Bioenergy Entrepreneurship in Rural China

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Abstract

The Chinese Central Government has made the promotion of industrial utilization of bioenergy one of the priorities in the national plans on renewable energy. However, there is a general lack of understanding on how bioenergy entrepreneurship works on the ground level in China, particularly in rural areas. This thesis therefore aims to investigate the emergence and development of rural bioenergy business in China, and to identify and evaluate the key factors and enabling conditions for bioenergy systems.

The research is based on three empirical case studies and interviews with key stakeholders; it finds that the individual innovation from primary movers can become a major motivation to initiate rural bioenergy business, and this innovation is derived from primary movers' ambitious and personal value judgment. During the system development, local networks play a critical role to formulate business strategies. One of the key market advantages of rural bioenergy business is the naturally ready local networks in rural China, given the inherent close relationship inside the village system, which works effectively to activate relevant actors and integrate resources. Given these attributes, the internal primary movers are more likely to bring positive performance than external primary movers. A joint force of internal and external actors is also promising in terms of performance, when the internal actors take the leading role.

The research highlights three conceptualized development mechanisms of rural bioenergy that have been derived from the empirical cases. They include environmental oriented development, social welfare oriented development and entrepreneurial oriented development. The three mechanisms start with different entrepreneurs' orientations with the focus on environmental protection, social welfare improvement and innovative business development, and bring out different system outcomes based on value-creation consideration. The enabling solutions for the development of rural bioenergy business therefore require comprehensive institutional improvement, including enhanced supportive policies, and various education, information sharing facilitations.

Executive Summary

Bioenergy enterprises in China are starting to emerge under the global context of climate change and energy security, and the local requirements on pollution control and rural development. To cultivate market forces and involve private sectors to promote bioenergy development is a new route for China. A better understanding of this new business is meaningful to improve the effectiveness and sustainability of bioenergy by providing private sector insights and development mechanisms. For this reason, this thesis aims to address research questions, covering the general situation of rural bioenergy entrepreneurship; who are the primary movers; what are the development mechanisms; how does the value chain change; and what are the key enabling conditions.

In order to explore these research questions, decision-making theories are applied to follow the entrepreneurs' decision processes during bioenergy business establishment and operation. In total, 3 case studies are selected, which are the Heyong biogas system, Liuminying biogas projects, and Shengchang Bioenergy Limited Company, based on 3 villages in China. Interviews have been carried out to investigate key stakeholders' insights. A 4-factor analytical framework has been applied to analyze the empirical data, which breaks down a bioenergy system into four key factors: actors, resources, networks, and institutions. The 4 factors have strong interactions.

This thesis consists of 6 chapters covering 4 main stages. In Chapter 1 and 2 the research purpose, implementation plan and analytical framework are formulated. In order to give an overall picture of the bioenergy development situation in China, Chapter 3 introduces the bioenergy in the Chinese context as the second stage, during which relevant literatures have been reviewed. The third stage is to present the empirical data from 3 case studies, which builds up Chapter 4. The last stage represented in Chapter 5 is to analyze the cases, based on the empirical information from Chapter 4 and the integrated theories. Chapter 5 and the conclusion part respond to the research questions, and summarize the research implications.

By analyzing the key influential factors, this thesis finds that internal primary movers and strong local networks play vital roles to motivate and enable the development of rural bioenergy business. Individual innovation, ambitious and personal value judgments from primary movers is a main motivation to initiate a rural bioenergy business in general. Internal actors' participation can be particularly important, given the strong attributes that internal primary actors are more likely to control their own raw material resources, possess more experiences regarding local natural and socio-economic situations, and have strong naturally formed local networks.

Local networks play a critical role during entrepreneurship development by activating actors and integrating resources. Given that the current resources in terms of monetary capital, technologies, know-how, information, etc. are generally limited in rural China, the inherent strong networks in rural China is one of the most important advantages that rural bioenergy entrepreneurship can rely on. Without such a naturally ready network, the cultivation of new networks can be too resource-consuming for enterprises to bear.

By investigating the decision-making processes of new bioenergy businesses, this thesis conceptualizes 3 development mechanisms, including environmental oriented development route, social welfare development route and entrepreneurial oriented development route, which are based on different orientations of decision-makers. The local projects often focused on environmental protection and social welfare improvement, it is possible to transform such projects into commercial production, when opportunities are identified. An entrepreneurial oriented mechanism, which highlights the technology innovation, risk taking and proactive

behaviour does not always achieve the sound performance under the institutional deficiency and market immaturity. The orientations also lead to different system outcomes in terms of value creation. A positive development route is likely to be achieved when there are environmental, social and economic benefits; while an unfavourable development route tends to trade-off the benefits, shrink the value adding, and miss the original targets.

Finally, the enabling conditions (with a focus on institutional improvement) have been discussed in the thesis. The Chinese Central Government has identified the main policy barriers for bioenergy industrial development as policy inconsistency and fragmentation as well as market safeguard mechanism deficiency and insufficient R&D input. Some supportive institutions are recommended in this thesis, covering comprehensive policy coordination, education and training, knowledge transfer and information access.

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1 Introduction

1.1 Background

The importance of links between energy and sustainable development is globally acknowledged. In the context of climate change, with the consideration of energy security, different countries have promised to act and reshape the energy economy. Global attention has been drawn to explore the potential of renewable energy and the higher energy efficiency.

As a new booming giant in the world economy, China is facing both the need to sustain the economy development rate and the need to find solutions for more sustainable energy and energy-related CO_2 emission issues. In 2006, the real GDP increased by 11.1% in China (NBSA, 2007). And the country's primary energy demand is projected to reach an average annual growth rate of 5.1% between 2005 and 2015 and of 3.2% over the period 2005 to 2030 (OECD, 2007a). In order to meet the increasing demand, China is projected to rely more and more on import of conventional energies, i.e. gas, oil and coal (OECD, 2007a). Energy security is therefore a main concern of Chinese government. At the same time, the increasing consumption of conventional fossil fuels is projected to accelerate the climate change and air pollution by the increasing CO_2, NOx and SO_2 emissions (OECD, 2007a).

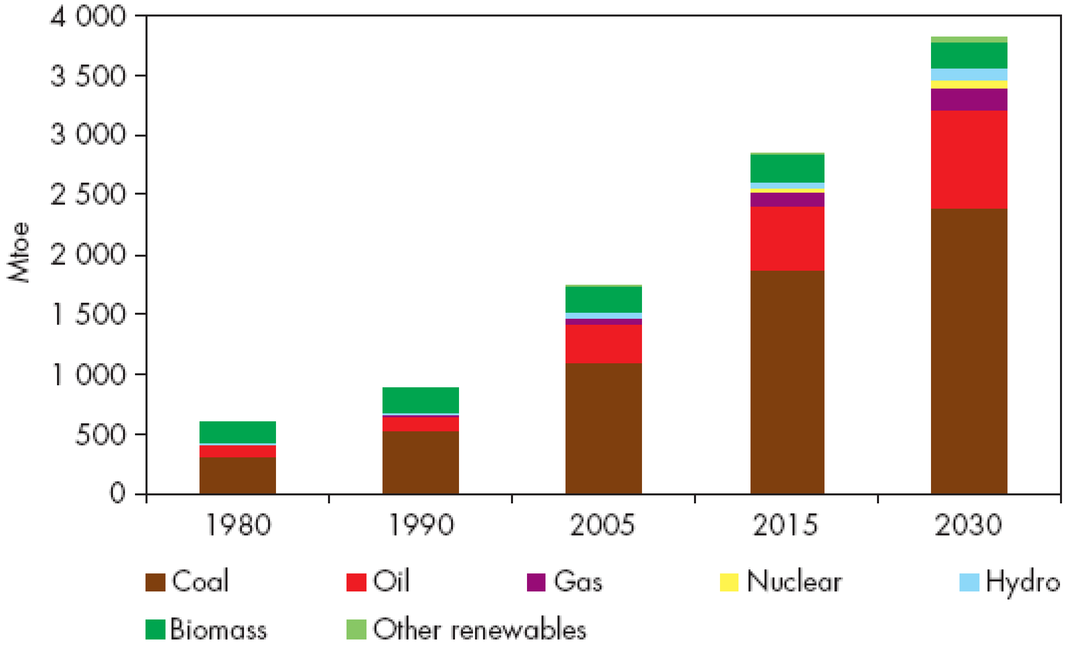

Figure 1-1 China's Primary Energy Demand in the Reference Scenario

Source: OECD, 2007a. P 287

Additionally, in order to meet UN Millennium Development Goals (MDGs), energy issues are critical for poverty alleviation and equitable development in developing countries, especially rural areas. For the millions of poorer inhabitants, energy is essential to meet their basic human needs as well as a solution to build up local capacity for productive activities that enables them to share in the development benefits. There are different pathways and niches for developing countries to address the energy issue, based on specific local conditions. In general, the availability, reliability, affordability and security of energy are key factors in social and economic development (REDP, 2005).

Traditional biomass has long been the energy source for cooking and heating and remains so for around one third of the world's population (OECD, 2007b). In China, biomass such as crop straws, stalks and fuel wood has been the one of main energy sources, despite the dominant energy source - coal. In 2000, biomass accounted for around 13% of primary energy consumption in China, with a higher proportion in rural areas up to 22%, where the most biomass is located (Li *et al*., 2001). The proportion of population relying on biomass for cooking and heating in developing countries is projected to increase by 9% from 2000 to 2030 (OECD, 2002). However, the direct-burnt biomass is considered low-level energy, and causes serious health issues relating to indoor pollution and smoke inhalation; and social issues regarding to gender equality and the advancement of women (UNDP, 2007). Therefore, the utilization pattern needs to be changed from traditional direct burning to modernized clean energy outputs, e.g. gas, electricity and other fuels with high heat value.

On another hand, the traditional utilization of biomass is usually insufficient, which causes regional environmental problems. In China, apart from using biomass for domestic cooking and heating, traditionally the agriculture residues can also be used for fertilizer, animal forage, and raw material of paper. However, the utilization rate of these residues is less than 50%, and the main part is field-burnt (Li *et al*., 2001). The burning straws cause serious air pollution and resource waste. With a growing demand of traditional biomass energy in developing countries, the concerns of negative impacts on social development, health improvement, and environment protection are raised. The development of modern bioenergy system becomes a possible solution to address these issues. Since the Chinese government has been demonstrating the ambition to reach a more sustainable energy future, the development of bioenergy is also highlighted as one of the renewable energy strategies in the new national plan.

Globally, there is a growing trend that local communities take responsibilities for their local resources and environment (OECD, 2007b). Once rural communities are able to use the sources of bioenergy available for them and build their own capacity towards initiation production and utilization, the implication of economic, environment, social and cultural aspects can be significant. Economically, the stimulation of bioenergy in developing countries may bring poverty alleviation and mitigate the extreme income gap. From the social perspective, bioenergy projects can protect existing rural employment, create new jobs, transfer skills, provide educational opportunities and raise the environmental awareness (OECD, 2007b). Culturally, the process may bring a sense of pride and independence, and self-identities towards indigenous culture (OECD, 2007b). Chinese rural community is traditionally built upon self-sufficient economy and human-nature integrated Taoism philosophy. Inside such a system, seeking for an integrated and sustainable way to use local resources is logical and necessary. International society and Chinese government therefore paid great attention on the development of localized bioenergy in rural areas. The promotion of rural bioenergy has been put in priority in the 11th 5-year national plan of renewable energy by Chinese government. The efforts to promote rural bioenergy have been noticeable in recent years. However, how to develop an effective and sustainable way to popularize local bioenergy is still an issue that requires further and deeper research.

Based on market mechanisms, fostering the local market capacity and involving private sectors in the rural bioenergy industry is a new route towards effectiveness and sustainability of bioenergy. This concept has not yet been widely established among certain group of people in Chinese society, since traditionally biomass energy has been viewed as cheap, even free energy type associated low levels. As one of most widely used bioenergy types in rural China, biogas, for example, was traditionally used in household level, under self-production and self-consumption mode. However, since the breeding industry developed in recent rural China, beyond the household biogas system, the large-scale centralized biogas projects have been expanded and are looking for new ways of consumption. At the same time, the increasing amount of solid waste generation and sewage water also require more sophisticated solutions. The situation has provided great potential for biogas production. Some forward-thinking rural entrepreneurs start to get involved at a relatively small scale in the initiatives and in the process to commercialize bioenergy. The rural bioenergy industry as a brand new field starts to emerge in different areas.

However, the entire industry of modern bioenergy in both China and world is still premature. The mechanism of the booming or phasing out of the enterprises is still lack of understanding. Since the industry in general situation is at the starting point, to understand the decision-making processes of the key actors can help us to understand such a development mechanism. Furthermore, the key factors which are influencing the bioenergy industry are worthy for research and discussion. Under certain specific contexts, these influential factors can differ greatly, and various conclusions are drawn from different researches. For example, the critical factors of forest-based bioenergy and bio-product development in the Southern United States are identified as sustainable biomass production, sustainable forest operations, product delivery logistics, manufacturing and energy production, environmental sustainability, consumer demand, and rural economic development (Mayfield *et al.*, 2007). The key barriers obstructing the expansion of bioenergy in Europe are identified as economic conditions, know-how and institutional capacity, and supply chain co-ordination (McCormick & Kaberger, 2007). Based on economic concepts, transaction cost theory and industrial organization, critical elements for the implementation of bioenergy industry are identified as the integration with other economic activity, scale effects on bioenergy markets, competition in bioenergy markets, competition with other business, national policy, local policy and local opinion (Roos, *et al.* 1999). Socio-economic factors, such as employment creation, energy security and so on are also considered as drivers to implement bioenergy projects (Domac, 2004). Given the specific context in rural China, the mechanism and key factors involved in bioenergy sector can be extremely complex. Apart from the general reasons that bioenergy industry involves a wide range of stakeholders, different technologies, and divers knowledge aspects covering e.g. scientific, social, environment, political, cultural issues, the specific, sometimes unique background in rural China add more complexity to this issue. Therefore a better understanding of the fundamental development mechanisms and the key factors and enabling conditions for the bioenergy diffusion and commercialization in rural China is needed in this very early stage. This will enable stakeholders to look deep into the reasons behind phenomenon and make better decisions in various aspects, which are further specified in 1.2 *Purposes and focus* section.

1.2 Purpose and focus

1.2.1 Purpose

The purpose of this thesis is to investigate the emergence and evolution of rural bioenergy business in China, to evaluate the key factors of the commercialization of rural bioenergy, and to indentify the enabling conditions for the development of bioenergy entrepreneurships.

1.2.2 Audience

The decision making process regarding investing in a private rural bioenergy business is fundamentally important, therefore the rural entrepreneurs are the focus group for this research. The potential contribution for different stakeholders from this research is intended to be:

- for policy makers, to establish effective supportive policy scheme that eliminate the policy gaps;
- for entrepreneurs / investors, to have a better knowledge towards the risk and opportunity in Chinese rural bioenergy market;
- for rural communities, to raise the awareness of energy and sustainable development issues;
- for researchers and students, to gain an original knowledge area and raise further research interests.

1.2.3 Research questions

This thesis aims to address the following research questions:

- What is the general situation of rural bioenergy entrepreneurship?
- Who are the primary movers? Where does the initiation come form?
- What are the development mechanisms that Chinese rural bioenergy businesses are following? How does the value chain change?
- What are the key enabling conditions for rural entrepreneurs to take on the bioenergy business?

1.3 Methodology and justification

This research is focused on the dynamics how bioenergy businesses emerge, develop and encounter barriers in rural China, therefore the research design is based on theory building, literature studies and 3 case studies under different context. Figure 1-1 shows the research design and technical route.

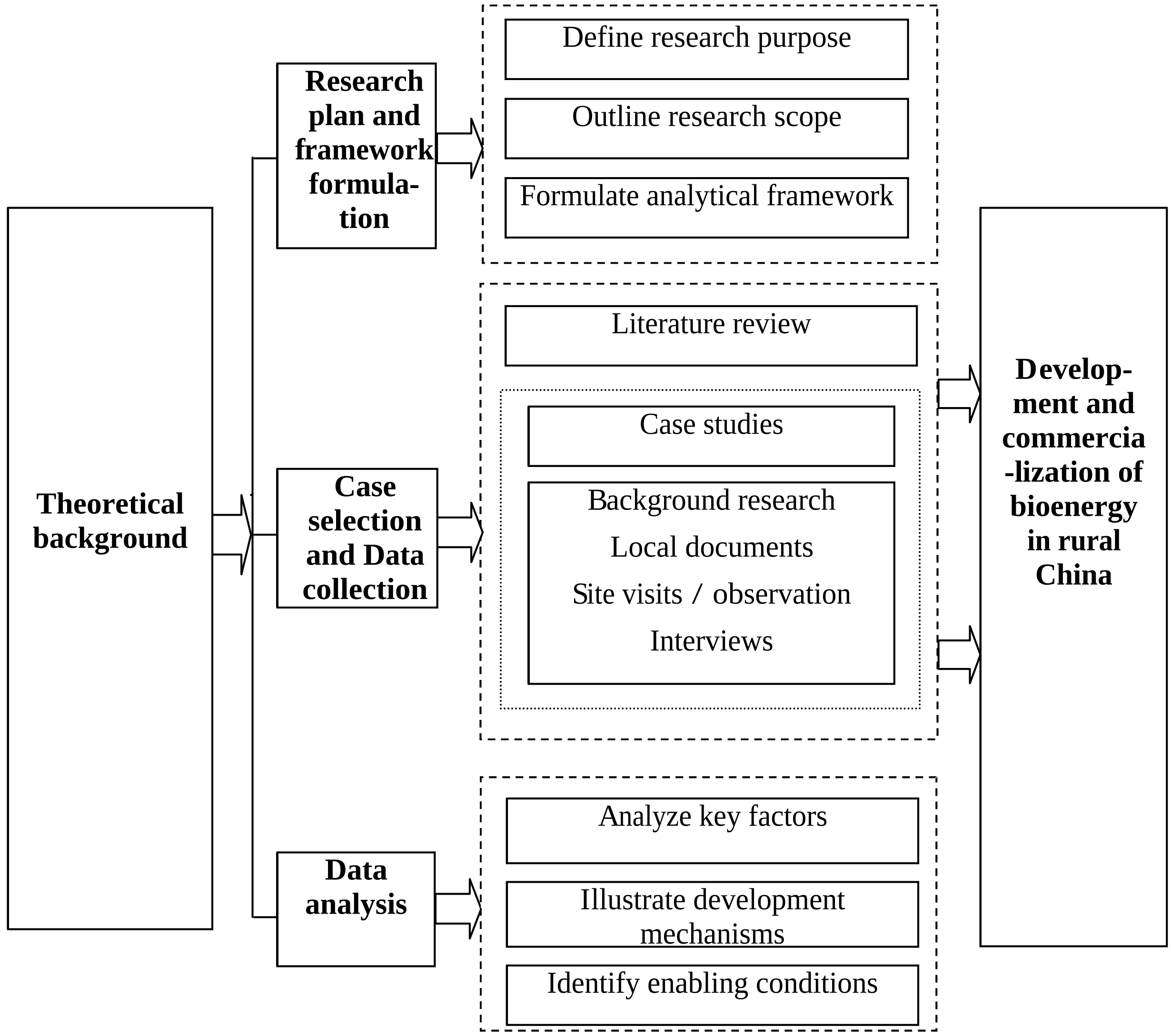

Figure 1-2 The research design and technical route

1.3.1 Case selection

The selection of cases is based on strategic case selection principles (see Table 1-1) (Flyvbjerg, 2006). Because the objective is to gain key stakeholders' insights and to clarify the deeper causes behind the given phenomenon, rather than describe the symptoms of the problem, a random sample may not be the most appropriate strategy (Flyvbjerg, 2006).

The three selected cases differ in size, production form, management, and socio-economic context. In term of socio-economic context, the Heyong Biogas plant is located in a region where the economy is in a drastic transition from traditional self-sufficient agriculture to modern industry and commerce. It also received the first hit from the "Reform and Open" national policy, therefore the concept of free-market economy is widely accepted by local people. Shengchang Bioenergy is a newly emerged entity which is completely new for local dwellers, including their product, the people inside company and the way they manage. It engaged external venture, aiming at modern industry management from the beginning. In contrast with, Liuminying remains the rural collective economy, which means the village works as a big economy entity including agriculture, breeding farms, industries, commerce, and other activities, villagers share the property, employment, and benefits. This used to be that economy form for almost the entire Chinese rural areas from 1950s. In 1980s, the system broke down in some regions, but the influence from collective economy remains in different levels. A village like Liuminying is among those with strong influences and still works in the collective way for some activities.

Together, these three cases are maximum variation cases that allow me to discover different dynamics under different contexts. Individually, they are considered critical cases. Firstly, they are in the places where at least one or more resources, e.g. the policy, finance, information and other factors are more available compared to the rest of rural areas. Secondly, they are regional demonstrating projects, which mean they are representing the most likely development paths for the rest of industry.

1.3.2 Data collection

Three main data collection tools are applied in this research: literature study, interview and observation. The literature studies include primary data (e.g. first-hand statistics, local documents, etc) and secondary data (academic publications, official documents, etc.) The search sources for secondary data include Lund University Library, CNKI (Chinese electronic academic publication database), OECD database, Google scholar, Chinese governmental websites, and various hardcopy publications.

The interview and observation from field trips on 3 case sites are the main sources as empirical data. The site visits and interviews were carried out from January 2008 to May 2008. Based on the case selections and feasibility, desired informants are pre-categorized in 4 main actor groups: (a) industries, (b) government, (c) experts and (d) local residents. Based on the stakeholder structure, the interviews are conducted through a snow-balling approach. Cross checking through multiple information sources is imposed on the research to ensure the validity of key information that interviewees provided. Table 1-2 shows the actual number of interviewees during the research. Interview questionnaires are designed as semi-structured and open-ended questions (See Appendix II: Sample of the interview questionnaires). The structure of questionnaire refers to the four hypothetic factors generated from theoretical framework: actors, resource, network and institute (Jacobsson & Johnson, 2000).

Table 1-1 Number of interviewees by stakeholder category

Sector	Industries		Government		Experts			Local residents
	Bioenergy entrepreneur	Contracted partner	Centr. gov.	Local gov.	Agri.	Forestry	Energy	
Number	**4**	**1**	**3**	**2**	**3**	**2**	**1**	**6**

1.3.3 Case study process

The case studies follow an open-ended, continuously improved process (see Figure 1-2). Each step responds to the information gathered previously, to decide whether further actions are needed, and contributes for the improvement of research design. When additional information is needed, the data collection is carried out by several series of interviews, following-up phone interviews are often applied in this research, and sometimes with site-revisiting.

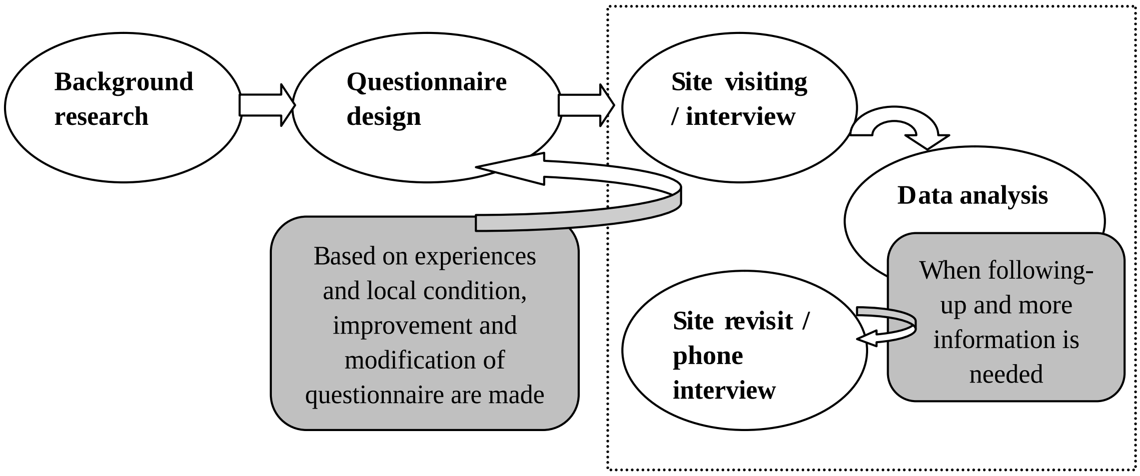

Figure 1-3 The continuous improved process for the case studies

1.4 Scope and Limitations

1.4.1 Scope

- This thesis focuses on commercialization of bioenergy in rural China. The "commercialization" refers to the production and consumption mode of bioenergy products based on market trade. The existing household biogas projects are out this scope, since there is no market trading for the household biogas production and consumption. The research is focus on the industrial production and utilization of biomass energy. Refer to biogas, the medium and large scale of biogas projects are the research targets of this thesis.

The Chinese definition of "medium and large scale biogas project" refers to the scales that covered in Table 1-2, and with the facilities that allow raw material pre-treatment, integrated utilization of biogas, biogas slurry and liquor.

Table 1-2 Requirements of medium and large scale biogas project

Scale	Volume of single digester (m3)	Total volume (m3)	Daily gas production (m3/D)
Large	>500	>1000	>1,000
Medium	50-500	50-1,000	50-1,000

Small	<50	<50	<50

Source: Qin, 2007

- The term "Rural Entrepreneurship" is frequently used in the paper. There is no clear definition for this term under the research context, while in this research, some boundaries are drawn to define "rural entrepreneurship" as: (a) whose main business activities are happening in rural areas; (b) directly linking at least one section of the business chain with local people, e.g. raw material supply, product consumption, etc; (c) in small or medium business scale which is based on one or several villages. These limitations are set based on location, scale, and production process. The economy entity can be registered and operated both in rural area, or can be financed and registered in urban area but run the business activities in rural area. There are three types of business enterprise in China: State-owned Enterprise, private company and Township and Village Enterprises (TVE). In this research, the legal forms of the economy entities are not taken into consideration. The "Rural Entrepreneurship" concept here is not equalized to Chinese Township and Village Enterprise (TVE), but includes TVE. TVE is non-specific and covers a wide range of business types and complexities from the smallest cottage industry producing goods for strictly local consumption to complex factories with foreign investment producing goods for export; the main attribute is to involve both public (usually local government) and private sector (Field et al., 2006). The potential rural entrepreneurship is also taken into the scope, since there are some organizations in rural China running the business activities and functioning as an economy entity, but not registered as an independent company.

- According to the Agriculture Ministry's action plan 2007-1012, the bioenergy put on strategic targets are biogas, straw-based energy (including compacted biomass briquettes and biogasification), and biofuel plantation. For plantation, there is no specific target, but stated as a "moderate development" (Chinese Ministry of Agriculture, 2007). No matter on policy level or practical situation, the main bioenergy types in rural China are local-resource based, therefore, in this study, the emphasis is put on biogas and solidified biofuel (e.g. compact bio-briquettes), which the in-depth case studies are based on. Since the development of liquefied biofuels (biodiesel and bioethanol) is in highly controversial status, as specific energy types, they are not highlighted in this research. Biomass power plants are left out of the deep research boundary in this thesis also, mainly because they are often in large-industrial scale, and thus the mechanism of the industry development is different, although mostly they are located in rural area. As parts of the overall picture, the relevant information about the other types of bioenergy is given in the overview section for a general understanding.

The inputs of bioenergy production include agricultural residues (straws), forestry residues, organic waste from livestock industry, municipal solid waste (landfills), waste water (sewage farms), and energy plantations (NDRC, 2007a). The straw production is around 600 million tons per year, among which around 300 million tons of straws which can be used as fuel (NDRC, 2007a). Forestry residues are around 900 million tons, among which 3 million tons can be used as energy (NDRC, 2007a). The organic waste from livestock industry and other industrial organic waste water can produce 80 billion m^3 of biogas theoretically, and the amount of municipal waste is increasing (NDRC, 2007a). The rich resource base is therefore a precondition for rural bioenergy to be promising. The resources that are widely distributed in rural China include agricultural and forestry residues, as well as organic waste from the livestock breeding industry. Biogas is one of the most important outputs. The current and potential applications of biogas include heating, lighting, cooking energy, power generation, and transportation fuels. In current China, the main application is for heating and providing household cooking energy. Power generation is getting more attention. The large scale breeding farms and landfills are encouraged to set up electricity generation projects (Qin, 2007). Biogas has not been used as transportation fuels yet in China.

1.4.2 Limitations

The research design does not lead to a data collection, which allows for a quantitative analysis. Although the qualitative research is applicable for this research topic, which focuses on a series of social studies, including people's decision-making process, influential factor analysis, and policy research. A quantitative methodology can be also meaningful to further illustrate the issues. A transaction cost analysis, for example, could be interesting to identify the socio-economy effects in different steps of different development mechanisms.

In the research scope, the big-scaled bioenergy industries are not taken into consideration. Therefore the conclusions drawn from the 3 case studies in this research can not be generalized for entire bioenergy industry in China. The large-scaled bioenergy industry is certainly another piece of research topic whose development and impact require further research.

2 Theoretical background and analytical framework

2.1 Theoretical background

In this chapter, a wide range of theoretical basis is applied in order to address the research questions, and an analytical framework is designed to be most relevant to the 3 empirical cases. The development of individual bioenergy enterprise and bioenergy industry in general is a highly complex process, to understand the issues, interdisciplinary theories are needed. An appropriate analytical framework for this research should be flexible and comprehensive enough to cover the different aspects of information and to adapt to the movement of different situations.

Since the commercialization activities of rural bioenergy in China are in the early stages, it is fairly important to study the decision-making processes in which the ideas of initiating rural bioenergy businesses are generated. Therefore, decision-making theories are highlighted as the main theory base to support the analysis. Decision theory itself is truly interdisciplinary, and is typically pursued by researchers who identify themselves as economists, statisticians, psychologists, political and social scientists or philosophers (Hansson, 2005). There is a large overlap from different subjects with various methods and perspectives.

In the micro-economy, an individual is defined as "rational economic man", who represents the objective rationality in an ideal model, however, the cognitive limitations of decision makers have to be considered through the concept of bounded rationality (Simon, 1976; Simon, 2000). According to Simons, H.A. (1976), decisions in an organization will be based on premises including both empirical and normative elements. These two different kinds of premises are called factual and value premises. The factual factors are derived from knowledge and information about the organization and its environment as well as the understanding of the impact of environment, which can be identified and verified; while the value premise is the decision-makers' value judgement, based on the decision-makers' desire and goals, their value and morality preference under specific context, the personal interpretation of information and situation, etc (Simon, 1976). In the real decision-making process, the factual and value factors are interacting and influence the final decision. Under the given limitations and constrains, a concept of "administrative man" is outlined (Simon, 1976). The rational behaviours of an administrative man include simplifying the situation and make decision from limited choices, with limited resources. Different from economic man, the orientation of administrative man's decision processes is mainly to search and select among satisfying alternatives rather than always looking for maximizing solutions (Simon, 1976).

During recent years, the theory has been developed by other researchers, and the value premise of decision-making has been highlighted. Contextual perspective for example has been adopted to view decision-making process as situational and context-based interpretations of actors, their values and the way their organization works (March, 1994; Martensson &Westerberg, 2007). In this research, the decision-makers are considered as an administrative man during the decision-making processes, both factual elements and the contextual perspective are taken into consideration, based on which a four-factor analysis framework is following developed. In order to avoid the dichotomy, the four factors comprise the basis of factual and value judgments and highly interact with each other.

Although the development process of bioenergy has been widely studied, and various frameworks have been produced to analyze the issues, the studies are usually highly context-dependent with focus on a region or country (Mayfield *et al.*, 2007; Sourie & Rozakis, 2001), or from a single perspective, e.g. microeconomic based (Roos, *et al.* 1999), socio-economic focused (Domac, *et al.*, 2005), which may not be directly applied to draw the full picture under rural China context. Decision-making theory is again applied to analysis the development process of rural bioenergy system here.

Decision-making processes are usually divided into different stages in order to explain the route of system development. Previous researchers have developed different expression and explanations of the processes. Two basic models of decision-making processes are generated: sequential and non-sequential processes (Hansson, 2005). In the sequential model, decision-making processes follow a certain order or sequence, with consequences among different stages (Hansson, 2005). The influential subdivisions of the sequential decision processes include J. Dewey's five consecutive stages, H.A. Simon's 3 principal phases, and another five steps proposed by Brim *et al.* (Hansson, 2005). The non-sequential model takes into consideration of reality that human-beings can take various decision processes simultaneously or in a changeable order.

Mintzberg et al.'s 3-phase model is one of the most influential non-sequential models (Mintzberg *et al.*, 1976). The three principal phases are named as *identification, development* and *selection* (Mintzberg *et al.*, 1976; Hansson, 2005). Each major phase consists several sub-phases (see Fig 2-1), and the relationship between the sub-phases is circular rather than linear. Box 2-1 interprets the implications of different sub-phases.

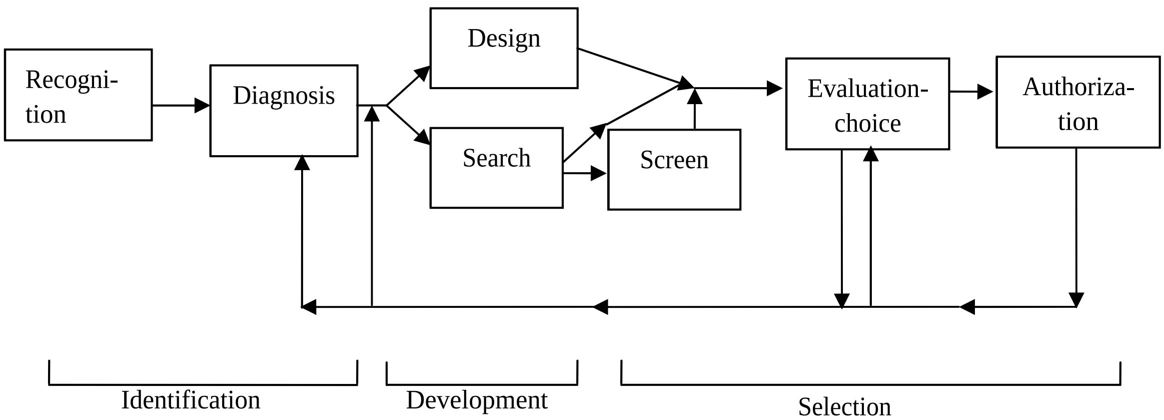

Figure 2-1 Mintzberg et al.'s 3-phase decision-making process model

Source: Hansson, 2005

The identification phase consists of two routines. The first of these is *decision recognition*, in which "problems and opportunities" are identified 'in the streams of ambiguous, largely verbal data that decision makers receive'. The second routine in this phase is *diagnosis*, or "the tapping of existing information channels and the opening of new ones to clarify and define the issues".

The development phase serves to define and clarify the options. This phase, too, consists of two routines. The *search* routine aims at finding ready-made solutions, and the *design* routine at developing new solutions or modifying ready-made ones.

The last phase, the selection phase consists of three routines. The first of these, the *screen* routine, is only evoked "when search is expected to generate more ready-made alternatives than can be intensively evaluated". In the screen routine, obviously suboptimal alternatives are eliminated. The second routine, the *evaluation-choice routine*, is the actual choice between the alternatives. It may include the use of one or more of three "modes", namely (intuitive) judgment, bargaining and analysis. In the third and last outline, *authorization*, approval for the solution selected is acquired higher up in the hierarchy.

Box 2-1 The implications of Mintzberg et al.'s sub-phases

Source: Hansson, 2005.

2.2 Analytical framework

Combining the above theories and extensive literature studies, with the advice from supervisor, a basic framework is developed comprising both the analysis parameters and analysis processes. A basic layer of analysis parameters are modified and adopted from Jacobsson and Johnson (2000). The second layer is filled in with specific factors of Chinese rural bioenergy industry mainly from the empirical data. The framework here is to be used to assist a systematic analysis, rather than fitting the empirical situations in, therefore, the empirical data can be used to modify and enrich the framework as well, this process happens in an iterative way. The analysis process follows 3 stage-processes proposed by Mintzberg, Raisinghani, and Theoret (1976).

Although Jacobsson and Johnson's framework is for studying the transformation and diffusion of renewable energy technology, the theoretical perspectives adopted in their research starts with individual entrepreneurial acts, but also emphasizes a collective act within technical innovation system (Jacobsson & Johnson, 2000). The same perspective is also logical when the commercial bioenergy system is viewed as an innovation and individual enterprise, which makes decision within the system under assists and constraints. The key elements which are identified for a renewable energy technology system are: actors, networks and institutions (Jacobsson & Johnson, 2000). The authors give broad implications for these elements, which develop more detailed analysis under specific context. However, technology itself is just one element in a bioenergy industry, together with other resources. Therefore, the original framework is modified as a new 4-factor one covering *actors*, *resources*, *networks*, and *institutions*. The implications of these 4 elements are illustrated as follows:

1. The *actors* include all the involved stakeholders in the rural bioenergy system, as well as their competence. The 'primary movers' are particularly important (Jacobsson & Johnson, 2000), which means actors who are technically, financially and / or politically

powerful enough to initiate or strongly contribute to the development of bioenergy system.

2. The *resources* include technology, raw materials, finance, internal know-how, information and specific resources like land. In the system, the characters of good resources refer to not only availability also sustainability and innovation. Availability is pre-conditions of establishing a system, while sustainability and innovation are particular important to certain resources, e.g. land use, technology and know-how.

3. The *networks* refer to the external relationship with other organizations. They constitute important modes for the transfer of tacit and explicit knowledge (Jacobsson & Johnson, 2000), and external technologies and information. A strong network is conducive to identify new problems and develop new solutions, to diffuse information and to support other stakeholders' participation (Martensson & Westerberg, 2007). Individual enterprise can increase its resource bases and the degrees of freedom through strong integration in a network (Jacobsson & Johnson, 2000). It is possible to contribute to the diffusion of a new energy system by building networks with important stakeholders, even when the resources are limited (Martensson & Westerberg, 2007). The basis of greatly using a network is openness, continuous feedback between sub-goals, continuous search-and-learning processes, and the exploration of new connections between different systems (Martensson & Westerberg, 2007). On the other hand, the network can also constrain the individual enterprise and sets limitations to its decision-making process (Jacobsson & Johnson, 2000).

4. The institutions can be both "hard" ones, for example legislation, economy system, political system, cooperate organization or educational system, and "soft" ones such as culture, morality, etc (Jacobsson & Johnson, 2000). The role of the different institutions varies (Jacobsson & Johnson, 2000), some may enable a strong network, therefore enhance other resources in the system, and others may influence the incentive and drivers for the stakeholders.

The 4 aspects are not separated, but interact and sometimes reinforce with each other. In an actual case of transformation to new bioenergy business, it doesn't necessary cover all of the four factors in strong way, but the system transformation can be achieved through at least one strong element.

Based on the illustration of first-layer 4 factors, the second layer of analytical parameters are more flexible and strongly context-based. These parameters are further explained in the analysis section. Figure 2-2 shows the overall analytical framework for this research, with example second layer factors.

The framework should not be viewed as a simple "check list", but rather as a tool to structure the analysis of currently or potentially commercialized bioenergy projects, based on the theoretical considerations. The factors consider factual and contextual elements both of which influence the decision-making. The boundary of these two types of decision-making elements is not drawn very strictly. For this research, the implication of various factors to the development of rural bioenergy business system is more important, the description of factors without a theoretical boundary does not interfere the understanding and analysis of the research questions. The second-layer factors are given as example and not listed in any order of priority or weights. The relationship between different factors are not simply linear, but in an interacting route.

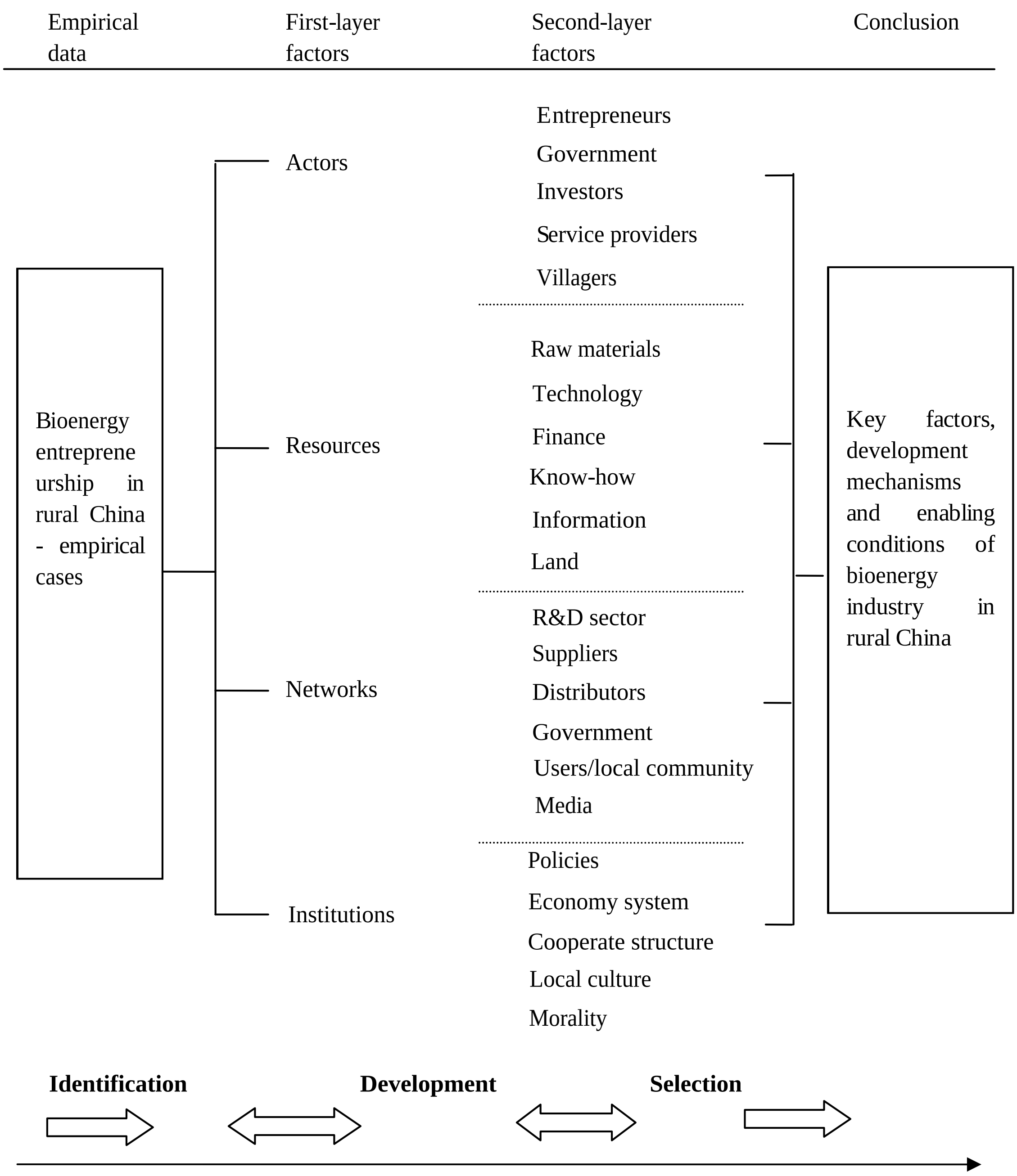

Figure 2-2 Analytical framework for development and commercialization of bioenergy in rural China

3 Chinese context

In order to understand the rural bioenergy field, an overview of the development of the bioenergy industry in China in general is important. The development and current state of commercialization of bioenergy in China covers a wide range of technologies, regions, and actors. However, the emphasis and development levels vary greatly. The focus of this research is given to rural bioenergy particular, while in this part of thesis, all types of bioenergy are viewed, in order to catch the overall picture of bioenergy industry, and provide a context for the further analysis.

3.1 Biomass resources in China

The primary biomass resources in China include: (1) agriculture and forestry residues; (2) manure from livestock farms and rural households; (3) municipal waste, including landfills, sewage farm, waste cooking oil; (4) energy plantations.

3.1.1 Agricultural and forestry residues

Agricultural residues mainly come from straw, and husk of crops, for example, rice, wheat, corn, beans, sugarcane etc. The forest residues come from both fuelwood and waste from forest industries. In general, this type of biomass is widely available in all regions of the country with an unbalanced distribution (Li *et al.*, 2001). Agriculture residues are mainly distributed in Shangdong, Henan, Hebei in North China, and Heilongjiang province in Northeast China, where agriculture is the dominant economic activity; Fuelwood as a resource is mainly distributed in Heilongjiang, Inner Mongolia and Sichuang, Yunnan provinces in Southwest (See Table 3-1).

Table 3-1 Regions with highest agricultural and forest residues resource availability

Region	Agricultural residues available for energy (Thousand ton)	Order	Region	Forest residues available for energy (Thousand ton)	Order
Shandong	44,070	1	Heilongjiang	29,486	1
Henan	30,637	2	Inner mongolia	26,049	2
Hebei	29,549	3	Sichuan	24,624	3
Jiangsu	27,949	4	Yunnan	20,874	4
Heilongjiang	26,372	5	Jilin	11,200	5
Jilin	24,079	6	Jiangxi	10,676	6
Sichuan	21,632	7	Hunan	9517	7
Hubei	16,894	8	Guangxi	9264	8
Anhui	15,790	9	Guangdong	9219	9
Inner Mongolia	15,739	10	Shanxi	8927	10

Source: Liao et al., 2004.

The annual production of crop stalks alone surpasses 600 million tons; among which 300 million tons are suitable to energy production, with an estimated energy potential of 12,000 PJ annually (REDP, 2005).

Scraps from forestry and forest product industries represent a resource equivalent to 8,000 PJ annually, and it is expected that the amount of forestry residues used in energy applications will increase substantially, with the potential of reaching 12,000 PJ per annum by 2020 (REDP, 2005).

One of the bottlenecks of using this type of resource can be the high collection and transportation cost, due to the massive volume and extensive distribution (Li *et al.*, 2001).

3.1.2 Livestock manure

Wastes from livestock farms and agricultural processing in theory could yield nearly 80 billion m^3 of biogas, which equals 57 million tons of standard coal equivalent (REDP, 2005). In reality, the livestock manure from small-sized farms and families are difficult to collect. Thus the medium-sized and large farms for pigs, cattle, sheep and poultry can be the main sources for the available animal manure (Li *et al.*, 2001). The manure from collective rural households can be another available resource for small-scale local use. The geographical distribution of this resource is also in the main agricultural areas, for example Shangdong and Henan provinces.

3.1.3 Municipal waste

The municipal solid waste (MSW) in China has increased at a rate of 8% -10% in recent years (Zhang & Ling, 2003). 140-160 tons of MSW was generated in 2000 (Zhang & Ling, 2003). It is expected to reach 210 million tons in 2020 with great potential for methane production (REDP, 2005) and electricity generation.

The utilization of landfill methane and sewage biogas has been a concern for the government. By 2005, the power generation from MSW was 0.2 million KWh (NDRC, 2007a).

Recently, the waste cooking oil from restaurants and meat processing industry become a popular resource. The overuse of fried oil used to cause sanitation issues in the Chinese food industry and the disposal of waste oil can result in water nitrification. The development of biodiesel brings commercial value for the waste oil. The most active area for waste oil utilization is in South China, including Fujian, Guangdong, and Jiangsu Provinces.

3.1.4 Energy plantations

Although the overall effects of growing energy plantations are still debatable, the experiment and development of suitable energy plantations has been put in schedule by Chinese government and industries. In the National Energy Plantation Development Plan (2006-2010), the State Forestry Administration has selected key species, e.g. *jatrophacurcasL., Pistacia chinesis Bunge, Cornus Wilsoniana Wanaer, Xanthoceras sorbifolia Bunge*, as development emphasis in different regions of the country (SFA, 2006). Southwest China will focus on *jatrophacurcasL*, the Mid-South will develop *Pistacia chinesis Bunge and Cornus Wilsoniana Wanaer*, While the Northwest will focus on *Xanthoceras sorbifolia Bunge*. Companies also show interests to invest in energy plantations to secure the raw material supply.

3.2 Modern applications

3.2.1 Biogas from anaerobic digestions

Chinese biogas application includes both household biogas and medium and large scale industrial biogas system.

Currently, the utilization of biogas from an anaerobic digester is primarily used at the household level. By 2003, there were about 13 million household digesters with a collective annual gas production of 4.6 billion M3 (Hu *et al.*, 2005). In 2005, the number of new household biogas digesters increased 3.15 million, with total gas production 7 billion m^3, serving for more than 11 million household users (REDP, 2005). The rapid development of household biogas in China received strong government support and subsidies from local governments. The national debt program provides finance support of around 1 billion per year for rural household biogas digester construction and maintenance. It was recognised by local governments that the popularization of biogas would only be successful when the direct benefits to the farmers were obvious (Abraham *et al.*, 2007).

In this level, the biogas as a final product is not for commercial purpose, but for the home consumption. It is recognized that the main advantages of household biogas digesters are convenience, system simplicity, and economic affordability. There is few space and need to commercialize the household biogas as a final product, though the equipment supply and other service delivery are running on a market-based mechanism. By 2005, for the manufacture of biogas digester equipments and service, there are more than 3,000 enterprises, with total sales 1.66 billion Yuan (REDP, 2005).

The potential of large and medium scale of biogas has not yet been fully exploited, which is hence the study focus of this research. According to the NDRC's (National Development and Reform Commission) recent statistics (Qin, 2007), the number of established large and medium biogas projects is around 700, which only counts for 6.6% of total livestock breeding farms. In this research, the possible biogas business projects are based on large or medium scaled biogas system.

The development of biogas projects on large and medium-scale has closely paralleled the booming breeding industry and the increasing concern of environmental protection (Li *et al.*, 2001); as well as integrated waste treatment. The technology is developed from household biogas technologies to a more sophisticated level to treat animal waste from livestock farms and industrial organic wastewater (Hu *et al.*, 2005). The landfills and sewage farms have developed the biogas collection and utilization technologies (Qin, 2007).

Although there is no official statistic showing the commercial level of these industrial-based biogas projects, empirical information shows the commercial ideas have been introduced by entrepreneurs for the biogas production based on local energy market. This research focuses on these market initiatives.

3.2.2 Gasification of crop residues

Biomass gasification systems have been adopted in China for drying and heating, domestic cooking, and power generation areas (Leung *et al.*, 2004). Table 3-3 shows the main applications in China.

The biomass gasification, combined with heating equipment, can substitute coal or oil, and benefit by conserving energy (Leung *et al.*, 2004). For domestic cooking, the technology takes an important role in upgrading the living conditions of rural areas. The combination of biomass gasification and power generation system (BGPG) is suitable for domestic and small-scale industrial application particularly in rural area, thus is most promising technology in developing countries because of its flexibility and economy (Leung *et al.*, 2004).

Table 3-2 Major applications of biomass gasification system

Application	Drying and heating	Domestic cooking	Power generation
Gasifier type	Down-draft	Down-draft	CFB
Gas cleaner	No	Water scrubber, filter	Dust separator, water scrubber
Pre-treatment	Cutting	Cutting	Crushing
System efficiency (%)	70–80	75	16–18
Operation time (h/year)	6000	2000	5000
Lifetime (years)	10	20	15

Source: Leung et al., 2004.

In contemporary China, there are more than 800 drying systems for wood and agricultural products, around 500 village-scale gasification stations, and more than 20 promoted biomass gasification power generation systems (CAREI, 2005). During 15th National Plan, the government is planning to support 6 MW BGPG demonstration projects (CAREI, 2005). Besides, there are more than 40 factories and enterprises that provide biomass gasification equipment and facilities in China (Leung *et al.*, 2004). Biomass gasification had played an important role in the energy developments, in order to promote its application and industrialization, some excellent demonstration projects have been built and operated successfully in this country (Leung *et al.*, 2004). All the biomass gasification for heating systems is established by private enterprises without any assistance from government. For power generation projects, some local governments have provided some financial supports at the beginning of its development, but now almost all projects are economically independent. However, most of the domestic cooking fuel projects have been under government financial support until now (Leung *et al.*, 2004).

3.2.3 Compact biomass briquettes

Biomass briquettes refer to pressing biomass into various shapes after chop, and further carbonization. The loose biomass bulks with density 10-20 kg/ m^3 can be compressed into briquettes with a density of about 1,000-1,300 kg/ m^3, and the heat value is about 30,000 kJ/kg standard coal equivalent (Zeng *et al.*, 2007).

Biomass briquettes are currently in the process of commercialization in China, although there is still space for technology improvement and market penetration, e.g. extending the lifetime of screw, reducing the production energy input, improving the carbonization process, raising the awareness of users, etc. The entire domestic industry is at the groping stage, with limited experiences and know-how expertise.

The market for drying equipment and briquette making technology and machinery is emerging in China. Most biomass briquette making machines in China are aiming at small and medium scale application, with the main targeted market in rural area. The on-site pressing is one of the sale points for the enterprises, which reduce the cost of transportation and storage for biomass energy use. The promising target market can be areas with rich forest resources or forestry industries, e.g. Heilongjiang, Jilin, etc. and the main agriculture region with abundant agricultural residues, e.g. Shangdong, Henan, Hebei, Hubei (Lin *et al.*, 1999). Efficiency in energy input and the convenience of operation are highlighted by equipment producers. However, there are very few professional producers and there has no industry standards and requirement yet.

There are some high-level residential communities using the bio-briquette products. Rural households are becoming the potential consumers of the final products in the efficiency improved stove. Another big potential consumer is the newly established biomass power plants, however, due to the cost issues, the bio-briquette products are not widely accepted by power plants.

3.2.4 Biomass power generation

A monopolized market

Biomass power generation uses solid biomass and the gas from biomass gasification projects. In China, by 2003, biomass power generation included bagasse co-generation, with an installed capacity of 1,700 MW and annual electricity generation of 4,000 GWh; power generation fuelled by agriculture and forest waste, installed capacity of 50 MW; municipal solid waste incineration power generation, installed capacity of 100 MW; and landfill gas generation, installed capacity of 10 MW (Hu *et al.*, 2005). In 2006, the NDRC approved 36 biomass power plant projects with total investment 10 billion Yuan.

In December 2006, a new national demonstration project in Dan County, Shangdong was launched, which will consume biomass 150-200 thousand tons per year, mainly cotton stalks and wood residues, with 40 million expected annual revenue for local farmers (CAREI, 2005). In November 2007, another project based on corn stalks was put in operation in Heilongjiang province (NEB, 2007a). Both projects belongs to National Bio Energy Company which was registered in July, 2005, a business directly under State Grid Corporation of China (NEB, 2007b). Some other state-owned power companies also showed interests in biomass power projects, for example, Huadian Power International (Shangdong), which is under Huadian group, one of the top 5 power companies in China (HPI, 2006); Jiangsu Guoxin Investment Management Group and Jiangsu New Energy Development Company, which are run by local government (SASAC, 2006). These are not all. The new projects are emerging in a rapid rate.

Favourable policies and bottlenecks

Electricity incorporated into the power grid is a precondition that assures a steady profit of biomass power stations (Leung *et al.*, 2004). The newly introduced Chinese Renewable Energy Law provides for the compulsory connection to the grid of power plants producing electricity from renewable. It stipulates that all energy offered, which is generated from renewable sources, must be purchased and that utilities must provide grid-connection services and related technical support (OECD, 2007a). The law provides a subsidy of 0.25 Yuan/kWh for biomass-fired projects.

There are some bottlenecks for biomass power plant development. First, the raw material is seasonal, and the cost is around 0.4 Yuan/kWh higher than conventional coal power plants

(NDRC, 2007b). Collection, transportation, and storage of biomass are still problems, due to the scattered small scale agriculture production. Secondly, it is lack of the key technology for boiler design and manufacture, and the experiences of biomass power plant operation and maintenance. The agricultural machineries also need improvement; some of them have bad quality and low efficiency. Thirdly, the support from government needs to be enhanced (NDRC, 2007b). Tax reduction is mentioned in government documents, but without specific and operational indication. The biomass electricity price is set up by the government, and the price is too low to promote the industry (NDRC, 2007b). The 0.25 Yuan/ kWh subsidies are too low to give real incentive for enterprises (NDRC, 2007b). The central government has realized these issues, and more favourable policies would be implemented, especially in term of pricing, taxation, and research and development input.

3.2.5 Liquid biofuels

The production of liquefied biofuels in China includes non-food-grains bioethanol and biodiesel. Both fuel types have been commercialized. China designated biofuels as a priority in both Medium- and Long-Term Development Programme for Renewable Energy and the 11^{th} Five-Year Plan (OECD, 2007a).

Bioethanol

In China, the biofuel research and experiments were initiated in 1980s. In 2001, bioethanol (E10) was selected as suitable gasoline substitute, standards were introduced and pilot projects were launched (OECD, 2007a). By 2004, the pilot projects had been spread in 9 provinces (Hu *et al.*, 2005). By 2005, bioethanol was available at petrol stations throughout Heilongjiang, Jilin, Liaoning, Henan and Anhui Provinces, with local market share more than 80% (OECD, 2007a; Hu *et al.*, 2005). At present, bioethanol is also available in Hebei, Jiangsu, Shandong and Hubei provinces and it is expected to spread to more areas of the country (OECD, 2007a).

Originally, the government in Jilin, Heilongjiang, Henan, and Anhui provinces approved four bioethanol production companies. For these producers, the initiated raw material was the stale food stocks, mainly expired corn (Hu *et al.*, 2005). Sinopec and PetroChina participate in the production and distribute bioethanol through their retail networks (OECD, 2007a).

At the end of 2006, the NDRC suspended the use of edible grains for bioethanol production because of concerns on increased domestic and international crop prices and food security (OECD, 2007a). In September, 2007, the NDRC issued an urgent notice on the development of corn processing industry, indicating that the government will not approve new corn-based bioethanol projects (NDRC, 2007c). The policy change has huge impacts on the four initiated production companies and other small producers, for which corn was the main raw material.

In June 2007, the Ministry of Agriculture published an Agricultural Biofuel Industry Plan (2007-2015), which aims to develop some new crop bases for growing ethanol and biodiesel demand without competing with the food sector (OECD, 2007). The new energy crops include sugarcane, cassava, sorghum, etc. Non-food-grain bioethanol became new strategy for bioethanol development in China. COFCO, the leading oil and food import and export group, as a new but strong player participates in the production and investment for non-food-grain bioethanol. In 2006, COFCO purchased the two original government - approved producers in Heilongjiang and Anhui. In late 2006, the company launched a cassava based bioethanol project in Guangxi, with annual capacity 0.4 million tons, the first phase started to operate in late 2007.

Issues such as biodiversity, soil degradation, water consumption, and the growing financial burden of subsidization still exist. The Agricultural Plan recognises the importance of new crop production technologies and new crop hybrids, as well as stronger support policies for non-grain fuel ethanol (OECD, 2007a).

Biodiesel

Private companies mainly run the Biodiesel industry, with experiences in chemical production. The key issue in developing biodiesel is the raw material supply. The national scale projects refer to the biodiesel plantations under State Forestry Administration. Sinopec, PetrolChina, and China national offshore oil company are all interested in energy plantations and biodiesel production. COFCO is also involved in biodiesel business, with cooperation with State Forestry Administration.

For most private companies in China, biodiesel from waste cooking oil is the main business. The dominant private companies are from South China, e.g. Guangdong, Fujian, Zhejiang, Jiangsu. However, the market is at the initiative stage, the participated companies vary in large scale, ranging from family-workshops to stock companies. And the relevant standards which are necessary in order for biodiesel to be sold in petrol stations are still awaiting approval (OECD, 2007a).

4 Case description

The 3 case studies are called *Heyong biogas system*, *Liuminying biogas projects* and *Shengchang Bioenergy Ltd. Co.* The 3 cases are considered as critical cases, with at least one or more resources more available than the rest of the rural China. The focus groups of the case studies are these 3 enterprises (or potential enterprise). From a systematic perspective, the villages and surroundings are also included in the scope of case studies.

4.1 Overview of case studies

The 3 cases are located in both South and North China. Heyong biogas system is located in a village called Yangcheng, at Putian County, Fujian province. Shengchang Bioenergy Ltd. Co. is located in a village called Lixian, at the boundary between Hebei province and Beijing. And Liuminying biogas system is at Liuminying village, Daxing district, suburb area of Beijing (see figure 4-1).

Figure 4-1 The locations of 3 cases

Since biogas is the most mature and widely used bioenergy type in rural China, in both the Heyong and Liuminying cases, biogas is the main output. The inputs are based on animal manure. The main product of Shengchang Bioenergy is the identified biomass fuel. The inputs are various agricultural and forestry residues. The three cases have different development history and commercialization status, with the earliest – Liuminying biogas system which started from early 1990s, and the latest Shengchang Bioenergy Co. which launched in 2006. While, there are two phases of biogas projects in Liuminying case, which are called "new project" and "old project" for short. From the market point of view, these cases are in different market development stages.

Table 4-1 The overall situation of the 3 cases

Cases	Starting year	Production input	Production output	Legal form	Commercialization status
Heyong	2003	Pig manure	Biogas & Heat	Private	Market trial
Liuminying	1991 (old) 2007(new)	Chicken manure	Biogas & Electricity	TVE	Partly commercial (old) Designed to be fully commercial(new)
Shengchang	2006	Agricultural & forestry residues	Compact biomass fuels & Biomass stoves	Private	Fully commercial

4.2 Heyong biogas system

Heyong biogas system is affiliated to Heyong Breeding Company. The project is based on the manure waste from pig farm, establishes large scale biogas production system and distribution system, connecting the breeding farm to the local households. The Company is considered as a leading rural enterprise in Putian County. Its biogas project gains a good reputation locally. Therefore, it is selected as a critical case. However, this research is to look into the different aspects of its development path and the mechanism behind, therefore both the strong points and weak points of the project are discussed in this research.

4.2.1 Background

Natural conditions

The company and the biogas system are located at Licheng district, Putian County, in Southeast China. The biogas project is located in one of the 90 natural villages in Licheng district.

Geographically, the landform in the region is combined with hill, coastal mesa and coastal plain. The agriculture land and rural residents are mainly located on coastal mesa and coastal plain, with a small proportion distributed on the valley basin. The main agricultural activities include fruit planting, aquiculture, animal husbandry, vegetable planting, and edible mushrooms. It is in the subtropical oceanic monsoon climate zone. The average annual temperature is 30.3 ^{o}C, with extremely highest temperature 38^{o}C, and lowest 1^{o}C. The average annual rainfall is 1,355.8mm, the rainy season is between March to June, with rainstorm in typhoon season between May and September. The average annual sunlight time is 1933.3 hours per year, with no frost during entire year (Lin, 2008). The climate conditions are favorable for pig breeding and biogas production.

However, the soil in that region is not naturally fertile. In order to gain more productivity, modern agriculture applies great amount of fertilizer, pesticide, which together with waste from animal husbandry polluted the agricultural land, products and rural environment, therefore endanger the rural development. Moreover, in the hilly area, soil erosion intensified the degradation of agricultural land. As one of the solutions, biogas systems are integrated with animal breeding farms, fruit and vegetable gardens to mitigate pollution in certain degree.

The Heyong pig farm is one of the properties belonging to Mr. Wang, the owner of Heyong Breeding Company. It takes 13,364 m^2 of land, with agricultural land surrounding. There is no residential area or other breeding farm within a radius of 500 meters, and no mainstream river within a radius of 200 meters (Lin, 2008). A country road passes through the gate of the company.

Socio-economic conditions

The county is one of the most populated areas of China, with a current population density 780 people/ km^2 (NBSC, 2007b)[1]. The annual average net income of rural residents in Putian County is 4922 Yuan / person in 2006 (Putian Municipal Government, 2007). Compared with national figure 3,587 Yuan/ person (NBSC, 2007c), this region is above average, and considered one of the richer rural areas in China.

The local economy is under fast transition from traditional self-sufficient agriculture to modern industry and commerce. The industrial structure has been adjusted from a ratio of 20.2 : 45.3 : 34.7 in 2000, respectively corresponding to agriculture, industry, and the third sector (commerce and service) to a ratio of 14.0 : 53.9 : 32.1 in 2005 (see figure 4-2) (Putian Municipal Government, 2007). According to the 11th Five Year Plan (2006-2010) from Putian municipal, the emphasis will be put on industry and the third sector continuously, agriculture is shrinking. More rural residents are going to be urbanized.

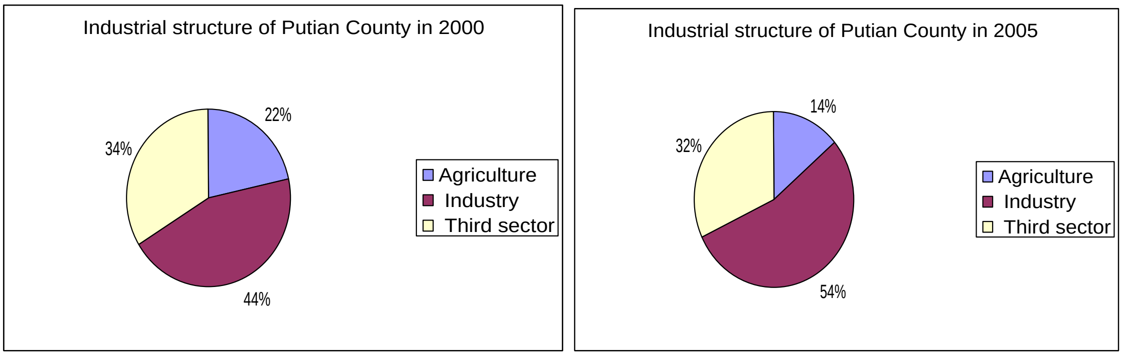

Figure 4-2 The transition of industrial structure in Putian County

Source: Putian Municipality, 2007

Under such circumstances, the development of rural renewable energy has multiple implications. In the short time, it is essential to maintain the local energy system, avoid the crisis of energy shortage, and establish the consensus of using bioenergy. In the long term, it provides a premise for the future urbanized residents to accept and continuously use the

1 Data estimated from regional population and land area in Fujian province.

bioenergy based on modern market. There is a potential for bioenergy to be integrated into municipal infrastructure.

Socio-cultural conditions

As a region where the reform and open-up policy were implemented at the very early stage, the local private economy is active, and the concept of free-market economy is widely accepted by local people. On another hand, the same as the rest of Chinese rural communities, living generation by generation in one village makes the relationship among neighborhoods very close. A Chinese saying describes such a relationship perfectly: "Neighbors who live nearby can be closer than relatives who live far [*yuan qin bu ru jin lin*]" Such a connection makes strong local network. Based on it, the new ideas and information can be passed in the village very efficiently. These two aspects play an important role in the decision-making process to establish the business plan for biogas.

4.2.2 Biogas system in the region

In order to understand the context of Heyong biogas project, a site investigation at 3 natural villages in Licheng district was conducted before visiting Heyong breeding farm. The 3 villages are called Shan Xiang, Long Tou, Yang Cheng. As a micro-system, there are different scales of biogas projects including single household, combined households from medium breeding farms, and large system from big farms in Licheng District. At Shan Xiang and Long Tou, the emphasis is given to develop household biogas. While, at Yangcheng village where Heyong biogas project is located, the emphasis is given to develop industrial scale centralized biogas production.

Local biogas system and market potential

The local energy consumption structure is a combination of electricity, coal, LPG (Liquefied Petroleum Gas), and biogas; in very rare situations, firewood is still used. However, since 2006, the price of LPG has increase greatly, biogas became the main substitution of LPG. The feedback of using biogas is very positive among local villagers, due to the convenience and the sound combustibility.

The anaerobic digestion technology has been introduced to the households in this region since 1970s. The typical household biogas system is usually a "3-in-1" model, which connected animal husbandry farm, household sanitary toilet, and kitchen. The manure and other agricultural waste are fed into inlet of the anaerobic digester, in 2 or 3 days, biogas is produced and piped to kitchen through desulfurization and desicator equipments. An 8 m^3 anaerobic digester can supply enough gas for a typical rural household.

However, the maintenance has been in poor condition in this region for a long time. Most biogas digesters were abandoned before 2000. From 2001, under the biogas national debt program, local government started to promote the biogas projects. New digesters have been established in a large scale. Local investigation shows at Licheng district of Putian County, before 2000 (including 2000), 6,364 biogas digesters have been built, however, among which around 70% have been abandoned. By the end of year 2000, the actual number of biogas digesters in Licheng District, Putian was 2, 108, this figure has been increased to 9,144 by the end of 2006 (see table 4-2).

Table 4-2 Statistics of rural household biogas digesters at Licheng District, Putian

Total Number (till 2006)			Before 2000 (including Year 2000)		
Newly constructed	Abandoned	Actual number	Newly constructed	Abandoned	Actual number
13,400	4,256	9,144	6,364	4,256	2,108

Source: Agriculture Bureau of Licheng District, Putian County, 2008 (First-hand survey)

A medium size breeding farm (with more than 50 pig livestock, for example), can supply biogas more than its own demand. The extra biogas is connected to the neighbors. On average, each household shares every $8m^3$, which means a $30m^3$ biogas digester can be connected to 4 households maximum, including the breeding farm itself. Most of the medium breeding farms build the infrastructures, such as outdoor pipes with their own investment, and supply the biogas to neighbors for free. It is not difficult to understand such a behavior when the neighbors are mainly relatives, for example brothers or cousins, or old friends. Recently, the subsidies from government compensated part of the investment. The subsidies for this type of connected biogas system are often allocated according to the number of livestock and the volume of the digesters. For each connected household, the breeding farm can get around 800 cash subsidy.

Heyong biogas system is one of the largest scale biogas projects in this region. Currently, there are 189,000 livestock in Licheng district, and 197 similar large-scaled breeding farms. Among them, there are 3 biogas projects established and the marketing design is on trial. The big scale biogas systems follow a “4-in-1” model, which connect the breeding farms with households, agricultural food production and fish ponds or duck ponds. The breeding farm owners launch the in-advanced investment, and supported by government. According the Licheng Rural Energy Station, the goals of these projects are set up as: 1) utilization of biogas and biogas residues as fuel and fertilizer; 2) emission mitigation and environmental protection; 3) a new biogas-based eco-economy to increase rural income (Lin, 2008).

The household biogas users normally do not participate in the centralized biogas projects anymore; therefore, they are not direct players in a local commercialization system. While, the existing of the household biogas gives a social consensus on using biogas and fosters villagers’ awareness of supporting biogas, and indirectly contributes for the development of large-scale commercial biogas schemes in the nearby neighborhoods.

The role of local government

The Licheng Rural Energy Station is the smallest and most basic governmental organization implementing the national biogas scheme, under the governance of Agriculture Bureau of Putian County. Its main responsibility is to register the applicants who are seeking financial support for newly constructed biogas digesters or successful operated and maintained biogas systems, and to allocate subsides to them. In 2006, the local subsidy level for rural biogas projects increased from 600-700 Yuan per household to 1,200 Yuan per household. The subsidies are under National Biogas Debt Scheme, in which the central government and local government co-finance the projects. The 1,200 Yuan subsidy has been divided into 2 parts, with around 320 Yuan spent on the biogas equipment, such as biogas oven, pipes, metering and monitor equipments, which belong to the household at the end; and other part around

880 Yuan goes to the gas supplier. Outdoor piping is constructed by biogas suppliers, indoor pipes are fixed by qualified technicians from Rural Energy Station. So far, there is no international or other external financial support. Local people think it s because the initiatives there are still too small-scaled to cover the transaction cost for external schemes.

At the same time, the local governments also play important roles in providing training programme, technical services and education. The higher lever government (Agriculture Bureau on County level) has organized and provided several training programmes for the villagers. Villagers are very motivated and interested to participate. After training, they can try to get a national certification to be a recognized technician, and work for the Biogas Maintaining Services Station under Rural Energy Station, or be self-employed local technician serving around the neighborhoods.

4.2.3 Heyong case

4.2.3.1 Initiation and motivations

Building biogas system together with breeding farms is a common concept in the region, while operating the biogas system based on market scheme is innovative. The owner of the Heyong breeding farm, Mr. Wang Heyong, pushed this process. He is a rural resident, running private livestock breeding industry. In recent years, the pork price increased a lot in China, pig breeding became a promising industry, and business is thus growing. In 2003, he initiated the biogas system. And the 600 m^3 anaerobic digesters were built even before the pig farm was built.

The motivation for the local businessman to start biogas project is stated by Wang as: “To protect the agricultural land. The waste from pig farm can pollute and completely destroy all the agricultural fields in this region, I don’t want to wait until all the villagers start to complain.” (Personal communication 1, 2008). This statement is based on the understanding of Chinese farmers’ traditional value – to cherish agriculture land. Although some of local villagers quitted the agricultural activities, and started their own business outside the hometown instead, they are still sharing such a value. The conflict happens several times between local villagers and industries, mainly due to the waste water and land pollution. This view also reflects the risk management considerations for his main business.

While, as a rural entrepreneur, the compliance of environmental regulations seems to be equivocal for him, so does the concept about “renewable energy”. Regulation on the management of livestock breeding waste was implemented from 2001 nation-wide. However, he did not know about the national regulation even when he initiated the biogas system. When the term “renewable energy” was mentioned, Mr. Wang also showed confusion (Personal communication 1, 2008). The link between his biogas project and national or global “renewable energy strategy” seems quite feeble for him. But he does have his own interpretation of “renewable energy” which is more an integrated perception to use local resources (Personal communication 1, 2008). Economic benefit is also one of the concerns, given the sound cost-benefit performance that a biogas system can play.

4.2.3.2 Network expanding

At the beginning, the biogas was connected to some nearby households. Since the scale of pig farm expands, the biogas production exceeds the original consumption. In 2007, Heyong breeding company started the centralized biogas and fertilizer supply system. Currently, there are around 3000 livestock in Heyong breeding farm. The 600 m^3 anaerobic digesters have treatment capacity of 35 tons of waste water, and produce 180-220 m^3 biogas daily (Lin, 2008). The biogas is connected into 100 households in a distance of 2 km, through PVC pipes with descending diameters from DN66-26 mm. The biogas sludge is used as fertilizer. After a 150 m3 sedimentation pond, the biogas liquor is connected to the 36 ha agriculture field for irrigation and fertilization, through other PVC pipes with descending diameters from DN100-50mm.

The biogas system has been built up step by step. The investment has also been followed up gradually by Wang. As Wang described, it is an "unexpected" result (Personal communication 1, 2008), and probably better than what he expected. As the situation going on, the inputs come from all aspects; more stakeholders are involved in this project. The system is designed by Licheng Rural Energy Station, the chief engineer Lin therefore work very closely with Wang to further develop this project. Local technicians participated into the construction work and maintenance. At the same time, local villagers also play important roles in the system. As final consumers, they not only accept the biogas and fertilizer, also work as monitors for the system. They help to check the damage or leakage from pipes and the quality of generated gas, report to Heyong Company for repair or improvement. Under the subsidy scheme, the new connected villagers got the biogas equipment from government for free, which makes the popularization of biogas easier.

4.2.3.3 Commercial plan

After several months of trial period, the Heyong Breeding Farm started to implement the charging scheme. It was part of the project plan. Regarding this issue, Mr. Wang has a sufficient argument: "I think it should be commercialized. It is benefiting both sides. For the maintenance of the system, we need to have input. In 3-5 years, the piping system has to be renewed. For the villagers, biogas is cheaper than other energy consumption, even cheaper than burning coal. And after charging, villagers can use the biogas in a more appropriate way, rather than keeping it burning entire day." (Personal communication 1, 2008). The fee is designed as 30-50 Yuan / household*month, after all the metering fixed, it would be charged 0.6 Yuan/ m^3, according to the consumption amount. The collected fee is to balance the expenses, such as salary of biogas management staff, the maintenance of pipes and equipments, and the fertilization of agriculture field. However, due to the study time (Feb, 2008), the fee has not been collected yet.

At the end of 2007, a second-phase of biogas project was planned and the construction was started. It is expected to supply biogas to 200 households additionally. Wang is ready to put continuous efforts on the new projects, and expect it to work "sustainably" for at least 30 years. However, as an investor and service provider, the land availability is a main concern for him. In this fast economy transition area, more and more agricultural land are expropriated by local government, and transferred for other land use purpose, for example, real estate or industrial factory. Mr. Wang's breeding farm and biogas system are on the agricultural land. The insecurity has been raised by the government's changeable land using plans. This rural entrepreneur is "worried that his effort may be washed once the land is expropriated" and "lost his heart" to put everything in (Personal communication 1, 2008).

4.3 Liuminying biogas projects

Liuminying biogas projects consist with two phases of centralized biogas projects. The first one was established as early as 1991, supplying cooking biogas for Liuminying village, which is called "Liuminying village biogas project", here it is called as "old project" for short; and the recent one is under construction, with a target to supply biogas to 7 villages, which is called "7-village biogas project", in this research it is called "new project" for short.

4.3.1 Background

Liuminying is a village located in Daxing District, under the administration of Beijing Municipality. There are currently around 260 households. The economy of the village is doing well since 1980s. The average annual net income of rural residents in Daxing District is 6,724 Yuan in 2004, and the annual net income of villagers in Liuminying is at the top-level in the region (Daxing government, 2008a). The infrastructure system in the village is therefore sufficient and under well management. There are village roads, parks, Central Square, supermarkets, hotels and other public facilities in the villages.

Liuminying is one of the earliest villages in China where the "eco-agriculture" vision has been promoted. As early as 1982, the entire village with 168 households built household biogas digesters, and created the household based eco-circulation systems. Nowadays, agriculture is still the dominant sector in the village. There are 580 Mu (around 38 Ha) organic vegetable plantations with annual output 5 million kilogram vegetables, a chicken egg farm with 200,000 hens which produce 2.5 million kilogram eggs per year, dairy farms with more than 100 cows, and pig breeding farms with more than 3000 pigs. Their organic vegetables and chicken eggs are branded with "Liuminying", and sold to big supermarkets in and around Beijing. Eco-tourism is another famous activity of the village. The village created an eco-agriculture garden, invites tourists to visit and participate in the agriculture activities. There are around 10 village-run factories. The vegetable plantations, breeding farms and processing are linked as a production chain, and the local ecosystem has been linked based on centralized biogas projects.

In Liuminying, there are two accounting systems. One is independent account for the independent factories, enterprises or other entity. Another is collective account for the village-shared production activities. In the later case, the village works as a big economy entity managing agriculture, breeding farms, industries, and other activities, villagers share the cost and benefits from these activities. This is based on rural collective economy, which was the main economy system in rural areas of China, and was broken down in many parts of China later by market economy reform. It is important to understand this rural collective economy, as the old centralized biogas project was initiated and managed under such a system background.

The economic stability and strategic village-based activities promoted the cultural integrality in Liuminying. When in many rural areas of China, villagers move to urban areas to look for a new livelihood, most of the villagers in Liuminying stay and work locally. Villagers tend to share the value, living habit, and economic benefit. A long-term self-identity of "eco-village" may work as an unnoticed factor for the biogas project to be established and promoted in Liuminying.

4.3.2 The old biogas project

4.3.2.1 History

In 1991, organized by Energy office of Beijing Municipality, a centralized biogas project was launched in Liuminying village under the aid from UNEP. UNEP provided biogas equipment as support, and Liuminying village financed and invested in the construction and management of the biogas project. Due to the limited internal fund, the village applied a national loan with interest subsidies. The villagers also invested in the equipments, e.g. meters, stove, etc.

In 1992, the first 100m^3 high-temperature (50-55^{o}C) anaerobic digester was built and launched in use. It is connected with solar panel to keep the temperature in winter. In 1997, another 200 m^3 medium-temperature (<35^{o}C) anaerobic digester was built. The annual capacity of two anaerobic digesters is 300,000 m^3. They replaced the small-scaled household digesters and supply gas to 260 households in entire village and some collective factories. The main resource is the chicken manure from the egg farm next to the biogas station.

4.3.2.2 Management

Together with the operation of the biogas projects, the biogas station in Liuminying village was established, and takes charge of the daily management of the biogas projects. There are five permanent staff members working in the biogas station, who are all villagers of Liuminying. Their main responsibilities are to maintain the facilities and equipments, and to deal with biogas sludge and biogas liquor. The biogas sludge and liquor can be used as up-graded fertilizer, which are shipped every day into the field by several tank trucks owned by biogas station. They are used as fertilizer for the vegetable plantations and other crop fields. However, it produces 1.4 tons of biogas sludge and 16 tons of biogas liquor everyday, which may not be fully assimilated by the local agriculture. Without a scientific instruction, farmers are suspicious to use them as fertilizer. The extra biogas sludge and liquor may be discharged into local water system, and cause the secondary pollution.

From the initiation of project, the two biogas projects were aimed to serve as “welfare” for the villagers, therefore the accounting of the projects are in the village collective account system. Villagers are charged 0.8 Yuan/ m^3 for the biogas consumption, and the actual consumption is around 300 m^3 per day for entire village. Villagers don’t pay directly to the biogas station, but the quantity they used will be deducted from their personal account in the village’s collective accounting system. According to the chief of biogas station, the payment is “token”, there is no profit out of it, and instead the village has to put in more than 100,000 Yuan per year for the operation (Personal communication 2, 2008). The operation cost consists with the maintenance of biogas equipments, pipes, the trucks and staff’s salary. And it doesn’t include the cost of chicken manure, since the egg farm is part of village’s collective property, the manure is given to the biogas station for free. According to biogas station, the actual cost of the biogas is 1.53 Yuan/ m^3. However, there is no enough detailed data showing how this cost actually happens, and there is no access to the village account to validate the cost-benefit effects of the biogas operation. One sure point is that the old biogas projects do provide the affordable clean energy to the villagers in Liuminying, and so improved local social welfare.

As an “eco-village”, biogas has been used for more than 20 years. The old centralized biogas project has been operating for more than 10 years. As the widely accepted cooking energy, biogas created and stabilized the new cooking habit, and enhanced the cultural identity of Liuminying.

4.3.2.3 The new biogas project

In the old project, the objective for biogas production is “to be sufficient for the villagers” (Personal communication 3, 2008). The resource and production capacity was not fully exploited. In the egg farm, there are 200,000 hens, and only a quarter of the manure has been used for the old project. The manure from the cow farm, pig breeding farms has not been collected and used either. The village leaders and staff in biogas station have thought about to expand the scale of the biogas system.

In recent years, the “new rural construction” has been one of the main tasks of the central government. The main purpose is to improve the rural livelihood, and the social facets are taken into consideration, for example, sustainable development, local capacity building. Government pays attention to biogas again as part of the task by popularizing clean, renewable energy in rural areas. In 2007, with local government’s support, a “7-village biogas project” was launched in Liuminying village. The purpose of the project is to build a regional rural biogas system based on existing case, and to explore a self-sustained rural biogas operation system. Liuminying is not the only case to promote its own experiences, together with it, there are 7 similar new projects going on at other villages in Daxing District.

The new “7-village” project is based at Liuminying, expands the original centralized biogas system, and connects the new biogas to other 7 villages nearby. The project is under construction currently, the two anaerobic digesters are with the designed volume of 800m3 each. The original investment is 20 million Yuan, among which the NDRC in Beijing Municipality invested 80%, and the rest 20% is financed by Liuminying village. The 20% of investment is still a large financial burden for the village; therefore the village is still actively seeking for other external funds. The staff in the biogas station complained that they are not updated with latest national policies and financial schemes; therefore the seeking of external fund is difficult (Personal communication 3, 2008). The metering equipment and stoves are invested by households, which is around 500 Yuan per household. The generated biogas will supply to 1,700 households as the cooking energy.

The existing biogas station will take over the management of the new project. At the same time, training program will be given to more villagers. The new project will have the independent accounting system, and registered as an utility enterprise. It is going to charge 1.6 Yuan/ m^3 for the biogas. “Compared with the 1.53 Yuan/ m^3 cost,” says the chief of biogas station, “this price is just high enough to cover the cost, we need to utilize the biogas sludge, sell as fertilizer to make up the profit.” (Personal communication 2, 2008).

The staff members in the biogas station show qualified expertise towards biogas; however, they require a deeper know-how in the treatment of biogas sludge and liquor. The secondary pollution from the redundant biogas sludge is a problem. To solve the problem, the know-how directly passed to farmers is essential. It require the external technical and financial support from the government, in which the government can promote the R&D regarding to the fertilizer and crops, give training courses regarding to how to mix and use the bio-fertilizer to certain crops, or give a feed-in subsidies for the farmers to use the new fertilizer at the beginning.

4.4 Shengchang Bioenergy Company

Shengchang Bioenergy Company is located in Lixian town, Daxing district, and suburb area of Beijing. The main products are various compact solid biomass fuels in different shapes, e.g. biomass briquettes, bricks, sticks, bars, and biomass granules, from agricultural and forestry residues.

4.4.1 Background

Lixian town is located in the South suburb of Beijing, near the boundary between Hebei province and Beijing. It consists with 45 villages. The total area of the town is around 94 sqkm, with a population of 33,000 (Daxing Government, 2008b). Agriculture has been the primary sector for hundreds of years. The infrastructures are basic, there are roads connecting different villages, two centralized water stations supplying safe water to half of the population. Although under the administration of Beijing Municipality, the local socio-economy condition is far different from the downtown area of Beijing, but closer to the rural area in Hebei province. The agriculture production mode and cultural atmosphere are typical among rural areas in North China.

Since the rural livelihood has been improved these years, coal and other conventional fossil fuels replaced the traditional biomass, e.g. straws, stalks, and became the main energy sources for cooking and heating. Each year, straws and other agricultural residues are abandoned in the field, and most often burnt in the field. The burning straws cause serious air pollution and resource waste, especially in the grain harvest season. The situation has been lasted for years, and the problems have been accelerated during the process of modernization of rural China. Therefore, to utilize agriculture residues through various modern and efficient technologies has been a concern for the society. The development of biogasification of crop residues and the compact biomass fuel - biomass briquettes are furthermore put as priority of the country's rural bioenergy strategy. In recent years, the domestic research and development is active. The universities, research agencies, together with some agricultural machine manufacturers are involved in the R&D of biomass densification equipments, and make various equipments available in the market.

At the same time, the biomass densification technology has been matured in some developed countries. Japan, for example, started the research on biomass densification equipment in 1940s. As early as 1980s, Japan established solid biomass fuel (with 75% coal and 25% biomass) factory with annual output 600 tons (Japan Energy Study Association, 2006). In Germany, there are more than 100 biomass briquette manufactures at present. This industry also blossoms in Scandinavian countries, e.g. Denmark, Sweden. In Sweden, there are more than 10 compact biomass fuel manufacturers with annual output more than 200,000 tons (Jiang *et al.*, 2006).

4.4.2 The development story

4.4.2.1 Establishment

In 2003, a venture investment company named Omai established a bioenergy project in Beijing. Jointly considering the rural energy situation, national policies, and industrial prospect from international experiences, the venture company decided to invest in the market of compact biomass fuels. Before this bioenergy project, Omai already successfully invested in the bio-tech field. During the 3 years' preparation, Omai invested in the compact biomass equipment and technology research. As a conjunct of technology and capital, in February, 2006, Shengchang Bioenergy Ltd. Co. was registered with initial capital 5 million Yuan. At the same time, Mr. Fan was doing his PhD research about biomass densification equipments and the specifications of various compact biomass products. He was invited to join the new company as a vice general manager. It is a manufacturer of not only various compact biomass fuels, also biomass stoves and the biomass densification equipments.

The modern corporation management mode was introduced and applied in Shengchang from the very beginning. The top-management board consists with an investment board, a general manager, a vice-general manager. Under that, there are two vice-mangers taking charge of compact biomass fuel production, equipment R&D and maintenance; together with three directors taking charge of finance, marketing and human resources. The company employed a high-level team with expertise in engineering, research, market development and corporate management. The development goal was set up as "to be the new leading enterprise in rural biomass fuel industry", and the company's long-term duty is "to devote in the development of bioenergy industry" (Shengchang Bioenergy Ltd. Co., 2008).

However, the management structure doesn't necessarily lead to an easy management. The sectoral-wide experiences and know-how affect a lot at the company's operation stage.

4.4.2.2 Networks expanding

The factory of compact biomass fuels was launched in April 2006. And first batch of products were produced 4 months later. Before and after this time, different political officials from local government, Beijing Authority, and Central Government, have visited the company, and made positive comments. Apart from government, the company is also active in communicating with local villagers and other users. Since both the upstream and downstream of their business chain are closely linked with local dwellers, in order to develop the market, it is important to involve the villagers.

Firstly, the raw materials including cotton stalk, corn stalk, peanut husk, wheat straw, and branches are collected and purchased from local farmers. The company designed a raw material collect system, which combined the farmers, raw material base and the company (see figure 4-3).

Figure 4-3 Raw material collection system of Shengchang Bioenergy Co.

Source: Shengchang Bioenergy Ltd. Co., 2008.

On the other side, the farmers are also users of biomass fuel products and stove equipments. However, high cost and the high sales price make the market penetration in rural area difficult. Moreover, rural residences are more used to burning coal rather than densified biomass fuel. The users' psychological habit is also one of the barriers to develop their market. In order to promote the products in rural area, the company participated in biomass stove competition organized by Beijing Municipality in 2006, showed the stove products to rural residents, and gave instructions about how to use them. In 2007, the company also gave subsidies to the local farmers to buy the biomass fuel, which according to the general manager is to foster the users' new habit by supplying them with cheap biomass fuels. However, since there is no external financial support apart from the company's fund, the subsidies of biomass fuel was not in large scale. In 2007, the government provided some subsidies for users. For each stove, the government gives around 1000 Yuan subsidy. Farmers can buy stove with 500 Yuan which the market price is 1,500 Yuan. Due to this policy, in Lixian area, the company sold around 30 stoves in 2007.

As the market capacity in rural areas is limited, the company expanded the sales network by involving some more matured stove manufacturers. Laowan is one of the stove brands, and the main client of Shengchang Bioenergy. Shengchang Bioenergy assists Laowan to develop new stoves. When Laowan sells the stoves, Shengchang's biomass fuel products are sold together with the stove and supplied continuously (Personal communication 7, 2008). Laowan is not the only stove manufacturer the company is cooperation with, but Shengchang Bioenergy mainly rely on Laowan's network to sell the products. The products go mainly to high-standard residential area (private houses). In high-standard residential areas, coal is hardly used, because of the house owners' own indoor environmental requirements. The price of the compact biomass fuel products can compete with oil and gas. That's the sale point.

The biomass power plants are supposed to be the main clients for Shengchang Bioenergy, and they showed high interests at the beginning. However, the biomass power plants can not accept the price, which is even higher than coal. During the market development, the company also tried to have international clients. There was a multinational company asking for the products for their boiler because of the sound environmental performance, however Shengchang bioenergy's productivity is too small to fulfill this multinational company's requirement. The export channels are also explored. While transportation cost is a main issue to consider. It is possible for the neighborhood countries, e.g. Japan, South Korea, but not Europe or further, where the transportation cost is not affordable for the company.

4.4.2.3 The role of the government

The industry and the company were initiated under the context of national policies. The policy environment has been favourable to the development of renewable energies, which also gives the strong signal for private sectors to get involved with the bioenergy industry. However, a practical and workable policy framework is more vital to individual enterprise. As the vice manager and general manager of Shengchang Bioenergy both mentioned, "The favourable policies from government, like the Law, and other big words, don't mean so much for us. The law or government's ambition doesn't apply in real implementation for our industry...Not even the financial supports are not in place for our industry, neither are the industrial standards and market regulations." (Personal communication 4 & 6, 2008)

Although the government has shown great concern on the compact biomass fuel industry, and the development of biomass fuel has been integrated into "new rural constructions", there is no specific policy instrument given to the compact biomass fuels. The enterprises could apply for one-time subsidies, but the procedure is redundant, and the amount they can get is usually small. The need towards a workable policy framework is keen from the companies, especially the incentive policy instruments, for example, subsidies, taxation, and the sector standards.

4.4.3 The current operation

At present, the production of Shengchang Bioenergy is not at the maximized designed capacity. On the raw material stack field, 3,000-4,000 tons of biomass materials are stored, while the designed capacity is 6,000 tons. In the optimal situation without machine broken-down, the monthly production is 400-500 tons, which means 6,000 tons/ year. And the designed annual production capacity is 20,000 tons. The production equipment breaks down quite often, and the loss during downtime cannot be neglected.

On the other hand, the raw material collection diameter is big enough, and the raw material supply is sufficient to support the production. Surroundings of the factory are all agriculture areas. The collection diameter covers 10-20km, which is in the cost-effective collection range.

One of the main barriers for the company's market development is the high sales price of their products. The reasons can be found by looking into the company's operation stages. During the company operation, there is still a lack of the know-how regarding to the raw material logistics, cost control, and quality control. The costs can be broken down into 3 parts, which are raw material cost, management cost and energy-input cost.

The direct prices of raw materials from farmers are not high (*see table 4-3*). In Shandong, Henan area where the agriculture residues are more abundant the price can be a bit lower. However, the company and the entire industry do not have experiences about how to manage the raw material stack, transportation and storage. The collected raw materials are piled up in an open area without protection. Lots of biomass underneath have gone bad and start to decompose. The raw material loss from storage step is up to 20%-30%, which makes the raw material cost much higher than it should be.

The management cost is also high, because it's brand new, and proactive industry; there is a lack of know-how in sectoral level regarding to how to manage all the operation steps, how to manage the risks and how to find the ways for its development. As Shengchang Bioenergy is one of the first-movers in the industry, there is no existing experience to learn from, especially domestic experience. The company is therefore sending employees to other industry and abroad to learn the management know-how. For example, employees are sent to hay industry to learn the biomass logistics and storage experiences.

Energy-input cost is a big part of expense for the company as well. The company use electricity to run the equipments and mold the biomass under room temperature. Although the equipment is relatively low energy-consumed compared with others in China, the electricity bill takes a big part of the operational cost.

The quality of densification equipments is declared by the Company as "no problem, can almost catch up the technical level in developed countries" (Personal communication 3, 2008), however, the broken-down rate is high, thus the lost workday due to equipment repair is considerable. A sum-up of the operation status in 2007 of the company is shown in table 4-3.

Table 4-3 The operation status of the company in 2007

	Raw material			Products		coal
Actual capacity	3, 000-4,000 tons			6,000 tons/year		-
Designed capacity	6, 000 tons			20,000 tons/year		-
Price (Yuan/ton)	Cotton stalk 160	Corn straw 140	Sawdust 300	Biomass briquette 430	biomass granules 600	700 - 800

Note: the data represents the operation status in 2007 only, the market price can differ in a big range year to year. The price of coal in China in 2007 is listed for comparison. The heat value ratio between Shengchang biofuel and coal is 2:3.

5 Analysis and discussion

5.1 Factor analysis

All the 3 cases involved in the commercialization process of bioenergy business comprise the 4 basic factors: actors, resources, networks and institutions. The implication of these factors may require further interpretation. The analysis of four elements explains both the factual and value reasons that why a decision-making process of bioenergy business is taken, and how do the factors influence the business development of bioenergy. This therefore shapes the different development mechanisms of bioenergy entrepreneurship in rural China. Table 5-1 summarizes the general findings from the 3 case studies, followed by further explanations.

Table 5-1 Key factors of bioenergy entrepreneurship in rural China and their impacts

Factors	**Implication-s**	**Heyong Case**	**Liuminying Case**	**Shengchang Case**	**Impacts**
Actors	Primary movers	Local private entrepreneur	Village committee & local government	External private venture	Internal primary movers' actions are more likely to bring sound performance; Flexible supportive schemes from local governments;
	Government	Technical support	Financial support	Communication support	
	Villagers	Mild acceptance	High acceptance	Lack of knowledge and acceptance	
	Others	Local technician	International agency	Equipment contractor	
Resources	Baseline resources	• Local experiences • Monetary budget	• Raw material • Local experiences	• Capital • Institutional information	Very limited baseline resources
	Mobilized resources	• Technology • Know-how • Land	• Financial schemes • Technology • Know-how	• Technology • Know-how	
Networks	All the relevant external relationships	Strong local networks in village level	• Strong local networks in municipal level • External support	• Weak local networks • Growing external networks	Vital to the system development
	Regulative institutions	• Under priority of renewable energy plan • Delayed implementation of sectoral	• Under priority of renewable energy plan • New rural developmen	• Under priority of renewable energy plan • No sectoral standard	Generally undeveloped;

		regulations	t policies • Lack of up-dated information	• No specific incentive	Stronger impact on entrepreneurs facing higher risks than those with controllable risks
	Cognitive institutions	Positive social consensus	Positive social consensus	Positive social consensus	
Institutions	Normative institutions	Local expertise	Local expertise	Lack of expertise sector-wide	

5.1.1 Actors

The actors in a rural bioenergy system can be generally summarized as government, investors, companies, service suppliers, villagers, contractors, and consumers. Li, jingjing et al. (2001) summarized a typical actor model of rural bioenergy system (see Fig.5-1). In a specific case of commercial system of a specific type of rural bioenergy, the system tends to be simplified, and some of the actors can play multiple-roles or overlap the roles with others.

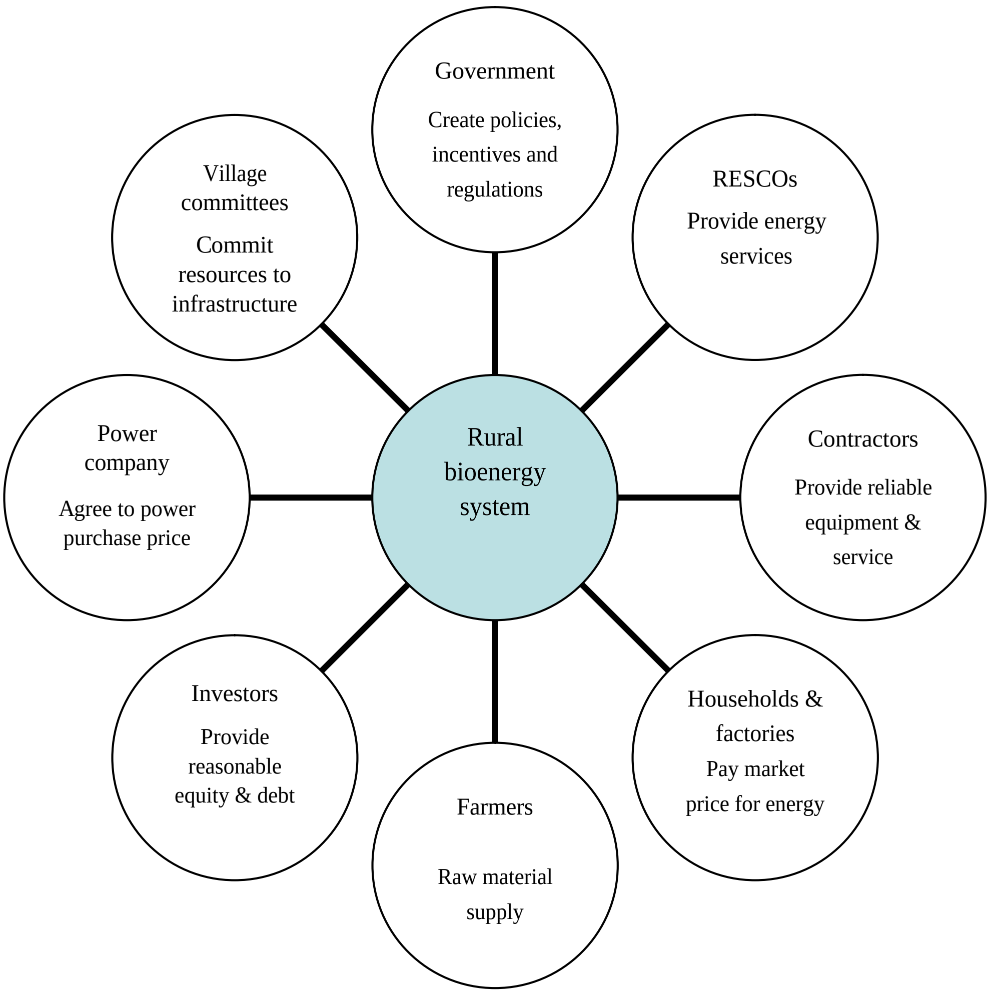

Figure 5-1Actors in successful development of a market for rural modern bioenergy system

Source: Li et al., 2001

5.1.1.1 Primary movers

In each rural bioenergy system, there are some key players, so called "primary movers", who play particularly important roles to initiate and develop the system. The primary movers are usually powerful in one or more elements, for example capital, technology, raw material, or political networks, so that they are able to push the system initiation, and implement the system transformation (Jacobsson & Johnson, 2000). At the same time, primary movers need to have unique insights regarding to the changeable environment, and are able make innovative decisions. Due to these characters, in a rural bioenergy system, the first mover can come from both the internal and external actors, who could be local government, local entrepreneur, an external aid agency or a group of joint forces. In the commercial rural bioenergy projects, the first-movers are usually rural entrepreneurs or the manager of the local bioenergy projects.

In the case of Heyong biogas project, Mr. Wang, the owner of the Heyong pig breeding farm and the biogas system as a "first mover" initiated the centralized biogas system and pushed it to the commercial operation. In this case, Wang has at least two of the key resources, the raw material and the capital, which empowered him to have chance to consider bioenergy as a solution of his "identified problems"[2] At the same time, Wang's personal background and life experiences enable him to develop his own insight and judgments in order to identify the problem, integrate the information and resources to develop his strategy. Being a local entrepreneur in breeding industry, he understands the potential impacts of pig breeding activities on the agricultural activities, has the experience about transforming the manure waste into resources, and possesses the local network to implement his strategies. Furthermore, the morality and personal emotion to agriculture land make him motivated enough to take the primary action. In this biogas system, this first mover plays multiple-roles as investor, entrepreneur, and service and infrastructure supplier.

In the case of Liuminying biogas projects, the old project was a TVE-based biogas project, although the profitability was not the preferred concern. The Chief of Liuminying Village Committee as a first mover represented the villagers to initiate the centralized biogas project. The Chief had governed Liuminying village for more than a decade by that time, with high reputation and authority in the village. Although Village Committee is not a recognized political unit in Chinese political system, it can still be concluded that the political and cultural authority of this first mover makes the establishment of biogas project possible. The new project was planned by the local government, and Liuminying was chosen as a participant of the overall rural bioenergy plan. The internal movers then lead the village and manage the biogas projects. The primary movers of the new project can be viewed as a combination of external and internal actors, which is different from the completely private organizations in the other 2 cases. The group of joint forces including the local government and Liuminying village as primary movers, who share the multiple roles in the implementation of biogas projects, including investment, providing raw materials and supplying biogas products.

In the case of the Shengchang Bioenergy Ltd. Co., the venture company Omai as the founder of this company performs as the primary mover not only in initiating the company's bioenergy business, also in exploring the new bioenergy industry field in China. It is not

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[2] The analysis in this section follows the 3 sub-processes of decision-making: problem identification, decision development and selection. Problem identification happens before a first mover starts to gather the information and resources for the potential solutions.

uncommon for such a venture company with bio-technology experience to step in bioenergy industry, given its cutting edge on integrating capital and information. While energy shortages become one of the hottest issues in China, favourable policies are made for sustainable energy, successful stories are not news anymore from international industries, and the founders cannot wait any more but launch the bioenergy project. In the business operation, the role of the established company is an overlap of investor, energy and service provider, and equipment supplier.

Generally, the emerging of the primary movers in rural bioenergy business has both the factual reasons, in terms of resource possession and personal experiences; and the value attributes, in terms of personal insights and judgment. In the system development, a first mover can play multiple roles; or a group of primary movers share a combination of responsibilities. There is no a rigid prototype to describe which role the first mover should play. During the development of decision-making processes, these primary movers, especially first movers with internal connections are able to integrate more actors through various networks. Other actors later become equally important in the system.

5.1.1.2 Government

Government policies, incentive programs, and various regulations play a critical role in encouraging the other market players, especially private investors to fulfil their roles (Li *et al.*, 2001). Different levels of governments have influences on the foster of local bioenergy market in different scales. The key to sustainable market development is that investors in new bioenergy enterprises must see reasonable returns on investment and manageable business risks (Li *et al*., 2001).

International policies usually play the roles in providing indirect information for first-movers to make decision based on a general estimation of market trend. In Shengchang bioenergy case, the international concern on climate change and renewable energy strategy contributes as one of the motivations for the investors to initiate bioenergy business. The involvement of UNEP in Liuminying's old project also gives incentive for local village committee to take actions. Nevertheless, in some parts of rural areas where the local system is rather close, the international policies may not have impact on local initiatives.

The influence from the central government can be strong by setting laws, sectoral regulations, and providing direct incentives schemes. The NDRC is the key actor to participate in the law-making, energy-related national plans and incentive schemes together with other actors in central government. The Ministry of Finance usually takes part in the decision-making on financial programmes. The private sectors are strongly driven by these policies, and identify the opportunities in their own ways. However, at present there are still gaps between the industrial need and the national policies. A complete market platform is not in place. Policies on market capacity building are in urgent demand.

The implementation of national policies relies on the local government and other sectoral governments. However, the boundary of responsibilities is vague, and there is space for local authorities to interpret the policies in their own way. Given different concepts and understanding towards bioenergy, it can be categorized as green energy, rural energy or future energy; different sectors and different levels of government put on various emphases. Agriculture, forestry, conventional energy sector are all involved in the policy implementation of bioenergy. The industries are confused about the responsibilities of different governmental sectors, and feel difficult to search for information and support.

The actual actions taken from local government vary widely; the effectiveness of local government can therefore differ greatly in different rural areas or in different bioenergy business fields. In some cases, the government provides direct and strong support by being the main investor and first mover of bioenergy popularization. In the case of Liuminying's new biogas project, local government, NDRC in Beijing Municipality invested in the project and designed the commercial schemes. Another main function of the government is to conduct education and training programmes to public or villagers in particular. Putian Agriculture Bureau for example has worked effectively in training local technicians to popularize biogas knowledge and support the local biogas systems. To promote the compact biomass fuel, Beijing Municipality hosted public events for biomass stove exhibition and bio-briquette using instruction; and provided local incentive schemes for villagers to buy relevant equipment. However, when the supportive scheme is not intensive and consistent enough in terms of effort level and time duration, its effectiveness is limited.

5.1.1.3 Villagers and others

In local resource-based rural bioenergy system, the role of villagers is a combination of raw material supplier, final product consumer (bioenergy and the equipments), and sometimes infrastructure builder and maintainer. The level of acceptance and knowledge about bioenergy using is a key indicator of the local bioenergy market capacity. Affordable price of the biogas or biomass briquette is a determine premise for the villagers to accept the bioenergy products. The affordability is a relative concept, based on the local rural residents' income and the existing domestic energy expense. The environmental awareness indirectly links to the popularization of bioenergy. It can be a parameter that contribute to the positive local vision towards bioenergy, but not necessarily have direct contribution to villagers' decision to choose bioenergy as product.

Other stakeholders who may get involved in the rural bioenergy business development include local technicians, equipment contractors, and international agencies. They play roles to provide necessary technologies, equipments, maintenance skills or sales networks.

5.1.2 Resources

In an enterprise, the "resources" can be defined as all the assets, organizational processes, capacities, company attributes, information, know-how, etc. which are controlled by the organization and enable the organization to design and implement its strategies to improve the efficiency and effectiveness (Daft, 2003). The resources for a business organization can be divers, which can be categorized as *physical capital resources*, *human capital resources*, and *organizational resources* (Barney, 1991). Physical capital resources include physical technologies (e.g. key equipments, workshop, etc), financial capital, raw materials and land. Human capital resources refer to experiences, know-how, intelligence, value judgement and insight of key decision-makers and other stakeholders inside the organization. Organizational resources include internal communication structure, and the external relationship that can be integrated with the organization's network and information channel (Barney, 1991). It has to be pointed out that the concept of "resource" implies the human judgement of the value in general, even for physical resources. Thus there is no strict boundary between "waste" and "resource". For most of the biogas production, the raw materials are derived from previous waste.

In a rural bioenergy system, all the above forms of resources can be found, for example, raw material, technology, financial capital, know-how, information, land and personal insight. But not all of them are strategically important to the organizational development. At the early stage of the development of rural bioenergy enterprise, resources are always limited. It is very rare that all the resource elements are ready in one system; nevertheless, new resources can be derived from other existing resources or from a strong network, during the system mobilization and evolution. In this thesis, the original resources at the problem identification stage are considered as “baseline resources”.

In the Heyong biogas system, the baseline resources can only refer to the limited financial capital, which is the budget for the construction of the breeding farm; the potential raw material; and the manager’s experiences and insight. During the development stage, the other surrounding resources are activated. The experiences and insight lead to the deeper information searching. Local technicians bring technology and know-how skills. The financial capital transfers to availability of technology and know-how. Local government approves the land for the breeding farm and biogas projects. After the villagers are involved, the external network and information expand, which provide more possible alternatives for the decision-making. At the same time, the baseline resources expand themselves when the breeding farm’s business starts to run, which means more available funds to be invested in biogas project, and more raw materials generated. The movement happens together with the decision-making processes in a circulate matter. The snow-balling resources bring the organization to an unexpected position, where the decision-maker is facing a wide range of alternatives to develop his biogas system, including the business plan.

The same processes are carried out in Liuminying biogas projects. As a village under collective economy system, the Liuminying has very limited baseline resources, which include raw material (the chicken manure from egg farm) and the experiences about biogas utilization. The key resources, such as financial capital and technology for centralized biogas projects, are not ready at the problem identification stage. A broad range of new actors are then involved and bring in the key resources. The bank provides loan, and international agency (UNEP) provides technology, villagers participate and invest in the necessary household equipments. After the first phase of old projects, the organizational resources are developed, in terms of an internal management team in the biogas station, and external networks based on the sound reputation the village gained from the former projects. The integration of new resources further support and formulate the possibilities for a commercial biogas plan.

The resource mobilization in the case of Shengchang Bioenergy Company works in a different way. The development of resources does not always follow the others, and continuously grows, but faces trade-offs at some points during the business operation. Capital and information are the two powerful baseline resource elements. During development, the financial capital later brings technology, know-how and other human capitals to the system. The information includes the experiences from international bioenergy industry, the interpretation of favourable nation policy of promoting renewable energy, and market estimation. The information gives the investors confidence and drives them to select bioenergy as the business field. However, the information does not always lead to improve the organization’s efficiency and effectiveness (Barney, 1991). The expected favourable policies do not bring direct positive impact on the bioenergy business; instead the non-satisfaction has been raised by the realized policy gaps. The original information has to be replaced by the new information that the organization has to search for. The more helpful resources are soon identified as human capital resources, such as know-how, human intelligence, consumers’ awareness, and organizational resources, such as a stronger external network. The limited baseline resources are therefore extensively consumed to pursue new resources.

Generally speaking, all types of resources are under development and transformation during the decision-making processes and actions. The rural bioenergy projects are mostly based on very limited baseline resources. The resource development can be achieved through a snowballing process with continuous increase, or a trade-off way in which original resources have to be replaced. The changes do not always lead to a positive way for the organization to carry out the strategic objectives. But the organization is able to search and acquire new resources by identifying the organization's situation, in order to broaden the decision alternatives. The sourcing is linked to the organization or decision-maker's unique background and historical position (Barney, 1991).

5.1.3 Networks

The networks of rural bioenergy business refer to all the relevant external relationship with other organizations, which can be local community, government, R&D sector, suppliers (equipment, infrastructure & raw materials), and media, etc. Small businesses are often advised to develop relationships with external organizations that have the potential to assist business development, survival, and growth, and have the vital external resources to move a small business toward increased success and profitability (Street & Cameron, 2007). The effects of networks on small-scale enterprises can be summarized as organization development (including access to resources and business plan development), competitiveness and competitive advantages (including creating the competitiveness awareness, increased economies of scale and scope, etc), and performance (including objective achievement such as sales and profitability and subjective terms such as increased innovation and added values) (Street & Cameron, 2007). In all the three case studies, these three effects have worked in the system through their key networks.

In the rural bioenergy projects, the limited baseline resources have to be enhanced through networks. Through the networks with local government and local technicians, Heyong biogas system acquired technology as a key resource and developed the business plan. Liuminying biogas projects got the access to finance, equipments, and social support through the networks with local government (Beijing Municipality), international agency and local community. Shengchang Bioenergy Company is able to access to the raw material resources based on the network with local farmers, and to develop the business plan by integrating contracted equipment manufacturers.

Through the expanding networks, the effect on competitiveness is also available. Based on the strong networks with local villagers in both Heyong and Liuminying cases, local dwellers fostered the awareness on using bioenergy and built up the trust on the biogas producers, which opens up local market. Because of the first movers' personal reputation and the close relationship in villages, the networks in these 2 cases are inherently formed, and therefore do not require high input. Shengchang Bioenergy Company also put efforts in building such type of relationship with local residents in order to increase the market competitiveness. However, as an internal investor, to acquire local network is a more resource-consuming process. The Company's solution is to participate in various exhibitions and provide subsidies to villagers with the own funds. All these actions take the internal resources and do always not achieve the expected results, since the internal resource can not support a long-term and intensive scheme.

The intrinsic competitiveness of the organization and the products is also essential, for example, the price, the quality and convenience of the services. The business plan of biogas projects can only be accepted by rural dwellers when the price is competitive compared to conventional energy, e.g. coal, electricity and LPG. Situation is the same for the bio-briquette market.

The performance is the most popular outcome of the small businesses (Street & Cameron, 2007). The networks enable the business operation on economies of scale; therefore an expected profitability can be generated. In the second phase of the Heyong biogas system, the original 100 households are going to be increased to 200. The new biogas project in Liuminying also provides service based on economy of scale, the biogas is going to serve around 1,700 households (Personal communication 3, 2008). Economic benefits from the commercial projects can be expected. At the same time, the value has been added into the entire value chain of the system, including the utilization of biogas slurry as up-grades fertilizers and the local ecological agriculture system. The business performance of Shengchang Bioenergy Company is mainly achieved through its network with the business partners. By joining the research capacity and sale network, Shengchang Bioenergy and its equipment manufacturer Lao Wan work together to develop the market for compact biomass fuels and the biomass stoves. Through this network, both Shengchang Bioenergy and Lao Wan are adding value to their businesses by introducing technology innovation. However, by using the contractor's sales network, the Company may loss the direct connection with consumers, which is again a traded off solution.

The development of networks can enlarge the rural enterprises' resource base, increase the competitiveness and at the end brings a higher possibility of success to the new bioenergy businesses. An expanding network enriches the possible alternatives for decision-makers, and pushes the enterprise emerging in the new business field. A basic premise to maintain and develop the networks is openness, which allows continuous feedback between the sub-processes inside the organization and continuous information exchange with external organizations (Martensson & Westerberg, 2007). It is based on the organizational ability to absorb and integrate all the available external resources.

5.1.4 Institutions

The institutions that affect the establishment of enterprises emerging in a new sector usually include the concepts of regulative, cognitive and normative institutions (Scott, 2001), which can be used to distinguish the effects of different institutions on the organization development. In a new sector, these institutions are embraced in different carriers: the *regulative institutions* refer to the laws, regulations and administrative guidelines that constitute the basic rules for the market transactions by directly providing incentives or indirectly providing socio-political legitimacy for organized action; *cognitive institutions* refer to the shared perceptions or social consensus of boundaries and viability of new activities deriving from local histories, morality judgement or cultural background; and *normative institutions* refer to "expert" sources of information about the nature of the new phenomenon, the values (what is important and good) and norms (how things should be done) (Sine *et al.*, 2005). The development of regulative, cognitive, and normative institutions legitimates new sectors and makes resources easier to acquire; in turn, these changes reduce perceived risks and increase entry rates (Sine *et al.*, 2005).

However, such institutional forces need to be differentiated in terms of the formal and informal status, or in terms of the implementation stages (Chiaburu, 2006). Generally speaking, in a new business sector, regulative institutions are usually undeveloped, limited in scope or subjective to debate; cognitive institutions are also largely absent from new sectors, and normative institutions take time to develop (Sine *et al.*, 2005). The empirical data shows this is partly true in Chinese rural bioenergy sector. As regulative institutions, although there are laws like <Renewable Energy> to ensure the legitimacy of new bioenergy enterprises, the implementation of the law at ground level has various limitations. The favourable policies do not cover all types of biomass energies and the industrial standards are generally missing. At village level, the information channels of new policies and regulations are not always open, the delivery of regulative institutions can be delayed, and so the supportive schemes do not work directly on rural bioenergy entrepreneurs due to lack of updated information.

There is a social consensus that bioenergy projects like biogas and bio-briquette are good for the society and environment, but the normative institution regarding to how to develop bioenergy industry is not clear. However, in a rather small system in rural China, some of the institutional elements can be strong when the local history and culture identity are taken into consideration. In Liuminying village for example, after almost 20 years' implementation of the old biogas project, there is a clear cognitive institutions that local community perceives biogas production as promising activity.

One institution force can have different effects on different business organizations, given their specific attributes. In terms of reducing sector-wide risks for new businesses, for example by constituting sectoral standards or providing incentives, the institutions tend to have stronger impact on entrepreneurs who seek innovative technologies, than on those who seek for established technologies, because for the entrepreneurs turning to mature technology, the probability to act is already high (Sine *et al.*, 2005). This explains the different degrees of demand on the supportive policy in the 3 case studies. In the Heyong and Liuminying cases, the biogas projects were launched without information on relevant policies, for example the biogas subsidies. For the decision-makers in these two cases, no matter there is subsidies or not, the biogas projects were going to be established, because there were other motivations and strong resources in the system. In Shengchang case, the investment decision was highly guided by policy environment. The existing or expected supportive policies have great impact on the investor's confidence and actions. After the business was established, entrepreneurs are still in great demand on the favorable policies to lower the business risks. One of the reasons is that the technology of biomass densification used in Shengchang Bioenergy is more innovative and less stable than anaerobic digestion technology used in biogas projects. Therefore both the establishment and the development of the Company rely more on the institutions.

5.1.5 Impacts of factors

The former factors work as a system to support the decision-making on the establishment of new bioenergy business. In the development sub-process the factors activate each other, develop themselves, transform into or replace each other in a mobile way. Generally speaking, the resources in rural bioenergy sector is still very limited, therefore networks play vital role for system development. A strong local network helps to activate actors, integrate resources and gain supportive institutions. Local networks are naturally strong in most rural areas of China, in the forms of close neighbourhood relationship, familiarity between village committee and villagers, recognition of local expertises and entrepreneurs. Fully using the local network seems to be critical for the successful establishment of rural bioenergy business. Although external investment can bring modern management skills and stronger resources, thus reduce the time to incubate the bioenergy business plan. When the local network is weak, the further-on development of the enterprise may have to bear higher cost. Investors may have to pour in internal resources and energy to build up a local network for the business development, in terms of raw material acquisition, local consumers' awareness on bioenergy, the sales channel, and local government's institutional supports.

5.2 Development mechanisms

In the situations where decision-making processes are involved, there are options to choose between, and human beings choose in a careful way, but as goal-directed activities (Hansson, 2005). Therefore, decision theory is concerned with *goal-directed behavior in the presence of options* (Hansson, 2005). The decision to establish rural bioenergy is also led by various goals. The decision-makers are considered "administrative man" to select solutions under various limitations and constrains. The decision-making processes are generally simplified and oriented to select the most possible and most satisfying alternatives (Simon, 1976). Based on this decision theory, thee development mechanisms are conceptualized from the case studies with the orientations, which are respectively to solve environmental problem, social-welfare issue, and business development. The three conceptualized development mechanisms hence bring the system different consequent out-comes during evolutions.

5.2.1 Environmental oriented development route

Problem identification

In the environment-oriented development mechanism of a bioenergy business, the key problem is identified as environmental-related issues by the decision-maker. The identification of environmental problems is based on the detection of environmental impacts or potential impacts of organizations' activities. And the evaluation of the impacts depends on the decision-maker's perspectives and value judgement at the very beginning stage. When the external and internal factors are taken into account, the problems can be specified with a further diagnose and a range of solutions may be listed.

In Heyong biogas case, the key problem that the livestock breeding company had to face was identified as pollution from the pig manure. Although at the problem identification stage there could be various important problems to be solved for a livestock breeding company, for example, the livestock market, investment input, etc., the potential negative environmental impacts was understood as the biggest risk for the company's future business.

The cognition of this problem is not based on sufficient external information. The decision-maker had limited information and knowledge about regulation by the time the decision-making started. It is more based on his value/ conceptual judgement, including his own experiences on breeding industry, his basic understanding of ecosystem, his personal emotion on agriculture land and morality responsibility to local community. The local networks and reputation of the company is considered significantly important, which may be destroyed by the environmental pollution from his breeding company's activities. After a further diagnosis, the potential environmental problem has been put in high priority, and considered as the key problem with high risks, which requires immediate solutions.

Development of decisions

There are various options to solve the waste pollution problem for a company. However, in the context of rural China, local waste treatment facilities are usually not available technically or economically. As an "administrative rational man", the decision-maker's alternatives are limited. The information searching starts from local background and integrate with available internal resources. The existing household biogas and the decision-maker's experiences make biogas production one of the potential choices. Apparently, the initial resources are limited, i.e. construction budget. The influence of resource limitation on decision-making processes and actions was described as "we see what we have, to decide how big scale our project should be." (Personal communication 1, 2008).

At the decision-making development stage, building anaerobic digesters to treat the waste and produce biogas was finally proposed as the ideal solution. During this process, more actors are involved and thus bring respective resources. The local networks helped to develop the organization's capacity, local technicians and local government showed interests in the company's idea, the concept of a centralized biogas supply was accepted by local people. The operation scale of the biogas projects got upgraded from internal use only to 100 households in the village. And the biogas slurry and liquor are treated and provided as up-graded fertilizer for local agricultural production. The biogas project therefore added value to entire local production and consumption chain.

Re-diagnosis and strategy selection

Since the project expanded, the maintenance of the existing biogas system is further identified as a new core issue. In order to maintain the biogas system, and continuously supply the biogas in an efficient way, the company was facing another round of decision-making for the future operation of the established biogas system. As an entrepreneur, the decision-maker's business perspective naturally leads to a market-based plan to maintain the biogas system sustainably. The solution is viewed by the entrepreneur as "necessary" and a win-win strategy which both insures the long-term operation of the biogas facilities and brings benefits to local community.

The design of the blue print was based on the expanded networks also. Local officials from rural energy station provided expertise to analyse the feasibility and risk, and even the project specifications and price level. At the same time, local officials also play important role to promote a better communication with higher level authority and the village residents, regarding to the new project.

However, there is another potential risk regarding to system stability. Although the entrepreneur has made commitment to guarantee long-term, stable biogas supply to local community, there are still unpredictable situations like extreme weather (extremely low temperature), or changeable land policies. The solution is to continuously seek for technical improvement, and to enhance the institutional stability and integration from government's policies.

The evolution of system out-come

The environment-oriented development of biogas business starts with the main target to solve the environmental problem, and therefore is considered waste treatment project more than energy production at the beginning. Based on the resource integration and network expanding, once the biogas project is well established and maintained, it is possible to bring the economic and social benefits, and better environmental results than what's expected.

According the feasible business plan, the price of charging biogas is lower than other type of conventional energy, therefore it saves the energy expenses for average rural households. On another hand, it covers the maintenance cost and brings extra income for Heyong Company. Both the biogas producer and the village community can gain direct economic benefits. The indirect economic benefits include the energy cost for the pig breeding farm itself and farmers' fertilizer expense. The environmental benefits go beyond the original target as the projects developed. Apart from waste treatment and agriculture protection, energy security and carbon emission mitigation are also achieved in village scale, although these extra benefits were not perceived by most villagers and even the company owner. The project also releases local farmers from the intensive fertilizing work, since the fertilizer is piped into the field directly. Together with job creation, it contributes as social benefits for the local system. The company therefore gained a sound local reputation, and improved the relationship with local government.

5.2.2 Social welfare oriented development route

Problem identification

A social welfare oriented development model places the social benefits as high priority for a business strategy, which aims to improve certain group of people' well-beings by providing products or services.

Liuminying biogas case represents this business philosophy and follows the social oriented development dynamic. Although both Heyong and Liuminying cases lead to the biogas production, the main difference between those two is that the manure from the egg farm has already been utilized as resource, with original value. Before biogas station established, the chicken manure was sold out as fertilizer. The environmental impact from the chicken farm was therefore not the main problem for the village. The local household biogas was started in 1980s. There is a social consensus that biogas in Liuminying village is affordable and convenient cooking energy. In order to continuously provide affordable and convenient energy to households and to better maintain the biogas system is therefore identified as the core target.

Development of decisions

The village committee as one of the primary movers played critical role to push the development and implementation of the plan. Based on the joint interests from the village committee, local government and international agency, the plan was finalized as a centralized biogas project, under the management of village committee. The Liuminying biogas station was therefore established and run as a Township and Village Enterprise. Instead of charging the price of biogas based on purely economic consideration, for example cost-benefit analysis, the Committee decided to charge based on villagers' affordability, as the main orientation of this project was defined as to improve local villagers' welfare.

Although it is a combination of local government's initiative and market force, the biogas station as a TVE is probably under an overly strong administrative control. The social benefits have been achieved based on the fact that villagers in Liuminying have used the cheap and stable biogas during more than a decade. However, the high economic cost behind has been pointed out by the manager in biogas station. If the situation kept going on in the same way, the old biogas project may face another crisis in terms of economic performance.

Re-diagnosis and strategy selection

Poor economic performance from the old biogas projects has been a main concern internally. However, it brings another valuable asset for the village. Successful operation of centralized biogas station in the sense of social welfare improvement has brought in the village external recognition. When the higher level government - Beijing Municipality - wanted to promote regional renewable energy, Liuminying mode was referred to. Under the principle to develop modern rural community, the interest of Beijing Municipality is to extend the social welfare to a larger scale. It is up to Liuminying village to develop a new strategy to balance the internal and external interests.

The satisfactory solution is finalized as to invest in new projects with enlarged productivity, and to raise the price to an economic feasible level. With the investment support from local government, the establishment of new project has been carried out, together with a detailed business plan, covering the cost-benefit analysis, management board proposal, and reform of corporate accounting system. The establishment of new project should no longer be viewed as the adjustment of the original biogas TVE, but a process to form a new energy company with independent legal status. The uncertainty comes from price setting. According to the preparatory cost-benefit analysis, the price of biogas can be controlled at competitive level compared to other energy types, e.g. natural gas and coal. By doing so, the biogas project can save the total expense of household energy consumption. However, the decision-makers are waiting for more feedbacks from price control office and the villagers.

The evolution of system out-come

The orientation of Liuminying biogas projects is to improve local social-welfare. During almost 20 years' implementation of the old biogas projects, this target has been achieved. The villagers have been using the clean cooking energy with price lower than any commercial energy on the market. However, the maintenance of the project is based on constant financial feed-in. The direct economic performance is negative.

Whereas, from the village point of view, the economic performance of the old project is not always negative. There is a smart point of the value-chain evolution. The implementation of the biogas project has been internalized as the village's cultural identity, and so brought social recognition of the village's "ecological" reputation. The village has therefore gained indirect economic benefits from ecological village tourism and a biogas-based local production chain linking organic agriculture, breeding farms and food processing.

The possibility to extend its biogas network is also based on such a social reputation. The new business plan is intended to bring benefits covering social, economic, and environmental aspects.

However, by the research time, in terms of value creation the project has not achieved optimal situation yet. In this system, value can be added by using the resources in a more sophisticated way. The manure from chicken farm was considered as basic fertilizer. Because of the high acidity, the manure fertilizer is low-level, with limited application. Local biogas manager has strong awareness and expectation to use the biogas slurry and liquor as up-graded fertilizer. However, due to the lack of expertise on using biogas fertilizer appropriately, the biogas fertilizer has not been widely accepted by farmers yet, thus has high risk to cause secondary-pollution in the area. To address this problem, the external supports are needed. The village is therefore seeking the attentions and support from local Municipality and research agencies, however, lack of network in this level is a biggest barrier.

5.2.3 Entrepreneurial oriented development route

Problem identification

Entrepreneurial orientation is defined by Morris and Paul (1987), when a company's top management tends to undertake calculated risks, as being engaged in technology innovation and to demonstrate proactiviness. Therefore, an entrepreneurial orientation provide a basis for the adaptive strategy making, which emphasizes careful but quick analysis of issues and tailor their actions to the turbulent environment (Miller, 1983).

Based on the institutional information, including favourable policies and social concern on renewable energies, the Company's mission of Shengchang Bioenergy is identified as "to promote the development of bioenergy industry"; and the development goal is set up as "to be the leading enterprise in the emerging Chinese rural biomass fuel industry" (Personal communication 5, 2008). The ambitious commitment shows the investors intended to operate the company based on entrepreneurial orientation from the beginning, and then the scope of the venture's choices has been narrowed down into bioenergy field. Because the risk, the technology innovation and proactivness of bioenergy industry are all in high level, the strategy to take rural bioenergy business is considered highly "entrepreneurial".

In the developed and mature market, high entrepreneurial orientation is likely to positively enhance the company's performance; however, given the Chinese context where both the internal organizational structures and institutional environment are significantly different from those in other mature economies, a company with high entrepreneurial orientation may not obtain a competitive advantage (Tang *et al.*, 2008).

Decision development and strategy selection

The Company's entrepreneurial characters all involve making large resource commitments to risky projects, untried technologies, new products or services to the market (Tang *et al.*, 2008). To prepare the business launch, Shengchang Bioenergy invested in the biomass fuel densification equipments research, product specification studies, raw material and market survey. Only with access to financial resources can entrepreneurial company build competitive capabilities and compete with their high-quality and innovative products and services (Tang *et al.*, 2008). The initial support was from the venture capital. At the same time, the company was expecting the favourable policy schemes to provide financial incentives to further enhance the company's competitiveness.

The risk from institutional environment is also taken into consideration by the company, based on the fact that the central government still controls resource, financing, and material distribution, investment size, industry structure, bank loans, business formation, and so on (Tang *et al.*, 2008). However, in transition economies, the institutional environments need to be differentiated in terms of their formal and informal rules, or in terms of the espoused rules and rules in use (Chiaburu, 2006). The favourable policy schemes can be predictable for many enterprises, but the time of enforcement may be delayed, which places the enterprises into a predicament.

On the other hand, the Company realized that networks are critical to the company's survival and success. There are two sets of networks that the Company has to cultivate: professional networks with suppliers, major clients, or customers, and political networking with governmental officials and regulators, given the extensive involvement of the government (Tang *et al.*, 2008). However, the cultivation of networks is very resource-consuming for the Company supported by external venture capital without the naturally ready local network. In order to raise the local villagers' acceptance level of using compact biofuels, the Company has to develop its own incentive schemes, which actually goes beyond a company's capability. One significant acquired network is with its equipment contractor, by sharing the technology and sales channel. However, this strategy makes the Company go different direction from the target, by providing service to more urban consumers than local rural residents.

The high entrepreneurial orientation also requires high quality human capital in order to respond to the emerging and changing environment. However, due to the lack of know-how and experiences in sectoral level, the internal human capital of the Company is inadequate. Therefore, the highly entrepreneurial projects are not adequately defended and protected, and so resulting in deficient performance (Tang *et al.*, 2008).

The evolution of system out-come

The entrepreneurial orientation is aimed to achieve economic profitability, environmental contribution and social recognition by running "good business". The Shengchang Bioenergy hence relied on external venture capital, started the resource-consuming organizational development. During the system evolution, the undeveloped institutional framework, the lack of local network and inadequate internal human capital make this goal mission impossible.

The targets therefore have to be traded off. Given all the barriers and unexpected risks, the Company is forced to choose survival strategy and to keep a waiting position for the future development opportunities. The social and environmental benefits are partly achieved but the effects have been diminished. The Company's activities raised local villagers' environmental awareness, solve the air pollution problem caused by burning agriculture residues, provide job opportunities, promote the innovative technologies (i.e. densification equipments and bioenergy stoves), and push the entire industry's innovative level. But raw material collection is now competing with fodder industry, which means the compact biomass fuel industry is taking resources from other industries. Moreover, due to the price issue, the products are now serving more urban residents than rural residents, which shifts local resource out of the system and so could not contribute much to the rural renewable energy development. While there are also positive regional economic performances, e.g. bringing extra income to local farmers and adding value to the agricultural residues. However, the effects have been weakened due to the deficient performance of the Company, in the forms of shrinking operation scales and increasing risks and tension.

5.3 System Enabling

5.3.1 Supportive schemes

The policies and relevant regulations and administrative guidelines as the regulative institutions constitute the basic rules for the market transactions by directly providing incentives or indirectly providing socio-political legitimacy for organized actions (Sine *et al.*, 2005). Different levels of policies can have different influences on the ground-level business activities.

To foster Chinese rural bioenergy industry, the central government has issued a series of policies, in the forms of law, national plans, and sectoral guidelines. The *Renewable Energy Law* valid from January 1, 2006 gave the bioenergy production activities a formal legitimacy.

The overall targets stated in *Mid- and Long term Development Programme on Renewable Energy* are: (a) to increase the proportion of renewable energy in total energy consumption; (b) to cover electrification in remote areas and to solve rural domestic fuel shortage. (c) to promote energy utilization from organic waste; and (d) to boost industrial development of renewable energy technologies. The programme set up general targets for renewable energy, which is aiming at 10% of renewable energy in total energy consumption by 2010, and 15% by 2020. There are also specific targets for biogas and compact biomass fuel. For biogas, it is targeted to reach production of 19 billion m^3 biogas by 2010, 44 billion m^3 by 2020; compared with the baseline of 7 billion m^3 in 2005; for compact biomass fuel, it is targeted to produce 1 million tons by 2010, and 50 million tons by 2020 (NDRC, 2007a).

The follow-up *11th Five Year Plan for Renewable Energy Development* specifies the near-term development targets of renewable energy in China. It also proposed implementations approaches by enhancing R&D of innovative technologies, carrying out subsidies and favourable taxation schemes (for biomass power, liquefied biofuels, and compact biomass fuels), constituting technical standards and application guidelines (for liquefied biofuels), and monitoring the biogas plant facilities in industries with high pollution risks (NDRC, 2007d).

These national policies can have direct impact on the fostering of rural bioenergy market. The favourable policy environment increases the private sector's investment confidence by providing expectable institutional supports. However, there is difference between the approved national polices and the policies implemented on ground-level. The delayed of actual implementation is possible under Chinese administrative system. The local government has the space to interpret the policy according to local conditions. Therefore, the private enterprises are still facing institutional risks. And the entrepreneurs who adopt the more innovative technologies are likely to bear higher risks from unpredictable policies (Tang *et al.*, 2008). Therefore, the stability and consistence of national policies are particular important to bioenergy entrepreneurs using more innovative technologies, including compact biomass fuel producers and liquefied biofuels.

The international influences come in different forms, which can be policy, for example, climate change policies, which put pressure on the Chinese government to adopt corresponding domestic policies; or actions, for example, an international aid project, (e.g. Liuminying biogas aid project) which raise the local people's awareness and the government's attention, and therefore attract the following investment and build up market capacity. At the ground level, the initiation from international private sectors can also stimulate the Chinese domestic bioenergy market. In Shengchang case, the international industries' actions and performance contribute as one of the motivations for the investors to initiate bioenergy business. However, the international information and aids cannot always reach all of Chinese rural areas due to the long information channel in between; in some instance the local system can be established without international actors.

5.3.2 Institutional barriers

Although the policies and other institutional environments for the Chinese bioenergy industry have been continuously improved, there are still policy gaps that hamper the bioenergy industry's development. According to NDRC (2007a), these policy barriers are analyzed as:

> "(1) The incentive schemes and policies are not intensive enough. Under current technology level and policy context, apart from hydro-power and solar water heater have the market competitiveness, most of the other renewable energies are lack of competitiveness due to the industrial attributes of high R&D cost, scattered distribution of raw materials, small scale and discontinuous production; therefore, the supportive policies and incentive schemes are needed. Currently, the national supportive policy system is not integrated; the intensity of economic incentive is low; the coordination of different policies is deficient; and the policy stability is weak. There is no long term mechanism to support the sustainable development of renewable energies.
>
> (2) The market safeguard mechanism is unperfected. For a long period, it has been lack of tangible development target of renewable energy in China; there is no stable and consistent market demand (on renewable energies). Although the country has enhanced the supportive schemes for renewable energy development gradually, the compulsory market safeguard policies have not yet been established, the consistent market demand is missing, the development of renewable energies is lack of consistent market forces to drive, due to these reasons, the development of renewable technologies is still slow.
>
> (3) The technology R&D capacity is weak and industrial system is loose. Apart from hydro-power, solar water heater and biogas (from anaerobic digesters), other renewable energy technologies are low-level, lack of R&D capacity. The equipment manufacturing capability is weak, most technologies and equipments rely on import, and there is a large gap between domestic technologies and the international advanced ones. Meanwhile, the industrial (supportive) system in terms of renewable resource assessment, technical standards, product inspection and certification is unperfected. The education system can not fulfil the requirement of a fast-growing market, therefore the development of renewable energy industry is lack of expertises and technical service system."

This statement is pointed out at the *Mid- and Long term National Plan on Renewable Energy*, which shows the central government's strong awareness of the policy gaps at macro-level, and shows the commitment to eliminate the gaps. The empirical studies from this research also find out some points which can either interpret the central government's statements, or supplement the above points.

(1) The "coordination of different policies" is definitely crucial for the rural bioenergy industry to grow. The implication of "policy coordination" has to be expanded from inner-sector to inter-sectors. The policy-making should no longer be sector-specific with a single focus on energy, but with systematic insights taking into account of other relevant fields. The possible relevant policies include <u>land planning</u> (which is essential to provide a stable long-term guarantee for private sector), <u>rural financial system reform</u> (which will allow rural private sectors to access to external financial support), <u>rural</u>

urbanization (which shapes the future development of the existing rural bioenergy projects), and other relevant development strategies.

(2) Currently, the market is in the cultivation stage, and the entrepreneurships of rural bioenergy are mixed with different legal forms or without an independent legitimacy, but affiliated to another business organization, e.g. a livestock breeding farm. The organizations are usually delicate. A strong market safeguard mechanism can help to create new markets for renewable energies. For example, the emission reduction regulations from central government may stimulate more power companies to shift from using coal to biomass. However, for most of the local initiatives in rural China, it is equally important to leave enough space for free market to work. Local residents may require a transition time to shift from conventional energy to renewable energy. And a local mechanism is often based on negotiation and voluntary participation. Government interference should not clamp down these initiatives. In paralleled with the market safeguard mechanism is the education schemes to raise public's environmental awareness, and to cultivate market demand.

(3) Together with the government subsidies and other financial supportive schemes, it is important to guide rural entrepreneurs to explore more external financing channels, and provide the access to the latest external financial schemes. The possibilities include the CDM scheme, voluntary carbon market, and domestic rural credit banking system. Education and training programmes are needed to up-date and broaden the rural entrepreneurs' knowledge and visions.

(4) The narrow communication and information channel can be one of the barriers that hampered the R&D development. There are various research institutes, universities and private companies are carrying out the research activities in a relevantly close system. When pouring in numerous research projects and funds, the government can play the role in integrating all these research forces and enhance the communication. At the same time, the popularization of mature technologies and know-how also requires a sound information channel. The access to information and new technologies has been one of major concerns for rural bioenergy entrepreneurs.

The complexity of bioenergy policies is high because of the divers technologies and various applications. The policy-makers may have to bear in mind that the policy impacts on bioenergy businesses with various technology levels are different. Those industries with more innovative level can be influenced more than those using relatively mature technologies. Therefore, the innovative bioenergy technologies may need more direct supportive schemes, e.g. subsidies, R&D support, taxation, etc.; while the established business with mature technology may require more indirect supports, e.g. educational system for relevant expertises, flexible sourcing system, and open communication platforms.

6 Conclusion

This research concentrates on bioenergy development in rural China, specifically the individual bioenergy entrepreneur's innovative abilities and also the organization's entrepreneurial activities. The purpose of this work is to evaluate the key factors for the rural bioenergy industry, and to reveal the emergence and evolution of rural bioenergy business in China. Decision-making and entrepreneurial theories are applied, along with a 4-factor analytical framework including *actors*, *resources*, *networks* and *institutions*, which provides systematic insights and comprehensive answers to the research questions. Based on the empirical case studies and analysis, this chapter synthesizes the key findings and provides author's insights on key issues.

The development of rural bioenergy business is highly motivated by primary movers' ambitions and personal value judgment. The individual's innovation from the ground level contributes greatly to the bioenergy system establishment. The primary movers have various backgrounds, which can be a local private entrepreneur, local village committee, an external venture company, or a group of joint forces. But all of the primary movers have common attributes in that they have experiences in the relevant fields and are able to perform innovatively to identify their own business opportunities and development paths in a turbulent environment. The primary movers can be categorized as internal forces, who are members of the system (village communities), e.g. local rural entrepreneur, and external forces, who are not originally affiliated to the system, e.g. external venture capital, external power company, etc.

The empirical evidence shows that **in the context of rural China, the businesses initiated by internal primary actors are more likely to gain better performance than those initiated by external forces.** The reasons are based on the facts that internal primary actors are likely to control their own raw material resources, possess more experience regarding local natural and socio-economic situations, and most importantly, have strong naturally formed local networks. To gain all this advantages, the external primary actors have to commit continuous and strong resources. The processes are often too resource consuming for the external primary actors to bear, it therefore leads to inadequate performance and missing original targets. While, A joint group with both external supporters and internal initiators as a primary mover can gain high performance by integrating the advantages of both sides, as long as the organization formed can avoid bureaucracy, and the leading role of internal actors can be guaranteed.

This research shows that **local networks play critical roles in the development of rural bioenergy business.** The baseline resource for a rural bioenergy business, no matter if it is an internally initiated biogas project or an externally supported compact biomass fuel company, is always limited. Local networks can activate relevant actors, mobilize necessary resources and bring in the supportive institutional schemes. The resources are generally limited in rural China in terms of monetary capital, technologies, know-how, information, etc., therefore the naturally ready network in rural China is one of the most important advantages that rural bioenergy entrepreneurship can rely on. This naturally ready network is rooted in the inherent close social relationship in villages, which can be acquired without resource input, and so becomes the most important competitiveness for innovative individuals and local market force to develop a business feasible strategy. Without such an inherent network, the efforts to build up new networks can be too resource-intensive for the new industry to take.

The development mechanisms of bioenergy entrepreneurships can be conceptualized as environmental oriented, social welfare oriented and entrepreneurial oriented development routes, based on the key decision-makers' business orientations. The 3 development mechanisms show that in a rural Chinese context, bioenergy business can be established even without being originally set up as a commercial project. The environmental oriented and social welfare oriented biogas projects are intended to address environmental pollution and to achieve social welfare improvement. Along with the further decision-making processes, the projects turn up commercial solutions based on integrated resources and expanded networks. The system outcome is possible to achieve the original goals and add extra value in terms of environmental, social and economic benefits. However, these two development routes require a long-term development stage, in which continuous financial inputs are engaged. The entrepreneurial oriented development route starts with a sufficient business plan through risk taking, technology innovation and proactiveness. This highly resource-consuming modern business mode can have high performance in a matured market (Miller, 1983). While given the undeveloped institutions in rural China, high cost in enterprise preparatory stage and limited internal human capital, the high entrepreneurial oriented mode does not bring strong competitiveness to the enterprise, but instead places the enterprise in a predicament, and so it is difficult to achieve the original targets.

To enable the establishment of bioenergy systems and to exploit the market potentials, the institutional enhancement should cover not only supportive policies but a more comprehensive institutional improvement, including education & training programmes, information access and knowledge sharing. At the macro-level, the Chinese Central Government has made strong commitments to support the industrial utilization of biomass energies, and sustainable rural energy has been put as one of the priorities. The policy improvement emphasis has been identified as policy stability and coordination; market safeguard enforcement; and R&D capacity building. Due to the complexity of bioenergy industries, the supportive policy schemes are recommended to be differential according to the technology innovation level and the market maturity.

Finally, from a broader perspective, this research also gains further implications when linking with the general Chinese context:

- The industrial utilization and commercialization of bioenergy is possible at the village level, and the potential can be enormous, given the fact more than 56% of the population in China are rural residents (NBSC, 2007c). Although the mainstream of commercial development of bioenergy in China is focused on large-scale industries with considerable input and output, the small and medium scale enterprises are also meaningful enough to gain more attention.

- The value creation of the new bioenergy projects is one of the main concerns in this research, when the system outcome is evaluated. A successful bioenergy project should bring added value to the system compared to the primary utilization of rural resources. In order to contribute for rural development and reduce the gap between rich and poor, local villagers have to be involved in the forms of employment, economic benefit sharing and upgraded product consumption.

- Since the urbanization process is occurring quickly in China, the current rural bioenergy enterprises can have deeper impacts to shape the future urban bioenergy industry development, by cultivating the bioenergy market, providing operational experiences, or continuously serving new urban residents.

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Abbreviations

Terms:

BGPG	Biomass Gasification and Power Generation
CDM	Clean Development Mechanism
DN	Diametre Nominel
DGs	Millennium Development Goals
IEA	International Energy Agency
LPG	Liquefied Petroleum Gas
MSW	Municipal Solid Waste
NDRC	National Development and Reform Commission
OECD	Organization of Economic Co-operation and Development
PVC	Polyvinyl Chloride
R&D	Research and Development
TVE	Township and Village Enterprise
UNEP	United Nations Environment Programme

Units:

Ha	Hectare
kWh	Kilowatt hour
MW	Megawatt
PJ	Petajoule
sqkm	Square kilometre
Yuan (CNY)	Chinese currency, 1 Yuan ≈ 0.1 EURO

Appendix I List of interviewees

Name	Interview time	Title	Category
Wang, Heyong	2008, February 20	Owner of Heyong Breeding Company	Industry
Li,Chunhai	2008, March 15; 2008, March 29	Head of biogas station of Liuminying Village	Industry
Liu, Yongtao	2008, March 15	Plant Manager of Shengchang Bioenergy Ltd. Co.	Industry
Fan, Fengming	2008, March 18; 2008, March 30	General Manager of Shengchang Bioenergy Ltd. Co.	Industry
Anonymous	2008, March 16	Sales department of Laowan biomass stove	Industry
Cai, Zhihua	2008, January 15	Staff of Energy Conservation and Emission Reduction Office, (NDRC)	Government
Ma, Huiling	2008, February 2	Staff of Renewable Energy Office, NDRC	Government
Li, Junfeng	2008, February 3	Vice president of Energy Research Institute, NDRC	Government
Lin, Zhonghua	2008, February 17	Head of Rural Energy Station, Agricultural Bureau of Licheng District, Putian County	Government
Zhu, Dongying	2008, February 17	Assistant and administrative staff of Licheng Rural Energy Station	Government
Xiao, Mingsong	2008, February 1	Senior Engineer of Chinese Academy of Agriculture Engineering	Researchers and experts
Guo Xianzhang	2008, March 8	Engineer of Chinese Academy of Agriculture Engineering	Researchers and experts
Deng, Liangwei	2008, March 28	Senior Engineer of Biogas Institute of Ministry of Agriculture, China	Researchers and experts
Wang, Gehua	2008, March 7	Professor & Department Dean of Energy and Technology Research, Tsinghua University	Researchers and experts

Hou, Yuanzhao	2008, January 21	Professor of Chinese Academy of Forestry	(cont.)
Liu, Ning	2008, January 21	PhD student of Chinese Academy of Forestry	Researchers and experts
Local resident 1,2,3,4	2008, February 14-20	Random household visiting. Putian County	
Local resident 5	2008, March 15	Random household visiting. Liuminying Village.	Local residents
Local resident 6	2008, March 15	Random household visiting. Lixian	

Appendix II Sample of interview questionnaires

For enterprises:

Q: What is the general situation of this company/project?

Q: Where are the raw material sources? How to collect?

Q: How is your raw material supply situation now? Is the raw material supply enough to support your future business plan?

Q: How is the production situation now?

Q: What's the most difficult part for business operation?

Q: What are the main costs for the company?

Q: how do you develop your technology?

Q: Who are the main consumers?

Q: What's the feedback from consumers?

Q: Do you have any market promotion approach?

Q: What do the Government's policies mean to you? Do you get any favourable support from government?

Q: What could be the future development possibilities?

For government:

Q: How is the situation of bioenergy industry in China? What are the roles of companies, rural residents and government?

Q: What are the relevant national policies towards bioenergy development?

Q: What are the main goals for central government to develop Bioenergy?

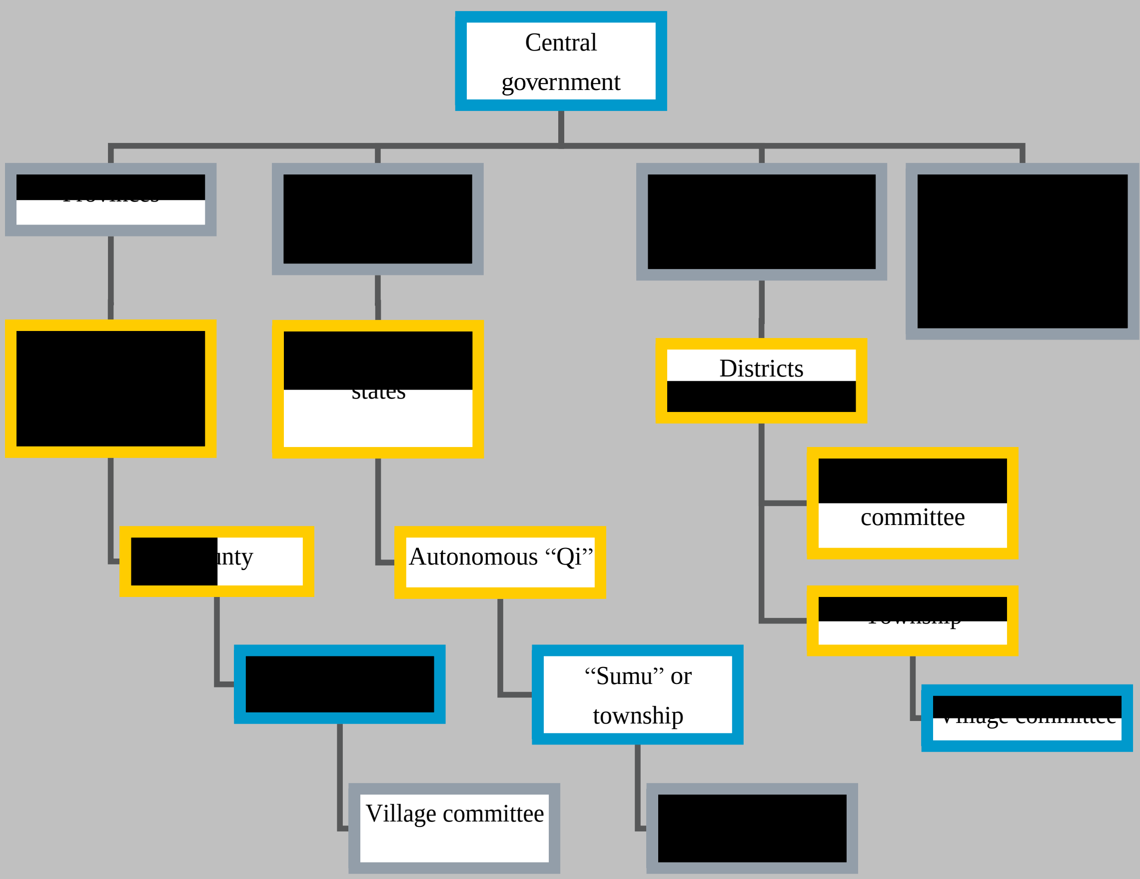
Q: Is there any policy focus among different types of bioenergy?

Q: How is the project approval process? How does Central government coordinate with local government?

Q: What types of information is the policy-making based on?

Appendix III The administrative organizations in China

The administrative organizations in China



The smallest unit is the village, with the administrative unit "Village committee". It is not a formal government organization, but with local administrative functions. Above the village community is the township, which is the lowest level of formal official organs. A township can have dozens of villages. In some areas, Townships are replaced by Districts. The level above townships is the county, which interprets and implements the policies directly. A county may include rural and urban settlements. Above the county is the Municipality (non-autonomy), followed by the province.

Appendix IV The Renewable Energy Law (key chapters)

Authorized Release: The Renewable Energy Law
The People's Republic of China (Full Text)

Table of Contents

Chapter 1. General

Article 1—In order to promote the development and utilization of renewable energy, improve the energy structure, diversify energy supplies, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society, this Law is hereby prepared.

Article 2—Renewable energy in this law refers to non-fossil energy of wind energy, solar energy, water energy, biomass energy, geothermal energy, and ocean energy, etc.

Application of this Law in hydropower shall be regulated by energy authorities of the State Council and approved by the State Council.

This Law does not apply to the direct burning of straw, firewood and dejecta, etc. on low-efficiency stove.

Article 3—This Law applies to territory and other sea area of the People's Republic of China.

Article 4—The Government lists the development of utilization of renewable energy as the preferential area for energy development and promotes the construction and development of the renewable energy market by establishing total volume for the development of renewable energy and taking corresponding measures.

The Government encourages economic entities of all ownerships to participate in the development and utilization of renewable energy and protects legal rights and interests of the developers and users of renewable energy on the basis of law.

Article 5—Energy authorities of the State Council implement management for the development and utilization of renewable energy at the national level. Relevant departments of the State Council are responsible for the management of relevant development and utilization of renewable energy within their authorities.

Energy authorities of local people's governments above the county level are responsible for the management of the development and utilization of renewable energy within their own jurisdiction. Relevant departments of local people's governments above the county level are responsible for the management of relevant development and utilization of renewable energy within their authorities.

Chapter 4 Promotion and Application.

Article 13—The Government encourages and supports various types of grid-connected renewable power generation.

For the construction of renewable energy power generation projects, administrative permits shall be obtained or filing shall be made in accordance with the law and regulations of the State Council.

In the construction of renewable power generation projects, if there is more than one applicant for project license, the licensee shall be determined through a tender.

Article 14—Grid enterprises shall enter into grid connection agreement with renewable power generation enterprises that have legally obtained administrative license or for which filing has been made, and buy the grid-connected power produced with renewable energy within the coverage of their power grid, and provide grid-connection service for the generation of power with renewable energy.

Article 15—The Government supports the construction of independent renewable power systems in areas not covered by the power grid to provide power service for local production and living.

Article 16—The Government encourages clean and efficient development and utilization of biological fuel and encourages the development of energy crops.

If the gas and heat produced with biological resources conform to urban fuel gas pipeline networks and heat pipeline networks, enterprises operating gas pipeline networks and heat pipeline networks shall accept them into the networks.

The Government encourages the production and utilization of biological liquid fuel. Gas-selling enterprises shall, on the basis of the regulations of energy authorities of the State Council or people's government at the provincial level, include biological liquid fuel conforming to the national standard into its fuel-selling system.

Article 17—The Government encourages workplaces and individuals in the installation and use of solar energy utilization systems of solar energy water-heating system, solar energy heating and cooling system and solar photovoltaic system, etc.

Construction authorities of the State Council shall cooperate with relevant authorities of the State Council in establishing technical economic policies and technical standards with regard to the combination of solar energy utilization system and construction.

Real estate development enterprises shall, on the basis of the technical standards in the previous paragraph, provide necessary conditions for the utilization of solar energy in the design and construction of buildings.

For buildings already built, residents may, on the condition that its quality and safety is not affected, install solar energy utilization system that conform to technical standards and product standards, unless agreement has been otherwise reached between relevant parties.

Article 18—The Government encourages and supports the development and utilization of renewable energy in rural areas.

Energy authorities of local people's governments above the county level shall, on the basis of local economic and social development, ecological protection and health need, etc., prepare renewable energy development plan for the rural area and promote biomass energy like the marsh gas, etc. conversion, household solar energy, small-scale wind energy and small-scale hydraulic energy, etc.

People's government above the county level shall provide financial support for the renewable energy utilization projects in the rural areas.

Chapter 5 Price Management and Fee Sharing

Article 19—Grid power price of renewable energy power generation projects shall be determined by the price authorities of the State Council in the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable, where timely adjustment shall be made on the basis of the development of technology for the development and utilization of renewable energy. The price for grid-connected power shall be publicized.

For the price of grid-connected power of renewable power generation projects determined through tender as stipulated in the 3rd paragraph of Article 13 hereof, the bid-winning price shall be implemented; however, such a price shall not exceed the level of grid-connected power of similar renewable power generation projects.

Article 20—The excess between the expenses that power grid enterprises purchase renewable power on the basis of the price determined in Article 19 hereof and the expenses incurred in the purchase of average power price generated with conventional energy shall be shared in the selling price. Price authorities of the State Council shall prepare specific methods.

Article 21—Grid connection expenses paid by grid enterprises for the purchase of renewable power and other reasonable expenses may be included into the grid enterprise power transmission cost and retrieved from the selling price.

Article 22—For the selling price of power generated from independent renewable energy power system invested or subsidized by the Government, classified selling price of the same area shall be adopted, and the excess between its reasonable operation, management expenses and the selling price shall be shared on the basis of the method as specified in Article 20 hereof.

Article 23—The price of renewable heat and natural gas that enters the urban pipeline shall be determined on the basis of price management authorities in the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable.

Chapter 6 Economic Incentives and supervisory measures

Article 24—The Government budget establishes renewable energy development fund to support the following:

1. Scientific and technological research, standard establishment and pilot project for the development and utilization of renewable energy;

2. Construction of renewable energy projects for domestic use in rural and pasturing areas;

3. Construction of independent renewable power systems in remote areas and islands;

4. Surveys, assessments of renewable energy resources, and the construction of relevant information systems;

5. Localized production of the equipment for the development and utilization of renewable energy.

Article 25—Financial institutions may offer preferential loan with financial interest subsidy to renewable energy development and utilization projects that are listed in the national renewable energy industrial development guidance catalogue and conform to the conditions for granting loans.

Article 26—The Government grants tax benefits to projects listed in the renewable energy industrial development guidance catalogue, and specific methods are to be prepared by the State Council.

Article 27—Power enterprises shall authentically and completely record and store relevant materials of renewable energy power generation, and shall accept the inspection and supervision of power supervisory institutions.

Power supervisory institutions shall do the inspection in accordance with stipulated procedures, and shall keep commercial secret and other secret for inspected units.

Chapter 7 Legal Responsibilities

Article 28—If energy authorities of the State Council and the people's governments above the county level as well as other relevant authorities breach this Law and have one of the following, people's government of their own level or relevant authorities of the superior people's governments may order them to make correction, and impose administrative penalty for competent personnel that are liable and other personnel directly liable; in case that such breaches constitute crime, criminal liabilities shall be legally pursued.

1. Failure to make administrative licensing decision in accordance with law;

2. Failure to make an investigation when illegal activities are discovered;

3. Other acts of not legally performing supervision and management responsibilities.

Article 29—If the power grid enterprises breach Article 14 hereof and fail to purchase renewable power in full, which results in economic loss to the renewable power generation enterprises, such power grid enterprises shall be liable for compensation, and the national power supervisory institutions shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than the economic loss of the renewable power generation enterprises shall be imposed.

Article 30—In case that enterprises of natural gas pipeline network and heat pipeline network breach paragraph 2 of Article 16 hereof and do not permit the connection of natural gas and heat that conform to the grid connection technical standard into the network, which results in economic loss to the gas and heat production enterprises, relevant enterprises shall be liable for compensation, and energy authorities of the people's government at the provincial level shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than said economic loss shall be imposed against them.

Article 31—If gas-selling enterprises breach paragraph 3 of Article 16 hereof and fail to include biological liquid fuel that conforms to the national standard into its fuel-selling system, which results in economic loss to the biological liquid fuel production enterprises, relevant enterprises shall be liable for compensation, and energy authorities of the State Council or people's government at the provincial level shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than said economic loss shall be imposed against them.

Article 33—This Law shall be valid from Jan 1st, 2006.

Source: The Central Government of China. [online] http://www.gov.cn/.