Bioenergy Thematic study: The China's Case

Executive Summary

China is a developing country with a wide geographic territory, the largest population of 1.3 billion, rapid economic development, increasing demand for energy use and also serious environmental challenge. So the relationship between population, resources, environment and development should be appropriately coordinated. During last 20 years, China strive to promote sustainable development by developing more renewable energy such as bioenergy.

In recent years, China has begun to increasingly focus and accelerate the utilization of biomass energy resources via modern bio-energy technologies., such as power generation, large and medium biogas, liquid bio-fuels (ethanol, bio-diesel), etc, to realize the huge potential. Specifically, biopower in China will be locally-oreinted small-scale biopower facilities, Combined Heating and Power (CHP). Biofuel will be ethanol and biodiesel from nonfood feedstock, mainly cassava, sweet sorghum and jatropha in near term but cellulose such as crop straw in the long term. Biogas, pellte and biomass gasification will play an important role in providing heating fuel.

sustainability of bioenergy is a very complex issues composed of a wide range of economic, environmental and social impact by a variety of bioenergy development and utilization. Comprehensive strategy, supportive policy, effective regulations and useful tools are needed. Firstly, to carry out resource assessment and planning for bionergy production consistent with sustainable economical, social, and environmental development. Secondly, to establish the suppotive law and policy system for sustainable biomass energy development. Thirdly, to accelerate the R&D, dissemination, and application of biomass conversion technologies.

1. Introduction

Biomass includes the plants, such as the crop and forest residues, and the non-plant residues, such as organic waste water, excretions of birds and livestock, organic substance in the rubbish, and so on. Bio-energy accounts for 14% of primary energy consumption in the world. It ranks fourth in major fossil energy supply, behind coal, oil and gas. Bio-energy mainly provides the living energy for the inhabitants in developing countries by the traditional direct combustion; however, this mode is low energy efficiency and wasting resource. Modern bio-energy utilization is to produce solid, liquid, gas, or high-grade energy to replace fossil fuels through a series of advanced conversion technology by thermo-chemistry, biochemistry and other methods, which can provide electric power, transport fuel, heat energy, fuel gas and other final energy products. The development and utilization of modern bio-energy has a real and long-term impact on environmental protection and the sustainable development of human society.

Generally speaking, modern biomass energy technologies, among all renewable energy technologies, have closest contact with and are likely to contribute most to the rural sustainable development. China is an agricultural country, with large part of the population living in rural areas. Bio-energy resources are scattered regional, mainly located in rural areas. China has an unbalanced development of the rural economy. On one hand, farmers from economically developed areas use cleaner energy, liquefied gas and other energy commodities and let the surplus straw burning in the fields, resulting in serious environmental pollution; On the other hand, in remote areas even a basic livelihood for some farmers can not be guaranteed, and there are still 7 million rural households without electricity supply. Straw, firewood and other bio-energy has always been their main livelihood of fuel. Traditional use of biomass through direct combustion still accounts for about 98 percent of total bio-energy in the rural areas, resulting in serious waste of resources and environmental pollution. In addition, 80% of large-scale livestock and poultry farms in rural areas lack the necessary pollution control facilities. Livestock and poultry manure directly discharges without treatment, serious pollution of air and water, endangering the health of farmers.

Utilization of bioenergy with different biomass conversion technologies producing various types of high-grade, high-quality and low-polluting energy products, could meet the pressing demand of energy in rural areas, but also could improve biomass thermal efficiency to 35~40%. There are other benefits such as saving resources, improving the living conditions of farmers, and improving the standard of living.

2. Country presentation overview

2.1 geographic, climate and economic conditions, population, infrastructure, etc

China is situated in eastern Asia on the western shore of the Pacific Ocean, with an area of 9.6 million square kilometres. The highlands and hill regions account for 65 percent of the country's total land mass . China's land drops off in escarpments eastward to the ocean, letting in humid air current and leading many rivers eastward. China is characterized by a continental climate. The latitude spans nearly 50 degrees. The greater part of the Chinese territory is situated in the Temperate Zone, its southern part in the tropical and subtropical zones, and its northern part near the Frigid Zone. Temperatures differ therefore rather strikingly across the country. The northern part of Heilongjiang Province has long winters but no summers; while the Hainan Island has long summers but no winters.

China is a country with a largest population of 1.3 billion which accounts for 23 per cent of the world's population but less arable land which accounts for only 7 percent of the world's cultivated land. China is the largest developing country in the world, and developing its economy and eliminating poverty will, for a long time to come, remain the main tasks for the Chinese government and the Chinese people.

Since the late 1970s, China, as the fastest growing developing country, has scored brilliant achievements in its economy and society. In the 30 years following reform and opening-up in 1979, China's economy developed at an unprecedented rate.

2.2 energy consumption – fossil / RE – current and future

China boasts fairly rich fossil energy resources, dominated by coal. By 2006, the reserves of coal stood at 1,034.5 billion tons, and the remaining verified reserves exploitable accounted for 13 percent of the world total, ranking China third in the world. The verified reserves of oil and natural gas are relatively small, while oil shale, coal-bed gas and other unconventional fossil energy resources have huge potential for exploitation. China also boasts fairly abundant renewable energy resources. The theoretical reserves of hydropower resources were equal to 6,190 billion kWh, and the economically exploitable annual power output was 1,760 billion kWh, equivalent to 12 percent of global hydropower resources, ranking the country first in the world. However, China's per-capita average of energy resources is very low, the development of energy resources is fairly difficult. And the distribution of energy resources is imbalanced. In 2008, the output and consumption of primary energy in China equaled 2.6 and 2.8 billion tons of coal equivalent respectively, largely depending on coal. The proportion of commercial re-newable energy in the structure of primary energy keeps rising. China pays great attention to improving its energy consumption structure. The proportion of coal in primary energy consumption decreased to 68.7 percent in 2008, with that of renewable energy and nuclear power rising to 9.5 percent. The shares of oil and gas have increased. More com-mercial energy and clean energy are being used in people's daily life.

Table 1 Primary Energy consumption in China (mainland)

Year	Total Constumption of Primary Energy（billion tce）	Share (%)			
		Coal	Oil	Natural Gas	Nuclear and Renewable Energy
1952	0.047	95.00	3.37	0.02	1.61
1978	0.57	70.67	22.73	3.20	3.40
2008	2.85	68.70	18.00	3.80	9.50

Source：National Energy Administration of P.R.China，2009

As a result, China is faced with increasing gap between energy supply and demand. In the meantime, energy and environment issues arouse wide concerns. In response , The Chinese government is accelerating its development of a modern energy industry, taking resource conservation and environmental protection as two basic state policies, giving prominence to building a resource-conserving and environment-friendly society, striving to enhance its capability for sustainable development.

From the beginning of this century, the China's government has highlighted the development and utilization of renewable energy more and more, and set up Renewable Energy Law, issued a series of support policy for renewable energy continually, and thus promoted the switch of policy target from only rural energy development to modern renewable energy industry, from previous distributed low-quality energy utilization to the on-grid generation and commercialized clean biofuel, and from the fragmental components to the compete and integrated system. Currently, the support polices for renewable energy, especially for renewable power generation includes: Overall Target Policy of Renewable Energy, compulsory grid connection (feed-in tariff), classified power price, incremental cost sharing mechanism, special fund, technology R & D and industrialized projects, tax relief, fiscal investment and subsides. Since the enforcement of Renewable Energy Law in 2006, the investment risk for renewable energy has been reduced, various entities have begun join into renewable energy development, and all the renewable energies grew rapidly. By the end of 2008, the installed hydro power capacity has reached 172 GW, ranking first in the world; the installed wind power12 GW, ranking the global top 4; annual solar PV battery production reached 2GWp as the first ranked solar battery production; the accumulative productivity of solar water heater can cover 120 million m2, representing 60% of the total solar water heater consumption; for the biomass energy biomass power installations are 3.15 GW; more than 14 billion cubic meter of biogas are generated in more than 1600 large-sacle projects and more than 30 million small-scale household projects; biodiesel production reached 100 thousand tons and bio-ethanol production reached 1.65 million tons.

3. Current situation of bioenergy in China

3.1 Introdution

For a long time, China's use of waste biomass resources is dominated by traditional and low efficiency direct combustion (and household biogas), which is with the problem of poor technology, few application approach, waste of resources, environmental pollution and others. In recent years, China has begun to increasingly focus and accelerate the application of biomass energy resources into high-grade energy via modern bio-energy technologies, such as power generation, large and medium biogas, liquid bio-fuels (ethanol, bio-diesel), etc. At present, some raw material utilization technology has a certain degree of economic competitiveness, and achieved the initial realization of commercial applications; of course there are some bio-energy technologies also needed to improve in term of the technical level and economic competitiveness.

3.2 Current bioenergy use

3.2.1 Biomass Power Generation

Biomass power generation refers to electricity generation through direct combustion or gasification using biomass as fuel. Biomass direct combustion power generation is similar to coal fuelled thermal power generation. Fixed-bed gasifier can be used with internal combustion engine for small scale power gasification, and fluid-bed gasifier can be used with gas turbine, steam turbine or internal combustion engine for medium and large scale power generation. Biogas power generation usually adopts internal combustion engine.

Before the end of 2005 when the“Renewable Energy Law” came into force, the policy measures were not complete, the support was weak, and the development of renewable energy including biopower was slow. Since the cost of biomass power generation is relatively low in the field of renewable energy, some small-scale off-grid bio- power projects still realized the commercial operation, mainly for the timber and rice mill waste treatment. It not only disposals the waste, but also saves the cost of electricity production ； However, the biomass power generation still has higher cost and lower competitiveness compared with conventional energy power generation. Therefore, the scale of biomass power generation is small and the developing speed is slow for this period of time. The total installed capacity of biomass power generation is about 2GW by 2005, mainly comes from the existing waste resource utilization projects which brought by agro-processing projects. The total installed capacity of mainly the bagasse-based power generation is about 1.7 GW while the rest comes from the rice husk gasification power generation.

From 2006, the implementation of “Renewable Energy Law” enhanced the confidence of corporate investors and significantly accelerated the pace of biopower development. With the “Renewable Energy Law”and related renewable energy price subsidy policies were promulgated and implemented, the new biomass power generation projects will enjoy the price subsidies of 0.25 Yuan/kWh for 15 years. Inspired by this policy, the investment enthusiasm is rapidly rising, and various types of agriculture, forestry, waste power generation projects have been constructed. According to statistics, 39 straw-based biopower projects were approved in 2006, with a total installed capacity of about 1.28 GW; By the end of 2008, the total capacity of biopower projects is 3.15 GW, in which the biogas and waste incineration power generation account for 22.5% and the rest are sugarcane bagasse- and straw-based power generation projects.

In overview, the newly built biomass power generation projects is mainly the crop stalks direct combustion power generation projects (such as straw the direct combustion power generation project at Dan county in Shandong province), but we also explored the construction of a straw-pulverized coal combustion power generation projects (such as the power plant in Shiliquan, Zaozhuang, Shandong) and thermoelectric cogeneration projects (such as the forest biomass thermoelectric cogeneration demonstration project in Naiman banner, Tongliao, Inner Mongol).

China also made notable progresses at the developments of biomass power generation equipments. In 2006, a straw direct combustion power generation project was put into operation in Suqian city of Jiangsu province, which is the first project using the domestic technology and equipment with the full autonomy of the property rights.

3.2.2 Liquid biofuel for transport

As an emerging industry, Chinese liquid biofuel industry is developing rapidly in recent years. At the “Five-Year Plan” period, China is at initial stage of liquid biofuel industry development, with 4 designated fuel ethanol enterprise with total production capacity of 1.02 million tons.

In 2008, China produced and used 1.65 million tons of fuel ethanol mainly from corn thus has become third largest bioethanol fuel producer and user following Brazil, the United States.

The “11th Five-year Plan” period (2006-2010)is a transition period of biofuel industry in China. The government issued the “Renewable Energy Law”, “Guide catalogue of renewable energy industry development”, “summary of national economy and social development 11th Five-year Plan”, “high-tech industry development 11th Five-year Plan”, “Bio-industrial development 11th Five-Year Pan”, “Medium and long term Renewable Energy Development Plan” and other laws and regulations. These laws and plans require promoting biofuel production from nonfood feedstock in line with Chinese land resources and agricultural production characteristics. As a result, a large number of enterprises, including big enterprises, entered the non-food liquid biofuel industry by strengthening technology research and development, constructing resource base and pilot projects, thus played a positive role in formation and expansion of non-grain liquid biofuel industry. At present, biofuel technology using cassava, sweet sorghum, Jatropha curcas, and other non-food crops / plants has entered the stage of the demonstration. In 2007 Guangxi constructed first fuel ethanol plant using cassava as feedstock. Some companies have been building and improving pilot project of cellulosic ethanol. Biodiesel is basically ready for industrialization. According to rough estimates, only a small group of enterprises can continuously producing biodiesel, with total annual output of hundreds of thousands of tones. Quite recently, National Development and Reform Commission has been organizing and supporting some enterprises to build pilot biodiesel plants using jatropha oil.

A number of Chinese research institutes have also carried out a series of research and development work on synthetic fuels from biomass and biomass pyrolysis oil technology, but still in the pilot phase of technology research and development. The current domestic related technology is still in the experimental study phase, still a long distance to the industrialization. In the future, technology research and development demonstration efforts on synthetic fuels from biomass and biomass pyrolysis oil need to be strengthened, in particular, to focus on the development of Fischer-Tropsch synthetic fuels compatible with existing vehicle-used fuel infrastructure, and strive to achieve industrial application as early as possible, resulting in realization of large-scale substitution of petroleum-based vehicle fuel in the medium- to long- term.

3.2.3 Biomass Thermal Energy Utilization

Biogas technology in China is characterized by the use of household-based biogas generating pits. Since the early 1970s, China has vigorously developed and promoted the household biogas pit technology to solve the shortage of rural energy, and our rural household biogas technology and building scale is in the world leading level. At all of the recent three consecutive five-year plans, the country takes the development of new biogas technology as the key task project in scientific and technological research. 3800 large and medium-sized biogas projects have been built at large-scale farms all over the country, which is about 0.06% of the total number of the large-scale farms in China. Currently, large and medium-sized biogas projects and landfill gas power generation is the best economical way to utilization of bio-energy.Currently, biogas in China usually follows the follow modes: One is the "energy and environment project" mode for livestock and poultry farms, so that livestock and poultry manure and other biomass resources can be fully utilized and treated harmlessly. The other is the "ecological energy" mode suitable for the animal farms around where there are appropriate croplands, fish ponds or water plants ponds, for the wastewater treated by anaerobic digestion can be completely eliminated by the surrounding farmlands, fish ponds or aquatic plant ponds.

Centralized biomass gasification system is the small system suitable for atural village with dozens to hundreds of households. The system can convert various straw-based solid biomass feedstocks into combustible gases of low calorific value by gasification, and then transmit and distribute the biogas to the home of village residents through pipe network for cooking fuel. The overall efficiency of system is up to 30~40%, which is over doubled than the traditional stoves. In the developed countries with mature biomass gasification technology, the application of centralized biomass gasification supply is not much, for the use of natural gas is more common. In China, the technology has been a newly developed technology of bio-energy utilization since 1990s. It can convert the rich solid biomass materials in rural areas into easy-to-use and clean combustible gas for residents' cooking and heating. Since China's first pilot projects of centralized biomass gasification supply was built up in 1994 at Dongpan village in Huantai county, Shandong province; Shandong, Hebei, Liaoning, Jilin, Heilongjiang, Beijing, Tianjin and other provinces and cities were promoting the application of centralized biomass gasification supply technology in succession, and it has become one of rural energy emerging technologies in China. At present, the biomass gasification supply system in China for the drying of wood and agricultural by-products is more than 800 sets, and the straw gasification supply system for households in villages and counties is near 600 sets, which can produce 20 million m3 combustible biogases every year. It is able to play a positive role on the efficient use of straw resources, reducing pollution, improving the quality of farmers' life and so on.

Biomass Pellete technologies are entering the demonstration phase of industrial applications and recently enterprises majoring dense biomass fuel processing and fuel stove manufacturing emerged, and gradually formed the industrial development. With the transformation of coal-fired boilers in China's large and medium cities, dense biomass fuels can be used as a new fuel for the heating of urban residents in winter, and could be used as the fireplace fuel in scattered residential areas (high-grade villa area).

3.3 Perspective of bioenergy use

3.3.1 General Biomass Resource Potential

Biomass refers to various organisms growing from photosynthesis which include all animals, plants and microorganisms. Biomass energy refers to the solar energy stored within biomass in the form of chemical energy which means that biomass is just a carrier for energy.

Based on a variety of sources, biomass can be categorized as below: (a)Agriculture resource: includes agricultural crops (including energy crops) and remaining of agricultural production such as crop straw and waste of agriculture processing. Energy plants refer to plants that can provide energy, including energy crops, oil crops, and water plants. (b)Forestry resource: includes firewood forest, scattered wood from forest fostering and cutting operation, remaining branches, leaves, and wood crumbs, twig, sawdust, and wood tips from wood transportation and processing, waste of forestry by-product processing such as fruit hull and fruit core.(c)Waste water and industrial organic waste water: includes waste water from households, commerce, and service industry; industrial organic waste water includes waste water from beverage and food factories, paper making, and slaughter industry.(d) Municipal solid waste: mainly consists of garbage from households, commerce, and service industry and construction industry.(e)Livestock waste: is the excrement of livestock, including manure and the mixture of manure and the mat grass.

China is a large agricultural country, development and utilization of biomass energy, especially crop residues and energy plants, has far-reaching historical importance and significant influence to the sustainable development. Survey shows that in China, the total amount of straw biomass is more than 720 Mt per year, equaling to 360 Mtce, except the other usages such as returning to the field, livestock feed, and raw materials for paper making and construction material, 300 Mt of crop straw can be used for energy purpose; the annual production of firewood is 127 Mt, equaling to 74 Mtce; the annual production of livestock waste is 130 Mtce, and the annual production of municipal solid waste is 120 Mtce which keeps increasing by 8％ ~ 10% per year. It is estimated that the total of exploitable biomass resources of China is about 700 Mtce.

3.3.2 Perspective of bioenergy use

According to the Mid- and Long Term Plan for Renewable Energy issued in 2007, priorities for biomass energy development will be biomass power generation, biogas, biomass pellets (used directly as fuel), and liquid bio-fuels.

1. Biopower generation for electricity

Biopower includes power generation using biomass from agriculture and forestry/forest product wastes, MSW, and biogas.

(1) Biopower from agriculture and forestry/forest product wastes. By 2020, the installed capacity of biomass power based on agricultural and forestry wastes and energy crops plantations (bagasse included) is expected to be be 24 GW. Energy plantations are expected to be grown in marginal areas (including barren mountains, barren land, and sandy areas suitable to afforestation) to supply feedstock for agriculture and forestry based biomass power generation.

(2) Biopower from biogas. By 2020, 10,000 large-scale biogas projects on livestock farms and 6,000 biogas projects utilizing industrial organic effluent are expected to be built with a total annual production of 14 billion m^3 biogas and total installed capacity of 3 GW. MSW combustion plants are expected to be built in economically-developed but land resource-constrained areas. Landfill gas recovery and power generation facilities are expected to be installed at large and medium-sized landfill sites.

2. Biomass Pellets, biogas and biomass gasification for heating

(1) Pellets. By 2020, the use of biomass pellet fuels in China nationwide are expected to reach 50 million tons. By that time, biomass pellets will have become a widely used form of high quality fuel.

(2) Biogas and Biomass Gasification. Making full use of biogas technologies and technologies for biomass gasification of agricultural and forestry wastes is an important measure for raising the share of gas in the energy used to meet the daily life needs of rural people. It is also an important measure for resolving the environmental problems associated with rural wastes and organic industrial wastes. In rural areas, the main emphasis will be put on household biogas digesters. In small and medium-sized towns, as well as livestock farms and in cases of industrial organic effluent, larger scale biogas projects will supply gas in a

more concentrated fashion. By 2020, 80 million households (300 million people) are expected to use biogas as their main fuel.

3. Biofuel as transportation fuel

Biomass could and would be transformed into various kinds of energy carieer to meet increasing demands for electricity, transportation fuel, and heating fuel in China to contribute sustainable development and poverty reduction. However, It is widely recoginzed that huge demands for low carbon electricity and heating would be met by a series of new and renewable energy technologies, such as nuclear power, wind power, solar PV, solar heating, geothermal heating, etc. Meanwhile, the transport sector will in a long term depend on liquid fuel including biofuel. Therefore, biomass energy is expected to play an strategically important role in transport sector in form of liquid biofuel, hopfuelly second generation biofuel.

China has modest raw material resource potential for 1st generation biofuel but rather large potential for 2nd generation biofuel. (1) as a result of growing population continuous rising standard of diet, limited high-quality arable land, China is going to faced with pressure for sufficient supply of food, thus making biofuels using grain, sugar and vegetalble oil as feedstock not an viable direction in Chinese context. (2) China sugar industry produced 3 million tons of waste molasses per year, with an annual potential output of about 800 thousand tons of ethanol; In addition, each year the food processing industry and catering industry can collect and use 1 million ton waste oil, cotton-planting sector can collect 1 million ton cottonseed oil each year which can meet feedstock demand for 2 million tons of biodiesel. (3) China can collect and make use of half of about 250 to 300 million tons of crop stalks and forestry residues at present time or potential 600 million tons in the medium and long-term to produce tens of million tons of cellulose based biofuel. (4) In the near future, energy crops with the greatest potential include starch and sugar crops such as sweet sorghum, cassava, sweet potato, etcl,. as well as oil plant sucha as Jatropha. Existing land-related assessment shows that China now has about 32~76 million hectares of marginal land including 7.34 to 9.37 million hectares of backup arable land, 8.66 million hectares winter fallow fields, 16~57 million hectares of backup forestland. (5) On the whole, resource potential in near and near term is roughly estimated at about 15 million tons of bioethanol from non-food sugar and stach crops (cassava, sweet potato, sweet sorghum and other crops), and 2 million tons biodesel from waste oil; In the mid- and long-term, newly added resource potential is estimated at million tons of biodesel from oil plant, and tens of millions of cellulose based ethanol and synthetic fuels.

It is expected that China's oil consumption will continue to maintain a high growth rate. It is predicted that China's demand for gasoline and diesel in transport sector will reach 90 million tons and 15 million tons respectively by 2020. As a result, liquid biofuel could meet with 20~30% of the road transport fuel demand. in the mid- and long-term period in China. If blending all gasoline with 10% ethanol and diesel with 5% biodiesel in transport sector, fuel ethanol and biodiesel demand will reach 6.7 million tons and 5.5 million tons respectively by 2010, and 9 million tons and 7.5 million tons by 2020. If introducing flexible fuel vehicle (FFV) with higher blending ratio or pure liquid biofuel, the fuel ethanol and biodiesel demand will be even higher. According to the Mid- and Long Term Plan on Renewable Energy, it is proposed that annul fuel ethanol and biodiesel production from non-food feedstock shall reach 10 million tons and 2 million tons by 2020 to replace about 10 million tons of oil.

4. Rural Renewable Energy Applications

In rural areas, renewable energy applications will be developed to resolve issues of daily use energy for China’s vast rural population, to improve rural production and living conditions, and to protect the ecological environment. Use of renewable energy will effectively raise rural incomes and increase the speed of social and economic development in rural areas. The priorities for development are the following:

(1) Supply power to rural areas without electricity: For those areas to which it would not be economic to extend the power grid, full play should be given to the strengths of local resources. In these areas, through the application of small hydro, solar, and wind, as well as other renewables, the basic electricity demand of people without power supply will be solved. In areas with rich resources of small hydropower, top priority will be given to develop small hydropower stations (including micro hydropower stations), resulting in the supply of energy to around 1 million households. In those areas lacking small hydropower resources, electricity will be supplied to around another 1 million households by means of (depending on local resources) building small-scale off-grid solar PV power stations and wind-PV hybrid power stations, as well as by promoting the use of small household wind turbines, solar (PV) home systems, and wind-PV home systems.

(2) Improve conditions of rural daily-life energy use: Rural living conditions and the quality of rural peoples' lives will be improved by means of utilization of various renewable energy technologies. Small hydropower will serve as a substitute for fuel in those areas rich in small hydro resources. Household biogas digesters, biomass pellet fuel, solar water heaters, and other renewable energy technologies will also be used to supply clean energy to rural areas. By 2010, 30 percent of rural households will use clean renewable energy, with 40 million rural household biogas digesters, and 50 million m2 of solar water heater collector area in use in rural areas. By 2020, 70 percent of rural households will use clean renewable energy, with 80 million rural household biogas digesters, and 100 million m2 of solar water heater collector area in use in rural areas.

3.4 Existing Policies

1. Biopower generation

China encourages biopower projects that are well designed and operated to meet local biomass resources characteristics. Since July 2010, newly grid-connected biopower projects using agricultural and forestry residue in the country are eligible for the same fixed feed-in tariff of 0.75 RMB/kWh in continuous 15 years since starting operation. However, the co-fired generation plant that using more than 20% percent traditional fuel (such as coal) are deem as traditonal power plants rather than biopower plants, thus ineligible for the feed-in tariff. Furhtermore, all kinds of biopower using biomass waste are eligbile for refundding VAT.

2. Biomass thermal energy utilization

Chinese Ministry of Agriculture provide susidy of 1~2 billion RMB to biogas and gasification projects, with major focus on expanding and improving the use of biogas and gasification technology. Since Oct 2008, Chinese government decided to give fianacial support to energy utilization of crop straw and stalk, such as colllection, pellet produciton, gasification, etc.

3. Liquid biofuel for transport

Since china launched the fuel ethanol program in 2002, denatured ethanol fuel production could enjoy favorable policy such as exemption of consumption tax, reimbursement of VAT, subsidies to feedstock, guaranteed price related to gasoline price. Since 2007, for biuofuel from non-food feedstock, the central government will provide subsidy of 3000 RMB/hectare and 2700 RMB/hectare to forestry resource base and agricultural resource base.

4. Rural Renewable Energy Applications

Chinese government is establishing Pilot Green Energy Counties to promote rural bioenergy and other kinds of renewable energy applications. Adopting the principles of flexibility, diversification, and taking action suitable to local circumstances, China will establish pilot Green Energy Counties in areas with abundant renewable energy resources, striving to make full use of all kinds of renewable energy. The criteria for a Green Energy County will be: (a) more than 50 percent of household energy comes from renewable energy, and (b) various biomass residues and wastes are treated and utilized in reasonable ways. The Green Energy County pilot program will be combined with promotion activities for each of biogas, biomass pellets, and solar energy. The number of green energy counties will be 50 by 2010 and 500 by 2020.

4. Study cases

4.1 Biogas

In China, large and medium size biogas projects appeared since the end of 1970s. The developing progress was linked with the development scale and level of livestock feeding industry. Between the end of 1970s and mid of 1980s, purpose of building biogas plants in livestock farms was to obtain energy resources (biogas) in order to make up for the shortage of energy supply in rural areas. At that time, because large and medium livestock farms are not popular, the biogas plant even used crop to compensate inadequate animal waste as feedstock.

Biogas power generation also started in early 1970s in China. Restricted by the small quantity of biogas production, the engine power is low. In recent years, with the medium-and large-scale biogas projects become more popular, biogas engines with high power were produced and used in these biogas power projects. Currently, biogas is used not only for lighting and cooking, but also as centralized gas and electricity supply for entire villages.

Hangzhou Lighthouse Animal Farm uses their self-produced biogas for power generation, and the generated electricity is for the water pumps and equipments of the biogas project. Remarkable social and economic benefits have been achieved. Gas consumption rate of the most advanced international biogas engine is around 0.4Nm3/kw • h, coupled with a comprehensive utilization of waste heat, a comprehensive efficiency of heat utilization has reached 88%.

4.2 Pellet from agricultural residue

The biomass pellet fuel has many characters, like big specific gravity, convenient to store and transport, easy to fire, good combustion performance, more heat of combustion, low ash content, zero SO_2 released. The agricultural waste materials, like plant stem, rice husk, tree bark, sawdust, leaf, sugarcane bagasse, etc., could be used as materials for the biomass fuel. Yanglin Biomass Pellet Project was built in central China Henan province in 2007. This project produces 20 thousand tons of biomass pellet from corn straw. Most of the products are sold as alternative fuel to nearby biopwer project and the rest to nearby modified coal-fired boiler. However, the energy input and cost for production is still high, and the expected life of the production equipments is relatively short.

4.3 Biomass gasification from agricultural residue

Biomass Gasification and Centralized Gas Supply started in 1990s in China. Usually, it takes natural village as a unit. A biomass gasification station provide combustible gas to 100~1000 households. Beijing Haidian Che'erying Straw Gasification project processes 3 tones of straw and produce 700 cubic meters of syngas per day as cooking fuel for more than 700 rural household. It is estimated that the processing cost and revenue for every tone of straw is 1,208 CNY and 1302 CNY. As a result, given government support to initial investment, the system may just economically survive with small profit. In fact, it is the case for many other straw gasification projects, indicating that the necessity of public financial support, especially for initial investment because of low profitability and high public benefit.

4.4 Biopower from agricultural residue

1. Guoneng Shanxian Biomass Electricity Project

Guoneng Shanxian Biomass Electricity Co. Ltd. is invested by Guoneng Biomass Electricity Co. Ltd. Approved the local DRC in Sep. 2004, the 25 MW project started its production on December 1, 2006. In 2007, the estimated operating hour is 8200, and electricity production is 200 million kWh. Besides, 8,000 tons of vegetable-ash is produced annually which can be used as kalium fertilizer.

The project uses one 25 MW steam turbine combined with a domestic made biomass boiler with capacity of 130 t/h adopting Denmark technology. The feedstock pretreatment equipment and boiler have been adjusted to suit the Chinese biomass.

The plant consumes about 200,000 tons of straw fuels annually. The main biomass fuel is cotton straw, and can be mixed with forestry residues such as twigs. The fuel is mainly collected in Shanxian and surrounding counties. To ensure the steady supply of fuel straw, the plant established 8 collection stations to purchase and store straws in Shanxian. The site selection of these stations mainly considers the straw resource distribution, transportation conditions, topography, drainage, power supply, water resource, and sizes of land area. The stations purchase straw from farmer brokers, who sign loose contract with the station. Grid connected power production of the Guoneng Shanxian Straw Power Plant indicates that the system of collection, storage, and transportation of biomass resources in Chinese rural areas can well fit the demand of large scale biomass-electricity technology and equipments.

2. Xinmi Changyuan Group Power Project

Xinmi Changyuan Group Power Co. Ltd. established the first biomass-electricity innovation project in Zhengzhou City of Henan Province. The first phase of the project is well implemented and hopefully starts production and selling power to the grid by October 2008, and the second phase is expected to start production and connected to the power grid by March 2009.

The project adopted the boiler innovation technology and straw combustion technology from Shanghai Electric Group, which transform the three 65 t/h coal-fired boilers to 75 t/h biomass-fired boilers. The system continues using the original turbines without retrofitting.

The total investment of the project is 81.22 million RMB Yuan. With the policy of subsidy for biomass electricity (0.25 RMB Yuan per kWh), the project will achieve an annual sales income of 98.56 million RMB Yuan, with gross profit of 22 million RMB Yuan. The project consumes crop straw of about 250,000 tons annually, replacing coal of 145,400 tce. A significant reduction in so2 and co2 emissions as well as ash emission had been achieved. The slag and ash can be used as high-quality fertilizer and help to increase the income of farmers by as much as 40 million Yuan.

4.5 Fuel ethanl from sweet sorghum

Heilongjiang Sweet Sorghum Ethanol project was built as demonstration project. Preliminary assessment indicates that, the total investment of 100 million CNY may be paid back within 7 years with annul net profit of 15 million CNY, and farmers may gain expected average net income of 8,060 CNY per hectare of sweet sorghum, in comparison with 2,630 CNY per hectare of corn or 1,300 CNY per hectare of soybean. In addition, 48 out of 50 interviewed farmers expressed willingness to plant sweet sorghum in an investigation.

However, sensitivity analysis indicates that the payback period and farmer income larges depend on some key factors including sugar content, yield per hectare and procurement price of sweet sorghum. Therefore, it is of great importance to promote technological progress and market mechanism to raise sugar content, yield and stable price of sweet sorghum.

Since sweet sorghum is potentially much more profitable than corn and soybean, it may compete for arable land with such agricultural crop. So, it is essential to carefully assess and select target region for sweet sorghum plantation and bioethanol production plants. Further, it is desirable to integrate sweet sorghum plantation and cattle-raising industry to maximise profit and social benefit. In addition, modern machinery is needed to lower labour burden of sweet sorghum plantation activities.

5. Sustainability aspects for case studies

5.1 General legislation and policy regarding sustainability

Since the promulgation of the Environmental Protection Law in 1979, the first of its kind in China, many pollution-control statutes and natural resource conservation statutes have been enacted to promote sustainable development.

China's government officially adapted sustainable development strategy in 1992 and issued Agenda 21 for China in 1994, which emphasize that the relationship between population, resources, environment and development should be appropriately coordinated. The Priority Programme for China's Agenda 21 include 69 programme in nine distinct groups covering: (1)capacity building, (2)sustainable agriculture, (3)cleaner production and environmental protection industry, (4)clean energy and transportation, (5)conservation and sustainable utilization of natural resources, (6)environmental pollution control, (7)combating poverty and region development, (8)population, health and human settlement, (9) global change and biodiversity protection.

However, as result of rapid industrialization & urbanization compromise the efforts, the environmental situation and unsustainable development is getting even serious. More laws and regulations are issued to promote sustainable development. For example, The Energy Conservation Law was issued in 1997 and revised in 2007 to promote energy saving and renewable energy devlopment; The Renewable Energy Law was passed in 2005 focusing specifically on renewable energy including bioenergy; China National Plan for Addressing Climate Change was issued in 2007 to promote mitigating and adapting climate change in fields of energy, agriculture and forestry, etc.; The Circular Economy Promotion Law was issued in 2008 to promote reducing, reusing and recycling activities in the process of production, circulation and consumption in fields of Mining, Agriculture, Manufacturing industry, Waste recycling, etc. China's laws on agriculture and forestry also emphasize environmental and ecological protection to ensure sustainable agriculture and forestry.

However, more practical regulations and policy tools are needed to ensure sustainable development, especially in the field of bioenergy which involves a wide range of key issues. It is envisioned that the integration of agriculture and bioenergy industry may provide food and fuel security, mitigating and adapting to climate change, and freeing us from fossil fuel use altogether. However ， it is essential to keep in mind that China’s food security is precarious, as it has to uses only 7 percent of the world’s land to feed 22 percent of world population. Therefore, bioenergy production shall never compete with for grain, credible oil, arable land, and water with food production. In addition, the pattern of bioenergy production and utilization shall be effective, efficient and sustainable in terms of clean energy output, pollutants and GHG mitigation, natural and ecological system conservation, job creation and rural development.

5.2 The concept and framework of sustainability of bioenergy

The sustainability issues which relates directly or indirectly to rural development and achievement of the MDGs includes many aspects, such as : The ability of modern bioenergy to provide clean energy services to the poor and contributing to rural development and poverty alleviation, Job creation through agro-industrial development and contribute to development of SMEs , Implication to the structure of agriculture through analyzing the agricultural and policies, Existing forestry policies and compliances, Implications to food security, Land and land use, Environmental impacts including climate change issues, etc,.

In recent years, many initiatives try give an more detailed framework of assessing sustainability of bioenergy, among which the Global BioEnergy Partnership (GBEP) is designing a comprehensive on. The ongoing GBEP research suggest the following preliminary sustainability framework.Firstly, economic and energy security impacts dimension covers the following aspect: Resource availability and use efficiencies, Economic development, Economic viability and competitiveness, Access to technology and technological capabilities, Energy security / Diversification of Sources and Supply. Secondly, environmental Impact dimension covers the following aspect: Greenhouse gas emissions, Air quality, Productive capacity of the land and ecosystems, Water availability and quality, Biological diversity. Thirdly, Social Impact dimension covers the following aspect: Food security, Access to land and other natural resources, Labour conditions, Human health and safety, Rural and social development, Access to energy.

Many other international initiatives and countries is doing similar work. For example, According to the report of *Sustainability of Biofuels: Future Research Opportunities*, the biofuel sustainability covers three dimensions: (1) Environmental Dimensions of Biofuel Sustainability includes: soil resources and greenhouse gas emissions; water quality, demand,

and supply; biodiversity and ecosystem services; and integrated landscape ecology.(2)Economic Dimensions of Biofuel Sustainability includes: competitive in different regions, implications for food

Prices; indirect land-use effects of increased production of feedstock, etc,. (3) Social Dimensions of Biofuel Sustainability represent some of the most pressing and challenging sustainability issues.

5.3 Brief overview of sustainability of bioenegy case

As discussed above, sustainability of bioenergy is a very complex issues composed of a wide range of economic, environmental and social impact by a variety of bioenergy development and utilization. Based on case study, here give a brief overview of sustainability of bioenergy case, including biogas, pellet, biomass gasification, straw biopower, and bioethanol from sweet sorghum .

Table 2 brief overview of sustainability of bioenegy

		biogas	Pellet (based on straw)	Biomass gasification	straw biopower	Bioethanol from sweet sorghum
Economic impact	Energy security	small	Small	Small	Moderate	significant
	Macroeconomic development	small	Small	Small	Moderate	Moderate
	fianancial burden	Small	Small	Small	Moderate	moderate
Environment impact	Air/water pollution	Small	Small	Small	Small	Small
	Soil degradation	no,if managed well	NO, straw left enogh in land	NO, straw left enogh in land	NO, straw left enogh in land	No,if managed well
	Biodiversity loss	No	NO	No	No	Small, if marginal land managed well
	Lifecycle Fossil energy input	Small	Small/ moderate	Small	small	Small or moderate, depending on fertilizer consumption
	Lifecycle GHG emission	Small if managed well	Small	small	Small	Small or moderate, depending on fertilizer

						consumption
Social impact	Competition for Food/arable land	no	No	no	no	Small or moderate, depending on policy
	Competition for Land tenure	no	No	no	no	No, depending on policy
	Health harm or labor burden	no	No	no	no	Small or moderate, depending on mechanical facilities
	Job creation	Small	Small	small	small	Moderate
	Increased local access to modern energy	Significant	Moderate	significant	significant	significant

6. Certification issues

The sustainability of biomass for energy and transport fuels has been the warm attention in all strata of stakeholders and policy makers. The European Parliament, some EU national initiatives, international working groups and a number of NGOs advocate certification of biomass to ensure GHG emission reductions and production of biomass in a social and environmentally sustainable way. So far, four different types of certification systems have been investigated: forest certification systems, biomass energy crops certification systems, certification systems used in the power sector, certification systems related to emission trading.

However, the following main barriers exist toward successful achievement of expected benefit of certification programs, such as : certification systems are not regarded effective to monitor and manage indirect effects of biomass production, like competition with food or undesirable effects of indirect land use changes; only a limited number of obligatory sustainability criteria would hold ground in case of potential WTO conflict, biomass certification could make biomass producers switch their sales to less eco-sensitive markets. Further, the cost of certification can form a serious barrier to small biomass producers. A possible solution is to allow group certification in which the costs can be shared by a number of small holders.

Some developed counties , especially EU member countries, believe that the implementation of obligatory sustainability criteria and certification systems is possible, although practical issues limit the impact of biomass certification. Recently, EU and USA has started to implemented obligatory sustainability criteria and certification system in the renewable fuel for transportaion, with specifations focusing on only land use change and lifecycle GHG emission reduction compared with conventional diesel/gasoline.

In recent years, China attach great importance to the sustainability of bioenergy, especially liquid biofuel which may use grain, sugar, vegetable oil as feedstock and arable land for feedstock production. Since the beginning of this century, biofuel has been adopted in national energy strategy. In 2006, Chinese government stated clearly that the biofuel production must follow the principle of "no competition for food or arable land, no harm to natural environment and ecosystem ". As a result , more fuel ethanol production from corn or wheat as well as biodiesel from edible oil (such as rapeseed oil) is strictly prohibited in China. So far, there is no formal certification program for bioenergy or biofuel, because Chinese government will assess and approve the biofuel production projects one-by-one carefully to ensure the biofuel projects follow the above mentioned sustainability principle. However, some policy instruments such as or similar to certification programs may be necessary in future when a large and diverse group of biofuel projects are to be constructed and more comprehensive sustainability requirements are to be met.

7. Existing barriers

7.1 biopower

(1) Large and medium-sized agriculture and forestry biomass power generation project has been constrained by the distribution of resources. At present, the capacity of China's direct combustion of biomass power generation projects is mainly between 24MW to 50MW, among which the new and proposed projects after 2007 mainly adopted the units with 12 MW ~ 15MW. Large-scale direct-combustion biomass power plant makes the collection of raw materials costs and the cost of electricity is much higher than expected, resulting in a deficit. The mixed power generation or small and medium-scale biomass gasification / biomass gasification generation projects / installations are developed slowly.

(2) Biomass power generation electricity price level doesn’t match the level of resources distribution. As the biomass power generation take the electricity policy as coal benchmark price plus a fixed subsidy support price policy, resulting in the mismatch between the electricity price level and the level of resources distribution, i.e. some biomass resource-rich areas (such as Xinjiang) are with very low biomass power generation prices, but the areas with high prices are not suitable for biomass power generation.

(3) Domestically-made capacity of complete sets of equipment and the key equipment is still deficient. At present, the majority of direct combustion power generation use imported equipment, and foreign technology and equipment accounted for more than 60%. Domestic biomass power generation equipment, R & D and industrialization is still at the initial stage, and the equipment is less efficient, difficult to be integrated into one complete set, resulting in low capacity of manufacturing of key equipments, and high cost. Complete sets of biomass power generation equipment manufacturing capacity have become a bottleneck.

7.2 Liquid biofuel for transport

Raw material resource base is not concrete. (1) The actual available marginal land is still unclear. Although China has much saline land, degraded land, but still lacks land-use planning and scientific evaluation. If taking into account the actual utilization of land reclamation, water and soil conditions and land and ecological environmental protection requirements, it is not yet clear that how many land resources can be utilized for biofuel industry. (2) Breeding and cultivation technology and scale operation of the raw materials of plant need to be improved. Existing energy plant are with limited, low yielded, dispersed, and bad managed. Breeding of new varieties, high-yield cultivation, and harvest processing technology is not sufficient. (3) The type and quality of feedstock are diversified and differentiated. In particular, the current biodiesel raw materials include various types of waste oil and all kinds of oil-bearing plants with varied quality, which threat biodiesel fuel quality stability.

The technological and industrial capability is weak. (1) Lack of advanced processing technology and complete sets of advanced equipment. The first generation of liquid biofuel technology with low raw material utilization efficiency and high material & water consumption, and pollution problems are still prominent, but also lack standardized set of mature technologies and equipment. The second-generation liquid biofuel technology is still at research stage with a wide gap from industrialization. (2) Industry model is still not mature. It is necessary to achieve the commercialization and application of mass production, address the question of seasonal production of feedstock. (3) Indepth evaluation of impact of large-scale cultivation of the energy plants has not been conducted and technical criteria for sustainable production not yet established. Much work is needed to develop seed-breeding and forestation technology, specification on energy-efficiency, emission norms, and so on.

Lack of competitiveness and ability to resist risks. (1) The cost of liquid biofuel raw material accounts for 80% of the total costs and still remains quite high or even rise in 2007/8; (2) The nonfood biofuel industry still lack economies of scale and scope, comprehensive utilization of resources, thus failed to achieve efficient scale, diversification of products and efficient use of resources; The farmers enjoys limited economic benefit; (3) Constrained by the cost of raw materials, technical standards, and other factors, the cost of products and prices are still high, with no economic competitiveness, and this means a big market risk.

Support policies and market conditions are not in place. (1) Market access and marketing system is not ready for non-grain biofuel, which hampered the non-food liquid biofuel industry's further development, discourage the relevant enterprises to strengthen technology R&D and build pilot and demonstration projects. In particular, biodiesel still can’t enter the normal vehicle fuel market. (2) Industry monitoring and regulation need to be strengthened to mitigate social, economic and ecological risks. At present, China has not yet established comprehensive, transparent, regulation to combine biofuel industry with food agricultural development, land development and utilization, natural eco-environmental protection, international trade, etc,. (3) Support policies regarding pricing, financial and taxation are inadequate and far from being fair and reasonable, especially subsides for multi-year growth of forestry raw materials is obvious too low. (4) Market conditions to promote the use of the product are not ready. Although in 2007 China issued the recommended standard of biodiesel (B100), but has not yet formulated standard for blending biodiesel with common diesel. Biodiesel also lack of fuel marketing channels and technical standards, and the inadequate infrastructure for deployment.

7.3 Biomass Thermal Energy Utilization

(1) Technical level should be improved. Domestic biomass fuel processing methods are the traditional production methods, commonly with the problems of high energy consumption and short service life etc, and it need to strengthen R & D and improvement and improve energy efficiency. (2) Technical and service level to be improved. Currently, many biogas and biomass gasification equipment suffer the failure or even stop due to lack of professional technical services (3) the production and application cost is still high. Limited by the technology and imperfect equipment industrial chain, many of the projects are with huge investment and high production cost, less attractive for farmers and other users.

8. Policy recommendations for the country/region

China will develop bioenergy in a wide range of forms, hopfuelly fousing on biofuel for transport in the long term. Biopower in China will be locally-oreinted small-scale biopower facilities, Combined Heating and Power (CHP); biofuel will be ethanol and biodiesel from nonfood feedstock, mainly cassava, sweet sorghum and jatropha in near term but cellulose such as crop straw in the long term. Biogas, pellte and biomass gasification will play an important role in providing heating fuel.

Firstly, to carry out resource assessment. Resource evaluation is the basic condition for developing biomass energy industry. Survey on energy crop, marginal land resource, geographic distribution, and formulating energy crop plantation plan are necessary. For other biomass resources such as straw and livestock waste, quantity, distribution, and developing trend are also needed to evaluate.

Secondly, to establish the law and policy system for biomass energy development. Based on the Renewable Energy Law, formulate the relevant laws and policies to support the biomass energy development, implement economic encouragement such as financial subsidy, investment, tax, and users' subsidy. Besides, establishing biomass energy standard system is very important.

Thirdly, to accelerate the development, dissemination, and application of biomass conversion technologies. Increase the support for basic study of biomass technologies, accelerate the development of new energy technologies with independent intellectual property rights. Summarize the experiences and lessons, steadily promote the healthy development of biomass energy industry.

Particularly, biofuel industry in the future should accomplish the following strategic tasks.

(1) To transform the structure of feedstock mix and consolidate resource base. The resource base should be consolidated, through transition from relying on edible food feedstock such as grain, sugar and oil to a variety of agricultural raw materials such as non-food materials in order to avoid threatening food security and expand feedstock structure. In the near and middle term, great importance should be attached to collecting and making full use of abandoned molasses, plant oil and animal grease. In the medium to long-term when advanced biofuel like the Cellulosic ethanol and synthetic fuels commercialize gradually, much effort shall be made to collect and utilize agricultural crop straw and forestry residues, and to build the high-yield woody forest and microalgae production bases.

(2) To optimize the structure of product mix to improve the economic efficiency by developing and integrating related technology, extending the industrial chain, and improving comprehensive utilization of resource, producing high added-value byproducts and new products according to the characteristics of the non-food feedstock. In the near and middle term, attention should be given to collecting and making full use of waste resources of crop cultivation and processing such as the stems and leaves, waste residue, waste water, and glycerol for producing fertilizer, feed, gas, paper and chemical raw materials. In the medium to long-term, more work shall be done to integrate biochemical technology and realize biorefinery which produce a series of products such as biofuels, heat, electricity, fine chemical materials, medical products.

(3) To restructure the industrial organization chain to improve the efficiency of the industry. In line with the characteristics of non-food liquid biofuel industry, it should restructure the industrial organization chain, put much more emphasis on energy plant cultivation and raw materials production in the industrial chain, establish the business model integrating distributed pre-processing and concentrated refining", raise the enthusiasm of local government and farmers. Local small and medium enterprises should be encouraged and guided to collect and utilize waste molasses and oil resources in the production of fuel ethanol and biodiesel. It should support local farmers, small and medium enterprises, trade associations, intermediary organizations to carry out orderly energy plant cultivation, raw materials collection and the pre-processing activities, and encourage large and medium

enterprises of the middle and lower reaches and local farmers, small and medium enterprises and related organizations to establish a stable, mutually benefiting partnership and new agro-industrial development mode.

(4) To reconsider the concept of industrial development to ensure sustainable development. It should establish a wide range of new industrial development concept including comprehensive utilization of resources and the circular economy, energy conservation and greenhouse gas emissions, land exploration and finishing, construction of the modern agriculture and forestry, ecological restoration and protection, so as to realize macro-level integration of agricultural, industrial and environmental systems that ensuring concrete sustainable development. It should realize the transformation from the extensive and destructive mode of land exploration and plant cultivation to intensive and protective mode, reducing the ecological risks and potential leakage of carbon in the soil. It should make the comprehensively study, assess and reduce the energy and water consumption, conventional pollutants and GHG emissions in the whole process of the feedstock production, processing and conversion.

(5). To establish sound industrial policy system to promote the healthy development of the industry. It is urgent for the government to establish a sound policy system suitable to characteristics of non-grain liquid biofuel industry by formulating and implementing a series of incentive policy, clear regulations and effective mechanisms in line with the technological and industrialization progress, feedstock and products mix, characteristic of industrial organization and concept of sustainable biofuel, so as to ensure the construction of pilot projects and scale-up development of biofuel in China.

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