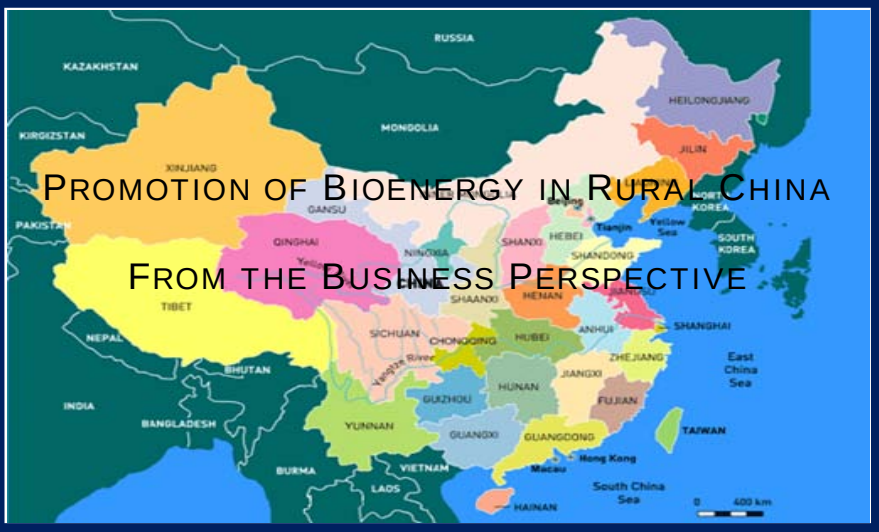
Huang He

Analyzing opportunities and barriers to bio-energy development in rural China, 2009

Huang is a graduate in Environmental Science from Fudan University, China. He studied for the Master of Environmental Sciences, Policy and Management (MESPOM) from the Central European University in Budapest, but is now based in Manchester.
Huang visited rural villages in Sichuan and Yunnan provinces of Western China to look at the utilization of solid waste from livestock farms and co-produced residues from processing harvested crops as sources of bio-energy. Such activities, if successful may help reduce poverty by creating sustainable livelihoods and might also play a role in mitigating climate change.

Below is Huang's PowerPoint presentation on his research.

Master Thesis Defense



Promotion of Bioenergy in Rural China

From the Business Perspective

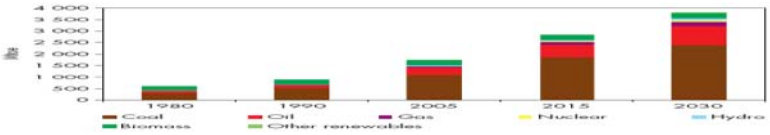
Huang, He Mespom 2007-2009

Supervisors: Kes McCormick

CONTENTS

1 INTRODUCTION

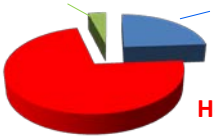
- Sharply increase of primary energy demand in China



Source: China's Primary Energy Demand in the Reference Scenario, OECD, 2007a. P 287

- A great potential and accessibility: Biomass to Energy
  300 million tons of biomass = 150 million tons of standard coal
- Big gap between the potential and current state

Around 8 % biogas or biomass stove



23.8 % Burnt directly

How to use the rest cost-effectively ?

Research Question Generation

1 INTRODUCTION

Research Question Generation

- 70% of the population live in rural areas and have a long history of relying on biomass for heating and cooking.
- help rural residents involve in the market economy for community development, to address poverty, environmental degradation and climate change problems
- Unlike wind, hydro and solar energy which are mostly run by state-owned companies, bioenergy projects can be organized by private and international investors

Rural areas =
untapped trillion dollar market !

Base of the Pyramid
Prahalad and Hart's (2008)

- The ambitious bioenergy development target in the "11th Five-Year Plan": 40 million household methane-generating pits; 6300 medium and large-scale biogas projects, 1m tons of solid biomass fuel; 5,5m kilowatt national installed capacity of biomass power generation
- multi-billion-dollar new energy stimulation package is coming soon

2 RESEARCH DESIGN

Research Aim & Objectives

Research Aim

The aim of this research is to investigate the emerging market for biomass utilization business in rural China, to analyze opportunities and barriers of the business and market, and to summarize successful models which can be diffused and replicated.

Research Objectives

- Identify the system boundary and key actors in the market, their needs, benefits, pursuits and concerns, existing examples of successful and failing bioenergy business in rural China. The role of government on promoting these technologies with related policy measures such as subsidies, tariffs, taxes, blending mandates etc. Other barriers and initiatives in the market, from social, economic, financial and environmental perspectives
- Summarize the possible business models and give recommendations on how to create opportunities for the market
- Provide further suggestions for government, NGOs, investors, and entrepreneurs on how to create and organize sustainable bioenergy business in rural China.

2 RESEARCH DESIGN

Research Scope: Technology

- Biomass Utilization in Rural China
  - Agricultural Residues Utilization and Power Generation
    - Direct Combustion
    - Gasification
    - Co – firing
  - Manure – Biogas
    - Medium – large Scale Biogas Project
    - Household Biogas Digester
    - Biogas Unitization

Biofuels are not included in this research

- current biofuels are the utilization of long-term storage crops and the utilization of swill and waste oil, both of them have no close relation with rural areas
- bioenergy plantations still have a highly controversial status and the non-food biofuels is still under the R&D
- biofuels are identified as an industry different from biogas and biomass in China's renewable energy plan

Forestry residue is also left out of the research boundary

- forestry production is around 900 million tons per year which is even more than agriculture production (600 million tons)
- the utilization of forestry residues is a different system from both regulation and practice perspectives
- forestry residues in agricultural areas can be included into the agricultural utilization system

2 RESEARCH DESIGN

Research Scope: Geography

Region	*Total*	*Per capita*	*Typical provinces*
North China	6540.1	0.79	Shanxi, Hebei
Northeast China	7638.0	1.63	Jilin, Liaoning
Middle -south China	12324.8	0.50	Hubei, Hunan
East China	12998.7	0.56	Shandong, Jiangsu
Southwest China	6289.7	0.48	Sichuan, Yunnan
Northwest China	3974.5	0.75	Gansu, Qinghai

The regional distribution of agricultural residues in China, Source: NDRC 2008

Geographical variability is a key issue for the policy-making and regulations in the bioenergy development in rural China

2 RESEARCH DESIGN

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Middle -south China	1		
East China	1		gsu

Region	Agricultural residues available for energy (Thousand ton)	Order	Region	Forest residues available for (Thousand ton)
Shandong	44,070	1	Heilongjiang	29,486
Henan	30,697	2	Inner mongolia	26,049
Hebei	29,549	3	Sichuan	24,624
Jiangsu	27,949	4	Yunnan	20,874
Heilongjiang	26,372	5	Jilin	11,200
Jilin	24,079	6	Jiangxi	10,676
Sichuan	21,632	7	Hunan	9517
Hubei	16,894	8	Guangxi	9264
Anhui	15,790	9	Guangdong	9219
Inner Mongolia	15,739	10	Shanxi	8927

Agriculture is the dominant economic activity in North China provinces like Shandong and Hebei. There is a great potential to utilize biomass in these regions.

2 RESEARCH DESIGN

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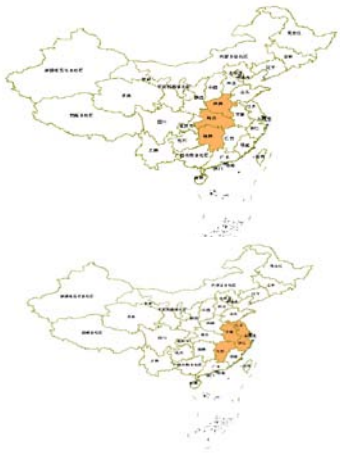
Northeast China is not included in this research

- Northeast China has the highest per capita agriculture biomass production
- Agriculture in this area is organized by state-owned large agriculture farms which is not typical in other areas
- There is a big potential to development large scale biomass combustion power station

2 RESEARCH DESIGN

Research Scope: Geography



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2 RESEARCH DESIGN

Research Methods

- **Literature Reviews**
  NDRC's reports and documents are a big help in this research which are considerably as being close to the real situation.

- **Case Studies:**
  Different cases were selected with clear and specific purposes, and were assumed to provide different results or outcomes

- **Stakeholders Interviews**
  Fieldwork and interviews are great challenges. It is not easy to get information in practice, to meet people who really know the situation and are still willing to tell the truth.

- **Data Collections**
  Only small scale survey is employed during the fieldwork due to the lack of capacity and other political concerns

3 CASE STUDIES

Overviews of Case Studies

Case Study 2. Mishan Biogas Generation and Community Utilization Project, located in Jincheng, Shanxi Province

Case Study 1. Shanxian Biomass Power Station located in Heze, Shandong Province. The biomass resource collection area cross four provinces: Shandong, Jiangsu, Anhui and Henan with a collection radius of more than 100 km

Case Study 3. Taihua Breeding Farm Waste Treatment and Biogas Residues Utilization Project, located in Pingxiang, Jiangxi Province

Case Study 5. Hangzhou Energy & Environment Engineering Co.ltd. Energy Service Company Model, located in Hangzhou, Zhejiang Province

Case Study 4. Shenlong Biogas and Carbon Credit Generation Project, located in Gaoan, Jiangxi Province

Case Study 6. Global Environmental Institute Household Bio-digester and Rural Cooperatives Program, located in Baoxing, Sichuan Province

3 CASE STUDIES

Case 1. Shanxian Biomass Power Station

Shanxian National Bio Energy Co., Ltd (NBE) 25 MW biomass direct combustion and power generation station:

- The annual biomass consumption is more than 200,000 tons with the electricity generation of 160 million kWh
- The technology is the Ultra Super Critical steam boiler from BWE Denmark
- is the first biomass direct combustion power station in China which is approved and supported by NDRC as a demonstration project
- is invested by Dragon Power and the National Grid and also financed by CITI Bank
- is supported by a 0.25 Yuan/ kWh renewable energy subsidy plus a 0.2 Yuan/ kWh temporary subsidy as the first demonstration project

is still unprofitabl

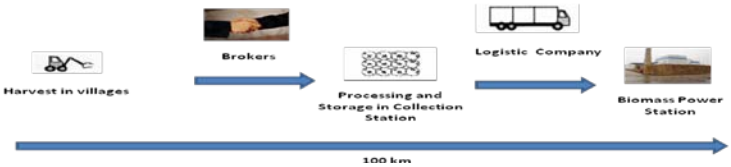
On-grid price is 0.796 ￥/ kWh

the resource price or straw is around 250 Yuan/ton	Cost(￥/ kWh)
the resource price or straw is around 250 Yuan/ton	0.92
the resource price or straw is around 250 Yuan/ton	0.88
the resource price or straw is around 250 Yuan/ton	0.84

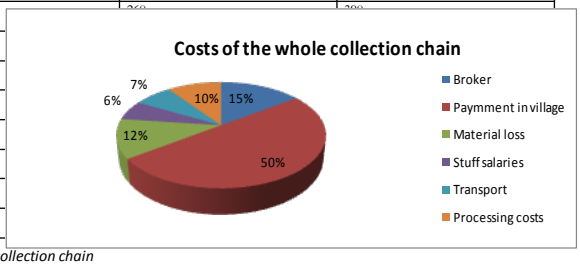
This calculation is based on the resource price is around **250 Yuan/ton** in the power station.

3 CASE STUDIES

Resource Cost & Supply Chain



Name of resource	Price in which brokers collected from villages (Yuan/ton)	Price in the collection station (Yuan/ton)	Cost in the power station (Yuan/ton)
Wood scraps	220		
Cotton stalk	140		
Sawdust	180		
Branches	180		
Bark	160		
Corncob	160		
Peanut shell	200		
Average	177		



The cost of resources in different stages of the collection chain

3 CASE STUDIES

Case 2. Mishan Biogas Project

The project is a 300 cubic meters digester facility which is suitable for the treatment of manure of more than 12000 pigs and agriculture residues. The biogas is provided to local residents for cooking, shower and heating.

➢ **Partnership with local residents**

Households hand in 800 kg straw each year can then purchase the biogas with a discounted price of 0.8 Yuan per cubic meter as a return, the normal price is 1.5 Yuan per cubic meter. Also biogas sludge is free as organic fertilizer

➢ **Comparative Analysis**

	Stove and	Cost	Fertilizer	Production
Biogas	Free	24 Y / m for partnership 45 Y / m for no partnership	Free organic fertilizer	Increase 30% of production Sale with higher price
Coal & LPG	Not Free	100 Y / m	Purchase chemical fertilizer	Lead to environmental problems

LPG: liquefied petroleum gas

3 CASE STUDIES

Case 2. Mishan Biogas Project

➢ **Energy Service Office**

Local office is set up in the village to collect fees and provide service like consulting, monitor, sell stoves and facility maintenance. People work in the office are from villages as well. They have a good knowledge of their customers and even personal know them.

One or two local staff from the office is trained to be technicians in the village. They are required to visit each household once a quarter to monitor the facility and system and also in charge of unexpected technical problems.

This is a cost-effective way because first, it provides job opportunities for local villagers which makes the project much more popular, second, all customers know the person who works as a technician and can always find him/her easily not always in the working hours, third, technician lives in the village which is a clear advantage especially if the project is in remote area with bad road conditions, fourth, the payment is much cheaper than hiring a technician from outside and has to spend money on transport to the village.

➢ **Smart Payment System**

Each household has one intelligent IC card to activate the main gas valve and has to go to the local office to charge the IC card before using the biogas

3 CASE STUDIES

Free! Biogas is free Biogas equipments are free from the government as well.

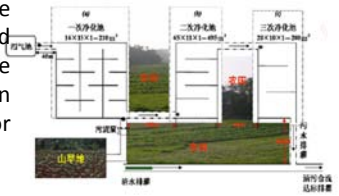
Case 3. Taihua Biogas Project

The volume of the digester is 1200 m^3; biogas is connected into around 100 households through PVC pipes in a distance of 1.5 km; one 200 m^3 biogas storage tank has be built to maintain the stability of the biogas supply

Residues Utilization & Rural Co-operative

The system consists of three sediment ponds and aerobic channels connected the ponds which are distributed in a piece of farm land of 200 acres. The quality of the liquor is good enough for direct irrigation in the end. Villagers can also freely open the channel to get sludge for fertilization purpose

Pig-Sludge-Agriculture



3 CASE STUDIES

Case 4. Shenlong Biogas Project

➢ **Barriers for private investors**

Four local breeding farm owners come together to scale up their business and to reduce risk. The plan is to use biogas generator for the on-site use of electricity like heating and mixing of fodder. This will help them reduce the consumption of electricity from the grid.

They do not want supply biogas to local communities around and this makes it hard to get subsidy. They decided to apply for CDM project and four farms together can actually generate a big amount of carbon credit.

World Bank would like to provide 30% loans for this project if the local government can vouch for the return. The local government does not provide certification for this project. This finally failed the biogas project.

	Cost	Amount	Total
Biogas Generator	7500 Yuan	2	15000
Construction cost	130 Yuan/m^3	180	23400
Material cost	280 Yuan/m^3	180	50400

The initial cost of a medium size biogas project

3 CASE STUDIES

Case 5. Hangzhou Energy Service Model

Hangzhou Energy & Environment Engineering Co., Ltd. (HEEE) is a leading high-tech enterprise in China, specializing in designing, constructing and general contracting large-scale biogas projects, as well as developing and manufacturing complete equipments of large-scale biogas projects.

Market Dilemma

The leading player in the market faces a big problem for further development:

there is no strong drive for the farm owners to invest on the waste-to-energy system due to the lack of knowledge and capacity. Once the manure and waste water can be treated properly to meet the national standards, they are not willing to pay extra money for the energy facilities.

Market Dilemma

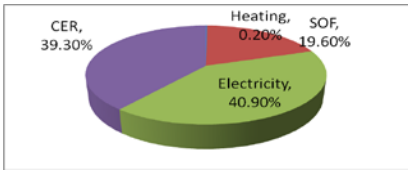
3 CASE STUDIES

Case 5. Hangzhou Energy Service Model

Energy Service Company Model (ESCO)

➢ The equipment manufacturing and construction companies play the role as the energy service company. They invest or partly invest on the anaerobic digester and the energy generator facility, provide waste water and manure treatment service for the livestock farms and share in the profits generated from the project as a return.

➢ The main benefits of the energy service company are from the electricity generated from biogas as renewable energy, carbon dioxide reduction credits (CERs) and solid organic fertilizers (SOF).



The profits generated from biogas power stations, Wang 2008

Barriers:

- The grid connection can be delayed
- The huge gap between actualized CERs and expected CERs in China.
- The market of SOF
- Fee for the waste
- The temporary renewable energy subsidy

3 CASE STUDIES

Case 6. GEI Household Biogas Association

Cooperative Association

➢ Organize local residents to help each other for the construction of the digester.
➢ Invite technicians for training and monitor.
➢ One or two members will be chosen to learn maintenance skills

Micro-finance

- Members can borrow the money only as a group of 4 or 5 households.
- They all take the responsibility to repay money together so if one household fails to return his portion, the rest households have to return for him instead.
- The money is for association members only to help their agriculture production.

Advantage:

✓ Members have a strong belief with each other
✓ Members can mutually supervise each
✓ Avoid many political risks

4 DISCUSSION

Problems of Biomass Power Stations

Technology
The biomass resource in rural China is a mixture of many different kinds of resource from both agricultural and forestry residues. Comparing to the sole resource in the developed countries, it has lower energy density and higher inorganic constituent concentration. This leads to a higher operation and maintenance costs.

Installation Capacity
The capacity of single combustion facility is more than 20 MW and requires a high initial investment (0.2 billion Yuan). Large scale project requires 0.2 million tons of biomass per year at least. This brings a high risk for investors. Neither private investors nor local companies would like to go into this field.

Logistic Chain
The biomass resource is distributed into large amount of individual households scattered in small villages. This leads to a sharply increase of costs on collection, processing, storage and transportation process

Resource investigation
Accessibility under the market price (15-20% VS 50%)

4 DISCUSSION

Solutions of Biomass Power Stations

Small scale biomass power station (5-10 kW)
- There are domestic technologies of both gasification and direct combustion which can highly reduce the initial investment (15 million Yuan)
- The biomass demand is around 50000-100000 tons per year and the collect radius can be easily
- The small scale project also has a better flexibility with biomass resource and can be broadly used in rural China
- The large scale biomass power station has more potential in large farming areas like Northeast China

Small scale projects also face some problems
- Grid connection (much smaller than coal fire stations and are not very stable which makes a big problem for the safety of the grid)
- The resource competition between small scale power station and paper industry can be very intensive in some areas if without proper plan

Co-firing
With low cost equipment upgrading, biomass can be added into the coal fuel supply of the existing coal fire power station, it has a low elasticity of demand of biomass resource and has a stronger capacity to control the price. However, co-firing is not included in the renewable energy law and can not get renewable energy subsidy. So it does not develop in China. Only Shanghai Xiejin Co.ltd has 21 small thermal power stations in East China which add small portion of biomass for co-firing.

4 DISCUSSION

Problems and Solutions of Commercialization of Biogas Projects

Summary of the financing situation of biogas power stations in China

Types of Biogas Utilization	Financing resource	Problems
domestic utilization like cooking and heating (either being charged in Mishan Case or not being charged in Taihua Case)	subsidized by the government	due to the high initial cost, the governmental funds can support no more than 20 projects each year
on-site electricity generation (Shenlong case)	no governmental funds, searching for investment by the farm owners themselves	due to the high risk of this new industry, it is not easy to find money
on-grid electricity generation	is included in the renewable energy subsidy scheme. But the initial investment is still from the government	due to the scarcity of the national funds, the government cannot support the best technology

Energy Service Company Model (HEEE case)

- Profits can be generated from renewable energy, carbon dioxide reduction credits (CERs) and solid organic fertilizers (SOF)
- Venture Capital are willing to be involved in the market promotion

Uncertainties are still exist:

grid collection, carbon income, sales of SOF, venture capital,

4 DISCUSSION

Problems of Biomass Collection & Trust Building

Current broker system	Impacts on power stations
work in the villages, easy to collect biomass	lower the transaction cost
have a strong capacity to bargain	lower the transaction cost
have the capacity to store biomass	save the storage cost, maintain a relatively stable supply chain, but increase the price
ask for a higher price from power stations, monopoly	increase the resource collection cost (15% of the total cost currently), and is increasing sharply

Other problems

✓ Due to the lack of resource accessibility, power stations have to enlarge the collection radium

✓ The cultural and social barriers, mainly the lack of business sense of the people in rural China

✓ primary movers want to control the market, which leads to the blind investment and a sharp increase of resource demand in a short period of time and the irrational increase of the collection price.

4 DISCUSSION

Solutions of Biomass Resource Collection & Trust Building

Solutions	Successful examples	Limits
public-private partnership	Mishan case	Only for biogas for cooking and heating projects
secondary rebate mechanism	Local honey industry	Projects are at the demonstration level and are not profitable
order in	Tobacco industry	Trust building and quality control
rural professional co-operatives	GEI and Pingxiang case	a third part is usually necessary
localized service stations or resource collection stations	Mishan case, local brokers	Increase the transaction
Government promotion, education and demonstration	Mishan case	Lack of capacity

4 DISCUSSION

Policy and Governmental Barriers and Recommendations

Barriers	Recommendations
Lack of resource investigation: leads to a rapid increase in demand side and the current supply and demand tension	organize biomass resource investigation as soon as possible. Economic indicators, market conditions and local social and cultural situations should all be involved in the investigation.
Lack of integrated management: province has a strong willing to promote its development. But the resource collection area usually covers more than one province	The responsibility of the project authority should be national government with a more strict regulation process. The strict regulation should also be put on the total installation capacity of each region.
Price determining: the renewable price is based on the cost of coal-fired power station which varies among different provinces	separation of coal-fired power price and renewable energy subsidy
Subsidy sharing: the subsidy is not from fiscal money but shared among the provincial grid	share the cost among the national grid.
Co-firing policy: the regulation delays the development of biomass co-firing industry	Including coal-firing station into the subsidy system with the necessary monitoring methodology

5 CONCLUSION

- The development of rural bioenergy business can bring benefits to local communities for sustainable development and these activities will be further stimulated by the government.
- Current bioenergy demonstration projects face some problems and are not profitable in general. The sharp increase of the biomass resource price makes it hard to be profitable.
- Bioenergy business can hardly work without the involvement of the local community in the market economy and this requires the establishment of local networks and trust building with local people both of which are crucial for the operation of bioenergy business.
- Both the biomass collection chain and trust building are systematic challenges that require the cooperation of energy companies, local communities and the third party (Co-operatives, NGOs and brokers). According to this research, the professional rural co-operatives are a good model to help local people to be involved in the market economy.
- The Energy Service Company model (ESCO) can play an important role in bioenergy development in rural China, especially for the large biogas power stations.
- The role of the government is important for the new bioenergy industry in rural China. Especially the renewable energy law and related regulations which have already stimulated the development of the whole industry.