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## Study on government subsidy decision-making of straw power generation supply chain

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### Abstract

Straw power generation is a good substitute for fuel coal power generation of power plant, but the shortage of straw resources supply severely restricts the development of straw power generation industry in China. To promote the development of straw power generation, the government needs to adopt fiscal subsidies to encourage members of the supply chain. To this end, this paper studies the decision-making of government subsidy on straw power generation supply chain. First, the influencing factors of farmers-brokers-power plants straw power generation supply chain are analyzed, and the dynamic game models of the supply chain under the government incentives are built. Second, the impacts of government subsidies on three members' decision-making are analyzed. Then, under different incentive conditions, the changes of members' profits and chain's profits are discussed. Finally, an example is used to show the supply chain in the straw power generation, which verifies the proposed models and analysis. And several suggestions from farmers, brokers and power plants aspects are put forward to establish long-term cooperative relationship in straw power generation supply chain.

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### 1. Introduction

With depleting fossil fuel reserve and deteriorating environment, the utilization of renewable biomass energy has earned great concerns, especially in straw power market. Supporting by a series of policies, China's straw power industry has developed rapidly since 2006. As an agricultural country, straws of various crops yield rich. But the survey data shows that crop straws used for power generation account for only a quarter of the total straw resources

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throughout the country. In practice, overall development situation of straw power generation industry is far from ideal, and straw power generation projects in many areas have been less profitable even loss-making. The main reason for the loss is due to undersupply of feedstock and high cost. Take yancheng city, jiangsu province for example, it has abundant straw resources, but up to eighty percent of straws are burned or discarded directly on the field, thus the whole straw utilization rate is low.

There are abundant straw resources in our country, but straws are always under supply in the actual operation of supply chain. Two main reasons account for this phenomenon. First, Raw material production is seasonal and dispersed, which causes difficulty to the storage and transport. Second, Farmers and brokers think they do not get the desired benefits, and straw purchasing price is not high enough to arouse farmers' enthusiasm to collect straws. Combined with busy crop harvest season, farmers would leave straws idle or burned in situ rather than waste time to collect. However, the burning of straws not only restricts the development of straw power generation industry, but also causes serious air pollution, which is a departure from the idea of sustainable development. Therefore, in order to solve the problem caused by the shortage of raw materials, the most important thing is to consider how to arouse the enthusiasm of farmers with straws, as well as carry out research on logistics cost of supply chain to minimize the cost of transportation.

At present, the studies on straw power supply chain mainly focus on the risk of project investment<sup>[1]</sup>, the cost of raw material collection<sup>[2]</sup>, the biomass supply organization structure<sup>[3]</sup>, the site selection of power plant<sup>[4]</sup>, the evolutionary game<sup>[5]</sup> and so on. F. Mafakheri, F. Nasiri<sup>[6]</sup> et al. have studied on the biomass power generation supply chain from biomass harvesting, collection, processing, warehousing, transportation, energy conversion and the entire supply chain coordination perspectives, so as to reduce the cost of supply chain and ensure continuous supply of raw materials of biomass power plant. However, apart from the economic behaviors of power plants, brokers and farmers, the government also plays an indispensable role in the rise and development of the straw power generation industry. A number of studies have indicated that the incentive policies taken by the government have important significance to the sustainable development of the supply chain. Mitra Set<sup>[7]</sup> et al. established two-stage game model of manufacturer and remanufacturer and analyzed the important role of government subsidies in remanufacturing activities by comparing three cases: the government giving manufacturers subsidies, giving remanufacturer subsidies and giving both subsidies. Zhu Qinghua<sup>[8]</sup> et al. built and analyzed a three-stage game model containing product's green degree and government subsidies in green supply chain, and concluded that when the marginal cost of green product is too high or consumers' awareness of environmental protection is too low, the government can appropriately reduce subsidy ceiling to guarantee producers' profit. Likewise, based on contract theory and Nash bargaining theory, Chen Zhisong<sup>[9]</sup> constructed models of wood-based panel green supply chain under centralized optimization decision-making, decentralized equilibrium decision-making and negotiation coordination decision-making, and finally verified the effectiveness of government incentives for the operation of wood-based panel supply chain. Similarly, under the government policy regulations and incentives in the straw power supply chain, farmers' and brokers' initiative to collect and process straws will be significantly enhanced, conducive to continued stable operation of straw power supply chain.

## **2. Model and analysis without government incentives**

### *2.1. Influencing factors of straw power supply chain cooperation*

Straw power supply chain cooperation is a complex dynamic game process, which involves the production, collection, transportation, storage and so on. Farmers are straw producers. Brokers buy original straws from farmers and provide collection, storage, processing and transportation services. Then brokers sell the processed straws to straw power plant. Finally, straw power plant transform purchased straws into straw power sold to state grid corporation. The influencing factors of straw power supply chain cooperation are as follows:

**Purchasing price.** Profit is the top priority for supply chain members. Too low straw purchasing price will directly reduce the enthusiasm of farmers to collect straws, so brokers also make it difficult to do a good job in the acquisition of raw materials. Besides, too high straw purchasing price cannot guarantee power plants' interest.

**Trust.** In reality, the information is incomplete or asymmetric, and there is a game between the two sides. Due to the reality of the collection difficulties (e.g. busy agricultural work, storage space), farmers will select other simple

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