Current status and prospects of biomass technologies in Japan - Use of bioethanol

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Summary

This paper reviews the progress and present status of biomass energy in Japan and introduces the newest research concerning bio-fuel. In addition, the reduction of carbon dioxide is briefly discussed.

Japan is obliged under the Kyoto protocol to reduce carbon dioxide emissions to about 14 percent below 1990 levels by 2012. The scheme of "Biomass Nippon" ("*Nippon*" means Japan in Japanese) was established as a government plan in 2002. The target of this scheme is the achievement of a sustainable society through general biomass utilization based on market-based efforts. In August 2003, the law for "a warranty on volatile oil" was established in Japan. This law permits up to 3% ethanol in petrol. Because of the limited experience with ethanol blends in our country, research and experiment under various conditions will be necessary for future acceptance. And, information for fuel distributors and dealers, who have not had any experience using such blends, is also of great importance.

In 2004, a project was started in Hokkaido (Tokachi area) to raise awareness and understanding of biofuels. The project also included experimenting with alternative fuel materials and their effect on vehicle engine performance. Irregular wheat was selected as the raw material and the production cost per liter was calculated. The experiments under various testing conditions (temperature; -30 deg C to + 10 deg C) were carried out on car performance and tanking facilities at Obihiro University of Agriculture and Veterinary Medicine.

These experiments demonstrated the feasibility of using 3% denatured ethanol blended with 97% gasoline for gasoline vehicles in cold regions.

Key words: biomass, biofuel, biogas, BDF (Bio Diesel Fuel), bioethanol

Introduction

According to the latest statistics, bioenergy and biobased products - such as crops, trees, and agricultural, industrial, municipal and forestry waste – amount to 1,757PJ/y. Of this amount, 1,327PJ/y (75.5 percent) is usable as energy. Examples are shown in Table 1. Wood biomass occupies 52% of total volume and about 20% is biomass from agricultural processes (animal waste and crop residue).

We can gain bioenergy and biobased products from biomass. And we derive products - such as food and feed, heat and electricity, fuels and lubricants, paper, clothing and other products - from bio-resources, while a great interest has to be put on the feed problem. The self-sufficiency ratio of food in Japan is about 40% (2003). The cause of this low self-sufficiency is due to the low importance placed on it. The rate of feed production in daily farming has decreased to 23.6% (2003). To stabilize daily farm management the increase of self-sufficiency is an important subject.

On the other hand, the Kyoto protocol on global climate changes came into effect this February (2003) by Russian ratification last November. Japan is obliged under the Kyoto protocol to reduce carbon dioxide emissions to about 14 % below 1990 levels by 2012. For the Kyoto protocol the biggest problem is the refusal of the USA, the biggest emitter of carbon dioxide, to ratify the protocol. As Japan is the host country of the Kyoto protocol, the government has to support the Kyoto protocol at all costs. The exercise of Japan's premier role is also important in obliging the Kyoto protocol.

Table1. Bioenergy volume (PJ/y)

Wood	438
Wood (paper industries)	254
Garbage	287
Animal waste etc.	185
Crop residue	84
Sewage	78

The Kyoto protocol demands that developed countries lower their carbon dioxide emissions, relative to the amount of emissions in 1990, to cope with global climate changes caused by the warming effect of carbon emissions and other GHG (greenhouse gasses) sources, mainly as a result of burning fossil fuels.

Developing countries are particularly vulnerable to the effects of climate changes and adaptation is a top priority for them. Developing countries are at greater risk than developed countries, but they are less well prepared to face up to those effects. And current knowledge of adaptation and adaptive capacity is insufficient. The development of new technology has to be urged to reduce vulnerability.

The national vision for biomass technologies

The scheme of "Biomass Nippon" ("*Nippon*" means Japan in Japanese) was established as a government plan in 2002. The target of this scheme is to achieve a sustainable society through general biomass utilization based on market-based efforts. The scheme has set goals that should be attained as soon as possible.

These are:

- **Biopower** - By 2010, biomass electric energy will increase to 330,000kW (340,000kL equivalent to crude oil; 6 times greater than 1999). Biomass consumption in heat utilities will increase to 670,000kL (equivalent to crude oil).
- **Biobased products -** Manure utilities will increase to 40,000,000t.

The strategy for achieving these goals will require significant developments in the field of technical research, including IT and an appropriate understanding and cooperation of people concerned with biomass technologies. And advances in research will accelerate integrated production of biofuels, electric power, and bioproducts by introducing effective biorefineries. Similarly, a proper mix of market and political measures will also require making competitive conditions in biomass technologies.

This vision was established as a challenge for enabling us to leave sufficient resources for the next generation and to lower carbon emissions that will cause global climate changes.

Current status of biofuel in Japan

Biogas

In recent years, manure management in daily farming has been an important problem that needs a solution. Biogas plants are expected to be an effective solution to the manure management problem; and, in addition, the benefits of biogas plants are renewable energy production and efficient organic waste recycling as fertilizer. Consequently, biogas plants can help to lower GHG emissions. Biogas is usually utilized for gas engines for CHP, and it is used by daily farmers. The application of biogas for fuel cells has also been researched in several institutions. But the most serious problem is the running cost. To solve this problem, the sale of biogas needs further discussion.

BDF

Biodiesel has enjoyed widespread acceptance as a vehicle fuel due to planned tax exemption policies that recommend its use. In Germany, for example, where diesel engines power close to 40% of passenger cars, biodiesel consumption in 2004 was about 3.3% of the total diesel market.

In 2002 the Japanese government published the “Biomass Nippon” scheme to promote the greater use of biomass fuels that include the production of biodiesel fuel from rapeseed, sunflower and frying oil. But the use of BDF is extremely limited. Standardization and the effective production of BDF is being enthusiastically researched now.

Bioethanol

Ethanol is known as ethyl alcohol produced from biomass. It contains hydrogen and carbon like gasoline, but also contains oxygen in its chemical structure. The oxygen makes ethanol cleaner than gasoline. It can be produced biologically from biomass. On the grounds’ of such a production system, it is classified as a renewable fuel. And it is accepted as a neutral carbon fuel by the Kyoto protocol.

Brazil and the USA are world leaders in the production of ethanol and its usage. The usage of bioethanol as a fuel begins with the processing of raw materials for vehicles with different types of engines. Moreover this usage has external effects such as lower emissions and other marginal values. Sweden has already come a long way with approximately 1.2% use of biofuels in the transport sector and can now expand its established production of cereal-based ethanol. 5% of the fossil fuels have already been replaced by bioethanol. Bioethanol has obvious advantages when compared to fossil fuels with regard to emissions such as hydrocarbons, nitrogen oxide, etc...

Alcohol fuel blends are designated by E for ethanol or M for methanol, followed by a number representing the percentage of alcohol by volume in the blend. Additional gasoline is added to the ethanol to make up the desired percentage in the blend. The fuel E5 is 5% “denatured” (unfit to drink) ethanol blended with 95% gasoline. E100 is 100% denatured ethanol.

In August 2003, the law for “a warranty on volatile oil” was established in Japan. Under this law, blends of up to 3% ethanol ,known as E3(97% gasoline and 3 % ethanol) were permitted. Many related technical problems, and handling procedures for safety and refueling equipment for ethanol fuel have been researched. Distribution is a very important part when introducing a new fuel. Tanking facilities and dispensing equipment are also essential factors that need development in the infrastructure. It should be easily available to customers, without requiring a big investment or freight cost for distributors. For these reasons, the popularity of E3 fuel has not progressed. Because of the limited experience with ethanol blends, research and experiments in various surroundings will be conducted for wider acceptance. And, it is also very important to provide information from experiments to fuel distributors and retainers who have not had any experience with ethanol blends.

In 2004, a project was started in Hokkaido (Tokachi area) to surmount the above situation. Agriculture in Tokachi is based on upland farming and livestock. Tokachi is one of the most important food producing regions in Japan. The main agricultural products are wheat, potatoes, beans, milk and beef.

The aims of the project are to:

- Discuss the raw materials available for fuel ethanol (including prices and taxation)
- Contribute to the technological development of the usage of engine alcohols in cold regions
- Develop the infrastructure for the usage of ethanol blend fuels (distribution systems and tanking facilities)

Figure1. Test car and tanking facility

The project also includes the selection of raw materials and evaluation of engine performance.

Irregular wheat was selected as the raw material and the production cost per litre was calculated. The cost of the required raw materials was 22,000 yen per ton and the production cost of ethanol was 98.4 yen per litre.

Experimentation (testing conditions; -30 deg C to + 10 deg C) is being carried out on car performance and tanking facilities at Obihiro University of Agriculture and Veterinary Medicine.

The volatile property of ethanol is lower than gasoline. Ethanol's low volatility means increased difficulty in starting at low temperatures. Ethanol-fueled vehicles may be hard to start when the engine is cold, especially in cold regions.

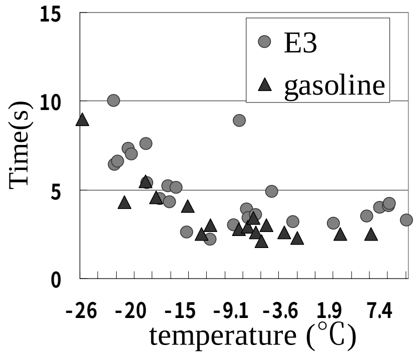

Figure2. Required time for starting

In our tests, the characteristics of starting and acceleration in the E3-fueled vehicle did not show a significant difference from vehicles running with gasoline only in cold regions (*Figure 2*). Surveys of the emissions from these tests show that there is a reduction in carbon monoxide for all temperature ranges (*Figure 3*). The only problem was that gaskets and packing of the refueling system became deformed after a short time (*Figure 4*).

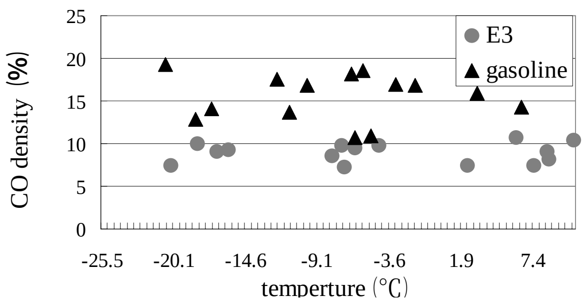

Figure3. Temperature and CO density

Experiments, hereafter, will be carried out on fuel consumption for ethanol-fueled cars, the durability of tanking facilities, phase separation of ethanol gasoline blends in contact with water, and the usage of E3 fuel for agricultural machinery.

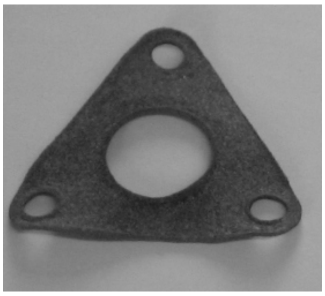

Figure4. Deformation of cork gasket material

Some materials are known to become degraded by contact with ethanol. Aluminum, brass, and lead etc. are sensitive materials for ethanol. E3 fuel has been permitted by being compatible with gasoline use for vehicles and refueling systems. However, given the limited experience, research and testing is expected to continue for more successful operation of ethanol-fueled vehicles.

Phase separation of ethanol gasoline blends in contact with water is also very important problems, especially in cold regions.

Conclusion

In this paper, the present status of bioenergy was briefly introduced, and the usage of E3 fuel was described. At present, we have to consider environmental problems, food security and energy issues simultaneously. These three issues we refer to as a tri-lemma.

In June 2005, the posted price of crude oil reached a record-high price of over 60 dollars per barrels in the USA. While the focus on conversion of hydrogen gas into electricity has taken on surprising speed. A multi-faceted approach must be key to resolving the present-day tri-lemma structure.

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