LAPPEENRANTA UNIVERSITY OF TECHNOLOGY

Faculty of Technology

Degree Programme in Bioenergy Technology

Master of Science Thesis

POTENTIAL TO DECREASE GHG EMISSIONS FROM BIOMASS RESOURCES IN CHINA

Lappeenranta 2016

ABSTRACT

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Title: Potential to decrease GHG emissions from biomass resources in China

Faculty of Technology

Year: 2016

Master's thesis, Lappeenranta University of Technology

87pages, 25 figures and 28 tables

First supervisor: Professor Risto Soukka

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Keywords: environment issues, policy, biomass resources, sustainable technology, life cycle assessment

This paper describes the environment issues which are caused by fossil fuel utilization, and the available of biomass resources and relevant applications in China and relevant policy for supporting biomass resources development. In addition the sustainable technology for energy and fuels generation in China and the advantages and disadvantages of technologies are presented as well. This paper aims to find out how the policy can promotes the biomass resource development and from environment aspect to see why the biomass resources should replace fossil fuels in the future. In this paper the life cycle assessment of straw biomass resource will be as an example to present the same amount of energy produced by straw and coal, the different amount of emission will be emitted.

Contents

ABBREVIATIONS

IEA	International Energy Agency
TEC	Total Energy Consumption
EIA	Environmental impact assessment
PM	Particulate Matter
NBS	National Bureau of Standards
CFB	Circulating fluidized-bed
NMVOC	Non-methane Volatile Organic Compounds
AQI	Air Quality Index
PC	ASSENGER CAR
MC	Motorcycle
LDV	Light duty truck
HDT	Heavy duty truck
BGPG	Biomass Gasification and Power Generation System
FAME	Fatty Acid Methyl Esters
FAD	Flavin Adenine Dinucleotide
FFA	Free Fatty Acid
GHG	Greenhouse gas
GLO	Global
GWP	Global warming potential
HP	Heat Plant

ISO	International Standards Organization
LCA	Life cycle assessment
LCI	Life cycle inventory
LCIA	Life cycle inventory analysis
LHV	Low heating value
S0	Scenario 0
S1	Scenario 1
S2	Scenario 2
S3	Scenario 3

Units

g	gram
kg	kilogram
km	kilometer
MJ	Megajoule
MWh	Megawatt-hour
t	ton

Chemical elements and compounds

CH4	methane
CO2	carbon dioxide
H2O	water
BC	Black carbon

OC	Organic Carbon
N2O	nitrous oxide
NOx	nitrogen oxide
SO2	sulfur dioxide

1. INTRODUCTION

China is the most populous country in the world and its economy is growing rapidly in recent years, which make it become the giant in consuming and manufacturing power all over the globe. According to the information from IEA, in 2009, China's TEC reached about 2.15 billion toe, among the energy, fossil energy accounts for the largest scale: coal accounted for around 70%, followed by 18% oil and 4% natural gas. Coal is the primary fossil fuel used in China, because it is inexpensive and amounts are available. In contrast, in the United States and the rest of the world, coal accounts for the lower share of the fossil-fuel base. In 2009, China became the world largest energy consumer. Besides, the information from IEA's report shows that the consumption of fossil energy remains unchanged in the last 30 years, hence, follow such consumption speed the fossil energy will deplete after two hundred years then China will face energy crisis. (IEA, 2012)

Except energy crisis, at the moment, climate change and related environmental issues are the challenging issues as well. One of the problems is the air quality which is getting worse in many areas. Emissions from humans' activities have led to the serious air pollution, which is believed to be greatest cause to people's health issues. There are many sources that rise to the decrease in air quality; however, energy in general and electricity in particular is considered to be the major source of the issue in most places. For example, when oil is used for vehicles energy, which are expensive, caused heavy pollution and not renewable energy as well. While, the biofuel as the traffic energy is cleaner and safer, which made by lignocellulosic biomass. Considering the advantages from biofuels that may be the new popular energy for vehicles.

China as a fast developing country, in order to develop the economy and protect the environment at the same time, reduce the consumption of fossil energy is necessary and find green and renewable fuel is important.

Today implementation of biomass is wide in China, especially in rural areas. Most of wood and agricultural residues are used for cooking and heating, by this way, the price is inexpensive, but the indoor pollution cannot be avoided, and some unhealthy impacts. In addition, this is fine for temporary not for long term. The people who collect these biomass would lost more others activities. However, if the fuels can be used by modern technologies to produce heat then not only the environment can be protected but also people's living standard can be huge improved, and promote the rural industrialization and rise employee rate in rural. Moreover, with sustainable biomass utilization, global warming and climate change will be under controlled. (Youding, 2016) (A. Witter, 2009)

This article focus on discuss the availability of biomass resources in China, the current modernized biomass technology development, and implementation of biofuels. The paper also indicates policy support for biomass utilization in China, in the end the life cycle assessment of (wheat) straw will be presented as an example to show how it is important that biomass resources should replace fossil fuels.

2. FUELS CONSUMPTION IN CHINA

In China, coal is the dominant energy sources for energy production and account for 70% of country's TEC in 2009, the rest fossil energy-oil and natural gas are indispensable as well. Although, strong growth in consumption of oil. The share of TEC (total energy consumption) fell from 22% to 18% in 2009. While the utilization of coal increase even faster to meet to demand. The share of natural gas doubled from 2% in 2000 to 4% in 2009. (IEA, 2012)

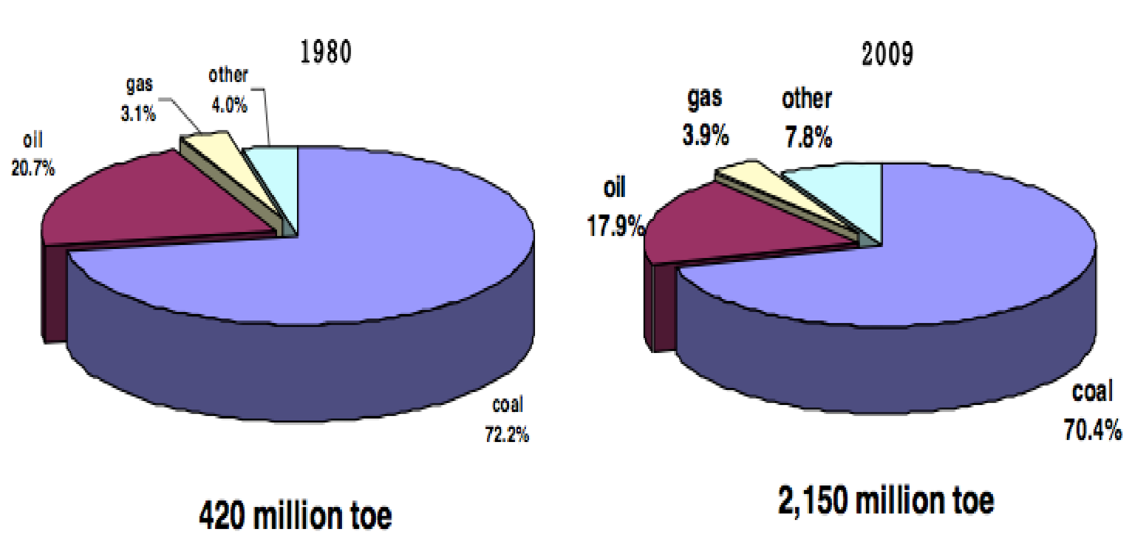


Figure 1. Total primary energy supply. (IEA, 2012)

The energy demand has increased with higher rate than developed countries, and from following figure 2 it can be find out that in 2002, the energy consumption rise exponentially, rapidly increase from about half the level of U.S. demand, around 2009, the consumption almost reach the same level and Chinese demand surpasses the U.S. demand after 2009.

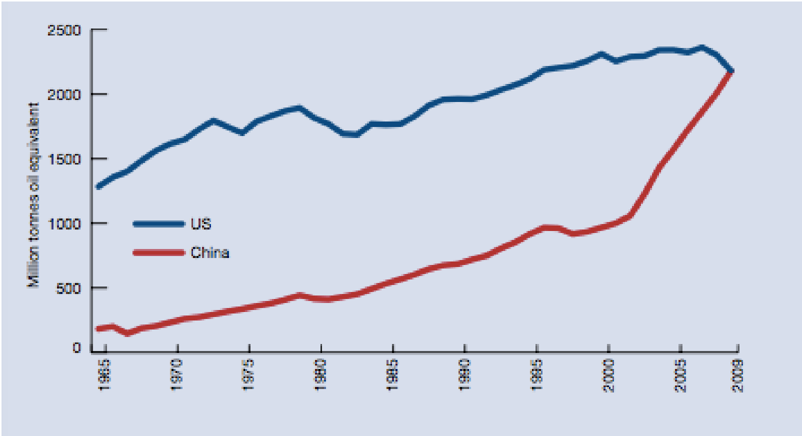


Figure 2. Primary Energy Consumption, 1965–2009. (Anon., 2010)

Because of high energy demand, fossil fuels contribute more in China, the hydropower, nuclear power and other renewables such as wind and solar contribute very little.

2.1. Coal

The vast coal resources enable the fuel to remain the mainstay of China's energy sector and to be a key driver of economic growth over the past decade. In the recent years, consumption of coal account for almost half of the global coal consumption, also is one of the important factors associated with energy related CO_2 emissions. (WEC, 2013)

In China, there are 28 provinces where produce coal and amount of coal resources are in Shanxi, Xinjiang and Shanxi. So far, about 12000 coal mines are producing primarily bituminous coal and a huge amount of anthracite and lignite. These factors result in thermal coal, which used for generating electricity, heat in the industry and coking coal that used to smelt iron ore and produce steel. Almost of thermal coals are located in the north central and northwestern regions, while, coking coal reserved in central and coastal parts of China.

2.2. Oil &Natural gas

In 2009, China consumed nearly 10% of global oil supply, whereas about 22% oil consumption in U.S. Nevertheless in U.S. the growth of oil consumption is expected to flatten out and the share of global oil demand to decrease in the next two decades. While, in china oil demand will grow strongly, and global share will reach to 15% by 2035. (IEA, 2012)

Because of less recoverable oil reserve, and in order to meet domestic demand China has to import oil from outside. In 2000, the domestic oil production rose to 17%, but even with increase, the production still cannot meet the consumption. ‘China is thinking and acting strategically through its national oil companies to ensure stable supplies of oil to meet its growing demand’. (EIA, 2004)

China is a net importer of natural gas. Comparing with coal, natural gas is not a significant part. Same as oil resources, natural gas resources are quite small and less than 2% of recoverable reserves globally. Even in 2000, production has tripled, but it still amounted to only 3% output.

2.3. Renewables

In recent years, the demand of renewable energy keeps increased gradually, while the shares remain relatively lower than fossil energy consumption. The consumption of hydropower achieves around 6% of domestic energy consumption. Figure 3 shows energy mix in China in 2009, the consumption of as wind, ethanol, solar, and geothermal occupied smaller shares. From figure 4, as it can be seen that wind power consumption in China and the United States are same.

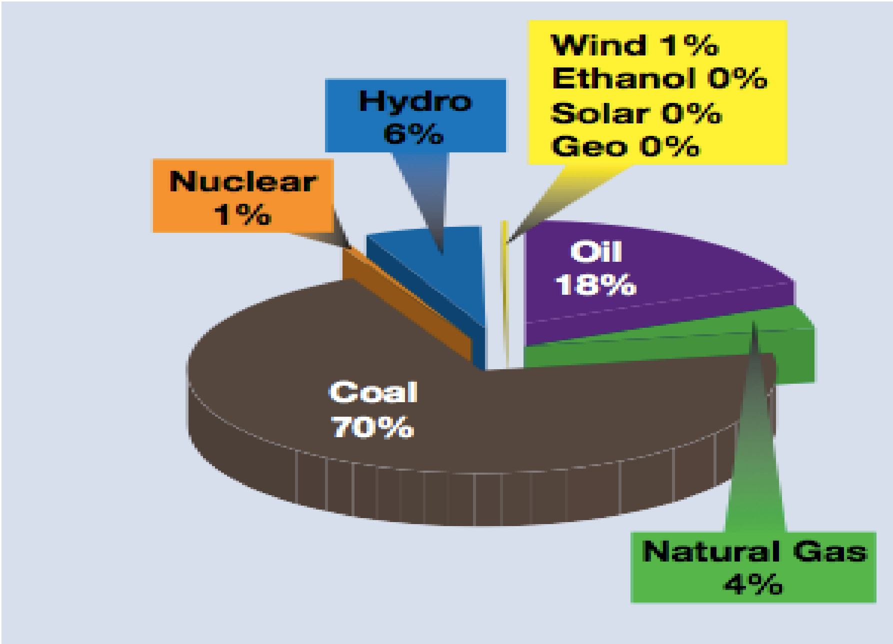


Figure 3. China energy mix in 2009. (Anon., 2010)

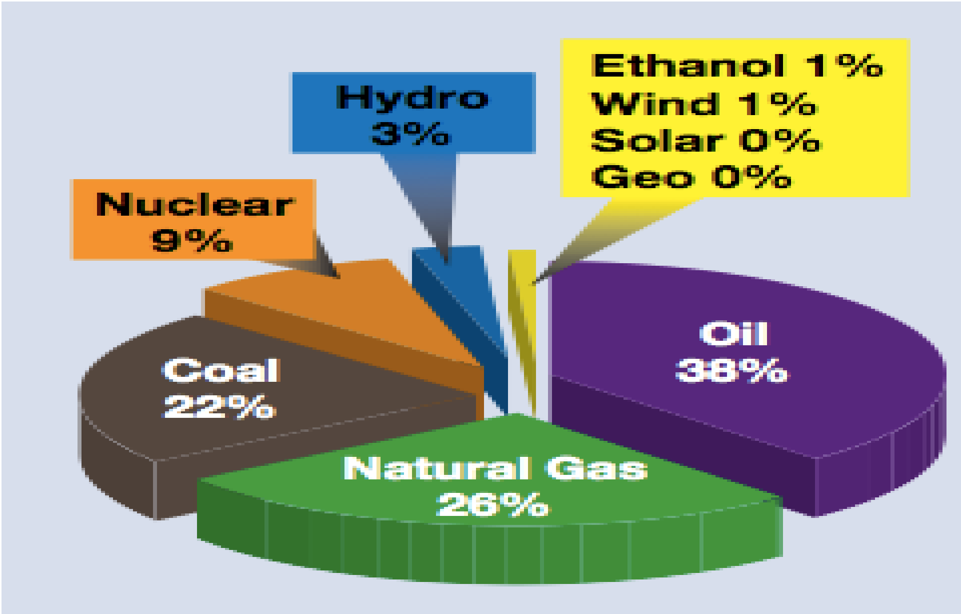


Figure 4. U.S. Energy Mix in 2009. (Anon., 2010)

Table 1 presents other renewable sources are used in different countries, as it can be seen, in China, the share of ethanol and solar energy is small. Only less than 3% share of global ethanol consumption and 1.3% share of solar.

Table 1. Shares of Global Renewable Energy Consumption and Capacity of Top 10 Countries.

Hydroelectric	Wind	Ethanol	Solar	Geothermal
China (18.8)	U.S. (22.0)	U.S. (52.9)	Germany (42.2)	U.S. (28.8)
Canada (12.2)	China (16.1)	Brazil (33.9)	Spain (14.9)	Philippines (17.8)
Brazil (12.0)	Germany (16.1)	China (2.7)	Japan (11.5)	Indonesia (11.2)
U.S. (8.4)	Spain (11.7)	Canada (2.2)	U.S. (7.2)	Mexico (8.9)
Russia (5.4)	India (6.8)	France (1.4)	Italy (5.2)	Italy (7.9)
Norway (3.9)	Italy (3.0)	Germany (1.0)	Korea (2.3)	New Zealand (5.9)
India (3.2)	France (3.0)	Spain (0.6)	Czech Rep (2.0)	Iceland (5.4)
Venezuela (2.6)	U.K. (2.7)	Thailand (0.5)	France (1.6)	Japan (5.0)
Japan (2.3)	Portugal (2.2)	Colombia (0.4)	Belgium (1.6)	El Salvador (1.9)
Sweden (2.0)	Denmark (2.1)	Australia (0.3)	China (1.3)	Kenya (1.6)

3. ENVIRONMENTAL ISSUES

Pollution is one of the most serious issues in China, and also restrict the economic development. Keep increasing use of energy is one of the reasons of environmental pollution. While the pollution can be largely decreased by developing bio-energy which is more environmental friendly and helpful to economic sustainable development. This chapter, pollutants of electricity industry and transportation sector will be discussed in detail.

3.1. Pollutants of electricity industry in China

The high dependence on coal-fired power plants has made China's electricity industry produce large amounts of emissions, thus contributed to serious environmental impairments. Emissions of sulfur dioxide, carbon dioxide, nitrogen oxides, particulate matter and other atmospheric pollutants from coal- fired power plants have been closely observed by the environmental protection agency. 'In average, in China, each 1000 kWh generated electricity would produce approximately 0.21 ton of CO_2, 4.6 kg of SO_2 and 2 kg of particulate respectively (Yang, 2006)'.

Figure 5 presents the emission from China's power plants from 2005 to 2010. As can be seen, the amount of emissions for each kind of pollutant is quite large. It is positive that the amount of SO2 and PM (both PM10 and PM2.5) have been significantly reduced from 2005 to 2010.This is probably because that Chinese people and government have realized the serious environmental issue and have taken measures to control the pollution.

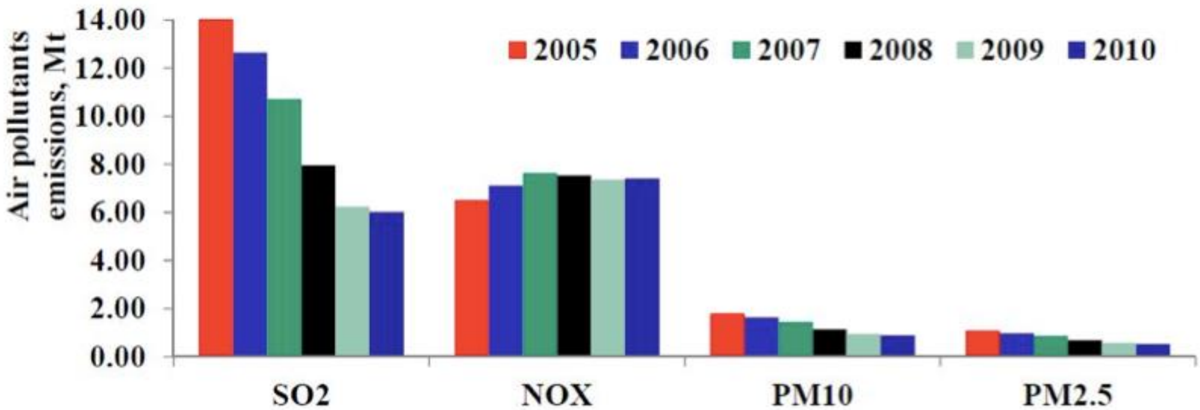


Figure 5. Emission from China's power plants: 2005-2010. (Zhen, et al., 2015)

'In the ambient atmosphere, SO2 and NOx, together with their secondary pollutants, can have serious impacts on the environment and human health (Suna, et al., 2014)'. 'PM2.5 is a major contributor to the regional haze (i.e., visibility reduction) and has considerable effects on respiratory diseases and global climate change (Yang, et al., 2013)'.

3.2. Pollutants of transportation sector in China.

As the living standard improved, the more number of vehicles has reached (such as, in 2011, the number was 4 times of in 1999), and the emissions from transportation tool have largely increased in the world.

Vehicles significantly contribute the CO (carbon oxide), NMVOC (Non-methane Volatile Organic

Compounds), NOX (nitrogen oxide), BC (black carbon) and OC (Organic Carbon) emissions internationally (Cheng, et al., 2013). Abundant vehicular emission has influence on the air quality. For example, in Beijing the road vehicles contributed to 64.1%, 57%, 11% and 35% of the atmospheric NOX, NMVOC, POC and BC respectively (Cai & Xie, 2007). The emission on the global warming has received the attention in China (Shindell, et al., 2011).   Among these emissions, BC is one of the important pollutants, and made huge contribution to climate change. Moreover, these emissions also threat human' life and have adverse effects on economy, thus it is great important to develop vehicular emission inventory (Papapostolou, et al., 2011).

Figure 6 indicates the vehicular emissions from 1999to 2010. The trend of vehicular CO, NOx and BC emissions keep increasing during this period. The NOx, BC and CO emissions increased from 2200Gg, 48Gg and 22000Gg in 1999 to 7500Gg, 180Gg and 32500 Gg in 2010 respectively. In addition, the change rate of CO and NOx is larger than BC emission, and according to this average change rate, the global warming will be heavy in the future years if no effective actions are taken out.

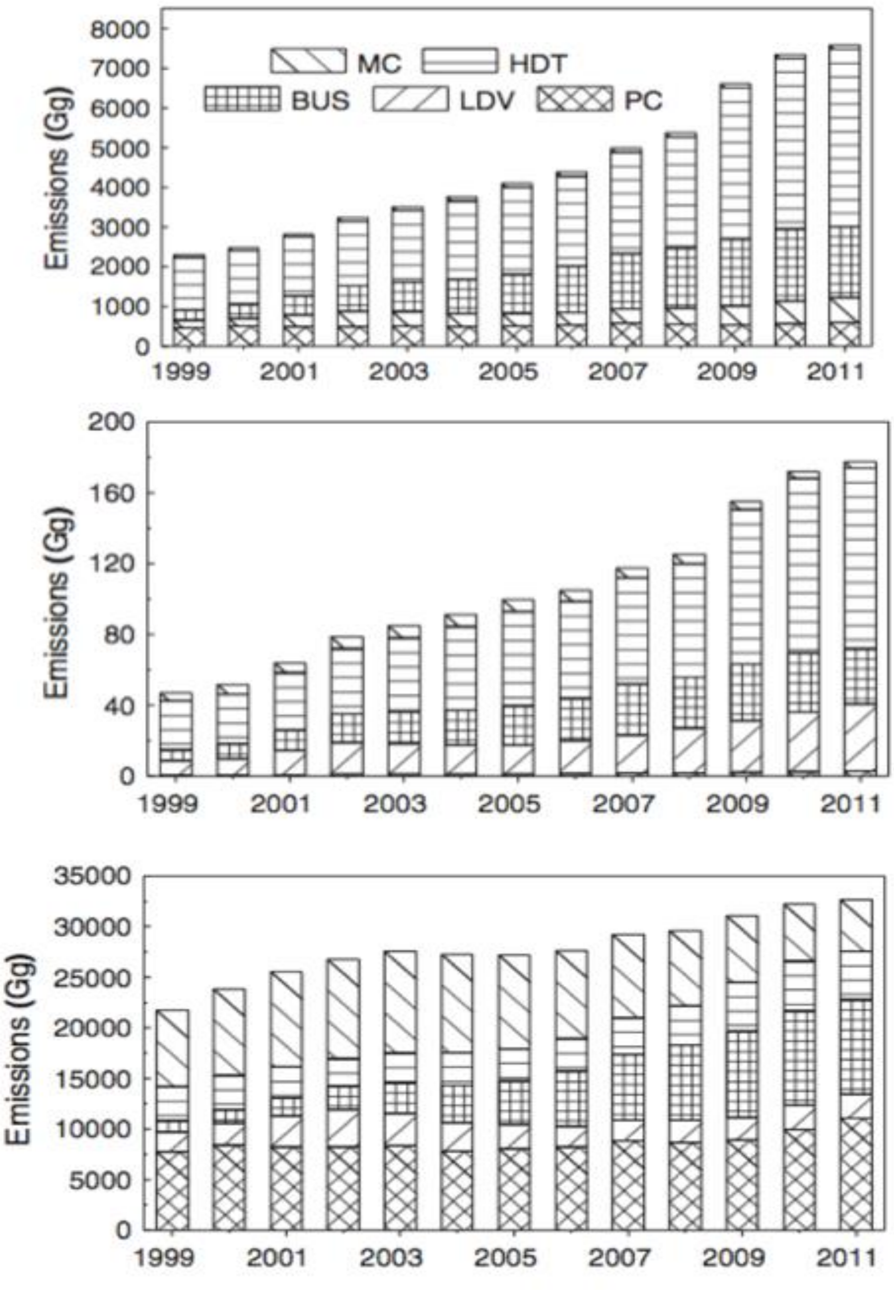


Figure 6. The vehicular emission of NOx, BC and CO respectively form 1999-2011. (Lang, et al., 2014)

3.3. The consequence of environmental pollutants

In 2014, smog is extraordinary heavy in many cities of China. Discharging waste from coal-based plants is the main reason of haze's formation. As table 2 shows the various level pollution in different 30 cities in China. Among them, 12 cities' AQI level (table 3) is hazardous and the rest are very unhealthy. For example, in Beijing (figure 7), the major share of PM2.5 are burning coal, motor vehicle, discharge of catering industry and others, such as burning biomass.

Table 2. Air pollution of different cities. (Blog, 2010)

Air Pollution in China's cities							
Top	City	PM 2.5	Levels of Health Concern	Top	city	PM 2.5	Levels of Health Concern
1	Cangzhou	**469**	Hazardous	16	Nanjing	**282**	Very unhealthy
2	Hengshui	**447**	Hazardous	17	Wuhan	**277**	Very unhealthy
3	Jinan	**374**	Hazardous	18	Baoding	**275**	Very unhealthy
4	Tianjin	**357**	Hazardous	19	Changzhou	**270**	Very unhealthy
5	Tangshan	**341**	Hazardous	20	Qihuang dao	**259**	Very unhealthy
6	Lian Yungang	**332**	Hazardous	21	Jinhua	**278**	Very unhealthy
7	Hefei	**329**	Hazardous	22	Dalian	**257**	Very unhealthy
8	Yancheng	**328**	Hazardous	23	Henzhou	**250**	Very unhealthy
9	Taizhou	**322**	Hazardous	24	Qindao	**239**	Very unhealthy
10	Langfang	**320**	Hazardous	25	Handan	**237**	Very unhealthy
11	Huaian	**313**	Hazardous	26	Suzhou	**236**	Very unhealthy
12	Yangzhou	**308**	Hazardous	27	Zhujiang	**236**	Very unhealthy
13	Zhenjiang	**296**	Very unhealthy	28	Suqian	**232**	Very unhealthy
14	Xuzhou	**292**	Very unhealthy	29	Shaoxing	**232**	Very unhealthy
15	Huzhou	**282**	Very unhealthy	30	Nanchang	**223**	Very unhealthy

Table 3. Meaning of Air Quality Index (AQI) Basics. (Anon., ei pvm).

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects.

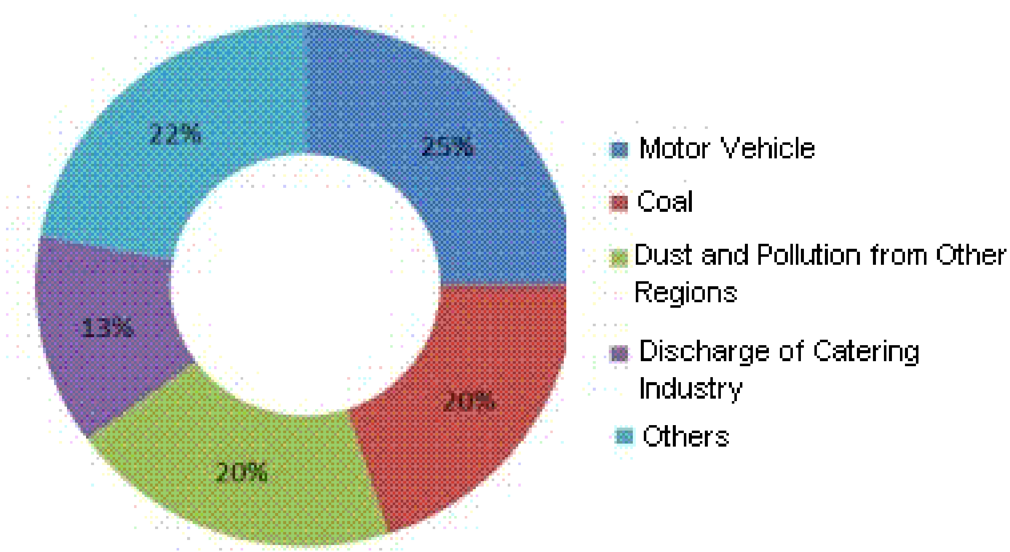


Figure 7. Major source of PM2.5 in Beijing (2013). (Yang, et al., 2013)

4. AVAILABILITY OF BIOMASS RESOURCES IN CHINA

Compared with developed countries, China's new energy development and utilization time is relatively late, new energy production technology level is lower as well. At present, the new energy development and utilization are mainly dependent on imported technology. Because of immature technical skill, which lead to higher cost and lower competition compared with other energy production. Nevertheless, considering the long-term running of energy, development and utilization of biomass energy is imperative, and the prospects for development is very broad. (A. Witter, 2009)

4.1. Biomass energy

Biomass energy is solar energy in the form of chemical energy stored in the organism, which is directly derived from the ground or the photosynthesis of plants. Among various energy, biomass energy is the only renewable carbon source, and can be converted into solid, liquid and gaseous fuels. Because of its clean and renewable, which grasps much attention around the world. Using biomass as raw materials to produce ethanol, methanol, diesel and other liquid fuels, has become an important way to new global energy development. (Klass, 2016)

Biomass as one of the most important parts of renewable, and plays an important role in the future energy structure in the world. China’s primary energy source is contributed by coal which brings heavy global environment pollution (Cherni JA, 2007). On the contrary, biomass is renewable, sustainable and relatively environmental friendly energy. As the population scale continue to enlarge, the demand for energy will rise and the price of energy will increase as well such as electricity and petroleum products (A. Witter, 2009).

The following table 4 shows the consumption of biomass in China account for 12.7% in 2000. Most fractions of biomass resources are located in rural areas, where is more convenient for biomass collecting. However, the high quality of energy carrier is more important than the primary energy sources to users. ‘If clean, convenient energy carriers were produced cost-competitively from biomass, these carriers would be as attractive to users as the same carriers made from other primary sources (Li Jingjing, 2001)’.

Table 4. Primary energy consumption in China in 2000. (NBS, 2001)

Primary energy source	Energy consumption (PJ)	Percentage
Conventional energy		
Coal	25,128	56.9
Crude oil	8,852	20.0
Natural gas	938	2.1
Large-scale hydro power	2,587	5.9
Nuclear energy	-	-
Total conventional energy	37,504	84.9
Renewable energy (RE)		
Traditional biomass	5,617	12.7
New RE	1,072	2.4
Total RE	6,689	15.1
Total	44,193	100.0

In China, most biomass is not converted into modern energy carrier, the wood and agriculture residues are used for cooking and heat generation in rural areas, and normally bring adverse impacts for health and environment. People are exposed in high concentration pollutants which excess specified standards. The research presents more rural people are died than urban resident, because of some diseases (lung cancer, pulmonary heart disease and chronic pneumonia) that are caused by environment issues. (Lucas, 2010).

4.2. Situation of biomass resources in China

China has abundant biomass resources with theoretical around $3.02*10^9$ tce, and the primary biomass resources are agriculture residues, wood, manure from farms and municipal waste water and solid waste resources (table 5), which have high energy potential as can be seen in the following table 6, and The distribution of acquirable quantities of total biomass energy in China is presented in figure 8.

Table 5 Total non-plantation bioenergy potential in China (PJ). (Bhattacharya, et al., 2005)

Types of biomass	China		
	1997	2005	2010
Primary and secondary residues	5236.4	5589.2	5307.2
Waste water	101.9	101.9	101.9
Black liquor	157.3	207.4	287.1
Palm oil			
Animal manure	1102.5	1598.5	2094.5
MSW	49.9	77.6	91.1
Fuelwood released through efficiency improvement	717.9	104.4	104.4
Fuelwood released through substitution by other fuels		456.8	913.6
Total	7365.8	8135.7	8899.8

Table 6. Biomass resources potential in China. (Yanli, et al., 2010)

Conversion way		Material: Category	Material: Resource amount (10^4 t)	Conversion efficiency	Caloric value (kJ/kg)	Utilization efficiency (%)	Amount of coal saved (10^4 t)	CO_2 emissions reduction (10^4 t)	Coal saved per unit material (tce/tce)	CO_2 emissions reduction per unit material (t/tce)
Stove burning		Crops straw	33,056.04	100%	12,572.7	15	9933.34	14,681.47	0.500	1.035
		Firewood	6583.59		15,444.8		1978.37	2924.03	0.376	0.778
Boiler combustion		Crops straw	33,056.04	100%	12,572.7	30	7946.67	13,278.89	0.400	0.936
		Firewood	6583.59		15,444.8		1943.48	3247.55	0.369	0.864
Biomass compressing and shaping		Forest biomass	49,891.43	92%	18,828	45	27,276.92	45,263.87	0.684	1.589
		Crops straw	33,056.04				18,072.58	29,990.00	0.910	2.115
Biogas fermentation	Heating	Crops straw	33,056.04[a]	$0.3\ m^3/kg$	20,934		9272.22	15,135.97	0.467	1.067
		Excrement	84,282.08[b]	$0.35\ m^3/kg$	25.585	55	32,448.60	54,553.55	0.526	1.239
		Wastewater	830.37	$0.67\ m^3/kg$			731.26	1193.71	0.809	1.849
	Power generation	Crops straw	33,056.04	$1.25\ kW\,h/m^3$	3601.83	–	4056.60	6778.57	0.204	0.478
		Excrement	84,282.08				14,196.26	25,306.41	0.230	0.575
		Wastewater	830.37				591.67	445.39	0.295	0.690
Gasification	Heating	Forest biomass	49,891.43	$2.39\ m^3/kg$	4808	55	22,009.77	36,778.32	0.552	1.291
		Crops straw	33,056.04				14,582.78	24,367.82	0.734	1.718
	Power generation	Forest biomass	49,891.43	$0.56\ kW\,h/kg$	3601.83	–	10,671.22	17,831.61	0.267	0.626
		Crops straw	33,056.04				7070.32	11,814.50	0.356	0.833

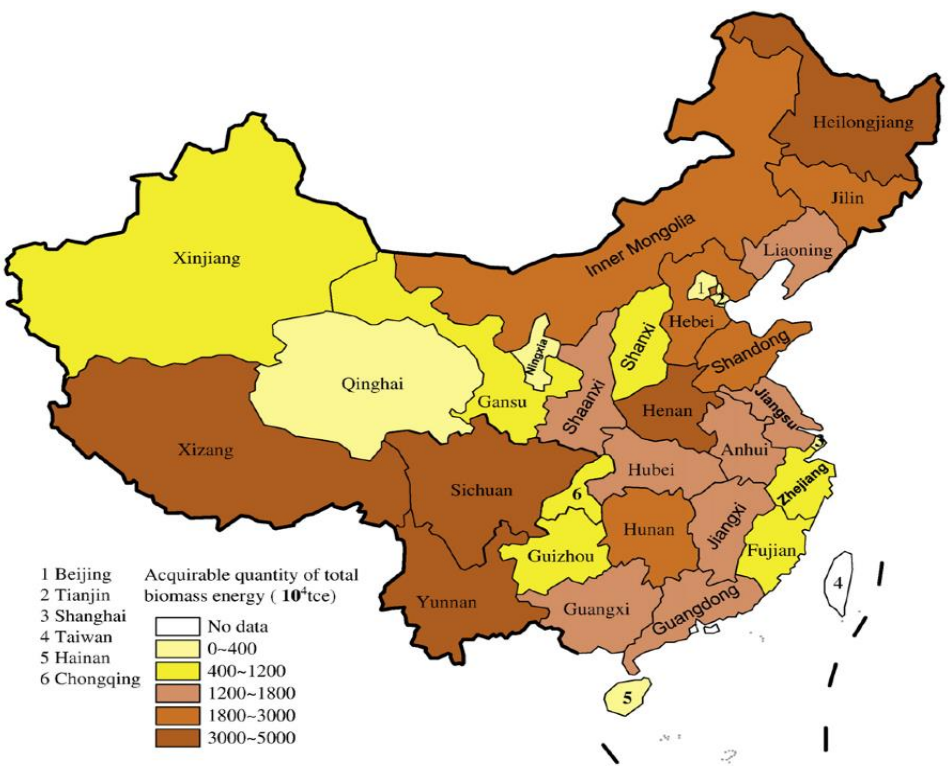


Figure8. The distribution of acquirable quantities of total biomass energy in China. (Deng, et al.,

2010)

4.2.1. Agriculture residues

As a large agricultural country, China has an amount of straws resources, such as oil crops, cotton, wheat straw and rice straw, which can be used as fertilizers and also the raw materials for industrial process. According to the statistics, the production of straw is around 700 million tons per year, on the top of world and account for 30% of the world total straw. However, the rapidly develop economy and build of new countryside have lead to decrease the share of straw fuels and the amount of straws are unused. China’s straw production occupied half of total biomass resources. Development of straw resources will occupy an important position in China. (Xiao, 2012)

Affected by growth environment, acreage estimation accuracy and other factors, the China straw resource estimation has difference during years. As be shown in table 7, the total amount of straw resources in 2000 up to 680 million tons and in 2008 total of straw source is 842 million tones, 142 million tones differences caused by several possible, such as climate conditions. The more advanced technological skills, the more straw resources may be collected, an amount of resources to the greater statistical straw. (Peng chunyan, 2014)

Table 7. Straw resources estimation in China. (Peng chunyan, 2014)

Year	Amount of straw (hundred millon)	Amount of rice straw (hundred millon)	Amount of wheat (hundred millon)
2000	6.8	1.88	1.39

2001	6.1, 6.7	1.11, 1.72, 1.78	1.28, 1.31
2002	6.23, 6.9	6.23, 6.9	1.23, 1.26
2003	6, 6.5, 7.7	6, 6.5, 7.7	1.18, 1.21
2004	6.52, 7.2	6.52, 7.2	0.95, 1.26
2005	7.29, 7.5	1.75, 1.81	1.07, 1.36
2006	7.6	1.76, 1.826	1.12, 1.149
2007	-	1.8	1.13
2008	8.42	1.86,2.22	1.16,1.46
2009	-	1.89	1.19
2010	-	1.9	1.19
2011	-	-	-

4.2.1.1. Current utilization of straws

In recent years, China's major straws production areas appeared serious straw burning pollution. Especially during harvest occasion, the approach not only waste resources but also cause air pollution, car accident on the highway and series of issues that threat people's life. Therefore, the national authorities have done lots of work to minimize the threaten, but still very serious phenomenon of burning straws. In order to solve the problem between human resources and development, efficiently use precious is necessary. Currently, straw resources have various utilizations (figure 9). (wengen, et al., 2010)

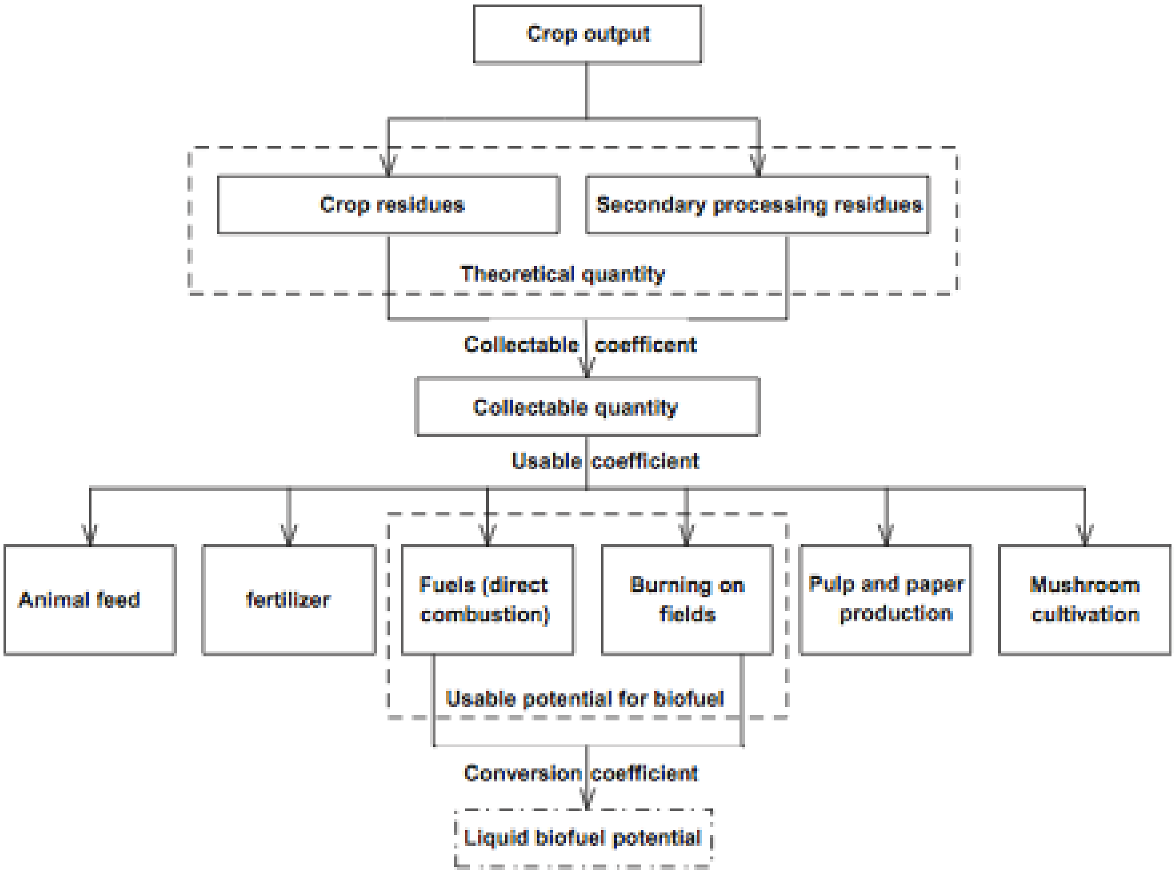


Figure 9. Schematic diagram of agricultural residue resources and biofuels potential estimation. (wengen, et al., 2010)

At present, the domestic research for biomass energy mainly from the use of technology, including biomass gasification, liquefaction and straw power generation. Now the general utilization of straw that used as industrial raw materials, including materials for paper and used as building insulation materials. Due to advances technology development, and utilization of new technology, the process of converting straw to biomass energy will be speed up and which will improve the environment and achieve goals of rural modernization. (Wu zansong, 2009)

4.2.2. Forest residue

China has rich and widely distributed forest biomass resources. The annual forest biomass production reach to 8 million tons to 1 billion tons, and more than 3 million tons can be used as energy production and replace 2 million tons coals which equal to 1/10 total fossil fuels consumption. (Xi, et al., 2009)

Figure 10 shows the distribution of forest residues in China. According to data from “the sixth national forestry survey (1999–2003)”, it is estimated that 2.45 billion tons of forest residues were produced annual, and mainly distributed in the southwest and northeast’ (Tan, et al., 2010).

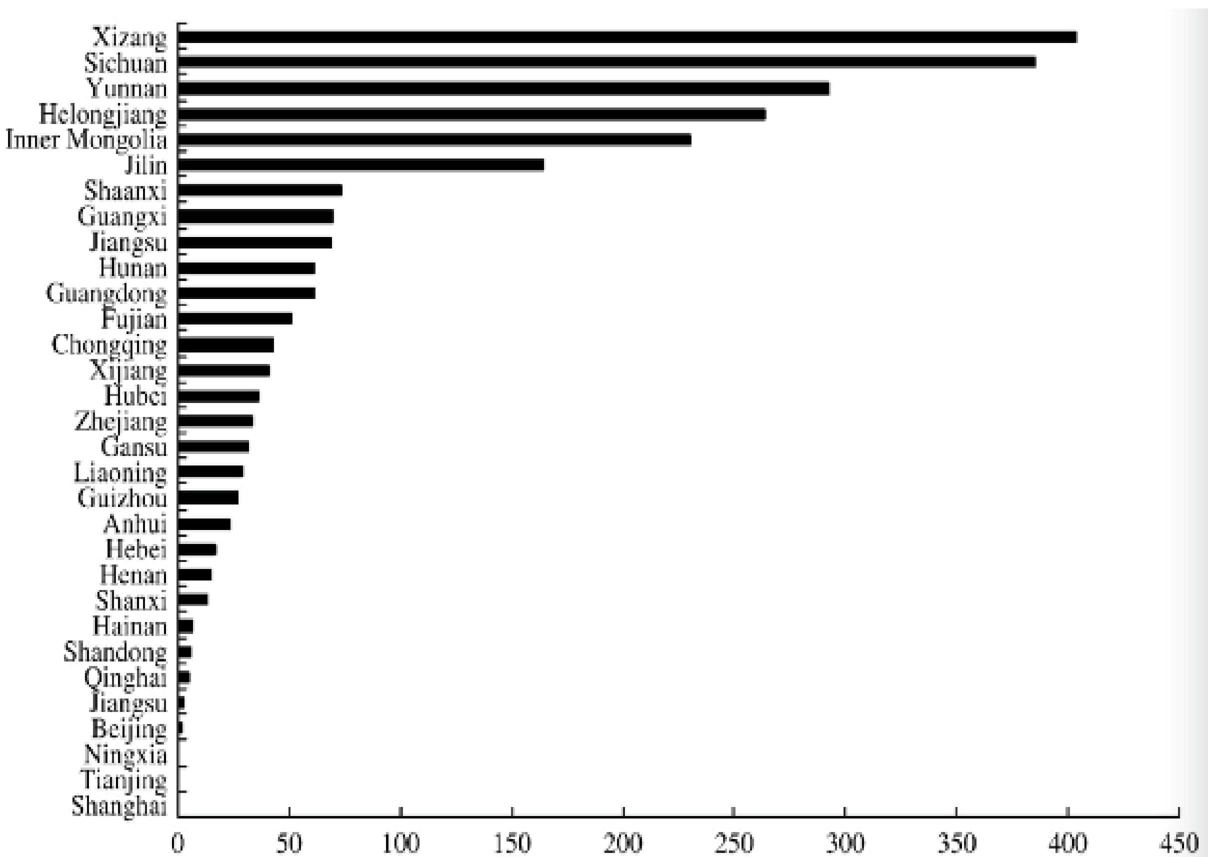


Figure 10. Distribution of forest residues in China. (Tan, et al., 2010)

“The sixth National Forest Resources General Investigation” presented $1.75*10^8$ hm^2 of forest and

$1.25*10^{10}$ m^3 of growing stock existed in China and $2.8*10^8$ -$3*10^8$ ton of biomass resources can be provided (table 8)

Table 8. Forest biomass resources in China. (Peidong, et al., 2009)

Type	Plant area	Supplied biomass resources	
		Resource type (unit)	Yield
Fuelwood forest	3.0×10^6 hm^2	Wood energy ($\times 10^8$ t)	0.8–1.0
Shrubbery	4.5×10^7 hm^2	Wood energy ($\times 10^8$ t)	1.0
Large sapling and middle age forest	5.7×10^7 hm^2	Wood energy ($\times 10^8$ t)	1.0
Oleaginous forest	6.1×10^6 hm^2	Oilseeds ($\times 10^4$ t)	400
Total		10^8 t	2.8–3.0

4.2.3. Animal manure from farms

Poultry and livestock manure is important biomass resources which is the main raw materials for biogas fermentation. In 2007, there are $3.972*10^9$ manure in China. (Peidong, et al., 2009)

Table 9. Poultry and livestock manure resources in China. (Peidong, et al., 2009)

Animal species	Breeding quantity ($\times 10^4$)	Manure discharge rates	Breeding cycle (day)	Excrement amount ($\times 10^4$ t)
Cattle	13944.2	8.2 t/a	365	114342.5
House	719.5	5.9 t/a	365	4244.8
Donkey/mule	730.6/345.1	5.0 t/a	365	5378.1
Pig				
Sale	68050.4	5.3 kg/d	300	105200.1
Stock	49440.7		365	95643.1
Chicken	731852.17	0.10 kg/d	55	40251.87
Sheep	36896.6	0.87 t/a	365	32100.1
Total				397160.6

In China, there are total of 6000 domestic animal farms, and about 1 Mt manure is discharged every day. It contains sufficient amounts of organic matters. So far, there are 20% of manure is processed to different degrees and about 10% is processed through biogas projects. In addition, 80% of all farms discharge the refuse and sewage to the rivers. The detail information are shown in table 10, which presents the resources form animal manure in 1997, 2005 and 2010. The total energy potential of animal manure was 1102.5PJ in 1997, 1598.5PJ in 2005 and increased to 2094.5PJ in 2010. (FH, et al., 2006)

Table 10. Energy potential from animal manure in 1997, 2005 and 2010. (Junfenga, et al., 2005)

Item	1997				2005				2010			
	Human	Pig	Cattle	Chicken	Human	Pig	Cattle	Chicken	Human	Pig	Cattle	Chicken
No. of animal (million)	915.3	389	116.9	7658.7	954.6	694	177.3	8047.2	994	999	237.8	8435.8
Animal manure generated per head per day (kg head^{-1} day^{-1})	0.6	2	20	0.1	0.6	2	20	0.1	0.6	2	20	0.1
Annual animal manure generation (Mt)	200.4	284	853	279.5	209.1	506.6	1294.6	293.7	217.7	729.2	1736.2	307.9
Fraction recoverable	1	1	0.6	0.6	1	1	0.6	0.6	1	1	0.6	0.6
Proportion of dry matter (%)	13	20	18	20	13	20	18	20	13	20	18	20
Dry matter (Mt)	26.1	56.8	92.1	33.5	27.2	101.3	139.8	35.3	28.3	145.9	187.5	37.0
Biogas yield (m^3 kg^{-1} DM)	0.2	0.3	0.2	0.36	0.2	0.3	0.2	0.36	0.2	0.3	0.2	0.36
Biogas potential (Gm^3)	5.21	17.04	18.42	12.08	5.44	30.40	27.96	12.69	5.66	43.75	37.50	13.30
Energy potential (PJ)	108.9	356.1	385.1	252.4	113.6	635.3	584.4	265.2	118.3	914.5	783.8	278
Total energy potential (PJ)	1102.5				1598.5				2094.5			

4.2.4. Industry and municipal waste water and solid waste resources

Ensure the progress of industry, the resources extract from natural and discharge to natural as well. According to the information “China Statistical Yearbook 2008”, in China, the total volume of industry and municipal waste water discharge reached to 55.68 billion tons in 2007. The wastes are mainly from Guangdong, Jiangsu and Shandong province, while significant amount volume of industry waste are discharged from Zhenjiang and Guangxi province as well. In the following figure 11, it can be found that the total amount of industry and municipal solid waste produce are around 1750 and 152 million tons, respectively. (Tan, et al., 2010)

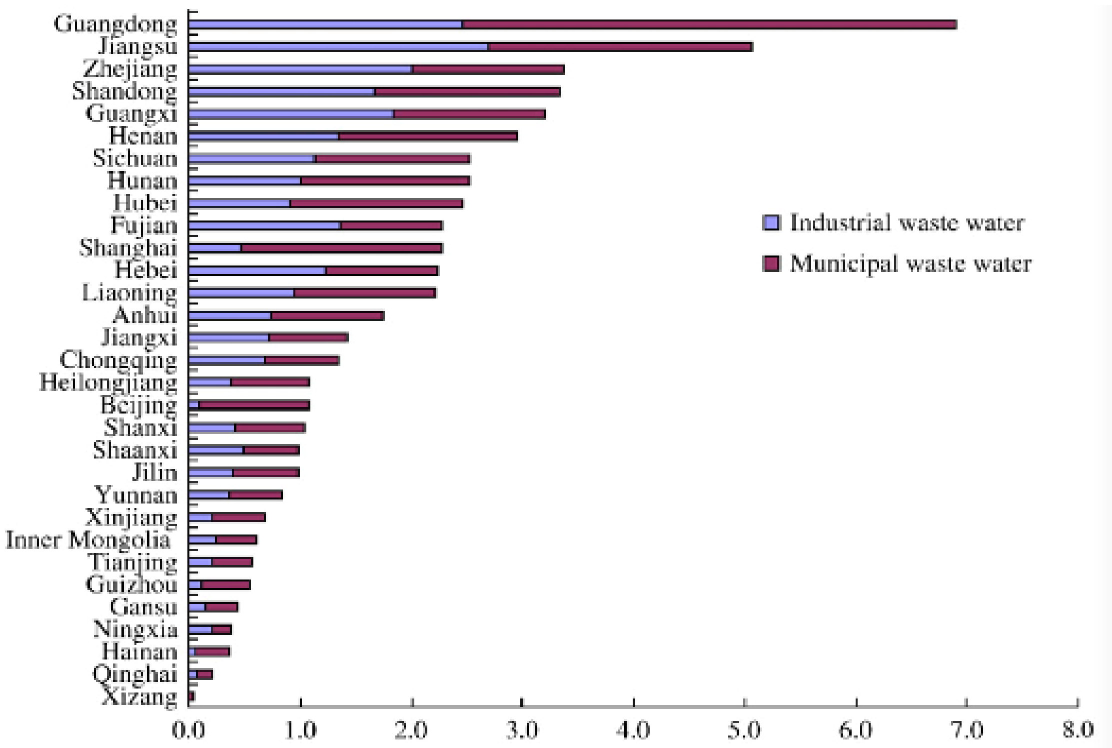


Figure 11. Amount of waste water (unit: billion tons). (Tan, et al., 2010)

4.3. Benefits from biomass energy utilization and development

As a new clean energy, by developing biomass energy, there are several advantages can get. Firstly, solve the deteriorated environment. Fossil fuel as the primary energy will run out after hundreds of years' over exploitation and significant consumption, but associated with global warming, dust storms, flood and other problems are serious threat to human survival. However, the development of new energy reduces greenhouse gas emissions, an effective way to address climate change and protect the ecological environment.

(A. Witter, 2009)

Secondly, to maintain economy sustainable development. Energy is the basic material for economic and social development. With the stable economic growth and living standards increase, the energy demand and consumption will rapidly increase also. At this moment, the domestic consumption of fossil fuels, except for coal is able to achieve self-sufficiency, the domestic oil supply is insufficiency, oil imports increased year by year. In 2008, China's dependence on foreign oil reached close to 50％, 2020 is expected to exceed 60%. In case of fossil energy depletion and irreversibly towards the future of fossil energy supply and demand have become increasingly prominent, it is necessary to find substituted energy sources to maintain sustainable economic development (Klass, 2016).

Thirdly, ensure long-term energy security. Nowadays, fossil fuels include coal, oil and natural gas, non-fossil energy sources including hydro, nuclear, etc. Among them, fossil fuels are non-renewable. According to “BP World Energy July 8, 2008” released in Beijing in 2008 "reports that global oil reserves unchanged in 2007, remains at the level of 12,400 barrels, can still be mined for 41 years, natural gas and coal can be exploited over 60 years and 150 years respectively. While, a few years age, oil shortage and natural gas shortage affect market and result high price which increase fear and force the country pay more attention to energy supply security. Therefore, developing the use of biomass, solar and wind power and other new energy sources can solve the problem of energy supply security. (jianyuan, 2015)

The last important benefit is that finding a new economic growth point. By the end of 2006, the total output of ethanol is about 3.5 million tons, while the fuel ethanol production reached 1.3 million tons. By using waste oil as raw material to produce biodiesel to reach 60,000 tons, rural biogas production exceeded 170 million cubic meters. The rapidly development of new energy is gradually changing the country's energy production and consumption structures. With the continuous expansion of new energy development and utilization in the field and expansion of production scale, the new energy industry is becoming a new economic growth point. (jianyuan, 2015)

4.4. Drawback of biomass energy utilization and development

From utilization aspects, firstly, biomass energy is expensive. Extraction of biomass is not cheap and need amount of biomass to convert it into fluid fuels, and compare with the same volume of fossil energy, biomass has less energy. Secondly, consume more fuels. Not only it takes more fuels to do the same work than conventional fuels, but also bring s environment issues. In order to have enough wood to drive the vehicles or even power plants, amount of forests have to be cut, that make will threat plant and animals’ life. Thirdly, require more land. More lands where it can be burnt easily and it produces methane to air. Hence, the lands need to far from the residential homes (Xinshi Zhang, 2010). Fourth, compared with fossil energy, it is inefficient, such as, ethanol inefficient when compared to gasoline, and sometimes it has to be mixed with some gasoline to make it work properly anyway. In addition, over long time use ethanol which is harmful to engines. Finally, not environmental friendly. Although, using manure to produce power can reduce CO2 emission, but it produces methane gases, which destroy ozone layer. Using wastes which is not physically harmful, but the odor is horrible and spread bacteria and infection. (Youding, 2016)

From political aspect. A series of laws and tax policies have issued by Chinese government to ensure the sustainable development of biomass. These policies promote the development and utilization of biomass resources, but they are still not enough for biomass resources development. For example, in table 11 the more specific information about forestry biomass development can be found. (Tan, et al., 2014)

Table 11. The political barriers. (Tan, et al., 2014)

Classification	
Barrier 1-policies	1. The lack of standardards and regulations and incentives. For example,tax policies about forestry biomass power generstion have not yet been implemented since the "Renewable energy law" was published. 2. The lack of incentive mechanism of supply. Forestry biomass energy industry is a high-risk industry, but the ecffect of incentive policies for overcoming market risk is not obvious. 3. The ignorance of need in policy orientation. The policy orientation only attaches important to supply, so the market strength to support the adjustment of energy consumption structure is not developed and there is not stable market demand.
Barrier2-system	There are nospecificrules to regulate the work of comprehensive utilization of forestry biomass resource, and there are no specific penalties for not using behaviour that should be comprehensively used.
Barrier 3-regulation	There is no special mechanism to manage the development of forestry biomass resources industry and no specialized department to manage the implementation of relevant national standards

Form technological aspect. As the main factor for developing biomass resources-technology, in China, the existing technologies are immature, the advantages of biomass resources are not reflected in the current fossil fuels prices. Lots of issues are existed during the development of biomass resources. 'These issues cause the insufficient development of forestry bioenergy industry, and it is difficult to create economies of scale' (H, 2009), the detailed information are presented in the following table 12.

Table 12. The technological barriers. (H, 2009)

Classification	
Barrier1-Biomass power	The technology of forestry biomass power generation is simple and the level of technology is low. There is no complete technical system. Inadequate investment constrains the improvement of technical level.
Barrier2 -Fuel ethanol	The processing technology of forestry biomass fuel ethanol still needs further development; the main constrains are the high costs of cellulosic feedstock pretreatment and cellulose degradation.
Barrier 3-Biodiesel	Because the core technology of production does not break through and industrial chain is limited, it causes a great waste of resources and influences the development progress of forestry biomass energy.

5. SUSTANABILITY TECHNOLOGY OF BIOMASS RESOURCES IN CHINA

Nowadays, biomass resources have a wide utilization in China, and biomass technology research is the core research area in the Five-Year Plans.

Biomass based electricity generation increase to 2 MW in 2005, during the Tenth Five-Year Plan (2001–2005), and under the Eleventh Five-Year Plan (2006–2010), the total amount of biomass generation power obtained 5.5 MW (Zhou, et al., 2009). Among them, power generation from crop and forest residues reached 4.0 MW, from marsh gas was 1.0 MW and the rest from industrial and municipal solid waste. (Zhang, et al., 2014)

In China, three main technologies are used to generate power from residues are direct fired and biomass gasification.

5.1. Direct fired generation with straw

In China, biomass power generation is mainly based on the direct combustion with straw. The following table 13 indicates the major biomass power plants in China. While, the big challenge of power plants is the scale which is not reach to standard, due to fuel supply constraints and table 13 clearly present that the largest scale is only 50MW.

Table 13. Major biomass power plants in China. (Zhao & Zuo, 2016)

Company	Category	Installed capacity(MW)	Annual power generation (10^9 kWh)
Wangkui Bio-energy Co. Ltd.	Straw direct combustion	25	2.75
Shanxian Bio-energy Co. Ltd.	Straw direct combustion	25	2.29
Shenzhen Nanshan Waste Refuse Power Station	Refuse incineration	12	0.9
Meihekou Bio-energy Co. Ltd.	Straw direct combustion	50	3.5
Hongze Biomass Thermal Power	Straw direct combustion	15	1.0
Awati Bio-energy Co. Ltd.	Straw direct combustion	12	0.8
An'qing Biomass Power Co. Ltd.	Straw direct combustion	30	1.95
Suqian Straw-Fired Biomass Power Demonstration Projects	Straw direct combustion	24	1.56
Suzhou Biomass Power Co. Ltd.	Straw direct combustion	25	1.56
Sheyang Bio-energy Co. Ltd.	Straw direct combustion	25	1.5
Rudong Biomass Power Co. Ltd.	Straw direct combustion	25	1.5
Yitong Biomass Power Co. Ltd.	Straw direct combustion	30	1.8
Changchun Biomass Thermal Power Co. Ltd.	Straw direct combustion	30	1.8
Haikou New Energy Power Co. Ltd.	Refuse incineration	24	1.4
Chifeng Bio-energy Co. Ltd.	Straw direct combustion	50	2.75
Dongguan Kewei Energy Power Co. Ltd.	Refuse incineration	36	1.96
Yunnan Shuangxin Energy Power Co. Ltd.	Refuse incineration	30	1.5

In rural area, energy efficiency of burning straw is quite low, account for 10%, and with heavy environmental pollution. By using traditional stoves, direct combustion caused fuel waste and heavy pollution, such as, CO and SO2. In order to increase energy efficiency, the fuel saved stoves have been applied by government, and almost 400 million tons CO2 are reduced. However, we cannot expected fuel save stoves to save environment, the only way is to reduce direct combustion not reform it. (Liu, et al., 2008)

5.2. Gasification

Recently, in order to meet the demand of energy there is huge achievement in the development of biomass resources gasification technology, and many of gasification demonstration projects are existed in China (table 14).

Table 14. Gasification projects in China. (Leung, et al., 2004)

Project	Material	Purpose	Capacity	Gasifier	Location
(a) Gasification for heating					
Huairou Wood Equipment	Sawdust	Drying	200 kWt	Down draft	Beijing
Zhanjiang Timber Mill	Wood powder	Boiler	1000 kWt	CFB	Guangdong
Lushuihe Timber Mill	Wood powder	Boiler	7000 kWt	CFB	Jilin
(b) Gasification for cooking					
Huantai Integrate Gas-supply System	Crop residues	Cooking	300 kWt	Down draft	Shangdong
Dalian Biomass Pyrolysis and Gas System	Wood residues	Cooking	700 kWt	Fixed bed	Liaoning
Dalian Integrate Gas-supply System	Crop residues	Cooking	300 kWt	Down draft	Hunan
(c) Gasification for Power Generation					
PutianHuagang Rice Mill	Rice husk	Electricity	1000 kWe	CFB	Fujian
Sanya Timber Mill	Wood powder	Electricity	1000 kWe	CFB	Hainan
Handan Steel Works	Corn straw	Electricity	600 kWe	CFB	Hebei

5.2.1. Types of gasifier designs

For different types of resources, the gasifier can be different, and the application are in different fields as well. ‘A remarkable progress is the economic production of circulating fluidized bed (CFB) gasifier and down draft gasifier for straw’ (Zeng, et al., 2007) as can be seen in table 15. Based on the application of CFB reactor, the resources are converted into gaseous, as fuels to generate electricity, both CO and H2 are included in these fuels as combustible factors.

Table 15. Different types of gasifier in China. (Leung, et al., 2004)

Gasifier type	Up-draft	Open core	Down-draft	CFB
Fuel types	Tree barks, timber block	Husk	Straw	Straw, husk, sawdust
Output	2–30 kWe	60–200 kWe	60–200 kWe	400–2000 kWe
LHV of gas	4100–5300 kJ/m^3	3800–4600 kJ/m^3	3800–4600 kJ/m^3	4600–6300 kJ/m^3
Temperature	~1100 °C	700–800 °C	~1000 °C	650–850 °C
Efficiency (η)	70–75%	50%	75%	65–75%
Application field	Boiler fuel	Electricity generation	Domestic cooking	Boiler fuel, electricity generation

5.2.2. Utilization processes

Table 16 presents the major applications of gasification system. The first one is gasification system can cooperated with heating equipment, and coal can be substituted by gaseous fuels that are produced in this case. The second is used for domestic cooking. This system can convert agricultural waste into cooking gas, and supply (Leung, et al., 2004)' rural areas by setting up small gas stations with pipe network'. In addition, this technology plays an important role in improving the rural living standard. The last one is biomass gasification and power generation system (BGPG). It can generate electricity by different kinds of biomass resources in any scale, and even better for small-scale industries. BGPG is inexpensive and flexibility, and will be widely applied.

Table 16. Applications of biomass gasification system. (Leung, et al., 2004)

Application	Drying and heating	Domestic cooking	Power generation
Gasifier type	Down-draft	Down-draft	CFB
Gas cleaner	No	Water scrubber, filter	Dust separator, water scrubber
Pre-treatment	Cutting	Cutting	Crushing
System efficiency (%)	70–80	75	16–18
Operation time (h/year)	6000	2000	5000
Lifetime (years)	10	20	15

5.2.3. Advantages and disadvantages of application

- *Advantage of applications*

Scale and feedstock flexibility. Various gasifier and gasification system can be designed for different fuels according to operators' demand. The system scale can be designed with suitable technologies and raw materials. While, the large scale system waste money and have insufficient fuels and too small decrease economic development and cost ineffective. (energy, ei pvm)

Economic feasibility. China owns large volume of biomass residues which are widely distributed, and most of them are treated as waste, because it is not necessary to fully use. In some areas, the biomass residues can be utilized in small and medium scale gasification system, and avoid the transportation problem, but increase the competitiveness with other technologies. Therefore, form the economic perspective, the most effective way is capital reduction to make economic feasibility. (Energy, 2010)

Extensive applicability. The biomass resources can be converted into combustible gaseous by pre-treatment technology, and gaseous fuels can be used in various industries such as, transportation sectors, food production process.

Environmental friendly. Comparing with combustion technology, biomass gasification technology has advantages for emission control. The reason is that produced syngas have high temperature and pressure which is easier to remove sulfur and NOx. Gasification technology can reach the lower emission level.

- *Barrier of application*

Capital limitation. For small and medium scale gasification technology, the system should be as simple as possible, hence the dust removal and cleaning process can be perfectly designed, and operation issues and emission can be minimized. (Ruiza, et al., 2013)

Recently, China emphasized on energy saving and high requirement of environmental protection, while not all the biomass gasification technology can meet the demand. For example, straw based resource gasification for domestic cooing system can make large social advantages but because of the high cost for handling pollution problems, it is impossible to make profits. (Leung, et al., 2004)

5.3. Biodiesel

As mentioned before, ‘China is the second largest oil consumer country in the world, and the external dependency of oil is close to 50% (Wang, 2010)’. In 2010, the requirement for diesel reach to 100 million tons and will continue to rise to 130 million tons in 2015. Furthermore, environment pollution becomes aggravation, therefore, environment protection and biofuels development is more important in China. In the production of biodiesel, China is developing use of different biomass resources as raw material, such as waste oil, rapeseed oil, cottonseed oil, etc. (Chen, 2012)

5.3.1. Cottonseed oil

Cottonseed contains rich fatty acid, but low utilization rate of cottonseed oil in China, so it is suitable feedstock for biodiesel production. Per ton of land, which can harvest about 0,6 ton of cottonseed. In addition, per ton of cotton oil which contain nearly 0, 55 ton linoleic acid, palmitic acid, and 0.15 tone oleic acid (Li, et al., 2009). Therefore, such rich content of acid ensures a higher production of biodiesel from cottonseed oil.

In China, cotton land is wide and mainly distribute in Hebei and Xinjiang. Among them, Xinjiang has greater condition for producing biodiesel from cottonseed. The reasons are: Xinjiang has largest cotton land and almost 3.5 million tons cotton with 5.5 million tons cottonseeds had been reached in 2013; The utilization of cottonseed oil is really low as can be found in figure 12 (Qian, et al., 2008), and after 1970, the ratio of cottonseed oil in cooking decline; 'Xinjiang has mature technologies and complete supporting facilities on oil producing and refining (Wu, et al., 2006)'. Sum up these reasons, building biodiesel industry and developing biodiesel production in Xinjiang is the best choice.

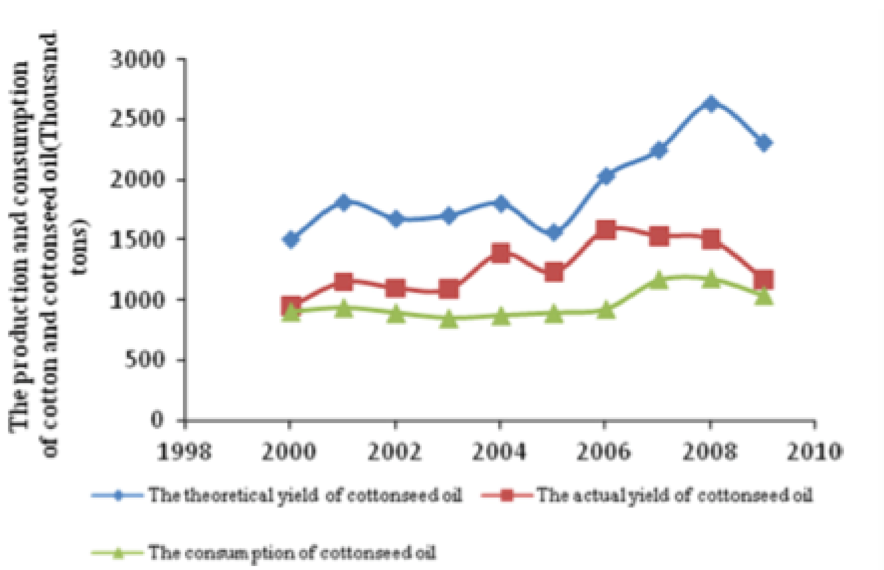


Figure 12. The theoretical/actual yield and consumption of cottonseed oil in China. (Qian, et al.,

2008)

5.3.2. Rapeseed oil

As shown in figure 13, the rape yield has increased to 11000 Ttons in 2001, and then the curve started to roil. If followed the current growth tendency, in the end of 2015, the yield would be predicted to around 14,000 Ttons (Fao, 2013). About 1 ton of rape can produce 1 ton of biodiesel, and in 2005, the production of rapeseed-based biodiesel will reach to 2000 Ttons. (Xu, et al., 2016)

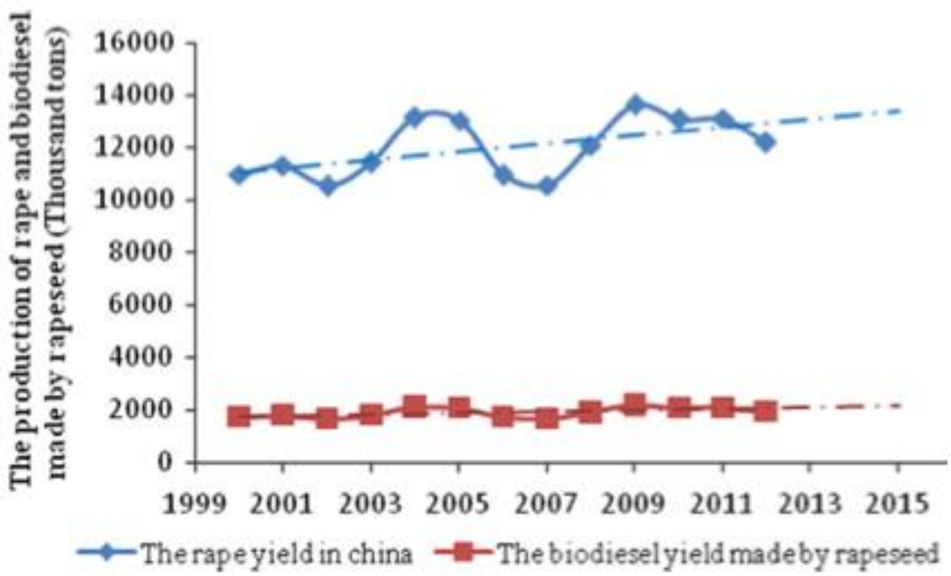


Figure 13. The yield of rape and biodiesel which is made by rapeseed in China. (Fao, 2013)

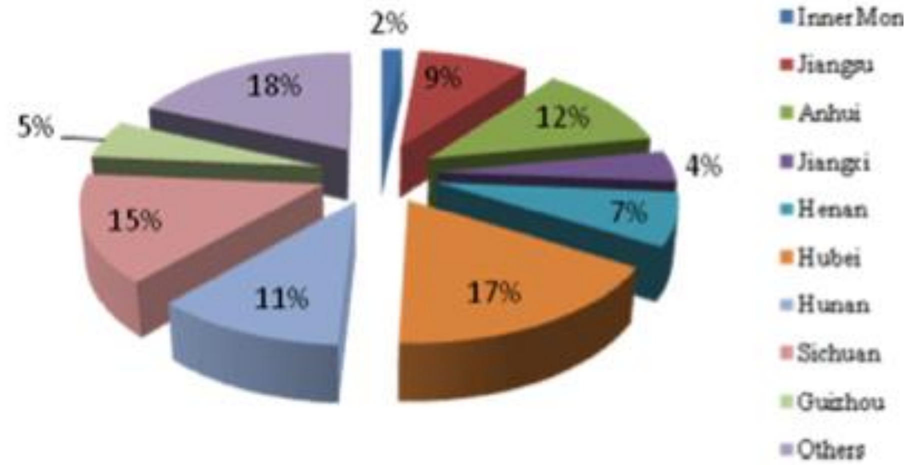


Figure 14. The rapeseed production in different regions. (Anon., 2007)

As can be seen from figure 14. Hubei, Sicuan, Guizhou and Hunan where produce 17%, 15%, 12% and 11% of total amount of rape respectively. Although, the amount of production in the major area is noticeable, while it is still cannot meet the demand if the consumption of cooking oil is considered. In fact, the rapeseed oil used for cooking is low quality which cannot meet the foot standard in China. Therefore, the rapeseed oil used for biodiesel can be more relaxed by enlarge planning land.

In addition, as the technology development, in China, Canola has been produced, which has high yield and high quality. If Chinese government focus on planning Canola with large lands, the productivity of biodiesel will be increased by 1.8 times than before. The demand for rapeseed oil can be satisfied (firstly meet the demand of edible oil and the rest can used for biodiesel production).

From commercialization perspective, cottonseed oil based biodiesel generation has more advantages than the other. Because firstly, the current market price of cottonseed oil is less than 800 U.S dollars, and will gradually decrease. Secondly, compare with rapeseed oil, cottonseed oil is not edible oil, so the price will not affected by edible oil market that is why the price of cottonseed oil is stable in China. (Xu, et al., 2016)

5.3.3. Forestry resources-Jatropha oil

In addition to agricultural resources, forestry resource is another raw materials, such as Jatropha which contains high oil about 42-61% (Misra & Murthy, 2011).

The following table 17 indicates that Jatropha mainly distribute in Guangxi, Yunnan, Guizhou, Sichuan and Chongqing. (Wang, et al., 2005), the total planning area have reached to 756.74 (10 kha), and have more suitable land for planning. In addition, the larger planting area in Guangxi and Yunnan, the more potential productivity can be obtained (Anon., 2007). During 11^{th} and 12^{th} five-year plan period, the land for planting Jatropha has enlarged because of the artificial afforestation in these provinces.

Table 17. The planning area and potential productivity of Jatropha in China. (Wang, et al., 2005)

Province	Planting area (10 kha)	Potential productivity (10 kt)
Guangxi	394.28	236.00
Yunnan	259.52	110.39
Guizhou	57.51	22.62
Sichuan	29.05	11.83
Chongqing	16.38	6.31
Total	756.74	387.15

It is hard to promote Jatropha-based biodiesel production by enterprises, because the cost of Jatropha is too high to afford the cost of building jatropha afforestation, and the high price is not easily accepted by customers. Therefore, Jatropha-based biodiesel production and development must be relied on financial and policy support from government.

In fact, there are plenty of lands are suitable for Jatropha planting and not be used, if the government can realize that and take some actions, the production of raw Jatropha will be increased in the future. Some of enterprises have realized the business opportunity and leased the lands for Jatropha planting and sell the Jatropha seed for another industry to make benefits. Furthermore, if the government support to build industry chain for diesel production which will reduce the cost and increase the production of bio-diesel. For example, the industry covers the whole life cycle of biodiesel production (Jatropha planting, collecting, oil refining and biodiesel production).

Apart from these oil can be used for biodiesel production, the waste oil can be used as well, such as, low quality animal fats, acidic oil and wasted cooking oil. In the current china, the waste oil composed by 33% animal fat, 15% acid oil and 45% cooking oil. Among them, wasted cooking oil is the major feedstock for biodiesel production. For example: almost 50,000 tons wasted cooking oil are produced in Shanghai per year, while the amount in Beijing is about 40,000 tones. (Meng, et al., 2008)

5.3.4. Biodiesel utilization

China's major energy demand meet by fossil fuels, while biodiesel still make a huge contribution for energy demand. Currently, biodiesel is widely used in the field of energy as a fuel. (Yan & Crookes, 2009)

According to the current consumption situation of biodiesel which is mainly concentrated in transportation sectors, power generation sector, industry and agriculture sectors. In addition, biodiesel used for transportation sector account for 63% of total biodiesel consumption in China, and the other sectors only 6%, 12% and 8% respectively.

Here biodiesel consumption in transportation sector as an example to be discussed. As presented in figure 15, biodiesel consumption begins to decrease since 2008. According to the economic development speed in 11th five-year plan, the diesel consumption should reach to 110 million tons in 2011, while, the actual consumption amount in 12th five-year plan is only about 95 million tons in 2011. The reduction caused by national policy, because of environmental issues. However, such reduction hidden trouble to national economy in long- term, hence, with these troubles, replacing diesel with biodiesel is a wise choose.

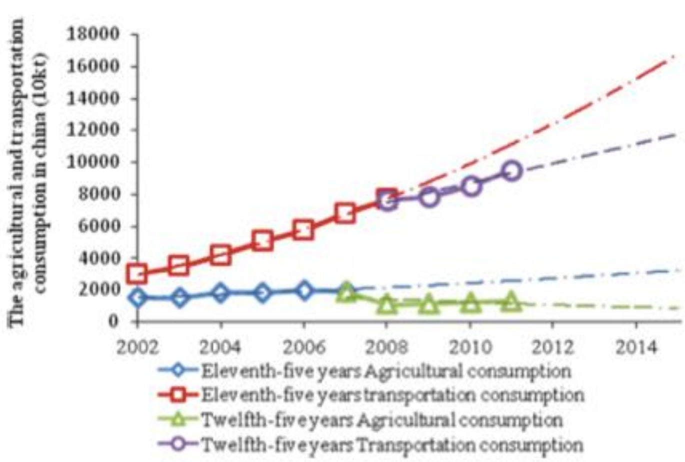


Figure 15. The diesel consumption in agricultural and transportation sectors in China. (energy, ei

pvm)

At present, biodiesel used as alternative fuel in China for engines in transportation sector. According to the standard, two forms of fuels are used for engines: biodiesel-diesel blended fuel with a blending ratio of 5% and pure biodiesel. If the latter can replace the part of diesel consumption, the consumption can promote economy development for sure. (Xu, et al., 2016)

5.4. Bioethanol

In the context of “deepening dependence on oil imports” and high oil price in the future years, the demand for fuel ethanol is increasing. In China, the fuel ethanol expectation will reach to 5 million tons in 2018. Hence, China is developing the biomass resources to generate ethanol. (Teng, et al., 2010).

Comparing with normal gasoline, bioethanol has higher octane number, flammability limits, higher flame speeds, higher heats of vaporization, and less emission (SO2 and CO2) (Saxena, et al., 2009). Furthermore, particulate matters emission for 10% (E10) and 20% (E20) ethanol are decreased by 6.0–6.6% and 29.4–41.8%, respectively (Storey, et al., ei pvm). At present, most of bioethanol are produced from sugarcane. In the world, USA is the largest producer from cone and Brazil is followed from sugarcane. While, these production can not meet the bioethanol demand, therefore, in order to minimize the crisis, lignocelluloses biomass as the alternative fuels to produce bioethanol. (Sarkar, et al., 2012).

5.4.1. Bio ethanol production process

The raw materials need to be delivered to the plants carefully to avoid early fermentation and bacterial contamination. According to different feedstock, the main steps are presented in figure 16 (CE, 2004).

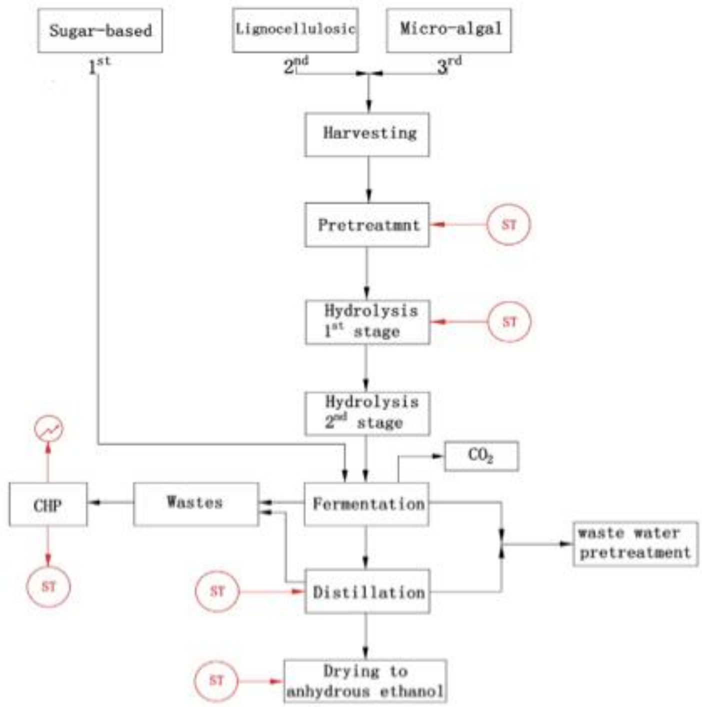


Figure 16. Bioethanol production process. (Baeyens, et al., 2015)

Bioethanol is produced mainly through fermentation, which occur at 298e314 K and last 1 to 3 days depending on both the feedstock composition, and the type, amount and activity of the yeasts. The following biochemical reactions are (Guo, et al., 2015):

$$(C6H10O5)n\ (starch, cellulose, sugar) +\ nH2O \rightarrow nC6H12O6\ (glucose, fructose)$$

$$(C5H8O4)_n\ (hemicellulose) +\ nH2O \rightarrow$$

$$nC5H10O5\ (xylose, mannose, arabinose, etc)$$

$$C6H12O6 \rightarrow 2CH3CH2OH(ethanol) + 2CO2$$

$$C5H10O5 \rightarrow 5CH3CH2OH(ethanol) + 5CO2$$

6.4.2. Applications of bioethanol

The bioethanol can be used as feedstock for chemical synthesis of some products.

Table 18. Application of bioethanol

Objectives	Main results
Bioethanol-diesel fueled engine (Park;Yoon;& Lee, 2013)	- Reduced HC and CO emissions - Premixed combustion phasing decreases when bioethanol fraction increases.
CHP using blends of gasohol in IC engine (internal combustion engine) (Ameri;Ghobadian;& Baratian, 2008)	- E20 recommended - With increasing bioethanol, CO deceases, cylinder pressure and temperature increase
Alternative fuels for gas turbines (Alyson, 2012)	-Brazilian ethanol has the lowest environmental performance
China's bioethanol development and national application of E10 (Tao;Yu;& Wu, 2011)	-Linear optimization model used to consider the economic cost of distributing ethanol - Cassava, sweet potato, sweet sorghum and sugar beet are promising feedstock for bioethanol expansion
Bio-fuels for the gas turbine (Gupta;Rehman;& Sarviya, 2010)	-Low emissions and substantial fuel flexibility obtained in lean, premixed, pre- vaporized (LPP) combustion with ethanol - NO emission reduction from gas turbines.

6. POLICY OF BIOMASS ENERGY

Policy occupies a critical role in the process of biomass energy generation. The government attach high importance to promote the biomass-based energy production and issued a series of policies about biomass energy development after 2006, such as" The Eleventh Five-Year Plan (2006-2010) "and " The Twelfth Five-Year Plan (2011-2015)" which are both proposed biomass power goals (table 19), and on the basis of goals number of laws are introduced. The reason is that, in China some of enterprises have been losing money, and they got financial support from government. While the grid price subsidy is 0.500– 0.646 RMB/kW h, until 2010 the subsidies maintained 0.75RMB/kWh, but this change cannot make some enterprises earn money and they hoped for higher subsidies in the future.

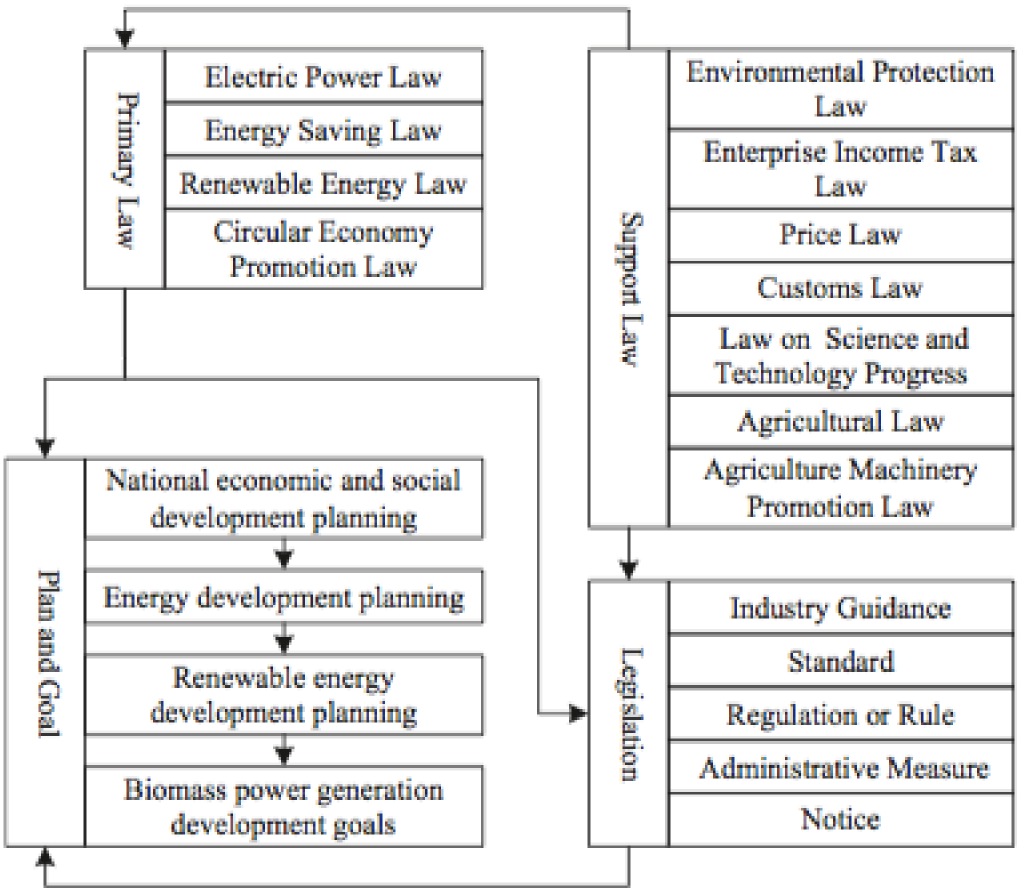
Table 19. Strategic goals of biomass power generation development. (Zhang, et al., 2014)

Main content	To 2010	To 2015	To 2020
Installed capacity	4000 MW	8000 MW	24,000 MW
Generating capacity		480 billion kW h	
Demonstration project	Direct-firing power; gasification power	Direct firing power; co-firing power; combined heat and power	
Biomass planting			The forest used as energy covers about 20 million ha
Technology research	Power generation technology	New equipment; boiler corrosion control; measure and test of co-firing	

6.1. Relationship Between different policies

Table 20 indicates the general framework of energy policies. There primary laws and support laws, which the front one as guild role and the other is being the support role. In addition, based on the demand and laws, the government has issued appropriate plan and legislation. (Zhang, et al., 2014)

Table 20. General framework of the policies. (Zhang, et al., 2014)



“Renewable Energy Law” was carried out in 2016, which is the first energy law in China. It presents the government has realized how important of renewable energy and given high support for renewable energy development. (Energies, 2016)’. Moreover, “Promotion and Application” emphasized that promote and encourage the biomass resources development (Energies, 2016)’.

At the end of 2009, the “Renewable energy law” was revised by state, and the revised edition was implemented in 2010. This new version has established the “Renewable Energy Development

Fund “to promote and protect the renewable energy power generation.

6.2. Biomass energy financial subsidies

Comparing with fossil energy the utilization of biomass energy has remarkable benefits, but the cost of the energy development is higher, so in order to share the higher cost, the Chinese government has committed financial subsidies for the biomass energy development and utilization and encourage the enterprises to join the development of biomass energy.

Figure 17 shows the subsidy for different types of renewable energy power, the biomass power hold 35% as the second largest share of total subsidies, wind power received the largest subsidy, and solar PV power received the least subsidy. In addition, for figure 18, it can be found that the subsidies for electricity price account for 95.60% of the total subsidy amounts, and subsidy for accessing grid projects and public independent renewable energy power system are 4.21% and 0.19% respectively.

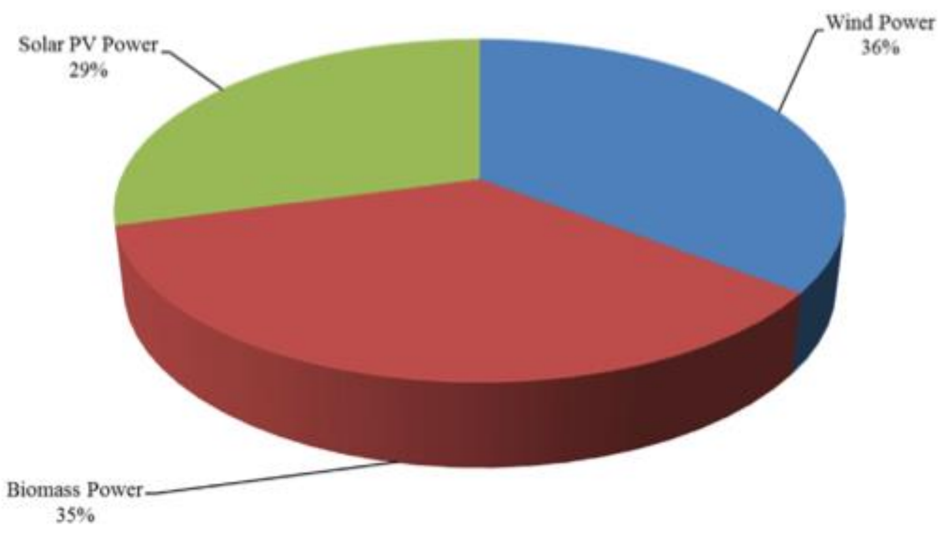


Figure 17. Subsidy for different types of renewable energy power. (Zhao, et al., 2014)

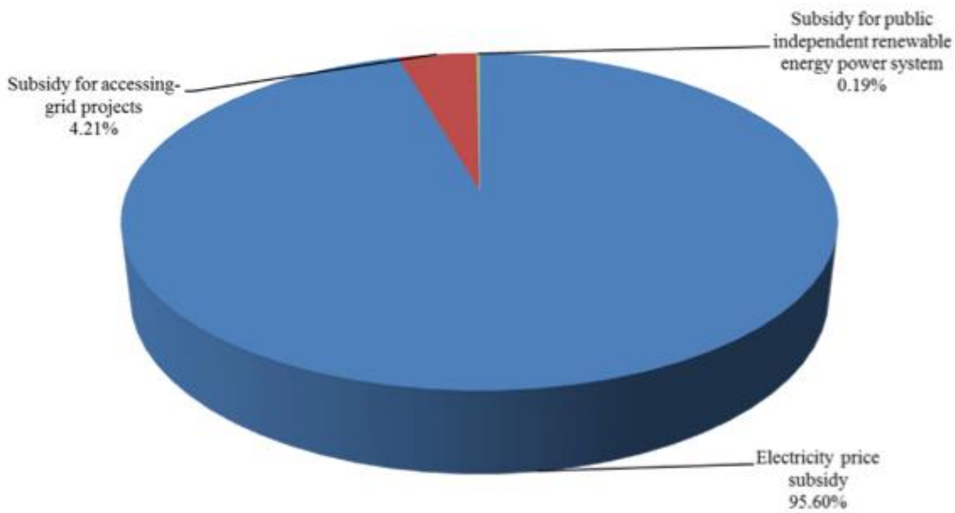


Figure 18. Subsidy-obtained share of different renewable energy power categories. (Huiri, 2014)

6.2.1. Subsidies for feedstock

- Feedstock base subsidies

The subsidies for forestry based resources is 30 RMB/ ton, which is identified by Ministry of Finance according to implementation plan, and for agricultural resources the subsidy is around 27RMB/ton, this criterion is approved according to saline-alkali soil, types of land and the implementation plan. (Zhang, et al., 2014)

- Straw subsidy

These enterprises whose registered capital is more than 10 million RMB, the annual straw energy consumption excessed 10000 tons, the straw based energy products are actual sold and have stable consumers can get the 140 RMB/ton subsidies. The types and quantities of straw and the related products determine the amount of subsidy. (Bridle & Kitson, 2014).

- Fuel ethanol subsidy

For the production of fuel ethanol and losses during the process of allocation and sales, the government sets quotas for subsidies to the associated organizations. In 2012, the amounts of subsidy for ethanol fuels and non-grain ethanol fuels are 490 RMB/ton and 740 RMB/ton, respectively. (Zhang, et al., 2014)

6.2.2. Project subsidy

- Rural household biogas project

In 2003, the rural biogas technology has listed into the national debt fund support, and every year China has expend more than billions for supporting biogas service system and technologies.

- Green energy country project

For green energy country project, the subsidy reach to around 25 million RMB, and this project includes “biogas centralized gas supply engineering”, “biomass gasification engineering”, “biomass briquette fuel engineering” and others engineering. (Energies, 2016)

- Urban heating engineering project

During the period 2014-2015, there are 120 biomass briquette boiler heating demonstration projects are built in Beijing, Tianjin, Shandong, Yangtze River Delta region, Pearl River Delta region and other areas where have heavy pollution and have mission to reduce the coal consumption. 5 billions RMB are invested for these projects. (Energies, 2016)

6.2.3. Low interest loan

Renewable energy development projects have field in the national renewable energy industry development guidance catalogue and meet the credit conditions as well. Discount interest fund which is adjudged based on the existent bank load appropriate and rate of interest. Besides, the discount period is one to three years and the maximum discount rate can reach 3% blow. (Zhao, et al., 2014)

6.2.4. Tax

Almost 80% tax of the income of the companies from their products that are not limited by nation and meet the required standards. Furthermore, the raw materials are specified in "Catalogue of Resources for Comprehensive Utilization Entitling Enterprises to Income Tax Preferences" which are decreased and accounted in the total income. (Shen & Luo, 2015)

6.2.5. Pricing mechanism

- Fixed feed-in tariff

As mentioned before, after 2010, the feed in tariff for agricultural and forestry resources energy generation projects have reached to 0.75RMB/kwh (including tax) (Zeng, et al., 2013). However for the mixed biomass fuels power projects, energy over 20% of the power consumption which do not have the subsidy feed-in tariff (Energies, 2016).

- Fuel ethanol price

The "National Development and Reform Committee" published the price of fuel ethanol is equivalent coefficient 0.9111 multiply the cost is the final price. This regular for promoting the ethanol development and protecting the enterprises. (IRENA, 2012)

In order to promote the biomass energy development, protect the environment and ensure energy sustainable development, Chinese's government has invested large amount of subsidy. Thus project not only bring benefits (such as, environmental benefits (figure 19), energy security, technology innovation (Bayer, et al., 2013) and economic development (figure20) but also accompany many problems (such as, poorly carry out the policy, flaw on the policy and energy loss). Therefore, in order to minimize these issues, it is necessary to make the policy carefully and strictly implement the policies.

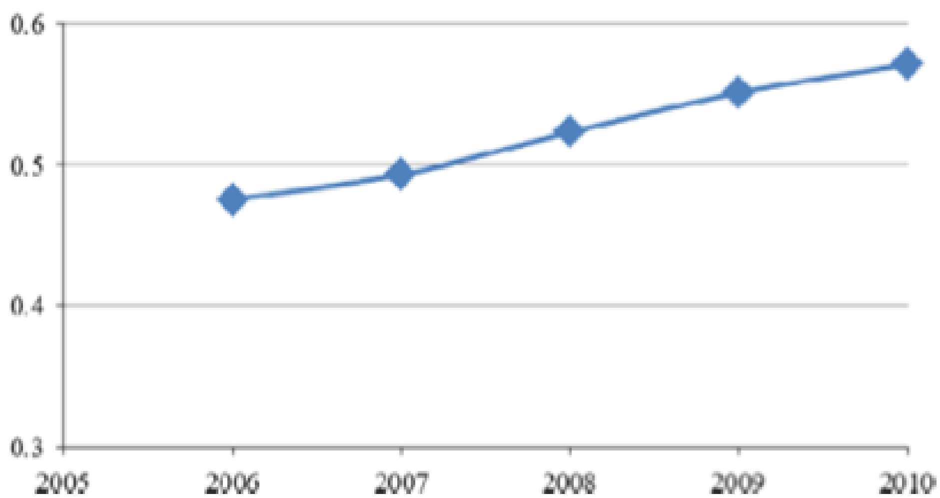


Figure 19. Average electricity sale price during 2005-2010. (Bayer, et al., 2013)

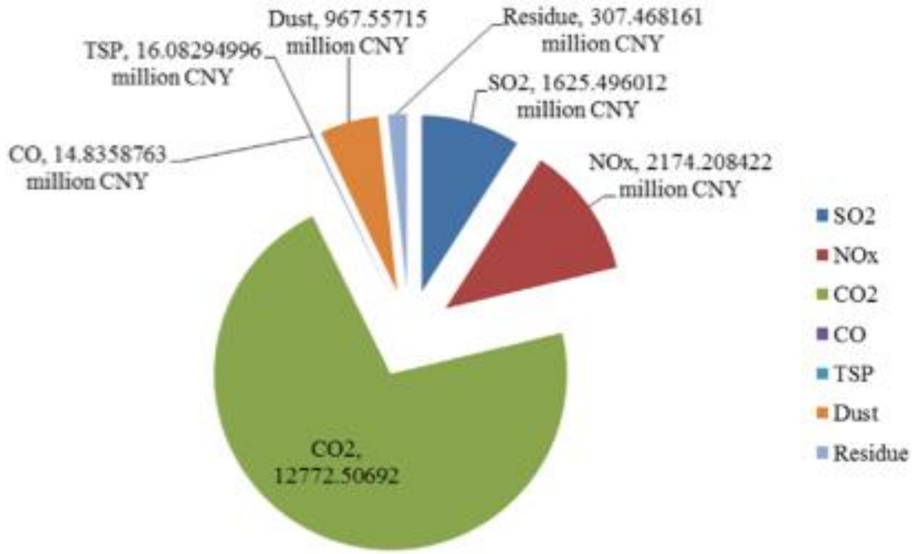


Figure 20. Environmental benefits of emission reduction (total environmental benefit is 17.88 billion RMB). (Zhao, et al., 2014)

7. CASE STUDY-LIFE CYCLE ASSESSMENT OF WHEAT STRAW

In order to show how it is important to promote biomass resources development, the life cycle assessment of straw in Sichuan province will be analyzed by Gabi software as an example in here.

Recently, human activities have been emitted a huge amount of greenhouse gas (GHG) to the environment, which is believed to be the role key of the climate change recently. Many international and national authorities have put many efforts to reducing the emissions to protect the environment. This leads to the legislations and possible penalty consequences forced organizations to comply with rules. Energy industry is considered to be one of the biggest contribution to this issue. Furthermore, human consumption of energy is surging and will keep rising in the future, which leads to the queries of alternative fuels to satisfy the demand to lowering the speed of natural fuel expenditure. This results in the idea of burning biomass resource as an alternative fuel. However, owing to the fact that straw biomass resource consists of many of elements, so it is not good to burn direct.

In order to find a better option for straw handling, as well as to lessen the effects of industrial activities on the environment, here use different technologies to generate energy and fuels form straw and fossil fuel, to see the climate change. By doing this, to figure the effects of recovery operations on the quantities of GHG emissions, as well as to find out the best option applied.

Life cycle assessment (LCA) is an important tool to understand the impacts of different products and processes around us on the environment that we are living in. In fact, LCA has been commonly used in waste management research, thus it seems fit to study the case at hand. The whole study will be carried out in an LCA framework following ISO standards.

7.1. Goal and scope

LCA is a tool that enables to strategic study of a process in order to assess on the possibility of reaching a final point. This goal and scope in a LCA study should be determined at the beginning of the process with accuracy.

7.1.1. Goal and scope definition

The goal of this study is to analyze the difference on the amount of emissions from the present straw management approach and several alternative scenarios to check out the CO2 emission reduction.

The function of this case study is the management of annual straw produced from the Sichuan region in kilograms. Therefore, functional unit of this case study is recovery of mentioned annual straw. The recovery management is being done by comparison of different scenarios and outcomes using the same functional unit every time.

7.1.2. System description

The amount of straw in Sichuan China will be burning in the field or transported to CHP for energy generation or transported to compost facility or to the industry for bio-ethanol production as can be seen in table 21.

Table 21. Scenario description

Scenario	Difference to S0 (250km)
S1	-straw sent the CHP plant (200km) - NPK fertilizer needed to replace the compost product -Gasoline needed to replace the straw based bioethanol
S2	-straw sent to industry for refinery (100km) -energy produce from coal -NPK fertilizer needed to replace the compost product
S3	-straw sent to compost (150) -energy produce from coal - Gasoline needed to replace the straw based bioethanol

7.1.3. System boundary

In order to define what to include or exclude to the system, system boundary is required. The system boundaries present clearly the process and interaction between each section. For this case study gradle-to-gate is used to identify the system boundaries, to understand their environmental impact by collecting evaluating, and interpreting associated data. gradle-to-gate only covers the process production stage; it is used in order to find out of single production stage's environmental impacts. (International, ei pvm). For this resources handling re-arrangement case study, the life cycle assessment starts from the resource generation phase from the province. Waste produced is transferred where it is utilized for heat, electricity or compost products therefore those resource utilization facilities (composting facility, bio refinery or CHP) are the gate for the process.

For each of those facilities, internal energy consumption is neglected. Also the transportation energy is neglected but emissions are taken into account. The effects the amount of soil enrichment product needed by the province therefore decreases NPK fertilizer acquired from the producer company. Therefore, that company's emissions are included or partly excluded from the system boundaries as soil enrichment material is compensated.

For the electricity demand, straw is utilized in scenario1 with electricity output. As a consequence, always a portion of the total electricity demand of the city is provided. Yet the city requires electricity drain from the coal plant for all the time. Therefore, production or change in demand are excluded from the system boundaries as we assume the electricity is set to response changes.

Addition to those, the energy consumption due to loading and unloading of the trucks between every stage are neglected within the system boundaries. Similarly, the internal energy consumption for the operation of each facility are excluded from the system boundaries. To sum up, energy consumption during the straw transportation between the points and utilization of the straw are not included to case system boundaries.

7.1.4. Unit process

According to ISO 14044 (2006), all the relevant unit processes should be included inside the system boundary. The gate-to-gate analysis is applied in this case study as we only analyze the GHG emissions after the straw is collected until it has been under different managing solutions with the main products, heat, electricity and bioethanol, and emissions released in each case.

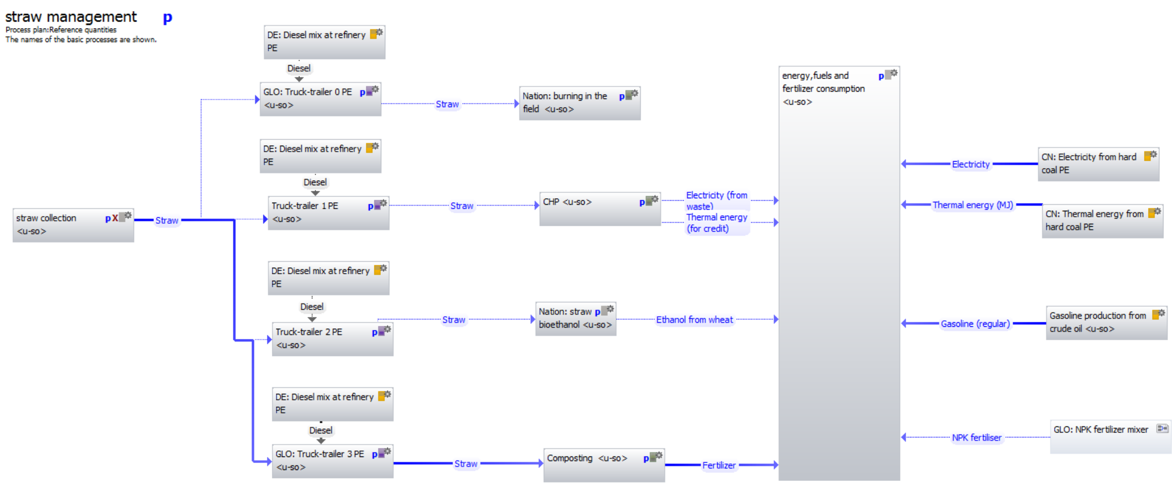


Figure 21. The flow of plan.

All the unit processes included in this plan can be seen in figure 21 and are presented in table 22 with information on the scenarios applied and its function served. More information on the distance and payload are included for all the trucks in the scope.

Table 22. Unit process in the plan.

Process	Scenario	Function served	Distance (km)	Payload capacity(t)
GLO: Truck-trailer PE	S0	Transportation of straw from city to the	200	27

		burning facility		
	S1	Transportation of straw from city to the CHP	250	27
	S2	Transportation of straw from city to the bio-refinery facility	100	27
	S3	Transportation of straw from city to the composting facility	150	27
EU-27: Diesel mix at refinery PE	All	Fuel supplied to the truck-trailer		
Burning facility	S0	Burning process		
CHP	S1	Local CHP plant		
Bio-refinery	S2	Local refinery industry		
Composting facility	S3	Composting process		
Energy consumption	All	Energy and fuels demand of the region		
Energy	all	Energy demand covered by coal based		

		fuels		
Fuels	all	Fuels demand covered by oil		
Fertilizer	So, s1, s2	Fertilizer demand covered by NPK		

7.2. Life cycle inventory analysis (LCI)

Life cycle inventory analysis (LCI) is the second main phase of LCA. In this phase, data collection regarding the study within goal and scope definition will be collected in order to quantify the inputs and outputs of each process in the whole plan. (ISO 14040, 2006)

7.2.1. Data collection

Straw are collected from Sichuan China, and average annual production is around 40760000tons. The moisture content and chemical composition are indicated in table 23.

Table 23. Chemical composition of straw. (Strömberg, 2006)

Amount of straw (tons/a)		Chemical composition of straw on dry basis %							Low heating value(MJ/kg)
	Moisture%	C	H	O	S	N	Ash	Cl	
40760000	12,4	47,32	5,03	43,05	0,08	0,6	3,8	0,12	14,31

Table 24. The initial data from each unit process

Unit process	Relevant initial information	Reference
CHP	--Total energy efficiency: 85% --Electricity generation efficiency: 15%	(Anon., 2014)
	--Efficiency of desulfurization: 97%	(Chi, 2015)
Bio-refinery	--1 ton wheat can produce 0,336 m^3 of bioethanol	(EUBIA, 2010)
Composting	--16,27% compost product is obtained from 1 ton of straw	(Zhang & Zhang, 2003)
	--1 tone compost product contain 0,15% fertilizer --76.5 kg CO2-equiv./ton of straw, CH4 is 10 kg CO2-equiv./ton of straw and N2o is 4.6 kg CO2-equiv./ton of straw --assume energy consumption around 100kwh/ton straw	(Zhu, et al., 2012)
Energy and fertilizer consumption in Sichuan	--Total population: 81400000 --Electricity for each person: 417 kwh/a --Energy demand for each person: 2079	(Yuning, 2014) The world bank
	--Fertilizer demand: $5.2*10^7$ tons	(Zhu, et al., 2012)
	--Fuels demand: $2,67*10^8$ M^3	(EIA, 2014)

7.2.2. Data calculation

The dry amount of each chemical composition are presented in table 25.

DS (dry straw) =40760000*(1-0,124)

=35705760(tons/a)

Table 25. The amount of dry chemical composition

Amount of straw (tons/a)	Amount of chemical composition of straw (t)							
	Dry %	C	H	O	S	N	Ash	Cl
40760000	87,6	2E+07	1796000	15371330	28564,61	214234,6	1356819	42846,91

While incinerating, reactions the combustible compounds in the 'fuel' occur according to following equations:

$$C + O_2 \rightarrow CO_2$$

$$H_2 + 1/2\ O_2 \rightarrow H_2O$$

$$S + O_2 \rightarrow SO_2.$$

Molecular quantity (n) of the composition is calculated by amount of substance equation. Molecular masses of C, H, S and O are considered to be 12, 1, 32 and 16 respectively.

It can be seen from the mentioned reactions that the molecular amount of C, H and S will produce the same amount of CO_2, H_2O and SO_2 molecules respectively. For the flue gas calculation, we would like to assume that the process is perfect combustion, which only require the theoretical amount of combustion air for all the fuel to be burnt. Unlike C and S, which require the same amount of oxygen molecules for the reactions, the oxygen reacts with hydrogen is only half of hydrogen in molecules.

$$n_{C} = n_{CO2} = n_{O2\text{-demand-C}}$$

$$n_{H2} = n_{H2O} = 2\ n_{O2\text{-demand-H}}$$

$$n_{S} = n_{SO2} = n_{O2\text{-demand-S}}$$

The result of emission calculation are shown in table 26.

Table 26. The amount of flue gas.

Component	**Flue gas [10*3 kmol/a]**			**Flue gas [t/a]**		
	CO_2	**H_2O**	**SO_2**	**CO_2**	**H_2O**	**SO_2**
Straw	1407997	89799986	892,644	61951873	1616399755	57129,216

Because of uncontrolled temperature and pressure, N2O cannot be calculated, therefore, according to the information (Meiqiu & Yahui, ei pvm) the amount of N2O can be calculated which is 154888 tons. An average heating value as received (wet basis) for straw was provided. Derived from this data, the annual thermal potential of straw is calculated by equation 2 with EP_i, LHV_i and m_i are thermal energy potential, low heating value and quantity of fraction I respectively.

$$EP_i = LHV_i \cdot m_i \qquad \text{(Eq 2)}$$

So: EP=40760000 (tons/a)*14,31(MJ/Kg)=162021000 MWH

7.3. Life cycle impact assessment

In this case study, the most of the emissions from the process units are CO2 and N2O which are the main types of GHG emissions which help trapping heat in the Earth's atmosphere (Anon., 2016). Therefore, the impact category "Global Warming Potential, (GWP 100 years)" will be used to assign life cycle impact assessment (LCIA) result to detailed environmental issues.

In this part, not all the unit processes' result will be presented, only the relative more contribution unit process will be analyzed.

7.3.1. Baseline scenario

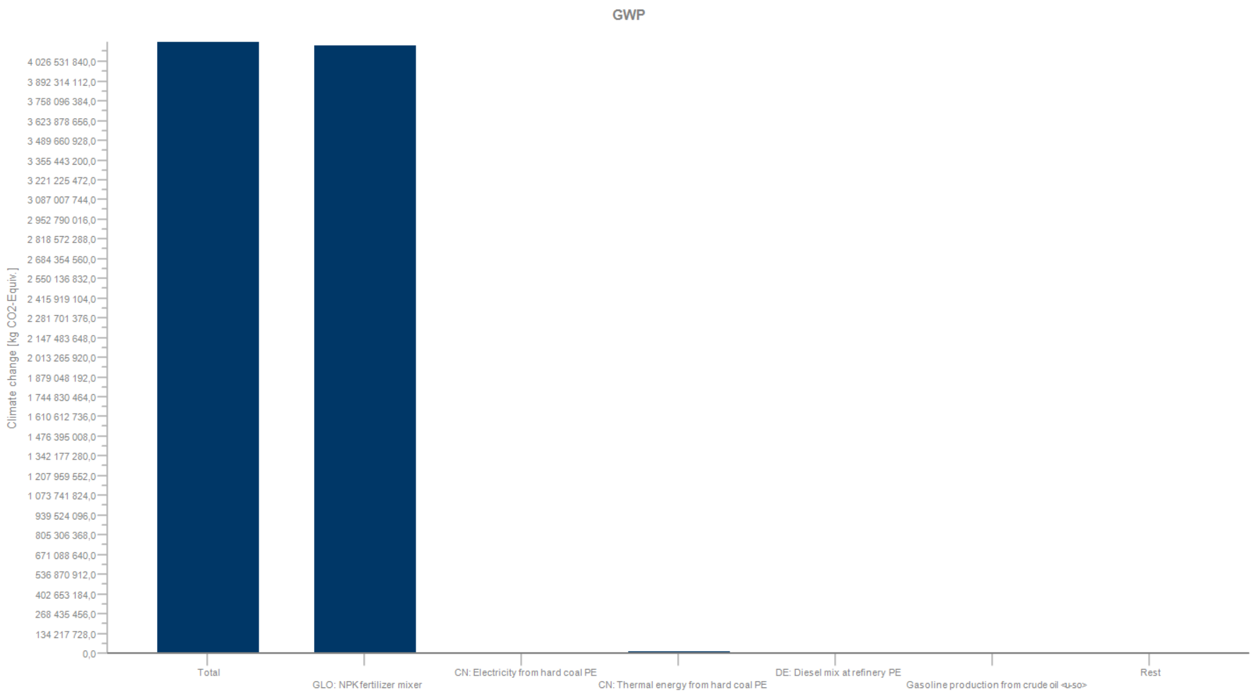


Figure 22. Contribution of baseline scenario unit process in GWP.

Figure 22 show the contribution of baseline scenario unit process in GWP. As can be seen that the main emissions are from process ‘Nation: burning in the field’ is 93.67 and because in scenario 0 all the straw are burned in the field, so the emission from the unit process ‘GLO:NPK fertilizer mixer’ which are the second largest contributor. Moreover, the emission from the unit process ‘CN: Thermal energy from hard coal PE’ which account for 0.0187% of total emissions (table 27).

7.3.2. Alternative scenario

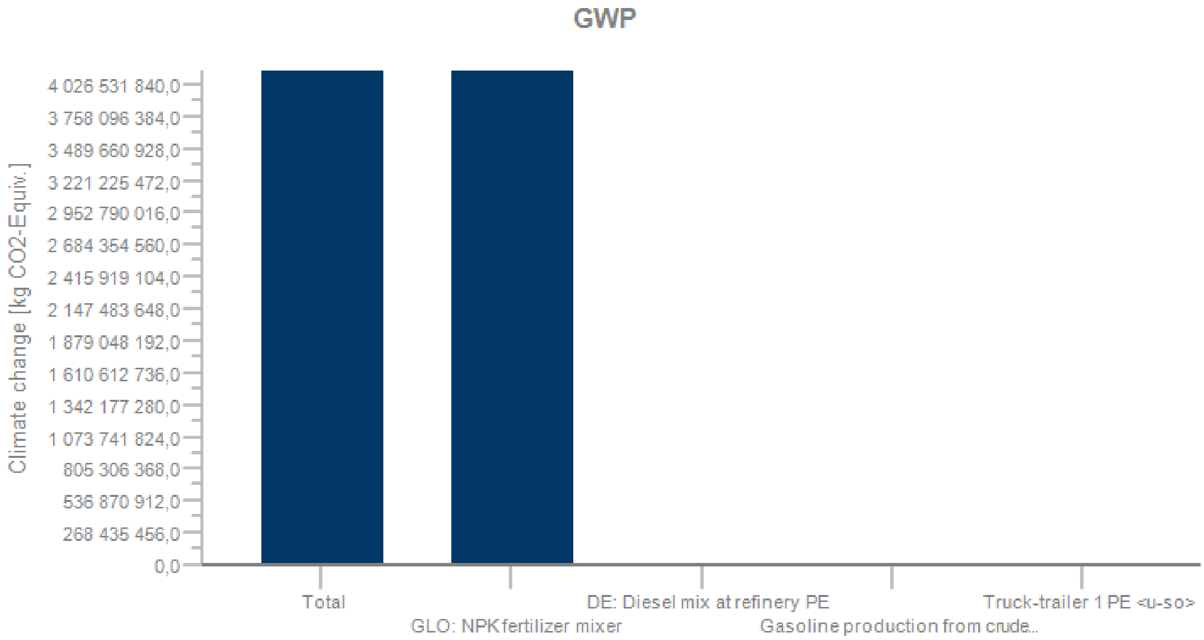


Figure 23. Contribution of scenario 1 unit process in GWP.

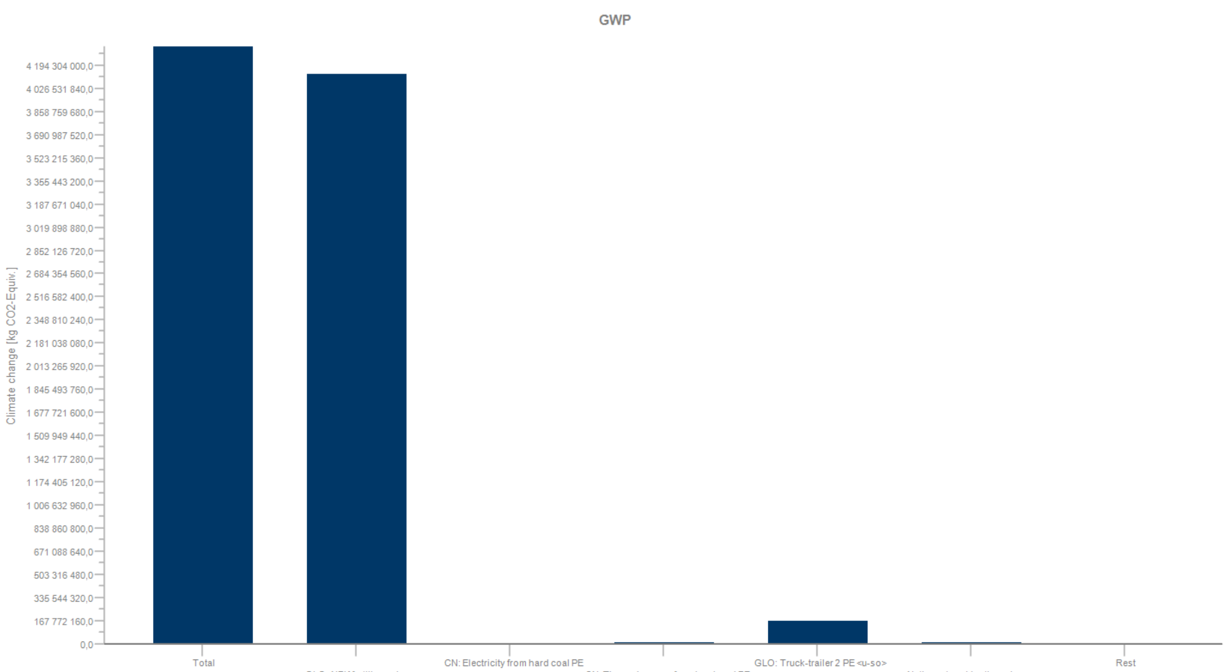


Figure 24. Contribution of scenario 2 unit process in GWP.

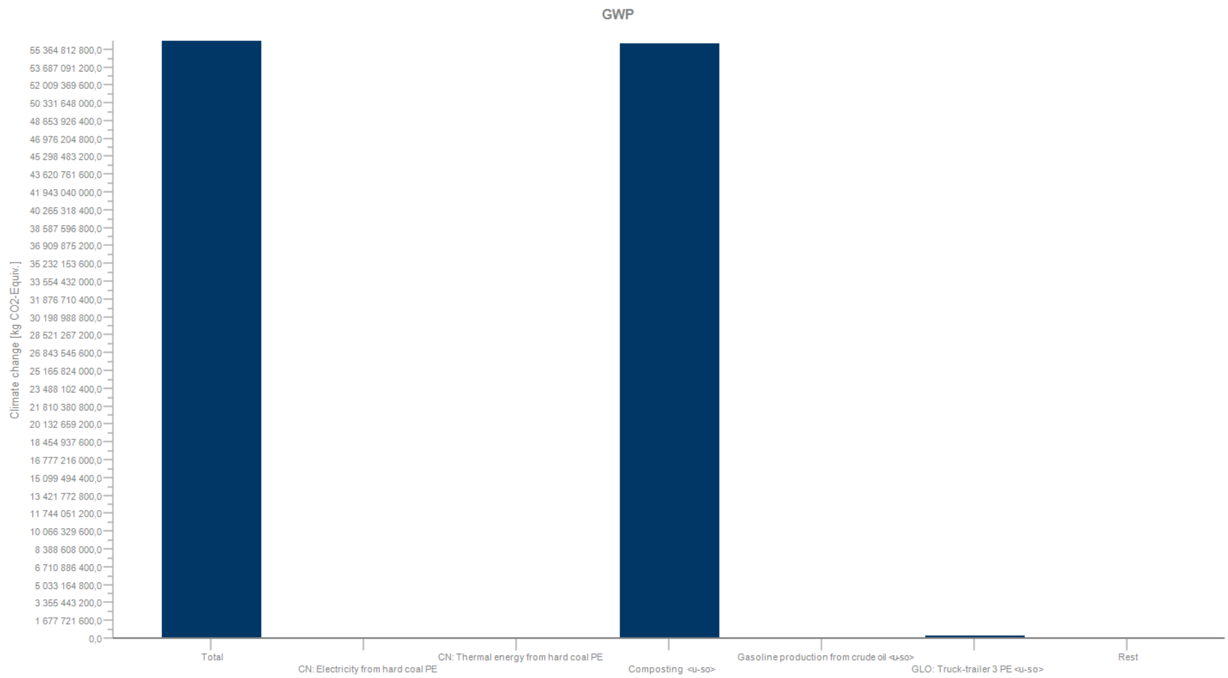


Figure 25. Contribution of scenario 3 unit process in GWP.

The emission result in the alternative scenario1 is almost same as in the baseline scenario. The largest contributor is unit process ‘NPK fertilizer mixer ‘ which account for 57.26% (table 27) and the second largest amount of emission in scenario 1 from unit process ‘CHP plant’ which accounts for 42.65%, and in scenario 2, the largest amount of emission from process ‘NPK fertilizer mixer’ as well which is 95.29% (table 27). While, in the last scenario, the largest amount of emissions from the unit process ‘Composting’ which is 99.48%.

Table 27. Share of emissions of main contribution unit process for each scenario by using CML2001 - Nov. 2010, Global Warming Potential (GWP 100 years)’

0	CML2001 - kg CO2-Equiv.									
			straw management	straw management	straw management	straw management	straw management	straw management	straw management	straw management
				GLO: NPK fertilizer mixer	CN: Electricity from h	CN: Thermal energy from hard coal PE	DE: Diesel mix at refinery PE	Gasoline production from crude oil ‹	GLO: Truck-trailer 0 PE <u-so>	Nation: burning in the field <u-so>
	Flows	Flows	100	6,286551816	0,011496013	0,018723541	1,54E-12	0,009152942	3,44E-14	93,67407569
		Resources	-0,274388864	-0,274358143	-1,11E-05	-1,96E-05	-1,25E-12	0	0	0
		Depositec	0	0	0	0	0	0	0	0
		Emissions	100,2743889	6,560909959	0,011507162	0,018743113	2,80E-12	0,009152942	3,44E-14	93,67407569
		Emissions	0	0	0	0	0	0	0	0
		Emissions	0	0	0	0	0	0	0	0
		Emissions	0	0	0	0	0	0	0	0
		Emissions	0	0	0	0	0	0	0	0

1	CML2001 - kg CO2-Equiv.							
			straw management	straw management	straw management	straw management	straw management	straw management
				GLO: NPK fertilizer mixer	CHP <u-so>	DE: Diesel mix at refinery PE	Gasoline production from cru	Truck-trailer 1 PE <u-so>
	Flows	Flows	100	57,25765456	42,65898082	1,13E-11	0,083364614	1,18E-10
		Resources	-2,498842649	-2,498842649	0	-9,14E-12	0	0
		Depositec	0	0	0	0	0	0
		Emissions	102,4988426	59,75649721	42,65898082	2,04E-11	0,083364614	1,18E-10
		Emissions	0	0	0	0	0	0
		Emissions	0	0	0	0	0	0
		Emissions	0	0	0	0	0	0
		Emissions	0	0	0	0	0	0

2	CML2001 - kg CO2-Equiv.					
			straw management	straw management	straw management	straw management
				GLO: NPK fertilizer mixer	CN: Electricity from h	CN: Thermal energy from hard coal PE
	Flows	Flows	100	95,29798075	0,174268322	2,84E-01
		Resources	-4,159466979	-4,159001281	-0,000169002	-0,000296696
		Depositec	0	0	0	0
		Emissions	104,159467	99,45698203	0,174437324	2,84E-01
		Emissions	0	0	0	0
		Emissions	0	0	0	0
		Emissions	0	0	0	0
		Emissions	0	0	0	0

3	CML2001 - kg CO2-Equiv.									
			straw management	straw management	straw management	straw management	straw management	straw management	straw management	
				CN: Electricity from hard c	CN: Thermal energy f	Composting <u-so>	DE: Diesel mix at refinery PE	Gasoline production from crude oil ‹	GLO: Truck-trailer 3 PE <u-so>	
	Flows	Flows	100	0,013537619	0,022048702	99,48744466	1,09E-12	0,010778435	0,466190585	
		Resources	-3,62E-05	-1,31E-05	-2,30E-05	0	-8,86E-13	0	0	
		Depositec	0	0	0	0	0	0	0	
		Emissions	100,0000362	0,013550748	0,02207175	99,48744466	1,98E-12	0,010778435	0,466190585	
		Emissions	0	0	0	0	0	0	0	
		Emissions	0	0	0	0	0	0	0	
		Emissions	0	0	0	0	0	0	0	
		Emissions	0	0	0	0	0	0	0	

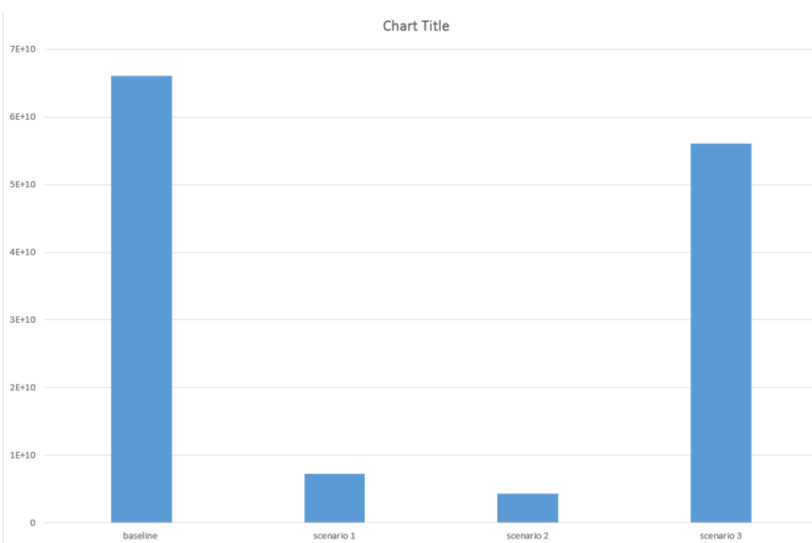


Figure 26. Total emission of each scenario (kg CO2-Equiv.)

According to the information that presented in figure 29, burning the straw directly is not a good optional, because 6.6*10^{10} kg CO2-Equiv. will be produced in this case. However, if management the certain amount of straw in CHP power plant, the emissions will be lower than burn directly which is 7.3*10^{9} kg CO2-Equiv. In addition, if the city's straw are sent to bio-refinery industry will be the best option. However the straw can be sent to the CHP for energy production as well

7.4. Sensitivity analysis

In this chapter, since emission parameters are fixed and they cannot be changed, the aim of this sensitivity analysis was directed to changing the efficiency levels where heating energy had a mayor role.

The case studied until now (S0) is in this chapter case references as in table 28 can be seen. The efficiency levels of the plants, in their case references is 90% for CHP plant. From the CHP, 15% is electricity efficiency and the rest until 85% is heating efficiency. The sensitivity analysis comparing the scenario 1 was performed and the values are shown in table (CML2001-Nov2010). For this analysis Global Warming Potential (GWP 100 years) will be used.

Table 28. Variation in GWP changing CHP plant efficiency values

CML 2011-Nov.2010, Global Warming Potential (GWP 100 years)[kg co2-Equiv.]			
Scenario	case reference	case 1	case 2
el&heat efficiency	15% &75%	20% & 70%	10% & 80%
emission to air	7261293259	7259584470	7263002049
relative changes %		-0,000235329	0,000235329

The values of the CHP plant (S1) decrease on electricity efficiency aiming for a better heating efficiency. The total efficiency of the CHP plant is assumed to stay constant at 90% while the ratio of power to heat changes, increasing heat and reducing electricity efficiencies. In the CHP scenarios 1, the aim of the reduction on electricity efficiency was to improve the heating efficiency, otherwise reduce the heating efficiency. As can be seen in this table 28 relative emissions were decrease in case 1 while in case 2 when decrease the electricity efficiency, the emission get higher than the reference case. Therefore, when increase the heating efficiency in CHP plant, the emission should be considered as well.

8. CONCLUSION

In China fossil fuels are the dominant energy sources for energy production, and the energy demand has increased with higher rate than developed countries. In 2002, the energy consumption rise exponentially, rapidly increase from about half the level of U.S. demand, until 2009, the consumption almost reach the same level and Chinese demand surpasses the U.S. demand after that.

There are 28 provinces where produce coal and amount of coal resources are in Shanxi, Xinjiang and Shanxi. So far, about 12000 coal mines are producing primarily bituminous coal and a huge amount of anthracite and lignite. Between 2011 and 2012 coal production increased 4% from 3.8 billion short tons to 4 billion short tons which account for 66% of TEC in 2012 and represent half of the world total. In addition, the demand for oil grows strongly as well, Because of less recoverable oil reserve, and in order to meet domestic demand China has to import oil from outside. In 2000, the domestic oil production rose to 17%, but even with increase, the production still cannot meet the consumption. However, comparing with coal, natural gas is not a significant part. Same as oil resources, natural gas resources are quite small and less than 2% of recoverable reserves globally.

Because of the increasing demand of energy, air pollution get worse in China. The main emissions from the coal fired power plants, because of the high dependence on coal-fired power plants has made China's electricity industry produce large amounts of emissions, thus contributed to serious environmental impairments. Emissions of sulfur dioxide, carbon dioxide, nitrogen oxides, particulate matter and other atmospheric pollutants from coal- fired power plants have been closely observed by the environmental protection agency. While in order to control the pollution and promote the economic development simultaneously, developing the biomass resources is one option. Comparing with fossil fuels, biomass is renewable, sustainable and relatively environmental friendly energy. Recently, China has abundant biomass resources there, such as agriculture residues, wood, manure from farms and municipal waste water and solid waste resources. In addition, China is an agricultural country which has an amount of straws resources, such as oil crops, cotton, wheat straw and rice straw, which can be used as fertilizers, generate energy and bio-fuels.

In order to promote the development of biomass resources in China, the government attach high importance to promote the biomass-based energy production and issued a series of policies about biomass energy development, such as, "Renewable Energy Law", "Agriculture Law", "Energy Saving Law" and etc. Beyond that Chinese government has committed financial subsidies for the biomass energy development and utilization and encourage the enterprises to join the development of biomass energy. For example: "Project Subsidy", "Low Interest Loan", "Tax " and etc.

At last, in order to find out an optimal option for agricultural biomass resources management. There are different technology are applied for straw management (direct burning, CHP plant, bio refinery and composting). Because of the most of the emissions from the process units are CO2 and N2O which are the main types of GHG emissions which help trapping heat in the Earth's atmosphere. Therefore, the impact category "Global Warming Potential, (GWP 100 years)" is used to assign life cycle impact assessment (LCIA) result to detailed environmental issues.

Moreover, from the result of LCIA, after comparing the results, transport the straw into CHP plant for energy generation is better than directly burning, because the total emission is lower relative and the best option for straw management is for bio-ethanol production. Furthermore, the electricity efficiency of CHP plant cannot be too much low, even has higher thermal efficiency, because from this case study can be seen that if the electricity efficiency is lower than the baseline scenario, the total emission will be higher, therefore, the electricity efficiency of CHP plant is an important factor which affect climate change.

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