STAKEHOLDERS' RISK PERCEPTION OF SUSTAINABLE BIOMASS POWER PLANT DEVELOPMENT ---A CASE STUDY OF WANGKUI COUNT, CHINA

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***ABSTRACT*:** Global warming and climate change are putting enormous pressure on governments and industry to rethink their attitudes towards sustainability issues. Since China is facing a number of energy challenges，especially shortage of energy supply and environmental pollution, the use of renewable energy is being encouraged and is playing an ever more increasing role in energy supply in China. Agricultural residual, such as crop straw, is a main form of biomass and a significant energy resource in China at present, particularly in rural areas. However, currently, most agricultural residual is used as cooking fuel, livestock feed, and household heating fuel, or is burned directly in the field in rural areas. These activities not only waste energy but also cause environmental problems. In rural China in 2011, the burning of 802 million tons of crop straw produced 4.2 million MWh/a electricity. The construction of a biomass power generation plant in a rural area, using rich local biomass resources, could significantly increase the standard of living and employment in that area, and would reduce environmental pollution. Biomass power plant (BmPP) has developed rapidly in the past decade in China; however, the biomass power industry, still in the process of development, offers both opportunities and challenges. This paper presents a sustainable BmPP development strategy reflecting various stakeholders' perspectives, based on the findings of a case study of Wangkui County in China. A multi stakeholder survey was conducted to identify and analyze stakeholders' potential risks regarding a proposed BmPP in Wangkui County. In this paper, controlled perception risks are ranked though quality approaches to identify main risks of each stakeholder. The results of the paper indicate that the establishment of "farmer-based system", agreement between agents and BmPP, and government policies are essential for the sustainable development of the biomass power generation industry. These results also provide valuable stakeholder information relevant to sustainable development of the industry. Policy requirements and outreach strategies for encouragement of people's acceptation of BmPP are suggested.

KEYWORDS: stakeholders, biomass power plant, sustainable development

1. INTRODUCTION

Biomass power generation system is a complex process that transforms raw material into electricity, including various risks, for example, human factor risks, technology risk, organization risk, policy risk. It is important to highlight that mitigating risk of stakeholders involved in biomass power systems would promote biomass power industry development to some extent. This paper contributes to the identification and analysis of main stakeholders' risk, aiming exploring approaches to mitigate risk and promoting biomass power industry development in China.

Biomass energy resources play a pivotal role in the current global strategies for reducing greenhouse gas emissions and partially replace fossil fuels. And there is growing public awareness that consumption of fossil fuels on large amounts is contributing to global warming. In addition, extraction of large quantities of coal, natural gas, and crude oil are leading to faster depletion of the finite reserves of fossil fuels. China is the world's most populous country with over 1.3 billion people (Xinhua News Agency, 2010). It has experienced tremendous economic growth over the last three decades with an average annual increase in gross domestic product (GDP) of 9.8% during that period (Roger Ballentine, 2009). This rapid economic growth has led to an increasing demand for energy, spurring China to use an average of 53 gigawatts (GW) of electricity capacity each year over the last ten years (Junginger et al, 2006). However, 70% of China's current electricity is generated by coal. The environmental consequences of burning coal and the limited domestic reserves of coal, natural gas, and oil give Chinese government impetus to seek renewable energy to generate electricity.

Agricultural residual, such as crop straw, is a main form of biomass and a significant energy resource in China at present, particularly in rural areas. However, currently, most agricultural residual is used as cooking fuel, livestock feed, and household heating fuel, or is burned directly in the field in rural areas. These activities not only waste energy but also cause environmental problems. In rural China in 2011, the burning of 802 million tons of crop straw produced 4.2 million MWh/a electricity (Xinhua News Agency, 2010). However, although the mount of residual straw is large, biomass power plant faces lack of crop straw. Sufficient biomass resources should combine with a well-functioning biomass market that can assure reliable, sustainable, and lasting biomass supplies. Van Dam et al. (2005) discuss policies for securing renewable resources supplies for changing market demands in a bio-based economy. The authors suggest that the development of sustainable bio-based economy requires a joint effort from the agricultural sector, industries, governments and consumer organizations, fully utilizing the available scientific infrastructure and multidisciplinary expertise. Junginger et al. (2006) examine the opportunities and barriers in the context of securing sustainable bio-energy trade. A detail analysis is carried out by Koopmans (2005) to determine the sustainability of biomass energy demand and supply in 16 Asian countries. McCormick and Kaberger (2007) propose strategies including policy measures for altering the economics of bioenergy pilot projects to support the learning processes and offer guidance for network building and supply chain coordination. Several researchers in the field of agricultural science discuss contraction with farmers, such as Hoverlaque et al. (2009), Key and Macdonald (2006). Mathews (2008) , Poole et al. (1998). Roumasset and Lee (2007) discuss and propose methods for estimating the monetary value of agricultural residues, defining the minimum amount that the farmers have to be paid, as well as the upper limit that the biomass end users can pay for the agriculture residues.

However, there is no research on concrete risk analysis of main stakeholders in biomass power plant in China. The objective of the study is to determine, analyze and discuss the main stakeholders' risk perception. Based on a case study of National-Bio Energy power plant in Wangkui County in Heilongjiang Province, interview and questionnaire approach were used to explore the perception risks of main stakeholders. The survey results indicate that increased cooperation, trust and understanding among stakeholders in the system, would promote risk mitigation and BmPP development.

2. THE DEVELOPMENT OF BIOMASS POWER INDUSTRY IN CHINA

Industrialized production of biomass power generation in China started from 2004. With the support of national tax incentives, China's biomass power industry had made significant progress during the year from 2008 to 2011. Until 2011, more than 100 biomass power projects were approved by national and provincial Development and Reform Commission. The installed capacity and electricity generation of biomass is shown in Fig 1(China bank, 2009). For the effect of resource factors and region's characteristics, regional distribution of biomass power generation was more distinctive. Biomass power generation was mainly concentrated in East China (Jiangsu, Zhejiang, Anhui, Jiangxi, Fujian and Shanghai). Jiangsu's biomass power installed capacity ranked first, reaching 439,800 kW.

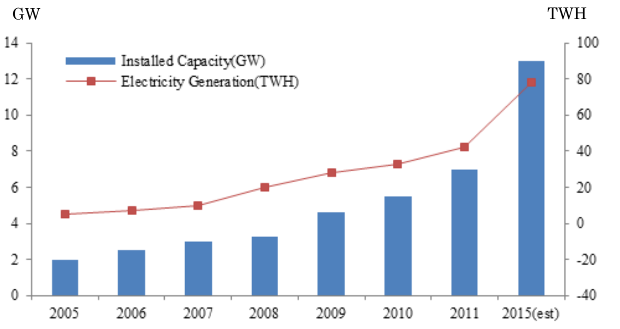

Fig.1 Biomass installed capacity and electricity generation from 2005 to 2011

For biomass power generation investment, by the end of 2009, the total investment of the biomass power generation in China was 45 billion RMB, compared with 17 billion RMB in 2006, which increased 37.7% averagely during that time. The total installed capacity that has been put into operation was 2.5 GW in 2006 and increased to 7 GW in 2011, with an average annual growth rate of 22.87%. The cumulative investment has been reached to 59 billion RMB in 2010 (China bank, 2009), as shown in Fig.2.

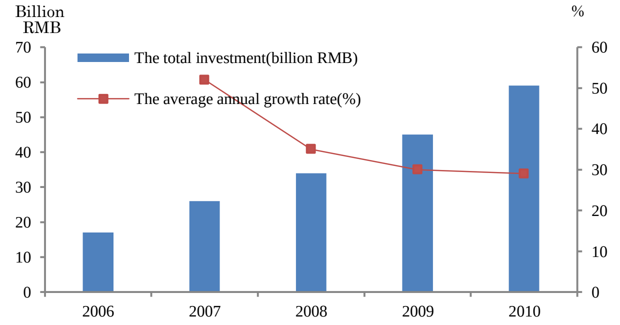

Fig.2 Biomass power investment from 2006 to 2010 in China

Since the Renewable Energy Law was enacted, China has made a significant increase in biomass power subsidies. As it shown in Fig.3(China bank, 2009), with the incensement of electricity capacity of grid feed-in, the amount of subsidy increased rapidly, from 30 billion RMB in 2006 to 1600 billion RMB in 2010. The increasing subsidies became significant incentive for promoting biomass power industry developing.

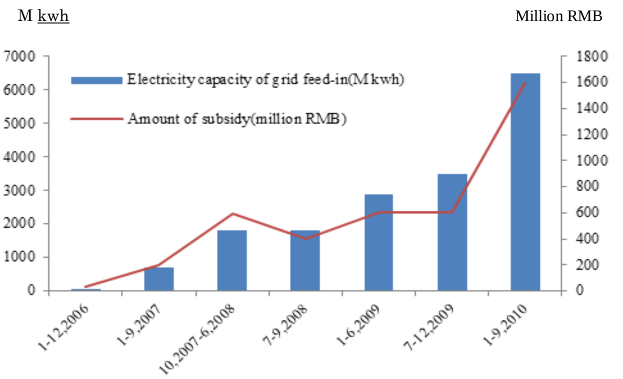

Fig.3 Amount of subsidies for biomass power Generation projects

Biomass power generation development represents an important pillar of future renewable energy contributions to China's electricity. Based on China's mid-and long term renewable energy targets, biomass power generation shall be 30 GW in 2020. To reach the strategic target, development and deployment of biomass power generation, from non-technology and utilization technologies perspectives, are all in need of enhancement, whilst taking consideration of key sustainability factors such as environmental and social impacts.

3. METHODOLOGY

This paper aims to identify and analyze risks of key stakeholders in biomass power plant in China. A case is taken in Wangkui County in China. An investigation into the National-Bio Energy power plant is conducted to explore stakeholders' risk perceptions which are determined by personally selected sources of values, interests, and individual experiences. In this case, National-Bio Energy power plant and the local government are in good relationship with sufficient communication. However, there is information gap between the power plant and the farmers (crop straw suppliers). This is because agencies take the responsibility of collecting crop straw from farmers and carrying it to the power plant.

The first step of the survey on stakeholder risk perceptions is to identify key stakeholders related to biomass power plant. The process was conducted with the help of local government who were familiar with the power plant since it was established. The selected stakeholder representatives were interviewed to identify risk. Finally, this study analyzed perceived risk of main stakeholders aiming to rank risk perception and propose strategies to mitigate main risks.

4. CASE STUDY OF NATIONAL-BIO ENERGY POWER PLANT IN WANGKUI COUNTY

4.1 The background of Wangkui County

As the center of Heilongjiang Province, Wangkui County belongs to Suihua City. Fig.4 and Fig.5 illustrate the main location of the place referred to this paper. Wangkui County governs 7 towns and 12 townships, covers 2,314 square kilometers, and has a population of 442,867 thousand. The annual agricultural yield is over 1,197,000 Ton, with stalk production of 1,113,000 Ton. This area basically depends on agriculture. Meanwhile, the industries grow very fast. Wangkui enjoys a plenty of stalk resources, and its utilization will positively contribute to the energy consumption in the area, which is significant to improve the economic and social development.

Fig.4 The location of Suihua City in Heilongjang Province

Fig.5 The location of Wangkui County in Suihua City

Through the spot survey of rural resident about 1,000 households in Wangkui, the output of straw or purchasing is about $111.3*10^4$ ton (shown in Table 1). Furthermore, the density of straw resource is high. In 50 km radius, there are 340 villages, and the output of straw is about $251.6*10^4$ ton (shown in Table 2). In 30 km radius, there are 161 villages, and the output of straw for purchasing is about $144.5*10^4$ ton, which can fully supply the biomass power plant (shown in Table 3).

Table1 Crop straw output in Wangkui County

Species	Acreage (10^4 mu)	Total crop production (10^4 ton)	Total crop straw Production (10^4 ton)
Corn	119.5	62.7	81.3
Soybean	79.4	13.1	14.3
Rice	40.9	43.9	15.7
Total	239.8	119.7	111.3

(Note: 10000 square meters=15 mu)

Table2 Crop straw output in 50 km radius

Species	Acreage (10^4 mu)	Total crop production (10^4 ton)	Total crop straw Production (10^4 ton)
Corn	247.1	129.7	168
Soybean	164.2	27.1	29.6
Rice	142.5	151.1	54
Total	553.8	307.9	251.6

Table3 Crop straw output in 30 km radius

Species	Acreage (10^4 mu)	Total crop production (10^4 ton)	Total crop straw Production (10^4 ton)
Corn	154	80.9	104
Soybean	94	15.5	17
Rice	62	65.8	23.5
Total	310	162.2	144.5

However, currently, on one hand, the stalk is basically used for cooking (roughly 50% to 60%), with direct combustion. The utilization efficiency is 5-8%. On the other hand, there are substantial stalks that are burned directly inside the plowing field. This kind of situation wastes the precious energy resources, as well as seriously pollutes the environment.

4.2 The introduction of National-Bio Energy power plant in Wangkui County

National-Bio Energy power plant, belonging to National Grid Company, was established in 2006. The biomass power plant is located in the developing area, taking 110 thousand square kilometers. This project imported biomass direct combustion technology of BWE Company from Denmark. The total investment was 553 million RMB. In 2007, the biomass power plant injected into National Grid Company to generate electricity, which became the first power generation company combusting yellow straw in the world. In 2011, the output value of this company was 140 million RMB, as well as increasing 20 million RMB incomes of farmers. In addition, this power plant could reduce 100000 tons of CO_2 emission annually. Biomass power plant could provide clean and reliable energy to local economy development, and contribute to local power grid. It could also replace small steam coal-fired power plants whose development has been strictly controlled by the government, so as to reduce the coal consumption for power generation, which will be beneficial to the local environment and ecology protection. It is consistent with the government's sustainable energy strategy.

Wangkui biomass power plant is one of the important components of new energy base construction in Wangkui County. The total capacity is 25MW. In line with the National Renewable Energy utilization target, National-Bio Energy power plant aims to import the oversea mature biomass power generation technology and devices through international cooperation, so as to absorb and achieve the commercialization and scaling up of the biomass power generation.

4.3 Stakeholder relationship in National-Bio Energy power plant

Although the biomass power supply market is not completed, the relationship among stakeholders is significantly important for the biomass power plant development. From macro perspective, the current stakeholder relationship is shown in Fig.6.

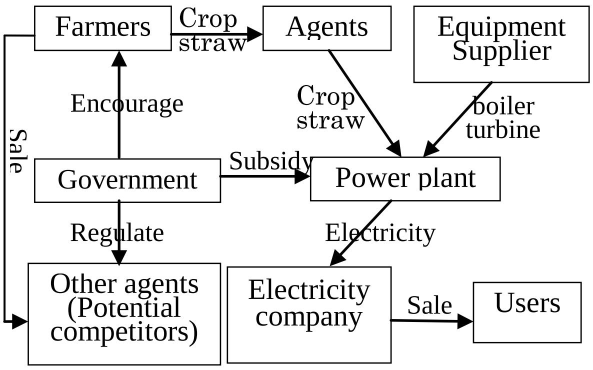

Fig.6 The current stakeholder relationship

In this relationship, farmers are the suppliers of biomass. Between farmers and power plant, the agents play a vital role in collecting biomass. However, in order to get more profit, farmers might sell the crop straw to other factories instead of biomass power plant. This kind of situation causes lack of crop straw for power plant. The local/central government, as a kind of coordinator, takes the responsibility of encouraging farmers to sell crop straw to agents, and giving subsidy and controlling the price of electricity.

For biomass power plant, the difficulty in crop straw collection hinders biomass power development. The main stakeholders in biomass collection and supply systems include farmers, agents and power plant owners. Because the long distance transport of raw material is not feasible, the market of biomass will be local or regional, usually within 30 km. In order to collect more crop straw, biomass power plant also set sub-agents in remote area in case of lack of raw material in some year, as it is shown in Fig.7 (F indicates farmers).

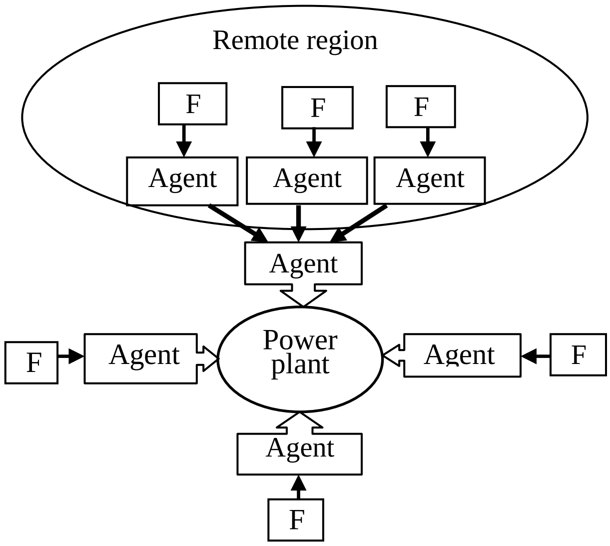

Fig.7 Multi-agent supply system

4.4 Stakeholder risks analysis

A national biomass market does not exist at present in China now. The study suggests that a long-term agreement among stakeholders is essential to stabilize the biomass feedstock price, which can be beneficial not only for the power plant but also for the agents and farmers who are involved in biomass trading. In order to build long-term agreement among stakeholders, it is essential to analyze risks, and try to reduce the risk and building balancing benefit through which win-win relationship can be built. In biomass power industry, power plant, agent and farmers are the main stakeholders. Government is also significant in the system, taking the role of coordination and making regulation or policy to give incentive to the stakeholders involved in biomass power system. The risks of main stakeholders are shown in from Fig.8 to Fig.10.

- Biomass power plant: natural risk is one of the vital risks that people cannot control, especially in raw material collection process. From macro social risk perspective, macro-economic fluctuation influences the developing speed of electricity industry. It is evident that the amount of biomass power generation takes a small amount of the whole country's electricity generation. However, considering if coal power generation is in serious financial loss in most areas, the central government would balance benefits of all parties. Thus, the expectation of rising price of renewable energy might not be as strong as before, which means that macro-economic fluctuation may bring negative influence on biomass power industry. Policy risk refers to policy environment stability and uncertainty. Nowadays, biomass power industry is at the beginning stage of development, which is difficulty to survive without policy support. The Chinese government issued a series of laws and regulations, for example, *Renewable energy electricity prices and cost-sharing management pilot scheme*, intending to encourage BmPP development. However, with technology improvement and industrialization of biomass power generation, the policy will be adjusted, which probably influences biomass power electricity price and power plant revenue. In biomass power technology level, because the biomass power project in China develops late, the technology is not mature, causing low combustion efficiency and biomass waste. For example, the biomass power project in China lacks independent research capability in some equipment, such as vibrating grate and dust removal device. The supply and demand risk is relatedly low, because of *the Blanket Guarantee Acquisition Policy*. It means that the Electricity Grid Company purchases as much electricity as the power plant produces. Under the government renewable energy policy, *the Blanket Guarantee Acquisition Policy* will not be changed for coming some years.

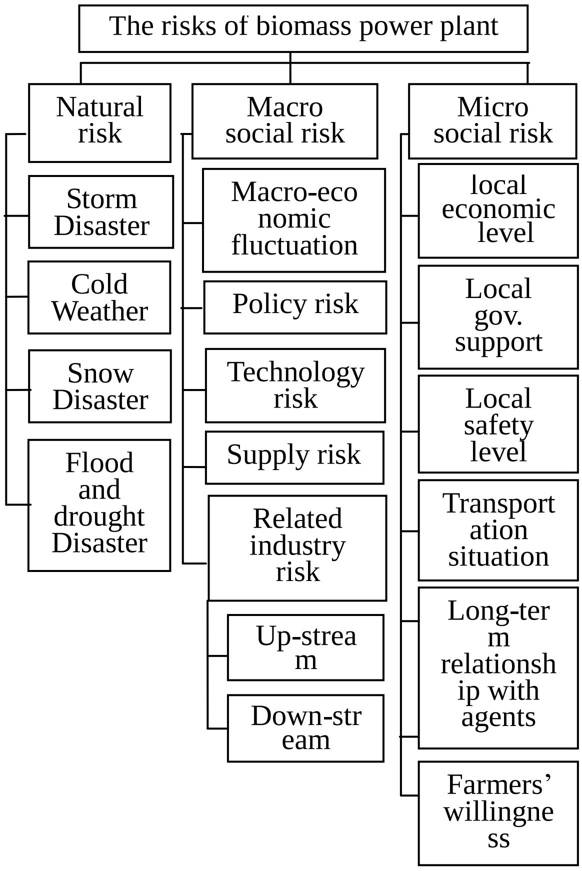

Fig.8 The risks of biomass power plant

From micro perspective, local economic level, local government support, local safety level, transportation situation and farmers' awareness have great impact on the development of biomass power industry. Biomass power industry, especially for the supply, collection and transportation processes, requires the support of local region. The development level of biomass power plant closely relates to crop production scale, climate condition, the number of transportation trucks and transportation condition. For example, transportation limitation will influence the biomass supply rate and quantity; thereby affect the power plant's normal operation. In addition, farmers' awareness would also influence cost change. In the biomass collection process, because of the large quantity of biomass is needed, some farmers who want to get more profit with less crop straw might sell biomass not reaching standard, such as mixing dust or not dry enough crop straw, to the power plant, which increases costs for biomass power generation. Another considered risk is regional security level. If the security level is low, biomass power plant may face risk of losing raw material.

- Agents: agents are the connection between power plant and farmers, taking a considerably important role in biomass supply chain. During crop straw collection, building trusts with farmers is an essential step without which it would be troublesome to collect crop straw from farmers. In China, on account of no formal crop straw market, negotiating crop straw price becomes difficult part since both agents and farmers are eager to get more profit. In addition, since 2012, farmers began to use new harvester which would smash the corn crop straw directly in the field. Using new harvesters are more convenient for farmers to harvest corn; however, it makes crop straw collection more troublesome. The agents have to use new machine to collect the smashed crop straw in the field. In addition, the limited crop straw collection time, from the middle of October to November 5^{th} , the bad road condition, and cold weather, increase the difficulty in crop straw collection. Since the labor cost becomes increasing higher, the agent cannot obtain much profit, which is the main reason that some agents give up the job. After crop straw collection, agents also take charge of crop straw storage, processing and transportation. The most important business objective for agents is to obtain profit, which stimulates agents' motivation for crop straw collection. However, nowadays, the agents' profit is decreasing. As it is indicated in the table below, agents can get only 40 yuan/ton averagely, with taking the main collection risks (storage risk, processing risk, transportation risk), causing some agents to consider quitting the job.

Table4 the profit that agents can get (Yuan/ton)

Cost (labor, transportation, electricity, oil, etc.)(Y/ton)	Average cost (Crop straw)	The average price that power plant provides	Profit
190	40	270	40

However, for some agents who already build sound relationship with farmers, it is much easy to collect crop straw. Since the farmers trust the agents, they would like to let agents collect crop for free. In this case, agents can get more profit.

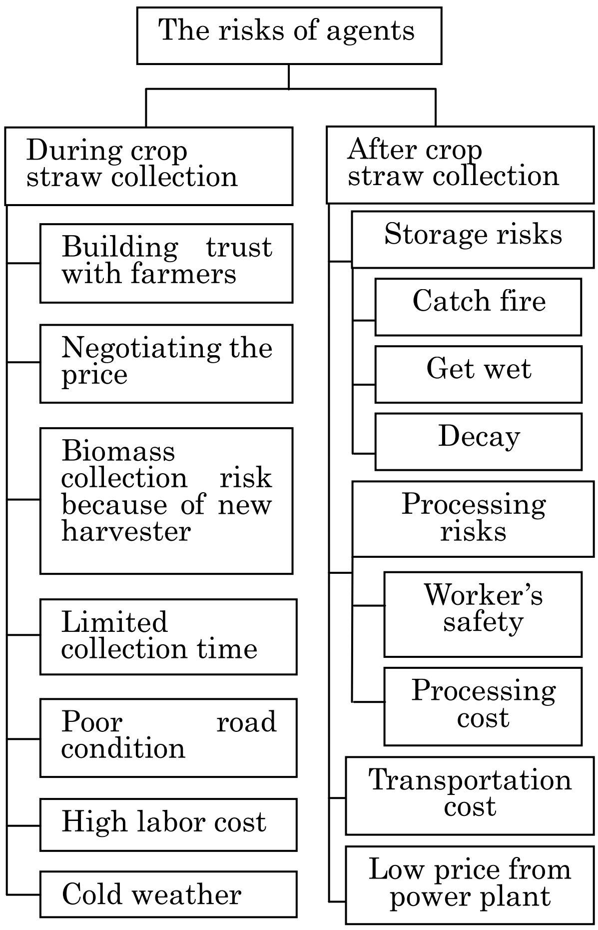

Fig.9 the risk of agents

- Farmers: Farmers are the crop straw suppliers, whom the power plant operation relies on. However, farmers have less motivation to sell their crop straw mainly because they can get less profit and they have to worry that agent might destroy the farm land. Since few farmers have environmental awareness, they prefer to burn crop straw directly in the field. In that case, it's no necessary for them to consider the limited time of cleaning the field and the destruction of farm land. Conversely, if the farmers trust the agent, they may have less trepidation of destruction of farm land. Nowadays, some agents already built trust with farmers, and those farmers would like to give the crop straw to agent without charging money. However, for poor farmers, they consider profit more than other factors.

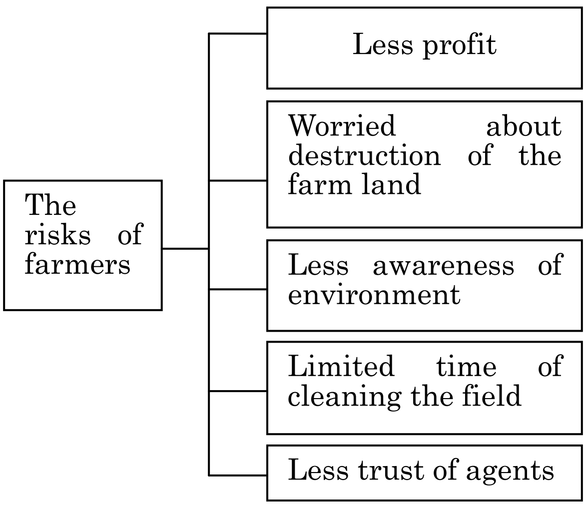

Fig.10. the risks of farmers

5. RESULTS

This study divided risk into controllable risk and uncontrollable risk. From the biomass power plant's perspective, the risks of local government support, local social safety level, transportation situation and farmers' awareness are could be controlled. For agents, the risks of building trust with farmers, negotiating the price (with farmers and the power plant), and the risk of biomass collection after using new harvester can be controlled. For farmers, trepidation of farm land, less awareness of environment, and less trust of agents are under control. This study focuses on controllable risks, and tries to explore strategies to mitigate controlled risks.

In this study, interview method has been used to score each risk. During the interview, each stakeholder stated and valued the risk from their own standpoints or benefits. However, if stakeholders evaluate their own risk (for example, power plant staffs evaluate risks from R_1 to R_4), they may expand the surface risks level, ignoring potential risk level. From this perspective, this risk assessment value combined different stakeholders' value to ensure the mean value approaching to the objective reality. For the risks related to biomass power plant, in addition to two factory directors, one government officer and two agents were selected to give scores of each controllable risk. Because power plant and government have sound connection since the power plant was established, thus, the government is familiar with the growth process of the power plant. Also, an agent is selected to assess the risk from objective perspective. In terms of agents, two factory directors, two agents and one farmer scored the risk. Agents are the connection between farmers and power plant. Therefore, it seems reasonable that power plant directors and farmers give scores of agents' perception risk. For farmers' item, four farmers and one agent gave scores. This study uses the mean score to rank the risk. 0 is the lowest level and 10 is the highest level. (P: power plant director, G: government officer, A: agent, F: farmer)

Table 5. Key stakeholders' risk score

stakeholders	Risks	Scores					
		G	P	P	A	A	Mean
Power plant	Local government support R_1	10	10	10	8	7	9.0
	Local safety level R_2	8	5	4	6	7	6.0
	Transportation situation R_3	5	5	6	9	8	6.6
	Farmers' awareness R_4	7	8	9	8	9	8.0
	Long-term relationship with agents R_5	10	10	10	10	10	10.0
		P	P	A	A	F	
Agents	Building trust with farmers R_6	8	9	10	10	8	9.0
	Price negotiation with farmers R_7	6	7	9	10	7	7.8
	Price negotiation with power plant R_8	6	6	8	9	5	6.8
	Biomass collection after using new harvester R_9	7	6	9	10	7	7.8
		F	F	F	F	A	
Farmers	Trepidation of farm land R_{10}	6	7	5	4	3	5.0
	Environmental awareness R_{11}	2	1	3	2	3	2.2
	Less trust to agent R_{12}	8	9	7	10	9	8.6
	Less profit R_{13}	9	9	10	9	7	8.8

Apparently, the value rank of power plant's risk is as follows: $R_5 > R_1 > R_4 > R_3 > R_2$. The government's support considerably contributes to the biomass power plant growth, without which the power plant will bankrupt. Biomass power plant cannot get profit in first 6 years since it was established. Although the power plant is financially becoming stronger, government's support is still an essential element for biomass power plant to survive. For example, the Chinese government has begun to carry out the policy of purchasing all the electricity generated by biomass power plant, guaranteeing the sale channel. Farmers' awareness is also an extremely important factor that influences the crop straw supply. With low awareness and less motivation of selling crop straw to agent, it will be difficult to cooperate with farmers in biomass collection. In terms of agents, results were $R_6 > R_7 = R_9 > R_8$. Building trust with farmers is substantially vital in biomass collection. Specifically, in the Northeast of China, each farmer has approximate 10,005 square meters. It is extremely hard for farmers to harvest all crop straw in such broad land. If agents can help them harvest, they prefer to give all the extra crop straw agents for free. However, for agents who haven't built trust or failed to build trust with agents, they suffered a lot from price negotiation with farmers. Apart from R_6 and R_7, since 2012, farmers began to harvest corn with new harvester which would smash the crop straw in the field directly, increasing difficulty to collect biomass. For farmers, the most considerable factor is profit. In their opinion, selling crop straw can obtain less profit, however, at the same time; they should burden the risk of farm land trepidation. In that case, it makes farmers feel easy to burn the crop straw in the field.

6. CONCLUSION

Biomass power industry is a promising industry, which is beneficial not only for environment but also regional development. However, as each party involved in the project is facing various risk. Mitigating risk and increasing stakeholders' motivation to participate in the project is significant to solve biomass collection problem. This study explores strategies to reach the goal of mitigating risk that was analyzed above.

6.1 Building a "farmer-based system"

Due to the important role of farmers, a "farmer-based price system" should be promoted to ensure benefits to farmers, which would enhance relations between agents and farmers as well as enable the whole biomass supply chain to deliver a long-term stable stream of biomass. In order to build "farmer-based system", farmers' benefits should be given high priority in biomass collection system. Building trust with farmers is essential for effectively collecting biomass residues. However, it takes a long time to build trust with farmers. In order to let farmers trust agents and power plant, the most important step is to give benefit to farmers without cheating. Economic incentive is one of the most important approaches to attract farmers to cooperate with agents. If government's subsidies transfer partly from power plant to farmers, farmers would have more motivation to cooperate with power plant. Meanwhile, agents should be the persons who have reputation and trust credibility in local place. Technical service and support from local government, for example, special equipment for quick biomass collection, should be available to assist farmers and agents to attain maximum benefits from the biomass resource utilization business. With the efforts of agent, power plant and local government, increasing number of farmers would prefer to cooperate with agents and power plant. Therefore, in short term, the "farmer-based system" may rely on economy incentive; in long-term, this system will gradually turn to win-win system based on trust.

6.2 Achieving agreement between agents and biomass power plant

Based on studies of the National-Bio Energy power plant, stable and long-term agreement between the agents and the power plant is critical for ensuring biomass at a reasonable price. An agreement should be signed between agents and the biomass power plant for the required amount of biomass. For example, the power plant pays 90 percent for the first delivery and the rest during the second delivery. Requirement should be given for the agents. For example, agents should have sufficient cash flow to prepay for biomass collection in case emergency happens during crop straw collecting, storage or processing. However, for the power plant, it is also essential to ensure the economic benefit of agents; otherwise, they will have less motivation to cooperate with the power plant. For example, if agents achieve the required amount of biomass, it is better for the power plant to give reward to attract agents. According to the investigation, agents burden substantial amount of risk, they therefore should get equivalent pay back. It seems that more fair profits redistribution system should be built based on risk share.

6.3 Establishing policy and regulation framework for biomass supply chain

According to main stakeholders' risk perception, central and local government's policy and regulation is one of effective factors that may improve biomass power plant development. In particular, the biomass power plant's profit relies on the subsidy policy, which means that the profit depends on the amount of subsidy. Nowadays, both central government and local government's policy emphasize the power plant's benefit. However, in the biomass supply chain, agents and farmers are extremely important. A reliable source of biomass requires long-term guaranteed contracts with biomass suppliers. This was also stressed by agents and farmers interviewed in this study. Thus, in development of biomass power industry, government should not only consider power plant's profit, but also agent and farmers' profit. It would be advisable to give incentives to agents and farmers to encourage them to be cooperators. If the government subsidies not only the power plant but also the agents and farmers, it would be more willing for agents and farmers to join the biomass power scheme since they also burden considerable risks for biomass power development, particularly, agents.

In summary, one seemingly basic but nonetheless crucial finding is that, various risk factors co-occur with biomass power operation. They are not limited to uncontrollable risks but also cover a very broad spectrum of controllable risk that is related to stakeholders. Our results suggest that building a "farmer-based system", achieving agreement between agents and biomass power plant, establishing policy framework to guarantee agents and farmers' benefit may mitigate controllable risk to some extent.

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