論 文 内 容 の 要 旨

In China, the consumption of fossil fuel has been increasing dramatically. Huge external costs caused by pollution and the shortage of fossil fuel reserves are becoming serious concerns. These concerns are increasing motivations for the development of a new type of power plants assumed to be environmentally friendly and based on endogenous resources. The use of biomass is a promising alternative to fossil fuels, which would mitigate environmental pollution and optimize energy structures. In China, a major application of biomass is combustion to generate electricity and heat. However, the current straw-based biomass power plants face difficulty in development. Farmers perceive various risks. Not a few of them are willing to cooperate with the middleman, who takes on the responsibility to collect straw from the farmers. Their risk perceptions decrease the motivation in participating in crop straw collection activities. To solve the problem of insufficient collected straw for the biomass power industry, the National Bio-energy Power industry area in Wangkui County, China was selected as a case study to investigate the problems. This study was divided into four parts including eight chapters.

The first part (Chapter I) introduces the current situation of biomass supply chain and the barrier of development of biomass power plants in China. The dilemma of insufficient crop straw in developing biomass power plant is derived from the situation introduction. For biomass power industry, government's policy is considerably significant. Therefore, in the first part, the current policy, guidance and regulation in China were also introduced. The existing problems of insufficient straw supplying that related with policy was derived.

In the second part (Chapter II), combing the developing dilemma, literature review on problems in biomass power plants, and this study explores the root cause of problems of developing biomass power plant by investing in the National Bio-energy power plant in Wangkui County in Heilongjiang Province, Northeast China. Problem is formulated by analysis of the current situation. Results of the problem formulation results indicate that risks perceived by farmers are the root causes of the barriers in the biomass supply

chain. Mitigation of farmers' risk perception could be significant in solving straw supply problem in biomass power industry in China.

The third part is from Chapter III to Chapter VII. This part explores farmers' risk perceptions in supplying straw and strategies to mitigate risk perceived by farmers to enhance their motivation in engaging straw supplying activities.

To comprehensive understand farmers' risk judgement in supplying straw, in Chapter III, an exploratory FROSS (Farmers' Risk perception Of Straw-Supply) model was developed combining and integrating socio-demographic characteristics, policy guidance factors, economic factors and trust factors. The conceptual model was tested empirically on a sample of responses to risk perceptions, by 275 farmers living around a biomass power plant in Northeast China. The model was analyzed comprehensively, as well as vertically (different economic levels of villages) and horizontally (different risk perception dimensions) to determine factors influencing farmers' risk perception of biomass-supply. The results indicate that the full farmers' risk perception of straw-supply model can account for more than 90.9% of the variance in farmers' risk perception of straw supplying. Education level, income, economic factors such as no payment, outweighing benefit, farmland damage cost, and trust factors such as trust of no farmland being damaged, trust of no extra cost caused by unclearing up farmland, trust of no cheating and trust feeling are all significant predictors. Especially, education and income factors can predict 46.7% of farmers' risk perception. The results of vertical analysis show that both economic factors and trust factors are statistically significant. However, policy guidance factors can only predict farmers' risk perception in village with high annual income. Horizontal analysis confirmed by factor analysis that farmers' risk perception can be conceptualized along two dimensions, named: personally and environmentally related risk perception. Implications of the results are discussed in this study. The predictors can predict 80.5% of personally related risk perception, while only 16.2 % of environmentally related risk perception. The results demonstrate that currently economic and trust factors are crucial factors affecting farmers' risk perception. Therefore, to solve economic and trust problems, this study derives the solution into short-term solution to economic problems and long-term solution to trust problems.

In Chapter IV and V explore new incentive scheme for straw supply as the short-term solution. In Chapter IV, in order to break through the biomass supplying dilemma, this study applies Stackelberg game theory to model biomass supply chain and design incentive scenarios for stakeholders to cooperate stakeholders under risk and uncertainty. The impacts of incentive to the farmer and the middleman were demonstrated. The proposed methodology is illustrated using an empirical case study of China. Three scenarios are simulated in this chapter: the current situation (incentive to the biomass power plant), incentive to the farmer, and incentive to the middleman. The results show that with incentive, both the quantity of straw supplied by the farmer and stakeholder's' profit will increase. Particularly, incentive to the farmer has remarkable effect. It is also shown that the incentive to the farmer scenario generates highest social welfare. Moreover, perceived risk and uncertainty seems to affect stakeholders' profit dramatically. Decreasing perceived risk would potentially contribute to developing biomass power industry and reducing incentive level to each stakeholders in inventive design policy. In each scenario, highly perceived risks by stakeholders decreases the social welfare. It implies that impact of perceived risk on the biomass market is substantial. Although the incentive could generate social welfare, the financial found are still needed.

In order to justify introduction of the incentive schemes, in Chapter V, the external costs of coal-fired and biomass power plants were compared using the lifecycle apprach in Northeast China. First, the structures of external costs are built in line with coal-fired and biomass power plant life cycle activities. Then the external costs of a biomass power plant are calculated for each stage for comparison with those of a coal-fired power plant. The results highlight that the external costs of a coal-fired plant are 0.072 US $/kWh, which is approximately 600 times as high as that of a biomass power plant, 0.00012 US $/kWh. The external cost of coal-fired power generation is as much as 90% of the current price of electricity generated by coal, while the external cost of a biomass power plant is 1/1000 of the current price of electricity generated by biomass. Thus, by internalizing the external costs, the sum of the current electricity price and the exteral costs, for the coal-fired power plant becomes higher than that of the biomass power plant. In addition, for a biomass power plant, the external cost associated with SO_2, NO_X, and $PM_{2.5}$ are particularly lower than those of a coal-fired power plant. The prospect of establishing precise estimations for external cost

mechanisms and sustainable energy policies is discussed to show a possible direction for future energy schemes in China. The chapter has significant value for supporting the biomass power industry and taxing or regulating coal-fired power industry to optimize the energy structure in China. The external cost of coal-fired power plants could be resource to incentive biomass power plants.

However, the development of biomass power plants should not depend on economic incentive all the time. Therefore, in the long-term, to be sustainably develop the biomass power industry, trust between farmers and middleman or the biomass power plant should be built. To keep long-term relationship with farmers in supplying biomass to biomass power plant, building trust with farmers becomes a long-term solution to the shortage of straw supplying. Chapter VI explores how significant building trust is in mitigating farmers' risk perception, lowering transaction cost of crop straw and enhancing farmers' engagement in supplying crop straw. Based on a survey of residents living in National Bio-energy power plant area (n=275) in China, the following observations are made. Firstly, this study offers empirical evidence that affirms the theoretical connections between trust and risk perception, transaction cost and farmers' engagement in the context of supply straw. Secondly, the regression analysis demonstrates that demographic characteristics and trust are factors explaining farmers' risk perception, lowering transaction cost and enhancing farmers' engagement in supplying straw. Thirdly, the conceptual model of trust enhancement sheds light on the complexity of the trust concept, and specifies aspects of trust that are influential in the contexts of risk perception, transaction cost and farmers' engagement. The findings suggest that to keep sustainability of biomass supply, building trust between middleman and farmers plays a significant role. The middleman should behave well. Results of more detailed studies on trust show that care, credibility, moral integrity are all important factors to improve trust relationship with farmers. In addition, farmers should be educated. With education, farmers could realize the significance of straw-supply.

In the fourth part (Chapter VII), in line with the analysis on solving biomass supplying problem in biomass power plant in Northeast China, it is clear to see that understanding risk perceptions and motivation that influence stakeholders' behavior is at the heart of changing stakeholders' behaviors and policy-making. As a new industry (biomass power industry), to achieve cooperation among stakeholders, effective policy

making is significant to guide stakeholders' behaviors. Thus, the RMB (Risk perception-Motivation-Behavior change) model was developed to not only focus on policy making, in the long-term, changing stakeholders' behavior is the ultimate goal which is also a sustainable approach for the development of biomass power industry. In the RMB model, there are generally three steps to reach the final goal (behavior change). First, understanding risk perception is the fundamental step to behavior change. Accurate and comprehensive investigation of stakeholders' risk perceptions and their relationship is the most important task in mitigating risk perception. Second, through investigation and analysis of risk perceptions, the affecting factors of motivation for change can be identified. In the last step, to change stakeholders' behaviors, change of the factors that affect motivation is proposed, such as appropriate policy making, regulations, and cooperated partners' behaviors. Moreover, extrinsic motivation should be given to stimulate intrinsic motivation. Behavior can be changed automatically with intrinsic motivation.

Chapter VIII is the conclusion and future work of this study. In conclusion, from empirical perspective, the goal of the study is to solve biomass supply problem from the perspective of mitigating key stakeholders' risk perception. To achieve the goal, there are five parts in this study. First is to analyze the current situation and dilemma in biomass supply chain. Then, after formulating problems in the second part, it is found that farmers' risk perceptions are the crucial cause of insufficient straw supplying. Economic factors and trust factors are the major reasons leading to farmers' risk perception. Therefore, economic incentive strategy was analyzed and proposed based on game theory. However, depending on economic incentive cannot last long. In the long-term, trust between farmers and middleman/biomass power plant should be built. Trust enhancing model was generated in line with the analysis of trust affecting factors. Theoretically, this study derived exploratory RMB model expecting to further improve organization cooperation by mitigating risk perception and enhancing motivations of stakeholders. There are several recommendations for future work. (1) The list of affecting factors of farmers' risk perception is based on the literature and investigation, which is certainly not exhaustive. Future research can be constructively done on the current study by further exploring the interrelated nature of policy guidance factors, economic factors, and trust factors. (2) In development of game model part, future research may be conducted in a few directions. First, more sophisticated situations may

be considered, such as competition straw among middlemen and among biomass power plants. Second, middlemen's behaviors changes have influence of actions of other companies based on straw as feedstock. The third investigation would be to consider effectiveness of longer-term contract between the biomass power plant and the middleman, and also between the middleman and the farmer. Then cooperative game model can also be a further research to decide better allocate the benefit among stakeholders in the supply chain. (3) Regarding the external cost of coal-fired power plant and biomass power plant, it is worth studying issues related to localization in the future, such as coal production areas. (4) Regarding trust part, further development of trust model to facilitate the interaction of stakeholders could be interesting and beneficiary for cooperation of stakeholders. For the relationship of biomass power plant and the middlemen, to build contract trust is significant to guarantee middlemen's benefit and maintain sustainable straw supplying. To further study the contract trust and goodwill trust is also another approach to identify farmers' trust and set up appropriate regulation to improve trust. (5) The exploratory RMB model is derived from the case study. It requires a future empirical study to examine and validate the effectiveness of the model.