

## Biofuel development in China and its potential impacts

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- **Background**

China has undergone over 30-years fast development that nowadays it is one of the largest economic entity among the world with expanding energy demand. Increasing proportion of imported energy as well as other resources has become serious security problem for China's sustainable development. To be noted, the oil consumption in China reached 365.7 mmt in 2007, and 53% of which was imported.

Along with increasing fuel consumption and energy imported, environment problem became serious during recent decades as well. Air pollution and greenhouse gas emission has threatened the development and human well-being that the awareness of environment protection has been raised. For instances, the air pollution problem of main cities like Beijing, Shanghai, Tianjin has raised great public concerns about the country's development mode and urged the society to increase investment and improve the governance over the economy and environment. At the meantime, the search for clean energy became urgent and bio-fuel at this time stepped into the middle of the stage.

Generally, the bio-fuel industry is beneficial for China's agricultural and rural development. Massive lands of low soil fertility could be reused for crops like sweet potato, cassava, which are main feedstocks for bio-fuel production. The health and fertile of the lands can be remained with suitable bio-cycle. Besides, the rotting grains that used to be wasted could be used for bio-fuel production directly without complex pre-processing. In this way, the farmers as well as the whole agriculture sector could benefit from ecosystem maintenance, efficient land usage and economic interest. The whole society could also benefit from reduced fossil fuel consumption, improved human well-being and sustainable development system.

Since 2000, China has established a series of policies to promote bio-fuel productions and managed to upgrade its energy structure. With full consideration of the food security and water consumption, the biodiesel production were carefully regulated and developed. Until today, China has established a complete bio-fuel industry system. Although that the output is still insignificant comparing to the huge total energy consumption.

Although that the society and humans can benefit from biofuel production, the concerns about feeding the world's most populous nation could limit the growth of the biofuel industry. The food security is always one of the top issues for China.

- **Laws and policies for biofuel development in China**

The laws and policies play important roles for biofuel development in China. In 2001, “National Standard of Denatured Fuel Ethanol” and “National Standard of Vehicle Bioethanol” were officially released, laid the foundation of the fuel ethanol industry in the following years. The massive investment in 2002 (5 billion RMB on the pilot experiment bioethanol production in Henan, Heilongjiang, Jilin and Anhui) led to earliest consumption of E10. After the establishment of “Expanded Pilot Testing Program of Bioethanol Gasoline for Automobiles” in 2004, the E10 has been used in transportation sector in 9 provinces of China.

After a series of attempts about promoting the experiment about biofuel application and production, the law of “Renewable Energy Law” was released in 2005, encouraging the use of biofuel as well as other renewable energies. Bio-ethanol production reached 1 million tons in this year.

In 2007, a new policy balancing food security and new energy was set up. The biofuel expansion is suggested to be limited to non-cereal feedstocks that produced on marginal lands. The arable land for cereal production must not be substituted for biofuel feedstocks.

The twelfth five-years’ plan (2011-2015) has made a planning objective that the production of fuel ethanol, biodiesel would reach 4 million tons and 1 million tons respectively. The main problems of lacking technology and high cost are projected to be solved or at least partially solved by increasing subsidies, realizing industrialization, developing and applying new technology to lower the cost. Specifically, 5% consumption tax for biofuel will be waved; Biofuel production can receive refunded VAT (17%). Direct subsidy to biofuel plants is 2130 RMB (US\$300) per ton. And subsidy to the biodiesel feedstock production base is 200 RMB/mu (US\$425/ha). These subsidies are designed and applied under a background of all the mentioned encouraging policies and laws over renewable energy.

Generally, as shown in Table 1, in 2012, the total consumptions of bio-energy was about 20 million tons in terms of standard coal, which occupied 0.27% of the total energy consumption of China, as shown in following table. As a part of bio-energy, biofuel played an important role.

Table 1. Bio-energy production of China in 2012

Utilization	Scale		Annual Production		Convert in TCE
	Amount	Unit	Amount	Unit	10,000t/a
Biomass power	5960	MW	14	Trillion Wh	440
Household biogas	40	Million	13	Billion m <sup>3</sup>	930
Large-scale biogas projects	50000		1	Billion m <sup>3</sup>	70
Biomass Briquette	6	Million tons	-	-	300

Fuel ethanol	2	Million tons	-	-	200
Biodiesel	0.6	Million tons	-	-	80
<b>Total</b>	-	-	-	-	<b>2000</b>

- **Biofuel production in China**

- **Fuel ethanol**

Bioethanol, or fuel ethanol, is an alcohol made by fermentation, which is the main type of bio-fuel and also earliest one encouraged by Chinese government. Since 2001, ethanol alcohol gasoline began to be supplied in 9 provinces of Henan, Heilongjiang, Jilin, etc. During “tenth five-years’ plan”(2001-2005), several first generation bio-fuel enterprises were founded. The fuel ethanol production of China has been steadily increasing since 2001 and China is demonstrated in Fig. 1 as below.

Figure 1. Fuel ethanol production in China (2005-2011) (unit: 10,000t)

Since 2006, there are mainly five operating fuel ethanol refineries running, as shown in Table 2. A system of production, compounding, storage, delivery and marketing are established, as indicated in Fig. 2.

Table 2. Main plants for fuel ethanol production in 2006.

No.	Company/Cooperation	Location	Main feedstocks	Capacity
1	China Resources Alcohol Co.	Heilongjiang Province	Corn and rice	180,000t/yr
2	Tian Guan Fuel-Ethanol Co.	Henan Province	Wheat	410,000t/yr
3	BBCA Biochemical Co.	Anhui Province	Corn	400,000t/yr
4	Jilin Fuel Ethanol Co.	Jilin Province	Corn	470,000t/yr
5	Guangxi COFCO Bioenergy Co.	Guangxi Province	Cassava	120,000t/yr

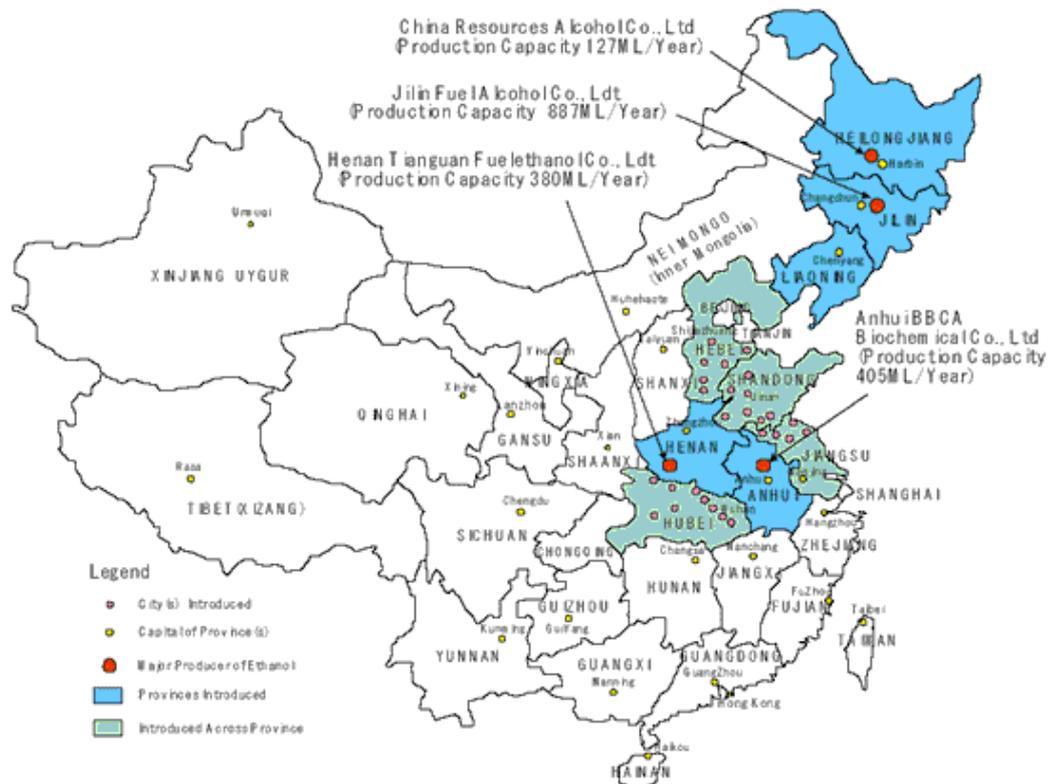


Figure 2. The main fuel ethanol production centers in China in 2008.

However, the fuel ethanol production in China is still at its primary stage in terms of the technology. Most of the fuel ethanol is made from corn, grain and wheat. Concerns about the food supply and high prices of cereal feedstocks led the industry to turn its attention to non-cereal feedstock, such as cassava, sweet sorghum, and sweet potato. They are also main feedstocks for second generation bio-fuel, which will relieve the pressure on arable land.

- **Biodiesel**

Biodiesel is still at its early development stage in China, compared to fuel ethanol. Since 2008, the development of biodiesel speeded up. The principal biodiesel producers are Fujian Zuoyue New Energy Co. Ltd, Sichuan Gusan Biodiesel Co. Ltd, and Hainan Zhenghe Biodiesel Co. Ltd, etc. The provinces of Jiangsu, Shandong, Hebei are places with most biodiesel production, together occupied almost 63% of the total biodiesel production of China in 2012. But recently, the biodiesel industry has undertaken higher pressure from expanding petroleum refining industry and lack of strong incentives from policies. Many biodiesel producers are operating under their production capacity. In 2012, the capacity of biodiesel in China was over 2 million tons that the real output is only 0.88 million tons, just slightly higher than the level in 2010. The problem of over-capacity is becoming acute that the whole industry is backed into a corner.

Figure 3. Biodiesel production in China (2005-2010) (unit: 10,000t)

Feedstock supply is a key factor in limiting biodiesel development in China. Vegetable oils are the main feedstock for plants elsewhere, but it is not economical for China to import them to make biodiesel. The more realistic feedstocks are cooking oil, acid oil and animal fat. Waste oil and grease from Chinese cooking habits are also important economical feedstocks for China. Nowadays, over 1.2 million tons of waste oil in China could be used for biodiesel production instead of being discharged directly into the ecosystem or been used elsewhere.

From a long-term perspective, the nonedible feedstock such as Barbados nut (*Jatropha Curcas*), Chinese pistachio (*Pistacia Chinensis*), Chinese tallow tree (*Sapium Sebiferum*) could be considered to support larger biodiesel industry.

### **(3) Economics**

#### **a. Price**

The price of biofuel is always an important factor when considering the markets. According to data from NDRC, the price of fuel ethanol and biodiesel is quite high. In 2007, the price of fuel ethanol in terms of feedstocks is 5000 RMB/t from corn, 4000 RMB/t from sweet sorghum, 4500 RMB/t from cassava or sweet potato. The price of biodiesel from used cooking oil is about 4000 RMB/t.

The real prices of biofuel are affected by feedstocks' market. Therefore, the change of land use and even the grain market and relevant factors can have significant impact on the biofuel market. The average gross profit of biofuel is relatively low and many small enterprises went bankrupt in recent years.

The price policie has played an balance role in the market. According to *Pilot Program Extension Plan of Ethanol Alcohol Gasoline for Vehicles* and *the Detailed Rules of Implementation for the Extension of the Pilot Program of Ethanol Alcohol Gasoline for Vehicles*, the price of fuel ethanol is set as the price of #90 gasoline times a parameter of 0.9111. And in 2011, the price of fuel ethanol was adjusted as the price of #93 gasoline times 0.9111.

#### **b. Tax**

As mentioned above, in order to promote the biofuel industry. A series of preferential tax policies were established that the 5% consumption tax was waved and the VAT was refunded, for both fuel ethanol and biodiesel industries, which effectively lowered the stress from fixed price.

But since 2011, the preferential tax policies for fuel ethanol have been adjusted along with the development of the industry. From Oct. 1<sup>st</sup> 2011 to Dec. 31<sup>st</sup> 2011, the VAT refunded percentage was 80%, and 60% in 2012, 40% in 2013, 20% in 2014 and finally will call off the VAT refunded policy in 2015. And the consumption tax was collected at 1% from Oct. 1<sup>st</sup> 2011 to Dec. 31<sup>st</sup> 2011, and 2% in 2012, 3% in 2013, 4% in 2014, and finally will reinstate the consumption tax of 5% since 2015.

While the preferential tax policies for fuel ethanol are under adjustment, the biodiesel industry has not been affected.

#### **c. Subsidy**

Since 2011, the main targets of subsidies has transferred from aging cereal fuel ethanol to none-cereal fuel ethanol. According to the production cost and market settings, the quota subsidy for fuel ethanol was from 1500 to 2500 RMB/t before 2011, while after 2011 it declined to about 400 to 500 RMB/t. However, similar as the tax policies, the subsidy policy for biodiesel industry is not changed.

#### **(4) Development plans**

The twelfth five-years' plan (2011-2015) has made a planning objective that the production of fuel ethanol, biodiesel would reach 3.5 million tons and 1 million tons respectively. The main problems of lacking technology and high cost is projected to be solved or at least partially solved by increasing subsidies, realizing industrialization, developing and applying new technology to lower the cost.

According to the revised national plan, the fuel ethanol production will increase to 10 million tons/year by 2020 and the biodiesel will grow to 2 million tons/year by 2020. Under this plan, E10 sales are to expand in more provinces, and E20, E85, B5 and B10 will be introduced by 2020. Although some periodical objectives are not realized as planned but since the target is set, a bright future of biofuel industry in China shall not be sumptuous to be expected.

- **Issues and concerns**

Food security is always a key issue for a populous nation like China. The restricted land resource means that if the bioenergy production expands without clear regulation, the food production will be declined due to loss of arable land, and more imported food from oversea will bring serious security problem. Comparing with national security, the development of bioenergy shall be carefully promoted.

Besides, as a nation that facing serious water shortage, too large biofuel industry will definitely increase the water consumption and aggravate water scarcity. The distribution of water resources among sectors will therefore be changed and the stability of agriculture and even the whole economy may be disturbed. Uncertainty for water, food and energy may lead to imbalance of social structure.

- **Impact assessment**

- **Domestic agriculture and land resources**

Biofuel development will change the demand-supply relation in agricultural market and land market. The biofuel production will increase the production and prices of feedstock crops (maize, soybean, other oilseeds and sugar), while the production and prices of other many

grain crops and livestock will be declined in short-term. The opportunity varies remarkably among sectors.

- **Global trade**

The world market of biofuel will inevitably affect China's biofuel industry in its early stage, while the influence will decrease when China builds its own biofuel system and produces enough biofuel products. The trade of biofuel products and feedstocks between China and the world will link their agricultural markets. The supply-demand relations of food, water and energy in China will be more sensitive to global issues and more pressure is inevitable as well.

- **Variability among regions and socio-economic settings**

Opportunities from China's biofuels for regions vary significantly for different cropping pattern. The biofuel industry will raise the nominal income of farmers but the real income varies by regions and income groups. For lower income group of farmers, produce feedstocks for biofuel will gain more income but also higher expenditures for food.

- **Water consumption and security**

Development of biofuel industry will bring more pressure on water resources. With increasing demand for feedstocks used for biofuel, the water consumption for agriculture will increase. Climate change would likely result in increased demand for irrigated water. The direct and indirect impact of biofuel industry on water scarcity and allocation is depending on type of crop, farming system (rainfed or irrigated) and regions with different socio-economic settings.

- **Risks**

After over ten years development, China possess the third largest bio-fuel industry around the world, after United States and Brazil. Due to great demand for new clean energy to support the nation's further development as well as the consideration of the energy security, the bio fuel industry is encouraged in China. However, the bio fuel production in China is restricted by the following factors.

- **Lack of technology**

Until today, China's biofuel production is still mainly based on first-generation technology that cereal crops like corn, wheat and rice are the main raw materials. The 1.5-generation technology that uses non-cereal feedstock like cassava, sweet sorghum is under promotion and the second-generation technology depending on fiber materials shall be soon massively introduced and promoted in near future. Overall, China still lack the advanced technology in biofuel technology and international cooperation is extremely important for the development of biofuel industry in this emerged market.

- **Lack of adequate land resources**

The lack of marginal land resources suitable for non-cereal crops like cassava, sweet sorghum, limited China's effort and it is quite impossible for China to follow the pattern of

United States and Brazil that possess adequate arable land. According to National Energy Administration of China, the conservative estimate of marginal land is 23.34 million hectares.

- **Threat for other industries**

The main non-cereal crops for biofuel production are also main raw material for medicine, livestock industries, etc. The fast development of biofuel production would increase the competition between economic sectors. A new economic structure problem will appear and some important industries may be threatened.

- **Competition between cereal and non-cereal crops over water**

The demand for more marginal arable land for raw material of biofuel industry will also increase the consumption of water resources and other natural resources. Which will intensify the current state of imbalance allocation of water between social and natural systems. At the same time, the food security and water security issues together seriously restricted the effort in developing biofuel industry which will inevitable increase the competition between cereal and non-cereal crops over water.

- **Mitigation of Risks and policy recommendation**

- **Industries regulation and management**

Improve the industry management and regulation to enhance the adaptation of the market and supply-demand relation. Proper and strict project approval system and market access system need to be established and supervised. Excessive land and water consuming must be controlled within an extent permitted by food and water security concerns.

- **Technology research and promotion**

Researches on feedstock cultivation technology and fuel conversion technology should be both invested and promoted. Second-generation technology of biofuel should be supported with adequate finance and policies.

- **Incentives for supply chain**

The stakeholders in the complicated supply chain of the biofuel industries and relative industries must be taken in consideration and their benefits must not be fatally harmed. A complete and effective system that shall encourage and protect the new born innovative industry and its fragile supply chain must be established and equipped with corresponding preferential policies.

- **Enhancement in resource and technology adaptation**

The application of biofuel should be regulated and guided by governmental agencies or industry associations, to avoid the underlying uncertainties due to diversity and complexity of raw materials production and markets. The technology, therefore, need to be adaptable to the specific situation of feedstock productions and local conditions in marketing, transportation and storage.

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