SIXTH FRAMEWORK PROGRAMME

FP6-2004-INCO-DEV-3

PRIORITY A.2.3.: Managing Arid and Semi-arid Ecosystems

Second Periodic Activity Report (01.01.2008 – 31.12.2008), January 2009

ANNEX 4-2-3: Biomass Resource Assessment for China

Deliverable D4.1 (Lead contractor: CAREI, Due date: December 2008)

COMPETE

Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa

Responsible Partner:

Chinese Association of Rural Energy Industry (CAREI), China

Project Co-ordinator:

WIP, Sylvensteinstrasse 2, 81369 Munich, Germany

COMPETE is co-funded by the European Commission in the 6th Framework Programme – Specific Measures in Support of International Cooperation (INCO-CT-2006-032448).

Project Partners

Partici-pant role	Partici-pant number	Participant name	Participant short name	Country	Date enter project (month)	Date exit project (month)
CO	1	WIP – Renewable Energies, Germany	WIP	DE	1	36
CR	2	Imperial College of Science, Technology and Medicine	Imperial	UK	1	36
CR	3	Utrecht University	RUUTR.STS	NL	1	36
CR	4	Stockholm Environment Institute	SEI	SE	1	36
CR	5	Austrian Biofuels Institute	ABI	AU	1	36
CR	6	Höhere Bundeslehr und Forschungsanstalt für Landwirtschaft, Landtechnik und Lebensmitteltechnologie Francisco Josephinum	FJ BLT	AU	1	36
CR	7	ETA - Energia, Trasporti, Agricoltura s.r.l.	ETA	IT	1	36
CR	8	European Biomass Industry Association	EUBIA	BE	1	36
CR	9	Practical Action	Practical Action	UK	1	36
CR	10	Consiglio Nazionale delle Ricerche	CNR	IT	1	36
CR	11	E+Co, Inc. (not funded)	E+Co	USA	1	36
CR	13	Institute for Sustainable Solutions and Innovation	ISUSI	DE	1	36
CR	14	AGAMA Energy (Pty) Ltd	AGAMA	ZA	1	36
CR	16	Center for Energy, Environment and Engineering Zambia	CEEEZ	ZM	1	36
CR	17	Environnement et Développement du Tiers-Monde	ENDA-TM	SN	1	36
CR	19	Food, Agriculture and Natural Resources Policy Analysis Network of Southern Africa	FANRPAN	ZIM	1	36
CR	20	FELISA Company Limited	FELISA	TZ	1	36
CR	21	Mali-Folkecenter	MFC	Mali	1	36
CR	22	MOI University	MU	Kenya	1	36
CR	24	Tanzania Traditional Energy Development and Environment Organisation	TaTEDO	TZ	1	36
CR	25	UEMOA - Biomass Energy Regional Program (PRBE)	PRBE	BF	1	36
CR	26	University of KwaZulu Natal	UKZN	ZA	1	36
CR	27	University of Cape Town - Energy Research Centre	UCT, ERC	ZA	1	36
CR	28	Chinese Academy of Agricultural Sciences	CAAS	CN	1	36
CR	29	Centro Nacional de Referencia em Biomassa, Brazil	CENBIO	BR	1	36

Project Partners (continued)

Partici-pant role	Partici-pant number	Participant name	Participant short name	Country	Date enter project (month)	Date exit project (month)
CR	30	Indian Institute of Science	IISC	IN	1	36
CR	31	The Energy and Resources Institute	TERI	IN	1	36
CR	32	Universidad Nacional Autonoma de Mexico	UNAM	MX	1	36
CR	33	Universidade Estadual de Campinas	UNICAMP	BR	1	36
CR	34	Winrock International India	WII	IN	1	36
CR	35	Interuniversity Research Centre for Sustainable Development - University of Rome "La Sapienza"	CIRPS	IT	1	36
CR	36	Universitetet i Oslo	UiO	NO	1	36
CR	37	University of Bristol	UNIVBRIS	UK	1	36
CR	38	University of Botswana	UB	Botswana	1	36
CR	39	University of Fort Hare	UFH	ZA	1	36
CR	40	TWIN	TWIN	UK	1	36
CR	41	Joint Graduate School of Energy and Environment	JGSEE	TH	1	36
CR	42	African Development Bank Group (not funded)	AFDB	Int.	1	36
CR	43	Energy for Sustainable Development Ltd.	ESD	UK	1	36
CR	44	Eco Ltd.	Eco	UK	1	36
CR	45	Chinese Association of Rural Energy Industry	CAREI	CN	1	36
CR	46	Food and Agriculture Organisation of the United Nations (not funded)	FAO	Int.	1	36
CR	47	Conservation International Foundation (not funded)	CI	USA	1	36
CR	48	Foederation Evangelischer Kirchen in Mitteldeutschland	EKMD	DE	1	36

INTRODUCTION

This work has been conducted in the framework of the project COMPETE (Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa), co-funded by the European Commission in the 6th Framework Programme – Specific Measures in Support of International Cooperation (Contract No. INCO-CT- 2006-032448).

This report provides an overview of the biomass resource assessment in China including:

- Current relevant laws and regulations on the development and application of agricultural wastes, forestry wastes, energy plants/crops, landfill gas and livestock.
- Combustion characteristics, land utilization conditions, annual output of agricultural wastes, forestry wastes, energy plants/crops, domestic solid waste and light industry wastewater.

Editing and Reporting: COMPETE – Annex 4-2-3

Prof. Wang Mengjie
Xiao Mingsong
Chinese Association of Rural Energy Industry (CAREI), China
E-mail: Mj-wang@tom.com Xiaoms@163bj.com

CONTENTS

Biomass resource Assessment for China

1. Crop Straws

Crop straws are the residual inedible parts like roots, stalks and leaves of wheat and corn etc. during agricultural production. Due to its abundant crop straw resources China has great potential for energy development and utilization.

The main components and heat value of crop straws are shown in Table 1.

	Unit	Yellow straws	Grey straws	Wood chips	Coal	Natural gas
Moisture content	%	10-20	10-20	40	12	0
Volatile component	%	>70	>70	>70	25	100
Ash	%	4	3	0.6-1.5	12	0
Carbon	%	42	43	50	59	75
Hydrogen	%	5	5.2	6	3.5	24
Oxygen	%	37	38	43	7.3	0.9
Chloride	%	0.75	0.2	0.02	0.08	-
Nitrogen	%	0.35	0.41	0.3	1	0.9
Sulphur	%	0.16	0.13	0.05	0.8	0
Gross calorific value	MJ/kg	18.2	18.7	19.4	32	48
Lower calorific value	MJ/kg	14.4	15	10.4	25	48
Ashing temperature	□	800-1000	950-1100	1000-1400	1100-1400	

Table 1: Components and heating value of crop straws in China

1.1 Total crop straw resources

The total yield of seven main agricultural products (i.e. paddy, wheat, legume, oil plants, cotton and potato) was 510 million tons in 2005 in China (see Table 2 and Figure 1). According to the ratio of stalks and paddies, the total annual straw resource could reach 498 million tons. The yield of main crop straws of China in 2010 and 2020 will reach 720 million tons and 800 million tons respectively, based on the China Food Development Plan.

Crop species	Paddy	Wheat	Corn	Legume	Potato	Oil plants	Cotton	Total
Planting area(k ha.)	28847	22793	26358	12901	9503	14318	5062	119782
Crop yield(million tons)	180.588	97.445	139.365	21.577	34.685	30.771	5.714	510.146
Crop straw yield(million tons)	116.398	104.376	166.115	27.978	15.000	52.772	15.020	497.660

Note: the data of the planting areas and the crop yield are from the China Statistics Yearbooks of 2006.

Table 2: Yield of main crop straws in China

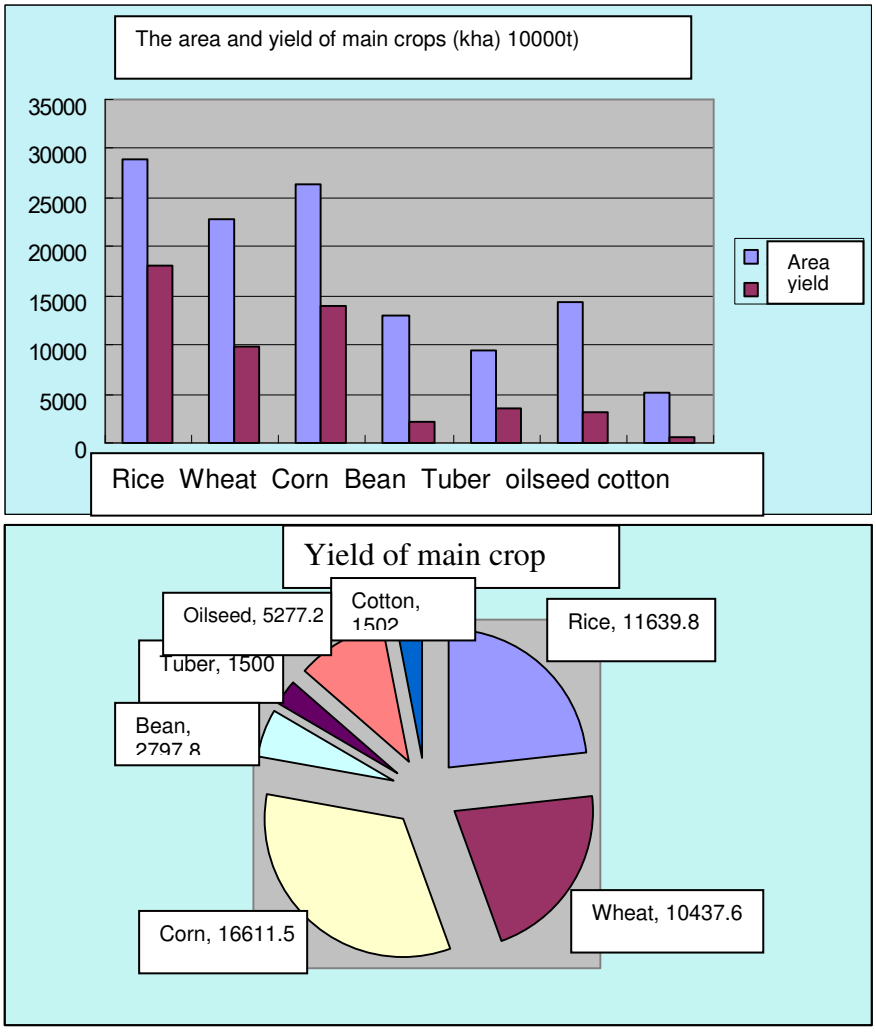

Figure 1: Yield of main crop straws in China

Byproducts of agricultural product process

Agricultural byproducts, chiefly rice hulls, corncobs, bagasses etc. from primary processing, are mainly produced by grain processing plants, packinghouses, sugarhouses and brewhouses. Producing areas of these byproducts are comparatively centralized, which is favorable for collection and processing. Rice hull, the main residues from rice processing, accounts for 20% of the total paddies' weight and is concentrated in Northeast China, Hunan, Sichuan, Jiangsu and Hubei. Corncobs account for about 20% of the total corns' weight and are chiefly produced in Liaoning, Jilin, Heilongjiang, Hebei, Henan, Shandong, Sichuan. Bagasses are the main byproducts from sucrose processing, chiefly produced in Guangdong, Guangxi, Fujian, Yunnan, Sichuan. The total amount of byproducts is 100 million tons, equalling 50 million tce. (China Agricultural Biomass Energy Resources Assessment Outline Report; conference materials from National Development and Utilization Biomass Energy Resource in 2006)

1.2 Crop straw resource distribution

Crop straw resources are concentrated in the main grain production areas like Hebei, Neimenggu, Liaoning, Jilin, Heilongjiang, Jiangsu, Henan, Shandong, Hubei, Hunan, Jiangxi, Anhui, Sichuan, and Yunnan. Taking into account the cost of collection, provinces with large per capita resources are Jilin, Heilongjiang, Neimenggu, Xinjiang, Liaoning, Shandong, Ningxia, Henan, and Hebei. Detailed information on the distribution of crop straw resources is shown in Table 3 and Figure 2.

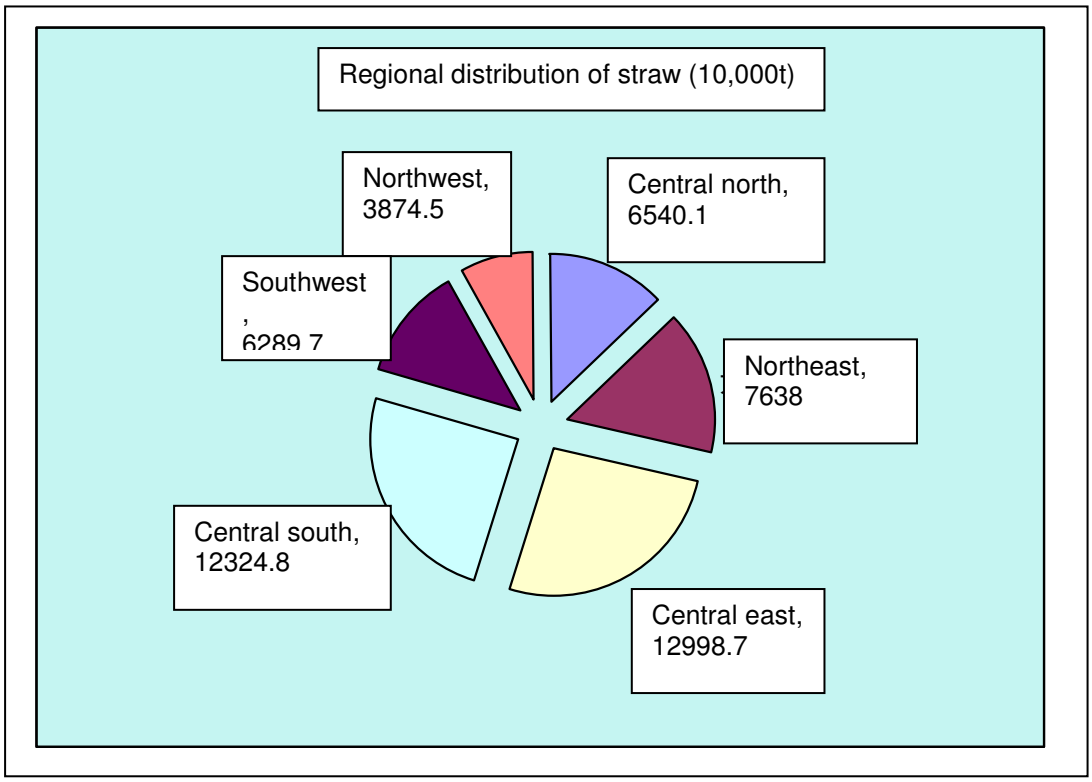

Figure 2: Crop straw resources in China

Province	Paddy	Wheat	Corn	Legume	Potato	Cotton	Oil Plants	Total	per capita crop straw resource *
Total amount in China	**11639.8**	**10437.6**	**16611.5**	**2797.8**	**1500.0**	**1501.9**	**5277.2**	**49765.9**	**0.67**
North China	**82.0**	**1682.0**	**3590.0**	**334.8**	**135.1**	**201.7**	**514.4**	**6540.1**	
Beijing	0.3	28.6	74.6	3.1	0.9	0.5	4.3	112.4	0.45
Tianjin	7.9	50.8	87.2	5.0	0.3	22.0	2.2	175.3	0.68
Hebei	33.2	1232.1	1423.0	66.4	40.9	151.7	261.9	3209.2	0.75
Shanxi	0.6	216.7	734.4	47.5	25.6	27.1	36.5	1088.3	0.56
Neimenggu	40.1	153.8	1270.8	212.7	67.5	0.5	209.5	1954.8	1.55
Northeast China	**1296.4**	**112.0**	**4742.9**	**1136.5**	**88.7**	**1.2**	**260.5**	**7638.0**	
Liaoning	268.5	8.5	1353.4	56.5	18.1	0.7	63.2	1768.9	1.01
Jilin	305.1	2.9	2146.3	198.2	32.8	0.5	93.4	2779.1	2.16
Heilongjiang	722.9	100.7	1243.1	881.7	37.8	0.0	103.9	3090.0	1.73
East China	**3852.7**	**3613.5**	**2650.0**	**448.9**	**277.8**	**421.7**	**1734.1**	**12998.7**	
Shanghai	55.1	10.6	3.4	4.1	0.4	0.5	11.9	85.9	0.44
Jiangsu	1100.1	780.3	208.3	106.9	23.9	84.8	370.4	2674.8	0.72
Zhejiang	415.6	23.4	30.9	61.5	26.8	5.7	86.0	649.8	0.30
Anhui	806.2	865.6	315.7	123.8	53.6	85.3	464.2	2714.5	0.69
Fujian	339.4	2.1	15.7	32.0	63.3	0.0	47.0	499.6	0.27
Jiangxi	1074.6	2.9	7.4	32.2	23.6	22.9	130.5	1294.3	0.48
Shandong	61.7	1928.6	2068.5	88.4	86.1	222.5	624.0	5079.8	1.00
Central South China	**4246.3**	**3003.0**	**2271.6**	**341.0**	**362.3**	**328.7**	**1771.9**	**12324.8**	
Henan	231.9	2761.0	1547.1	96.5	99.5	178.0	771.0	5685.1	0.87
Hubei	989.6	223.7	232.3	84.3	67.6	98.6	504.0	2200.1	0.68
Hunan	1480.0	14.4	159.7	73.5	73.2	51.9	241.8	2094.5	0.53
Guangdong	720.0	2.0	73.3	31.6	80.2	0.0	132.1	1039.2	0.29
Guangxi	753.5	1.9	252.7	52.3	26.9	0.2	108.4	1195.9	0.39
Hainan	71.3	0.0	6.4	2.8	15.0	0.0	14.6	110.2	0.24
Southwest China	**2028.3**	**762.1**	**1918.0**	**378.4**	**506.3**	**6.6**	**689.9**	**6289.7**	
Chongqing	336.1	84.2	277.9	54.7	121.2	0.0	73.2	947.4	0.62
Sichuan	970.5	457.8	692.3	170.5	215.5	6.5	398.5	2911.5	0.53
Guizhou	304.7	78.2	410.4	49.0	92.2	0.1	145.6	1080.2	0.40
Yunnan	416.6	114.5	535.5	100.1	77.2	0.0	62.1	1306.0	0.42
Xizang	0.4	27.4	2.0	4.2	0.2	0.0	10.5	44.7	0.45
Northwest China	**134.2**	**1265.0**	**1438.9**	**158.1**	**129.8**	**542.1**	**306.4**	**3974.5**	
Shanxi	57.5	429.7	547.9	48.1	18.2	20.4	77.8	1199.7	0.51
Gansu	2.6	283.7	296.2	54.0	82.1	29.1	86.3	834.0	0.46
Qinghai		42.1	1.1	15.2	14.0	0.0	54.6	127.1	0.39
Ningxia	39.4	85.1	144.7	7.8	11.9	0.0	20.9	309.8	0.90
Xinjiang	34.7	424.4	449.0	33.0	3.5	492.6	66.8	1504.0	1.49

Note: 1. Data of grain output and rural population are from China Statistics Yearbook of 2006.
2. *Per capita crop straw resource are calculated with data of rural population in each counties.

Table 3: Crop straw resources in China

1.3 Utilization status

Rural energy

Traditionally, crop straws serve as fuels in rural areas. Nevertheless, with the economic development in rural areas and the increasing of peasants' income, the energy mix has already changed evidently, and commercial energy like coal, oil, gas and electricity etc. are widely used in these regions. Crop straws, except the parts returned to the farmland as fertilizer, are regarded as waste that is piled in the field or burned. Such disposal is not only wasting resources, but also polluting the environment.

Crop straws used as materials for fertilizer, fodder, paper making

About 40% of crop straws in China are used in the traditional way according to the investigation of typical regions and the prediction by experts. Taking into account the further increase of peasants' income, crop straws serving as fuels will reduce gradually. The government will adopt strict measures to shut down small paper plants because of their severe water pollution, which means straws are no longer used as paper making materials and will be used in less traditional ways.

At present, there are advanced efficient utilization ways of crop straws including generation, centralized gas supply and compaction for the production of briquettes.

Straw power generation

50 large-scale power generation projects from biomass has been approved by the NDRC, with the total installed capacity of 1500 MW by the end of 2006 and more than 7 large-scale power generation projects from direct biomass burning have been put into production by the end of June, with total installed capacity of 175 MW. With 25 MW of installed capacity for each power plant and 160 thousand tons per year of straw consumption, 8 million tons of crop straws per year will be burned for the 50 power plants.

Gasification for power generation

The current popular generation technology from straw gasification is the biomass cycling flow bed gasification technology developed by CAS Guangzhou Energy Research Institution. The institution has built up the first 1MW biomass paddy hull generation system of China in Fujian Putian, and then set up more than 30 biomass gasification generation systems. There are 20 gasification generation systems from agricultural solid waste of hulls and straws in the Heilongjiang Provincial Land Reclamation Bureau. The annual generation is 75 million kWh and the annual treating capacity of agricultural solid waste is about 100 thousand tons.

Centralized gas supply from crop straws

China has already developed various small-scale gasification stoves of fixed beds and fluidized beds, with straws, wood chips, paddy hulls and woods as feedstock. Presently, 800 of them are used for drying woods and agricultural byproducts, 600 of them are used in the centralized gas supply systems from straw gasification in the countryside, producing 20 million m^3 of biomass fuel gas with a heat value of 4-10 MJ/m^3. The annual consumption of crop straws is 10 thousand tons if the fuel gas output is 2 m^3 every kg of crop straws.

Briquette Biomass Dense Fuel

Briquette Biomass Dense Fuel (BBDF) are mainly produced from crop straw. Nearly 20 sets of equipment, mainly screw extruders, have been induced into China from Korea, Taiwan and Japan since the 1980s. Relevant technologies from Holland and Belgium have also been introduced into China. However, all the equipments are stopped from production because of quick abrasion and lack of market. Relevant research work on BBDF in China has started in the 1990s, such as by the China Academy of Forestry, Shanxi Wugong Machinery Works and some institutions in Hunan, Hubei, and Liaoning. After 1995, Henan Agriculture University was commissioned by the State Economic and Trade Commission to research on the hydraulic molding machines. Currently, all the technologies are at the pilot stage and not generalized due to the disadvantages of price and market compared with coal.

1.4 Available crop straws as energy resource

The energy potential of crop straw resources is measured in the three following steps:

A. The total amount of crop straw resource is the sum of products of annual yield of each crop type and its corresponding ratio of stalks and paddies. Actually, this is the theoretic total amount of straw resources, including all parts of crops after threshing their roots, stalks and leaves and without consideration of type or regional differences and the influence of reaping methods. The actual straw resource amount in a certain region, however, is related to the local crop types and its reaping mode. Thus, there is certain inevitable discrepancy between the actual and the theoretical resource potential. The total amount of straw resources from the seven main crops of China including paddy, wheat, corn, legume, oil plants, cotton, potato were 498 million tons in 2005.

B. The available amount of crop straw resources is the actual amount except roots under the ground and the stalks left in the field after reaping. It is projected that total amount of straw resources from the seven main crops of China is 400 million tons, according to the field investigation and the measured results in some typical regions in China.

C. Subtracting all other current utilizations of crop straws provide the energy potential of crop straws. In addition, due to the large territory of China, the distribution of planting areas and the planting densities are vastly different, especially in remote countryside and mountainous regions, where there are adequate crop yields, but the condition of collection and transport can hardly meet the requirement of straw purchasing.

According to the investigation in typical areas, the available straw resource amounts to 240 million tons, equalling 120 million tce.

2. Forest biomass energy resources

Forest biomass energy resources are energy sources from biomass converted from solar energy via forestry operation activities. On basis of the 6th National Forestry Resource Inventory (2005), the total forestry area of the whole country is 175 million m^3. The forestry coverage rate is 18.21% and living trees are 13.618 billion m^3, of which the forest growing stock is 12.456 billion m^3. With 10.593 billion m^3 of growing stock, the wildwood area is 115.762 million ha.

Most wildwood forests are distributed in Heilongjiang, Neimenggu, Jilin, Yunnan, Sichuan and Xizang. With a growing stock of 15.05 billion m^3, plantation area is 53.26 million ha. Most plantation forests are distributed in collective owned forest regions of South China like Guangdong, Guangxi, Hunan, Fujian, and Sichuan. The economic forest area is 21.39 million ha, with bamboo forest of 4.8426 million ha, distributed in Fujian, Jiangxi, Zhejiang, Hunan, Guangdong, Sichuan, Guangxi, Anhui, Hubei, and Chongqing. It is calculated that the above-ground forestry biomass of China is 16.746 billion tons and the total forestry biomass is 19.258 billion tons.

Based on the actual situation of the forestry in China and the utilization ways of energy, the forestry biomass energy resources could be divided into two groups of woody biomass resources and oil biomass resources. The woody energy resources include fuelwood forests, wood processing remainders, stumping and rejuvenation of shrubs, pruning of economic forests, stumping of afforestation seedlings, plants for urban afforestation and the wood chips from pruning plant hedges. The oil biomass energy resources are mainly woody oil plant species, whose seeds or/and fruits can be processed to biodiesel.

2.1 Output

A. Woody biomass energy resources

Fuelwood forest

Fuelwood forest is one of the five major forest species and chiefly used as the material for producing fuels. The construction of fuel woods has achieved remarkable progress since the 6th Five-Year Plan. According to the 6th National Forestry Resource Inventory, its area in China is 3.0344 million ha, with a stock amount of 56.27 m^3. Based on the stock amount in each province, the total amount of fuelwood biomass is 66 million tons.

Wood processing residues

These residues come from felling, bucking and processing, chips and small-diameter woods from tending, felling and pruning. The information is detailed in the Research Report on Forest Biomass Energy Resources of China as the following:

a. Remainders from felling and bucking: according to the sampling survey in all the major forest regions, the remainders from felling and bucking (including shoot, branches and leaves) account for about 40% of the forest biomass. At present, in accordance with the felling standard, the area of mature and overmature forests in China is 14.6857 million ha, the growing stock volume is 2.74 billion m^3, and the total biomass quantity is 3.214 billion tons. The area of protection forests, special forests and overmature forests in need of felling and succession is 3.0775 million ha, growing stock volume is 0.713 billion m^3 and the total biomass quantity is 0.836 billion tons. Therefore, the total forest biomass quantity which can be felled and renewed is 4.05 billion tons, and the remaining biomass resources from felling is about 1.62 billion tons with an estimation of 40% of the total volume. Nevertheless the forest felling should be done year by year and restricted by other policies.

b. Residues from timber processing (including barks, lathes, slab edgings, parings and sawdust etc.): according to the requirement of limiting felling activities during the 5 Year Plan replied by the State Council, the felling of industrial material forests has been increased during the 11^{th} Five-Year Plan. For most industrial material forests with short cycle planted by all kinds of social entities has come into the felling period and the felling management experiment range of the planted commercial forests in Nature Forest Resources Conservation Project and the cropland protection forests has been further enlarged The timber output in 2006 reached 66.1178 million m^3, an increase of 18.91% compared to 2005. Among the total timber output, logs are 61.1168 million m^3 (except fuelwood). Besides, China has imported 32.1365 million m^3 of logs in 2006. To sum up, the total processing volume of logs is 93.2533 million m^3. According to the sampling investigation of timber processing factories and the actual situation in local areas, it is estimated that timber processing residues account for 34.4% of logs, meaning these remainders are 32.0791 m^3 (28.8712 million tons in weight).

c. Volume of tending, felling, and pruning: According to regulations by the State Forestry Administration, middle-young aged forest need 2-4 times of thinning felling during their growing period. With the average timber output of 6.0 m^3/ha (the intensity of thinning felling is calculated at 20%), the output of thinning felling is 0.551 billion m^3 of small diameter timbers, equalling to 0.5 billion tons of biomass. The average pruning frequency of coniferous forests and broad-leaves forests is 2-3 times during the tending period, which can produce 0.184 billion tons of branches. To add up the above two kinds of output, the tending, felling and pruning volume of middle-young aged forest is 0.684 billion tons.

Shrubs

The total area of shrubs in China is 45.2968 million ha. Estimated with the areas of major species in each province and the biomass quantity per unit area, the total biomass quantity of stumping and rejuvenation for shrubs in China is 0.3-0.4 billion tons.

Others

The biomass from pruning of economic forest and bamboo forests, stumping of nurseries and shrubs under forests and pruning for city greening etc. can reach 0.1 billion tons per year.

B. Oil biomass energy resources

The area of economic forests in China is 21.4 million ha., of which the total area of woody oil plants is 8.042 million ha. The annual output of oil plant fruits is 2.245 million tons.

2.2 Distribution

Fuelwood forests are widely distributed in China (except Shanghai, Tianjin). Yunnan ranks first, followed by Shanxi, Liaoning, Jiangxi, Neimenggu, Guizhou, Hubei, and Hebei. All 8 provinces own 76% of the fuelwood forests in China.

The residues from forest processing are mainly produced in major forest areas and developed areas of wood processing, including Northeast, Southwest, collective forest areas in South China and planted poplar forests in plain regions.

Shrubs are located all over the country including mountainous regions, banks of rivers and plain regions. The major species of woody oil forest including tung-oil tree, Chinese tallow, oil-tea camellia, and Jatropha curcas are the major economic forests in South China. Walnuts are widely distributed in southern and northern areas of China, and olives are growing in Shanxi and Yunnan. The 6 major distribution areas of biodiesel feedstocks are listed below:

a. Jatropha curcas: Naturally growing or planted in Sichuan, Yunnan, and Guizhou. Suitable areas include Guangxi, Guangdong, Fujian, Hainan and Chongqing. Dry and hot valleys are quite suitable for this species.

b. Pistacia chinensis: Wild species are widely growing in the north including Hebei and Shandong, the south including Guangdong, Guangxi, and the east including Taiwan and the southwest including Sichuan and Yunnan. Hebei, Henan, Shanxi, and Shaanxi are the major producing areas.

c. Swida wilsoniana: Mainly growing along Changjiang River valley and in limestone areas of southwest regions, and also distributed along Yellow River valley and the south of it. Hunan, Hubei and Jiangxi are the major producing areas.

d. Xanthoceras sorbifolia: Widely located in North China, quite helpful for greening barren hills and conserving water and soil and also the significant oil plant specie in North China. Its major producing regions are Neimenggu, Shaanxi, Shanxi, Hebei, Gansu, and Xinjiang.

e. Tung-oil trees: This species has a long history in China, and is widely distributed in 15 provinces of Gansu, Shaanxi, Yunnan, Guizhou, Sichuan, Henan, Hubei, Hunan, Guangdong, Guangxi, Anhui, Jiangsu, Zhejiang, Fujian, and Jiangxi. It is most concentrated in Sichuan, Guizhou, Hunan, Hubei, Jiangxi, Guangxi, Guangdong and Fujian.

f. Chinese tallow: Mainly growing in more than 10 provinces and regions south to the Changjiang River and concentrated in Zhejiang, Hubei, Hunan, Sichuan and Guizhou.

2.3 Utilization status

Fuelwood forests are planted for firewood supply, and they are the indispensable major fuel in mountainous rural areas, although living quality has been improved and more and more substitutional fuels have come into use for mitigating the dependency on fuelwood forests. The wood burned by rural residents in 2006 was about 40 million tons, although the timber output of fuelwood forests was only 4.5 million tons.

For forestry residues, the branches and roots from felling are collected for fuel in regions with convenient traffic, while in some regions with inconvenient traffic, they are abandoned on the cutting areas and collected by local people. With the rapid development of timber processing industry in China, the demand is far more than the supply, and the forestry processing residues of lathes, slab edgings and parings are mainly used in reprocessing.

Sawdust from producing flakeboard, fiberboard, and paper are partly reprocessed, and partly used as fuel for factories. Most of the output of forest tending and felling, pruning and shrub stumping are used in timber processing and paper making for producing flakeboard, fiberboard and wood pulp due to the shortage of timber resource in China. The roots and small branches are collected by local people, and the rest is left behind on the cutting areas.

Currently, the processing and utilization of woody oil plant fruits are less than 25%, most of the fruits are abandoned. Only very limited oil plants like oil-tea camellia and walnuts are widely used. The management of these species is extensive because of the restriction of processing and utilization, causing low levels of output.

Energy utilization includes wood burning, thermo chemical conversion and biotransformation. The thermo chemical conversion consists of pyrogenation, liquefaction and gasification. Forest biotransformation produces methane, hydrogen and fuel ethanol. In China, the main utilization ways are wood burning and producing biofuels from oil plant seeds.

2.4 Available amount as energy resource

The available amount of forest biomass resources is not only affected by natural factors of species, distribution, age, growing situations, but it is also restricted by forestry policies, laws and regulations on utilization of forest resources. In addition, it is influenced by market, collection, transportation, processing cost and efficiency, and the competition of forest biomass resources with other industries.

a. Woody biomass energy resources

Fuelwood forests

Fuelwood forests can be fully treated as energy resource. The available amount equals the total amount (about 66 million tons), because the aim of planting fuelwood forests is to supply firewood. Most of fuelwood forests are wildwoods or natural secondary forests with convenient conditions for collection and transportation.

Forest felling residues

The residues from forest felling and tending are restricted in several aspects. The major forest resource in China is wildwood, accounting for 68.94% of the forestland and 87.56% of the forest growing stock. Most of the residues from the existing wildwoods can hardly be utilized because of remote locations and inconvenient transportation. Besides, the wildwood felling has been strictly limited by the government since the Natural Forest Protection Project was implemented in 1998.

Forests in other regions are mostly plantations and easy for utilization with better transportation. According to the National Forestry Resource Inventory (2005), the actual annual average consumption of timbers in China is 365 million m^3 (329 million tons in weight). Estimated with 40% of felling residues, there are nearly 131 million tons of felling residues. Among these residues, those in natural forest areas and remote regions are hard to be collected, and those in plantation areas and regions with convenient transportation are collected for comprehensive utilization and forest product processing, leaving small branches and leaves. Therefore, the available biomass energy only accounts for 20%, about 26 million tons in weight.

Timber processing residues

The total amount of these residues is about 29 million tons, most of which are used in fiberboard producing and paper making, and only little can be used for fuel.

Shrubs

Shrubs, as the important forest resources, are mostly growing in those regions above the forest distribution line and with unfavorable natural conditions and vulnerable ecosystem, for example the desert regions in West China and parts of Tibet Plateau. Shrubs in these areas, playing a role of protecting major ecosystems, are difficult to use due to the strict limitation in utilization and bad transportation. The time of stumping and rejuvenation for different species is 1-4 years and with the average time of 2.5 years, it is estimated that 42 million tons of biomass per year could be obtained, 60% of which (nearly 25 million tons) are available for biomass energy resources except for knitting and paper making.

Other forest resources

Available biomass from pruning of economic forests, bamboo forests shrubs under forests, woods for city greening and planting hedge are estimated at 100 million tons. However, only 15% of them can be collected due to dispersed location, large volume, expensive cost for transportation and low utilization efficiency.
In total, the annual available woody biomass resources are about 161 million tons, amounting to 92 million tce (see Table 4 and Figure 3)

Resources	Amount (million tons)	Available amount (million tons)	Tce (million tons)
Fuelwood forest	66.00	66.00	37.71
Felling remainders	131.00	26.00	14.86
Processing remainders	29.00	29.00	16.57
Shrub stumping	42.00	25.00	14.29
others	100.00	15.00	8.57
In total	368.00	161.00	92.00

Table 4: Biomass resources available from forestry in China

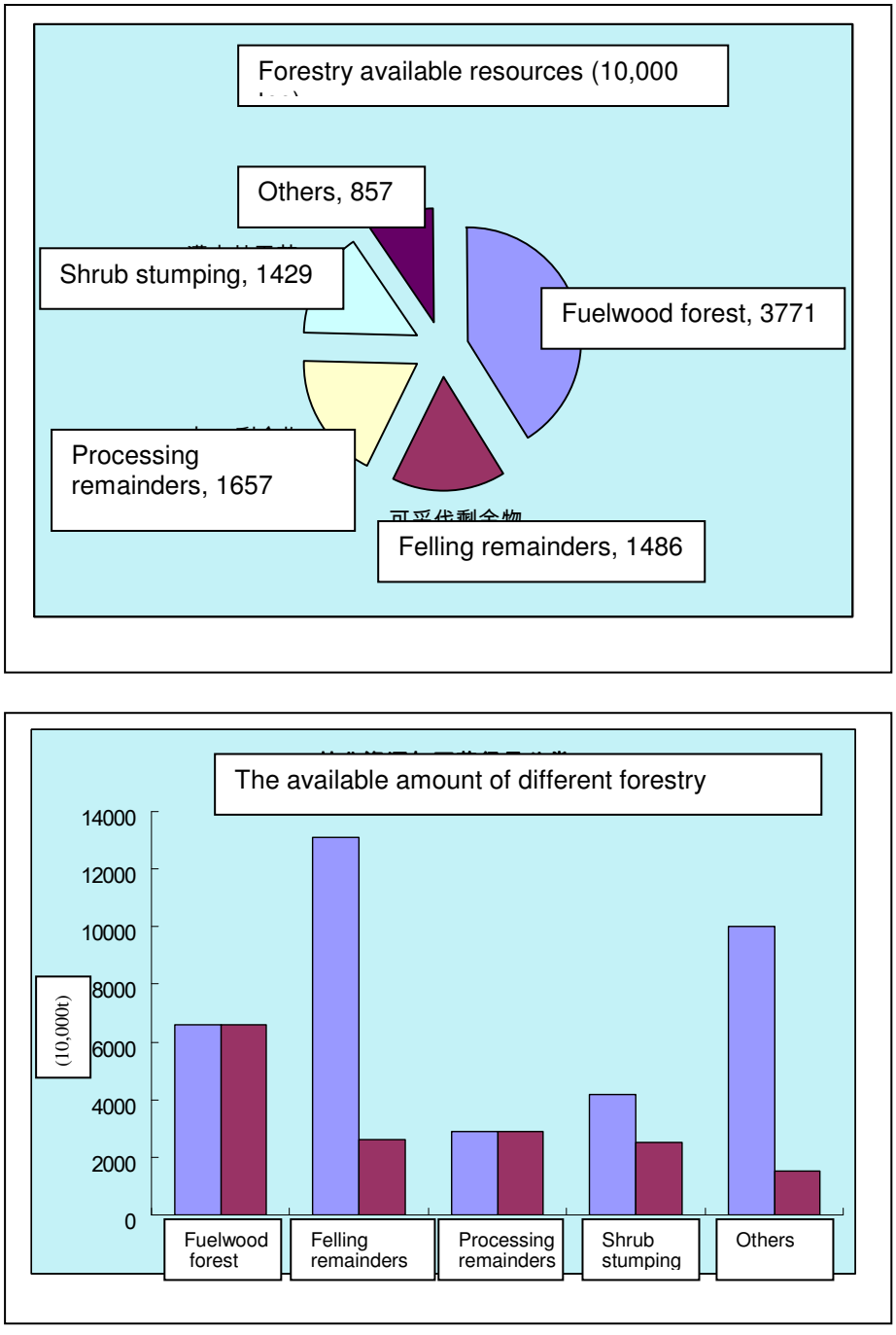

Figure 3: Biomass resources available from forestry in China

b Oil biomass energy resources

Seeds and fruits of woody oil plants are used without any restrictions. It is estimated that the major oil plant fruit output in China is 2.245 million tons, while the processing use is only 0.547 million tons. The output of oil plants can be greatly increased via intensive operation in the future, and part of the oil plants suitable for biodiesel can be changed into oil energy forests.

3. Residues of livestock

3.1 Output

According to the amount of livestock, species, weight and excrement, the total amount of livestock residue can be estimated.

The animal husbandry has smoothly developed during the 10th Five-Year Plan, and the amount of pigs, broilers, layers, cows and beef cattles has respectively reached 759.12 million, 5985.05 million, 2378.51 million, 3.51 million and 52.65 million.

From these data, the total livestock residues of China in 2005, 2.942 billion tons can be calculated out (see Table 5 and Figure 4).

Table 5: Total livestock residues of China in 2005

	species	Livestock on hand	Coefficient for excrement (kg/d)		Total amount of residues (billion tons)	
		(million)	Excrement (kg)	Urine (kg)	Total amount of excrement	Solid amount
The whole nation	Live pigs	523.5224	2	3.3	1.013	0.382
	Livestock	6110.0067	0.12	0	0.268	0.268
	Dairy cows	12.6658	20	10	0.139	0.092
	Beef cattles	133.999	20	10	1.467	0.978
	Sheep	382.8001	0.4	0	0.056	0.056
Total					2.942	1.776

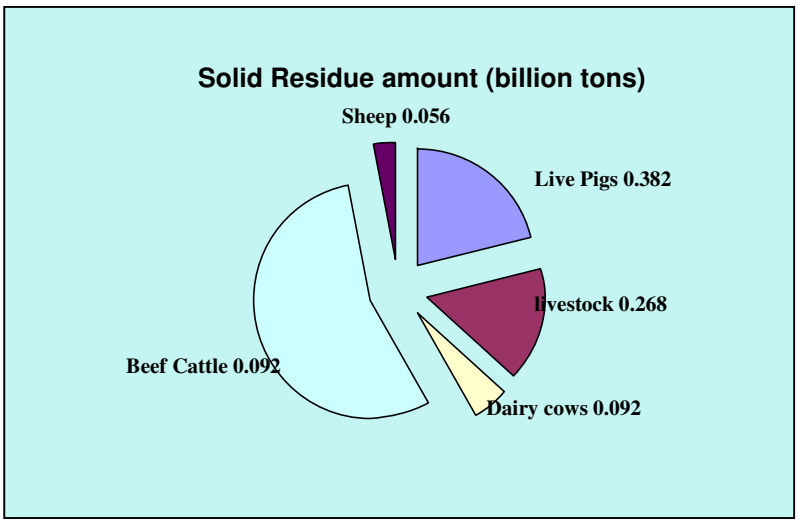

Figure 4: Total livestock residues of China in 2005

In China animal husbandry can be divided into two forms practiced by rural household and large-scale breeding. At present, the total amount of separate breeders with live pigs is 90 million households, that of dairy cows and beef cattles is 15.7 million households, that of broilers and layers is 85 million households and that of sheep is 26 million households in China. Taking into account the influence on the methanogenesis process from livestock residues by factors of multiple culturing, climate and social economy, about 148 million rural households are suited for developing rural household biogas.

The large-scale breeding farms of pigs, cattles and chicken are 3.91 million, of which the large-scale breeding districts of various livestock reached 40 thousand or more. The number of is 570 million, and the quantity of animal residues is 1.12 billion tons. Large or middle farms (with more than 3 thousand pigs) are 119.52 thousand, with a total breeding number of 75.28 million pigs and 142 million tons of animal residues.

3.2 Distribution

According to the development status of the animal husbandry in China, the animal residue resources are mainly distributed in Sichuan, Henan, Shandong, and Hebei. Sichuan is the largest production region with 450 million tons in weight, which can produce 27 billion m^3 of methane. The residues in Henan can produce 20 billion m^3. Animal residues in Shandong, Hebei, Guangdong, Guangxi, Hunan, Hubei, and Yunnan can produce 10 billion m^3.

3.3 Utilization status

Presently, most animal residues in China are directly discharged into the environment, except a few is used as fertilizer and for generating biogas. This direct discharge can not only pollute the surface water, groundwater and the atmosphere, but also severely threaten health of rural residents due to the pathogens in those residues. Such pollution caused by animal breeding has become the major source of rural pollutions in China, equalling to the total amount of industrial pollution.

In some regions, the animal residual pollution has already become more significant than environmental influences by domestic, agricultural, township enterprises and catering business and one of the major causes of polluting water source, rivers and lakes.

A. Breeding in rural households

The government has invested 3.4 billion RMB to the biogas construction and benefited 3.74 million households during the 10th Five-Year Plan. Until the end of 2005, 18.07 million rural households in China started to use the biogas digesters with an output of 7 billion m^3 biogas, equalling 5 million tce or 15.4 million tons of coal. 3556 biogas projects have been constructed in the whole country, producing 230 million m^3 of biogas per year, able to substitute 0.17 million tce.

B. Large-scale breeding

Large-middle scale biogas projects in operation are 3764 till the end of 2005 and the total capacity of biogas digesters is 1.7241 million m^3, disposing 123 million tons of waste, producing 341 million m^3 of biogas for 1.38 million households and 40 million kWh of electricity. 3556 projects of them are disposing agricultural waste, and the total capacity of them is 1 million m^3, treating 87.10 tons of waste and producing 230 million m^3 of biogas for nearly 1.32 million households.

3.4 Available amount as energy resources

Livestock residues are mainly utilized in two ways of fertilizer and energy of biogas via anaerobic fermentation. Considering biogas residues and fluid produced from methanogenesis process can be used as fertilizer, all the collected livestock residues are available forenergy utilization.

A. Rural biogas for households

There are 90 million households breeding pigs, 15.7 million breeding dairy cows and beef cattle, 85 million broilers and 26 million sheep. Besides, more than 300 million tons of crop straws are available for utilization. Thus, biogas resources are suitable for about 146 million households. Taking into account urbanization and change of animal husbandry, biogas resources will be suitable for 120 million households in China till 2020. According to the requirements for rural development, about 84 million households need rural biogas. China has already constructed rural biogas for 18.07 million households by the end of 2005, only accounting for 11.6% of the total suitable households.

B. Biogas projects in breeding farms

With consideration of the amount, species, weight and excrement of livestock, their residue resource can be estimated. There are 3.36 million large-scale breeding farms of pigs, cattle and chicken in 2005, with 582.5 billion pigs and 1.12 billion tons of livestock residues, producing 67.2 billion m^3 of biogas. Among these farms, there are 10532 large-middle scale farms (with more than 3000 pigs), breeding 85.1 billion pigs producing 135 million tons of residues and 8.1 billion m^3 of biogas.

China has already constructed 3746 large-scale biogas projects at breeding farms till the end of 2005, only accounting for 0.11% of the total amount of breeding farms. Among these projects, 700 are large-middle scale, only accounting for 6.6% of the total amount of large-middle scale breeding farms.

In addition, with the increasing breeding cost, management skills and requirement of exporting agricultural products, the household breeding method in China will be gradually substituted by large-scale breeding. With the improvment of food structure and living quality for Chinese residents, the consumption of grain has smoothly declined, while the consumption of livestock products has continuously increased, showing a sustainable development of animal husbandry. Meanwhile, the demand for building large-scale breeding farm biogas projects will be further enlarged with the increase of environment awareness and the strengthening of treating environment by the government.

4. Municipal domestic waste

4.1 Waste production

The production of domestic waste is influenced by the scale, energy supply, per capita income, climate, and living habits of cities. In the recent two decades, China has been experiencing rapid economic development, urbanization and increase of the population in cities. By the end of 1998, China has already built up 668 cities among which there are 4 municipalities directly under the central government, 15 vice-province cities, 202 prefecture level cities, 447 county level cities, 13 super large cities with more than 2 million population, 24 very big cities with 1-2 million of population, 48 big cities with population of 0.5-1 million, 205 middle scale cities with population of 0.2-0.5 million and 378 cities with population of less than 0.2 million. The amount of waste dumped was 109.82 million tons in 1997 and 113.02 tons in 1998.

According to the actual situation in China, the annual average production by urban residents is 200-220 kg per capita. The population of cities and towns reached 562.12 million till the end of 2005, and the annual average domestic waste should be 112.42-123.67 million tons. Nowadays, as many rural people have migrated to cities for working and living, domestic waste should account for more than 150 million tons.

4.2 The waste disposal situation

At present, the ratio of harmless treatment is still small and the harmless treatment amount in the whole country was only 81.078 million tons in 2005, accounting for nearly 54% of the production. The major disposal ways are sanitary landfill, compost and combustion for power generation. Table 6 shows the disposal method of combustion for power generation, most perfectly meeting the requirement of “minimization,harmlessness,reuse” by the SEPA. This method is only implemented in 66 factories, disposing only 32.2 thousand tons per day of 12.7% of the harmless treatment and 5% of the waste production. Besides nearly 25% of wastes are disposed by simple landfill and 25% of wastes are discharged without any treatment.

Disposal ways	Treatment units	Capacity (tons per day)	Treating capacity (million tons per year)
Harmless treatment	479	25.7054	8107.8
Sanitary landfill	365	21.2627	6924.4
Compost	46	1.1767	345.4
Incineration	66	3.2210	780.4
Simple disposal		11.9634	4397.4

Table 6: The amount of harmless waste treatment in 2005

4.3 The potential of energy utilization

Domestic wastes contain large quantities of organic components, making them valuable as energy resource. The heat value of domestic wastes in China is about 900-1500 kcal/kg, which is determined by various factors, among which the first one is the living quality of residents. Table 7 shows the different components and heat values varied with locations in the same city.

	Component of domestic waste (dry base %)										Heat value of wet base(kj/kg)	
	Metal	Glass	Plastic	Paper	Fabric	Vert	Kitchen wastes	Ash	Tile	Moisture content	High level	Low level
Common residence	1.96	12.8	14.6	15.1	2.86	11.2	32.6	1.92	6.74	53.9	3869	2036
High-grade residence	8.75	18.4	15.6	35.1	4.16	1.48	16.3	□	0.22	33.2	7100	5682
College districts	7.18	25.2	12.7	17.6	4.64	13.6	11.7	10.7	0.79	36.2	4934	3462
Business districts	6.69	11.5	18.5	38.5	6.24	12.5	2.65	□	0.31	346	8136	6598
Large hotels	4.79	25.1	18.2	44.4	2.43	0.20	4.68	□	0.30	10.3	10337	9120
Hospitals	1.25	26.1	14.1	38.9	3.55	1.04	13.3	1.71	□	39.4	5436	3923
Parks	6.56	9.52	12.4	12.2	1.63	14.8	5.52	22.6	12.8	26.0	5996	4698

Table 7: Different components and heat values in the different districts of the same city

Data from table 7 suggests that the heat value in high-grade residence is twice as much as in common residence, and the differences of paper and water content are most evident. Paper wastes in high-grade residence areas, where people live with better economic conditions are far more than those in the common uptown where residents are poorer.

The energy composition can heavily influence the heat value of waste. Besides, the management system of dumping and treating wastes as well as annual precipitation are also factors determining the heat value of wastes. According to the investigation of ten cities including Beijing, Shanghai, Tianjin, Guangzhou, Shenzhen, Dalian, Shenyang, Ma'anshan, Hangzhou and Anshan, the average heat value is 5100 kJ/kg (1220 kcal/kg).

City	Heat value (kJ/kg)	Density (kg/m^3)	Water content (%)
Beijing	6413	220	58.81
Tianjin	6413	330	60.02
Shanghai	4389	290	58.85
Shenyang	5080	450	63.89
Dalian	6420	323	70.5
Hangzhou	6029	430	57.28
Shenzhen	4605		55
Guangzhou	4418	250	50.12
Ma'anshan	2836	370	49.1
Anshan	4400	400	44

Table 7: Heat values, densities and water content in each cities

The above investigated cities are all large or middle scale developed cities, these data of investigation are higher than the average level of the whole country. Taking 90% of the average value of these ten cities as the mean value for the whole country (i.e. 4590 kJ/kg (1100 kcal/kg)), the annual waste production in China is 150 million tons equalling to 23.57 million tce.

5 Industrial organic wastewater

Agricultural byproducts and food processing such as grains, food, refined sugar, paper making, brewing and starch producing can produce large quantities of organic waste and waste water. The utilization methods of industrial wastes are composting, incineration and anaerobic fermentation. The major treatment of wastewater is anaerobic fermentation for generating biogas. It is estimated (Liuying, 2005) that organic wastes from production and processing of agricultural products in China can generate 50 billion m^3 of biogas equalling 35 million tce of energy. With the rapid urbanization and increasing living quality of residents, domestic waste resources are expected to increase rapidly.

5.1 Production

According to the data of relevant industries surveyed by the Ministry of Agriculture, the wastewater production from alcohol making, sugar refining, brewing, paper making and production of yellow wine, liquor, starch, monosodium glutamate and beverage were 846 million tons. The wastewater from other major sectors like pharmacy, butchers, vegetable oil, sauce, food industry, canning industry, petroleum chemical industry, caoutchoouc and furfural reaches 1.674 billion tons. The wastewater production from major industries is 28.5 billion tons referring to the data from National Statistics Bureau (see Table 8 and Figure 5).

Sectors	**Wastewater from industry** (million tons)	**COD** (tons)	**Percentage of COD□%□**
Food processing industry	867.64	636574.60	0.07
Food industry	320.77	186393.20	0.06
Beverage industry	358.87	244643.90	0.07
Leather, fur, plume production	118.74	66622.60	0.06
Timber processing and industry of bamboo and rattan products	40.47	19594.50	0.05
Paper making and industry of paper products	3193.03	1639084.10	0.05
Pharmacy	366.91	192608	0.05
Municipal wastewater	23254.22	7829006	0.03
Total	28520.65	10814526.90	

Table 8: Wastewater production by sectors

Data in Table 8 include municipal wastewater which is the major source of wastewater. The total wastewater should be only 5.27 billion tons by subtracting the municipal wastewater.

Among these sectors, most wastewater comes from paper making processes. Wastewater from beverage and food processing industry contains most organic compounds.

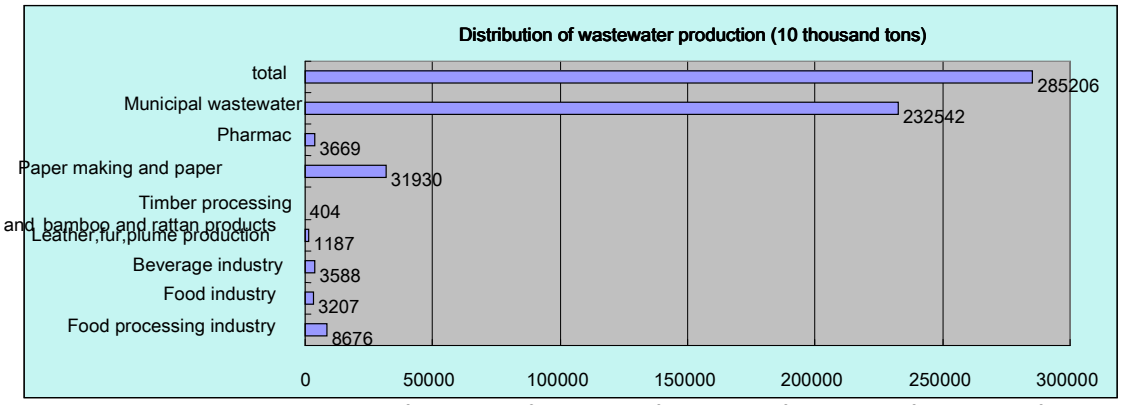

Figure 5: Wastewater production by sectors

6 Energy crops

6.1 Types of energy crops

Energy crop can be divided into three major types: fuelwood forests for firewood, oil plants and plants containing starch or sugar.

Fuelwood forests

Fuelwood forests are mainly fast-growing species with high heat values. In China, the suitable species are

(1) Eucalypt, cassia siamea, birch and sawtooth oak etc. in high mountainous regions of Sichuan and Yunnan provinces.

(2) Quercus acutissima, Quercus Variabilis, alder, Coriaria Sinica and acacia in mountainous regions of Sichuan and Shaanxi provinces.

(3) Sawtooth oak, eucalypt, Acacia mearnsii, Zenia insignis and Schima superba etc. in low mountainous regions of South and Central Yunnan.

(4) Sawtooth oak, Pinus massoniana, Platycarya Strobilacea, acacia, Lespedeza, Choerospondias axillaris etc. in low mountainous and hilly regions of Northwest Zhejiang, South Anhui provinces, Northeast Jiangxi province.

(5) Acacia dealbata, Castanopsis Luminifera, Pinus massoniana, eucalypt, Zenia insignis, and Schima superba etc. in mountainous regions of South Jiangxi

province, Southwest Hubei province, Southeast Guizhou province, Central and Norther Guangzhou and Guangxi provinces.

Oil plants

In China, there are 1554 oil plants species belonging to 151 families and 697 taxonomies, 154 of which are species with more than 40% oil content in seeds. There are 30 categories of arbors and shrubs with wide distribution, better adaptability, capability of supplying biomass fuel oil for scale biomass fuel material bases, for instance, the woody species of Pistacia chinensis (Anacardiaceae), Sorbifolia Bunge (Sapindaceae), Euphorbia lathyris (Euphorbiaceae), jatropha curcas, Swida wilsoniana (Cornaceae) and herbaceous plants of cole, palm, soya, peanuts, sunflower and castor-oil plants etc.

Starch and sugar plants

These plants can be use as feedstock for fuel ethanol. Major species are tapioca, sweet potato and Canna edulis Ker, and Tapioca, mainly used as food, fodder and material of brewing concentrated in Sichuan, Shandong, Henan and Anhui provinces. Species with rich sugar are sorgo, sugarcane and sugar beet. With better adaptability to climate change, capacity of drying-resistance and innutrition-resistance, easy planting methods and favorable heredity and aberrance, sorgo is popular in the whole world and its planting experience is popularized in a lot regions.

6.2 Study status on energy crops

With few systematic research projects, the study on energy plants has been slowly developing in China. Work focusing on selecting and cultivating fuelwood forests has been completed in the past few years, while series of researches on cultivating rural oil plants just started in recent years, focussing on surveying, introducing, selecting and cultivating energy plant resources.

Relatively systematic researches on cultivation and selection of jatropha curcas have been achieved by Yunnan Normal University, Sichuan University, Sichuan Forestry Academy, Nanjing University, Jiangsu Forestry Technology Popularize Station and Beijing Forestry University. Researches on resource survey, selection and cultivation of advanced species of Pistacia chinensis was just completed by China Forestry Academy. Hunan Forestry Academy induced energy plant of Euphorbia tirucalli and its utilization technologies, get involved in researches on local cultivation technology, breeding as well as cold tolerance gene introducing technology.

6.3 Development potential of energy crops

The area of woody oil forests in China is more than 8 million hectares, with more than 2 million tons of fruit and seed yields of major species annually. 6 types including Jatropha curcas, Pistacia chinensis, Sorbifolia Bunge, Betula Luminifera, Tung-oil tree and Chinese tallow have already been developed with relatively mature technologies and taken as the cultivation species for biodiesel feedstock. The above oil plant species with better

adaptability are growing in temperate zones, tropic zones and semi-tropical zones, which makes them suitable for afforestation on waste mountains and lands.

Besides the above traditional fuelwood forests, 1000 species of energy shrubs are growing in North China where planting area is enlarged by over 600,000 ha. per year in recent years. It is estimated that 100 million tons of the energy materials per year from these shrubs can be collected.

It is the large quantities of afforestation projects in the future that contributes to the potential of the development and utilization of woody energy plants. According to the National Energy Forest Construction Plan constituted by the State Forestry Administration, more than 10 million mou of demonstration energy forests will be built up during the period of 11th Five-Year Plan.

By 2020, the area of energy forests will reach 200 million mou or more, providing more than 6 million tons of biodiesel for meeting the fuel requirement of power plants with more than 11 million kW of installed capacity. During the period of 11th Five-Year Plan, the State Forestry Administration will focus on developing 6 million mou of jatropha curcas in Yunnan, Sichuan, Guizhou and Chongqing provinces, 3.75 million mou of Pistacia chinensis in Hebei, Shaanxi, Anhui and Henan provinces, 0.75 million mou of Betula Luminifera, in Hunan, Hubei and Jiangxi provinces, 2 million mou of Sorbifolia Bunge in Neimenggu, Liaoning and Xinjiang provinces, and 10 million mou of energy shrubs like Salix psammophila, eabuckthorn, Amorpha Fruticosa, Robinia Pseudoacacia, Chinese tamarisk and Quercus in North Shaanxi, East China, Central China and collective forest areas in South China.

7. Total available biomass resources

It can be concluded from the above analysis in each Chapter that with a total amount of 191 million tce., China is abundant in biomass resources (see Table 9 and Figure 6).

Resource types	Available amount(million tons)	Standard amount(million tons tce.)
Crop straws	497.66	213.28
Livestock residues	1776.00	761.14
Forestry wastes	161.00	92.00
Oil crops	2.25	0.80
Organic wastes	28520.65	814.88
Domestic wastes	150.00	23.57
Total		1905.68

Table 9: Available biomass resources in China

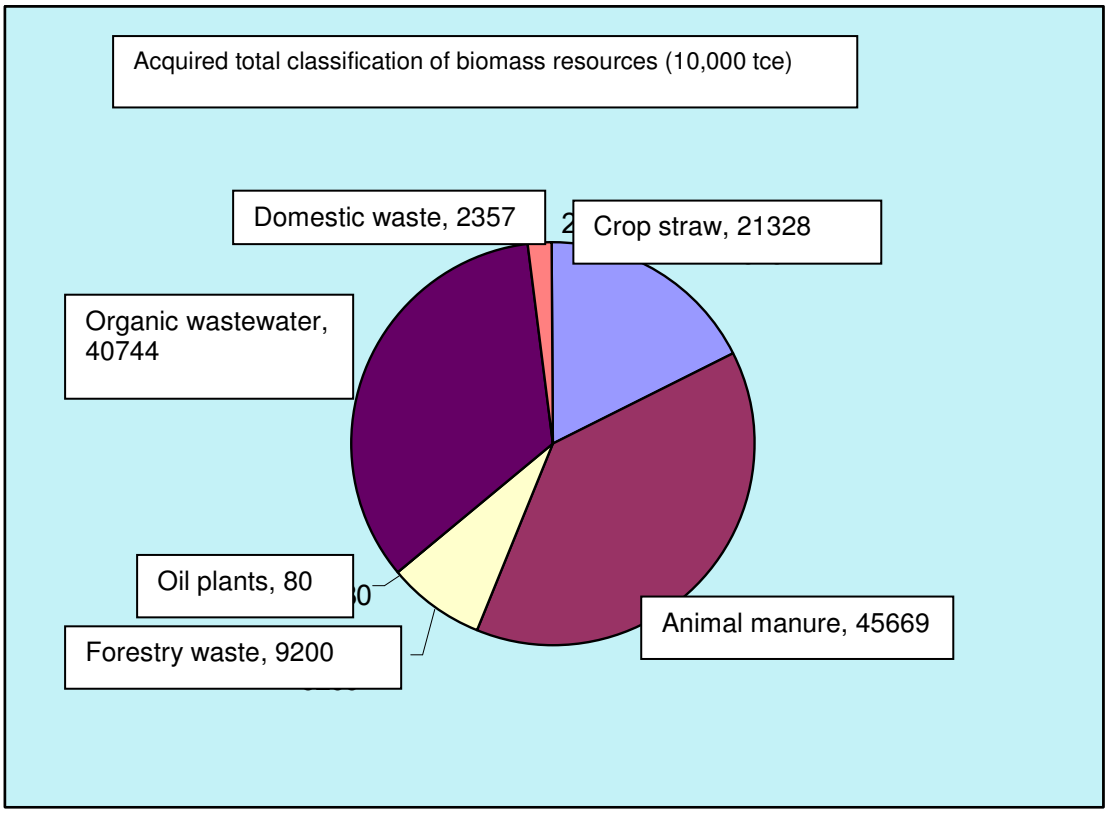

Figure 6: Available biomass resources in China

COMPETE Project Coordination
WP7 Coordination - Dissemination

WIP Renewable Energies
Sylvensteinstr. 2
81369 Munich
Germany
Contact: **Dr. Rainer Janssen**
Dominik Rutz
Phone: +49 89 720 12743
Fax: +49 89 720 12791
E-mail: rainer.janssen@wip-munich.de
dominik.rutz@wip-munich.de
Web: www.wip-munich.de

WP1 Coordination – Current Land Use

University of KwaZulu-Natal
School of Environmental Sciences
South Africa
Contact: **Dr. Helen Watson**
E-mail: watsonh@ukzn.ac.za
Web: www.ukzn.ac.za

WP2 Coordination – Improved Land Use

Utrecht University
Dept. Science, Technology and Society
The Netherlands
Contact: **Dr. Andre Faaij**
Dr. Edward Smeets
E-mail: A.P.C.Faaij@uu.nl
E.M.W.Smeets@uu.nl
Web: www.chem.uu.nl/nws

WP5 Coordination – Financing

Energy for Sustainable Development
United Kingdom
Contact: **Michael Hofmann**
Stephen Mutimba
E-mail: michael.hofmann@esd.co.uk
smutimba@esda.co.ke
Web: www.esd.co.uk

COMPETE Project Coordination
WP3 Coordination - Sustainability

Imperial College London
Centre for Energy Policy and Technology
South Kensington Campus, London, SW7 2AZ
United Kingdom
Contact: **Dr. Jeremy Woods**
Dr. Rocio Diaz-Chavez
Phone: +44 20 7594 7315
Fax: +44 20 7594 9334
E-mail: jeremy.woods@imperial.ac.uk
r.diaz-chavez@imperial.ac.uk
Web: www.imperial.ac.uk

WP4 Coordination – International Cooperation

Winrock International India
Contact: **Sobhanbabu Patragadda**
E-mail: sobhan@winrockindia.org
Web: www.winrockindia.org

Stockholm Environment Institute
Contact: **Francis Johnson**
E-mail: francis.johnson@sei.se
Web: www.sei.se

European Biomass Industry Association
Contact: **Stephane Senechal**
E-mail: eubia@eubia.org
Web: www.eubia.org

WP6 Coordination – Policies

Food, Agriculture and Natural Resources Policy
Analysis Network of Southern Africa
South Africa
Contact: **Khamarunga Banda**
Dr. Charles Jumbe
E-mail: khamarunga@hotmail.com
charlesjumbe@bunda.unima.mw
Web: www.fanrpan.org

COMPETE is co-funded by the European Commission in the 6th Framework Programme – Specific Measures in Support of International Cooperation (INCO-CT-2006-032448).