CONSERVATION OF RESOURCES IN THE AUTOMOBILE INDUSTRY

1 Introduction

In April 2014, the Japanese government approved the new Strategic Energy Plan (the fourth plan), which forms the basis for Japan's energy policies for the immediate future [1]. The basic concepts behind this plan are ensuring stable energy supplies, economic efficiency, and environmental suitability. Safety was also added to these concepts, so the plan is now summed up as "3E+S". For more specific commentary on this plan please see Reference (2).

In terms of primary energy, the plan discusses the use of nuclear power and ensuring safety, improving the efficiency of electricity generation (such as through the application of an integrated gasification combined cycle for coal), expanding the use of liquid natural gas (LNG) and liquid petroleum gas (LPG), and places an emphasis on reducing the cost of renewable energy. In terms of secondary energy, the plan cites the need to reform the structure of electricity generation. Consequently, on April 30, 2015 the Ministry of the Environment (MOE) and the Ministry of Economy, Trade and Industry (METI) presented a government proposal that targets reducing the level of greenhouse gases in 2030 by 26% compared to the level in 2013. The use of hydrogen as a fuel source was also widely discussed in the plan, which promoted the creation of a roadmap for the production, storage, transport, and usage of hydrogen, as well as the strategic development of supply systems and infrastructure. As a result, the Strategic Roadmap for Hydrogen and Fuel Cells, which looks at the way that hydrogen fuel will be used in the future, was compiled in June 2014. For more commentary on hydrogen as a fuel source, please see Reference (3).

Figure 1 shows the global energy consumption trends since 1990 and the outlook up to 2035, as prepared by BP[4]. Although fossil fuels are likely to account for the lion's share of energy demand, the development, introduction, and use of renewables and other energy sources will be a key issue. It is hoped that energy demand will gradually switch to renewables in the future since these energy sources also have the effect of helping to reduce CO_2 emissions.

However, recent market reaction to the sudden increase in the production of shale gas and shale oil has caused a plunge in the price of crude oil since the summer of 2014. This had a major impact on the renewable energy market and further efforts to reduce the price of renewable energy are urgently needed.

The following sections outline the latest trends and developments in natural resources and energy for automotive use.

2 Energy for Transportation

2. 1. Current situation of energy resources

In 2013, worldwide oil consumption was 91.33 million barrels per day (B/D). Broken down by the top 10 oil consuming countries, oil consumption in the U.S. amounted to 18.89 million B/D (20.6%), followed by China (10.76 million B/D, 11.8%), Japan (4.55 million B/D, 5.0%), India (3.73 million B/D, 4.1%), Russia (3.31 million B/D, 3.6%), Saudi Arabia (3.08 million B/D, 3.4%), Brazil (2.97 million B/D, 3.3%), South Korea (2.46 million B/D, 2.7%), Canada (2.39 million B/D, 2.6%), and Germany (2.38 million B/D, 2.6%) [5]. These top 10 oil consuming countries account for approximately 60% of all global oil consumption. Oil consumption has been increasing steadily in the Middle East and South America in recent years, indicating that countries in these regions are continuing to grow as their economies develop and living standards rise.

Figure 2 shows the market price trends (in units of yen/liter) for crude oil [6], and the average price changes in the gas station retail price of diesel oil and gasoline in Japan. The price of crude oil reached an all-time high in 2008 due to speculation during the sub-prime loan crisis, but then plummeted and has continued to rise again at

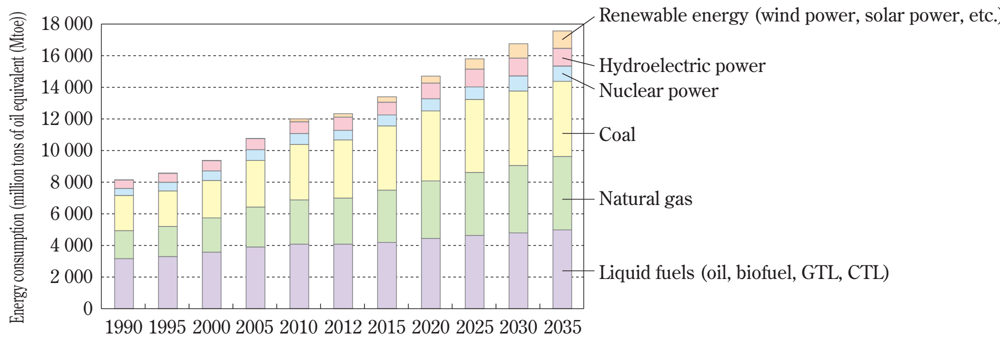


Fig. 1 Global energy consumption trends and future outlook

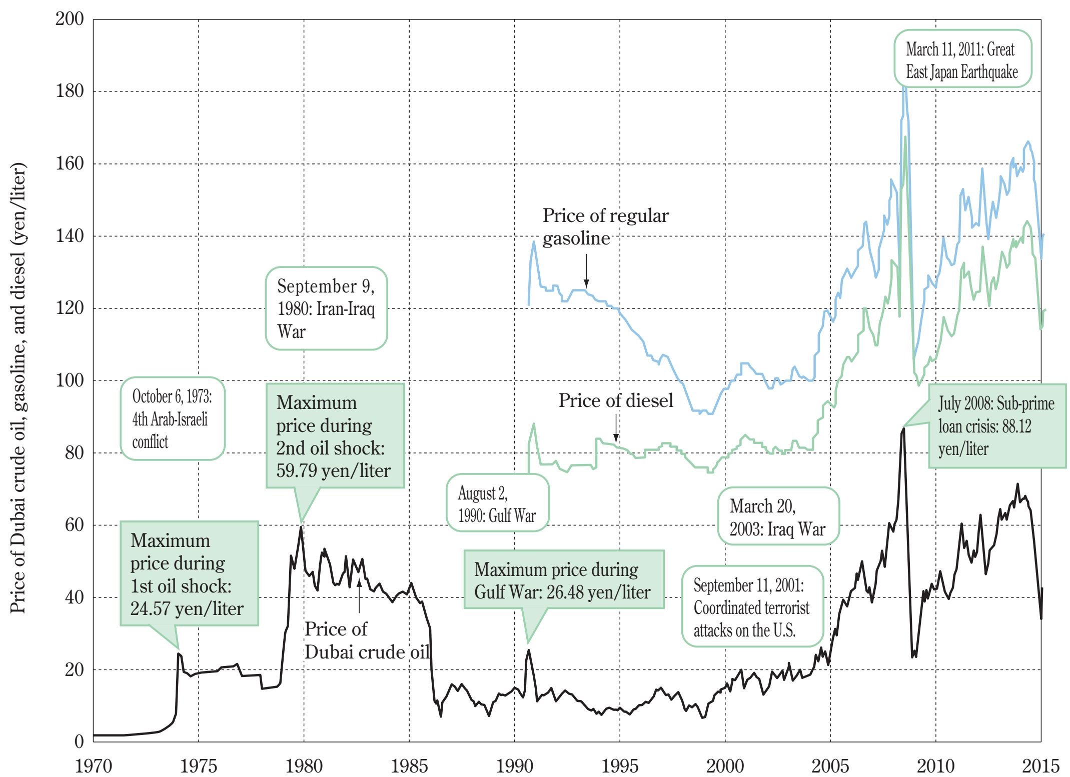


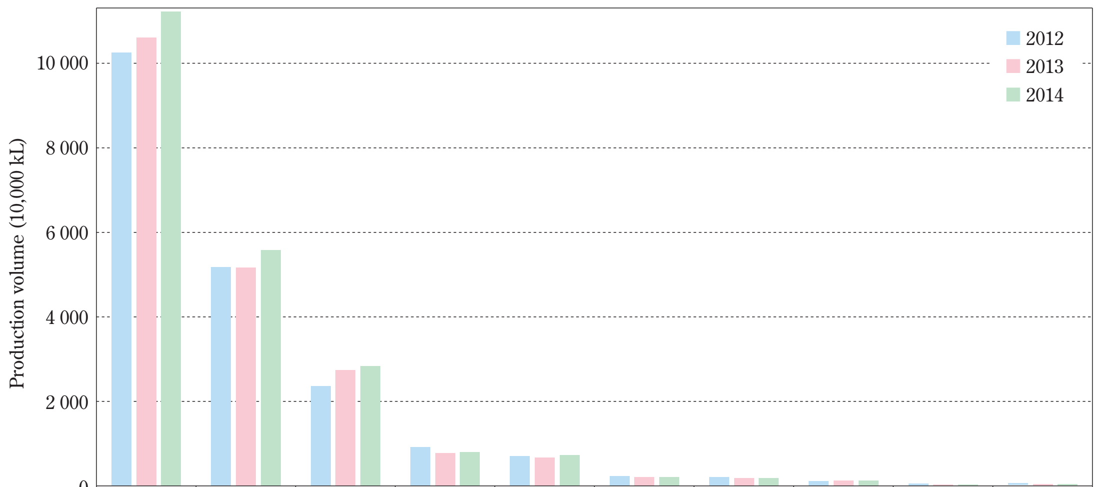
Fig. 2 Crude oil, gasoline, and diesel price trends

a constant rate since then. However, factors such as the increase in shale oil, economic slowdowns in emerging nations, and efforts by OPEC to maintain market share by refusing to reduce oil production have caused the price of crude oil to fall since the summer of 2014. At the beginning of 2015, the price in Japan was about 40 yen/liter.

2. 2. Biofuels

2. 2. 1. Bioethanol

According to statistics compiled by F.O. Licht GmbH, global ethanol production continued to increase in 2014 by roughly 6% to a new record high of 112.23 million kL [7]. Of this, approximately 84% was used for fuel. Figure 3 shows the annual production trends in each country. The two main ethanol producing countries (U.S. and Brazil) account for approximately 75% of total global production. Although the so-called blend wall issue continues in the U.S., the amount of ethanol production increased by approximately 8% compared to 2013 due to an increase in the corn crop yield and an increase in export volume. In contrast, the amount of ethanol production in Brazil was initially expected to decrease due to the impact of a drought that decreased the sugar cane crop yield and other factors. However, ethanol pro-



	Total	U.S.	Brazil	China	EU	India	Canada	Thailand	Australia	Pakistan
2012	10 245	5 180	2 354	895	678	211	187	97	34	53
2013	10 617	5 185	2 765	787	672	209	195	125	34	47
2014	11 223	5 576	2 867	811	734	212	196	141	30	47

Fig. 3 Ethanol production of main global producers

duction in 2014 actually increased by approximately 4% compared to 2013 due to strong domestic demand. In Thailand the sales rates of blended gasolines with high amounts of ethanol, such as E20, are also increasing and the production of ethanol increased by approximately 13% compared to 2013.

In Japan, the main activities promoting the use of biofuels are the three biofuel production site establishment projects between 2012 and 2016 managed by the Ministry of Agriculture, Forestry and Fisheries (MAFF). However, since it was determined that it would be too difficult to achieve the secondary objective of self-reliance and commercialization of these projects from FY 2017, budgetary support as auxiliary projects of the MAFF was only provided up to FY 2014 [8]. The project to popularize the use of biofuels in Okinawa supplied roughly 70,000 kL of E3 and E10 fuel in FY 2014 and has established 57 service stations supplying E3 fuel, and 29 service stations supplying E10 fuel as of April 2015 [9]. In contrast, the number of service stations in Japan selling bio-gasoline blended with ethyl tert-butyl ether (ETBE) decreased by approximately 2% from April 2014 to 3,300 (as of May 10, 2015) [10].

In Thailand, the New Energy and Industrial Technology Development Organization (NEDO) (outsourcing contractors: Sapporo Breweries Ltd. and Iwata Chemical Industry Co., Ltd.) has started demonstration operation of a plant to produce bioethanol from tapioca residue (production capacity of 80 kL/year) as a new bioethanol production technology [11]. In addition, Iogen Corporation and Raizen, Inc. announced the start of continuous commercial production of ethanol from cellulose in Brazil beginning with the harvest in 2015 [12].

Test methods for ethanol fuels are being standardized by the International Organization for Standardization (ISO). A standard describing the determination of total acidity by potentiometric titration was issued on October 3, 2014 and one describing the determination of electrical conductivity was issued on January 15, 2015 [13][14].

2. 2. 2. Biodiesel fuel (BDF)

The main trend in Japan concerning biodiesel over the past year was the provision of subsidies by METI in co-operation with MAFF for regional biodiesel distribution system technology demonstration projects as a measure to help encourage the use and popularization of biomass-derived fuels.

These subsidies will be used to support the main operators in each region to address technical issues surrounding an integrated and advanced distribution system for biodiesel. This is being done in an effort to promote and stabilize the supply, production, distribution, and production volume of biodiesel. The subsidies provided by METI will help the operators cover business expenses, giving METI and the operators the opportunity to identify and resolve issues blocking the wider use of biodiesel. This project and the subsidies began in FY 2013 and in FY 2014 the 16 operators shown in Table 1 were selected to participate.

Outside Japan, Thailand had conventionally required diesel fuel to be at least 5% blended biodiesel (B5). Starting in January 2014 this requirement was raised to 7% (B7). The following is a list of the main countries that currently require blended biodiesel fuel and the required concentration of the blend: Argentina B10, India B10, Brazil B7, Thailand B7, Malaysia B5, the Philippines B5, Indonesia B2.5, Australia B2, Canada B2, and South Korea B2. In the EU it is now obligatory for 10% of all fuel used for transporting goods to come from renewable energy and a biodiesel fuel standard of B7 has been specified. In the U.S. there are target amounts for the introduction of biofuel and in general fuels in the B2 to B5 range are required with a further target of B20 fuels by the year 2015 in some states.

In terms of fuel properties, the JIS K 2390 standard has been aligned with the guidelines determined by the Economic Research Institute for ASEAN and East Asia at East Asia Summits (EAS-ERIA), which is the unified standard for Southeast Asia. This was accomplished in four ways: 1) the provisions concerning kinematic viscosity, flash point, and iodine value were loosened to accommodate the diversity of oils derived from raw materials, 2) the provisions for monoglycerides related to vehicle cold startability were made stricter and the items in the test method (cloud point and cold filter plugging point) for cold startability were clearly specified, 3) the provisions concerning phosphorus related to catalyst poisoning in aftertreatment devices were made stricter, and 4) a subcommittee of the Society of Automotive Engineers of Japan (JSAE) discussed how to clearly specify a standard value for oxidation stability. In regard to 2) above, the European standard that concerns the low-temperature fluidity requirements for biodiesel fuels is EN14214:2012. It divides fuels into six classes through a complicated method that combines the cloud point, cold filter plugging point, and monoglyceride content. However, in Japan the distribution of biodiesel fuel has not progressed very far and Japanese manufacturers would likely be unable to adequately follow complicated standards. Therefore, the JSAE committee agreed to stop at the specification of two grades based on the monoglyceride content. However, this has not yet been reflected in

Table 1 Operators selected for BDF subsidies in FY 2014 (source: Japan Organics Recycling Association website)

Name of operator	Main implementation region
- ECO ERC Co., Ltd. - Tokachi Energy Network, a specified NPO Tokachi area biodiesel fuel distribution system project	Tokachi region
- Dream Co., Ltd. Sapporo sustainable biodiesel promotion project	Sapporo region
- Chida Clean Co., Ltd. Biodiesel fuel distribution system demonstration project in Osaki, Miyagi	Area in and around Osaki City
- Ushiku City Hall BDF distribution system expansion demonstration project in Ushiku, a designated biomass industrial city	Area in and around Ushiku City
- Business Union Worker's Co-op Chiba Hokusou Agureen Eco Project	Hokusou region
- SI Corporation Saitama City biodiesel dissemination and promotion technology demonstration project	Saitama City
- Hokuto Transportation Co., Ltd. Biodiesel truck distribution system technology demonstration project	Keiyou region
- Best Trading, Inc. - Yamaguchi Katsuo Gasoline Station Atsugi area biodiesel distribution system construction business	Atsugi region
- Itami Automobile Co., Ltd. Regional biodiesel distribution system technology demonstration project	Area in and around Nagaoka City
- Kotobuki Bio Co., Ltd. Shinshu Chushin area biodiesel distribution system technology demonstration project	Chushin region
- Marusan Shoji Co., Ltd. Demonstration project for distribution efficiency via installation of simple refueling tanks	Tokai region
- Revo International Inc. - Nantan City Biodiesel "C-FUEL" distribution network maintenance demonstration project	Kyoto Prefecture
- Tezuka Shoji Co., Ltd. Promotion of further popularization and stable use of BDF through expanded production volume and improved quality	Kyoto/Osaka region
- Hamada Kagaku Co., Ltd. Demonstration project of a development model for B5 fuel using a new enzyme-catalyzed production method for production stabilization and promoting greater BDF use	Hyogo Prefecture
- Nishida Shoun Co., Ltd. Regional recycling system demonstration project for promoting the popularization of biodiesel (and improving quality)	Kyushu region
- Murasato Transport Co., Ltd. Activities to promote and stabilize the biodiesel distribution system in the Kyushu region through the introduction of simple refueling tanks and product transport vehicles	Kyushu region

the JIS standard.

2.3.Natural gas

In 2013, the global confirmed accessible reserves of natural gas stood at 185.7 trillion m^3. These reserves are mostly located in Iran (33.8 trillion m^3, 18.2%), Russia (31.3 trillion m^3, 16.8%), Qatar (24.7 trillion m^3, 13.3%), Turkmenistan (17.5 trillion m^3, 9.4%), the U.S. (9.3 trillion m^3, 5.0%), Saudi Arabia (8.2 trillion m^3, 4.4%), the UAE (6.1 trillion m^3, 3.3%), Venezuela (5.6 trillion m^3, 3.0%), Nigeria (5.1 trillion m^3, 2.7%), and Algeria (4.5 trillion m^3, 2.4%) [(5)]. According to statistics published by the Japanese Ministry of Finance (MOF), Japan imports most of its liquid natural gas from Qatar, Australia, Malaysia, and Russia. In 2013, the import price into Japan was 16.2 U.S. dollars/MMBtu. This indicates that Japan was forced to pay a higher price in comparison to the import price into the UK (10.7 U.S. dollars/MMBtu) and the U.S. (3.7 U.S. dollars/MMBtu). (Note: MMBtu is an abbreviation for one million British thermal units and is roughly equivalent to 25 m^3 of natural gas.)

2. 4. Natural energy and hydrogen

Natural energy sources such as wind, solar, and geothermal power have rapidly gained prominence in recent years. In Europe, roughly 72% of additional power generation in 2012 came from natural energy sources. In Denmark, all new buildings constructed starting in 2013 were prohibited from having a fossil fuel boiler, with the aim of covering 40% of heat supply needs with renewable energy. The number of countries and regions that are aiming to provide 100% of electrical power generation from renewable energy is increasing and includes Djibouti, Scotland, and the Tuvalu islands [(15)].

The capacity of new wind power generators in 2014 was 44.8 gigawatts (GW), with China (23.4 GW) accounting for 45% of the global growth in wind power. This was followed by Germany (5.3 GW), the U.S. (4.9 GW), Brazil (2.5 GW), India (2.3 GW), Canada (1.9 GW), and the UK (1.7 GW). Total global wind power capacity has now reached 369.6 GW [(16)].

The capacity of new solar power generators in 2014 increased 8% from 37 GW in 2013 to 40 GW. In Europe the capacity of new solar power generators in 2014 declined 36% compared to 2013 to 7 GW, but in the UK, the capacity increased from 1.5 GW to 2.3 GW. The market for solar power generators continued to be led by China, Japan, and the U.S. [(17)].

In Japan the most common use of natural energy (renewable energy) in the form of automotive fuel is hydrogen obtained via water electrolysis. In anticipation of the eventual realization of a hydrogen fuel-based society in the future, NEDO, a national research and development institute, has compiled the NEDO Hydrogen Energy White Paper that outlines the current state of research and development into hydrogen-based fuels. In this white paper, all manner of information concerning the use of hydrogen as an energy source, both inside and outside Japan, has been brought together and summarized systematically. Starting with the characteristics of hydrogen itself, the white paper also discusses the significance of using hydrogen as an energy source, the technology trends concerning hydrogen manufacturing, transportation, storage, and use, as well as the policy trends toward developing a hydrogen fuel-based society, current issues, and future directions. The white paper also contains a section that introduces the basics of hydrogen energy to someone starting to take an interest in the subject.

The Toyota Mirai hydrogen fuel cell vehicle (FCV) went on sale in December 2014. In conjunction with this event, Iwatani Corporation and JX Nippon Oil & Energy Corporation started selling hydrogen fuel at 1,100 yen/kg and 1,000 yen/kg, respectively. Therefore, it is now possible to compare the fuel costs of FCVs to existing gasoline engine and hybrid vehicles. Figure 4 compares the fuel cost in yen per kilometer (km) of driving distance at a gasoline price of 120 yen/liter. The fuel economy values for the gasoline engine vehicles and hybrid vehicles are the catalog values provided by each manufacturer. For the FCVs, the Japan Hydrogen & Fuel Cell Demonstration (JHFC) Project has not published the fuel economy of each vehicle, so the red box in Fig. 4 shows the range of fuel economies gleaned from the available public information. Although the test cycle fuel economy of the Toyota FCV-adv was published, this information has yet to be published for the Mirai. Therefore, the value shown in Fig. 4 was calculated based on the volume of the hydrogen fuel tank and the travel distance.

Although it is difficult to make a direct comparison because the vehicle sizes are different, the Mirai has approximately the same fuel cost as a hybrid vehicle in the same vehicle class. Furthermore, according to the NEDO project and other sources, the cost of supplying hydrogen around the year 2030 is predicted to be 20 to 40 yen/Nm^3 (approximately 230 to 450 yen/kg). Depend-

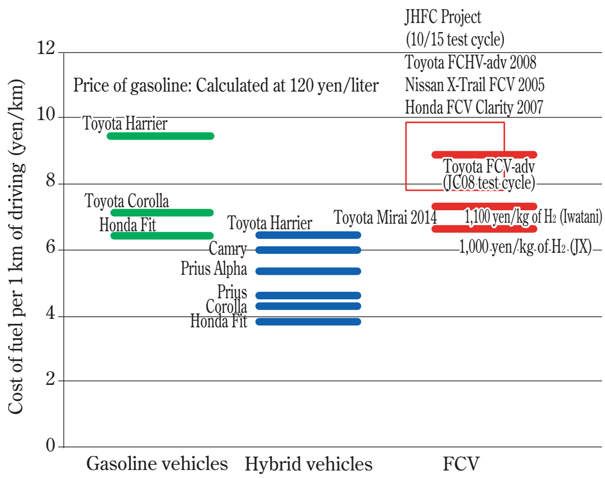


Fig. 4 Comparison of fuel costs per 1 km of driving

ing on the price of crude oil, there is a strong possibility that the market will accept this price range.

2. 5. Methanol and dimethyl ester (DME)

Currently, methanol is mainly produced from natural gas and coal. The worldwide demand for methanol in 2014 is assumed to be 72 million tons and the Chinese demand for methanol alone exceeds half of that total at 40 million tons. In terms of usage, methanol as a source of energy (for gasoline blends, DME, and biodiesel) accounts for 20% of the worldwide demand and 30% in China [18]. In China, some local governments, such as Shanxi and Shaanxi Provinces, which are major coal producing regions, are planning to introduce government policies promoting the use of methanol-blended gasoline [19].

DME is attracting attention as an alternative fuel to diesel that can be produced easily from methanol. In North America, Oberon Co., Ltd. and Volvo Truck Corporation are planning to produce DME and run some vehicles on DME. Mitsubishi Gas Chemical Company Inc. and Mitsubishi Corporation have similar plans in the works in Trinidad and Tobago, and Isuzu Motors, Ltd. is also producing low-pollution vehicles with DME engines [20].

2. 6. GTL (gas to liquid)

GTL is a refinery process to convert natural gas into various types of liquid fuels. A plant being built in Turkmenistan that would produce 600,000 tons of gasoline a year is scheduled for completion in 2018 [21]. Although greater attention is being focused on GTL again due to the price difference between crude oil and natural gas, the impact of the shale gas drilling boom and less expensive crude oil will also need to be monitored.

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