy plan, the government determined that oil could supply the electric grid for peak demand periods but would decline to 3% of electricity generation by 2030.[48]

Nuclear

Before the Fukushima accident, Japan was the third-largest nuclear power generator in the world behind the United States and France. After the accident, the country had lost all of its operating nuclear generation capacity by 2013, as its remaining reactors were removed from service for regular maintenance or to meet safety requirements set by the regulatory body, the Nuclear Regulatory Authority (NRA). Although the Japanese government favors restarting nuclear power plants to increase energy security and lower energy costs, progress has been slow because of local opposition and legal challenges. Japan's most recent energy plan, in 2018, stated 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 power plant efficiency and by the acceleration of renewable energy supplies.[49]

More than 10 GW of nuclear capacity at the Fukushima, Onagawa, and Tokai facilities stopped operations immediately following the earthquake and tsunami in 2011. Other reactors were permanently damaged from emergency seawater-pumping efforts and are not scheduled to return to service. The government officially decommissioned all six reactors at the Fukushima Daiichi nuclear plant, which had a combined capacity of 4.6 GW.

Two nuclear reactors (Ohma Unit 1 and Shimane Unit 3), which have a combined capacity of 2.7 GW, were under construction and nearly complete, but work was suspended on these plants following Fukushima. The owners of these reactors applied to NRA for safety examinations. Both units have to be approved according to the new standards before the plant owners can complete construction. The reactors that were in the planning phase before Fukushima are currently canceled or delayed indefinitely while the country focuses on bringing back some of the operational reactors. The timeline for restarting many of these reactors is uncertain because of the more stringent regulations and the need to overcome political opposition and restore public confidence of nuclear power in several provinces.[50]

Japan has a full nuclear fuel cycle, including enrichment and reprocessing of used plutonium and uranium fuel. This process provides Japan with higher energy security and resource conservation, and it reduces Japan's reliance on imported fossil fuels. Historically, Japan has promoted nuclear electricity as a means of diversifying its energy sources and reducing carbon emissions and has emphasized safety and reliability. Overall, carbon emissions have risen substantially since Japan's operating nuclear capacity was significantly reduced. Japan's commitment to lower greenhouse gas emissions by 2030 is also driving the country to optimize its fuel slate and to promote nuclear use for power generation.[51]

Hydroelectricity and other renewables

Japan's government has invested in small hydropower projects to serve local communities, and the capacity of pumped storage facilities is growing. However, the potential for hydroelectricity growth in Japan is limited.[52]

As part of the revised energy policy plan, Japan is trying to encourage more renewable energy for power generation from sources such as solar, wind, geothermal, and biomass. The Japanese legislature approved generous feed-in tariffs (FIT) for renewable sources in July 2012, obligating electric utilities to purchase electricity generated by renewable fuel sources, including small hydroelectricity projects, at fixed prices for up to 20 years. The costs are shared by the government through subsidies and end users.

Most of the renewable capacity growth since 2012 has occurred in solar energy as a result of heavy investment in large-scale solar photovoltaic units. Although solar capacity climbed sharply in the past several years, many projects have encountered problems connecting to the grid and challenges selling the electricity to the regional utility firms, slowing the process for actual generation increases.[53] Japan's government revised the FIT subsidy levels down each year and modified the FIT policy for project tendering in 2017 to reduce the backlog of large-scale solar projects. The new FIT policy also requires each project to procure an agreement for grid connection.[54]

Japan has one of the largest biomass markets for power generation in the world, and the government is providing financial incentives to promote more biomass projects.[55] The potential for geothermal power in Japan is significant, but strict regulations have kept geothermal power from growing.[56]

Notes

- In response to stakeholder feedback, the U.S. Energy Information Administration (EIA) has revised the format of the Country Analysis Briefs. As of December 2018, updated briefs are available in two complementary formats: the Country Analysis Executive Summary provides an overview of recent developments in a country's energy sector, and the Background Reference provides historical context. Archived versions will remain available in the original format.
- Data presented in the text are the most recent available as of October 2020.
- Data are EIA estimates unless otherwise noted.

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