CONSERVATION OF RESOURCES IN THE AUTOMOBILE INDUSTRY

1 Introduction

2020 was a year of drastically change for the Japanese energy sector. In reaction to the COVID-19 pandemic, discussions about the so-called green recovery expanded, particularly in Europe, prompting many countries to pledge measures to realize carbon neutrality with the aim of limiting global warming to a more environmentally conscious level of 1.5℃ rather than the 2℃ stated in the Paris Agreement. Prime Minister Suga also declared Japan's commitment to carbon neutrality in 2050, giving a sudden boost to energy-related discussions.

This article summarizes recent energy trends, primarily in Japan. In addition to crude oil, natural gas, and other natural energy sources, it also presents recent trends related to automotive fuels, such as bioethanol, biodiesel, methanol, and dimethyl ether (DME).

2 Energy Trends in Japan

2. 1. Trend toward Carbon Neutrality and the Green Growth Strategy

Discussions about how to achieve a green recovery from the COVID-19 pandemic that mainly centered in Europe have started to spread and actions toward realizing carbon neutrality are gaining traction throughout the world. As of April 2021, the number of countries and regions committed to carbon neutrality has reached 126, which accounts for 39% of total global greenhouse gas emissions. With the new U.S. government also declaring its intention to realize carbon neutrality by 2050 and China stating a commitment to realize this goal by 2060, the total has increased to more than 60% of total global greenhouse gas emissions.

Japan had previously announced a target to cut its greenhouse gas emissions by 80% by 2050. Prime Minister Suga raised this target to full carbon neutrality on October 26, 2020. This is evidence of a major turnaround that has occurred. Instead of measures to address global warming from the standpoint of restricting economic growth and the expense of the measures, countries are now committed to more proactive measures that will transform industrial structures and social economies and lead to major growth, a concept known as the "green growth strategy."

After the political commitment was made, the details of Japan's green growth strategy were announced in December 2020. A total of fourteen fields were highlighted as industries with growth potential, including four in the energy sector (the offshore wind power generation, ammonia fuel, hydrogen, and nuclear energy industries), as well as the automotive and storage battery, marine, aircraft, carbon recycling industries, and the like in the transportation and manufacturing sectors. The green growth strategy also included predictions for energy in 2050. The strategy calls for maximizing the electrification of sectors that have not previously been electrified and predicts the following energy mix. Renewable energy will account for 50 to 60% of energy, nuclear energy and thermal power generation accompanying carbon dioxide capture and storage (CCUS) or carbon recycling will account for 30 to 40%, and hydrogen and ammonia will account for 10%. Accordingly, the strategy lays out a pathway for the decarburization of power supplies and the utilization of carbon neutral sources such as hydrogen, methanation, synthetic fuels, biomass, and the like for sectors in which electrification is difficult as a way of absolutely minimizing CO_2 emissions. Then, the strategy aims to compensate for emissions that cannot be decarburized at all through tree planting or carbon removal technologies such as direct air carbon dioxide capture and storage (DACCS).

In April 2021, the Japanese government also raised the target for emissions in 2030 from a 26% reduction compared to the level in 2013 to a 46% reduction, a 70% increase.

2. 2. Energy White Paper and Primary Automotive Energy Sources

According to the Energy White Paper 2021 (June 2021), final energy consumption in Japan increased at a higher rate than the country's gross domestic product (GDP) in the period of rapid economic growth extending up to 1970. However, prompted by the oil shocks, energy-saving measures primarily in the manufacturing industry have had an increasing effect and consumption started to decline in 2005. This trend further accelerated due to higher social awareness of energy-saving after the Great East Japan Earthquake in 2011. Although real GDP in 2019 declined by 0.3% from 2018, cool summer weather and a warm winter resulted in a 2.1% drop in energy consumption. The amount of primary energy supplied per unit of GDP was 35 PJ/trillion yen in 2019, little more than half the 69 PJ/trillion yen figure of 1973. This amount has decreased for nine consecutive years and the amount of primary energy supplied per unit of GDP in Japan is now substantially lower than the global average.

The amount of primary energy generated in Japan in 2019 was 19.12 EJ, with oil accounting for 37.1%, coal for 25.3%, natural gas for 22.4%, nuclear energy for 2.9%, hydroelectric power for 3.5%, and non-hydroelectric renewable energy sources for 8.8%. The proportion of energy consumed by the business/commercial, domestic, and transportation sectors was 62.7%, 14.1%, and 23.2%, respectively. Compared to 1973, these figures have grown by 1.0, 1.8, and 1.7 times, and total energy consumption has increased by 1.2 times.

The primary energy source for vehicles is mostly crude oil. In 2020, 136.46 billion kL of crude oil was imported from the following countries: Saudi Arabia (42.5%), the United Arab Emirates (UAE) (29.9%), Kuwait (8.6%), Qatar (8.3%), Russia (3.6%), Ecuador (1.9%), Bahrein (1.5%), the U.S. (0.7%), Iraq (0.9%), Malaysia (0.5%) and other countries (1.9%).

3 International Energy Trends

3. 1. Trends in Crude Oil

The total amount of crude oil produced around the world in 2019 was 4.48 billion tons. When this total amount is broken down according to the top ten producing nations, the U.S. accounted for 16.7% of production, followed by Russia at 12.7%, Saudi Arabia at 12.4%, Canada at 6.1%, Iraq at 5.2%, China at 4.3%, the UAE at 4.0%, Iran at 3.6%, Brazil at 3.4%, and Kuwait at 3.2%. Together, these ten countries accounted for 71.5% of global crude oil production.

Additionally, in 2019, worldwide petroleum consumption was 98.272 million barrels per day. Breaking this down by the top ten oil consuming nations reveals that petroleum consumption in the U.S. accounted for 19.7%, China 14.3%, India 5.4%, Japan 3.9%, Saudi Arabia 3.9%, Russia 3.4%, Korea 2.8%, Canada 2.4%, Brazil 2.4%, and Germany 2.3%. These top ten countries accounted for 60.5% of global crude oil consumption.

3. 2. Trends in Natural Gas

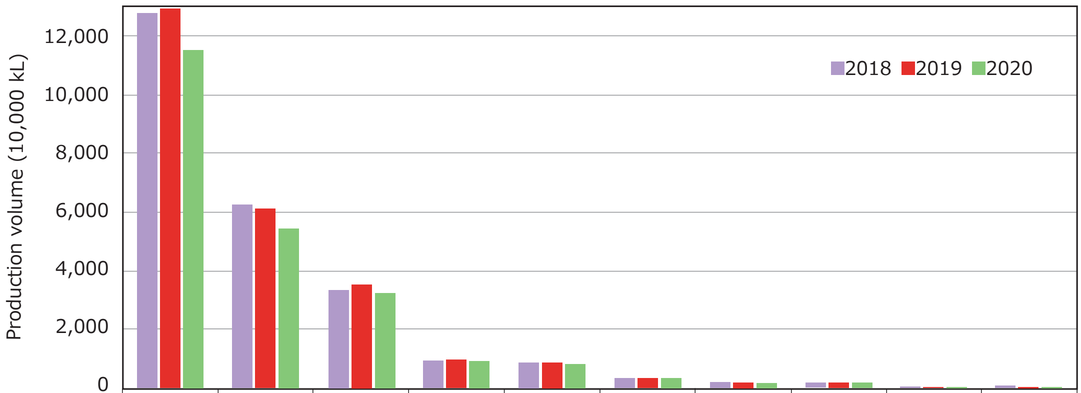
The total amount of natural gas produced around the world in 2019 was 3.99 billion m^3. Broken down according to the top ten producing nations, the U.S. was the leading producer, accounting for 23.1%, followed by Russia at 17.0, Iran at 6.1%, Qatar at 4.5%, China at 4.5%, Canada at 4.3%, Australia at 3.8%, Norway at 2.9%, Saudi Arabia at 2.8%, and Algeria at 2.2%. Together, these ten countries accounted for 71.2%, or approximately two-thirds, of global natural gas production.

Additionally, in 2019, worldwide natural gas consumption was 3.93 billion m^3. Breaking this down by the top ten natural gas consuming nations reveals that natural gas consumption in the U.S. accounted for 21.5%, Russia 11.3%, China 7.8%, Iran 5.7%, Canada 3.1%, Saudi Arabia 2.9%, Japan 2.8%, Mexico 2.3%, Germany 2.3%, and the U.K. 2.0%. These top ten countries accounted for 61.6% of global natural gas consumption.

4 Trends in Natural Sources of Energy

4. 1. Wind-Based Electric Power Generation

According to the Global Wind Energy Council (GWEC), newly installed onshore wind power capacity in 2020 amounted to 86.9 GW. When this is broken down by country, China accounted for 56.3% of this new capacity, followed by the U.S. at 18.6%, Brazil at 2.6%, Germany at 1.6%, France at 1.5%, Turkey at 1.4%, India at 1.3%, Australia at 1.3%, Argentina at 1.2%, and Sweden at 1.2%. Japan accounted for 0.6% of new capacity. The total installed onshore wind power capacity around the world as of 2020 amounted to 707.4 GW. In terms of the country-by-country share of this global total, China again leads with 39.3%, followed by the U.S. with 17.3%, Germany with 7.8%, India with 5.5%, France with 2.5%, Brazil with 2.5%, the U.K. with 1.9%, Canada with 1.9%, Sweden with 1.4%, and Turkey with 1.3%. Again, Japan accounted for 0.6% of wind power capacity.



	Total	U.S.	Brazil	China	Europe	India	Canada	Thailand	Australia	Pakistan
2018	12,740	6,238	3,307	952	883	308	190	169	35	73
2019	12,901	6,133	3,517	980	863	340	211	185	33	50
2020	11,530	5,440	3,260	920	834	330	190	173	31	47

Fig. 1 Changes in Annual Bioethanol Production Volume

In contrast, newly installed offshore wind power capacity in 2020 amounted to 6.1 GW. According to the country-by-country breakdown, China accounted for 50.4% of this new capacity, followed by the Netherlands at 24.6%, Belgium at 11.6%, the U.K. at 8.0%, and Germany at 3.9%. The total installed offshore wind power capacity around the world as of 2020 amounted to 35.3 GW. The U.K. accounted for the highest proportion at 28.9%, followed by China at 28.3%, Germany at 21.9%, the Netherlands at 7.4%, and Belgium at 6.4%.

4. 2. Solar-Based Electric Power Generation

According to the Renewable Energy Policy Network for the 21st Century (REN21), the total capacity of newly installed solar-based electric power generation around the world in 2019 was approximately 115 GW. Breaking down this new capacity by country indicates that China accounted for 26.2%, followed by the U.S. at 11.6%, India at 8.6%, Japan at 6.1%, Vietnam at 4.2%, Spain at 4.2%, Germany at 3.3%, Australia at 3.2%, the Ukraine at 3.0%, and Korea at 2.7%. The total installed solar-based electric power generation capacity around the world as of 2019 amounted to 627 GW. According to the country-by-country breakdown, China accounted for the highest proportion at 32.5%, followed by the U.S. at 12.1%, Japan at 10.0%, Germany at 7.8%, India at 6.8%, Italy at 3.3%, Australia at 2.3%, the U.K. at 2.1%, Korea at 1.8%, and Spain at 1.6%.

5 Bioethanol

According to statistics compiled by F.O. Licht GmbH, global ethanol production decreased by approximately 11% in 2019 to about 115.30 million kL, with decreases occurring in almost every country. Figure 1 shows the annual production trends for bioethanol in each country. The main reason for this decrease is the impact of the novel coronavirus COVID-19 pandemic as the resulting downturn in economic activity and reduction in distances driven by vehicles led to a fall in demand for ethanol fuel. The proportion of ethanol in the fuel mix is also likely to fall in almost every country. In particular, the fact that the two largest producers of ethanol, the U.S. and Brazil, accounted for the highest and second highest number of COVID-19 infections probably contributed to the large declines in those country (down 11.3% to 54,4 million kL liters in the U.S. and down 7.3% to 32,6 million kL liters in Brazil).

However, it should be noted that production of corn, one of the raw materials used to make ethanol, is rapidly expanding in the mid-western region of Brazil. In 2020, the production volume of corn in this region increased by 88% compared to 2019 to 2.5 million kL and accounted for 8% of total ethanol production. In addition, the utilization rate of plants operated by Raizen that produce next-generation bioethanol from cellulose and other forms of inedible biomass reached 80% in 2020, and the production volume of these plants is forecast to reach 30,000 kL in the same year.

With respect to initiatives aiming to encourage the use of biofuels in Japan, in 2020, sales of gasoline blended with Ethyl tert-butyl ether (ETBE) again achieved the target defined in the Act on Sophisticated Methods of Energy Supply Structures (500,000 kL (crude oil equivalent) of bioethanol and 1.94 million kL of bio-ETBE each year). According to trade statistics, approximately 54,000

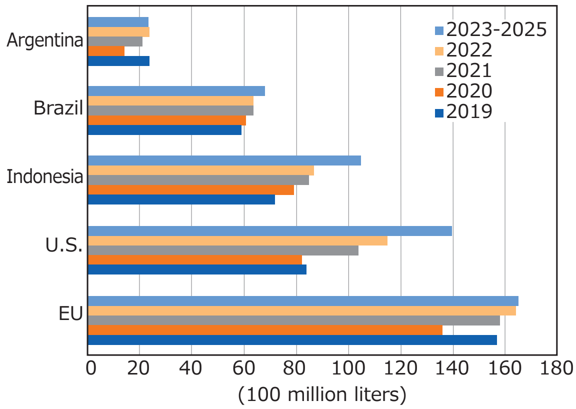


Fig. 2 Production Volume of FAME and HVO in Main Markets

tons of ethanol were imported, mainly from Brazil, in 2020 as raw material for ETBE (equivalent to roughly 124,000 kL of ETBE).

The Institute of Applied Energy issued a report entitled Comparative Survey Results of Bioethanol Introduction Technologies, which covered broad aspects of bioethanol manufacturing technologies. This report discussed competition with food production related to the use of bioethanol, and described a wide range of information on the economic viability, environmental friendliness, and sustainability of two types of blending technology options (direct blending and ETBE blending).

6 Biodiesel Fuel

Figure 2 shows predictions for the production of fatty acid methyl ester (FAME) and hydrotreated vegetable oil (HVO) biodiesel fuels in the main markets, as analyzed by the International Energy Agency (IEA). Global production of FAME and HVO reached 48 billion liters in 2019. This figure dropped by 5% to 46 billion liters in 2020 due to the COVID-19 pandemic. Most of this decrease occurred in the European Union (EU), and probably reflects the decline in diesel demand, even though this decline was not as great as that of gasoline.

It is likely that this decline in production would have been larger without the 2020 renewable energy directive (RED), which targeted 10% of renewable energy in the transportation energy mix. It should be noted that the proportion of diesel passenger vehicles registered in 2019 fell significantly to 30.5%, highlighting the growing move away from diesel fuel.

Production of FAME and HVO in the EU is forecast to recover in 2021. Combined with continued increases in ASEAN countries and the U.S., global production is likely to increase to 53 billion liters in 2021 and 56 billion liters in 2022. Average production between 2023 and 2025 is also predicted to rise by 30% from 2019 levels to 63 billion liters. More than half of this increase is likely to come from expanding production in Singapore and the U.S. RED II, the renewable energy directive that was recast in 2015 regulates the types of biofuels to be used for transportation. This directive limits the amount of FAME derived from waste cooking oil that can be blended into fuel to 1.7% from 2021.

The reduction in domestic production due to the COVID-19 pandemic was lower in the U.S. than in the EU. This is probably due to the impact of the federal Renewable Fuel Standard (RFS2) and the Low Carbon Fuel Standard (LCDS) in California, as well as the reintroduction of tax breaks for blenders. In the twenty-five year period from 2023, U.S. production of FAME and HVO is predicted to reach an annual average of 14 billion liters. The main driving force behind this growth is likely to be dramatically higher investment in production capacity at various fossil fuel refineries.

Production in Indonesia reached a record high of 7.2 billion liters. Although production in 2020 only increased slightly, it is thought that the government-mandated increase in blending ratio from 20 to 30% at the beginning of 2020 successfully offset the decline in demand caused by the pandemic.

Robust growth is predicted in Brazil. The factors behind this prediction include the gradual increase in the mandated blending ratio from 12 to 15% by 2023, the introduction of the Renova Bio policy, as well as higher production from waste cooking oil and animal fats.

Biodiesel production in Argentina reached 2.4 billion liters in 2019, but fell by 40% in 2020 due to the pandemic. It is thought that this decline is not simply due to the decrease in the number of diesel vehicles.

Therefore, as described above, production of biomass-derived FAME and HVO is predicted to increase once the COVID-19 crisis has abated. However, production may stutter from 2025 and beyond due to the growing move away from gasoline and diesel vehicles as efforts to electrify and eliminate emissions from passenger vehicles spread around the world. However, FAME and HVO are not likely to be displaced while issues such as the low energy conversion efficiency and high production cost of hydrogen and power-to-X fuel synthesized from CO_2 in the atmosphere using surplus electric power generated by renewable energy,(i.e., so-called e-fuel) remain unresolved.

7 Methanol and Di-methyl Ether (DME)

Methanol is mainly produced from natural gas and coal. In 2020 the worldwide demand for methanol was estimated at 80 million tons, with China thought to account for about 60% of that total. Possible applications for methanol in automotive fuels include blending it into gasoline, using it as a raw material for MTBE, biodiesel, DME, and synthetic gasoline, and even developing methanol engine automobiles. In China, methanol is synthesized from cheap domestic coal sources, primarily at inland coal fields, and either used directly as vehicle fuel or converted into other substances before use. The blending of methanol into gasoline is falling as the switch to bioethanol blends (E10) progresses in response to rising environmental awareness. The appeal of methanol as a raw material for synthetic gasoline production is also starting to wear off due to the price gap between methanol and crude oil.

Furthermore, DME, which can be produced easily from methanol, is mainly consumed in liquid petroleum gas (LPG)-blending applications, but can also be used as an alternative fuel to diesel. Companies and institutions possessing technology for DME diesel vehicles include Volvo, Ford, and Shanghai Jiao Tong University. In Japan, Isuzu Advanced Engineering Center, Ltd. has completed testing of this technology on public roads.

With environmental awareness continuing to increase, methanol or DME, which can be produced from carbon dioxide and hydrogen, have been suggested as feasible renewable energy sources in North America and Europe. In North America, Oberon Fuels is cooperating with the State of California in a project to help realize a recycling-oriented society using renewable dimethyl ether (rDME). In Europe, the FLEDGED Project has been studying technologies capable of synthesizing methanol and rDME from biomass, and has already published results. In Japan, although the New Energy and Industrial Technology Development Organization (NEDO) has commissioned a project aiming to develop technology to re-use carbon dioxide, this project does not envision the use of methanol or rDME as a vehicle fuel.

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