CONSERVATION OF RESOURCES IN THE AUTOMOBILE INDUSTRY

1 Introduction

The Fifth Strategic Energy Plan (July 3, 2018) was revised for the first time in four years, and a long-term plan looking ahead to 2030 and 2050 was presented. In that context, the Basic Hydrogen Strategy, the Tokyo Statement, and the Strategic Road Map for Hydrogen and Fuel Cells, which concern the hydrogen energy that is key to a low-carbon society, were announced one after the other. In addition to these announcements, this article introduces the Energy White Paper (June 8, 2018) that summarizes energy trends both in and outside Japan, and also summarizes international energy trends.

2 Energy Trends in Japan

2. 1. Strategic Energy Plan

The Strategic Energy Plan was formulated based on the Basic Act on Energy Policy established in June 2002, and is revised every four years to achieve safety, energy security, improved economic efficiency, and environment compatibility.

The Fifth Strategic Energy Plan[1] (July 3, 2018) outlines actions toward 2030 and 2050. For 2030, the steady realization of an energy mix that reduces greenhouse gases by 26% is targeted, and measures will mainly focus on (a) renewable energy, (b) nuclear power, (c) fossil fuels, (d) energy saving, and (e) hydrogen, electricity storage, and distributed energy resources. For 2050, achieving the challenge of energy conversion and decarbonization to reduce greenhouse gas emissions by 80% was set as a goal. In addition to the items mentioned previously, the main measures will emphasize heat, transportation and distributed energy, and promote decarbonization and distributed energy systems that rely on hydrogen and electricity storage.

2. 2. Long-Term Strategy for Hydrogen

The Basic Hydrogen Strategy[2] (December 26, 2017) defines a future vision focused on 2050, and also presents an action plan leading up 2030 to achieve of that vision. The strategy sets the goal of reducing hydrogen costs to the same level as conventional energy (e.g., gasoline and LNG). To achieve that goal, the strategy integrates policies ranging from hydrogen production to utilization scattered across ministries under a common objective.

The goals for 2030 are as follows: (a) supply: build international hydrogen supply chains and establish hydrogen production technology, (b) supply quantity: 300,000 tons, (c) Cost: 30 yen/Nm^3, (d) use (power generation): 17 yen/kWh, (e) mobility: 900 or more stations, 800,000 FCV units, 1,200 FC buses, 10,000 FC forklifts, and (f) FC utilization: 5,300,000 Ene-Farms. Moreover, the following goals are set for 2050: (a) supply: CO_2-free hydrogen (brown coal and CCS, renewable energy utilization), (b) supply quantity: 10,000,000 tons, (c) Cost: 20 yen/Nm^3, (d) use (power generation): 12 yen/kWh, and (e) mobility: substitution of gasoline and gas stations.

In addition, the Ministry of Economy, Trade and Industry and the New Energy and Industrial Technology Development Organization (NEDO) held the Hydrogen Energy Ministerial Meeting[3] (October 23, 2018), the world's first ministerial-level meeting to make discussing the realization of hydrogen-powered society its main theme. More than 300 people representing 21 countries, regions and organizations around the world participated in the meeting. They confirmed the importance of global collaboration in the field of hydrogen, and shared future directions concerning policies for the global utilization of hydrogen. The Tokyo Statement was released as an outcome of the meeting.

Following the announcements of the Basic Hydrogen Strategy, the Fifth Strategic Energy Plan, and the Tokyo Statement, the Council for a Strategy for Hydrogen and Fuel Cells revised the existing Strategic Roadmap for Hydrogen and Fuel Cells[4] (March 12, 2019). To ensure the goals of the Basic Hydrogen Strategy are achieved, (a) new targets to meet were set (specifications for basic

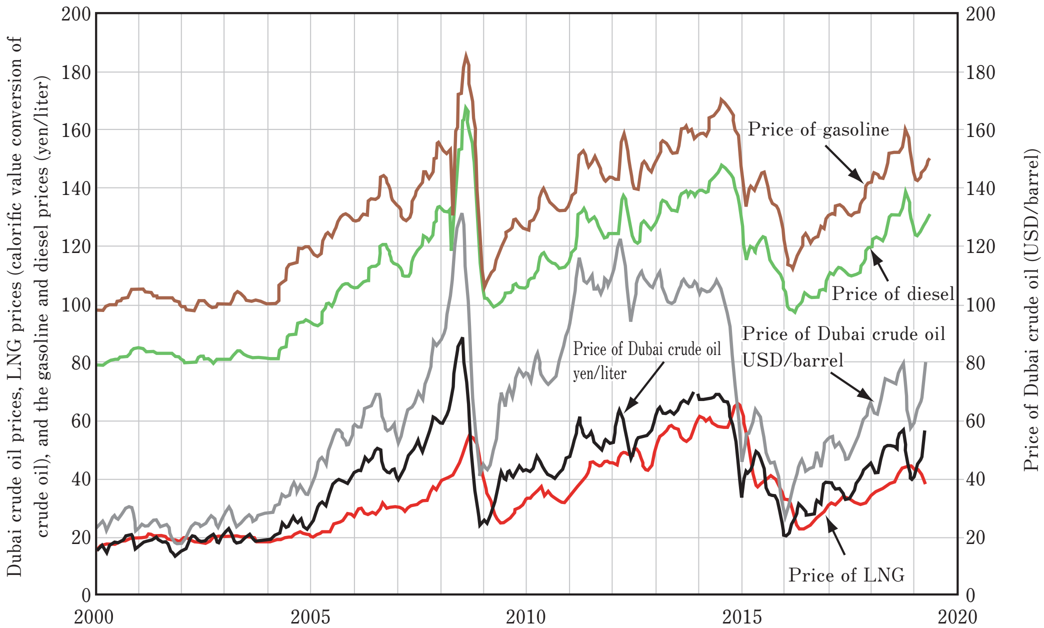


Fig. 1 Comparison of International Prices by Fuel Type

technologies, cost breakdown targets) and measures necessary to accomplish the goals were specified, and (b) an evaluation committee consisting of experts was established to follow-up on each field.

2. 3. Circumstances Affecting the Automobile Industry

The Energy White Paper 2019[5] (June 8, 2019) was issued. The final energy consumption continued to decrease from the peak value reached in 2015 (approximately 520 trillion yen, 2011 prices), and the real GDP in fiscal 2017 increased by 1.9% compared to the previous year. Final energy consumption increased by 0.4% for the first time in 7 years, and was approximately 440 trillion yen. The transportation sector accounted for 23.2% of the total final energy consumption, while the industrial sector accounted for 46.2%, the business sector for 15.7%, and the household sector for 14.9%. In the transportation sector, the passenger segment accounted for 59.3%, while the freight segment accounted for 40.7%.

The primary energy source for automobile consists mostly of petroleum, and the sources of the imports and the percentage of the total they account for (fiscal 2017) are as follows: Saudi Arabia (39.4%), the UAE (24.8%), Qatar (7.6%), Kuwait (7.3%), Russia (5.3%), Iran (5.2%), Vietnam (2.2%), Iraq (1.9%), Mexico (1.3%), Indonesia (1.1%), Oman (1.0%), Ecuador (0.9%), the U.S. (0.9%), Malaysia (0.5%), and others (0.6%).

Figure 1 shows the movement of Dubai crude oil prices, LNG prices (calorific value conversion of 1 liter of crude oil), and the market prices of gasoline and diesel, based on available statistical data. The crude oil prices are also shown in yen/L with the exchange rate taken into consideration, along with the USD/barrel price. To facilitate comparison, LNG is converted to the calorific value of one liter of crude oil. The price of crude oil bounced back from the low levels observed at the beginning of 2016, and maintained an upward trend until the end of 2018. The price of LNG is fluctuates at a lower level than that of crude oil. Trends in the market prices of gasoline and crude oil reflect the addition of profits or other margins, as well as taxes, to the price of crude oil.

The target prices for hydrogen are 30 yen/Nm^3 for 2030, and 20 yen/Nm^3 for 2050. Since the calorific value of one liter of crude oil is equivalent to three Nm^3 of hydrogen, the prices converted to one liter of crude oil are 90 yen and 60 yen, respectively. The price for 2050 is at the same level as that of LNG if there no tax is applied. However, the 30 yen/Nm^3 price for 2030 cannot compete with LNG and crude oil prices, unless there are factors such as incentives or a rise in crude oil prices.

In addition, new fuel economy standards for passenger vehicles[6] (June 3, 2019) were issued with the following specifications: (a) applicable fiscal year: 2030, (b) fuel economy standard value: 25.4 km/L (32.4% improvement over fiscal 2016 results), and (c) scope: gasoline, diesel, LPG, electric, and plug-in hybrid vehicles, extending the scope to various types of electric vehicles for the first time. High expectations are being placed on the development of automobiles that capitalize on the benefits of the various sources of energy.

3 International Energy Trends

3. 1. Trends in Crude Oil[7]

The total amount of crude oil produced around the world in 2017 was 4.39 billion tons. When this total amount is broken down according to the top ten producing nations, Saudi Arabia is the leading producer, accounting for 12.8%, followed by the U.S. at 13.0%, Russia at 12.6%, Canada at 5.4%, Iran at 5.3%, Iraq at 5.0%, China at 4.4%, the UAE at 4.0%, Kuwait at 3.3%, and Brazil at 3.3%. These top ten countries account for 69.2% of all crude oil produced in the world.

In 2017, worldwide crude oil consumption was 4.62 billion tons. Breaking this down by the top ten oil consuming nations reveals that petroleum consumption in the U.S. accounted for 19.7%, China 13.2%, India 4.8%, Japan 4.1%, Saudi Arabia 3.7%, Russia 3.3%, Brazil 2.9%, South Korea 2.8%, Germany 2.6%, and Canada 2.4%. These top ten countries account for 59.5% of all crude oil consumption in the world.

3. 2. Trends in Natural Gas[7]

The total amount of natural gas produced around the world in 2017 was 3.68 billion m^3. Broken down according to the top ten producing nations, the U.S. is the leading producer, accounting for 20.0%, followed by Russia at 17.3%, Iran at 6.1%, Canada at 4.8%, Qatar at 4.8%, China at 4.1%, Norway at 3.3%, Australia at 3.1%, Saudi Arabia at 3.0%, and Algeria at 2.5%. The natural gas production of these ten top producers accounts for 69.0% or approximately two-thirds of all production throughout the world.

In 2017, worldwide natural gas consumption was 3.67 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 20.1%, Russia 11.6%, China 6.6%, Iran 5.8%, Japan 3.2%, Canada 3.2%, Saudi Arabia 3.0%, Germany 2.5%, Mexico 2.4%, and the U.K. 2.1%. These top ten countries account for 60.5% of all natural gas consumption in the world.

4 Trends in Natural Sources of Energy

4. 1. Wind-Based Electric Power Generation

According to the Global Wind Energy Council (GWEC)[8], newly installed wind power in 2017 amounted to 47.31 GW. When this is broken down by country, China led the way and accounted for 37.5% of this new capacity, followed by the U.S. at 13.4%, Germany at 12.5%, the U.K. at 8.1%, India at 7.9%, Brazil at 3.9%, France at 3.2%, Turkey at 1.5%, South Africa at 1.2%, and Finland at 1.0%. The total installed wind power capacity around the world is now 539.12 GW. Breaking this down by country, China again leads with 34.9%, followed by the U.S. with 16.5%, Germany with 10.4%, India with 6.1%, Spain with 4.3%, the U.K. with 3.5%, France with 2.6%, Brazil with 2.4%, Canada with 2.3%, and Italy with 1.8%.

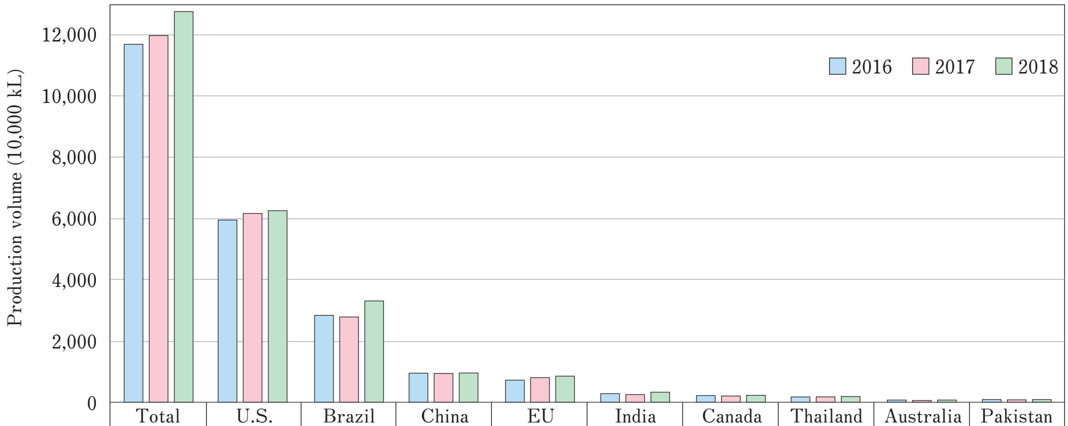
4. 2. Solar-Based Electric Power Generation

According to REN21, the Renewable Energy Policy Network for the 21st Century[9], the total capacity of newly installed solar-based electric power generation around the world in 2017 was approximately 98 GW. Breaking down this new capacity by country indicates that China accounts for 54.2%, followed by the U.S. at 12.7%, India at 9.1%, Japan at 7.0%, Turkey at 2.6%, Germany at 1.7%, Australia at 1.3%, South Korea at 1.2%, the U.K. at 0.9%, and Brazil at 0.9%. A look at the cumulative amount of solar-based electric power generation introduced in 2017, shows that China ranks first at 131.1 GW, which accounts for 32.6%, while Japan has reached 49 GW and ranks third in the world, following the U.S., which ranks second at 51 GW.

5 Bioethanol

According to statistics compiled by F.O. Licht GmbH, global ethanol production continued to increase in 2018 by approximately 6.5%, reaching a record high of about 127.68 million kL[10]. Figure 2 shows the annual production trends for bioethanol in each country. Approximately 85% of this total was used for fuel, which is about the same proportion as in 2017. The two main bioethanol producing countries are the U.S. and Brazil. The amount of bioethanol produced in the U.S was 62.38 million kL, a slight increase of approximately 1.4%. Although the Trump administration has tried to expand domestic demand by easing the regulations on E15, the actual effects are not very significant. In contrast, growing domestic demand in Brazil boosted production considerably (by approximately 19%) to 33.09 million kL. In addition, preparations to introduce the RenovaBio Project are ongoing, and the production of ethanol derived from corn other than sugarcane is also increasing gradually[10].

With respects to efforts to use of biofuels in Japan,



	Total	U.S.	Brazil	China	EU	India	Canada	Thailand	Australia	Pakistan
2016	11,696	5,953	2,819	930	695	244	190	150	35	45
2017	11,985	6,153	2,775	930	776	229	194	166	34	62
2018	12,768	6,238	3,309	955	801	311	203	169	35	70

Fig. 2 Changes in Annual Bioethanol Production Volume in Producing Countries

sales of gasoline blended with ETBE achieved the target stipulated in the Act on Sophisticated Methods of Energy Supply Structures (500,000 kL (crude oil equivalent) of bioethanol in fiscal 2017)[11]. An official notice in April 2018 prescribed that the target in the decision criteria formulated when bioethanol use targets were first set would remain at 500,000 kL (crude oil equivalent) every fiscal year from 2018 to 2022. The value for ethanol derived from corn produced in the U.S. was prescribed as one of the default values of LCA GHG emissions for bioethanol used in Japan in addition to the current value for Brazilian sugarcane-based ethanol[12].

With respect to bioethanol manufacturing technologies, NEDO, Toray Industries, Inc., Mitsui Sugar Co., Ltd., and Mitsui & Co., Ltd. announced the completion of a demonstration plant in Thailand, which is to start operating in late July 2018. The demonstration plant, which is the largest in the world, will produce the cellulosic sugars serving as raw material for bioethanol from bagasse, as well as high value-added products such as polyphenols and oligosaccharides[13]. At an event it organized in São Paulo, Brazil, Toyota Motor Corporation unveiled the world's first prototype vehicle that that runs on ethanol or other forms of alcohol in addition to gasoline (flexible fuel vehicle) and is also equipped with a hybrid system[14].

6 Biodiesel Fuel (FAME and BDF)

In Japan, certification criteria for biodiesel fuels made from used cooking oil were formulated, becoming the first fuels used for transportation to be added to the Eco Mark Program[15]. This allows certified biodiesel fuels to use the Eco Mark label, and raises expectations that biodiesel fuels will enjoy wider adoption thanks to highly positive appraisals not only of used cooking oil recycling, but also of proper treatment of harmful substances generated during manufacturing, and of the safe use, information, and quality associated with these fuels. In addition, B5 was listed as a product recommended use in the Ministry of the Environment's Act on Promoting Green Procurement[16]. Specifically, the Act clearly indicates that efforts to actively use vehicles using it as diesel fuel should be made in regions where a blended biodiesel fuel (B5) supply system is available, and local authorities and other groups have started to actively use B5.

On a global scale, the International Energy Agency (IEA) has presented the Sustainable Development Scenario (SDS) to achieve the goal of transport biofuel consumption for 2030 outlined in the Sustainable Development Goals (SDGs)[17]. According to the SDS, the 2017 transport biofuel consumption 81,000,000 tons (oil equivalent) will increase to 251,000,000 tons (oil equivalent) in 2030. That consumption breaks down as follows: the U.S. accounted for 33%, Brazil for 13%, the 28 EU countries for 13%, China for 9%, India for 4% , other countries for 15%, and airplanes and ships for 13%. Although it is unclear whether Japan is included in the other countries category, efforts to expand biofuel consumption to achieve the SDGs are underway.

It should also be noted that the total worldwide biodiesel fuel production has been steadily increasing, with the 38,360,000 tons produced in 2018, representing an increase of approximately 6.7% compared to the 35,950,000 tons produced in 2017. In addition, the percentage of oils used as raw material is highest for palm oil, followed by soybean oil, and rapeseed oil. Used cooking oil comes next, and its percentage of use is rising[18]. In Europe, notably, the percentage of used cooking oil has surpassed that of palm oil, and is the second highest after rapeseed oil[19]. Used cooking oil is as raw material for hydrotreated vegetable oil (HVO) as well as for FAME.

7 Methanol and Di-methyl Ether (DME)

Methanol is mainly produced from natural gas and coal. In 2018 the worldwide demand for methanol was estimated at 79 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 the local governments in major coal producing areas, such as Shanxi Province and Shaanxi Province, are planning to introduce policies to promote the use of methanol-blended gasoline[20], and construction of an MTG plant that synthesizes gasoline from methanol is underway[21].

Furthermore, DME, which can be produced easily from methanol, is mainly consumed in LPG-blending applications, but is also attracting attention as an alternative fuel to diesel. In North America, Oberon Co., Ltd. and Mack Trucks, Inc. carried out demonstrations using DME trucks with technology from Volvo Truck Corporation. Ford Motor Company in Germany is developing passenger cars with DME fuel, and the Shanghai Jiao Tong University in China is developing engines that run on DME. In Japan, the Isuzu Advanced Engineering Center, Ltd., is developing DME trucks.

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