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Case Studies on biofuel supply logistics for forest bioenergy in China

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ABSTRACT

In China, the poor supply logistic and the high feedstock cost are the most critical constraints to the development of forest bioenergy. The aim of this study is to identify the supply logistic from forest land to the final delivery for bioenergy utilization. A case study approach was used to collect the relevant information and data. And two different supply logistics of wood biofuel were designed for two locations in Inner Mongolia, one was from collective forests and the other was from state-owned forests.

KEYWORDS

Supply logistics;
Bioenergy;
Forest;
Case study;
China.

INTRODUCTION

Bioenergy is considered to be a fossil fuel that substitutes to offset greenhouse gas (GHG) emissions. In China, the development of forest bioenergy is emerging as a part of the solution to the country's energy challenges. Progress is being made with the establishment of several small-scale projects and China's central government predicts its power-generating capacity using agricultural and forest bioenergy will be some 24 GW by 2020[1]. Previous studies have demonstrated that forest biomass is particularly promising for bioenergy utilization because it is abundant, can play a positive role in the forest environment management, reduces carbon dioxide emission, and can contribute to improve human welfare[2-5].

The principal constraints associated with the increasing utilization of forest biomass for bioenergy are supply logistics of harvesting, collection and transportation. Supply logistics have been well documented in North America and European countries, focusing on supply system design with affecting factors of harvesting and transportation, models of estimating supply chains and costs[6,-8]. Whereas in China, only limited information is available for the supply logistics of forest biomass using for bioenergy. Several affecting factors were preliminarily considered in the previous studies, including harvesting machine, hauling distance and selection of storage location[9-11].

The primary purpose of this study is to identify the supply logistics for two locations in Inner Mongolia: Naimanqi which has a bioenergy plant supplied by collective forests and Arxan, where a proposed bioenergy plant would be supplied by state-owned forests. To evaluate supply logisticÿwe focused on factors such as geographic distribution, climatic conditions, ownership of the forest, production process and institutional arrangements.

FOREST OWNERSHIPAND MANAGEMENT IN CHINA

Forest ownership can influence forest biomass supply to bioenergy plants. Two main types of ownership exist in China, state-owned forests that are owned by the national state and managed by state Forestry Bureaus, and collective forests owned by collective organizations such as townships and villages. Generallyÿstate-owned forests are of larger scale and located in ecologically important or sensitive areas. Conservation is an important goal of most state-owned forests. Government strategies of the late 1990s led to severe financial difficulties for many state Forestry Bureaus by drastically reducing timber harvests and at the same time boosting afforestation and reforestation[12]. According to the current forest laws, Forestry Bureaus should run economically viable operations and improve the welfare of forest workers while at the same time protecting the ecological integrity of forests. Experience in several Forestry Bureaus (in Chongqing and Shanxi) has shown that this could be achieved by diversifying into new forest products and markets. Collective forests are divided into small plots that are contracted to local farmers or organizations. Harvesting requires a license issued by the local government and reforestation is mandatory.

Bioenergy from forest biomass has the potential to improve profitability of forest management operations if more harvested wood can be used commercially. Richardson et al.[13] even ascertained that bioenergy production under sustainable forest management provided widespread benefits at all levels of society. Aside from providing additional revenue to Forestry Bureaus and forest license holders in China, the use of forest biomass for commercial bioenergy may increase the economic viability of reforestation and shrub coppicing. A study of shrubs planted as shelterbelts to stop desertification in northern China found that shrub coppicing yields five to seven tonnes of branches per hectare every year[14] and that selling the biomass for bioenergy can generate 500 to 700 yuan per hectare annually.

METHODS

A case study methodology was used to collect and analyze the data and other pertinent information in this study. As an empirical inquiry method, a case study seeks multiple sources of evidence highly relevant to the research questions, and leads to an in-depth understanding of the case[15]. In the study, two cases in Inner Mongolia were selected in order to obtain independent conclusions from each case as well as to illustrate contrasting situations. And the data included interviews with representatives from related organizations, farmers and workers, field observations, and secondary data sourcing from institutional reports, company documents and government internet and research journals.

Arxan and Naimanqi, both located in the Inner Mongolia Autonomous Region of China, were chosen as cases in this study for the following reasons: (1) there is currently a lack of experience in forest bioenergy projects in China and few people are well-informed about forest biomass for bioenergy. However, Naimanqi has already established a bio-power plant using forest biomass as feedstock. Meanwhile, in Arxan, a bio-power plant have been in planning; (2) the two typical forest ownership types in China are state-owned forest and collective forests and they are represented by the two cases. Arxan has state forests while in Naimanqi the forest biomass mainly comes from collectively owned forest; and (3) the forest ecosystems in the two locations are very different but the two areas share key socio-economic attributes. Specifically, Arxan and Naimanqi are similar in the scale of the bioenergy power plants, forest biomass requirements, levels of regional economic development, and household energy consumption.

DESCRIPTION OF THE TWO CASES

Naimanqi case

Naimanqi, a county of Tongliao regionÿis located in the east of Inner Mongolia Autonomous Region. Twelve townships exist in Naimanqi with a total of 96 villages. The total area in Naimanqi is 815 900 ha with forest covering 216 000 or 29% (see TABLE 1). The forest is either collectively owned (80%) or state-owned (20%).

Within a radius of 80 km of the bio-power plant, about 630 000 tons of forest biomass is available for bioenergy, including shrub branches from coppicing,

TABLE 1 : Demographic and forestry characteristics of the two cases areas

Characteristics	Naimanqi	Arxan
Total area (Km^2)	8 159	7 409
Gross population	431 000	56 000
Forest area (Hectare)	216 000	464 000
Forest cover rate (%)	29	64
Household wood fuel consump	100 000	111 000

felling residues, thinning material and wood processing residues. Consumption of wood fuel as household fuel was estimated at 100 000 tons per year by the local Forestry Bureau. Therefore, the local forest biomass supply is sufficient to meet the fuel requirement of the power plant, 160 000 tons per year.

Arxan case

Arxan, a typical state-owned forest area, belongs to the Conservation Areas of Natural Forests of Inner Mongolia. Its forested area and forest cover rate are more than double than Naimanqi's (TABLE 1). The forest is administered by four Forestry Bureaus: Arxan Municipal Forestry Bureau, Arxan Forestry Bureau, Bailang Forestry Bureau and Wuchagou Forestry Bureau. The planning bio-power plant would be the same size as the Naimanqi case at a capacity of 24 MW. It is estimated that over 600 000 tonnes of wood residues was available as fuel within a collection radius of 50 km of the power plant. More than 110 000 tonnes of wood fibre is currently used for household heating and cooking annually. Per capita wood fuel consumption is higher in Arxan than Naimanqi because wood is more easily available from wood processing plants and wood fuel collection. This leaves sufficient potential forest biomass for the proposed bio-power plant.

FOREST BIOMASS SUPPLY LOGISTICS FOR FOREST BIOENERGY

Organisation and management logistics

In Naimanqi, forest biomass for bio-power generation is collected from the collective forests of 96 villages in the twelve townships. The forest is contracted out by tenure to local farmers in small plots of 0.5 to 2 hectare. A total of 12 township agents and 96 village agents arrange the forest biomass collection. Figure 1 summarizes the organization of the power plant, the Forestry Bureaus and the agents at the collection sites. The power plant signs contracts with the individual agents. The village agents organize the collection of forest biomass by the local famers, while the township agents supervise the village agents in their respective townships.

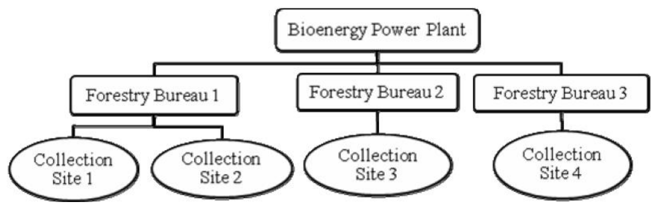

Figure 1 : Organization of forest biomass supply for bioenergy in Naimanqi case

The potential logistics of Arxan have been developed by the Forestry Bureaus, as shown in Figure 2. The proposed bio-power plant will contract with the three neighboring Forestry Bureaus within a 50 km radius: Arxan Municipal Forestry Bureau, Arxan Forestry Bureau and Bailang Forestry Bureau. There are four proposed collection sites for collecting, chipping and storing the forest biomass. Several factors were considered for determining the location of the collection sites: road infrastructure, suitable storage area, processing equipment availability and fire safety provisions.

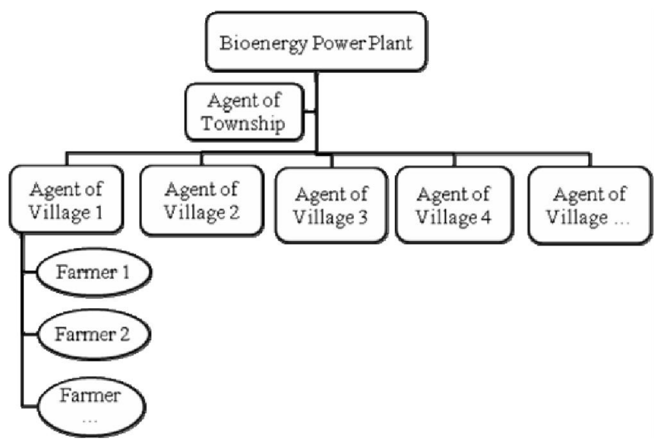

Figure 2 : Organization of forest biomass supply for bioenergy in Arxan case

Forest biomass supply chains for bioenergy

Figure 3 summarizes the main processing steps from the forest land to the bioenergy plant (skidding, hauling, chipping, storage and transportation). The two cases differ in some respects.

In Naimanqi, the collection, including skidding and hauling, is conducted by a single farmer or a family be-

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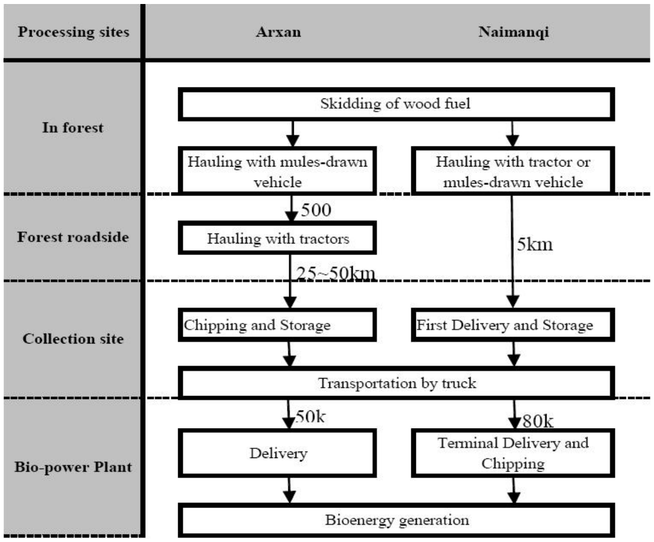

Figure 3 : Forest biomass supply chains in Naimanqi and Arxan

cause there are many collection sites and the hauling distance from the forest to the village collection site is short at no more than 5km. When a relatively large amount of forest biomass is accumulated at the collection site, it will be bundled and transported by truck to the power plant 80 km away. The forest biomass is chipped at the bio-power plant before being fed into the boiler furnace.

In the Arxan, the proposed forest biomass supply chain has more steps than the Naimanqi case. The collection activities from the forest land to the collection site would be carried out in three steps and by three separate workgroups because of the extensive distribution of the forest and the heavy snow in winter. Firstly, forest biomass is piled by hand in the forest land; then it is hauled an average 500 m to the roadside with a mule-drawn vehicle where the wood is transferred on to tractors that haul it to a collection site, 25 km to 50 km away. The chipping and storage steps are carried out at the collection sites with chippers special technical facilities. The chipped biofuel would be transported 50 km to the planned power plant by truck.

CONCLUSION

In conclusion, a detailed two-case study was carried out in Inner Mongolia, one case represented a forest biomass supply chain from collective forests and the other case from state-owned forests. The supply logistics differed in both cases in terms of how the forest biomass collection was carried out, the number of collection sites and the type and size of equipment used. A significant result of the study is that a shorter collection distance, a more simplified division in work and more larger-scale equipment was incurred in Naimanqi than Arxan. Based on the assumption of using the existing equipment in the Arxan case, more equipment and fuel would be consumed in the hauling process.

At present, commercial bioenergy from forest biomass is still in its infancy in China and little case data is available to compare with the supply logistics in Arxan and Naimanqi. So there are still some uncertainties in the evaluation of forest biomass use for bioenergy.

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