Dissertationes Forestales 131

Social climate of forest bioenergy development in China among forestry stakeholders

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Academic dissertation

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ABSTRACT

With industrialization and urbanization, energy security has become an increasingly pressing global issue. This situation is arguably one of the most challenging problems facing China. In order to not only continue its economic development, but also adopt a bioeconomy, energy efficiency needs to be improved and the use of renewable energy, such as forest bioenergy, increased. In China forest bioenergy has been developed through policy incentives as well as through the development of related technology. However, public acceptance of forest bioenergy might be one of the key obstacles to its development. Therefore, understanding and, if needed, improving the public acceptance of forest bioenergy is vital.

Forestry stakeholders play key operating and managerial roles in the development of forest bioenergy. Their perspectives influence the progress of the production, the orientation of the market, and the use of bioenergy, particularly in the early stages of the development. The dissemination of reliable information and knowledge provides support for the acceptance of forest bioenergy in society.

The main objective of this research is to study forest bioenergy development in China and to identify how forest sector stakeholders influence the policy development and its implementation in the country. More specifically, this thesis has the following research tasks: to determine, through content analysis, how the government and the public use Internet platforms to discuss bioenergy; to assess the current situation of forest bioenergy development in China among academic experts via a Delphi survey; to examine different stakeholders' (students and forestry professionals) knowledge and sources of information about bioenergy, especially forest bioenergy; to identify different stakeholders' energy use related behaviour in everyday life, future energy preferences, and perceptions of, and attitudes towards forest bioenergy in China.

The main findings of the work are: 1) the growth in the number of news articles reflects the changes and outcomes of the government's energy policies, 2) research and technical shortcomings, policy and regulation weaknesses, and low awareness and poor social acceptability are the main barriers recognized, 3) biofuels will be the most important transportation fuel in the future and the experts felt that it may replace oil in the next ten years, 4) the students and forestry professionals felt that the Internet and television are the most accepted media for disseminating information and knowledge, 5) the experts and professionals have similar perceptions concerning the development of forest bioenergy in China, and the students have somewhat difference perceptions compare with the experts and professionals. This research provides the first look at the perspectives of different stakeholders regarding the development of forest bioenergy in China. The findings indicate that there is wide support and great potential for forest bioenergy development in China.

Keywords: Climate change mitigation, content analysis, expert knowledge, forest bioenergy, professional attitudes, public perceptions, survey study, sustainable development in environmental issues.

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Joensuu, August, 2011

Mei Qu

LIST OF ORGINAL ARTICLES

This research thesis is based on the following articles, which are listed below, and referred to by Roman numbers. Articles I-III are reproduced with the kind permission from the publishers. Article IV is the author version of the submitted manuscript.

I Qu, M., Tahvanainen, L., Ahponen, P. & Pelkonen, P. 2009. Bio-energy in China: Content analysis of news articles on Chinese professional internet platforms. Energy Policy 31: 2300-2309. doi:10.1016/j.enpol.2009.02.024

II Qu, M., Ahponen, P., Tahvanainen, L. & Pelkonen, P. 2010. Chinese academic experts' assessment for forest bio-energy development in China. Energy Policy 38: 6767-6775. doi:10.1016/j.enpol.2010.06.047

III Qu, M., Ahponen, P., Tahvanainen, L., Gritten, D., Mola-Yudego, B. & Pelkonen, P. 2011. Chinese university students' knowledge and attitudes regarding forest bio-energy. Renewable & Sustainable Energy Reviews 15: 3649-3657. doi:10.1016/j.rser.2011.07.002

IV Qu, M., Ahponen, P., Tahvanainen, L., Gritten, D., Mola-Yudego, B.& Pelkonen, P. Practices and perceptions on the development of forest bioenergy in China from participants in national forestry training courses (Submitted manuscript).

The author's contribution

I Mei Qu originated the research idea, collected the data, analyzed the data, and wrote the manuscript. Pelkonen, P. helped with developing the research idea. Ahponen, P. gave advice on data analysis. Tahvanainen, L., Ahponen, P., Pelkonen, P. commented and improved the manuscript.

II Mei Qu originated the research idea, collected the data, analyzed the data, and wrote the manuscript. Pelkonen, P. helped with developing the research idea. Tahvanainen, L., Ahponen, P., Pelkonen, P. commented and improved the questionnaire and the manuscript.

III Mei Qu originated the research idea, collected the data, analyzed the data, and wrote the manuscript. Pelkonen, P. helped with developing the research idea. Mola-Yudego, B helped with the data analysis. Ahponen, P., Pelkonen, P. and Tahvanainen, L. commented and improved the questionnaire and the manuscript. Gritten, D. and Mola-Yudego, B. helped with the improvement of the manuscript.

IV Mei Qu originated the research idea, collected the data, analyzed the data, and wrote the manuscript. Pelkonen, P. helped with developing the research idea. Ahponen, P., Pelkonen, P. and Tahvanainen, L. commented and improved the questionnaire and the manuscript. Gritten, D. and Mola-Yudego, B. helped with the improvement of the manuscript.

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ACRONYMS AND ABBREVIATONS

A&F	Agriculture and forestry background
ANOVA	Analysis of variance
BOE	Bureau of Energy (China)
CASS	Chinese Academy of Social Science
CEC	Commission of the European Communities
EIA	U.S. Energy Information Administration
FAO	Food and Agriculture Organization of United Nations
FEB	Forest bioenergy
KP	Kyoto Protocol
MITRE	Monitoring and Modeling on the Targets of Renewable Energy project in EU
MOA	Ministry of Agriculture (China)
MOF	Ministry of Finance (China)
MOST	Ministry of Science and Technology (China)
NDRC	National Development and Reform Commission (China)
NGO	Non-governmental organization
NPC	National People's Congress
NWAFU	Northwest Agricultural and Forestry University in Shaanxi Province
R&D	Research and Development
RMB	Ren Min Bi (Chinese currency Yuan)
PFB	Provincial forestry bureau
PRC	People’s Republic of China
SFA	State Forestry Administration
SPSS	Statistical Product and Service Solutions
SRF	Short Rotation Forest
STAFA	State Academy of Forestry Administration (China)
SD	Sustainable Development
UNFCCC	United Nations Framework Convention on Climate Change
mill	Million
bill	Billion
ha	Hectare
Tce	ton of coal equivalent

1 INTRODUCTION

1.1 Background

Climate change is one of the great environmental, social and economic challenges currently facing the world. In order to go some way to address these challenges the United Nations Framework Convention on Climate Change (produced in 1992, coming into force in 1994) (UNFCCC) and the Kyoto Protocol (1997) (KP) have been ratified by numerous countries. Additionally, the principal aim of the Rio Declaration is to steer countries along a development path that is sustainable, the priority of which is to develop the energy sector by balancing the use of natural resources and protecting the environment (Rio Declaration 1992).

With continuing global industrialization and urbanization, climate change has become an increasingly serious problem. The rising sea levels, increasing occurrence and severity of drought, unstable agricultural production, the reduction of forest areas and the declining functions of wetlands are usually connected to climate change. The need to reduce greenhouse gas emissions is a fundamental issue concerning global sustainable development policies now and in the future. The climate change has greatly affected environmental conditions and human health in many countries including China (Hitz and Smith 2004). It is very likely that future climate change would continue to cause significant adverse impacts on the ecosystems, agriculture, water resources and coastal zones not only in China but also elsewhere (Lin et al. 2007). As a response, China has realized the urgency of mitigating climate change (He et al. 2007).

In 2007, China's National Development and Reform Commission (NDRC) drafted China's National Climate Change Programme to reflect the nation's and the world's commitment to combating climate change. The programme emphasizes the promotion of bioenergy development by attaching significant importance to bioenergy based power generation, biogas, biomass briquettes and biomass liquid fuels (NDRC 2007a). In its policies, China is firmly committed to sustainable development and is taking a series of strong measures and actions to address climate change under the UNFCCC and KP (He et al. 2007). It is a great challenge considering the current stage of the economic development in China. One of the latest concepts is to promote a low-carbon economy by improving energy efficiency and increasing the use of renewable energy (Zhang 2010a).

China has faced many challenges in the energy sector development. However, there is a large resource and technological potential to save energy and improve energy efficiency (He et al. 2007). China has been using two strategies: One is to call on citizens to save energy, and the other is to develop methods for promoting renewable energy. Since the early 1980s, China had been investing a great deal of human capacity, material and financial resources for promoting the use of renewable energy (Zhang 2010b), this includes the introduction of strong policy measures during the 1990s. For example, the Electricity Law of the People's Republic of China (PRC) was passed in 1995, the Energy Conservation Law of PRC in 1997 and the Air Pollution Prevention Law of PRC in 2000, encouraging the exploitation and use of renewable energy (Zhang et al. 2010). Since 2005 the government has introduced a range of policies aimed at

increasing the use of renewable energy, especially from biomass, with the establishment of the Renewable Energy Law (Sinton et al. 2005). In addition, in 2007 China set a new target to develop renewable energy. The aim is to meet 15% of its total energy demand through using renewable energies by 2020 (NDRC 2007b).

Developing forest bioenergy is an important option to achieve a low-carbon economy and mitigate climate change, as stated in China's National Climate Change Programme (NDRC 2007a). The major advantage of forests, especially tree based energy plantations, is their low energy inputs and ability of many tree species to grow on waste or marginal lands (FAO 2008). It would also encourage the use of barren mountains and wastelands. In addition, the forest residues can be fully used. Therefore, the use of forest biomass as an energy source can improve both energy security and the ecosystem (Zhang 2010a).

During recent decades energy supply and consumption have been dominated by fossil fuels, especially coal. However, the share of renewable energy has increased steadily and has begun to play an important role in the energy structure (Liu et al. 2011). In 2005, China's total primary energy supply was 2337Mtce, 2.5% of which was from renewable sources, of which biomass energy[1] accounted for 30% (Zhang et al. 2009a). With the promotion of renewable energy, the share of bioenergy is continuously increasing (Zhang et al. 2009b).

1.2 Forest bioenergy resources in China

Forest bioenergy has many positive characteristics. It is renewable, storable and substantive, and carbon neutral when based on sustainable forest management (Röser et al. 2008). Together with the other large forested countries, China has great opportunities to develop forest based energy solutions for mitigating carbon emissions (Table 1).

Table 1. Forest area and total forest biomass in selected countries in 2010 (FAO 2009, FRA 2010)

Country	Land area 1000ha	Forest area 1000ha	Forest area percentage	Total forest biomass Mill tons
China	942530	206861	22	12191
India	297319	68434	23	5178
Brazil	832512	519522	62	101236
USA	916193	304022	33	37929
Europe (excluding Russia)	576587	195911	34	23170

[1] Biomass energy refers to all energy fractions from agriculture, horticulture and forestry used for biogas, thermo-chemical gasification, biomass power generation, biomass alcohol and biodiesel conversion, or burning directly for cooking and space heating.

According to the Forest Law, issued in 1984 and revised in 1998, forests were divided into five types. Table 2 shows the area of the five forest types according to the Seventh National Forest Resource Inventory Report (NPC 1998). From the point of view of society, forests have different functions. Fuelwood forests can be used for harvesting fuelwood, energy plantations belonging to special purpose forests, and other biomass (for example forest residues from industrial loggings) can also be used as a fuel source. From the viewpoint of energy, any part of forests could be theoretically used as energy through burning or other kinds of conversion. However, this sort of purpose would likely cause conflicts with other societal targets, for example, with ecological balance, preventing soil erosion, protecting biodiversity, chemical and mechanical wood processing. Therefore, the sustainable development principles have to be made through legislation, certification and guidelines at different levels for the five types of forests (according to Chinese forest classification system) to fulfill their functions (Lunnan et al. 2008).

Table 2. Types of forests by Chinese forest classification system, functions and area in China (SFA 2009)

Types	Functions	Area[2] (mill ha)
Productive timber forest (yongcailin)	Producing timber for industry and fiber for paper production.	64.16
Economic forest (jingjilin)	Fruit, oil crops, chemical materials medicinal, and seasoning forests.	20.41
Protective forest (fanghulin)	Soil and water conservation, windbreak and sand fixation forest, farmland and pasture protecting forest, and fireproofing forests.	83.08
Fuel forest (xintanlin)	Firewood forest	1.75
Special purpose forest (tezhong yongtulin)	Scientific and education forest, natural preservation forest, seed resource forest, cultural and memorial forest, tourism forest, environmental protection forest, and national deference forest.	11.98

2 This data comes from the State Forestry Administration (SFA) in 2008. The total forest area is different from the amount of China's total forest area in table 1.

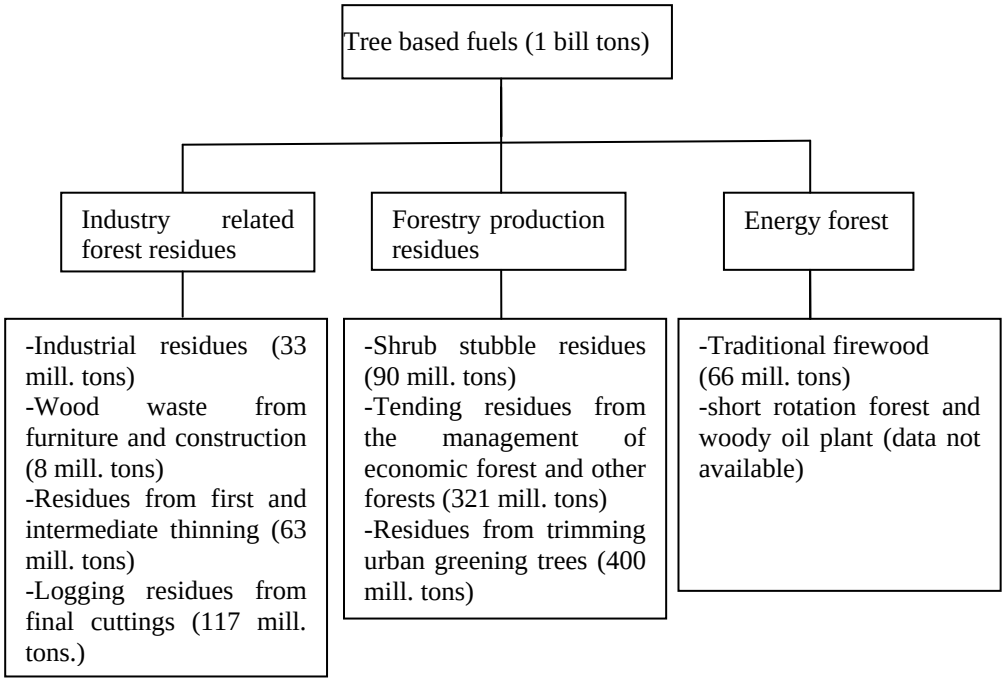

Fig 1. The annual potential of different shares of the total tree based energy in China (Zhang 2010b).

In this thesis, forest bioenergy refers to energy of tree biomass from fuelwood forests (in Chinese Xin Tanlin) and shrub forests, of oil from woody plants, of Short Rotation Forest (SRF) energy crops, of forest residues and waste wood from forest industries' loggings and processes. Figure 1 shows different shares of forest biomass energy resources and estimated yearly biomass potentials in China.

In addition to the existing forests, there are still abundant land resources for developing forest bioenergy. It has been estimated that about 57 mill. ha of barren mountains and deserts and about 100 mill. ha of marginal lands are suitable for cultivating energy forests (Lv 2005). China would gain environmental and economic benefits from developing energy plants (Zhang 2010b). However, the challenge is that the marginal areas lack many preconditions for growth, such as water, as well as favorable soil quality. On the other hand, there are opportunities to plant, for example, some oil plants, such as *Jatropha curcas*, *Pistacia chinensis* and *Cornus wilsoniana*, species which have high drought resistance and can grow in marginal areas very well (Jia and Xu 2006). Furthermore, laws and regulations for returning farm lands to forest or grass land have been formulated since 1999. From 1990 to 2008, the accumulated afforestation area was 27.66 mill. ha. In 2008, 12 000 ha of poor quality farm land was afforestated, while in barren hills and wasteland the area of afforestation was about 94 000 ha (SFA 2009). It is recommended, however, that the local authorities consider the

local conditions and then adjust measures to local farmers for cultivating plantations for energy purposes, if not this seriously jeopardises the sustainability of the continuous incomes from farming (Li 2005, Jia and Xu 2006).

1.3 Current development of forest bioenergy in China

Since the 1960s the Chinese government has paid a great deal of attention to the development of forest bioenergy. However, the development was slow. In the 1980s, energy use in rural areas was increasingly emphasized in developing efforts (biogas and fuelwood). In 2005, with the establishment of the Renewable Energy Law, the development of forest bioenergy entered a new era. In 2006, the National Long-term Scientific and Technological Development Plan and Bio-industry Development Program was introduced focusing on the development of bioenergy. Subsequently, the "11th Five-Year Plan (2006-2010)", National Support Plan, High-tech Development Plan, and High-tech Industry Development Plan were all emphasizing the research and development of bioenergy. In addition, the State Forestry Administration (SFA) included the development of forest bioenergy in the 11th National Forest Development Plan and prepared the National Energy Forest Construction Plan. In 2007, the Chinese government released the Medium and Long-term Renewable Energy Development Plan and in this plan the goal of developing bioenergy was formulated (NDRC 2007b). Furthermore, the Ministry of Finance (MOF), NDRC, and SFA launched a tax policy to support the development of bioenergy and bio-industry (Sun et al. 2010). The above mentioned policies and strategies provide theoretical and somewhat practical basis of forest bioenergy development in China.

There is over 10 years' experience of exploitation of briquettes and well-developed production technologies are available. The main feedstock for briquettes are agricultural residues, such as straw and forest residues. The briquettes are used for household cooking and heating. The use of briquettes as a replacement for coal does not necessitate the modification of the original stoves. Additionally their energy efficiency may be over 90% (Sun et al. 2010). However, biomass briquetting technology is in its early stages. The industry chain of technology and devices is incomplete, the investment and the cost of briquetting production are very high. Therefore, the development is restricted by the technology (Wu et al. 2010).

China produced the third largest amount of biofuels[3] in the world in 2005. In 2006, the NDRC set a target of meeting 15% of the nation's transportation energy needs with biofuels by 2020 (NDRC 2007b). At the start of 2009, the country's ethanol projects (in the provinces of Heilongjiang, Jilin, Henan, Anhui, Guangxi, and Chongqing) had a total capacity of 2.2 mill. metric tons. China's push on biofuels is focusing on production made from non-food feedstock such as waste oil, vegetable oil and Jatropha seeds (The Biofuels market in China 2010). The central government has given significant freedom to local governments to offer subsidies to biofuel companies (GSI-China 2008).

[3] Biofuel refers to liquid renewable fuels such as ethanol and biodiesel that can be a substitute for petroleum-based fuels.

The development of forest bioenergy for modern conversion (such as producing liquid biofuels) in China is in an early stage. There are barriers in the development of forest bioenergy technologies (Table 3). Although, some of the technologies started very early, bioenergy and forest bioenergy technologies are still in the research and development stage, pilot and demonstration stage, or in the early commercialization stage (Zhang et al. 2009b).

Table 3. Current progress in bioenergy technology research in China based on Zhang et al (2009b) and Wu et al (2010).

Type	Start time	Major problems
Biomass power generation (Sugar cane bagasse and rice husks)	Research started in the 1960s.	Low generating efficiency and poor reliability of the device.
Bioethanol (sweet sorghum and cellulose based materials)	Research started in the 1930s.	Storage and pretreatment of feedstock. Low conversion rate and high energy consumption in production process.
Biodiesel (Jatropha)	The experimental study of diesel produced from vegetable oil started in 1981. Large scale production of biodiesel started in early 21st century.	Mass production and mechanized collection of Jatropha crops; effective utilization of residues. Supply system has not been secured.

Furthermore, the public's awareness of the development and use of forest bioenergy is low. Although people's environmental awareness is increasing, the transition from traditional to modern use of biomass will likely take a long time (Gan and Yu 2008). Moreover, the many important aspects and functions of forest bioenergy, such as reliability and sustainability, have not been tested or recognized (Xu and Wang 2006). The policy of forest bioenergy in terms of price mechanism, tax policy, feedstock supply and bioenergy product markets have not yet been really formed (Liu et al. 2009). The future of bioenergy and forest bioenergy development is largely determined by effective and adequate dissemination of knowledge and information.

1.4 Public acceptance and perceptions on bioenergy issues

The development of forest bioenergy is becoming increasingly embroiled in controversy, just like the development of bioenergy in general and wind energy globally (Ek 2005, Agterbosch et al. 2007). For example, a variety of problems which may have social impacts, including water pollution, higher food prices, soil erosion and deforestation have been discussed in the Internet, television and scientific journals (Lunnan et al. 2008, Delshad et al. 2010). Most of the related literature shows that public knowledge relating to green energy is limited (Gossling et al. 2005, Delshad et al. 2010, Stidham and Simon-Brown 2011, Monroe and Oxarart 2011). Regarding biofuels, one study conducted by Van de Velde et al. (2009) found that public perceptions of biofuels do not correspond with the everyday life. Most participants in the study considered that they lack information on biofuels (Van de Velde et al. 2009). Despite the lack of knowledge, the public still want to be a part of the planning process. However, public acceptance and support are key factors in implementing forest bioenergy programs.

A lack of public acceptance of products of forest bioenergy is an obstacle to its development. This is a very common issue on a global level. Bioenergy and especially forest bioenergy development in China might face the same problems. It is necessary to study the social attitudes and how and from where public receive knowledge regarding forest bioenergy in its early stages. This may guarantee the success of biomass development strategies and further develop the decision-making process, including assuring the applicability of the results. On the basis of understanding the stakeholders' attitudes and knowledge, it is possible to accurately define the constraints, and consequently to identify the ways to overcome them. It can be assumed that, for example, improved understanding of modern applications of forest bioenergy and of the consequential benefits for the global climate can improve the social acceptance of the new ways of using forest bioenergy.

1.5 Theoretical framework

1.5.1 The interrelations among knowledge, perceptions, and attitudes

The development of a new industrial sector such as the renewable energy sector needs a strong commitment from society. In the societies based on technological and social innovations, knowledge, perceptions and attitude should be studied while citizens are taking steps towards acceptance of a new concept. Modern knowledge societies face complex challenges and rapid changes in technology. These changes influence people's understanding of science and culture (Beck 2009). Knowledge is also required because new technology helps to construct very complex systems which are abstract from the everyday users' perspective (Giddens 1990). Problems caused by the uncertainty regarding how the systems work and what are the long-term effects of technologically reasoned new solutions are very acute in the current society. Knowledge is demanded both to serve the development of technology, and as a tool for economic growth. Its role is also important in monitoring the social consequences of the technological progress for the collective decision making processes (Beck 2009)

Knowledge is generally defined as a construct formed by numerous interlinking intellectual components. According to Abhary et al. (2009) it is an "*established system of relations, which survives by being shared with more than one person*". On environmental issues, knowledge requires citizens to take interest, understand and discuss scientific matters in order to be able to have interaction with the environment, in addition to it being good regarding their own health and well-being (Bal et al. 2007).

Perceptions are a part of the process of developing the awareness and understanding with respect to the environment. This process is also leading to the state of organized and interpreted knowledge. Perceptions are influenced by knowledge but also beliefs. Perceptions occur also when you apply your experience to interpret sensations (Kasschau 1980).

Attitudes are based on values together with knowledge and perceptions and have feelings and willingness to do something. Environmental attitudes refer to an intention to show consistency regarding certain environmental phenomena (Kotchen and Reiling 2000).

Previous studies have reported that there is a significant relationship among attitudes, perceptions and knowledge (Prokop et al. 2007). In a knowledge society, knowledge strongly influences the formation of perceptions and attitudes are mainly originating from perceptions. Different stakeholders' knowledge of, perceptions of and attitudes towards renewable energy such as forest bioenergy are preconditions for people's acceptance of the value chains which are producing various forest bioenergy products. Stakeholders' knowledge, perceptions and attitudes (KPA) will influence the policy making and implementation in a society. In this thesis, knowledge, perceptions and attitudes form the core concepts. On the basis of the stakeholders' response, it is a challenge to try to find out how KPA are expressed among the selected groups and how KPA may influence the policy making in the forest bioenergy sector in China.

1.5.2 Sustainable development

The societies of today are meeting the challenges of development by applying the concept of sustainability that was proposed, for example, by the Brundtland Commission in 1987 (WCED 1987). There are many definitions about sustainable development, however, in this thesis sustainable development refers to "*development that can meet the needs of the present generation without compromising the ability of future generations to meet their own needs*" (WCED 1987). Generally speaking, sustainability is comprised of four dimensions: environmental, economical, cultural and social (Rogers et al. 2008). Environmental sustainability is the process of making sure that current human processes of interaction with the environment are pursued with the idea of keeping the environment as perfect as naturally. In practice the aim is to reduce pollution, the exploitation of the natural resources, and maintain the stability of ecosystems. Economic sustainability aims to increase of per capita income including a basic equality and to improve the standard of living of the local population. At the same time it should be possible to reduce energy dependence and diversify the energy sources to guarantee the needed supply. Social and cultural sustainability include, for instance, such aspects as the achievement of peace and social cohesion, stability, social participation, respect for cultural identity and institutional development (Rio and Burguillo 2009).

With the development of the concept of sustainability, the theory and concept of ecological modernization (EM) was created. It has been one of the most central environmental discourses since the 1990s (Andersen and Massa 2000). The concept of EM provides tools to solve ecological crisis and to redirect environmental policy making, for instance. The theory argues that the central institutions of modern society can be protected with the avoidance of ecological crisis. The perspective of EM is to offer a constructive approach to deal with environmental problems and EM is a theoretical and practical guide to an appropriate response to environmental challenges. EM has concentrated on the potential for environmental reform at the meso-level covering national government, environmental movements, enterprises and labour organizations while the sustainable development deals with the environmental problems from the international scale to the local (Gibbs 1998). The basic argument of EM and the environmental sustainability is similar and they aim to solve ecological crisis and assist with the environmental policy making (Langhelle 2000).

The third concept that was developed in 1980s is the industrial ecology (IE). There are two important factors of IE, one of which is the connection between the industrial system of humans and the natural ecosystems, the other is the primary goal of IE to strive for sustainable development at all levels from global to local (Snäkin 2003). According to it, industries could follow ecological processes and structures in planning and implementing new technologies. The concept of industrial ecology has influenced the development of quality assessments and standards. Thus also the development of forest bioenergy value chains will benefit from the theory of industrial ecology.

The principle of sustainable development was introduced in China in late 1980s. The first draft of China's Agenda 21 was completed in 1994 not long after the United Nations Conference on the Environment and Development (UNCED) in 1992 (Klawitter 2004). China's Agenda 21 was completed with the support of the State Planning Commission, the State Science and Technology Commission, and more than 300 experts. In the Agenda 21, China's sustainable development strategies and policies were clarified (ACCA21 1994). China's Agenda 21 can be categorized into four parts to coordinate the development of economy, society, resources and environment. These parts formed the key strategy and policy of sustainable development, while taking into account sustainable social development, sustainable economic development, rational utilization of resources and environmental protection (ACCA21 1994). The work for introducing the concept of sustainable development will be utilized when various forms of renewable alternative energies are developed in the different regions of the country. Especially, while China is facing problems of energy security, it is essential to integrate energy strategy with environmental, economic, cultural and social aspects for improving the country's sustainable development (Ma et al. 2011).

With the emergence of sustainable forest management (SFM) from UNCED in 1992, the relevant principles to forest bioenergy rose gradually. For example, the Ministerial Conferences on Protection of Forests in Europe (MCPFE 2011) stated that *"the extraction of forest bioenergy should comply with the principles of SFM to maintain forest productivity, health and vitality, and the protective functions of forest in relation to adjacent ecosystems"*. This has been concretized by forming the Forest Sector Technology Platform of the EU (Forestplatform 2011).

Forest biomass is increasingly considered as sustainable energy. However, the use of biomass is doubted by several scientists in different fields. The doubts are related for

example, to the continuing disappearance of tropical forest, forest or peat land conversion to biofuel production resulting in the immediate negative carbon balance, and even the increasing price of food has been seen as a consequence of the development of biofuels (Finco and Doppler 2010, Dam et al. 2010). The environmental consequences of various kinds of bioenergy on life-cycle basis are different. For instance, the differences between forest and agriculture based bioenergy has to be studied properly when advantages and disadvantages are discussed. The development of forest bioenergy must be managed in line with the principles of sustainable development. However, the values are not easily balanced. The realization of this depends on the support and input of all relevant stakeholders' participation in decision making and needs a synthesis operation through legislation, certification, recommendation, and guidelines at different levels (Lunnan et al. 2008). Various benefits will be gained from the participatory process, which includes the assessment of the public's knowledge, perceptions and attitudes and which ones increase the social understanding and acceptance of the bioenergy products.

1.5.3 Forestry stakeholders analysis

There are many research works discussing how to solve technological and societal controversies in forest bioenergy planning, production and use and how to promote more transparent and inclusive solutions (van der Horst et al. 2002). A dialogue is needed between the various stakeholders who are participating in the many activities of the value chain. Understanding of the stakeholders' interests and competence to facilitate energy policy implementation may help to guarantee many environmentally important issues such as protection and proper social development.

The whole stakeholder system includes authorities (central, provincial, county, township, village), experts, large state-owned energy producing companies, small local energy producing companies, contractors, investors, consumers and energy sector labourers. Among these experts, also policy-makers and customers together play key roles in the development of the forest bioenergy sector. The dissemination of reliable information and knowledge from various stakeholders provide a basic support for the acceptance of forest bioenergy in society. On the basis of academic experts and professionals' scientific and practical evidences, it can be concluded that the suitable and practical regulations and rules can support the implementation of the bioenergy promotion related projects (Dwivedi and Alavalapati 2009, Stidham and Simon-Brown 2011).

With the rapid development of the society and radical socioeconomic changes, the Chinese central government has undergone a remarkable transformation since the early 1990s. The government has been trying to become increasingly functional with transparency, responsibility and justice (Li 2009). For example, stakeholders in the society have started to take active roles in information dissemination. Comments of experts and professionals on different problems caused by the technological development and its side-effects such as air pollution, decreasing environmental quality, energy security, conflict between food and biofuels, have increasingly appeared in the Internet, television and other media.

Academic experts who work in research institutes or universities provide the Chinese society with knowledge that is an important resource for democratic policy-

making when promoting technological development, as well as by reasoning its acceptance (Pregernig 2000). The open-minded and versatile experts' knowledge has also a significant role when critically analyzing backlashes caused by the utilization of technological inventions without taking the long-term impacts on the environment into consideration.

In China where forests are principally owned by the state, professionals working in the field organizations play a key role in the decision making and knowledge dissemination in the development of forestry. Stakeholders, such as farmers, need advice from professionals when making practical decisions regarding management, and therefore the importance of the professionals has to be increasingly highlighted (Hamilton et al. 2006, MacDonald et al. 2010). Experts and professionals can offer scientific knowledge and practical guidelines of forest bioenergy for future development strategies. Similarly, the education sector plays a significant role in the development of China's civil society (Li 2009). Thus the central government and regional authorities are investing increasingly in education. The role of young people, including higher education students, as future experts, consumers and decision makers can be regarded as significant. Their consuming decisions influence on market development and their attitudes indicate how the energy markets will likely develop.

1.5.4 Internet representing the modern media

Since the early 1990s, the Internet has been growing rapidly throughout the world. It is in many ways having a profound impact on our social and cultural lives (CASS 2003). Compared to the global growth of the Internet, it has become an effective information medium for the Chinese public since it was introduced in the 1995. Since 2000, the Internet has grown into a powerful platform to disseminate government information and to allow the public to express their opinions (CASS 2005). In 2000, Chinese language search engine for websites, "Baidu", was created. "Baidu" has a similar function as "Google" (Baidu 2011). The Internet has the ability to reach large audiences and promote interaction between the public and the government. It is popular not only with the public, but also attracts the scientific community to release and discuss research findings. It is an effective tool for disseminating information and it can have a strong influence on the public's perceptions and attitudes toward the environmental issues (CNNIC 2008). China's online environmental communication has expanded with the growth of the Internet population and with increasing interest in environmental issues (Yang 2003). Both central and local governments in China use the Internet to disseminate knowledge and information about the development of renewable energy (NPC 2005, MOA 2007). The development of bioenergy has been discussed in the Internet rapidly since 2000. However, in China there are hardly any or none scientific studies done concerning the content of information or knowledge dissemination in the Internet. Therefore, due to the characteristic of the Internet and its possible influence on the development of bioenergy, the Internet based news articles were chosen as the research target.

Figure 2 presents the overview of this study. Academic experts, university students and forestry professionals were chosen to be the studied stakeholder group. The Internet plays an important role as an information dissemination and discussion platform among the stakeholders. The stakeholders are related or affecting the future development of forest bioenergy. In this thesis, four sub-studies investigate the stakeholders' perceptions of FBE development in China.

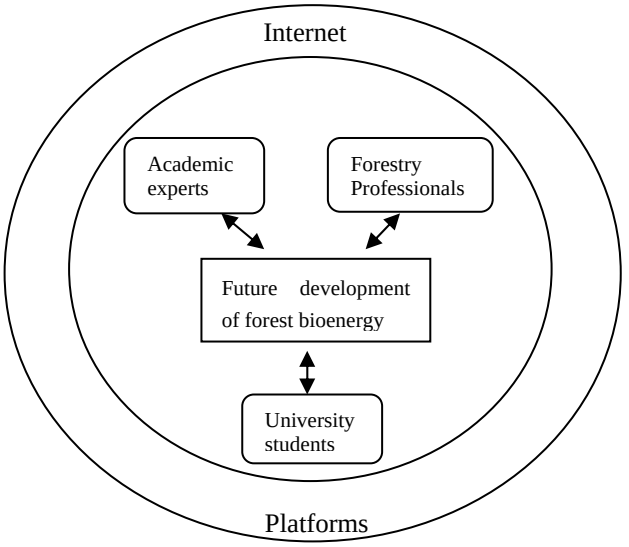

Figure 2. General layout of the thesis

2 RESEARCH OBJECTIVES

Forest bioenergy is identified as one source of alternative energy for mitigating climate change, promoting the environmental sustainability of the energy and forestry sectors. Although the Chinese government has put great emphasis on the development of forest bioenergy, its progress has been slow and its modularization is in the initial stage. There is a need of a strategy which supervises the development direction of FBE in China. The research question is regarding how Chinese forestry stakeholders perceive, discuss and project forest bioenergy in Chinese energy market and how stakeholders use the Internet to maintain their dialog. The reasons for and against the use of FBE among different stakeholders are examined by focusing on attitudes, perceptions, knowledge and information. Moreover, the main objective of this thesis is to focus on how forest sector stakeholders (including academic experts, college students and professionals) are realizing bioenergy related development and are interplaying in the policy development and implementation in the country. This thesis consists of a media study (the Internet) and three studies on stakeholders' perceptions, knowledge and attitudes.

The answers are approached in the internet based articles, a Delphi survey and questionnaire surveys. The basic research question has been approached in four papers, and each of them has its own specific research question:

- In paper I, how the government and the public discuss bioenergy by using Internet platforms are examined. Additionally, what kind of information the platforms provide about the utilization of renewable energy and especially bioenergy are investigated;

- Hypothesis 1: Whether the Internet platform plays an important role in forest bioenergy information dissemination in China.

- In paper II, the current situation of the forest bioenergy development in China is assessed (the research questions are related to the opportunities and barriers to converting forest biomass to energy and the potential recommendations to enhance bioenergy development);
- In papers III and IV, different stakeholders' knowledge and sources of information about bioenergy, especially forest bioenergy, are examined;
- In papers III and IV, different stakeholders' energy practices in everyday life, future energy preferences and perceptions of and attitudes towards forest bioenergy in China are identified;
- In papers II-IV, whether there is consensus among different stakeholders concerning forest bioenergy development potential trends in China is examined.
    - Hypothesis 2: Whether there is consensus or differences among stakeholders concerning forest bioenergy development potential in China, regarding their knowledge, perceptions and attitudes towards the development of forest bioenergy in China.

3 MATERIALS AND METHODS

3.1. Content analysis

The first stage of the study focused on how the government and the public discuss bioenergy using the Internet and what kind of information about bioenergy is provided by the Internet (Paper I). The study material was collected using a content analysis of news articles, Internet pages related to energy, renewable energy, and especially, bioenergy. These news articles were analyzed mainly because they illustrate relevant issues for the study, such as, the advantages or disadvantages of using bioenergy, and their prevalence in China. Moreover, the Internet is not only used by the public to discuss the viability and feature of bioenergy products, but also provides successful examples and a number of government policy documents which are conducive to the development of FBE.

In total, 19 platforms related to the study topic were identified (see Paper I, Table 1). From these 19 platforms, www.china5e.com was selected for a detailed analysis. There were three reasons for the selection of this site. Firstly, it has a large database and a relatively broad variety of news articles covering different types of energy sources from traditional energy to modern bioenergy. Secondly, the website contains articles from 2001 to the present date. As a result of the temporal depth of the archive, it is possible to trace the energy policy changes and developments in China. Third, the netizens[4], who daily visit this website, about 50 000 Internet Protocol addresses, make www.china5e.com the most frequently visited energy portal in China.

[4] China Internet Network Information Center defines the netizen as any Chinese citizen aged 6 and above who have used the Internet in the past half a year.

In this study, news articles were selected according to their energy types (such as hydro power, wind power and ethanol). Altogether 2806 news articles from www.china5e.com over a 7-year period from 2001 to 2007 were identified. These were 639 bio-diesel articles, 1477 ethanol articles and 690 biogas articles.

In order to identify and classify the contents of the articles, some categories and sub-categories were generated:

1) Platforms: When established, creator, subject, focus themes and English version of the platforms.

2). Samples of news articles: Bio-diesel, ethanol and biogas articles were chosen as the research samples.

3) Temporal variation of the number of articles on bio-diesel, ethanol and biogas and corresponding policy issues: total annual number of articles to measure the change of news.

4) Content of the articles: The overall view of each article was evaluated and grouped into positive and negative categories. A news article was classified as "positive" if the majority of the statements used in that article were in favor of bioenergy and its benefit to human beings. Similarly, an article was classified as "negative" if the article mainly talked about the disadvantage of the bioenergy and the negative consequences of its use.

5) Percentage of articles on geographic feature: the sub-categories were China and other countries.

6) Themes: the articles were classified into one of the following five themes:

1. Ongoing Project and program: the ongoing bio-diesel, ethanol and biogas projects, or the government decision on establishing bioenergy demonstration sites. Examples: bio-diesel project in Nanhe (2006-09-06); bio-diesel project in Shenyang (2006-10-17).
2. Discussion: the advantage and disadvantage of bio-diesel, ethanol and biogas, how the public evaluates the bioenergy product, and the forecast of bioenergy development. Examples: bio-diesel becomes the economic new beloved (2007-04-28); in early 2008, and there may be a shortage in supply of bio-diesel in Brazil (2007-09-27).
3. Technology: the new technology development and new product and bio-product sources. Examples: new bio-diesel technology is created and developed by Tsinghua (2007-07-26); new technology of extracting bio-diesel from oak is developed by Shaanxi (2007-11-27).
4. Factual narrative: the basic conception of bio-diesel, ethanol and biogas, and the development narrative. Examples: what kind of green energy can be the source of bio-diesel (2004-04-27); what is bio-diesel (2005-07-22).
5. Solution and suggestion: the government strategies and related policies which are made for the development of bioenergy. Examples: China adopts strategic measures to enhance bio-diesel industrialization (2006-03-14); China Petrol increases the productivity of diesel and National Development and Reform Commission (NDRC) will produce a new policy on bio-diesel (2006-08-21); the Chinese government starts controlling converting rapeseed into bio-diesel (2007-10-12).

It should be noted that many of the studied articles address more than one of the aforementioned topics. One article might be coded into two (or more) categories (or sub-categories) in the content analysis.

3.2 Delphi survey

The second stage of the work involved a two-round Delphi survey (Paper II). This was conducted in seven sites with sixty-one academic experts (scholars working in the Universities or research institutes in China and are responsible for academic research) (Paper II, Figure 1). These academic experts work at universities and research institutes in China. They have published articles related to bioenergy in international scientific journals, such as Energy Policy, Biomass and Bioenergy, and Applied Energy. Their main research topics were the sustainable development of forest bioenergy and its assessment in China. The experts were identified by studying the pertinent forest bioenergy publications and the latest forest bioenergy conference participation lists (conference on biorefinery technologies and industrialization, 2008, Xiamen (www.xdhg.com.cn)). The whole group was chosen to represent all relevant fields of national level academic expertise. All selected experts have participated in the development of FBE, however, most of them were not only limited to FBE. All the selected experts fulfill the criteria that the expert should have forestry as first bachelor degree. The experts, who are from diverse geographic regions, provide a broad representation of the expert judgment. The responding experts were between 30 and 60 years old, and 87% of the respondents were male. The researchers were working in the field of renewable energy related biology, ecology and environment, wood sciences, forest policy and economics, and energy and renewable energy. Furthermore, 36% of the respondents have been working for more than 20 years in research.

3.3 Questionnaire surveys

The third stage involved an on-site survey study with structured questionnaire which was carried out at the Northwest Agriculture and Forestry University (NWAFU) in Shaanxi Province, China, in March 2009 (Paper III). The survey was conducted in the class during lecture hours. A stratified random sample of students at the University of Agriculture and Forestry was surveyed. NWAFU is a comprehensive university with a strong specialization in agriculture, forestry, and related sciences. NWAFU is one of the top rated high level institutions for modern agricultural education in China, the only agriculture and forestry university in Shaanxi Province, in addition to being one of the leading universities (the highest rank of 38 universities) in the country. In total 464 questionnaires were delivered, with 441 students replying (response rate of 95%). The students' background was divided into two groups: the first group with background in forestry and agriculture consisted of 245 participants, and the second group with other academic backgrounds (including food sciences, biology, humanities, economics, ecology, water resources and architectural engineering) consisted of 195 participants. One respondent did not give their academic background, and was excluded from the calculations.

Similarly, the fourth stage of the study involved a survey with structured questionnaire. The survey was carried out during the two training courses organized by the State Academy of Forestry Administration (STAFA) in 2010 (Paper IV). The questionnaire was addressed to professionals (working at the provincial forestry bureau and are responsible for forestry extension and policy making) who participated in a

short-term training course in June and July. A total of 120 questionnaires were distributed, with 74 of the participants completing the survey (62% response rate). The respondents located in four regions of China, Xinjiang, Chongqing, Fujian and Zhejiang. From the view of the whole county's population, the representativeness of the sample is not high. However, these regions have large areas of plantations and the theoretical future forest biomass potential is high. Especially Xinjiang has large fuelwood forests. Among the respondents, 51% have their education in forestry, and with the remainder were educated in other fields. Most of the respondents have been working in the field of forestry for more than ten years, and some of them have thirty years experience.

3.4 Data analysis

Content analysis (Paper I), Delphi survey (Paper II) and survey studies with structured questionnaires (Paper III, IV) were the methods applied in the work presented here. For the analysis of the results of the survey questionnaires, the reliability and credibility of the data were checked with the Cronbach's alpha. Because stratified random sampling is applied for collecting the data, there are restrictions in the use of data analysis tests. Frequency analysis, and mean values were calculated using SPSS 17.0 and Microsoft Excel software. ANOVA analysis, Chi-squared test were also conducted using SPSS 17.0 for the data collected from the questionnaires. Mann-Whitney Test (U-test) was applied to compare different groups' mean value. The results of the tests are tentative and one has to be critical in generalizing the results. However, the results give indication of the development.

4 RESULTS

4.1 Internet platforms and bioenergy

The study found that bioenergy related Internet platforms disseminated multi-faceted information during the study period (2001-2007). Altogether 19 energy related platforms were found. These 19 energy platforms were established gradually since 1998. Most of them were created by companies (Paper I, Table 1). One-fifth were created by government organizations and another fifth were created by academic research institutions. Only a few were created by individual people or NGOs.

On the basis of the content analysis it was clear that the Internet platforms presented government policies in a broad and mainly positive manner. The number of news articles reflected the changes and outcomes of the government energy policies (Paper I, Fig. 2). According to the studied policy documents, the Chinese government has traditionally supported the development of bioenergy. Additionally, the policy documents showed that there has been an increasing trend to promote bioenergy since 2004. For example, in 2004, China made a strong commitment to the development of the renewable energy industry in the international Renewable Energy Conference in Bonn, Germany. After the conference in the same year, Medium and Long Term targets

for the Energy Conservation Plan were made by NDRC (2004). This was reflected by the increasing number of news articles since October 2004.

The government formulated the Renewable Energy Law in 2005, and it is one of the largest state-sponsored commitments towards renewable energy in the world. This law was a milestone in the development of bioenergy in China. In the same year, the government introduced a program called “Building the saving type society and developing recycling economy”. This provided the guidelines for China’s sustainable social and economic development. Subsequently in 2007, China’s National Climate Change Programme and the Medium and Long-term Development Programme for Renewable Energy were issued by the National Development and Reform Commission (NDRC).

In terms of the contents of the news articles, the most interesting question is whether, and to what extent, bioenergy was seen as acceptable and how visible it was in the Chinese Internet. The majority of the articles present bioenergy in a positive light. Biodiesel, ethanol and biogas were portrayed as alternatives and important renewable energy forms. However, during the period studied (2001 and 2007) the number of negative articles regarding ethanol increased. The reasons for the increasing concern were issues such as food security, deforestation and social acceptance. The number of articles dealing with ongoing projects and discussion on biofuels increased between 2004 and 2007 (Fig 2). The number of negative comments on biogas was relatively low, since biogas is common and widely accepted in rural China. On the basis of the news articles, the public recognized the benefits of biogas and the R&D emphasis was put on the advanced technology of biogas conversion and utilization. A large majority of the news articles presented biodiesel and ethanol as problematic since they were seen to weaken food security and the conversion efficiency was seen as low in the current stage of development. The articles were strongly demanding the definition of criteria regarding biofuels and other bio-products and resolve problems of raw material availability and supply (Paper I, Figs. 6 and 7).

In the light of Internet articles, biogas has been the main source of bioenergy in China, while liquid biofuels (bio-diesel and ethanol) will be the main bioenergy options in the future.

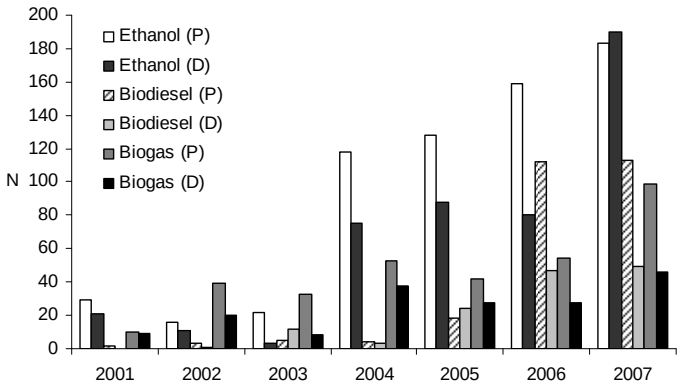

Fig 2. Number of ethanol, biodiesel and biogas on-going projects (P) and discussion (D) news articles from 2001 to 2007.

4.2 Current development of forest bioenergy in China

4.2.1 Key drivers affecting FBE

According to the experts surveyed, there are four key drivers for the development of forest bioenergy in China. These are: 1) energy security problems, 2) the Chinese national energy policy promoting the use of renewable energy, 3) the advantage of using bioenergy, such as, developing FBE that can mitigate CO_2 emissions, and 4) the country's rapid economic growth. The experts stated that the global energy crisis and nationwide energy security are the most important key drivers. The experts with long working experience (more than 20 years) considered the advantage of using bioenergy and rapid economic growth as more important drivers than the experts with shorter working experience (Paper II, Table 3).

4.2.2 Potential benefits and problems of FBE development

The academic experts and professionals were asked to identify potential benefits and problems of developing FBE. They had similar attitudes towards the benefits. However, they also had some different attitudes towards the problems. For example, both groups felt that there are research, technology, policy and regulation related shortcomings, as well as a lack of capital for investments, low awareness among the public and low social acceptability. These aspects were seen generally as problems. However, to some of the problems, experts and professionals had slightly different attitudes. The academic experts slightly agreed that the "use of forest biomass for energy can cause overuse of forest resources", yet, the professionals were neutral on this issue. The professionals agreed that "there are insufficient wood resources for energy production in China", while the experts disagreed. However, there were diverse opinions concerning wood resources and the use of forest biomass for energy in China between the experts and professionals (Table 4). The reasons for these slightly different opinions could be due to

their work experience and political role in the society. According to the definition in this study, academic experts refer to scholars in universities and research institutes, yet, the professionals are forestry extension agents and policy makers. Both of them have experience regarding forest resources in China. The latter group has more practical work experience than the former.

Table 4. Academic experts and professionals' opinions concerning the potential benefits and the problems of forest bioenergy (FBE) development in China (1=strongly disagree to 5= strongly agree). Nd=no significant difference

Statements		Mean value		Asymp.sig
		Expert	Professional	(U-test)
Potential problems	Use of forest biomass for energy can cause overuse of forest resources.	3.17	2.84	0.00***
	There are technical barriers, such as low conversion efficiency due to immature lignin-cellulose decomposition technology.	3.53	3.93	0.03*
	Lack of recognition of the potential of FBE among professional foresters.	3.87	3.34	0.05*
	There are insufficient wood resources for energy production in China.	1.49	3.18	0.05*
	There are abundant unused barren hills and wasteland.	4.08	3.81	0.08(Nd)
	There is a lack of national standards for FBE products.	3.83	3.68	0.16(Nd)
	Different stakeholders' investments have not been successful during the last ten years.	3.53	3.37	0.23(Nd)
	Low environmental awareness of the general public is an obstacle for developing forest bioenergy in China.	3.19	3.70	0.92(Nd)
Potential benefits	The development of FBE can reduce China's reliance on imported oil.	3.81	3.64	0.24(Nd)
	Increasing the share of FBE can reduce CO_2 emissions.	4.11	3.89	0.28(Nd)

Furthermore, according to the experts' assessment, woody oil plants and glucose and starch plants were considered to have the biggest potential. In addition, short rotation forests and firewood forests were considered to have lower potential.

4.2.3 Recommendations by academic experts and professionals

As a solution to promote forest bioenergy development, the experts and professionals proposed that different stakeholders, such as the government, researchers and the public, should be actively involved in the development of forest bioenergy. They especially emphasized the role of the national government. The professionals felt that the government should provide financial support for FBE development and both experts and professionals thought that the government should play a supervisory role in the development of the FBE industry.

In addition, the experts recommended that the Chinese government should take an active role in further development of basic research regarding forest bioenergy and in improving the national energy policy regarding forest bioenergy, as well as strengthening the basis of national forest planning and the extension of advanced technology. Moreover, the experts felt that a national forest biomass resource inventory of wood oil plants is urgently needed. A long-term plan for bioenergy development and coordination between different research institutions are also needed. The experts also suggested that the sustainable forest bioenergy criteria have to be established to help achieve sustainable forest management. The development of forests for energy use should also be included in the national forestry plan.

In terms of the future development of forest bioenergy in China, the experts felt that its development is largely determined by the oil price and that forest bioenergy may replace oil during the next ten years. However, the professionals' perceptions differed from experts concerning the future development of forest bioenergy in China (Table 5).

Table 5. Different perceptions of experts and professionals regarding the future development of FBE in China (1=strongly disagree to 5= strongly agree).

Statements	Mean value		Asymp.sig
	Experts	Professionals	(U-test)
The development of forest bioenergy is determined by the oil price.	3.74	2.74	0.00***
Biofuels will replace fossil fuels in the next ten years.	3.69	2.21	0.00***

In addition, in the students' survey, the students slightly agreed (3.26) with the statement that forest bioenergy would be a major source of energy in the future.

4.2.4 Different roles of the institutions

The academic experts felt that the NDRC, the Ministry of Finance (MOF), the State Forestry Administration (SFA), the Ministry of Science and Technology (MOST), the Bureau of Energy (BOE), and state-owned energy companies are all considered as the

most important institutions in the development of forest bioenergy. Both experts and professionals felt that the Chinese government should offer supervision and financial support, especially in the early stages of the development of forest bioenergy. This was also mentioned in their recommendations. In addition, they felt that the government should also play a coordinating role in research and development, as well as production and consumption in the early stages (Paper II-IV).

4.3 Stakeholders' current energy practices and future preferences

Over 95% of the professionals had both heating and air conditioning in their houses. The respondents mainly used coal and electricity for space heating. About 30% of the heating electricity was converted from renewable primary sources of energy. Cooling was also based on the use of electricity. One third of the respondents said that the main energy source for cooling was from renewable energy; however, cooking was mainly done by using gas (Paper IV, Table 3). This question was not presented to the experts or the students.

Concerning the future energy preferences, both students and professionals have positive attitudes towards renewable energy (including forest bioenergy), but the professionals (19%) were less positive towards forest bioenergy than the students (37%). The university students were more positive than the professionals towards renewable energy in general and especially towards biogas. For heating, the students preferred sources other than coal and firewood as their own energy choice.

The students with a general agriculture and forestry background (A&F) preferred forest bioenergy based electricity more than the other students. For transportation fuels, the students', especially female students, first preference was hydrogen amongst the transportation fuels, while the professionals preferred liquid biofuels. The security (80%) and the environmental friendliness (50%) of the energy source were considered to be the most important properties of the energy by the students concerning their energy preference.

4.4 Stakeholders' environmental behaviour and attitudes towards forests in China

According to the study, both students and professionals have a high awareness of protecting the environment and have positive attitudes towards the use of forest bioenergy. More than half of the students answered that they would probably be willing to change their non-renewable energy system to renewable energy based electricity (54.9%) or forest bioenergy based electricity (54%) even if that would mean additional costs. The students answered that they were willing to accept an increase in the price of energy as a result of the switch to renewables (including forest bioenergy) (Paper III, Table 2), with more than 50% willing to accept an increase of between 1-5% and about 20% willing to accept an increase of 6-10%. It has to be mentioned that university students in China receive a monthly stipend of 50 RMB (about 5.4€). The students have to pay the accommodation cost each semester. The accommodation cost includes rent, water and electricity. Similarly, students living at their parents' house are not likely to pay for energy. Consequently, the perceptions of the cost are arbitrary. According to the survey of the professionals, they would like to improve the consideration of low carbon

living. Most of them walk (43%) or use public transportation (31%) to go to work (Paper IV).

The results revealed that the professionals prioritize ecological and environmental forest values. The most important roles of forests were related to ecological balance, desertification, water resources, greenhouse effects and nature conservation. The role of wood production either for industry or bioenergy purposes was seen as less important than the ecological functions of the forest, but generally more important (except traditional firewood) than the social roles.

Among the social roles, those centered on recreation are seen to be more important than hunting and game management. The professionals also rated the current forest management practices: They felt that sustainable forest management, mitigation of climate change, nature conservation and forest tenure reform are the most important aspects of forest management (Paper IV, table 5).

4.5 Forestry and forest bioenergy related knowledge assessment and information dissemination

According to the survey, most of the students had heard about forest bioenergy, with those with a forestry and agriculture background being more aware of forest bioenergy compared to the others. A little more than a quarter (27%) of the students knew that there is a Renewable Energy Law of PRC, with 3.9% of the respondents stating that they had read it, with more male students stating that they have read this Law than female students (Paper III).

Almost all the professionals showed a good basic knowledge and high awareness dealing with forest resources and timber imports (Paper IV, Table 4). Most of them (78%) were not knowledgeable regarding the government targets with regard to 2020 renewable energy consumption targets for China. Most of the respondents thought that the target was higher than the official target stated in the policy document.

Both students and professionals felt that they are willing to disseminate the forest bioenergy knowledge and encourage people to learn and to receive information about forest bioenergy and related information. They also claimed that currently they have not received enough information and knowledge about forest bioenergy. The professionals expressed that they are willing to convince forest owners to develop forest bioenergy. The students said it is necessary to teach forest bioenergy related subjects at the school level.

The same question dealing with channels of information was addressed to the students and professionals. Students thought that education is important, but the professionals thought education is the least important channel regarding how they get information. For the other channels, both students and professionals had similar attitudes towards television, the Internet, newspapers and radio (Table 6).

Table 6. Students and professionals' attitudes towards the possible information channels for disseminating information of forest bioenergy (1=not important at all to 5=very important). Nd=no significant difference.

Information channels	Mean values		Asymp.sig
	Students	Professionals	(U-test)
Education	4.21	3.68	0.00***
Television	4.59	4.45	0.05*
Radio	3.6	3.79	0.07Nd
The Internet	4.36	4.30	0.20Nd
Newspaper	4.06	4.08	0.99Nd

5 DISCUSSION

5.1 The importance of the Internet in the development of forest bioenergy

Generally speaking, the Internet platforms are a preferred tool for disseminating information (Government on the Internet 2008). It provides convenient and timely services for the public. Moreover, the Internet, as a form of media, may be viewed as a medium for communication flow both from government to the public and from public to the government. The Internet gives comprehensive knowledge and marketing information to the audience (Liu 2006). A great number of energy related Internet platforms have been launched in the last few years in China. In this study, 19 energy-related websites were identified, with one of the sites (www.china5e.com) being analyzed thoroughly in the present study.

There is a general tendency found in the investigation of the Internet platforms that the Internet disseminates primarily positive information about bioenergy in China. The findings of this study are in agreement with the results of Guo (2007) that Internet platforms in China usually portray the policy documents and can radically improve an understanding of policies and also to some extent promote their implementation.

Furthermore, students and professionals felt the Internet to be one of the most important channels providing useful information on bioenergy and also an effective and efficient way for educating and training. The Internet plays an important role in the dissemination of information and in educating in bioenergy issues as well (Mara and Jennings 2001). Bhattacharya (2001) pointed out, on a global level, that the Internet is expected to play a significant role in university-level education in general and renewable energy related education in particular.

5.2 The discussion of knowledge, perceptions and attitudes

Knowledge, perceptions and attitudes are the key concepts in the thesis. Perception refers to the way of thinking and understanding (in Chinese "*Renzhi*") and the questionnaires were designed according to this approach. Using this kind of conceptual approach in the thesis it was possible to especially describe how forestry professionals

understand the forest bioenergy and its development in their society. Attitude can, for instance, refer to how a person proposes to act or what is the way of feeling (in Chinese "*Taidu*"). In the thesis, it refers to what are the stakeholders' feelings concerning the development of forest bioenergy in China. To some extent, in Chinese the meaning of perception and attitude has an overlap, for example, both have at least to some extent the meaning of a way of thinking and understanding.

There were some difficulties dealing with the translation of the questionnaires from English to Chinese. On the basis of the recommendations from the pre-test wording was improved. It was also found that the attitude questions were focused on stakeholders' preferences dealing with the usage of bioenergy and on their opinions of delivering related information, while the perception questions were focused on the general concept of developing bioenergy in China. This was not seen as a problem while taking into account the descriptive approach of the study.

The questions concerning knowledge of renewable energy issues were addressed differently to students than to forestry professionals, because their position in relation to expertise is different. Due to this reason only very limited comparisons between the respondents groups could be made on the basis of this data. All in all, the concept combining knowledge, perceptions and attitudes of stakeholders could be used for opening a new descriptive research avenue to assess the social climate of forest bioenergy development in China.

5.3 Current development of bioenergy in China

5.3.1 Development direction

Household biogas has been developed for a long period of time in China under the NDRC and the Ministry of Agriculture (MOA). It has been used widely in rural areas. Although it is very popular, with numerous applications of biogas, the discussion on the Internet is not high compared to biofuels. Emerging fields seem to be attractive since China's bio-diesel and ethanol industries are very much in nascent stages of development. Biofuels are regarded as becoming very important in the future as they are expected to improve energy security, provide environmental benefits, economic and social welfare and a new culture of the low-carbon society. However, some negative environmental impacts of using biofuels have also been reported and discussed in articles on www.china5e.com. Nevertheless, the energy-related Internet platforms show that biofuels are seen as one of the main development trends of the energy sector in China. A similar conclusion was presented in the study of Wang et al. (2007), which emphasized the importance of liquid biofuels as the main direction for the future development of bioenergy in China.

Academic experts, university students and professionals who participated in the current study showed similar attitudes towards the future forest bioenergy development. According to their responses the development is in an early stage and largely determined by the oil price. However, the professionals could be characterized as cautious since they felt that biofuels will not replace fossil fuels in the next ten years. Experts seemed to have the opposite feeling. The price trend of oil in the world market has risen since the 1990s (EIA 2010). In fact, the implementation of bioenergy has not developed greatly since the 1980s. However, since 2000, partly in response to the rising

oil price, the Chinese government started to strongly support the development of bioenergy. The situation is similar in the USA, Aguilar and Garrett (2009) mentioned that high energy prices in the global market promote the development of forest bioenergy. The perceptions of the respondents were in accordance with the policy orientation to continue with expanding the development of forest bioenergy under the supervision of the Chinese government. The 11th Five-Year Plan indicated that the government will increase financial support in the development of cellulose-based bio-ethanol and bio-diesel industries, and will reduce related taxes (GSI-China 2008). The efforts made by the government prove that the future forest bioenergy development is promising.

5.3.2 Potential benefits of developing FBE

The potential benefits of developing forest biomass as an energy source in China were analyzed on the basis of the responses of the academic experts, university students and professionals. The benefits can be divided into three areas, which are environmental benefits, rural economic benefits and encouraging sustainable forest management. The environmental benefits have been used as an argument for promoting forest bioenergy production around the world, at least in the environmentally oriented circles (Raison 2006, Dwivedi and Alavalapati 2009). The experts and professionals in China clearly shared the view that due to the large areas of wasteland, the renewable natural resources can be developed in China (Lv et al. 2005). In the current study different target groups were similar in their recognition that increased use of forest bioenergy can mitigate the CO_2 emissions.

The development of forest bioenergy can offer economic benefits, especially, for the rural economy in China (Lv et al. 2005), which was acknowledged by experts and professionals in the current study. The results seem to justify the argument that possible energy plantations on marginal lands in many rural areas in China could both enhance the national energy security and promote the development of the rural economy, for example, creation of employment through the cultivation and management of energy plantations as well as the collection of the crop. There is considerable agreement also in many other countries that rural regions will benefit from the establishment of forest bioenergy industries and cultivation of energy crops (Berndes and Hansson 2007).

The professionals considered the development of forest bioenergy to be part of multi-functional forest management, in which all the factors, such as cultivation of energy plants, forest bioenergy industrialization, and forest bioenergy research as well as the formulation and implementation of policies encouraging bioenergy development, have to be considered as a whole. This finding is in agreement with the results of the study of Bai et al. (2007). The professionals also thought forest biomass used as a renewable energy source not only can contribute to climate mitigation as mentioned above, but also may have significant impacts on the forest ecosystems in a positive way under sustainable forest management. From this perspective, the use of forest biomass for energy is generally acknowledged as being in agreement with the principles of sustainable development (Lv et al. 2005, Stupak et al. 2007, Amezaga et al. 2009). Moreover, Jurgens et al. (2004) concluded that there are strong synergies among climate change mitigation efforts, modern bioenergy development, sustainable development and poverty alleviation. The influences of bioenergy utilization are diverse, and especially

some bioenergy products from agriculture have to be recognized critically with respect to the mitigation of climate change and the poverty alleviation, for example. The promotion of sustainability managed forest bioenergy increases the efficiency of using raw material production and conversion process, which may improve human health and decrease environmental degradation. In this study, the professionals and experts clearly recognized this point. According to the results of the study, wood energy production, such as extracting biofuels from oil plants, should be part of sustainable forest management practices in China.

5.4 Knowledge and information dissemination

The research findings showed a low level of knowledge among the students about forest bioenergy, though the students with agriculture and forestry background had higher level than the others. This is likely to be because students with A&F background have better opportunities than the others to participate in courses with bioenergy relevant contents. The study curriculum and teaching module need to be developed with material on forest bioenergy issues and Internet based courses. Moreover, forestry education in China lacks an understanding of the public's perceptions and attitudes towards renewable energy since forestry education is strongly oriented towards ecological aspects. Therefore, the social dimension needs to be further integrated into forestry education.

Knowledge and attitudes regarding renewable energy and forest bioenergy appeared to be influenced by gender. Men have a greater interest or involvement in the field of renewable energy than women. A challenge is to increase the interest of women in these issues because their role in the daily consumption of energy is equally important as men. This study shows the high environmental awareness of university students regarding general environmental problems, such as water pollution, deforestation, soil erosion, air pollution and loss of farmland. Similar awareness was found in a survey of environmental awareness of university students in Beijing (Wong, 2003). However, overall the possibilities of acquiring knowledge and information about renewable energy, especially forest bioenergy, are still in a relatively nascent stage in China.

These possibilities of dissemination play important roles in the understanding and acceptance of forest bioenergy sources (Stern 1986, Reddy and Painuly 2004). Then it becomes possible for public to accept new types of energy tools. Therefore the information diffusion is an important aspect in the implementation of the new energy equipment (Roos and Rakos 2000).

5.5 Stakeholders' perceptions

The forestry professionals who are working at the provincial forestry bureau (PFB) have the duty of policy making and policy implementation (also technology and information dissemination). In China, the PFBs are responsible for making the ecological forestry planning for the regions and for organizing and advising afforestation and forest resources management locally. Supervisory and coordinating roles of the PFB are important in their work. Their educational background is relatively diverse which may show that leadership is the elementary part of their work and they are strongly influencing on the implementation of the forest policy.

The academic experts who are working at the agricultural and forestry universities and research institutes have the duty to provide the policy making with sound and scientific evidences of R&D. For instance, the experts' achievements are influencing on the contents of the professionals' platforms providing an efficient access to the outputs research community. Anyhow, the professionals and experts both receive basic guidance and instructions from the central government. This may be one reason why some of the perceptions towards FBE's development of the two respondent groups are quite similar.

The third respondent group, the young students are relatively independent both from professionals and experts and they do not belong to any organization. Meanwhile, they are currently going through the socialization process by means of education, as executed by professionals and their knowledge, perceptions and attitudes may change remarkably during the university studies. This could be seen as a greater variability within this group. There were slight indications in the data that students have somewhat different perceptions and attitudes concerning FBE development.

The students have positive attitudes towards the use of renewable energy in general and specifically towards the increasing possibilities of utilizing bioenergy. This result was similar with their peers in other countries (Greenberg 2009, Halder et al. 2010).

The current energy use does not necessarily reflect the professionals' preferences, since in China in most cases the city residents have limited opportunities to choose their energy source. People cannot choose their energy providers, and this restricts the ability of the consumers to pressure for the increased use of renewable energy. However, the awareness regarding alternative energy options and environmental behaviour are increasing. The active policy of the government and the easy access to various sources of information, especially the Internet, could be the reasons for increasing environmental awareness (Paper I, II).

A large share of the respondents gave their priority to the environmentally sound behaviour related to low carbon living. Results from a study about public environmental awareness and preferences of residents in Ningbo city, China, were similar in terms that people want to share environmental responsibility (Huang et al. 2006). Furthermore, according to the professionals' perceptions of the meaning of forest, a large majority of the respondents were clearly interested in environmental issues of life in general and also in ecologically sustainable energy. The public information on environmental issues is followed by media and this influences both opinion formation and current practices. Increasing environmental awareness is a good basis for meeting the substantial challenges of carbon emission mitigation in China (Huang et al. 2006). The media interest and the increasing public awareness would promote the development of sustainable forestry management based on the forest bioenergy sector.

5.6 Problems of developing FBE

Problems of increasingly developing forest biomass as an energy source in China were identified in this study. There are barriers related to research and technology, policy and law, and public awareness which were identified by the experts and professionals. According to the experts and professionals' opinions, China is rich in biomass resources in theory, but the supply of feedstock is insufficient. For example, there are obstacles in collecting and storing the feedstock for bioenergy production (Zhang et al. 2009b). In

addition, the forest bioenergy sector has a low level of industrialization. In recent years a few bioenergy demonstration projects (mainly biogas) have been established and operated successfully in China, especially, in southern rural areas (Zhang et al. 2009a). However, forest bioenergy technology is immature, equipment is lacking, and therefore, its industrialization is in a transitional stage. In addition, the lack of industry standards and underdeveloped conversion technologies are also the reasons why the development of forest bioenergy is relatively low in China in comparison to, for example, the EU and the USA (Zhang et al. 2009b).

The results also indicate that the policy implementation effort on supporting the development of forest bioenergy is insufficient in China. Although the Renewable Energy Law (NPC 2005) and the Medium and Long-Term Development Plan for Renewable Energy in China (NDRC 2007b) set detailed bioenergy plans which are clearer than the earlier laws, such as the increasing the target for developing bioenergy, there are no detailed plans to establish technical standards or guidelines for forest bioenergy (Wu et al. 2010). According to the answers by the experts and professionals in this study, it clearly shows that there is lack of technical standards and guidelines for forest bioenergy production. In addition, an incentive mechanism has to be established in the initial stage of the industrialization. For example, the Swedish incentive mechanism is an example in promoting the development of short rotation forest to some extent (Mola-Yudego and Pelkonen 2008). In the USA, the State governments have announced incentives to encourage forest bioenergy development, and this incentive mechanism is expected to give impetus to its development (Dwivedi and Alavalapati 2009). Therefore, forest bioenergy is to be developed with the support and subsidies from governments, not only in China but also in other countries (CEC 2005).

The study shows that the stakeholders' ecology-based environmental awareness is relatively high, but the awareness of using forest bioenergy is low, which indicates a lack of popularity regarding new types of energy sources. This could be seen when the most of the students chose "protect the environment" as the most important reason why they would switch from traditional to forest bioenergy and renewable energy. Moreover, the university forestry education in China is strongly oriented towards the ecological dimension. Although the Internet platforms play a significant role in delivering renewable energy information to the public, there is insufficient science-based and publicly accessible knowledge which is useful for recognizing and reasoning the new possibilities for using renewable energy in China. If the information dissemination and demonstrations are conducted in a timely and comprehensive manner in China, the forest bioenergy will likely become more popular, just like the case of biogas (Gan and Yu 2008). In the 12th Five Year Plan, China has committed to sustainably develop the energy sector, for example through supporting alternative energy sources. Similar to Han et al. (2008), it was also found in this study that there are three major reasons for the low public awareness of the development of forest bioenergy. First, the dissemination of information on climate change and energy crisis has been insufficient in rural areas. Second, the information on bioenergy technology is not widely disseminated in the remote areas of China. Third, the average income level in rural areas is low. Since people have direct access to firewood and coal is cheap, it is difficult to convince people to use new types of energy sources.

5.7 Evaluation of material and methods

In this study, regarding paper I, altogether 19 Internet platforms were studied, with the news articles of one Internet platform being analyzed in great detail. This seemed to be the most efficient research strategy taking into account the available time resources. However, this undoubtedly caused limitations in the findings of the research, due to the small number of platforms.

In this thesis, the target groups were not randomly chosen. According to Flyvbjerg (2006), when the objective is to achieve the greatest possible amount of information on a given problem or phenomenon, a representative case or a random sample may not be the most appropriate strategy. The objective of this study was to collect information dealing with some key forest sector stakeholders and open a new avenue of research within the forest bioenergy sector. Therefore, in order to get the richest information the samples were chosen by stratified random sampling. Due to Chinese culture and actual condition related to surveys and interviews the random sampling is more challenging and difficult than in many other European countries. There are features of case study in the four sub-studies, such as intensive investigations of particular individuals and groups. The case studies have limitations, such as the validity of the information and problems in making the generalizations (Blanche et al. 2006).

This thesis was a descriptive study. Public perceptions, attitudes and knowledge about bioenergy are useful to study before the strategies and policies will be completed. However, this type of study has not been done in China before. When we start looking for renewable energy implementation and especially biomass production and biomass energy in China, there might be clear differences between the public awareness related to the various benefits (environmental, social and economic) and the acceptance of the use of bioenergy. It is a problem, which cannot be solved easily. Usually the first step involves a public survey in order to determine the current situation among the population, as precisely as possible. The main results of this study describing the current situation may support the development of process towards acceptance of bioenergy.

The Delphi method is not a survey of national opinions, but reflects the bias and the expertise of the participants. The sample in this study was limited and may not reflect the opinions of all experts around the country. The survey of the professionals faces the same issue when talking about bias. However, the findings can serve as a starting point and a pre-study for further discussion of bioenergy development in China and internationally. The findings can provide a look at professionals' perspectives using a method that provides both qualitative and quantitative information. Further research will be required for determining which factors affect the various perceptions, attitudes, behaviors and their interrelations. This study is opening an avenue for research of these central questions of factors and relations.

Further studies should include more comparative analysis of news articles of different Internet platforms, also from the international ones. The procedure for conducting the content analysis on the Internet was in the preliminary stage in this study. The web content analysis from the methodological point of view needs to be further developed with validated instruments. In the future, research could be carried out also using in-depth qualitative content analysis to demonstrate how, for example, extreme weather events and the release of governmental policies affect news articles and portrayals of bioenergy issues. The public's perceptions and attitudes towards the

existing Internet information are challenging topics which will be of great interest for future studies.

In the sub-studies (Paper II), the Delphi survey and questionnaires were applied to collect data. The combination of methods has not been earlier used for collecting bioenergy related data in China. The Delphi survey was conducted through email, while the questionnaire surveys were conducted onsite in the institutions. It should be noted that the participating experts were from different regions of China, but it cannot be said that they completely represent the whole academic population. A similar methodological issue has to be taken into account when evaluating the university students' survey. The results based on this survey cannot be applied to the whole country. A case study approach gives a sort of national scope since NWAFU is one of the three universities (together with Beijing Forestry University and Northeast Forestry University) which are supported by the State Forestry Administration and Ministry of Education. In addition to the national status, NWAFU is also the only agricultural and forestry university in Shaanxi Province and is attracting students from many other provinces as well.

In the sub-study (Paper IV) concerning the professionals, the respondents came from two courses organized by STAFA. It would be very difficult to get responses from a similar group in China representing the whole country due to the large geographic area and due to the short traditions to carry out surveys in the field of forestry related with bioenergy. The professionals' may be incorporated into the current and forthcoming forest bioenergy development and related policies. In the Chinese forestry sector, this kind of incorporation should have remarkable influence on the future policy development. The thorough study of this is important for forest bioenergy strategy development. STAFA's positive attitude was necessary since it is a training institute and provides training opportunities for civil servants and other employees of the SFA in China. The participants in this study are heads of the bureaus of forestry and county leaders who are responsible for forest programs representing a high level of decision making and implementation of forest policies in different provinces.

In addition, with the maturity of forest bioenergy industrialization and the application of tenure reform in China, the availability of forest bioenergy can be severely affected by the forest owners' willingness to adopt bioenergy products. Therefore, it is important to examine 1) the farmers' perceptions of the development of forest bioenergy, 2) how to encourage farmers to put effort into oil plantations, and 3) how to encourage them to connect with the forest bioenergy enterprises. In China, the forest biomass resources and soil conditions vary throughout the country and the adoption of developing forest bioenergy will be different. The research can be conducted in different regions in China to determine the potentials for developing forest bioenergy. Finally, the management plans which are suitable for different regions should be made.

6 CONCLUSIONS

This research provides the first look at different stakeholder's perceptions regarding the development of forest bioenergy in China. The findings from the stakeholders' assessments and content analysis of the news articles on the Internet indicate that there is wide support and great potential for renewable energy, in general, including also forest bioenergy development. However, according to the results, it seems that other forms of renewable bioenergy, such as biogas, are more widely known as forest bioenergy.

According to the Internet based study (Paper I), the amount of news articles reflects the changes and outcomes of the government energy policies. The content was well in line with the government policy. In addition, biogas is the main source of bioenergy in China today and liquid biofuels (bio-diesel and ethanol) are the main bioenergy options in the future in the country.

The experts and professionals in this study (Papers II and IV, respectively) felt that China has abundant forest biomass resources and unused land areas for developing forest bioenergy. However, they also identified barriers, such as research and technical weaknesses, policy and regulation shortcomings, and low levels of awareness and low social acceptability. The experts and professionals emphasized that the early stages in the development of forest bioenergy mainly depends on the support of the central government. A long-term and effective policy and organization for enhancing the development of forest bioenergy is needed. Although the industrialization of forest bioenergy is a gradual process, the sustainable utilization of forest biomass and abundant land resources, decreasing the forest logistics cost, and marketing the bioenergy product are the priority development areas in China, which was also reflected from the experts and professionals' assessment on the development of the forest bioenergy in China.

The study also shows that students' knowledge about forest bioenergy is low (Paper III), while the professionals have a good basic knowledge and awareness concerning the forest resources and the development of forest bioenergy (Paper IV). Both students and professionals are willing to disseminate the forest bioenergy knowledge and encourage people to get bioenergy related information. According to this study, the recommendations for forest bioenergy education are: 1) public awareness of bioenergy should be increased, 2) professional training for forest industry's staff should be developed, 3) training for farmers should be offered to enable them also to use advanced technology, 4) higher education related to forest bioenergy should be developed, especially in the forestry and agricultural universities.

According to the results of this study both forestry professionals and university students emphasize the importance of information and claim that the Internet plays an important role and contains possibilities for increasing awareness of renewable energy. The role of government was seen as most important in the first stages of forest bioenergy development. The content analyses of energy related internet platforms showed that the use of internet as dissemination forum for renewable energy is increasing and that the content is well reflecting the government energy policy. This indicates that the government has main role in renewable energy development; however,

also the role of companies was recognized by the respondents of this study. According to the experts, national standards for the forest bioenergy production should be established. To guarantee the sustainable development, the government should develop criteria which take into account also sustainable ecosystem management, as well as the sustainability of the whole life cycle of the renewable energy products.

Although forest bioenergy has been seen as an example of sustainable development in international literature, the energy sector in China has not benefited much from FBE. By comparison with the forest bioenergy development in Europe, the Chinese national targets are quite challenging due to the rapid increasing economic growth. So far, the forest bioenergy industrialization is in the initial stage and the share of forest bioenergy has remained small. As recognized by the respondents of this study, companies might play an important role in renewable energy development. To get more reliable view of the future development of renewable energy sector in China the preferences of companies and similarly the preferences and choices of consumers should be studied. It would also be important to study the relationship between Chinese national energy policy and forest bioenergy technology development, as well as the effects of design and location of bioenergy plantation on local acceptability, and also the overall availability of biomass resources in China.

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APPENDIX

First round Delphi survey questions:

- Profile: location, professional background, years of involving the research field, gender, age, and email address.
- What are the key drivers for the development of forest biomass energy in China?
- Please explain the advantage and disadvantages of the forest biomass energy from the perspectives of economy, ecology, and social.
- Please list the major source of the forest biomass energy.
- What are the challenges that could prevent the implementation of forest biomass energy in China?
- Who should pay attention to the development of forest biomass energy in China?
- In your opinion, what kind of role should the governments play in supporting the development of the forest biomass energy in China?
- At present, the development of forest biomass energy is in its very beginning stage, how could it be in about ten years?
- What kind of practices you recommend in order to promote the development of forest biomass energy in China?

A survey of University students' acceptance of forest bioenergy:

1. How old are you?
2. Are you
   - ☐ Male
   - ☐ Female:
3. Where are you from?
   - ☐ Rural
   - ☐ Urban
4. What is your study subject, and please specify it:
5. What degree you are studying now, and please specify it:
6. Have you ever heard of forest bio-energy?
   - ☐ Yes
   - ☐ Never

7. What kind of energy is commonly discussed in your daily life?

Types	Choice
Coal	
Oil	
Solar energy	
Wind energy	
Firewood	

Hydro power	
Bioenergy	

8. What do you prefer for your own heating and transportation in the future?

CH:Heating			
1.Coal			
2.Fire wood			
3.Wind energy electricity			
4.Hydropower electricity			
5.biogas			
6.forest bioenergy electricity			
others			
CT:Transportation			
1.Diesel			
2.hydrogen fuel			
3.Blended petrol			
4.Petrol			
Others			

9. Which factors are important when you chose energy?

Factors	Most important	Important	N	Not important	Not Important At all
1.security or safety					
2.environmental friendly					
3.secure supply					
4.Renewable sources					
5.Cheapest energy source-price					
6.others					

10. How much would you like to agree or disagree with the following statements?

statements	Strongly agree	Agree	N	Disagree	Strongly disagree
1.More use of forest bioenergy can mitigate the environmental problems.					
2.It is justified to support the development of forest bioenergy.					

3.Forest bioenergy would be a major source of bioenergy in 10 years					
4.I would be happy to educate and encourage people to get more knowledge about forest bioenergy.					
5.It is necessary to teach knowledge about forest bioenergy in school.					

11. Would you change to renewable energy electricity if that would cause any additional costs?

☐ Yes
☐ Probably yes
☐ Neutral
☐ Probably no
☐ No

12. Would you change to forest bioenergy electricity if that would cause any additional costs?

☐ Yes
☐ Probably yes
☐ Neutral
☐ Probably no
☐ No

13. If renewable energy electricity would cause additional costs, how much more is acceptable for you?

☐ Less than 1%
☐ 1-5%
☐ 6-10%
☐ 10-15%
☐ More than 15%

14. If forest bioenergy electricity would cause additional costs, how much more is acceptable for you?

☐ Less than 1%
☐ 1-5%
☐ 6-10%
☐ 10-15%
☐ More than 15%

15. If you would use renewable energy for your daily life, what is the reason?

☐ Your own preference
☐ Required by the government law or rule
☐ Protect the environment

☐ Follow the trend
☐ I do not know

16. If you would use forest bioenergy for your daily life, what is the reason?
☐ Your own preference
☐ Required by the government law or rule
☐ Protect the environment
☐ Follow the trend
☐ I do not know

17. Does China have the Renewable energy Law?
☐ Yes
☐ No
☐ I do not know

18. Have you ever read Renewable energy Law in China?
☐ Yes
☐ Never

19. From which information sources have you got info about forest bioenergy and related matters?

Information sources	Yes	No
1.magazines		
2.newspapers		
3.Radio		
4.TV		
5.Education		
6.Energy company		
7.Friends/relatives		
8.Environmental movement		
9.The Internet		
10.this survey		
Others:		

20. What do you consider to be the main influence on your views toward forest bioenergy?

	Very important	Important	N	Not important	Not important At all
1.Television					
2.Newspaper					
3.Radio					
4.Education					
5.Advertisement					

6.The Internet					
Others :					

Professionals' knowledge, perceptions and attitudes towards the development of forest bioenergy in China

Social demographic information:

1. Gender A. ☐ Female B. ☐ Male
2. Year of born? _____
3. Are you A.☐ Single B.☐ Married C.☐ Cohabiting D.☐ Other, please specify:
4. What is your working place location? Please specify it by name of the city or village: _____
5. What is your living place? A ☐city, name of the city: _____
   B ☐countryside, name of the village: _____
6. What kind of house do you live?
   A ☐ Rented apartment
   B ☐ Owned apartment
   C ☐ Rented single family house
   D ☐ Owned single family house
7. What type of energy is used in your house?
   7a. For heating:
   A. ☐ Firewood B. ☐Wind power(own mill) C. ☐ Coal
   D ☐Solar power E. ☐ biogas F. ☐ Gas G. ☐ Oil
   H ☐Electricity, Please specify, if you know, how the electricity is generated (e.g. nuclear, wind power..): _____
   I Other:
   7b. For cooling:
   A ☐Wind power(own mill) B. ☐Solar power C. ☐ Oil
   D ☐Electricity, Please specify, if you know, how the electricity is generated (e.g. nuclear, wind power): _____
   E Other:
   7c. For cooking:
   A ☐ Firewood B. ☐Wind power(own mill) C. ☐ Coal
   D ☐Solar power E. ☐ biogas F. ☐ Gas G. ☐ Oil
   H ☐Electricity, Please specify, if you know, how the electricity is generated (e.g. nuclear, wind power..): _____
   I Other:
8. Can **you** decide what kind of energy is used at your house?
   A ☐ Yes I can B ☐ No, I cannot. Why: _____
9. What is the highest stage of **your education** (including if you are still doing this degree)?

   A. ☐ High school B. ☐ College
   C ☐ Vocational school D ☐ Polytechnic school
   E. ☐ Bachelor degree in the university

F. ☐ Master degree
G. ☐ Doctoral degree
H Other, please specify: _____

10. Do you have any education in forestry or in forestry related field?
A ☐ Yes, specify _____ B ☐ No
11. What is your current title at job?
How many years you have been working in this position? _____

12. What is the monthly gross income in your household?
A. ☐ > 8 000 Yuan B. ☐ 6000 – 7999 Yuan
C. ☐ 4000 – 5999 Yuan D. ☐ 2000 – 3999 Yuan
E. ☐ < 1999 Yuan

Part 1. Questions concerning <u>your</u> energy use in your everyday life

13. Do you have your own car?
A ☐ Yes, I have one and it is a normal emission car
B ☐ Yes, I have one and it is a low emission car
C ☐ I do not have a car
14. What is your water heater at home?
A ☐ Electric water heater
B ☐ Solar water heater
C ☐ District heating. What is the fuel if you know please specify it:
D ☐Other, please specify:
15. How do you go to work normally?
A ☐ By driving own car
B ☐ By public transportation
C ☐ By biking
D ☐ By walking
E By other means, please specify _____
16. Did you participate in the last “Earth Hour” actively?
A ☐Yes
B ☐No, because I did not care
C ☐No, because I never heard of “Earth hour”

Part 2. Questions about your knowledge concerning forest and energy issues in China. Please give the answer <u>you</u> think is right, even though if you are not sure.

17. What is the current forest coverage in China approximately?
A ☐ 10% B☐14% C☐18% D☐22%
18. What is the share (%) of imported oil of total oil consumption in China in 2009?
A ☐ 10-29% B☐30-49% C☐50-69% D☐>70%
19. What is the share of commercial forest bioenergy in total energy consumption in China?
A ☐ 20-30% B☐10-15% C☐5-9% D☐<3%
20. How many percents renewable energy will cover in future from the total energy

consumption according to Medium and Long-Term Development Plan for Renewable Energy in China?

A ☐ 10% B☐15% C☐20% D☐30%

21. What is the general trend of imported forest wood products in China during the last ten years?

A ☐ Increasing B☐ No change C☐Decreasing

22. What is the most commonly used type of bioenergy in China?

A ☐ Biogas B☐ Liquid biofuels C☐Forest bioenergy

Part 3. Questions concerning forest in general.

23. What is the meaning of forest in China according to **your opinion**? Please use the score from 1 to 5 (1=Not important at all to 5=Very important) to identify the importance of each item.

	1	2	3	4	5
A. Recreational function					
B. Timber production					
C. Provide raw materials for bioenergy production					
D. Maintaining the ecological balance					
E. The containment of soil desertification					
F. Water conservation					
G. Mitigate the greenhouse effect					
H. Beauty of landscape for amenity values					
I. non-wood forest product, such as berries and mushrooms					
J. Nature conservation					
K. Employment in timber production					
L. Hunting and game management					
M. Providing firewood					
N. Others, specify:					

24. How important do you consider the following issues that China is facing today concerning forests? Please use the score from 1 to 5 (1=Not important at all to 5=Very important) to identify the importance of each.

	1	2	3	4	5
A. Mitigation of Climate change					
B. Forest tenure reform					

C. Forest bioenergy development					
D. Pulp wood production					
E. Saw timber production					
F. Nature conservation					
G. Forest carbon sinks					
H. Sustainable forest management					
I. Forest certification					
J. Recreational use of Forests					
K. Nature tourism					

Part4. Your opinions on developing forest bioenergy.

25. Please indicate whether you agree with each of the following statements by using the score from 1-5.

	Strongly disagree (1)	Disagree (2)	Not agree not disagree (3)	Agree (4)	Strongly agree (5)
Increasing the share of forest bioenergy can reduce CO_2 emission.					
FBE is equally discussed issues in media in China with other renewable energy such as solar, wind energy, oil bearing crops.					
There are unused abundant barren hills and wasteland in China which are suitable to develop the forest bioenergy production.					
There is reliable policy dealing with FBE in China.					
The development of forest bioenergy can reduce China's reliance on imported oil.					
There is lack of recognition of the potential of forest bioenergy among professional foresters.					
There is lack of national standards for forest bioenergy production.					
The investments in the forest bioenergy industry by different stakeholders in					

China have not been successful during the last ten years.					
The utilization of forest biomass as energy in the current stage is restricted because of technical barriers (such as low conversion efficiency due to immature lignin-cellulose decomposition technology).					
Use of forest biomass for energy can cause overuse of forest resources.					
In China forest resources should be used more for energy.					
In China forest resources should be used only for forest industry (paper, furniture, construction etc).					
The Chinese government should provide financial support for forest bioenergy development.					
The Chinese government should play supervision role in the developing stage of forest bioenergy industry.					
The development of forest bioenergy is determined by the oil price.					
The development of forest bioenergy is determined by paper industry.					
The private industry should play important role in the development of forest bioenergy.					
It is difficult to develop forest bioenergy in China at present.					
There is not enough wood resources for energy production in China					
In China wood resources should be used in wood industry instead of energy production					

Part 5. Your perceptions/attitudes of forest bioenergy

26. Please indicate whether you agree with each of the following statements by using the score from 1-5.

	Strongly disagree (1)	Disagree (2)	Not agree not disagree (3)	Agree (4)	Strongly agree (5)
The production of forest bioenergy will increase in China.					
Biofuels will replace fossil fuels in ten years.					
I would like to spread the forest bioenergy knowledge to my family members and friends.					
I would like to learn more about forest bioenergy.					
I have received enough information and knowledge about forest bioenergy.					
Forest bioenergy production is conflicting with food production in China.					
I would be happy to convince forest owner to develop energy forest.					
Wood-energy production should be part of sustainable forest management practice in China.					
It is an exact time to take forest based environmental issues more into consideration when developing the economy in China.					
Low environmental awareness of public is an obstacle for developing forest bioenergy in China.					

It is necessary to develop forest management practices which takes into account also energy wood production in addition to timber production.					

27. How do you see the importance of following channels in dissemination of forest bioenergy knowledge and information? Please use the score from 1 to 5 (1=Not important at all to 5=Very important) to identify the importance of each.

	1	2	3	4	5
Television					
Radio					
Books					
Newspapers and magazines					
Government documents					
Internet					
Professional training program					
Degree education					

28. If you can freely choose and assuming that the price is the same for all energy forms, what would you prefer in your own heating and transportation in the future? Please rank them from best to worst, separately from heating, transportation, and cooking.

Heating	
1.Coal	
2.Fire wood	
3.Wind energy electricity	
4.Hydropower electricity	
5.Biogas	
6.Forest bioenergy electricity	
7. gas	
8. oil	
9. Other, specify:	

Transportation	
1.Diesel	
2.Hydrogen fuel	
3.Blended petrol	
4.Petrol	

5.Liqud biofuels	
6. Other, specify:	

Cooking	
1.Coal	
2.Fire wood	
3.Wind energy electricity	
4.Hydropower electricity	
5.Biogas	
6.Forest bioenergy electricity	
7. gas	
8. oil	
9. Other, specify:	