Conservation of Resources in the Automobile Industry

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1 Introduction

The exploitation of shale gas and oil reserves in the U.S. by the use of innovative technologies is the focus of attention in the field of global energy resources. Increasing shale gas production has alleviated pressure on natural gas demand in the U.S., resulting in large decreases in prices and the possibility that surplus gas may be exported. Imports of crude oil to the U.S. have also continued to decline as shale oil production increases. It has even been predicted that the U.S. will outstrip Saudi Arabia and become the world's largest producer of oil in 2020, before becoming a net oil exporter in around 2030 [(1)]. The energy dependence of the U.S. on the Middle East is likely to decrease, greatly changing the global energy security situation.

Global energy demand continues to increase as personal incomes and populations in emerging markets rise. Energy consumption in China is increasing particularly quickly and accounts for approximately 70% of the global increase. In contrast, although energy demand in the 34 Organisation for Economic Co-operation and Development (OECD) countries remains virtually unchanged, there are movements toward changing oil and coal (as well as nuclear power in some countries) for natural gas and renewable energy sources [(2)].

Despite gradual increases in the use of renewable energy, fossil fuels are likely to continue maintaining the lion's share of the world's energy market (Fig. 1). This is supported through fossil fuel subsidies, which increased by 30% in 2011 from 2010 to 523.0 billion dollars. This figure is six times larger than the subsidies for renewable energy. Subsidies are most widely adopted in the Middle East and North Africa.

2 Energy for Transportation

2. 1. Current situation of energy resources

Table 1 lists the total global energy reserves. The confirmed size and reserve-production ratio of oil and gas reserves in 2011 actually increased compared to 2010. Oil reserves increased due to greater development of oil fields in Iraq, and natural gas reserves increased due to further development of gas fields in Turkmenistan and greater shale gas development in the U.S. Confirmed reserves of coal in 2011 remain unchanged from 2010 but the reserve-production ratio fell due to a 6% increase in production. China accounted for approximately 70% of that increase.

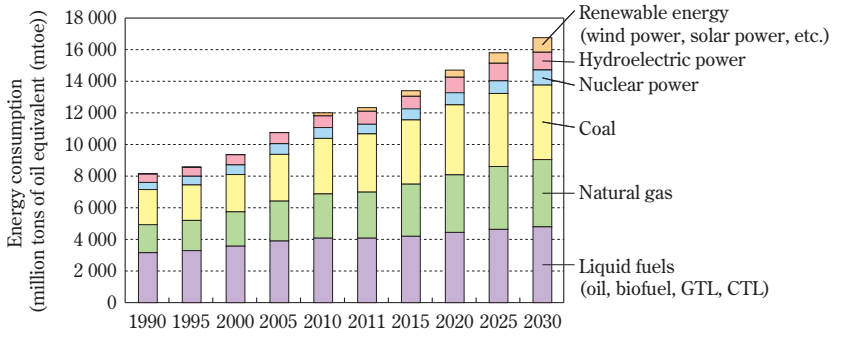
Consumption of oil, which remains the main energy source for vehicles, accounted for 33% of total global energy consumption. Although this is the largest ratio of any energy source, the proportion has fallen for twelve consecutive years.

From 2012 to 2013, oil prices remained high in historical terms at around 100 dollars/barrel (Fig. 2). Since around 2011, West Texas Intermediate (WTI), a grade of crude oil used as a benchmark in oil pricing in the U.S., has trended lower than European Brent Crude and Middle Eastern Dubai Crude. One factor in this trend is probably higher shale oil production in the U.S.

2. 2. Biomass

Biomass is a natural resource derived from biological material such as foodstuffs, fibers, livestock feed, and the like. Biomass is the fourth largest global primary energy source after oil, coal, and natural gas, making up approximately 10% of the global energy market. Fuel that uses the energy stored within biomass is called biofuel. Biofuels include bioethanol (i.e., fuels derived from maize or sugar cane) and biodiesel (i.e., fuels derived from soybeans, rapeseed oil, palm oil, used cooking oil, animal fat, and fish oil).

The total global production of bioethanol in 2011 was stable compared to 2010 (Fig. 3). The U.S. and Brazil account for large proportions of the bioethanol market (Fig. 4). Although production increased in the U.S. in 2011, production in Brazil fell by 18% due to lower investment



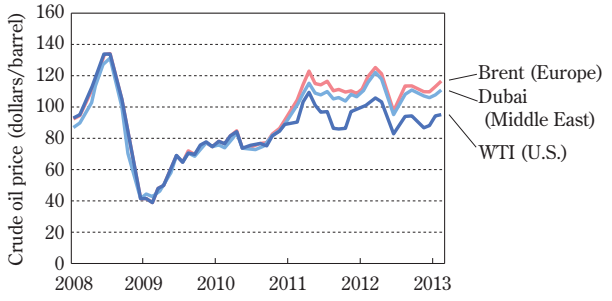
Source: Derived from BP Energy Outlook 2030 (2012)

Fig. 1 Global energy consumption trends and future outlook.

Table 1 Energy reserves and reserve-production ratios.

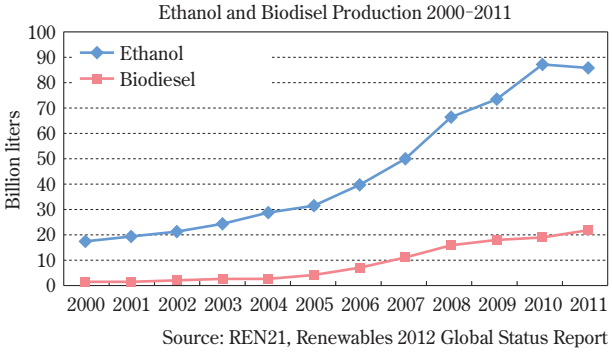
		Oil	Coal	Natural gas
2011	Energy reserves	1.6526 trillion barrels	860.9 billion tons	208.4 trillion m^3
	Reserve-production ratio	54.2 years	112 years	63.6 years
2010	Energy reserves	1.3832 trillion barrels	860.9 billion tons	187.1 trillion m^3
	Reserve-production ratio	46.2 years	118 years	58.6 years
2009	Energy reserves	1.3331 trillion barrels	826.0 billion tons	187.49 trillion m^3
	Reserve-production ratio	45.7 years	119 years	62.8 years

Source: BP Statistical Review of World Energy 2012 , 2011 , 2010



Source: Derived from data in IMF Primary Commodity Prices

Fig. 2 Crude oil price trends.

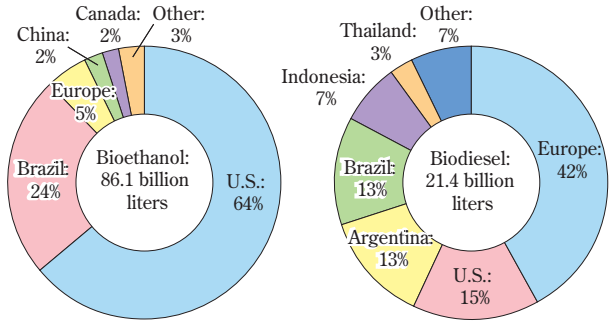


Source: REN21, Renewables 2012 Global Status Report

Fig. 3 Increase in biofuel production volume.

in sugar cane cultivation since the financial crisis, poor weather that resulted in lower harvests, and a global increase in sugar prices.

Global production of biodiesel continued to increase. From 2010 to 2011, production increased by 16% from



Source: Derived from REN21, Renewables 2012 Global Status Report

Fig. 4 Breakdown of biodiesel producing countries.

18.5 billion liters 21.4 billion liters (Fig. 3). The U.S. became the world's largest producer of biodiesel in 2011 due to record production of 3.2 billion liters, a 159% increase from 2010. One factor in this trend was the boost given to the oil refining industry in the U.S. by a law mandating the blending of 3.1 billion liters (0.8 billion gallons) of biodiesel into diesel fuel [3].

In the U.S., the Energy Independence and Security Act (EISA) of 2007 amended the renewable fuels standard (RFS2). Mandated biofuel usage was expanded to 36.0 billion gallons by 2022 and the volume of advanced biofuels derived from different sources than maize ethanol was also specified. Advanced biofuels include cellulosic bioethanol, biodiesel, and so on.

The production volume of bioethanol has increased due to its use as a replacement for methyl tertiary butyl ether as a gasoline additive to raise the octane number. The introduction of the RFS2 standard also boosted production. However, if the blend ratio is not increased further, it may be difficult to meet the volumes mandated by RFS2. Another market risk is ethanol price fluctuation due to rising prices of the raw material maize. Compared with bioethanol derived from maize, cellulosic bioethanol has a smaller impact on food supply. However, there are yet no concrete prospects for its development and commercialization.

In Europe, the usage of biofuels was given a boost by the introduction of the EU biofuels directive in 2003. In addition, the Renewables Directive (RED) that was introduced in 2009 targeted a minimum proportion of renewable energy in the transportation sector of 10% by 2020. To achieve this 10% target, wider adoption of fuels with the maximum blend rates that still meet the Fuel Quality Directive, i.e., E10 (gasoline blended with 10% ethanol) and B7 (diesel blended with 7% biodiesel), is not enough by itself. Possible solutions include increasing biofuel blend rates, blending in next-generation biofuels that can be counted twice (such as biofuels made from waste and leftover products, or non foodstuff-derived cellulosic and lignocellulosic biomass), or using new renewable energy sources apart from biofuels.

When growing plants for biodiesel, some biofuels may not satisfy standards for sustainability after considering the impact of indirect land use change (i.e., the impact that occurs when plants that were conventionally grown on a piece of land are moved elsewhere to accommodate the biofuel crop). Consequently, the European Commission has proposed a limit of 5% on first-generation biofuels derived from food and agricultural produce.

2. 3. Natural gas

Natural gas has a lower environmental load than other fossil fuels since it emits lower levels of CO_2 during combustion. Demand for natural gas for power generation in emerging markets such as China, India, and the Middle East is rising. Forecasts see natural gas overtaking oil as the largest energy resource in around 2030.

Since the price of natural gas is dropping in the U.S. due to the increase in shale gas production, trailers fueled by liquid natural gas (LNG) have been introduced in the truck business. Some passenger vehicle manufacturers are also promoting the sale of CNG cars.

However, appropriate measures will be required to respond to concerns about the impact of shale gas extraction on the environment such as wastewater processing. These concerns have led to some countries banning shale gas field development.

2. 4. Natural energy

Natural energy sources include wind power, solar power, geothermal power, wave power, and the like. These methods may be adopted as energy for vehicles by converting the generated power into electricity or hydrogen. The following section describes the situation for wind and solar power generation, which are relatively prevalent forms of power generation from natural energy.

In 2012, global wind and solar power generation achieved record growth.

The capacity of new wind power generators in 2012 reached 44.7 GW, with China (13.2 GW) and the U.S. (13.1 GW) accounting for more than half the growth, followed by Germany (2.4 GW), India (2.3 GW), and the UK (1.9 GW). Total wind power capacity has now reached 282.5 GW [4].

The capacity of new solar power generators in 2012 was 30 GW, bringing the total solar power capacity above 100 GW to 101 GW. Growth was strongest in Europe (17 GW), but impressive increases were also recorded in China (3.5 GW), the U.S. (3.2 GW), and Japan (2.5 GW) [5].

2. 5. Hydrogen

Hydrogen is a secondary energy source that can be manufactured from water and various fossil fuels. It has various merits, such as the emission of no CO_2 greenhouse gas in the use phase, a high heat of combustion per unit mass, power compatibility, and so on. Currently, about 90% of hydrogen is produced from natural gas. However, the production of hydrogen from natural energy sources that emit no CO_2 is an important option since this would reduce global warming and help to guarantee energy security. Hydrogen engines and fuel-cell vehicles (FCVs) have been developed to utilize hydrogen as an automotive fuel.

In Japan, three automakers and 10 energy companies announced a joint agreement to develop and launch FCVs from 2015. This project is leading to the mass-production and sale of FCVs and the establishment of roughly 100 hydrogen refueling stations, primarily in Japan's four main urban areas. Activities are also under way under the auspices of governments in the U.S. and

Europe from basic research to technological development and field tests. These countries are also aiming to achieve the popularization of FCVs and the establishment of a hydrogen supply infrastructure from 2015.

2. 6. Other

Other liquid automotive fuels include gas to liquid (GTL) fuels, which are synthesized from natural gas and other sources, dimethyl ester (DME), and the like.

GTL is a technique for manufacturing petroleum products such as naphtha, kerosene, diesel, and so on from chemical reactions with natural gas. Since GTL fuels contain no sulfur, aromatics, and the like, this method can be used to manufacture clean fuels with a low environmental load. Furthermore, since GTL fuels are derived from natural gas instead of oil, this method helps to diversify the supply sources of liquid fuels. As crude oil prices continue to rise, GTL fuels manufactured from cheap shale gas in the U.S. should become commercially viable.

From 2006 to 2012, Japan carried out a demonstration test project and studied the commercialization of GTL fuels under the auspices of the Nippon GTL Technology Research Association, formed between the Japan Oil, Gas and Metals National Corporation (JOGMEC) and six private-sector companies. Activities are now aiming to apply the technology to commercial plants.

DME is not a naturally occurring substance and is artificially synthesized from natural gas, coal gas, coke gas, biomass, and the like. Characterized by a molecular structure in which carbon atoms are joined by oxygen, DME fuel generates no soot or particulate matter (PM). Consequently, both DME and GTL fuels are seen as potential clean alternatives to diesel.

The Japanese Agency for Natural Resources and Energy began researching a DME strategy in 2000 to help identify the issues for practical application. In 2001, the LPG industry led studies into the feasibility of diverting infrastructure and the like. Government sponsored projects were then carried out into utilization technologies and basic equipment to facilitate widespread adoption. In 2009, nine private sector companies successfully completed trial operation of a DME fuel promotion plant. This plant supplied its first customer in 2009 and is commercially producing DME fuel for boilers and diesel vehicles.

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