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A Study on Biomass Power Generation in Rural India

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Abstract

India as a developing nation is one of the greatest energy consumer. Because of nonstop increment in energy request and utilization of non-renewable energy sources have caused numerous natural outcomes, particularly air contaminations and carbon dioxide discharge, which is main factor of worldwide worry about environmental change. India has dependably try endeavors on advancing the advancement of sustainable power source to respond to the call of carbon dioxide discharge lessening.

In the meantime, India, as a substantial agricultural nation also, is plentiful in biomass assets. As a sustainable power source, biomass control age has a quick development in past a couple of years in India. Numerous articles and reports think about on the general circumstance of sustainable power source or biomass usage. A few conclusions are vulnerable, since a few contentions are clashing with each other, a further examination is important to know this industry at nearer extend.

The point of this study work is to explore current circumstance of biomass coordinate burning force age in India. The examination is case-based investigations, which are regularly rung base investigations. The primary outcomes and conclusions originate from examination of undertakings went to amid field think about. In addition, general learning and investigation about biomass control industry utilized information from different sources including factual reports, writing, directions and strategies. Most information is direct and untreated to ensure the dependability of result and conclusion.

Through the examination of the plant parameters, economy, framework and related strategies, right now the primary impediment for proficient use of biomass control age is fuel source. To control fuel source is noteworthy to run fruitful business. Arrangements give the solid motivators to contribute biomass control age ventures. The discoveries not just comprehend the present status of the business, yet in addition give profitable experience to accomplish a superior future improvement

Introduction

The China, with 1.3 billion people, is the world's most populous nation and the world'ssecond largest economy. From 2000 to 2009, China has maintained an extravaganteconomic development, with an average growth of GDP at 9.73% per year. In parallelto this impressive economy growth, total primary energy consumption increased from1394 million tons (Mton) of equivalent standard coal in 2000 to 2920 Mton in 2009,reflecting an average annual growth rate in 7.7%. At present, China has become theworld second energy consumer [1] (Based on IEA data, China has surpassed the U.S.to become the world's biggest energy consumer [2]). From figure 1.1, it showsobviously that coal is still the dominant source of energy supply (Figure 1.1),representing roughly 74% of the supply [3].

The continuously increased energy demand and the use of fossil fuels has alsoresulted in many environmental consequences, especially air pollutions and CO2emission, which is key factor of global concern about climate change.China has always make efforts on promoting the development of renewable energy. Inthe "Mid- and Long-Term Development Planning for Renewable Energy" issued bythe National Development and Reform Commission (NDRC), China set an ambitioustarget for renewable energy in next fifteen years. The overall objective isl Increasing the proportion of renewable energy in total energy consumption;

Solving problems of electricity supply and fuel shortages in remote and rural
areas;
The Implementing utilization of organic waste as energy source;
Promoting technology development of renewable energy.

The concrete target is by the end of 2010, the renewable energy consumption reach to10% of total energy consumption. By 2020, it will account for 15% of primary energyconsumption [4]China is a large agricultural country as well, which is abundant in biomass resources.According to statistics, in China, more than 600 million tons of straw are producedannually, in which about 400 million tons can be used as energy source [5]. Theefficient use of biomass resources will make more rational allocation of resources andavoid pollution from direct burning of straw waste.Direct straw-based combustion has developed rapidly in recent years, since thetechnology applied is not quite complicated. In line with this development, thebiomass power industry faces some obstacles as well as challenges to move on.

Aim

The aim of this project work is to investigate current situation of biomass directcombustion power generation in China. The study will also take the policy analysisinto account, in order to see how policy, including clean development mechanism cansupport (CDM), support the development of this industry. The aim will be succeedmore specifically by exploring the following research question.

1. What is the general situation of development of biomass power generation inChina?
2. What are the important factors contributing to efficient application of biomasspower generation in China?
3. What kind of role do the policies (include CDM) play in biomass powergeneration?The aim is mainly achieved by literature review, field visiting and interview. Theexpected outcome of this paper is to find improvements or experiences in biomasspower industry.

1.2 Delimitations

- The biomass power generation in this study doesn't include the garbage power
- and biogas power generation
- Only biomass direct combustion technology is included in this study.
- No environmental analysis is done.
- Specific technical analysis is not included in the study.
- Some economic analysis is applicable to support the argument.
- The field study is to obtain the first hand information rather than to collect data
- for a quantitative statistical analysis.

1.3 Limitations

The study is carried out with limited time schedule. It is impossible to collect enoughand proper samples for univariate analysis. This has influence on the accuracy of theconclusion. Since the scale of biomass power plant is small, there is less informationpresented on the website. Hence, the statistical analysis is not completed.

2 Background

In this chapter, theoretical background information is presented for the thesis work. Itstarts with general introduction of biomass and biomass utilization. It is followed bysection 2, which discuss the technologies and production processes applied in thebiomass power industry. At the end of this chapter, it brings up a short introduction ofclean development mechanism (CDM).

2.1 Biomass

Biomass refers to a variety of organisms through photosynthesis in nature. Biomass isabundant in content and a wide range of materials, mainly including wood cellulose,starch and sugar and other form [6]. Bioenergy is originally from the sun, so thatbiomass is a form of solar energy. Biomass is the most important absorber of solarand storage, biomass through photosynthesis, solar energy can be enriched and storedin organic matter which is a source of energy for human development. The biomasscan be converted to conventional solid, liquid and gaseous fuels or burned directly.Compared to fossil fuels, the vital difference is one of time scale. Biomass takescarbon out of the atmosphere while it is produced, and returns it as it is burned [7]. Inthis perspective, biomass is the only current sustainable source of organic carbon.

2.1.1 Biomass resource in China

At present, biomass energy source has two categories. One category is from humanplanted biomass sources such as energy crops, energy forest. The other categorycomes from 'waste', such as crop residues, forest residues, municipal solid waste, andindustrial organic waste [8].Crop residues and forestry waste are currently the primary source for biomasscombustion power generation in China [8].

2.1.1.1 Crop residues

Agricultural biomass resources in China are mainly crop straws as well as rice husks,corn cores, and bagasse from food processing. The straw can take up to 50% of thecrops. [9] According to agriculture production, crop straw uses, and residues formagricultural product processing, it is estimated that in 2008, there were about 816million tons of crop biomass resources producing in China [8]. The primary use andestimated amount of crop straw can be seen from the following pie chart (fig 2.1). [8]Since the geology and climate vary a good deal from region to region in China, thedistribution of agricultural resource is different in different provinces. Table2.1presents the estimated quantity of agricultural residues in different regions ofChina in 2008. [49]

From table 2.1, it could be concluded that The geographic distribution of strawresources is significantly regionalized. Due to different natural climatic,socio-economic and customary traditions, the planting structure between regions isvastly different. The most agricultural product yields are in Central south and East ofChina, accounting for 35.5%, and 22.1%, respectively of the national yield. [49]Especially, some big agricultural provinces such as Henan, Hebei, Shandong, investmany biomass power generation projects. [50]

2.1.1.2 Forestry waste

Forest residues mainly include harvesting and wood processing residues, forestmanagement cuttings, small branches as well as municipal green forest cuttings. Theforestry biomass resources and availability in 2008 are estimated about 368 milliontons. [8] The residues can be used in rural household and paper mill.The energy potential of the two main kinds of sustainable biomass resources can beevaluated by comparing them to China's energy consumption in 2009. Lower heatvalue of standard coal is used for 35 MJ/kg, while the heat value of agricultural andforest biomass (dry basis) is 20 MJ/kg (seen from table 2.2). Coal combustion systemefficiency is increasing. The standard coal consumption of generating 1 kWh ofelectricity in China is 339 g during 2009 [49]. The biomass consumption ofgenerating 1 kWh of electricity in China is about 1000 g (see table 4.5). The availableagricultural and forest biomass can replace 123 000 000 tons standard coal, whichtake up 4% of China total energy consumption in 2009.

2.1.2 Utilization of biomass in energy sector

There are several technological options available to make use of biomass as a sourceof renewable energy. It may convert to other form energy carrier, such as liquidbiofuel or combustible biogas, through both thermochemical and biochemicalconversion technologies. It may release the energy directly, in the form of heat orelectricity as well.In general, at present, the utilization of biomass as a source of energy in Chinaincludes biogas heating, liquid fuels and biomass power generation as follows (figure2.2) [5].

China is famous for biogas technology in the world, especially in small scale biogasproduction for heating and cooking in rural area. The technology used is relativelymature and spread rapidly. Till the end of 2010, the annual biogas output in rural areais 13 billion cubic meters, which has been used by 40 million rural families [10]. Butthe operation situation is not that ideal. Since the peasants didn't gain enoughknowledge of biogas technology, especially the management experience, the biogassystem didn't spread well in countryside. [11]

Liquid biofuels can utilize diversified biomass feedstock, have various technicalprocesses, and produce different biofuel products. Currently, fuel ethanol from grainand sugar and biodiesel from oil feedstock has been used in industrial production andcan be competitive in the market, while other biofuel techniques are still immaturedue to the higher cost compared with fossil gasoline and diesel products. [8] In thelong-term perspective, biofuel still need more research on improvement of techniqueas a sustainable replacement of petrol.
The biomass power generation includes direct straw combustion, gasification powergeneration, garbage incineration and biogas power generation. [8] Among thesetechnologies of biomass power generation, the straw direct combustion is in themajority, since the technology is easy to access compared to gasification. In recentyears, the number of biomass power plants and installed capacity has increasedrapidly.

2.1.3 Combustion property of biomass
Biomass fuel is quite different compared to the coal. Biomass is highly oxygenated.Typically, 30 to 40 wt. % of the dry matter in biomass is oxygen. [13] The table2.1lists the compositions and heating values index for common biomass fuel used inChina and coal as an indicator. As shown from the table 2.1, the volatile matter inbiomass is 3 or 4 times higher than that in coal, while the fixed carbon is lower, whichis only 14%-22% in weight of biomass compared to 77% in coal. Another importantcharacter is element sulfur, which is very low content in biomass. Hence, biomass isbelieved less harmful to the environment.However, it is a fact that the heating value of biomass is much lower than that of coal.The heat value, or amount of heat available in a fuel (kJ/kg), is one of the mostimportant characteristics of a fuel because it indicates the total amount of energy thatis available in the fuel. The heat value can be expressed in one of two ways: thehigher heating value (HHV) or the lower heating value (LHV). The higher heatingvalue (HHV) is the total amount of heat energy that is available in the fuel, includingthe energy contained in the water vapor in the exhaust gases. The lower heating value(LHV) does not include the energy embodied in the water vapor. The heat content ofdifferent species can vary significantly depending on the climate and soil in which thefuel is grown, as well as other conditions. [12]

(Source a. http://www.mxswz.com/news/2011121361.html the heating value is measuredby oxygen bomb calorimeter.Source b Reference [13] Combustion properties of biomassc: here refer to the higher heating value of coal)There are three stages during combustion of biomass. First, the moisture content inthe biomass evaporated to water vapor at temperatures up to 100°C, using heat fromother particles that release their heat value. Second, as the dried particle heats up,volatile matter contain in biomass is released as gases such as hydrocarbons, CO

CH4. In a combustion process, these gases contribute about 70% of the heating valueof the biomass. Finally, the residual coke was burned and ash remains [14].This flow chart shows the general process for yellow straw-firing power generation,which is currently used in the biomass power plant constructed by National BioEnergy Group. The whole process contain sophisticated charging system, theheavy-duty bag filter, the four combustion processes, the water-cooling vibratingstoker, the unique flue gas and steam heat exchange system (high- and low-pressureflue gas coolers) and the steam-air heat exchange system (high- and low-pressure airheaters).Straw bale grabbed from fuel storage bin and the fuel is unpacked through the beltconveyor, and fed into the boiler through the feeder and water-cooling sleeve. In theboiler, some fuel is fired on the grate and the other fuels is suspended and burned inthe furnace. The high temperature and pressure steam produced by the boiler drivesthe turbine rotor to turn at a high speed. The generator and the turbine is connectedvia a coupling. The electricity produced by the generator is transmitted into the powergrid by certain voltage through the transformer.Flue gas produced through fuel combustion goes through the cyclone dust collector,bag filter to separate the dust particles. After that, the cleaned gas clean the flue gasemit into the atmosphere via the chimney. Fuel wastage can go back to farmland asfertilizer.

2.2.1 Boilers

Generally, there are two types of combustion technique applied in biomass powerindustry in China, grate combustion and fluidized bed combustion.[19]

2.2.1.1 Grate combustion

Grate combustion is a traditional technology and well developed technology forburning solid fuels. [15] Grate is the effective burning parts in the boiler. Usually, theentire grate contains two parts, frame and grate segment. Grate segment normally ismade of cast iron. There is necessary ventilation gap between the pieces of segment toensure the mix of fuel and air. Crushed stalks and other biomass fuels are transportedto grate boiler from the feeder. The fuel was rapidly dried by hot wind and ignited.The burning fuel was sent into the grate and burn out. Grate has various types, such asfixed, reciprocating, and vibrating, etc. [19]Grates are less tolerant for fuel quality variation than fluidized bed boiler. It requiredrelatively stable combustion property of fuel [15]. Due to the existence of hightemperature zone， fused ash will condense and cover on the heat surface. Besides, thefused ash cannot be fertilizer [16].

Method

In this chapter, the methods used for carrying out this thesis work are described. First,the structure of the methods is explained to give an overview on how the differentparts of analysis are connected throughout the work. Following this, the highlightedpart of the chapter, is constituted the description of the field study, includinginterviews and data collections

3.1 Structure of methods

The type of system analysis and the limitation of time make it hard to applyclassically statistical analysis with enough samples. The study can be regarded asproject-oriented studies, which are often called bottom-up studies. The result of studyis descriptive semi qualitative. The core part of this paper is to use the casesinvestigation to get the entire view of biomass power industry in China.The thesis work was carried out in three steps. First background knowledge wasgained by a literature review. Besides, the stage includes elementary data collectionand clarifies the research boundary that is the focus of research questions. Then astatistical analysis is taken to summary the general knowledge about the biomasspower generation. After that, a field study was taken during two months stay in China.

3.2 Data collection

The data for this report is collected in three ways, literature review, pieces of news ornotification from website, interviews from field study. A literature review was made at the beginning of the project, to gain basic knowledge about the situation of bio mass power industry in China. This information is mainly based on scientific articles. Some critical aspects formulated the aim and research questions of the study. The information from website is more complicated. The news reports sometimes are contradictory. The data is distributed and hard to be collected. The interview and field study are the most significant source for analysis and results. This part is to gain fisth and information and get deep knowledge about the current situation of this industry. The data from interview is not enough to do statistical analysis. It was only used for qualitative comparison.

4.1 China's biomass power industry

The first biomass power generation project was installed in Shandong Shanxian byNational Bioenergy Group and completed in December 2006. The project appliedDanish BWE technology manufactured in China. With total investment of 340 millionYuan, the installed capacity (rated power of steam turbine, similarly hereinafter) ofthe project is 30MW. [23] After this, the biomass power industry began to developrapidly. By the end of 2007, a total number of 16 straw direct firing projects havebeen completed with total installed capacity up to 367MW. 29 biomass direct firingprojects were completed in the year 2008 with total installed capacity of 618MW.These biomass projects were mostly developed in China's Shandong, Jiangsu, Henan,and Hebei, which are important agricultural provinces. [8] By 2009, 32 new projectedwere constructed, while the total installed capacity was doubled again up to 1253 MW.[24] After June 2010, since the policy changed, no complete statistic is available onofficial website. Based on 11th five years plan for renewable energy [48], the totalinstalled capacity of biomass power generation should reach to 4000 MW by the endof 2010. From the table 4.1, obviously the development of biomass power generationdid not reach the target.

6 Conclusion

Biomass power generation industry has just developed for recent years. But itdeveloped rapidly. Now, there are more than 100 biomass power generation project.Since the scale of this kind of biomass power plant is much smaller than that ofconventional coal fired power plant, little information could be found online. Thereare both positive and negative news about this. And there is few scientific articlesabout this specific area as well. This report aimed to investigate this area bycombining scientific articles, information online and case study. The case study iscarried out by field study and interview. The questionnaire was well prepared toanswer the specific questions in the beginning of this report. The collected answersfrom different projects are the main source of results in this report.From the case study, it can conclude that on the whole government policy is the keyfactor for the boom and development of biomass power generation in China.Generally, some projects are running well whereas some are not. Many new projectsare under construction. The entire industry develops vigorously in recent years.Considering that the target of renewable energy set by NDRC, the expansion of thisindustry is predictable in next ten years.From perspective of current situation, the fuel source apparently is the most severeproblem for almost all power plants. On one hand the fuel quality has the most impactof continuous production, on the other hand, the fuel price influence the profit directly. These are caused by two reasons. One is competition for the fuel source because of the close distance of power plants. Another reason is difficulty of collection caused by the distribution characteristics of agricultural planting. The former problem can be relieved by rational planning in one area. The latter is impossible to change. This is why large scale biomass power plant is hard to operate in China. Owning to the difficulty of fuel collection and bad fuel quality, it is more flexible to select equipment of smaller scale. Technology is another factor investigated in this report. In Zhen-yu Zhao's article, [5] a recent article on assessment of the biomass power generation industry in China, the author concluded that 'due to lack of core technologies, the operation and maintenance of China's biomass power generation system will continue to rely on the Western manufacturers in the near future.' However based on my study, technology is no more obstacle of development of biomass direct combustion power generation. Although there is no cost analysis for foreign technology and domestic technology, both of them can have good performance of continuous production. Two kind of technologies are both considerable when designing a new project. Therefore, a solution for current difficulties power plants face is to control the fuel source. Centralized fuel processing might be the direction of future development. For 47 the long term, the development of manufacturer and material suppliers as well as costumers is of great significance for the development of this industry. Renewable energy is strongly dependent on the preferential policy, especially the subsidy. Subsidy provides the economic incentive to do investment in biomass power generation. It is important to conclude that the current policies are enough to make this business profitable from perspective of economy without considering the uncontrollable straw price. As analyzed before, CDM makes up a small proportion in the whole revenue. But it is a beneficial complement for biomass power generation project. What should be done is that the implementation of policy and overall planning are still need more improvements. Especially, the fuel suppliers are usually a small private business, which lack of supervision. To be conclude, to promote the development of the whole industry chain should promote the healthy development of the biomass power generation industry.

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