Alternative Fuel Implementation Policy in China and its Assessment[1]

By Yue ZHANG *, Chong Siang CHEW **

1. Introduction

In China, the remarkable pace of economic growth it has achieved in recent years is driving such demand factors as a rapid rise in the number of private car ownership and causing a sharp increase in consumption and importation of petroleum. On the other hand, the country is pressed to take appropriate actions for environmental protection to deal with problems such as serious air pollution, or on energy security issues including construction of oil stockpiling facilities. In the face of soaring international oil prices occurring at the same time, the Chinese government has been launching a succession of domestic policy measures to promote, among others, energy conservation, construction of oil stockpiling facilities, or the use of alternative fuels in place of oil.

Focusing specially on the issues of alternative fuels among the above measures, this paper attempts to provide an overview of the background and salient points of the policy for promoting alternative fuels that the Beijing government currently takes, and examine the current status of developing and implementing alternative fuels produced from both energy crops and coal resources. The paper also makes an endeavor to grasp the discussions at the various organizations and agencies concerned and the process of establishing relevant policy instruments, and to evaluate and analyze the alternative fuel promotion policy in China and its challenges. Lastly, future direction of the alternative fuel implementation in China and its impact on Chinese as well as international oil markets are examined.

2. Background of the policy to promote alternative fuels

Since implementation of a market-oriented economic reform in the late '70s, China's economic growth has continued for many years and, keeping pace with it, its energy consumption has also continued to increase. China's annual primary energy consumption in 2005 reached 1,550 million tons of oil equivalent, in which petroleum consumption was 340 million tons and accounting for 22% of the total consumption (see Figure 1). On the

[1] This paper has been prepared by supplementing and editing a presentation for "The 23rd Conference on Energy, Economy, and Environment" held during 25-26 January 2007 in Tokyo.

* Researcher, International Strategy Analysis Group, Strategy and Industry Research Unit, Institute of Energy Economics, Japan (IEEJ)

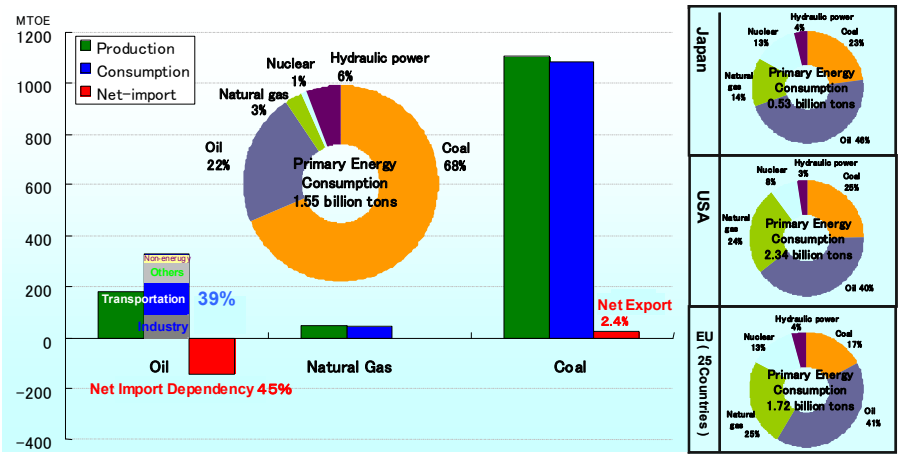
** Researcher, New & Renewable Energy Group, Strategy and Industry Research Unit, Institute of Energy Economics, Japan (IEEJ)

other hand, the domestic crude oil production in China has remained roughly flat for the last 15 years and, in 2005, it was no more than 180 million tons. To cope with the vigorous demand that continued to expand, the volume of petroleum import had to be increased rapidly and, in 2005, it exceeded 150 million tons and the oil import dependency rose to as high as 47%. As for other types of energy, while China still maintains a net-exporting position for coal, as LNG import began in Guangdong Province in 2006, it became a net importing country for natural gas as well.

Further examination of the consumption figures reveals that 130 million tons or approximately 40 percent of the total petroleum consumed in China in 2005 was for the transportation sector, and petroleum demand in the road transportation sector increased more than 10 million tons during the 2004-2005 period. Moreover, automobile sales, which significantly affect petroleum consumption, reached 7.7 million units in 2006, recording a year-on-year increase of 25%. With such a scale of expansion in fossil-fuel consumption, environmental burdens such as air pollution are aggravating.

According to a forecast[2] by the International Energy Agency (IEA), the crude production in China will decline to 140 million tons by 2030. By contrast, petroleum consumption will expand to 760 million tons, necessitating a net petroleum import of 620 million tons. This will bring China's oil import dependency to more than 80%, thereby making it the largest petroleum importing country in the world.

[Figure 1] China's Primary Energy Balance in 2005



Source: The BP Statistical Review of World Energy 2006

[2] IEA "World Energy Outlook 2006"

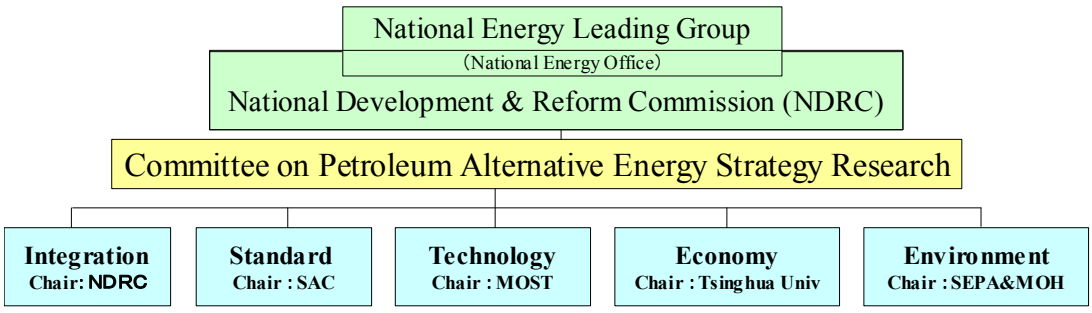
3. Policy measures concerning alternative fuels for replacing oil

Under such circumstances as mentioned above, the Chinese government has decided to aggressively promote the use of alternative fuels in the transportation and industrial sectors as one of the strategic movements to suppress petroleum consumption and the oil import dependency. In the "11th 5-year Development Plan" implemented since March 2006, clear guidelines were provided concerning alternative fuels for replacing oil (hereinafter, petroleum alternative fuels). More specifically, the guidelines refer to policy measures for developing coal liquefaction and gasification technologies as well as accelerating the introduction of biofuels, thereby to promote petroleum alternative fuels. Also explicitly stated in the above plan is a policy to promote the production of methanol or dimethyl ether (DME) by utilizing by-product gases available from industrial processes.

Concerning the biofuel development, the "Medium to Long-term Renewable Energy Development Plan" (May 2006) elaborates related policies more specifically. Among others, the plan sets the utilization goals of 2 million tons and 10 million tons respectively for 2010 and 2020 for bio-ethanol fuel, and likewise, 0.2 million and 2 million tons for bio-diesel fuel. To help achieve these goals, subsidy programs and preferential tax systems have been incorporated in the plan.

Additionally, in December 2005, the National Development and Reform Commission (NDRC) launched a "Committee on Petroleum Alternative Energy Strategy Research" (see Figure 2) under the instruction of the State Council to deliberate the future development policies for petroleum alternative energy among the concerned parties. While the findings of the committee and recommendations for specific policy measures were submitted to the central government at the end of 2006, the total picture is not available as the conclusions of the study by the committee have not been publicized.

[Figure 2] Composition of the "Committee on Petroleum Alternative Energy Research Strategy"



Sources: Prepared from various publications

4. Current status of the petroleum alternative fuels implementation in China

4.1 Introduction of biofuels as petroleum alternative fuels

(1) Background:

Employing environmentally superior biofuels to cope with the ever-increasing automotive fuel demand has an important meaning as it helps in the substitution of petroleum and contributes to improvement of the environment. Nonetheless, efforts towards biofuels by the Chinese government had originally begun as a means to help with disposal of old food stocks or spent cooking oil.

(2) Bio-ethanol fuel:

China's food production turned from the previous shortage to surplus thanks to bumper crops during the 1990s, resulting in excess food stockpile. Since the food reserve had been maintained with subsidies, such excess stockpile put a heavy financial burden on administrative agencies, thus prompting the Chinese government's decision to promote ethanol production by utilizing stale food stocks. China's production of bio-ethanol for automotive use was 1.02 million tons[3] in 2005, which was the third largest in the world following Brazil and the U.S.A., and in terms of E10 fuel[4], equated to approximately 20% of the total automotive gasoline consumption of 52.1 million tons that year. While E10 fuel is currently implemented in five provinces (Heilongjiang, Jilin, Liaoning, Henan, Anhui) as well as 27 cities (nine in Hubei Province, six in Hebei Province, seven in Shandong Province, and five in Jiangsu Province), expansion to major cities such as Beijing or Shanghai is expected in the future.

Furthermore, the Chinese government announced the "11th 5-year Plan for Ethanol and Automotive Ethanol Fuel" at the end of 2006, in which the target volume for the bio-ethanol production in 2010 was raised to 5 million tons[5] from 2 million tons stated in the "Medium to Long-term Renewable Energy Development Plan" mentioned earlier.

(3) Bio-diesel fuel:

China's consumption of diesel fuel in 2005 was 117 million tons[6] and roughly twice as large as the gasoline consumption. On the other hand, production of bio-diesel fuel in the

[3] According to statistical data by F. O. Lichts, total ethanol production in China including bio-ethanol for automotive use was 3,850,000 kl in 2006.
[4] The "E10" refers to a fuel blended with 10% bio-ethanol and 90% gasoline.
[5] Although the timings of announcement of the two targets are only half a year apart, no explanation has been made by the government for an amendment of the policy target.
[6] According to "China's Petroleum Supply and Demand Trends and Security Strategy", by LIU Keyu, 9 February 2007, the share of diesel fuel for automotive use (i.e. diesel-engined cars and farm trucks) in the total diesel fuel consumption in China was 41.4% or 48.45 million tons in 2005.

same year was only 60,000 tons. There are twenty or so small-scale production companies, all of them with annual production capacities of less than 3,000 tons. It is noted here that the Chinese government's production target for bio-diesel fuel is set at a modest level of 200,000 tons in 2010, possibly for the limited availability of raw materials and the delay in required technical development which is behind ethanol.

While bio-diesel fuel is produced by small businesses mainly from used waste cooking oil as raw material at present, production is expected to grow by using feedstock based on oil crops such as jatropha or rapeseed in the future. Since the government is developing a subsidy system under a policy to expand the use of biofuels, providing the supplying enterprises with more incentive to increase production, there is a possibility that the above-mentioned goal could be revised upward.

4.2 Introduction of coal-based petroleum alternative fuels

(1) Background:

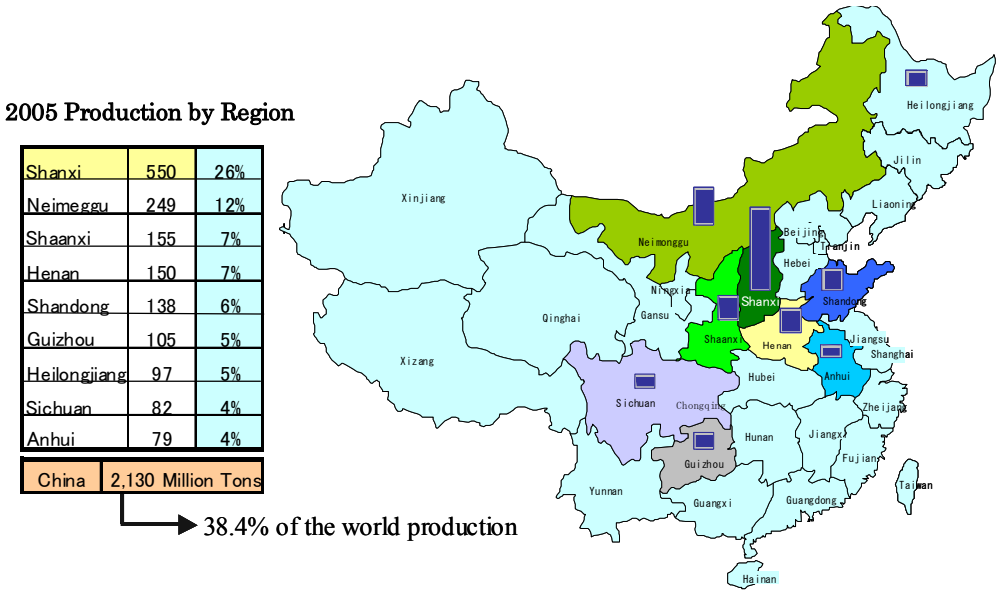
Abundant coal reserves in China have underpinned its economic development to date, and its future development could not be discussed without considering coal. China is a net exporter of coal with its proven reserves accounting for 12.6% of the global total at the end of 2005 (see Figure 3). The coal reserves are mainly distributed in mid-China regions where Shanxi Province, Shaanxi Province and Inner Mongolia Autonomous Region comprise the main coal producing regions.

On the other hand, many problems have often been pointed out mainly concerning the above coal producing regions, including air pollution caused by smoke and soot, or wasteful utilization of coke oven gas, coal-bed gas, or low-quality, high-sulfur coal. Production of coal-based petroleum alternative fuels is being promoted against this background, and to better utilize these coal resources, nurture new industries, and improve on the environmental burdens.

(2) Coal liquefaction (Coal-to-liquids, or "CTL"):

The CTL technologies provide an important option for petroleum alternative fuels in China, where there are abundant supplies of unutilized coal resources. At present, the CTL technologies are considered to offer the earliest possibility of realization and therefore the most promising option available for the coal-based petroleum alternative fuels. Both direct and indirect conversion processes are concurrently being developed.

[Figure 3] China's Coal Reserves Distribution



Source: China State Administration of Work /Coal Mine Safety

Currently a large-scale liquefaction project representing a direct CTL process is under way by a group led by the largest coal producer, Shenhua Group, for construction at Shendong Coal Mine located in Erdos, Inner Mongolia. The project started construction in 2004 and will be completed in two phases, with a planned annual production of 1.08 million tons initially in 2007 to be expanded to 5 million tons eventually. Concerning the indirect liquefaction process, two projects are being developed by Ningxia Coal Industry Group, which was acquired by Shenhua Group in 2006, and also by the Province of Shaanxi. Both projects are planned for annual production of 3 million tons each in 2010, to be eventually expanded to 5 million tons each.

Despite the progress as mentioned above, it is generally considered that CTL projects require a huge amount of initial investment as well as considerable consumption of electricity and water in the production process, thus creating high environmental burdens. While promoting the above-mentioned CTL projects, the Chinese government has announced a policy to prohibit local governments from approving small-scale CTL projects having annual production capacities of less than 3 million tons.

(3) Methanol:

Research and development work as well as demonstration tests for methanol as a petroleum alternative fuel have been undertaken since the '80s and chiefly in Shanxi

Province. During the period of the "10th Five-year Development Plan" (for 2001-2005) the Ministry of Science and Technology of China launched a "Clean Fuel Car Program" (2003). As a part of the program, a fleet of 25 buses fueled with M100 (i.e. 100% methanol) was introduced for demonstration by public bus service in Shanxi Province (Taiyuan City, Route #901), which is still continuing its operations today. In other parts of Shanxi Province, a total of four public bus companies are operating some of their fleet with M85 fuel or those with higher methanol content. In Taiyuan, about 300 taxis retrofitted for using M15 fuel and another 110 taxis modified as Flexible Fuel Vehicles (FFV) have been introduced. Elsewhere, several methanol demonstration tests are in progress in the coal producing regions such as Shaanxi Province, Henan Province, Inner Mongolia, and Xinjiang Autonomous Region.

However, Chinese experts in the related field are rather wary of promoting methanol-fueled vehicles. At the current stage of development, there are a number of unresolved technical issues in areas such as modifications required for the fuel distribution system or engine internals for the vehicle itself, cold starting characteristics, exhaust emissions, or safety management. Among these issues, the Chinese government is particularly concerned with the issue of formaldehyde emissions, and has not made clear its stand on the methanol fuel as yet. However, the above situation does not seem to alter the importance of methanol fuel as an option for China, as long as it has rich coal resources.

(4) Dimethyl ether (DME):

Unlike the case of methanol, the Chinese government has indicated definite support and a specific development plan for DME. In July 2006, the NDRC distributed to local governments and municipalities a circular entitled "The DME Industry Development Forum Minutes" and indicated a policy of bringing the DME production to a much larger scale in the future by utilizing coal as feedstock. At the initial stage of the implementation plan, DME will be introduced as an alternative to LPG mainly for household use in the coastal regions having greater economic strength.

Meanwhile, experiments on the use of DME as an alternate automotive fuel have been undertaken, led mainly by Shanghai Jiaotong University and Xi'an Jiaotong University, with demonstration tests using DME-fueled buses taking place in Linyi City in Shandong Province and Shanghai during 2006. The Shanghai Municipality has announced a plan in which its DME- fueled bus fleet will be enlarged to 1,000 vehicles by the Shanghai World Expo in 2010.

As of the end of 2005, annual DME production capacities of 1.3 million tons existed in plants located in Shandong Province, Ningxia Autonomous Region, and elsewhere, while the total production capacity currently under planning reportedly exceeds 6 million tons nationwide. In order to restrain over-investment into DME projects, the Chinese government has decided to apply a policy of approving only those having an annual production scale of one million tons or more in the case of projects to produce DME from coal feedstock.

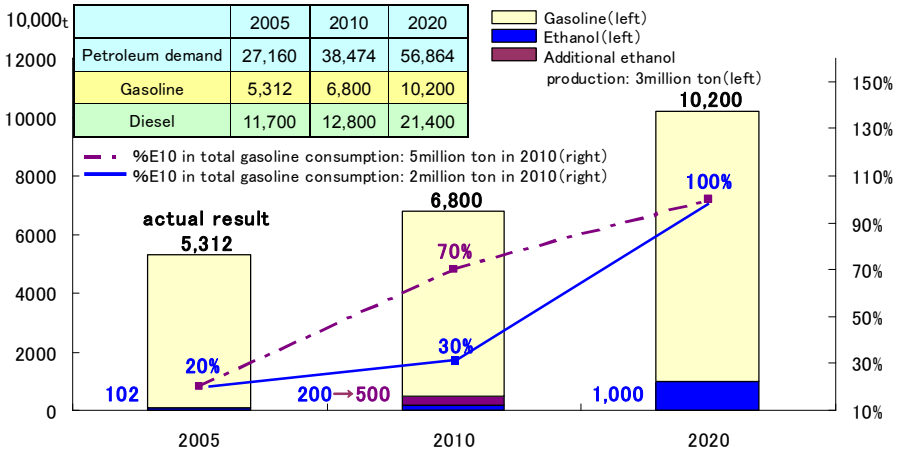
5. Outlook on petroleum alternative fuel implementation

5.1 Forecast on market size for bio-ethanol:

In the following sections, attempts will be made to forecast the market size for petroleum alternative fuels for automotive use in China. According to a study by IEEJ, China's demand for gasoline and diesel fuel is estimated at 68 million tons and 102 million tons respectively for 2010, and 102 million tons and 214 million tons respectively for 2020 (see Figure 4). Using these estimates, and assuming the production of bio-ethanol is to be expanded to 2 million tons or 5 million tons by 2010, according to the announced government targets as mentioned before, the bio-ethanol usage in the total gasoline consumption based on E10 fuel will increase to approximately 30% to 70%.

In terms of estimated fuel ethanol demand in 2020, on the basis of E10 fuel and a 100% usage rate, 10.2 million tons of supply will be required. This figure roughly coincides with the 10 million tons targeted for 2020 by the Chinese government.

[Figure 4] Forecasted Gasoline Demand Reduction by Bio-ethanol Use



Source: Prepared from "Supply and Demand Analysis on Petroleum Products and Crude Oils for Asia and the World - FY2005 Investigative Research on the Petroleum Industry", by IEEJ

5.2 Forecast on market size for other petroleum alternative fuels:

Meanwhile, compared to the diesel fuel demand that is expected to rise to 214 million tons by 2020, the production target of bio-diesel remains low at 2 million tons. When calculated on the basis of B5 fuel[7], that amount of bio-diesel could cover approximately 20% of diesel fuel consumption. However, to supply the entire diesel fuel consumption, at least 10 million tons of bio-diesel is necessary.

Information on the future prospect of petroleum alternative fuels sourced from coal is tangled and confusing at present, including a plan[8] announced by the NDRC which states expected production to grow to 30 million tons of CTL products, 20 million tons of DME, and 66 million tons of methanol by 2020.

6. Discussions on challenges in promoting petroleum alternative fuels

6.1 Challenges surrounding promotion and expansion of bio-ethanol:

Although China's effort in expanding the use of bio-ethanol as an automotive fuel seems to have progressed smoothly so far, it faces a number of challenges in expanding the production to satisfy the future demand. First, according to a study conducted in China, while it is estimated that up to 6 million tons of bio-ethanol could be produced annually until 2010 with the present system based on old food stocks as raw material, there is a possibility that supply of such raw material could become insufficient in the future. With further expansion of bio-ethanol usage and demand, it seems that a shift in feedstock selection is expected to occur toward crops that do not have an impact on food supply, including non-staple food crops such as cassava, sugar cane, sorghum, sweet potato or cellulose wastes.

Next, with the expansion in production and use of bio-ethanol, the Chinese government is reducing the subsidies for the production of bio-ethanol for automotive use in an effort to assist development of self-supporting capability of the industry. The subsidy rate in 2005 of 1,883 yuan per ton of bio-ethanol produced was reduced to 1,628 yuan in 2006 and subsequently to 1,373 yuan in 2007, and is planned to be abolished in 2008, according to a report.

It is also expected that production by several new companies will be approved since the production by the five companies designated for the existing production system can not meet the growing demand. If such a trend is to continue in the future, cost reduction and the improvement in competitiveness in bio-ethanol production will become important factors.

Further, along with the popularization and expansion of bio-ethanol usage, problems

[7] The "B5" refers to a fuel blended with 5% bio-diesel fuel and 90% petroleum diesel fuel.
[8] "East & West Report", Tozai Boeki Tsushinsha, 19 December 2006, Page 6

related to vehicle hardware are also pointed out. Although at present China has introduced E10 fuel without retrofitting vehicles, in the related standards established in Japan, the maximum permissible blending ratio for bio-ethanol applicable without engine modification is set at 3%. At ratios exceeding 3%, it is pointed out that there is a possibility of damage to the vehicle or accidents due to problems such as corrosion. It seems that China will need to study more on the development and production of E10 compatible vehicles and FFVs for the popularization and expansion of bio-ethanol in the future.

6.2 Issues concerning other alternative fuels:

As for bio-diesel fuel, in view of the large scale of demand expected for the future, development of fuel quality standards and establishment of production systems having a comparable supply capability are urgently needed. Currently, SINOPEC is taking initiatives in developing a fuel quality standard for bio-diesel fuel, which is expected to clear government review and approval in the near future to pave the way for full-scale implementation and popularization of the fuel.

Concerning CTL-based fuels, for the coal liquefaction project currently under construction by Shenhua Group with cooperation by Sasol in South Africa, it is reported that an international crude oil price of $40 to $50 per barrel would be required for the project to break even. As an added factor, since the domestic petroleum product prices in China are presently regulated by the central government at a level lower than that of the international oil market, the situation is affecting the sales of CTL products as well as the project profitability. Further, the discussion on whether the production of fuel products through coal liquefaction is efficient or not from the viewpoint of energy utilization remains open, because of the high energy consumption throughout the lifecycle of the products.

The largest obstacle for the popularization of methanol for automotive use is the issue of formaldehyde remaining in exhaust emissions. Although experiments are actively conducted with a view to full-scale introduction of methanol fuels based on either M15 or lower methanol content, or M85 or higher methanol content, mainly in Shanxi Province in coordination with Shaanxi Province and Inner Mongolia and for use with taxis or buses, the technology has not been established nor verified due to lack of proving data. Because of this, the Chinese government is still unable to proceed with full-fledged implementation of the methanol fuel. While the demonstration tests are expected to continue for another three to five years, the possibility of popularization may decline unless a technological breakthrough is achieved.

Meanwhile, the implementation of DME is being brought forward with an objective of introducing it as an alternative fuel to LPG for household use, where approximately 10% to 20% of DME was reportedly blended into 13.5 million tons of LPG used in the household sector in 2004. The ratio of DME blended is expected to rise as the future production grows, which is forecast to reach 16 million tons by 2010. While currently there are plans to build three pipelines from the production center in Inner Mongolia to areas around Beijing, establishment of a supply system is the challenge to be taken from now on.

6.3 Issues common to all petroleum alternative fuels

First of all, to promote the implementation of petroleum alternative fuels it is indispensable that all parties concerned cooperate with each other. The Chinese government is trying to convince the related parties that the implementation of petroleum alternative fuels has significant benefits in the aspect such as a stable supply of petroleum or improvement on environmental problems in China. However, as the introduction of petroleum alternative fuels could lead to a reduction in existing business for oil companies and an added cost in engine modifications for large automotive companies, they do not appear enthusiastic about the subject. Nevertheless, the two state-run oil enterprises, i.e. CNPC and SINOPEC, are deeply involved in production and marketing of bio-ethanol and CTL/methanol respectively, to maintain their fuel marketing shares after the implementation of petroleum alternative fuels. Similarly, the largest food and grain supplier, China National Cereals, Oils & Foodstuffs Corp. (COFCO), and also the largest coal supplier, Shenhua Group, are each taking initiatives in the production of bio-ethanol and DME. All of the above-mentioned enterprises are competing with each other with conflicting interests around the petroleum alternative fuel policies and pursuing strategies to secure their own market positions. Since all of the enterprises named above are large state-run corporations representing respective business fields in China, they have a strong influence over the policy formulation process in the central government. It is therefore extremely important that these parties cooperate with each other for smooth implementation of petroleum alternative fuels.

Next, it is also important to make a system of product distribution available together with the implementation of petroleum alternative fuels. At present, no standard has been established for the above-mentioned petroleum alternative fuels with the exception of bio-ethanol fuels. Also, in the case of introduction of bio-ethanol, inspection systems for monitoring the blending ratios appear to be inadequate and the same could be said of the introduction of bio-diesel fuel and the experimental introduction of methanol as well. Moreover, to cite an extreme example, in Henan Province, which is implementing

bio-ethanol fuels, an experiment based on methanol fuels is also being conducted in a part of the province. As a result, there will be vehicles using bio-ethanol based gasoline blends and those using methanol based gasoline blends mingling together. All of the above illustrates the importance of improving recognition and understanding of petroleum alternative fuels on the part of consumers, and also indicates that the reinforcement of operations and management in the distribution systems appears to be an important issue for the future promotion of such fuels.

Finally, the promotion policies of petroleum alternative fuels by the Chinese government could affect the international market prices for farm crops and fuel products. For instance, an increased import of ethanol producing crops, or a reduced export of coal due to increased domestic demand can both impact the respective international market prices considerably.

7. Conclusion and summary

As a conclusion of the above discussions and examination, future direction of the alternative fuel implementation in China and its impacts are summarized as follows:

An energy substitution policy ideally suited for China should take a two-pronged approach of promoting renewable energy as well as fossil energy with both elements working like a set of wheels. For the next fifteen years, implementation of biofuels will accelerate and development of coal-sourced liquid fuels will become the main focus of the petroleum alternative energy policy. For the implementation of bio-ethanol fuel (E10), establishment of a system with which securing raw material does not affect the food supply system becomes an important issue, and development of ethanol production technologies based on cellulose wastes and the like will become an important key. Meanwhile, as for coal liquefaction products, their use as petroleum alternative fuels is an important option for China that has rich unutilized coal resources, and there is a possibility of a significant growth for coal-based liquid fuels as a result of further development in coal liquefaction technologies.

However, since the distribution of resources in China is uneven and varying from region to region, development with a pluralistic approach should be sought so that a suitable petroleum alternative fuel for any region will be chosen based on the actual state of resource endowment and distribution, and the industry composition as well as the energy balance within the region. Additionally, in implementing petroleum alternative fuels, establishment of a safe production and distribution system is required along with

considerations towards the natural environment and health and safety of the people.

It should be also noted that, while introduction of petroleum alternative fuels is one of the means for easing pressure on the petroleum supply and demand and improving the present situation of air pollution, the impact of its implementation appears to be far less than the extent of the petroleum demand expansion in China, which tends to obscure the effects of the substitution measures. Accordingly, comprehensive measures must be sought including an effort for improving vehicle fuel economy by the automobile industry, or policies for energy conservation, stricter emissions standards, or other relevant measures. While introduction of petroleum alternative fuels is expected to contribute to stabilization of the Chinese as well as the international petroleum markets, if its achievement falls short of the expected goal, such measures could end up having only a limited impact on the overall picture.

Bibliography:

1) "Direction and Policy Issues of China's Petroleum Alternative Energy" (2007), by YU Zhufeng, "China's Energy Supply Demand Balance - Trends, Policy Issues, and Sino-Japan Cooperation, IEEJ Energy Seminar

2) "Possibility of Oil Substitution in Automotive Field in China – Present Status, Policies, and Long-term Prospects for the Oil Substitution", by CHEN Zhongyuan, IEEJ Website (2006)

3) "China's Medium to Long-term Renewable Energy Development Plan - Promotion of Bio-ethanol Introduction and Future Strategic Developments", by CHEW Chong Siang, IEEJ Website (2006)

contact: report@tky.ieej.or.jp