CHAPTER 8

Japan Country Report

Seiya Endo

March 2021

This chapter should be cited as:
Endo, S. (2021), 'Japan Country Report', in Han, P. and S. Kimura (eds.), *Energy Outlook and Energy Saving Potential in East Asia 2020*, Jakarta: ERIA, pp.122-133.

CHAPTER 8

Japan Country Report

Seiya Endo

1. Background

Japan is a small island nation in East Asia consisting of several thousand islands and spanning a land area of approximately 377,960 square kilometres, most of which is mountainous and thickly forested. Japan's gross domestic product (GDP) in 2017 was $6,158 billion (constant 2010 prices), and the population was about 127 million. In 2017, Japan was the third largest economy in the world.

1.1 Energy Situation

As of 2017, Japan's primary energy supply was 432.0 million tonnes of oil equivalent (Mtoe). Oil accounts for 40.7% of the energy mix, followed by coal at 27.0%, with demand for coking coal driven by steel production and demand for steam coal driven by power generation, pulp and paper, and cement production. Natural gas comes third at 23.4%, and is mainly used for electricity generation, reticulated city gas, and industrial fuels. Of the remaining 9.0%, nuclear energy accounts for 2.0%, while renewable energy (such as hydropower, geothermal, wind, and solar) represents 7.0%. In 2017, net imports of energy accounted for about 93% of the net primary energy supply. With scarce indigenous fossil fuel sources, Japan imported almost 100% of its oil and coal supply, and 97% of its natural gas.

Japan's final energy consumption increased slightly from 287.3 Mtoe in 1990 to 292.8 Mtoe in 2017 (roughly 0.1% per year). During this period the residential and commercial sector ('others') saw the highest growth at 1.0% per year, while the transport sector saw growth of only 0.1% per year. Industry consumption decreased at a rate of 0.8% per year on average from 1990 to 2017. Oil was the dominant fuel, accounting for 61.5% of final energy consumption in 1990; this

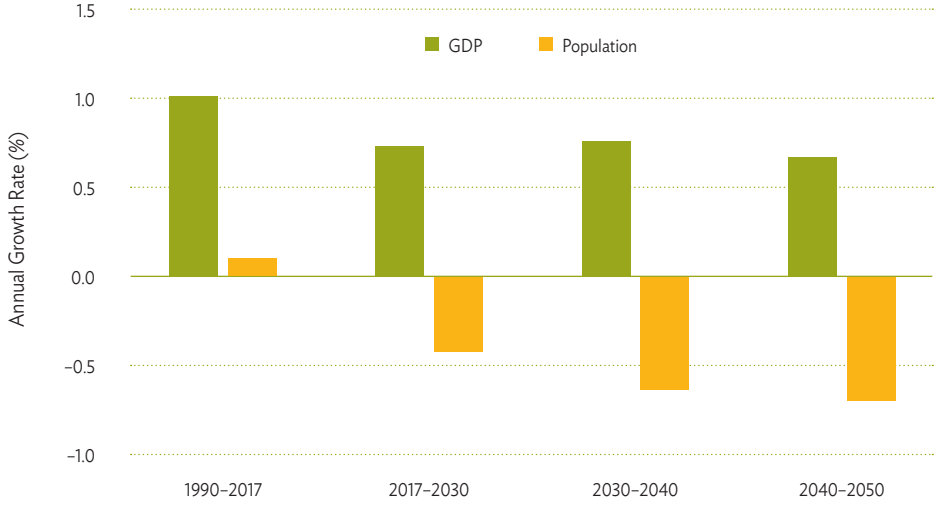
decreased to 51.6% in 2017. Electricity came second, accounting for 28.3% of final energy consumption in 2017.

In the same year, 292 gigawatts of power generation capacity was installed in Japan generating 1,061 terawatt-hours of electricity. Thermal power (coal, natural gas, and oil) accounted for 77.3%; nuclear, 3.1%; hydropower, 7.8%; and geothermal, solar, and wind the remaining 11.8%. Before the Great East Japan earthquake and severe Fukushima Daiichi nuclear power plant accident in 2011, nuclear accounted for about 30% of power generation in Japan. Nuclear reactors in Japan were stopped from operating after the accident, but some have restarted with government approval.

2. Modelling Assumptions

During this report's outlook period (2017–2050), Japan's slow and steady economic growth is expected to continue in the long run. GDP is expected to grow at an average annual rate of 0.7%, with the service industry as a key driver of overall new growth. On the other hand, population growth is expected to decline by about 0.6% per year from 2017 to 2050 as a result of the country's decreasing birth rate, and Japan's population is projected to decrease from 127 million in 2017 to 105 million by 2050. Figure 8.1 shows the assumptions for GDP and population growth used in this study. GDP per capita is projected to reach $74 by 2050, 1.5 times the figure in 2017.

Figure 8.1. Annual Growth Rate of Gross Domestic Product and Population

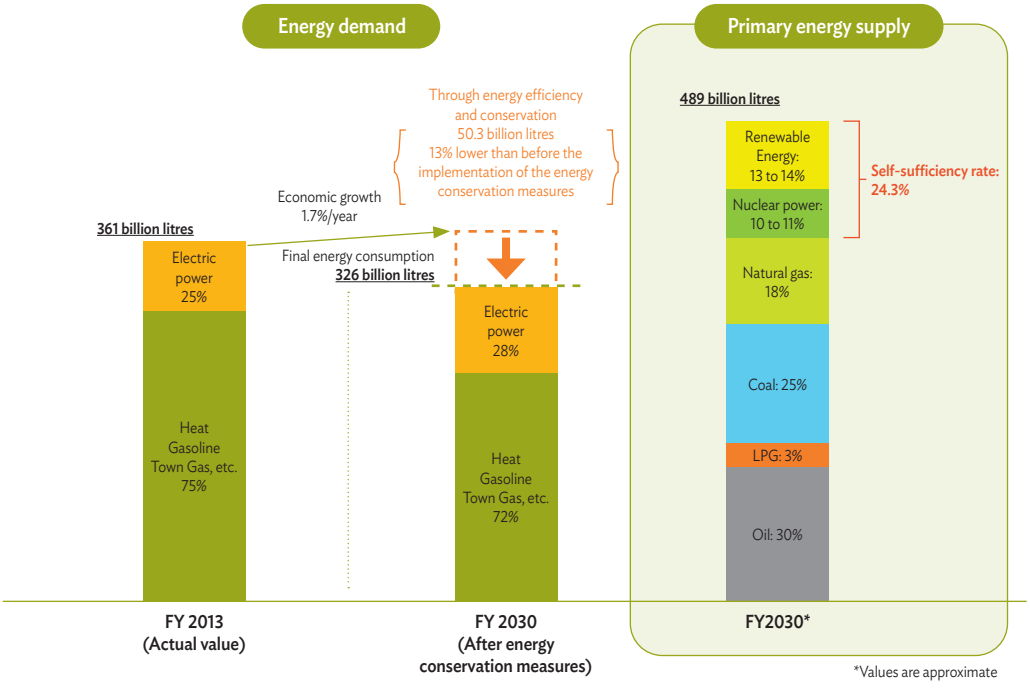


GDP = gross domestic product.
Source: Author's analysis based on United Nations and International Monetary Fund projections.

Japan's infrastructure and manufacturing facilities have already matured to some extent; and production of crude steel, cement, and ethylene will gradually decline over the outlook period. The number of automobiles will also decline as the population shrinks.

According to the Long-Term Energy Supply and Demand Outlook approved by the Ministry of Economy, Trade and Industry in July 2015, final energy consumption in 2030 will decrease to 326 billion litres of oil equivalent (a 9.7% decrease from 2013), while economic growth is expected to continue at a rate of 1.7% per year. The government aims to conserve 50.3 billion litres of oil equivalent from the baseline (Figure 8.2).

Figure 8.2. Energy Balance Target in 2030



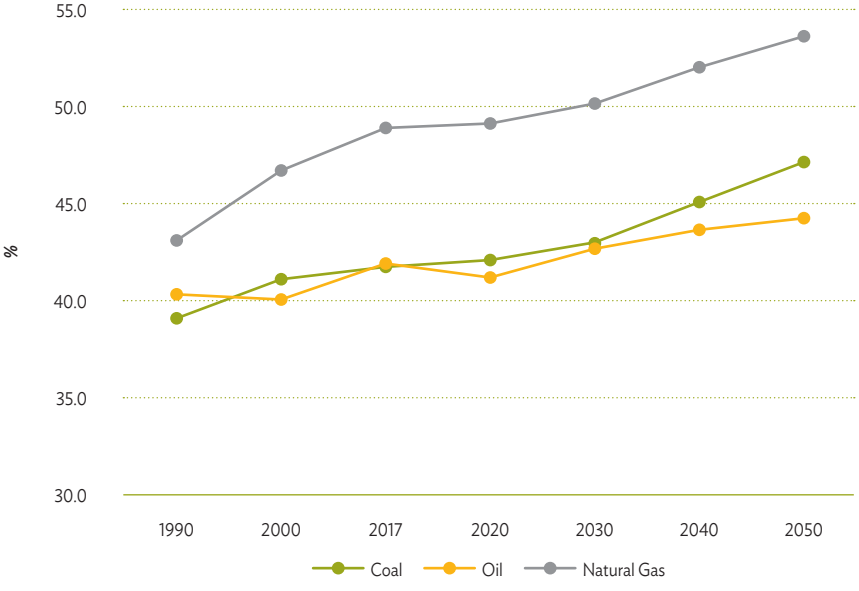
Note: The fiscal year (FY) of the Government of Japan ends on 31 March. 'FY' before a calendar year denotes the year in which the fiscal year ends, e.g., FY2020 ends on 31 March 2020.

Source: Ministry of Economy, Trade and Industry, Japan (2015), Long-Term Energy Supply and Demand Outlook. Tokyo.

The outlook also forecasts the power generation mix in 2030, projecting that the share of nuclear power will decrease from about 30% in 2010 (before the Great East Japan Earthquake) to 20%–22% by 2030; renewable energy will increase from 11% before the earthquake to 22%–24% by 2030; and baseload power from non-variable sources (e.g. hydropower, coal-fired thermal power, and nuclear power) will be 56%.

Japan's energy savings goal will be attained through the implementation of national energy efficiency programmes in all demand sectors. For the industry sector, energy savings are expected from improvements in manufacturing technologies. In the residential and commercial sectors, the Top Runner Programme[1] is projected to induce huge savings, in addition to programmes involving energy management systems and improvements in adiabatic efficiency, lighting systems, and heat pump systems. In the transport sector, vehicle fuel efficiency will be improved, including increases in the stock of hybrid vehicles and structural changes in vehicles. In the power generation sector, related lows set efficiency targets for thermal power plants. According to this benchmark target, the efficiency of new capacity should match the highest efficiency levels of current plants. Thermal plants will continue to improve their efficiency, and coal and natural gas in particular are expected to achieve significant progress because of advances in technology and regulatory frameworks. Figure 8.3 shows the assumed thermal efficiencies of thermal power plants under business as usual (BAU).

Figure 8.3. Thermal Efficiency, Business as Usual
(%)



Source: Author's analysis.

[1] This is Japan's energy efficiency programme, which aims to improve the energy efficiency of household and office appliances as well as vehicles. It sets the end-use energy performance of the best technology available in the market as the standard for each product category.

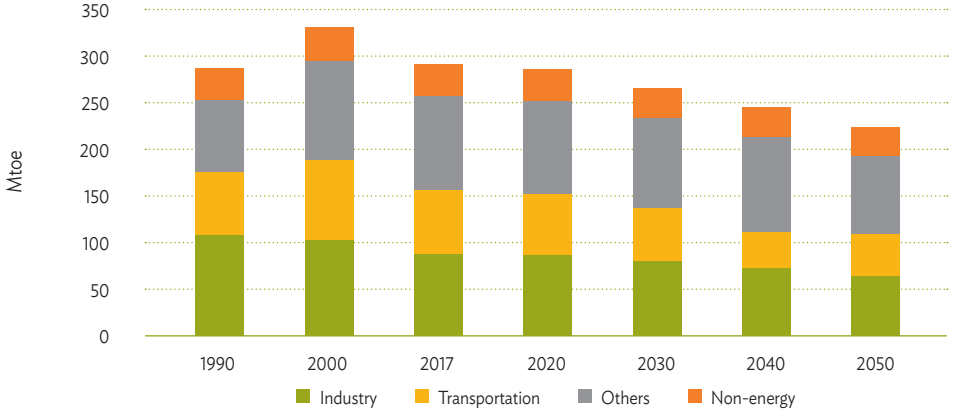
3. Simulation Results

3.1 Business as Usual Scenario

3.1.1 Final Energy Consumption

Figure 8.4 shows the projected final energy consumption by sector from 1990 to 2050 under BAU. Between 2017 and 2050, Japan's final energy consumption is projected to decrease by 0.8% per year, on average. Expectations of steady economic growth and population decline are both key contributing factors to this general trajectory. However, improved energy efficiency in the transport sector is also an important factor. During the outlook period, transport sector demand is expected to decrease by 1.4% per year because of fuel economy improvements for conventional internal combustion engine vehicles, and greater penetration of hybrid vehicles.

Figure 8.4. Final Energy Consumption by Sector, Business as Usual

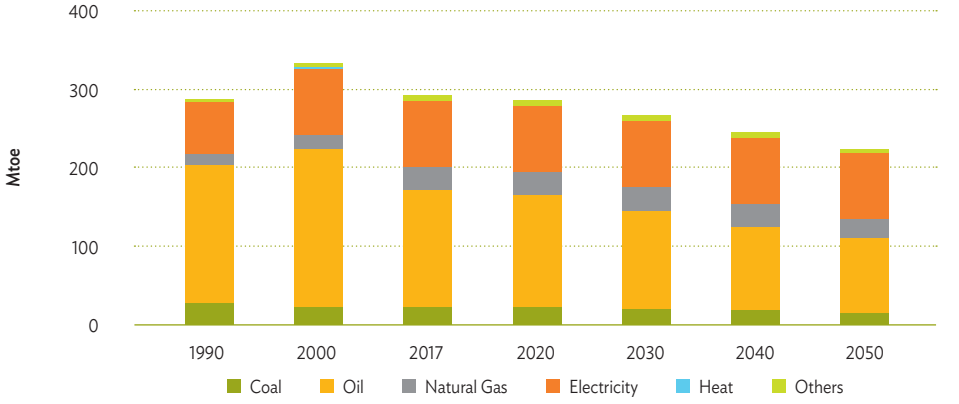


Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

Energy conservation and electrification will be promoted in the outlook period. By fuel type, fossil fuel consumption is projected to decrease at an average annual rate of 1.4% for coal, 1.4% for oil, and 0.4% for natural gas from 2017 to 2050. On the other hand, the share of oil is expected to reach 42.5% by 2050, making this the largest source of final energy consumption. Power demand is projected to remain steady over this period, while its share will increase from 28.3% in 2017 to 37.4% in 2050. Figure 8.5 shows the projected final energy consumption by source from 1990 to 2050 under BAU.

Figure 8.5. Final Energy Consumption by Source, Business as Usual



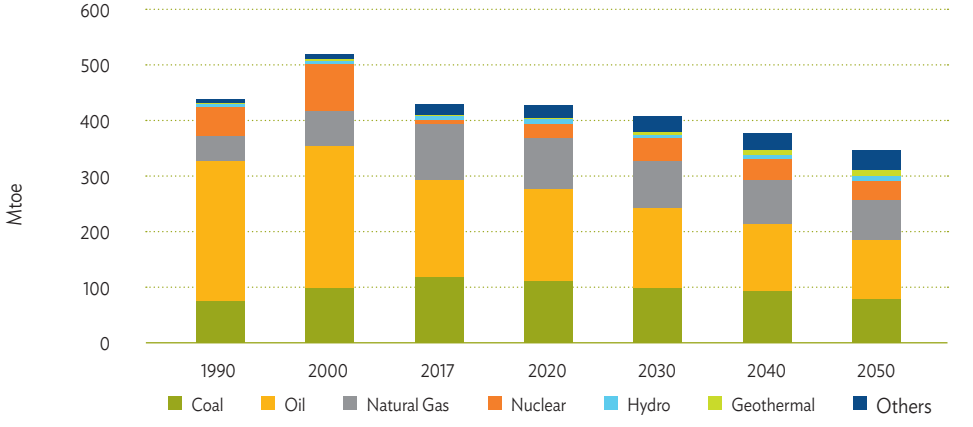
Mtoe = million tons of oil equivalent.

Source: Author's calculation.

3.1.2. Primary Energy Supply

From 2017 to 2050 Japan's primary energy demand is projected to decrease by 0.7% per year, on average, under BAU. Oil, the largest primary energy source in 2017, is expected to remain dominant in 2050. However, its share will shrink from 40.7% in 2017 to 30.2% in 2050 because of substitution with other fossil fuels and forms of renewable energy.

Figure 8.6. Primary Energy Supply, Business as Usual



Hydro = hydropower, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

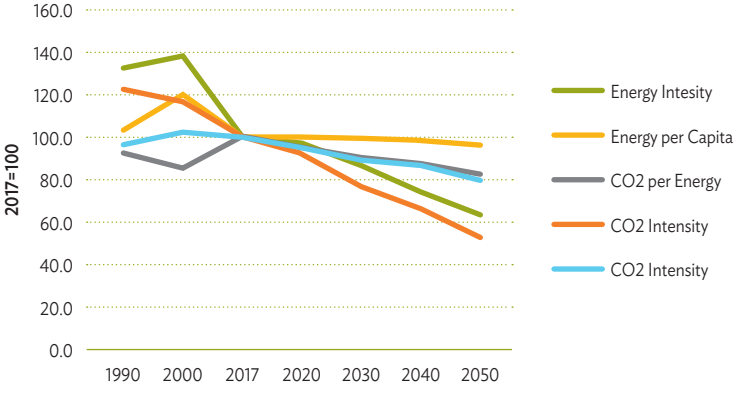
Under BAU, Japan's net primary energy supply is projected to decrease at an average annual rate of 0.7% from 432.0 Mtoe in 2017 to 346.6 Mtoe in 2050 (Figure 8.6). Oil will decrease at a rate of 1.6% per year, driven by energy conservation and fuel substitution in each sector.

On the other hand, nuclear energy will grow at an average annual rate of 4.5% and renewable energy by 1.7%. This energy transformation will contribute significantly to energy security in Japan. The self-sufficiency rate of primary energy will increase from 7.2% in 2017 to 20.8% in 2050.

3.1.3 Energy Indicators

Energy consumption per capita will diminish towards 2050, and energy intensity will drop by 36%. 'Decoupling' energy consumption and GDP will be achieved through energy conservation along with modest GDP growth. All energy indicators will decrease from 2017 to 2050, and carbon dioxide (CO2) intensity (CO2 emissions per unit of energy consumption) will almost halve. Figure 8.7 shows the evolution of indicators of energy consumption in Japan from 1990 to 2050 under BAU.

Figure 8.7. Indices of Energy and Carbon Dioxide Intensities, Energy per Capita, and Carbonisation Rate, Business as Usual (1990–2050)



CO_2 = carbon dioxide.

Source: Author's calculation.

3.2. Energy Saving and Carbon Dioxide Reduction Potential

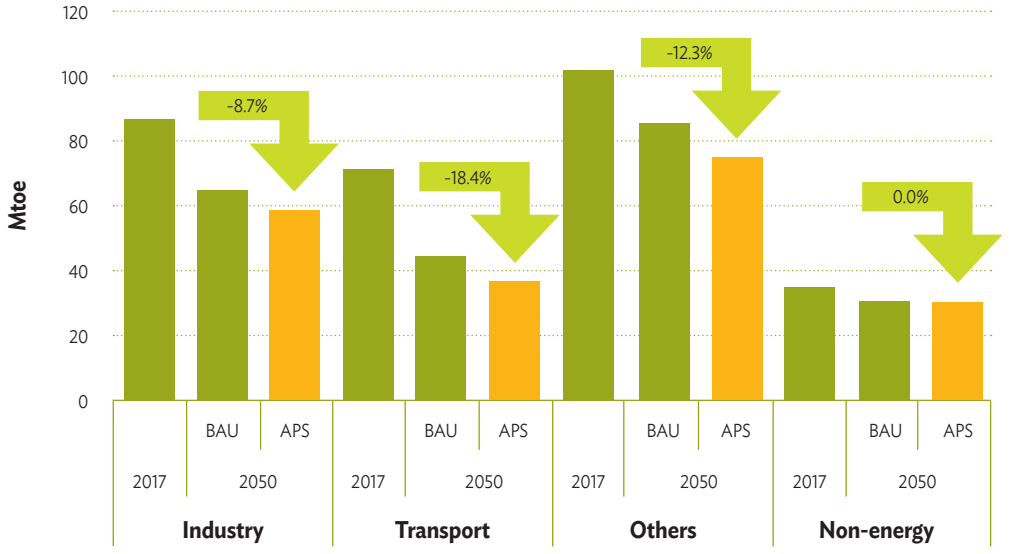
3.2.1. Final Energy Consumption

In the alternative policy scenario (APS), final energy consumption is projected to drop more quickly at 1.1% per year, from 292.8 Mtoe in 2017 to 200.0 Mtoe in 2050. In the APS, total energy consumption in 2050 is 11% less than under BAU. In all demand sectors (i.e. industry, transport, and 'others'), energy consumption will continue to decrease because of improved energy efficiency. The transport sector in particular will achieve remarkable savings of

2.0% per year due to the Top Runner Programme, greater penetration of electric and hybrid electric vehicles, and more advanced energy management systems. This scenario assumes that Japan will make continuous efforts to improve energy efficiency, especially regarding the penetration of energy-efficient passenger cars.

The industry and services sectors will also make efforts to improve their energy efficiency, although it will be difficult for these sectors to do so drastically because energy efficiency and conservation in those sectors has already been carried out. Figure 8.8 shows the final energy consumption by sector under BAU and in the APS.

Figure 8.8. Final Energy Consumption by Sector, Business as Usual and Alternative Policy Scenario (2017 and 2050)

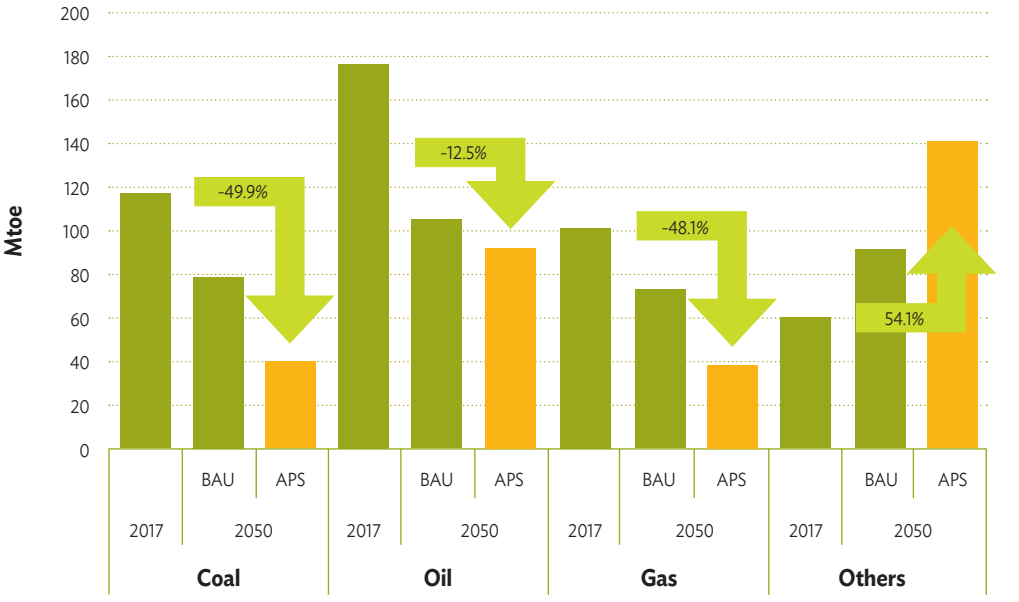


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of energy equivalent.
Source: Author's calculation.

3.2.2. Primary Energy Supply

In the APS, Japan's projected primary energy supply will decline at a rate of 1% per year to 308.7 Mtoe in 2050, 11% less than BAU. Coal and natural gas demands will drop by about half respectively from BAU, because of a substantial transition of power generation towards nuclear and renewable energy. Figure 8.8 shows the primary energy supply by source under BAU and the APS.

Figure 8.9. Primary Energy Supply by Source, Business as Usual and Alternative Policy Scenario (2017–2050)



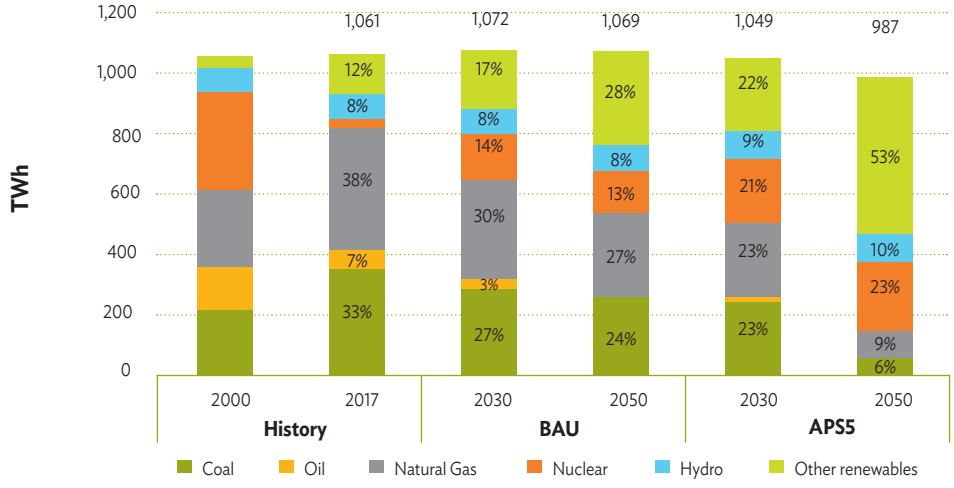
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.2.3. Power Generation

Under BAU, total power generation in 2050 will roughly equal that in 2017, since the effects of energy conservation and electrification will balance each other. The share of renewables and nuclear power will steadily expand, and zero-emission power will account for 50% of total power generation (Figure 8.10). In the APS, the share of zero-emission power generation will grow to 52% of the energy mix in 2030 and 85% in 2050. This power transition will significantly contribute to CO2 reduction and energy independence in Japan. On the other hand, many dispatchable power plants will be replaced with non-dispatchable plants, including photovoltaics and wind whose output fluctuates according to weather conditions. This requires greater effort to keep the power demand and supply in balance by using batteries, employing demand responses, and reinforcing the power grid.

Figure 8.10. Power Generation Mix, Business as Usual and the Alternative Policy Scenario (2017–2050)



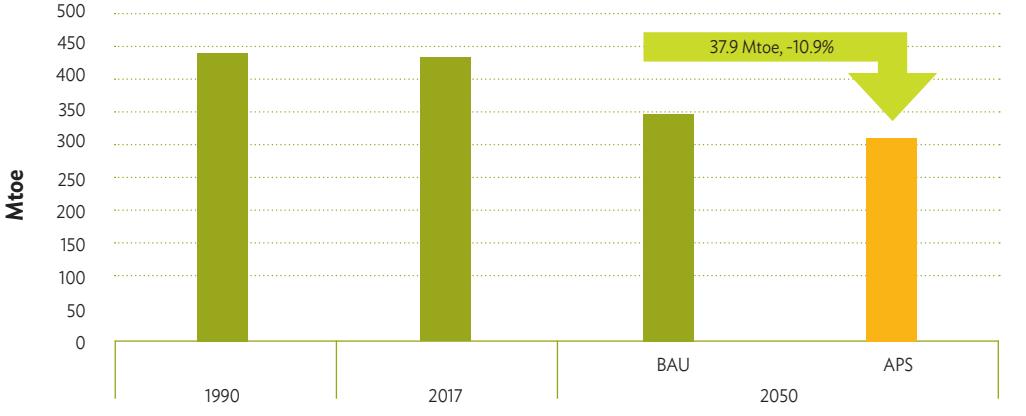
APS = alternative policy scenario, BAU = business as usual, Hydro = hydropower, TWh = terawatt-hour.

Source: Author's calculation.

3.2.4. Projected Energy Savings

Potential energy savings from efforts exerted in each demand sector in Japan amount to 37.94 Mtoe, the difference between the primary energy demand under BAU and that in the APS (Figure 8.11). This is equivalent to a 10.9% decrease in consumption under BAU by 2050. In the APS, estimated savings in final energy consumption will amount to 10.5 Mtoe in the residential and commercial sectors and 8.2 Mtoe in the transport sector by 2050. These sectors will drive energy conservation in the future.

Figure 8.11. Total Energy Consumption, Business as Usual and the Alternative Policy Scenario (1990, 2017, and 2050)



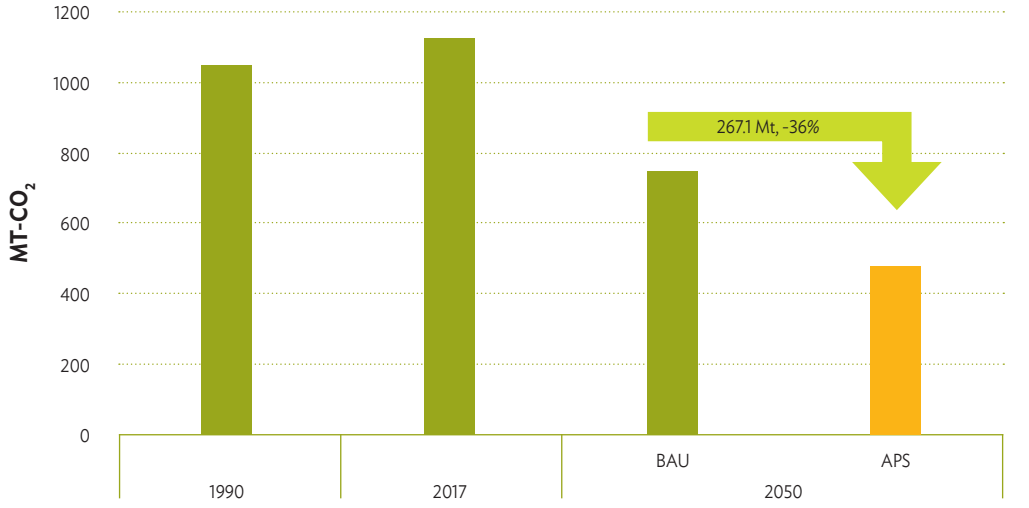
Mtoe = million tonnes of oil equivalent.

Source: Author's calculation.

3.2.5. Carbon Dioxide Emissions from Energy Consumption

Under BAU, CO2 emissions from energy consumption are projected to decrease by 66% from 1,122.5 million metric tonnes (Mt) of CO2 in 2017 to 475.1 Mt-CO2 in 2050. In the APS, a 36% CO2 reduction from BAU will be achieved and total emissions will decrease to 267.1 Mt-CO2 by 2050 (Figure 8.12).

Figure 8.12. Carbon Dioxide Emissions from Fossil Fuel Combustion, Business as Usual and the Alternative Policy Scenario



Source: Author's calculation.

4. Japan's Intended Nationally Determined Contributions

Japan's intended nationally determined contribution is to reduce greenhouse gas emissions by 26% from fiscal year 2013 to fiscal year 2030 (1,042 Mt-CO2 equivalent in 2030). The country's energy-related CO2 emissions target for 2030 is 927 Mt-CO2. That target is consistent with the Ministry of Economy, Trade and Industry's Long-Term Energy Supply and Demand Outlook with respect to Japan's quantitative policy target for energy mix by 2030. Under BAU, CO2 emissions will reach 952 Mt-CO2 by 2030, surpassing the emissions target by 2.8%. In the APS, emissions will decrease to 851 Mt-CO2 by 2030, well below the target.

5. Implications and Policy Recommendations

Japan's CO2 emissions are projected to be much lower by 2030 than in 1990, both under BAU and in the APS. However, to achieve and exceed the 26% reduction target for 2030, Japan could benefit from additional efforts with respect to both energy efficiency and zero-emission energy. To this end, energy efficiency can a play key role in reducing Japan's CO2 emissions. Japan's primary energy intensity has been declining since 1980, and the country's overall efficiency level is one of the highest in the world. This could be due to enormous improvements in energy efficiencies in both supply- and demand-side technologies developed and implemented in the country. Nonetheless, the APS highlights several ways in which the country might be able to achieve a 1.1% improvement per year for energy consumers in Japan. The transportation sector especially has significant potential for energy conservation through the improvement of internal combustion engines and greater penetration of electric vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles. The Government of Japan is targeting a 30–40% share in sales for hybrid vehicles and a 20%–30% share for electric vehicles and plug-in hybrid electric vehicles. In 2017, hybrid cars accounted for 31.2% of all cars, while electric vehicles and plug-in hybrid electric vehicles accounted for just 1.5%. This transformation of vehicle types is in progress but is only half completed. Fuel transformation from gasoline to electricity is the next challenge for the transportation sector.

Additionally, renewable and nuclear energy can both play a key role in decarbonising power generation and enhancing energy security, as suggested by findings in the APS. To achieve intensive renewable energy penetration like in the APS, it is necessary to reduce capital costs significantly, invest in grids to cope with fluctuating power from photovoltaics and wind, and implement effective grid rules. As for nuclear energy, advanced safety measures and sufficient communication with local communities concerning the possibility of restarting the plants are required.

Even in the APS, fossil fuels will play a key role in Japan's energy supply for the next 30 years; however, demand will gradually diminish to less than half the 2017 level. Japan is now a major importer of fossil fuel, and energy security is a key factor in its energy policy. Over the next 3 decades, the importance of energy security will not diminish and stabilisation of the fuel supply will be necessary.