환경위생공학, 제23권 1호(2008)
Journal of Environmental and Sanitary Engineering, Vol. 23, No. 1, pp.1~15 (2008)

REVIEW

A Survey of Bioenergy Resources Potential and the Prospect of Cooperation in Yanbian Korean Autonomous Prefecture

Zin-Oh Kim[1] · Sang-Myon Oh[1*] · Yong-Woo Lee[2]

[1]*Korea Energy Economics Institute 665-1, Naeson 2-dong, Uiwang-si, Gyeonggi-do, Korea*
[2]*School of Chemical and Biological Engineering Yanbian University of Science and Technology Beishan st., Yanji, Jilin province, China*

Abstract

Yanbian Korean Autonomous Prefecture(YKAP) possesses the potential to become the first testing ground for the North-East Asian Energy Cooperation in renewable energy sector. We found that production of biodiesel from rapeseed and CHP (Combined Heat and Power Plant) project utilizing abundant forest resources are the two main bioenergy development projects which may have further development potential considering the resource endowments and the focus of Chinese governments' current rural development policy. Provision of stable and transparent investment environments and the development of a close cooperation mechanism between Korea and China government are the prerequisite conditions for investments in the sector. Other international institutional agreements, such as CDM, shall be fully utilized for biomass CHP projects.

Key words : Biodiesel, Hioenergy, Yanbian Korean Autonomous Prefecture.

*Corresponding author E-mail : smoh@keei.re.kr

I INTRODUCTION

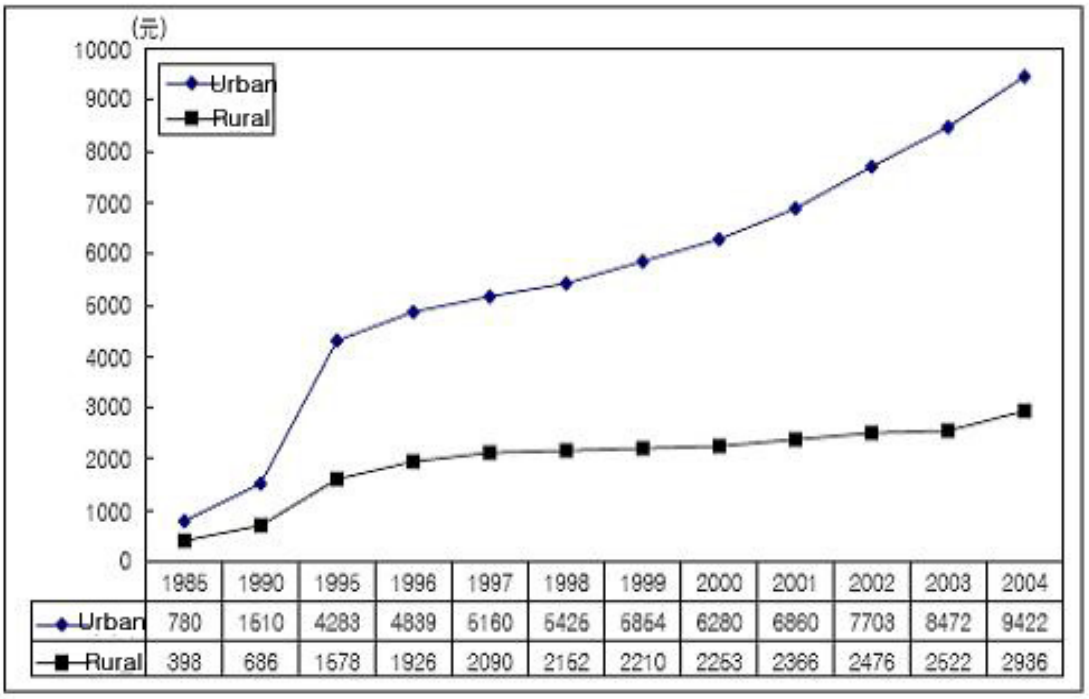
Three provinces in the north-eastern part of Chinapossess huge strategic and geo-political importance for North-East Asian Energy Cooperation. On top of the geographical proximity and the historical and ethnic heritage of the Korean community in the region, Yanbian Korean Autonomous Prefecture (YKAP) has the potential to become the first testing ground for the North-East Asian Energy Cooperation in renewable energy sector. In this report we tried to provide an analytical foundation forinvestment projects in the renewable energy sectors in YKAP. We collected and analysed the legal and institutional framework in Chinese renewable energy sector. We tried to enhance the practicality and credibility of the study by including the results from several meetings and discussions with government officials of the region at various levels and, also, by field trips to the project sites. Despite the limited availability of data and information required to perform feasibility studies of investment projects in bio-energy sector, we found that production of biodiesel from rapeseed and CHP (Combined Heat and Power Plant) project utilizing abundant forest resources are the two main bioenergy development projects which may have further development potential considering the resource endowments and the focus of Chinese governments' current rural development policy. Based on our study about bioenergy sectors in Yanbian region, the prerequisite conditions for successful implementation of the bioenergy investment projects can be summarized as; i) provision of stable and transparent investment environments in terms of market development and sector specific incentive schemes such as the introduction of compulsory quantitative restrictions (Renewable Portfolio Standard) and feed-in-tariff type preferential pricing arrangements for the concerned bioenergy projects in China, and ii) development of a close cooperation mechanism between Korea and China government as well as cost reduction efforts by incorporating these projects with 'New Rural Movement' policies promoted by the Chinese government.

II China's Renewable Energy Policy

1 Energy Supply and Demand in China

During past decades, China experienced high economic growth rates of around 10% p.a. Although the current GDP of China falls below 4% of world total output, the share of China's energy consumption has risen to 12% of world's total energy consumption. The phenomenal economic growth of Chinaalso resulted in widening income gap among regions, especially between urban and rural population, and in worsening environmental problems. Chinese government felt the urgent need for a new national development strategy to avoid social and political instability and to maintain sustainable economic development.

Recently, Chinese government shifted its economic development strategy from unconditional 'growth first' strategy to a more 'selective and qualitative' economic growth strategies. High technology industry clusters are established by fully accounting for the resource endowments of each region. Nationally balanced economic growth



	1985	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Urban	780	1510	4283	4839	5160	5425	5854	6280	6860	7703	8472	9422
Rural	398	686	1678	1926	2090	2162	2210	2253	2366	2476	2522	2936

Fig. 1. Income disparity between urban and rural population.

are promoted by strengthening the economic linkages among regional industry clusters. Rural economic development projects are actively pursued through 'New Rural Movement' policies. Per capita GDP is projected to increase 7.5% p.a. during the 11th 5 year economic development plan period reaching US$2,400.

China's energy consumption increased 5.9% p.a. during 1990-2006 period becoming the second largest energy consuming country in the world. Industry sector led China's energy demand upsurge during the period and the share of energy consumption by industry, household, commercial, and transportation sectors recorded 70%, 10%, 2%, and 7% in 2005 respectively.

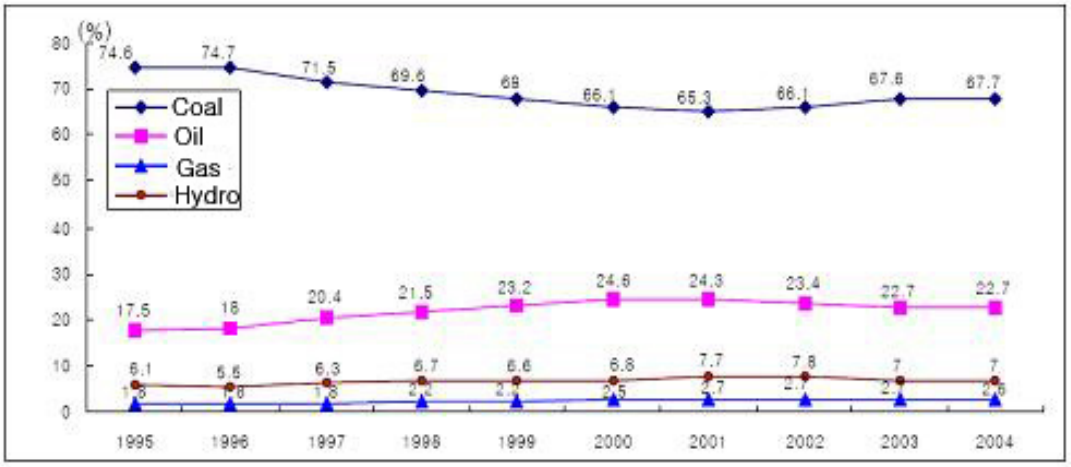


Fig. 2. Energy consumption by source.

China's energy consumption increased 5.9% p.a. during 1990-2006 period becoming the second largest energy consuming country in the world. Industry sector led China's energy demand upsurge during the period and the share of energy consumption by industry, household, commercial, and transportation sectors recorded 70%, 10%, 2%, and 7% in 2005 respectively.

The share of coal consumption decreased slightly but turned upward in 2006. Coal consumption in 2006 was 2.4 billion tons doubling the consumption record of year 2000. Despite the abundant domestic coal reserves, China's production of coal did not satisfy the rapid increase in demand for electricity generation and the increased use of coal was the main source of China's environmental problems.

'World Energy Outlook 2007' provides a medium to long term energy demand forecast of China. China's energy demand is expected to increase 3.2% p.a. reaching 3.8 billion toe in 2030, comprising 20% of total world energy demand. China's total energy consumption will exceed the energy consumption of the U.S. by 2010 and is expected to grow 5.1% p.a. until 2015. Transport sector is responsible for two thirds of total fuel consumption in Chinawhich is expected to quadruple during 2005-2030 period. Production of natural gas is expected to increase over the coming years from the current production level of 60 bcm, and a 20 bcm supply shortage is expected in 2010 when the demand for natural gas reaches 100 bcm. Longer time requirements for the construction of hydro-electricity generation facilities and nuclear plants in addition to the reduction in water resources caused problems for policy makers in China to reduce its dependency on coal. With regard to China's resources development policy, China's energy strategy shifted from inward-looking self-sufficiency strategy to outward-looking energy development strategy by participating in international energy exploration projects, and by diversification of energy supplies. The increase in China's energy demand is expected to put enormous pressures in the world's energy markets including resource exploration and development sectors.

The share of China's Greenhouse Gas(GHG) emission is expected to reach 40% of the world's total GHG emission by 2030 and China will become the 4th largest GHG emitter on per capita basis following the US, Japan and EU. There exist vast rooms for improvements in energy efficiency for China and, to achieve the environmental and energy security goal, Chinese government needs to implement strong GHG reduction policies, technology R&DD policies, the introduction of market mechanism in the energy markets and incentive schemes for the development of environment-friendly energy resources by strengthening international cooperation in this area.

2 Renewable Energy Policies in China

Major government bodies responsible for China's renewable energy policies are Ministry of Science and Technology(MOST), National Development and Reform Commission (NDRC), Energy Research Institute(ERI) and Center for Renewable Energy Development (CRED). Chinese government approved 'Renewable Energy Act' in 2005 where basic government renewable energy policy goals and principles were proclaimed. In '11.5 Economic Development Plan', Chinese government set its energy

and environmental policy goals of a 20% reduction in energy consumption, a 10% reduction in pollutants emission level, and a 20% increase in forest plantation area by 2010 to establish a resource-saving and environment friendly society.

In fact, the Chinese government recognized the importance of green energy and initiated the introduction of bio-ethanol in the markets of north-eastern provinces from 2002. Research and development in renewable energy became one of the government policy priorities in the '11.5 Plan'. In the Plan, the government declared its intention to promote FDIs in high technology green energy industries. In September, 2007, the Chinese government published 'Long-term Renewable Energy Development Plan'. According to the report, the share of renewable energy consumption is projected to comprise 10% and 20% of the total energy consumption by 2010 and 2020 respectively. Also, the share of electricity production from renewable energy sources is planned to reach 30% of the total electricity production by 2020.
Chinapossesses a hugh hydro-electricity development potential, especially in the western regions, and is planning to increase the electricity generation capacity to 300GW by 2020. Three northern regions in China, including Jilin province of northeast region, possess advantages in wind power generation and the wind power generation capacity in China will increase to 30GW by 2020. Wind power technology of China's local industry is still at infant stage and the local companies are not capable of producing large scale wind power generation equipments relying on foreign suppliers for critical parts. Chinghai-Tibet, Shinjiang, Liaoning & Jilinprovinces enjoy high level of solar energy resources and the Chinese government is currently running pilot-solar electricity generation projects for electrification of remote areas. But Chinese solar energy industries are currently dependant on silicon imports and there exists a big technology gap with other major international players. But, China is already the largest user of solar heater and is planning to increase its solar panel instalments to 300 million ㎡ replacing 40 million tons of coal consumption. Chinese government has also published ambitious plans to develop biomass, biogas, and biofuel energy sources. Biomass energy from agricultural waste, straw, and municipal wastes is expected to reach 500 million tce. China also has the largest rapeseed growing areas in the world. But food production remains the top priority of the government policy and Chinese central government encourages local governments and villages to grow energy crops and plants by usingvacant lands. NDRC also published GHG policy report forecasting 950 million tons of reduction in GHG emission by 2010 and Chinese government has introduced financial incentive schemes to entice more FDIs(Foreign Direct Investments) in energy industries for the development of renewable energy sources & GTL(Gas to Liquid), expansion of thermal energy utilization projects in energy intensive industries, and improvements in energy efficiency in buildings.

To achieve this goal, Chinese government is planning to make investments of 2 trillion yuans in the renewable energy sectors. Chinese government will mobilize investment funds required for renewable energy projects on Public Private Partnership basis. The selection of investment projects shall be

made based on the size of investment requirements, technology characteristics and the stage of China's technology development. The central and local governments of Chinashall make their best efforts to implement renewable energy legislations and to prepare details ofpolicies and standards. Governments at various level shall closely follow directives for renewable energy resources development and deployment as a major policy evaluation tool.

Based on the new renewable energy policy framework, the full implementation of the plan will increase the use of renewable energy to 300 million tce by 2010 and 600 million tce by 2020. It will also contribute to environmental improvement by reducing GHG emission and Based on the new renewable energy policy framework, the full implementation of the plan will increase the use of renewable energy to 300 million tce by 2010 and 600 million tce by 2020. It will also contribute to environmental improvement by reducing GHG emission and other environmentally harmful materials while saving 2 bcms of water resources. Apart from the environmental and energy security issues, the major goal of China's renewable energy policy is to improve the earnings potential and living conditions for rural population. Additional 10 million people in the rural area are expected to get access to electricity for the first time and 100 million rural residents will be able to enjoy better living conditions as the results of renewable energy policy implementation. The estimated income effect through biomass and agricultural waste projects amounts 1.5 billion Yuan and two million new jobs will be created in the rural area from the renewable energy projects including the expansion of renewable energy equipment production sector. Renewable energy sources not only lacks cost competitiveness compared to traditional fossil fuels but also demand large amounts of initial investments. Apart from hydro electricity generation, most of

Table 1. China's regional renewable energy development and specialization plan.

Source	Region/Type	Specialization
Hydro	Western China	-
Biomass	All the rural areas and big cities	- Agricultural waste: rural area, forest region - Municipal waste: Big cities - Biogas electrification: farms and industrial area
Biomass solid fuel	Rural area	- Cooking and heating for rural household - Surplus to be sold
Biomass gas	1. Rural area 2 Small to medium size cities	- Gas from agricultural waste - Large animal farms, industrial sewage
Bioethanol	Casaba, sweet potato, Sugarcane etc.	- Northeast regions, Shandong: Sugarcane - Guangxi etc.: Sweet potato
Biodiesel	Jatropa, etc.	- Sichuan, Guizhou, Yunnam, Hubei etc.
Windpower	1. Northeast shore and Three Northern region 2. Jiangxu, Hubei, Inner Mongolia	- 100 MW wind farms (30 sites) - 1 GW wind farms
Solar energy	1. Household solar electrification 2. Grid-connected Solar electric generation 3. Large scale solar energy/heat generation	- Tibet, Qinghai, Inner Mongolia, etc. - Shandong, Liaoning, Jilin - Big cities: Beijing, Shanghai, etc. - Gansu Dunhuang, Tibet Lassa
Others	Thermal and ocean energy	-

renewable energy sources are in their infant stage of development and require concrete government policies to establish markets and to provide stable and predictable investment environments in the renewable energy sector.

The Renewable Energy Act was enacted in 2006 but the details of government assistance schemes and action plans are yet to be legislated. The Chinese government is expected to publish details of assistance schemes for renewable schemes in 2008 including preferential tariff schemes(feed-in-tariffs), cost sharing formula for bioenergy supply and grid connection, product standards, certification requirements and procedures etc.

Bioenergy Potential and Bioenergy Projects in Yanbian Region

1 Major Economic Activities in China's North-eastern Provinces

Main industries in Liaoning, Jilin, and Heilungjiang provinces are traditional heavy industries. Also the region is one of China's major food supply bases. China is planning to further developmachinery & motor industries, chemical industries and food processing industries in the region. Low level of industrial diversification, mal-functioning linkage among industrial centers and supporting regions(especially between large cities and rural areas), are major obstacles for further economic development of the region. Deepening of industrialization through structural reforms and privatization of state-owned companies is the main economic development strategy of the region. Also, the agricultural and bioscience industries are other major industry groups that the government is planning to develop by utilizing abundant natural resources in the region.

Table 2. Major Economic Indicators of Jilin Province.

Item	2004	2005
GDP (100 million Yuan)	3,122	3,620
Primary industry	568	625
Secondary industry	1,329	1,580
Tertiary industry	1,223	1,413
Investments (100 million Yuan)		
Total investment in fixed assets	1,171	1,802
- Investment by state-owned and collective owned units	504	978
Agricultural production		
- Grains (10,000 tons)	2,510	2,581
- Oil-bearing crops (10,000 tons)	38	55
Population and income (1,000 person, Yuan)		
- Total population	27,085	27,160
- Employment	12,220	12,389
- Rural household per capita net income	3,000	3,264
Per capita GDP(Yuan)	11,537	13,348

YKAP is located in the eastern side of Jilin province covering land area of 43,457 ㎢. YKAP is created on September 3, 1952 as a special ethnic district and promoted to Korean Ethnic Prefecture in 1955. The population of YKAP isaround

2.7 million and the share of Korean ethnic background is around 40% of the total population. Underdeveloped supporting industries and high transportation costs were the major impediments to FDI inflows into the Yanbian region. But the region possesses a high level of strategic importance for our economic and energy cooperation with North Korea and other North-East Asian countries. Jilin province is located at the center of national border lines of China, Russia, DPRK (Democratic People's Republic of Korea). By taking advantage of its geological position, Jilin province initiated Tumen Economic Development Project and UNDP(United Nations Development Plan) made a positive decision for the project. It started as a result of seismic changes in world geopolitical environments following the collapse of communist regime. The border areas of Jilin province of China, far eastern province of Russia (Primorsky), north-eastern part of DPRK were the regions for the economic cooperation and the idea was developing the geopolitically important region as a hub of economic cooperation among major economies in the region including ROK, Japan and Mongolia as major stakeholders for the project. The participants of the projects envisioned that, by fully utilizing the complementarity of the adjoining regions and other major stakeholders, the region can be transformed into a fully functioning international production and logistic center. A large investments in infrastructure projects for road and rail constructions, developmentof international port facilities capable of large container vessel access, efficient cargo handling facilities, and in energy infrastructures were required to accomplish the goals. But, the project is currently delayed by a series of political events in the region and by the lack of interests from international investors. Chinese government currently provides preferential tax and tariff treatments for trade with neighbouring nations and major SOC(Social Overhead Capital) development projects to improve energy, communication, and transportation infrastructure are underway in the region.

2 Energy Consumption in Yanbian

There are six cities and two local districts in YKAP. They are Yanji, Tumun, Dunhua, Hunchun, Longjing, Helung, Wangqing, Antu. The total farming area is 230 thousand ha and rice, corn, and soybeans are the major agricultural products of the region. The forest area in YKAP region covers about 3.5 million ha and the estimated forest reserves amounts to 326 million m^3. The region also boasts abundant natural resources endowments including energy resources such as coal and crude oil. '2006 Yanbian Statistical Annual Report' provides statistical information of 2005 financial year on natural gas, LNG, and thermal energy supply. It also provides detailed information on electricity consumption by industry.

Table 3. Final energy consumption in the industrial sector(2005).

Steam	380 Thousand GJ × 0.238kcal/KJ = 9.044TOE
Hot Water	1.86 Mil. GJ × 0.238kcal/KJ = 442,680TOE
LPG	21,284 Tons × 12,000kcal/kg = 25,540TOE
City Gas	190 Tons × 13,000kcal/kg = 247TOE
Electricity	634.57 Mil. kWh × 13,000kcal/kWh = 54,573TOE
Total	532,084TOE

Table 4. Final energy consumption in the residential/commercial/transport & public sectors.

Gasoline	16,189 Tons × 8,300㎉/ℓ = 13,436TOE
kerosene	125 Tons × 8,700㎉/ℓ = 108TOE
Diesel	20,012 Tons × 9,200㎉/ℓ = 18,411TOE
B-C	2,092 Tons × 9,900㎉/ℓ = 2,071TOE
LPG	214 Tons × 12,000㎉/㎏ = 256TOE
Other gas	2,150 Tons × 0.8 × 0.9 × 539,000㎉/ton = 83TOE
Thermal energy	4,762,537 Mil. KJ × 0.238㎉/KJ = 113,348TOE
Electricity	1383.87 Mil. kWh × 860㎉/kWh = 119,012TOE
Total	2,450,139TOE

The estimated total energy consumption in Yanbian region amounts to 2,982,223TOE. Per capita energy consumption in Yanbian region is 1.37TOE which corresponds to about 40% of energy consumption in Korea. According to '2006 Yanbian Statistical Annual Report' the final energy consumption (TOEs) in the industrial and the residential/commercial/transport & public sectors can be summarized as below. The final energy consumption of the industrial sector amounts to 2,450,139TOE. The share of energy consumption by energy source is coal 87%, electricity 4.8%, thermal energy 4.6%, petroleum 3.5%. The final energy consumption for the residential/commercial/transport & public sectors is 532,084TOE. The share of energy consumption by energy source is thermal energy 83.2%, electricity 10.3%, LPG 4.8% respectively.

3 Bioenergy Potential in Yanbian

Table 5. Bioenergy resources in Yanbian.

Area/Type	Biofuel	Biogas	Biomass	Total
Yanji	3,355	1,287	0	4,642
Tumun	4,129	858	0	4,987
Dunhua	49,509	11,153	37,189	97,851
Hunchun	11,689	2,574	0	14,263
Longjing	25,184	1,716	16,904	43,804
Helung	6,982	2,574	11,833	21,389
Wangqing	14,104	3,861	6,762	24,727
Antu	9,907	3,432	11,833	25,172
Total	124,859	27,455	84,521	236,835

The estimated amount of exploitable bioenergy resources in Yanbian region for biofuel, biogas, and biomass totals to 236,835TOE; biofuel 57%, biomass 35.7%, biogas 11.6%.

Biogas is the most realistic bio-energy option in terms of economic feasibility because it can be produced from livestock excretions, agricultural and other wastes where other bioenergy sources would incur farming and collection costs. Among the eight cities and towns in the area, Dunhua city possesses the highest level of bioenergy resources development potential estimated to be around 97,851TOE while it is about 43,804TOE in Longjing city.

4 Bioenergy Projects Promoted by Yanbian Government

According to China's regional renewable energy specialization plan, the development of biomass energy sources (including biogas production and biogas electricity generation), expansion of bioethanol production, increase in wind power generation capacity, promotion of household solar heating system are the main focus of the renewable energy development plan for the three northeast provinces of China.

In response to the bioenergy promotion policy promoted by the central government YKAP government is actively engaged

in smaller scale bioenergy projects by fully utilizing the abundant agricultural and forest resources in the region. Major bioenergy projects promoted by the YKAP government are smaller scale biogas production for rural households and villages by using agricultural wastes/ animal excretions and the expansion of energy plants and crops growing area for bioethanol and biodiesel production. Farm household biogas and village biogas projects are the main focus of bioenergy project of the local governments in the region and the local governments encourage construction of biogas facilities in conjunction with 'New Rural Movement' promoted at national level. 'New Rural Movement' is the main policy vehicle aimed at increasing the income level and living conditions of people in the rural area. The governments expect that farmers earn additional income by participating in the construction works of biogas facilities. Those projects will also save time spent on collecting traditional biomass energy sources. If successfully implemented, the lower gas cost from the biogas projects is expected to raise farmers' real income too.

Energy Crops and Plants for Biofuel

Three provinces in Northeast China are the center of bioethanol project promoted by Chinese government as a part of China's renewable energy development policy from the 10th 5 year development plan. In case of bioethanol project, potatoes, beetroot, and sugarcanes are designated as bioethanol crops by Yanbian regional government. Technical and, in some cases, economic feasibility tests have already been completed for some of the energy plants and crops. Yanbian's cold climate is suitable for potato farming and the local government is planning to develop 10,000ha of specialized potato production farm with the technical assistance from Yanbian University. Beetroot produced in Yanbian contains a high level of sugar contents and the production volume per one ha is expected to reach 50 tons. The local government is currently studying mass plantation of beetroot mainly for export. For bioethanol from sugarcane project, Longjing local government carried out scientific tests for plantation.

Biogas from Agricultural Wastes

Yanbian government' official estimate of agricultural waste in the region amounts to 1 million tons p.a. But most of them are not utilized into energy sources yet. The government tried to exploit the potential of agricultural waste as alternative energy sources for rural households and villages and is currently studying the possibility of transforming the wastes into pellets for household heating. As mentioned before, it is expected to raise income level in the rural area in addition to the obvious environmental benefits of the projects.

(Village biogas project)

Three villages in Longjing are running centralized gas supply system. Wangqing local government also made an ambitious proposal to build centralized gas supply facility for 100 villages. The standard construction and equipment costs for each village biogas unit amounts to 1.8 million Yuan. It supplies biogas to the

surrounding village by 2 hours operation per week. Yet, the village biogas production facility had technical problems associated with pipeline blockage. Also, few years ago, a biogas production facility which produces biogas from burning agricultural wastes was installed with the fund from UNDP, but has never started operation because farmers were not able to pay for the pipeline connection costs.

Table 6. Biogas projects in YKAP region.

Locality	Biogas project	Progress
Longjing	- Biogas from excretions (individual household) - Biogas (village project)	- Constructed 200 individual units - Only 40% in working condition - Constructed 3 village biogas units - Operating 2 hours per week - Pipeline blocked after 3-5 years of operation
Tumun	- Biogas from excretions (individual household)	- Constructed 1,190 individual units - Only 200-300 units in working condition - Insufficient supply of farm animal excretions
Antu	- Biogas from excretions (individual household)	- Constructed about 500 individual units from the total farm households of 1,000 - Each farmer paid 800 Yuan due to financial problems of the local government
Helung	- Biogas from excretions (individual household) - Biogas (village project)	- Central government subsidy 1,200 Yuan, Local government subsidy 600 Yuan, farmer 600 Yuan. - Constructed 180 individual units, Planned to construct additional 3,000-5,000 units by 2009 - 95% in good working condition - Estimated annual income effect of 900 Yuan for each household by reducing LPG consumption, the use of fertilizers and by environmental protection - Additional income for farmers by participating in the construction (annual income increase of 3-5,000 Yuan) - A 70m^3 Biogas unit is constructed on a chicken farm - Need to develop ignition system for boilers
Wangqing	- Biogas from excretions (individual household) -Biogas (village project)	- Constructed 200 units in 2006. - Local government was unable to provide subsidy and supplied only some of the construction materials. - Central government subsidy payment will cease in 2010. - Planned to construct 100 village biogas units
Yanji	- Biogas from excretions (individual household)	- Constructed 2,300 biogas units from 2003 - Very low rate of working units(10%) due to low winter temperature and faulty construction work. - Insufficient farm animal excretions supply because the local government prohibited chicken and pig farming
Hunchun	- Biogas from excretions (individual household)	- Subsidy payment from the central government 1,200 Yuan + New Village Construction Fund 1,000 Yuan - Constructed around 100 units but only 20% in working condition
Dunhua	- Biogas from excretions (individual household)	- Subsidy payment from the central government 1,200 Yuan - High rate(95%) of working units due to good management

Local governments in Yanbian region have also actively promoted installation

of biogas production units which use agricultural waste and animal excretions for individual household cooking and heating. The standard construction costs for each unit is estimated to be around 2,400 Yuan and the central government, local government and farmers are expected to share the costs. Normally, the central government contributes 1,200 Yuan from New Rural Development Fund and the local government pays 600 Yuan leaving 600 Yuan as the farmers' share. But the projects confronted serious problems on several fronts. Firstly, the poor financial position of the local governments in the region made it impossible to contribute their share of the construction costs. Among the eight local governments in the region, only Helung local government was able to pay their share. Secondly, most farmers had higher expectation about the governments' contribution and were not willing to pay their own share from their already low income. The third factor was the decrease in the number of domestic cattle due to rapid urbanization and government regulations against domestic cattle farming in city areas. The final factor is the low operation ratio of the construction units due to faulty construction works and the cold weather conditions. The share of units operating normally 4-5 years from the construction date falls below 20% of the total units.

Bioenergy Cooperation

1 Feasibility Analysis for Bioenergy Projects in Yanbian Region

In this paper we abstract from the commercial and technical aspects of two bioenergy investment projects and will concentrate on the institutional and strategic plans to proceed with the biodiesel project and biomass CHP project.

1.1 Biodiesel from Autumn Rapeseed Farming

If autumn rapeseed farming is possible in Yanbian region, the estimated rapeseed oil production costs will remain economical when we compare it with the current wholesale market price of edible rapeseed oil in China. Apart from contribution to energy security and environmental problems, utilizationof idle land during winter season is the main feature of rapeseed farming project in the region. Assuming a similar rapeseed yield and quality is achievable in Yanbian as in Korea (4 tons/ha) and also assuming rapeseed price remains at the current international trading price level of A$400/ton, it is possible for farmers in Yanbian to earn approximately 70% of their current annual income from autumn rapeseed farming. Autumn rapeseed farming will also contribute to improve farmers' income level and decrease CO_2 emission. As in Korea, improvements in landscape and the associated income potential are additional benefits of the autumn rapeseed farming project.

In terms of biodiesel production potential from rapeseed, rapeseed biodiesel is unlikely to become competitive without government assistance. Although we do not have any concrete evidence whether autumn rapeseed farming is possible in

the region, we were able to get some preliminary economic feasibility study results as below.

There are many options for farmers in the region with regard to the choice of summer crops, such as sunflower farming, which may yield as high income as autumn farming. One way of augmenting farmers' income without financial woes to the central and local government in China is to provide autumn rapeseed growers entitlements to use state owned vacant lands near their farming areas. The farmers will be able to increase their income through higher output per household and through cost savings from scale economies.

Therefore, the biodiesel producers will be able to purchase rapeseed from autumn farming at international price and the government can promote biodiesel usage by subsidizing biodiesel production and/or distribution side of the supply chain.

1.2 Biomass CHP Project

Biomass project for CHP will help energy savings and increase employment in the rural area. We experienced difficulties in conducting meaningful feasibility analysis for biomass CHP project discussed in this paper due to access problems to firm level cost information.Major factors that affect the feasibility and profitability of the projects will be the collection and transportation costs, the nature of government assistance schemes in the region and the size of the additional revenue flows from CDM(Clean Development Mechanism). China's current rural policy indicates that the biomass collection costs, which is one of the most important production costs for biomass CHP project, may become flexible and other preferential arrangement may be negotiable with the local government.

2 Strategies for FDIs in Bioenergy Projects

Generally speaking, economic factors, legal & institutional factors and other social and cultural factors have influence on the feasibility and risk analysis results for investment projects. Salient features of investment projects in the energy industries are the lumpiness in investment and the time required to recoup profits from the investments. Also, to make an investment decision for a bioenergy project in China, comprehensive understanding of the legal requirements for FDI projects and of the bioenergy legislations and policies of Chinese governments are required on top of the commercial aspects of the investment projects.

Although the overall social benefits of using bioenergy exceed the social costs, most bioenergy sources lack price competitiveness when compared to the traditional fossil fuels. Therefore, many governments around the world provide financial assistances to nurture bioenergy industries. When we consider the fact that the most criticaldeterminant for investment decision is secure and predictable investment environments, the stability and credibility of government's bioenergy policies are the prerequisite condition for investments in the bioenergy sector.

Despite inherent production cost problems with the bioenergy sources, these types of green energy projects are actively recommended and promoted by the

Chinese government. It is also highly possible to get full cooperation from the regional government because of their obvious environmental benefits and because of the positive employment and income effects of bioenergy projects to rural population.

Once the possibility of growing rapeseed in Yanbian region is confirmed, it is strongly recommended to create active cooperation with the regional government in terms of assignment of rapeseed growing areas, the entitlement of access to the vacant land. For biomass CHP project, access to the forest resources and the reduction of collection costs of biomass material from forest thinning out projects by the local government is the crucial factors required for the success of the investment project.

In addition to the government policy factors, case study results on the previous FDI projects in Chinaclearly shows the importance of the understandingof the institutional and legal environments of the concerned industries on top of the commercial aspects of the investments. The importance of the institutional and legal factors looms large for investment projects in renewable energy sectors. Therefore, considering the facts that consulting service industries in Chinais under-developed, it is important to spend sufficient time to study the local industries and investment environments including the institutional and legal environments of the specific industry by participating in incubating center at the local universities before making the final investment commitment. In addition to the domestic institutional factors, international institutional factors such as CDM will have growing importance for investment decisions in the bioenergy industry. Recent study results shows that the returns from investments in renewable energy, such as biomass CHP, may be increased considerable by actively participating in the carbon market. Finally, in case of biodiesel from autumn rapeseed farming project, the success of rapeseed farming may be s sufficient condition for growing rapeseed in North Korea. It will widen up the avenues of energy cooperation with North Korea. Therefore, to prepare for the upcoming opening-up of North Koreato international communities, a strategic consideration should be made to fully utilize the logistical advantages of using ports and transport routes of North Korea to alleviate the cost disadvantages of the region.

Ⅲ CONCLUSION

YKAP is a region of geopolitical importance in terms of Northeast Asia Economic and Energy Cooperation. In this report we explored the possibility of FDIs in bioenergy sectors in YKAP as a part of Northeast Asia Energy Cooperation. 'Biodiesel from rapeseed farming' and 'Biomass CHP' projects have the potential considering rich resources endowments of the region and the active involvement by Chinese government towards the renewable energy sector. To proceed with these FDIs projects, we recommend that strategic aspects should be taken into consideration for bioenergy investment

project as below.

Although China's bioenergy industry is a booming industry, the legal frameworks for bioenergy industry development are yet to be fully established. The reduction of income gap between rural and urban population is one of the policy priorities for the Chinese government and the government implemented various policy measures, such as 'New Rural Movement' to raise the income level of farmers. Therefore, it is important to maximize economic feasibility of the bioenergy projects through cost reduction efforts via close cooperation with Chinese government as a part of their rural economic development policy. The role of Korean government is to provide a stable and minimum-risk investment environment through close inter-governmental cooperation with the Chinese government for FDIs in bioenergy sectors. The institutional framework can be extended to other North-East Asian Energy Cooperation projects.

We also recommend that investors go through a comprehensive analysis about the investment environments before making full investment commitments in a particular bioenergy project. Therefore, it is strongly recommended to take parts in an incubating process with higher education institutions in the region. Other international institutional agreements, such as CDM, shall be fully utilized for CHP projects.

REFERENCES

1. Cao Ying: Efforts of the Chinese government for promoting environmental innovation in the fields of energy efficiency and renewable energy" OECD Workshop on Environmental Innovation and Global Markets (Sept.20-21 2007, Berlin), 2007.
2. Chung, H.W.: China's New Rural Movement and its Implication, KISA Issue Paper, 06-05, 2006.
3. Han K.J.: The Current Status of China's Energy Industry, KIET Issue Paper, 200-211, 2006.
4. NEA Energy Bulletin, China's Medium to Long Term Renewable Energy Development Plan, KEEI, 2007.
5. UNEP, Global Trends in Sustainable Energy Investment, 2007.
6. Yanbian Annual Statistics Review, Jilin, 2006.
7. Yanbian Agricultural Commission policy report, 2007.
8. YKAP Land Survey, YKAP, 2007.