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Biomass Support for the China Renewable Energy Law

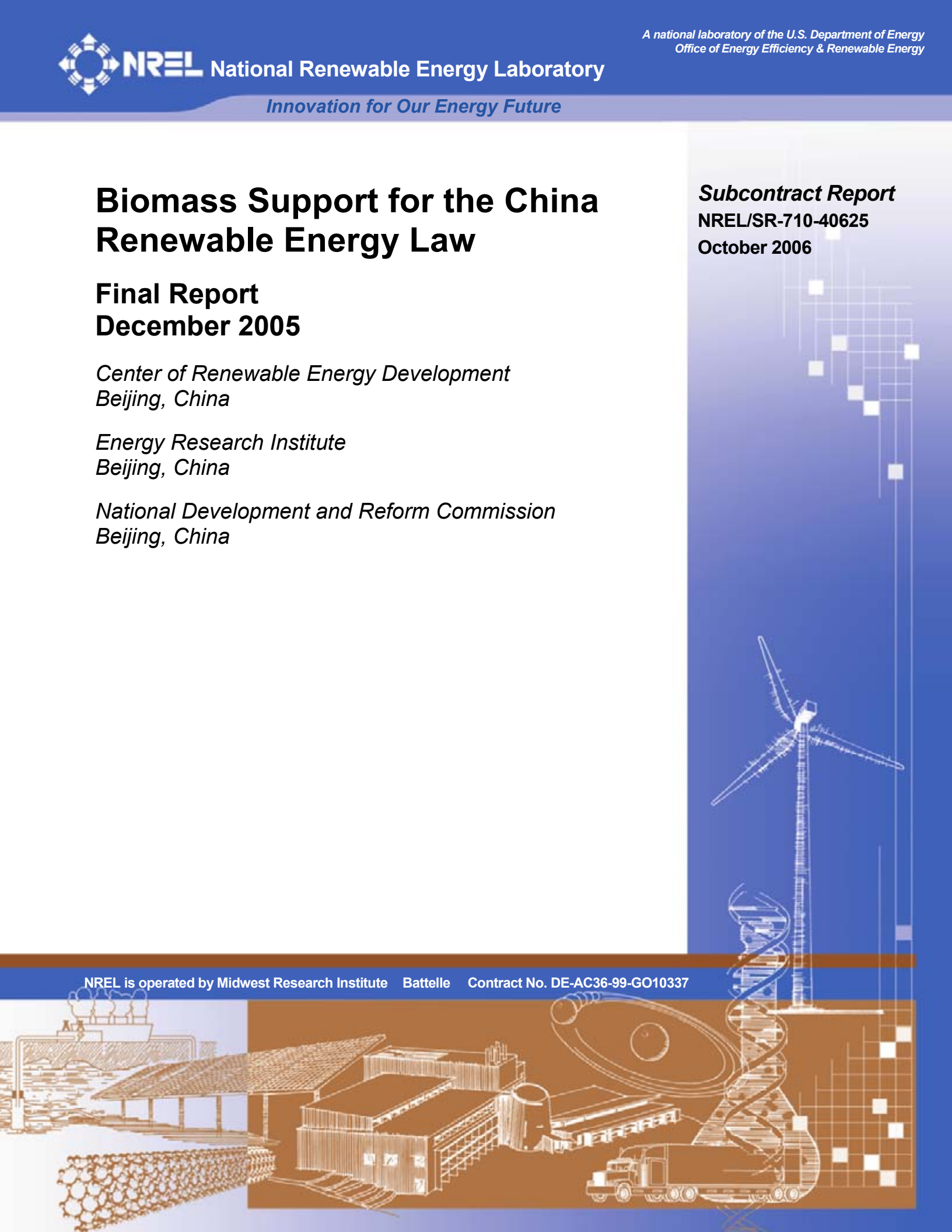
Final Report
December 2005

Center of Renewable Energy Development
Beijing, China

Energy Research Institute
Beijing, China

National Development and Reform Commission
Beijing, China

Subcontract Report
NREL/SR-710-40625
October 2006



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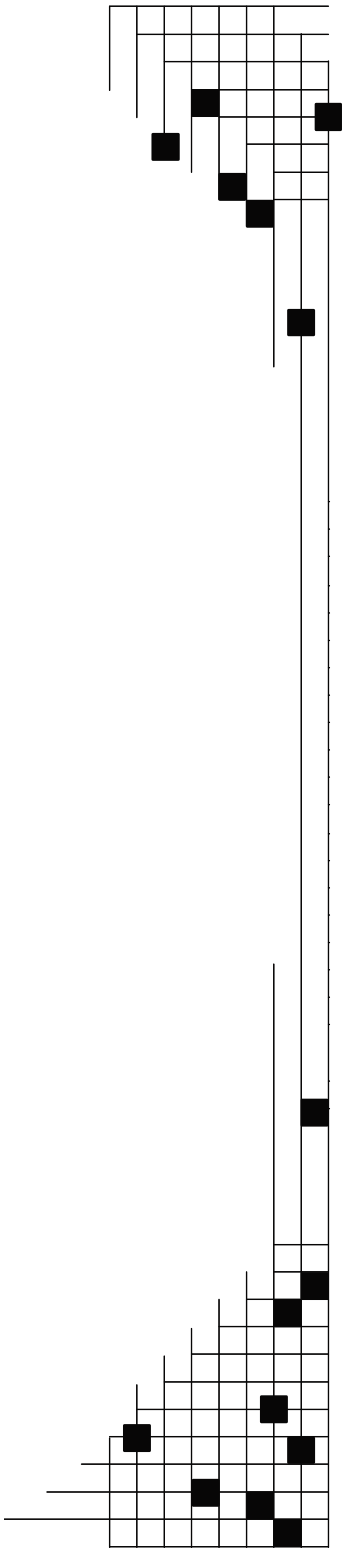

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CONTENTS

Final Report

1 Domestic biomass energy technology development and application

1.1 Biomass energy resource status

1.1.1 Crop straw resource

Based on *Assessment Report of Biomass Resource in China* in this project, the availability of straw resource should be considered because the straw output in theory is less meaning for the biomass utilization. The availabilities of straw resource in each province in 2002 are shown in Table 1-1-1. In this table, the total amount of straw as energy is about 250 million tons.

Table 1-1-1 Straw resource availabilities in each province in 2002(10000 tons)

Province	Total straw output	Paper raw material	Forage	Fertilizer	Energy and abandon
Beijing	99.8	0.3	4.4	15.0	80.1
Tianjin	167.3	6.7	15.6	25.1	119.9
Hebei	2746.4	102.9	536.6	412.0	1695.0
Shanxi	990.4	70.7	269.6	148.5	501.5
Inner Mongolia	1771.4	21.8	0.0	265.7	1484.0
Liaoning	1700.3	71.7	370.5	255.1	1003.0
Jilin	2703.9	68.3	456.9	405.6	1773.1
Heilongjiang	3166.5	53.9	629.0	475.0	2008.6
Shanghai	99.0	1.1	4.4	14.9	78.7
Jiangsu	2516.0	38.6	104.2	377.4	1995.9
Zhejiang	706.6	29.8	47.7	106.0	523.1
Anhui	2747.9	38.6	953.0	412.2	1344.0
Fujian	575.1	81.6	153.6	86.3	253.7
Jiangxi	1150.3	41.8	490.3	172.6	445.7
Shandong	4044.1	57.1	1055.6	606.6	2324.8
Henna	4674.4	288.7	1547.6	701.2	2136.9
Hubei	2028.8	49.6	471.1	304.3	1203.8
Hunan	1955.7	97.5	595.8	293.4	969.0
Guangdong	1143.1	86.4	556.3	171.5	329.0
Guangxi	1174.7	25.0	892.5	176.2	80.9
Hainan	149.2	1.0	120.4	22.4	5.4
Chongqin	948.2	31.6	351.9	142.2	422.5

Sichuan	2808.2	93.6	1042.2	421.2	1251.1
Guizhou	1098.2	6.5	911.6	164.8	15.3
Yunnan	1270.0	20.5	976.1	190.5	83.0
Tibet	29.3	0.0	0.0	4.4	24.9
Shaanxi	1021.3	89.0	308.0	153.2	471.0
Gansu	747.5	8.9	0.0	112.1	626.5
Qinghai	97.6	0.3	0.0	14.6	82.7
Ningxia	285.6	11.3	0.0	42.9	231.5
Xinjiang	1301.3	16.0	0.0	195.2	1090.1
Total	**45917.9**	**1510.7**	**12864.9**	**6887.9**	**24654.4**
Share	**100.00**	**3.29**	**28.02**	**15.00**	**53.69**

1.1.2 Forest residue resource

The forest residue is a high quality feedstock for the biomass generation electricity. But it is impossible and unpractical to utilize forest radiuses in the large sized power plants at the current situation in China. For water and soil conservation, the country has paid attention to the afforestation and the protection of forest, and strictly controlled the forest felling. Therefore, the forest residues are utilized to generate electricity in large-scale cannot realize during long times. The feedstock of forest residue will mainly come from felling areas and residue from processing factories.

In Table 1-1-2, the availability of forest residue for large power plant is about 24.77 million m^3.

Table 1-1-2 Forest processing residues availability in each province（10000 m3）

Province	Log	Wood residues	Sawn timber	Sawn timber residues	Total
Beijing	7.2	1.3	0.0	0.0	1.3
Tianjin	0.0	0.0	0.0	0.0	0.0
Hebei	40.9	7.4	41.2	16.5	23.9
Shanxi	4.2	0.8	0.5	0.2	0.9
Inner Mongolia	304.3	54.8	4.5	1.8	56.6
Liaoning	116.6	21.0	31.4	12.6	33.6
Jilin	389.1	70.0	24.2	9.7	79.7
Heilongjiang	512.0	92.2	10.4	4.1	96.3
Shanghai	0.0	0.0	0.0	0.0	0.0
Jiangsu	32.0	5.8	25.5	10.2	16.0
Zhejiang	218.7	39.4	158.1	63.2	102.6
Anhui	246.1	44.3	30.4	12.2	56.5
Fujian	459.1	82.6	61.0	24.4	107.0
Jiangxi	279.9	50.4	31.7	12.7	63.1
Shandong	45.0	8.1	83.0	33.2	41.3
Henna	180.7	32.5	3379.0	1351.6	1384.1

Hubei	77.0	13.9	5.4	2.2	16.0
Hunan	427.8	77.0	106.3	42.5	119.5
Guangdong	253.9	45.7	65.3	26.1	71.8
Guangxi	376.8	67.8	56.7	22.7	90.5
Hainan	22.4	4.0	7.3	2.9	7.0
Chongqin	9.9	1.8	21.7	8.7	10.4
Sichuan	3.2	0.6	0.0	0.0	0.6
Guizhou	17.5	3.1	2.4	1.0	4.1
Yunnan	161.2	29.0	35.1	14.1	43.1
Tibet	17.0	3.1	5.0	2.0	5.1
Shaanxi	6.4	1.2	0.3	0.1	1.3
Gansu	0.0	0.0	0.0	0.0	0.0
Qinghai	2.3	0.4	0.0	0.0	0.4
Ningxia	0.2	0.0	0.0	0.0	0.0
Xinjiang	8.7	1.6	0.0	0.0	1.6
Daxinanling	216.1	38.9	10.4	4.2	43.1
Total	**4436.1**	**798.5**	**4196.8**	**1678.7**	**2477.2**

1.1.3 Animal excrement resource

The large-sized utilization of animal excrement is also based on the collection. Therefore, the resource amount excludes the scattered feeding. Because the excrement cannot difficultly collected, the resource amounts of horse, ass, mule and camel are deducted from livestock, at the same time, the resource amounts are deducted from the total amount in Inner Mongolia, Xinjiang, Tibet and Qinghai. The data come from *Basement Report of Biomass resource in China*.

Based on research result, the availability of animal excrement resource amounts to 112 million tons. Table 1-1-3 lists the availability of animal excrement of each type.

Table 1-1-3 Availability of animal excrement

Kinds	**Availability（10000 tons）**	**Standard coal （10000 tce）**
Cattle	4714.6	2220.6
Sheep	148.0	78.3
Pigs	3966.2	1701.5
Poultry	2392.9	1538.7
Total	**11221.8**	**5539.1**

1.1.4 Industry organic waste water

According to data from Ministry of Agriculture, production of wastewater is about 846 million tons in light industry (include alcohol, sugar, beer, yellow wine, distilled spirit, amylum, monosodium glutamate, beverage and paper), and 1.67 billion tons in other industries (such as medicine, meat, cooking oil, sauce, can, oil chemistry industry, nature rubber and pyromucic aldehyde etc.)

The production of industry wastewater is about 28.5 billion tons in major industries shown as Table 1-1-4.

Table 1-1-4 Production of industry wastewater

Industry	Production （10000 tons）	COD（ton）	Thickness of COD （%）
Food processing	86764	636574.6	0.07%
Food Manufacturing	32077	186393.2	0.06%
Beverage Manufacturing	35887	244643.9	0.07%
Leather, Furs, Down and Related Products	11874	66622.6	0.06%
Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products	4047	19594.5	0.05%
Papermaking and Paper Products	319303	1639084.1	0.05%
Medical and Pharmaceutical Products	36691	192608	0.05%
Residential wastewater	2325422	7829006	0.03%
Total	2852065	10814526.9	

1.1.5 Municipal solid waste

At present, there are 660 cities in China. The population exceeds 1 million persons in 34 cities. Table 2-1-5lists the outputs of MSW of each province.

The heating value of MSW is closely related to economic development and average income level in the city. At the same time, the utilization of MSW will be directly influenced by MSW classifying. In economic developed cities of China, such as Shanghai, Beijing, Guangzhou and so on, the heating value of MSW is about 1500kcal/kw. The heating value of MSW is below 1000 kcal/kw in the common cities.

Figure 1-1-5 Resource quantity of municipal solid waste (10000 tons)

Province	Residential waste disposal	Night soil disposal
Beijing	321.4	311.7
Tianjin	162.6	25.6
Hebei	681.7	147
Shanxi	871.9	196.2
Inner Mongolia	379.8	99.3
Liaoning	774.4	152.4
Jilin	619.8	143.9
Heilongjiang	1007.3	256.7
Shanghai	376.9	194.1
Jiangsu	723.2	400.1

Zhejiang	576	120.9
Anhui	357.9	43.1
Fujian	251	29.4
Jiangxi	205	24.6
Shandong	888.9	122.7
Henna	607.5	85.2
Hubei	760	119.6
Hunan	459.4	50.3
Guangdong	1315.5	356
Guangxi	195.5	19.3
Hainan	73.5	9.1
Chongqin	211.7	31.6
Sichuan	471.1	68.4
Guizhou	173.7	6.3
Yunnan	174.6	54.9
Tibet		0.8
Shaanxi	277.4	11
Gansu	232.5	23
Qinghai	79	43.6
Ningxia	99.4	8.4
Xinjiang	321.4	4.3
Total	**13650**	**3159.5**

1.2 Biomass energy technology utilization status

The biomass energy utilization is mainly in rural area except for industry waste and MSW, especially straw and animal excrement. Table 1-2-1 lists the energy consumption of rural energy in China in 2003. The consumption of straw and firewood accounts for 56.2% of total residential energy consumption, which is the most consumption type in rural residential energy in China.

Table 1-2-1 China rural energy consumptions in 2003

Type	Residential energy		Industry energy		Total	Share
Unit	（10000 tons）	（10000 tce）	（10000 tons）	（10000 tce）	（10000tce）	（%）
Total		46127.22		35037.63	81164.85	100.00
Straw	33296.07	14284.1			14284.1	30.97
Firewood	20375.6	11634.5	5534.63	3159.94	14794.44	25.22
Coal	21435.29	15304.75	26563.12	18966.13	34270.88	33.18
Electricity	7502956.9	3001.83	15127757.75	6051.05	9052.88	6.51
Oil	704.57	1007.55	3527.26	5044.04	6051.59	2.18
Biogas	460590.27	330.21			330.21	0.72
LPG	311.54	533.99			533.99	1.16

Nature gas	15315.38	20.33			20.33	0.04
Coal gas	17427.5	9.96			9.96	0.02
Coke			1926.31	1816.47	1816.47	
Solar energy	3861.46					

Notes： 1. Source: Rural Energy Statistic Yearbook

2. The unit of electricity is 10^4kwh in table.

3. The unit of biogas, nature gas and coal gas is 10 thousand m^3 in table.

4. The energy consumption of solar energy means the installed acreage of solar water heater. In table, the unit is 10 thousand m^2

1.2.1 Crop straw utilization

The agriculture and forest residue is mainly used as energy in direct-fired. Recently, through the support of government, the advance utilization of agriculture and forest residue has been developed. The main methods are straw gasification to supply gas for rural resident, char fuel, and solidified fuel. The status of residue advance utilization is shown in Table 1-2-2. The total output is about 1360 thousand tons.

Table 1-2-2 China rural straw advance utilization in 2003

Utilization method	Supply gas amount (household)	Number (site)	Supply output (10000 m^3, 10000 tons)	Straw consumption (tons)
Straw gasification to supply gas	106676	525	17500.37	100596
Char fuel		18	4366	12558
Solidified fuel		2	450	23175
Total				136329

Source: Rural Energy Statistic Yearbook

Furthermore, China government (mainly Agriculture Department) also supports to improve the efficiency of cooking stove for direct-fired straw. The heat efficiency of traditional cooking stove is only 5-8%, but the heat efficiency of alteration stove can reach 30% in test, and 18-22% in using, which can save a lot of biomass resource. Therefore, the government arranges many projects of alteration cooking stove in rural every year. Table 1-2-3 shows the status of alteration stove. In the end of 2003, the alteration stoves have added up to 47 million.

Table 1-2-3 Number of alteration stoves in rural unit: 10 thousand

Area	Number at the banging of year	Alteration number	Abandoned number	Total number in the end of year
Total	4706.43	211.67	207.94	4710.16
Beijing	4.48	0.79	1.46	3.81
Tianjin	0.85	0	0	0.85
Hebei	279.64	16.97	18.08	278.53
Shanxi	54.52	0.5	0	55.02

Inner Mongolia	7.07	0.37	0.09	7.35
Liaoning	90.27	0	0	90.27
Jilin	26.81	0.52	1.35	25.98
Heilongjiang	119.04	4.21	0.8	122.45
Shanghai	0	0	0	0
Jiangsu	54.05	5.56	2.66	56.95
Zhejiang	0	0	0	0
Anhui	75.1	0.13	0.35	74.88
Fujian	226.5	5.98	0.79	231.69
Jiangxi	104.75	7.97	7.85	104.87
Shandong	303.34	15.2	19.33	299.21
Henna	271.11	30.28	10.11	291.28
Hubei	124.24	16.64	12.15	128.73
Hunan	374.09	38.83	18.82	394.1
Guangdong	284.28	8.56	9.79	283.05
Guangxi	303.54	4.45	5.08	302.91
Hainan	26.5	1.2	0	27.7
Chongqin	53.85	4.4	0.38	57.87
Sichuan	1102.61	25.3	90.73	1037.18
Guizhou	148.84	9.77	2.39	156.22
Yunnan	292.65	4.9	3.01	294.54
Tibet	0	0	0	0
Shaanxi	107.33	4.24	1.31	110.26
Gansu	208.1	4.64	1.41	211.33
Qinghai	62.45	0	0	62.45
Ningxia	0	0	0	0
Xinjiang	0.42	0.26	0	0.68

Source: Rural Energy Statistic Yearbook

1.2.2 Animal excrement utilization

There is the most small biogas digester in China in the world. Based on statistic by Agriculture Department, there have been 2.1 million small biogas digesters building in 2003, and the reserved amount has reached 12.9 million, and the biogas output has been about 4580 million m^3 (shown as Table 1-2-4).

Table 1-2-4 Rural residential biogas digester numbers in 2003

Area	Number at the banging of year (10000)	Building number	Abandoned number	Total number in the end of year (10000)	**Gas output (10000 m^3)**
Total	11090.98	2114614	310712	1290.37	457965.16
Beijing	5.43	2133	3867	5.26	935.52
Tianjin	0.37	397	120	0.40	84.06
Hebei	29.45	104789	10288	38.90	11594.27
Shanxi	2.01	20000	0	4.01	1080
Inner Mongolia	0.29	4714	283	0.73	149.24
Liaoning	27.37	32268	4102	30.19	7567.15
Jilin	1.78	4595	1584	2.08	642.05
Heilongjiang	0.23	16705	0	1.90	511.84
Shanghai	0.58	0	3421	0.24	7.1
Jiangsu	40.72	17394	18455	40.61	7405.66
Zhejiang	9.65	15471	12349	9.96	1771.94
Anhui	14.82	69750	2989	21.50	6112.46
Fujian	20.76	24352	3474	22.85	9045.13
Jiangxi	81.99	107732	15152	91.25	30654.62
Shandong	43.03	32888	9427	45.38	11746.86
Henna	25.24	179143	3648	42.79	11138.07
Hubei	82.60	133862	21997	93.79	27128.04
Hunan	93.52	246022	33021	114.82	57566.37
Guangdong	27.58	23144	2010	29.69	12440.14
Guangxi	169.17	382460	48952	202.52	86695.71
Hainan	6.67	36221	238	10.27	7394.33
Chongqin	48.20	38223	1918	51.83	15013.36
Sichuan	238.95	213084	69720	253.29	72246.05
Guizhou	30.49	107366	26438	38.58	17215.12
Yunnan	80.42	253833	14272	104.38	51163.77
Tibet	0.00	0	0	0.00	0
Shaanxi	21.17	22188	2143	23.17	7281.93
Gansu	5.14	11684	824	6.23	1898.4
Qinghai	0.20	5271	0	0.73	164.81
Ningxia	1.79	7718	0	2.56	1187.62
Xinjiang	0.36	1207	20	0.48	123.54

Source: Rural Energy Statistic Yearbook

Except for residential biogas digester in rural, the large biogas project is also the main method of husbandry waste disposal and animal excrement utilization. In Table 1-2-4, the main large and medium biogas project are excrement disposal in husbandry, among which including crop-processing residue. In 2003, the amount of waste disposal is about 36.11 million tons, and the electricity output is about 4.68 million kWh, and producing 456 thousand tons fertilizer and 427 thousand tons feedstuff.

Table 1-2-4 Amount of large and medium biogas project in 2003

Index	Unit	Agriculture waste	Industry waste	Total
Operating number	（number）	2124	231	2355
Total capacity	（10000 m^3）	55.08	33.21	88.29
Disposal amount	（1000 tons）	3611	2187	5798
Gas output	（10000 m^3）	5801.65	12590.78	18392.43
Supply gas to resident	（10000 household）	5.75	7.34	13.09
Installed capacity	（kw）	3936	2760	6696
Electricity output	（10000 kwh）	165	468.06	633.06
Fertilizer	（10000 tons）	42.44	45.69	88.13
Feedstuff	（10000 tons）	3.05	42.74	45.79

Source: Rural Energy Statistic Yearbook

1.2.3 Industry waste disposal

The industry organic wastewater disposal is main industry waste disposal, which is mainly used producing biogas as fuel or generation power (shown as Table 2-2-4). Moreover, the bagasse from sugar refinery and rice husk from rice mill is also mainly disposed in industry waste, which is used generating power. About these two-industry wastes, the report will discuss in followed chapter.

1.2.4 Municipal solid waste and sewage disposal as energy

At present, the disposal of MSW is mainly landfill, except for combustion generation power in especial cities. The gas generation power system is less installed in landfill. So the standard of MSW as energy is very low.

The disposal of living sewage mainly adopts biogas technology. In 2003, there are 131.6 thousand biogas digesters for living sewage. The volume of digester is 5228.5 thousand m^3, which can dispose 46.3 thousand tons sewage. (In Table 1-2-6)

Table 1-2-6 Biogas digesters for disposing living sewage in 2003 in China

Item	Unit	Toilet	Hospital	Residential building	Other public	Total
Biogas digesters number	Number	8216	1658	113697	8007	131578
Total volume	10000 m^3	43.94	13.72	412.76	52.43	522.85
Disposal amount	10000 tons	2522.04	790.22	38636.73	4390.32	46339.31

1.3 Biomass generation power technology summary

1.3.1 Agriculture and forest residue generation power technology

1.3.1.1 Straw direct fired generation power technology

- **Technique introduction**

The stalk resources come from the local farmers or the feedstock trader. In sequence with the collection, package, and transportation through rivers or vehicles to the factory storage, there comes to the following steps:

1. Stalk transported from conveyor and shredder to the boiler
2. Steam that produced from stalk combustion propels the steam turbines and generates electricity. The un-combusted stalk will stay at the bottom of the boiler. Meanwhile the ash enters the smoke filer chamber and emit through the chimney.
3. The residues inside the boiler and the ash could be harnessed as the agricultural fertilizer.

- **Utilization range**

At present, the typical scale of straw generation power plant is 24 MW which using this technology. The above three project approved by NDRC is also same scale. The straw consumption will be about 200 thousand tons in these power plants every year. It is difficult to collect these straws in the most region of China. The cultivated area per capita is small in the mostly rural area, and cultivation is based on household, which can provide 4-10 tons straw each one household. Therefore, the consumption about 200 thousand tons will be purchased from 100 thousand household of rural resident. The purchase work will be very heavy burden. Moreover, with the feedstock cost increasing, the benefit of project will be influenced.

In the opinion of this report, the technology can be used in some region such as Heilonjiang, Jilin and Xinjiang, where has very large cultivated area each people and some national farm. If the straw power plant is constructed in these regions, the straw purchase will be easy and the cost will be low. However, if the plant is constructed in populous regions, the enterpriser will need very carefully consider.

1.3.1.2 Biomass circulating fluidized bed gasification generation power

- **Characteristic**

The technology comes from the project supported by Ministry of Science and Technology (MOST), which have intellectual property. At present, some power plants with 1MW-installed capacity have been constructed, and one demonstration project with 4MW-installed capacity is building in Jiangsu.

The collection cost of straw is relatively high because the straw production is not centralized. In the opinion of this report, the straw power plant, which installed capacity 5MW (the largest is below 10MW), should be constructed in the most of region of China, except for the large farm. The key equipment of this technology is circulating fluidized bed gasification boiler. At present, it is difficult to enlarge the capacity of the boiler in the technology. But the capacity of boiler can match the above straw power plant. So the capacity of equipment is very feasible and economic.

Through circulating fluidized bed gasification generation power plant constructed, there are some problems being solved in the technology. For example, the separated tar contains a lot of ash in cleaning processing, so the use of tar is very limited. Moreover, tar, as waste, need be disposed farther.

- **Utilization range**

The technology is adapted to use in the most of region in China. At the same time, the technology can dispose the rice husk in many rice mills of China, which can greatly reduce the cost.

1.3.1.3 Straw fixed bed gasification generation power

- **Characteristic**

The technology of straw fixed bed gasification is relatively mature, which can use the mature normal equipment of coal fixed bed gasification. Especially the normal equipment about dedusts, detar, and desulfur for fuel gas can be directly used.

The shortcoming of technology is as followed. At present, though there are two hundred the power plants, the installed capacity is only 200 KW. The demonstration project of straw fixed bed gasification power plant will construct in Jiangsu.

- **Utilization range**

This technology can be adapted to the most regions in China. The installed capacity should be controlled from 5 MW-10 MW. The straw will be solidified in the station to be easy to reserve and transport and to reduce storage area. Therefore, the technology has advantage in the rural impacted area.

1.3.2 Animal excrement generation power

1.3.2.1 Hangzhou Denta husbandry biogas generation power

- **Characteristic**

The project is the typical wastewater disposal project in large husbandry of China. The total amount on hand is 120 thousand heads. The wastewater output is 30000 tons, including excrement and

washing water and living sewage. There is high concentrations organic matter in the wastewater. Therefore, if the wastewater is directly discharged, the environment will be polluted.

Table 1-3-1 wastewater quantity indexes

Index	TS（%）	COD_{cr}(mg/L)	BOD_5 (mg/L)	SS (mg/l)	NH_3-N (mg/L)
High concentration	1.4	17000	8500	12000	2520
Low concentration	-	400	200	200	50

- **Utilization range**

The project is adapted to the large or medium husbandry, especially husbandry for pig or cattle. Because the excrement of pig and cattle has low solid content, it is difficult to directly process the excrement to organic fertilizer. Therefore, the biodegradability will be feasible method to produce biogas. The biogas can directly generate electricity in internal combustion engine and be used as fuel for boiler to produce stream.

1.3.2.2 Shunyi husbandry biogas generation power

- **Characteristic**

The project has been supported by UNDP/GEF/SETC project "Capacity Building for Rapid Commercialization of Renewable Energy in China—large scale industry biogas demonstration project".

The husbandry is typical medium scale, which mainly disposes the pig excrement. The total amount on hand is 30000 head and the living wastewater is 611 tons.

- **Utilization range**

The breed method adopts feed in a pen through retting excrement, which is the typical breed method in North of China. Therefore, the project is of advantage to disposing excrement in medium or small-scale husbandry in North of China.

1.3.3 Industry waste utilization

1.3.3.1 Guitang plant bagasse generation power

- **Characteristic**

The large sugar manufacture is rebuilt in this project. During retrofit period, the basic condition can be fully considered. At the same time, the project also pays attention to comprehensive resource utilization and environment protection. The project will form ecotypes industry region, which center is sugarcane refinery, to realize the combination between industry and agriculture, and environment protection and economic benefit.

- **Utilization range**

Guangxi Guitang Bagasse Co-generation demonstration project is a technology reform project, which is supported by UNDP/GEF/SETC project “Capacity Building for Rapid Commercialization of Renewable Energy in China”.

Guangxi Guitang built in 1956. Through three enlarging scale period, the capacity has been enlarging 10000t/d. The enterprise has make progress in comprehensive utilization resource and cycle economy based on technology retrofit. The project can provide a good demonstration for the same type enterprise and explore an approach to sustainable development of old enterprise in China.

1.3.3.2 Rice husk generation power in rice mill

- **Characteristic**

Recently year, the rice husk generation power in rice mill rapidly developed in China. These projects didn’t been supported in finance and policy by government, whereas, the projects fully depended on the market. Jiangsu, especially the South of Jiandsu, is the center of rice production in East of China. There are many small rice mills in these regions, which have one rice grinding product line. The installed capacity of the product line is 130kw. When the rice was been input, the mill began to process the rice until finishing all products. Therefore, during operating period of the mill, the power load is so very stabile that the condition can be provided for the generating power system by the mill.

The generation power system matches the power consumption system in rice mill. Therefore, the economic benefit of project is very good. At present, the owner of these rice mills is private enterprise that has high decision-making power for investment and running. With economic benefit impulsion, the enterprisers will actively construct these type power plants.

There are some problems as follows. The gasification system of rice mill exists the secondary pollution because the mill does not strictly supervise the processing, which need reform and management further.

- **Utilization range**

The technology is adapted to use in rice mill. If altering the gasification boiler, the other medium or small factory producing biomass waste can be used.

1.3.3.3 Qingdao wine plant biogas power generation

- **Characteristic**

The digestion technology adopts international advanced EGSB reactor，namely grain sludge swell bed. At the same time, full mixed anaerobic digestion technology is adopted， match with whisking establishment, which makes the liquid in the pool and microbe to full mix, and adopts sulfide treatment measure and anaerobic digestion.

The project cannot only produce biogas as the high quality energy, but also dispose digested liquid as fertilizer. Therefore, the biomass resource will be made full use.

- **Utilization range**

The producing capacity of Qingdao wine plant is 18000 tons wine of corn and wine of potato. After the project is built, the annual production capacity will be 2.88 million m^3 biogas and 9600 tons feedstuff, which can provide demonstration and direction for the same scale wine plant in China. Because the relative facility is perfect in large biogas producing, the biogas can continue to produce; even the technology can be used in the cold region of North China.

1.3.4 Municipal solid waste

1.3.4.2 Hangzhou Tianziling land fill generation power

- **Characteristic**

The technology fully considers the leachate removing and disposing in the design. The problem of leachate disposal widely exists in south region of Yangtse Rive. The highest depth of Tianzilin landfill is 50m, which is a typical terrain for landfill. In the design for the project, the factor and experience of upright well depth and space will provides reference for the same project.

- **Utilization range**

In theory, all garbage can adopt the sanitation landfill method. But there are large populations and small area per capita in China, so the landfill is not fit for our country. The pyrogenation method for MSW disposal should be developed for the future.

The landfill gas generation power can use the built and building landfill, at the same time, the design at beginning need consider the gas generating power in the landfill building.

1.3.4.2 Shuangliu MSW gasification generation power

- **Characteristic**

The content of Dioxin from this system is very low. Toxicity equivalent quantity is very lower than national emission standard. Furthermore, compared with the same type international technology, it is the lower lost and wider market and industry potential. Furthermore, the investment is lower than the MSW combustion generation power.

- **Utilization range**

The production capacity of one boiler is 200 tons/day MSW. Based on the statistic data from state environment protection bureau, the output of MSW is 0.44kg per capita in the city. Therefore, the technology is adapted to dispose garbage in the city where there are 500-1000 populations.

2 Foreign biomass energy technology development and application

2.1 Biomass energy utilization in the some countries

2.1.1 United States

In United States, biomass generation power is a proven commercial electricity generation option. With about 9,733 MW in 2002 of installed capacity, biomass is the single largest source of non-hydro renewable electricity (EIA Renewable Energy Annual 2002). This 9,733 MW of capacity includes about 5,886 MW of forest product and agricultural residues, 3,308 MW of generating capacity from municipal solid waste, and 539 MW of other capacity such as landfill gas (EIA Renewable Energy Annual 2002) The majority of electricity production from biomass is used as base load power in the existing electrical distribution system.

More than 500 facilities around the country are currently using wood or wood waste to generate electricity. The majority of the capacity is produced in Combined Heat and Power (CHP) facilities in the industrial sector, primarily in pulp and paper mills and paperboard manufacturers. To generate electricity, the stand-alone power production facilities largely use non-captive residues, including wood waste purchased from forest products industries and urban wood waste streams, used wood pallets, some waste wood from construction and demolition, and some agricultural residues from pruning, harvesting, and processing. In most instances, the generation of biomass power by these facilities also reduces local and regional waste streams.

In the early 1990s, nearly all of the biogas electricity was produced in the United States. In 2001,the United States is still the largest producer with 4.9 TWh. At present, the biogas technology is mainly based on flexible liner systems and Co-digestion systems in US.

2.1.2 Europe

In Europe, biomass currently contributes about 60% of the renewable energy sources share (98% of renewable heat and 8% of renewable electricity) and is believed to be the renewable energy resource with the largest growth potential. Electricity generation from biomass is significant in Sweden, Finland and Denmark in CHP schemes. Biomass is used for power generation to a lesser extent in other countries and usually as co-generation or as a recent response to environmentally driven policy initiatives. As gasification and other advanced processes are still in the development and demonstration phase, most current deployment is conventional steam cycle technology. There is a minor amount of co-firing with coal in Sweden. Most of the biomass CHP schemes in Europe are operating in pulp and paper industries, followed by forest industry and CHP for large district heating systems. The largest producers of electricity from biomass are Finland, Sweden and Austria. The share of biomass electricity generation in its total electricity generation reached 11% in Finland, and in the Sweden and Austria, electricity generation based on biomass accounted for more than 2% of total electricity generation in 2001.

At present, most of the growth production of electricity from biogas has taken place in European countries. The United Kingdom is the largest producer in Europe, with 2.9 TWh in 2001. Germany produced nearly 2 TWh in 2001. Most of the European Plants are small or medium sized farm scale plants using 1-20m^3 per day. Nine large farm-scale plants in Germany use more than 20m^3 per day. There are also several plants of this size in concentrated livestock areas of northern Italy, the Netherlands, and Denmark. Germany and Denmark were the most dynamic countries in terms of installing farm digesters during this time and this continues to the present day.

2.1.3 Other countries

In 2000, the total installed ASEAN capacity of renewable energy for electricity generation was 20,942.46 MW (Table 2-1-1), among which 8.94% is from biomass power. In ASEAN, the potential of biomass for power generation is promising: about 50,000 MW for all biomass resources in Indonesia (NRSE-SSN Report, 2001); approximately 3,000 MW in Thailand (EC-ASEAN Cogen, 2002); about 1,117 MW in palm oil industry of Malaysia (PTM, 2003); about 60-90 MW from bagasse and 352 MW from rice hulls in the Philippines (NRSE-SSN Report, 2001); and 250 MW from bagasse in Vietnam (UN-ESCAP, 2000). About 920 MW in installed capacity could be expected from over 19 million tons of residues in ASEAN wood industry (UN-ESCAP, 2000). Many of this potential could be developed through cogeneration.

Table2-1-1 Biomass energy for power generation in ASEAN (2000) in MW

Country	Biomass	Total
Indonesia	302	4940.40
Malaysia	213	2446.34
Philippines	21	4691.5
Singapore	220	220
Thailand	1230	4218.47
ASEAN-10	1986	20942.46

2.2 Biomass generation power technology summary

2.2.1 Direct-fired power generation

- United States

The direct-fired boiler/steam turbine technology is mature and main generation power technology in US. The biomass power boilers are typically in the 20-50 MW range (the largest approaches 75 MW). The small capacity plants tend to be lower in efficiency. Although techniques exist to push biomass steam generation efficiency over 40%, actual plant efficiencies are in the low 20% range.

Table 2-2-1 lists the 8 power plants in USA after 1990. The types of biomass fuels used are abbreviated: “mill” refers to mill wastes, etc. Many boiler types are represented: two traveling grate stoker boilers, six water-cooler vibrating grate boilers, three fixed-grate boilers. From this table, the mill waste, urban waste and forest are the main biomass fuel.

Table2-2-1 Biomass direct-fired generation power plant in USA

Plant	**Location**	**Fuels**	**Boiler**	**Scale (MW_e)**	**Electricity generation (GWh/yr)**	**Heat rate (Btu/kWh)**	**Fuel consumptions (Tons/yr)**
Tracy	California	Ag, urban	1 water-cooler vib grate	18.5	130	14000	214000
Grayling	Michigan	Mill, forest	1 traveling grate stoker	40	200	13600	320000
Willams Lake	British Columbia	Mill	1 water-cooler vib grate	60	558	11700	768000
Multitrade	Virginia	Mill	3 fixed grate stokers	80	133	14000	219000
Ridge	Florida	Urban, tries, LFG	1 traveling grate stoker	40	200	16000	376000
Camas (cogen)	Washington	Mill	1 water-cooler vib grate	17	65	17000	194000
Snohomish (cogen)	Washington	Mill, urban	1 sloping grate	39	205	17000	410000
Okeelanta (cogen)	Florida	Bagasse, urban	3 water-cooler vib grate	74	454	13000	694000

- Europe

In Europe, a number of combustion technologies for CHP and Condensing power production from biomass are commercially available. The market for large scale CHP from biomass combustion is established in Sweden, Finland and Denmark.

For fixed bed boilers, there were some small, medium and large commercial power plants in Europe. However, the fluidized bed boiler is mainly in large scale CHP. Smaller boilers with acceptable capital costs have been developed but need further demonstration.

Denmark is a larger country as biomass CHP. At the beginning of this millennium Denmark had installed biomass fueled combined heat and power plants with a total power capacity of 200 MW_e. Biomass CHP

generation is accounts for 1.5 percent of the total capacity for electricity production in Denmark. The detail operating data on eight biomass direct-fired plants are listed in Table2-2-2.

Table2-2-2 Operating data on ten biomass-fired plants and systems

Data	Unit	Junckers K-7[1]	Junckers K-8[1]	Novopan[1]	Enstedv. EV3[2]	Masnedø Unit 12[2]	Vejen[2]	Hjordkær[3]	Assens[3]
Power output	MW	9.4	16.5	4.2	39.7	9.5	3.1	0.6	4.7
Heat output	MJ/s	Process steam	Process steam	Process steam + dist.heat		20.8	9.0	2.7	10.3
Steam pressure	bar	93	93	71	200	92	50	30	77
Steam temperature	℃	525	525	450	542	522	425	396	525
Fuels		Chips bark Sawdust Sander dust	Chips Bark Sawdust Sander dust	Chips Bark Sawdust Sander dust	Straw chips	Straw chips	Waste Straw chips	Chips Bio-waste	Various bio-fuels chips
Electrical eff.(gross)	%					28	21	16	27
Overall officiency						91	83	86	87

Notes:

1) Industrial systems.

2) Owned by power corporations.

3) District heating plants.

2.2.2 Gasification power generations

At present, the biomass gasification technology is very near to commercial availability with mid-size plants operating in Finland, the UK, the Netherlands, and Vermont. A cogeneration application of biomass gasification power could exceed 80%.

Pilot and demonstration units incorporating biomass gasification to fuel gas turbines are now under development the US, Brazil and the EU; indeed, the first such unit, at Värnamo in Sweden, was commissioned in 1993 and has been in test operation for three years. Centers of activity include the Renugas process unit in Hawaii, the UGas process unit of Carbona (formerly Tampella) in Finland, Imatran Voima Oy in Finland and TPS Termiska Processer AB in Sweden, working with the ARBRE project in UK and the Bahia project in Northeast Brazil. Both the US DOE and the European Commission are actively involved in biomass power demonstration programmes.

2.2.3 Co-fired power generation power

Biomass cofiring has been successfully demonstrated and practiced in a full range of coal boiler types and sizes, including pulverized coal boilers, cyclones, stokers, and fluidized beds. At least 182 separate boilers and organizations in the United States have cofiring biomass with fossil fuels. Of the 182 cofiring operations mentioned above, 114 (or 63%) have been at industrial facilities, 32 at utility-owned power plants, 18 at municipal boilers, 10 at educational institutions, and 8 at federal facilities.

In Europe, most existing coal fired plant uses pulverized fuel (PF) technology. Biomass fuels must be ground to a small size to be used in these installations.

fluidized beds, and low-percentage (Less than 2% biomass on a heat basis) cofiring in cyclone and PC boilers. For heating applications, this is equivalent to about $3 to $6/lb per hour of steaming capacity.

2.2.4 Anaerobic Digestion generation power

Technologies for anaerobic digestion of sewage sludge, industrial sludge and wastewater are fully commercialized, and they need no further R&D support and are not covered in this information. Anaerobic digestion of animal manure and organic wastes are still under development and are treated in detail here. The EU energy potential of sludge is given as 20,000 GWh/year, which is equivalent to 2500 MW/y. In comparison to the figures for agricultural and MSW feedstock this is about 20% of the total potential. However, the treatment of sewage sludge by AD is likely to see a greater immediate increase in EU countries compared to other feedstock due to the banning of sea dumping of this waste.

The technology of anaerobic digestion is now well developed and a range of digesters from 70m^3 capacity to 5,000m^3 is commercially available. The size and type depends on the manufacturer and the quantity and type of the material to be digested. Smaller digesters tend to use the biogas for heat production whereas larger units can generate up to about 2 MW of electricity.

3 Biomass energy technology application perspective

3.1 Straw utilization analysis

3.1.1 Characteristic of straw utilization in large scale

There are small-cultivated area per capita and low work efficiency of rural labor in China. In the most region of China, the household is regarded as a work unit, which is very small scale. These characteristics in rural region will influence the cost of agricultural and forest residue utilization, especially the collection cost. Therefore, the factor should be fully considered when the technology road map is done research on agricultural and forest residue utilization.

- **Purchase contract**

For ensuring stable supply of feedstock, the straw power plant should sign contract for straw purchase. The straw will be provided from farmer at last no matter what the purchase adopts any bargain mode. For example, the 25MW straw direct-fired generation power project, which is approved by National Development and Reform Commission (NDRC), need consume 140 thousand tons straw, which need be provided from 70-80 thousand household farmers. Therefore, the purchase contract signed will reach 70-80 thousand contracts.

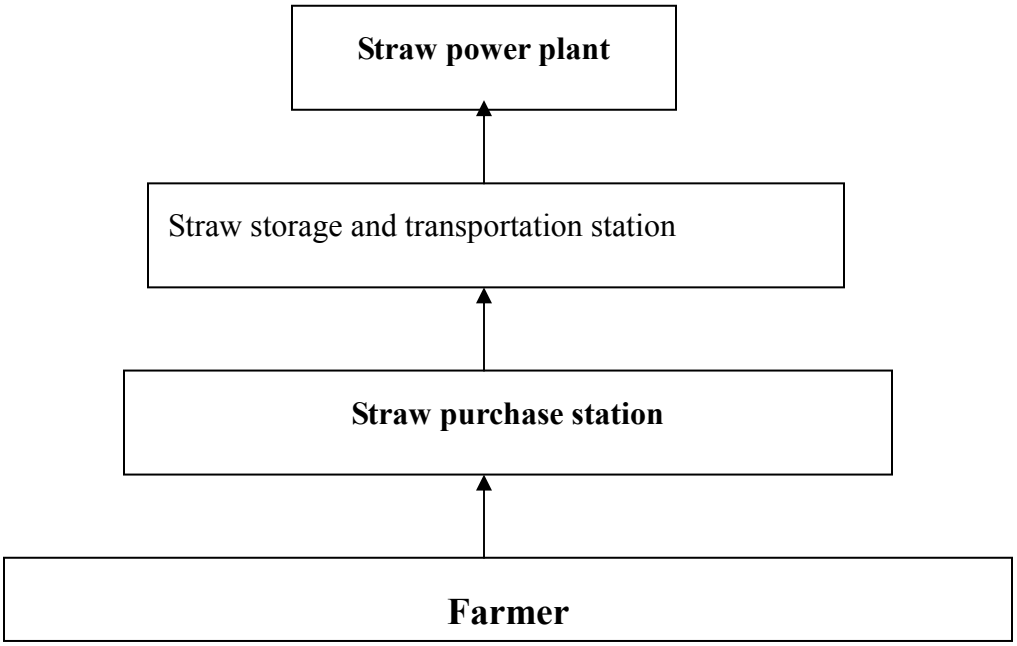
- **Bargain number**

If the straw produced from each farmer in whole year is purchased in each contract, the bargain number will also reach 150 thousand contracts because the straw will be produced in two seasons. The purchasing agency or purchasing agent can finish these bargains, but the setup of large agency or agent need the high cost, which will increase the collection cost of straw.

- **Bargain agency**

The agency setup, arrangement, and number will influence the collection cost of feedstock. At present, the approved project will adopt the multilevel purchase system, which is shown as Figure 5-1. As main control center, the straw power plant will ask each straw storage and transportation station to deliver the straw. The number of station will be built according to the scale of power plant.

The power plant with 25 MW installed capacity will consume 200 thousand tons straw every year, which need be provided form 10 straw storage and transportation station. Each station will manage 20 purchase stations that should have the capability of straw storage. The purchase stations will collect straw from purchasing agent. The station will manage 20 agents for straw collection. The agent, who will directly purchase from 50 household farmers, is mainly the rural resident in the local. The total amount of collection is about 100 tons straw from each agent.



3.1.2 Technology scale and feasibility

Based on above analysis, the large utilization of agriculture and forest residue in China, especially straw, should pay attention to the straw collection, and then, the collection cost will be an important condition to determine the scale of straw power plant. The source of straw is too dispersing to ensure the safety of collection. Therefore, when selecting the scale of straw power plant, the risk of straw collection should be considered as an important factor.

So far, there is not a technology, which can be adapted to utilize in the whole regions of China. In the opinion of report, it is very infeasible to extend a single technology in the whole regions of China. Each technology can be adapted to use in the different regions, in the same way, every regions can adopt the different technologies. Based on the existing condition in each region, the scale of power plant will be selected.

The straw direct-fired generation power will fit in the regions cultivating in the large farm, such as Heilongjiang, Jilin, Xingjiang and so on. There are relatively centralized cultivated and large producing unit in these regions. At the same time, the regions only cultivate crop in one season, therefore there are enough time and field to collect the straw. As a conclusion, the installed capacity of straw power plant can reach 25-50MW (even the larger scale) in this type region.

As far as crop production, there are the larger in Heinan, Shandong, Jiangsu, Sichuan and Hunan and so on. But there is such a high density of population in these regions that each farmer only provide very small amount of straw. The gasification generation power will be adapted to use in these regions. The installed

capacity can be 5-10MW in the straw power plant of these regions. Furthermore, when building straw collection system, the straw resource in the regions, which can be covered by the collection system, should exceed the consumption of the power plant to avoid the risk of collection price and supply in time.

3.2 Animal excrement utilization analysis

3.2.1 Technology utilization scale

The statistical data from China Agriculture Department indicates that there are 8241 medium and large-scale husbandries in China (the detailed describe of scale is shown in Table 3-2-1), which discharge 2 billion tons excrement and wastewater. Based on survey and calculation, the availability amount of excrement from husbandry, which can be used as potential feedstock for generating electricity, is about 55 million tce. (The detailed analysis is shown as China Biomass Resource Report).

Table3-2-1 The scale classifying of husbandry

Type	Amount of pig on hand （head）	Amount of hen on hand （10000）	Amount of chicken on hand （10000）	Amount of milky cow on hand （head）	Amount of cattle on hand （head）
Medium scale	3000-10000	5-20	10-40	200-600	500-1200
Large scale	>10000	>20	>40	>600	>1200

3.2.1 Technology feasibility

The generation power technology in animal husbandry is limited in the biogas generating electricity. There are many technologies for producing biogas, but the system mode is mainly excrement-biogas-electricity. At present, the pyrolyzed gasification and direct liquefaction is developed, but these technologies are during research. Therefore, the technology mainstream for animal husbandry electricity generation is still biogas generation power.

3.3 MSW utilization assessment

Based on the statistics from China Environment Protection Bureau, the garbage production of municipal resident is 440 kg per capita every year. With economy developing, the city scale is the larger and larger and number is the more and the more, in the result, the garbage production increases. At present, the deposit amount of garbage has reached 6 billion tons, which occupies 500 million square meters cultivated field. The number of city has reached 668, among which 200 cities has involved in the garbage.

Up to the present day, China has not process the mature garbage disposal technology by own intellectual right. The landfill is main garbage disposal technology. But the biogas output system was not built in the landfill plant as result that there is not the biogas generating electricity system. Therefore, the blast accident due to biogas happened in the landfill.

The combustion generation power is main technology of disposal MSW in the developed country (in Table 3-3-1). In china, the combustion technology is only used by few cities such as Shenzhen and Shanghai and so on, but the main technology and equipment was all imported from the foreign. The MSW combustion generation technology has been done researched by the domestic research institute and enterprise, but the mature demonstration project was not built.

Table3-3-1 MSW disposal methods in some counties

No.	Country	Sanitation landfill (%)	Garbage compost (%)	Combustion generation (%)	Combustion plant (site)	Combustion amount (10000tons/a)
1	Singapore			100	3	255
2	Switzerland	20		80	34	170
3	Japan	23	4.2	72.8	1899	3086
4	Denmark	18	12	70	46	145
5	Sweden	35	10	55	23	140
6	Netherlands	45	4	51	11	170
7	France	40	22	38	284	200
8	German	65	3	32	65	430
9	Belgium	62	9	29	29	132
10	Australia	62	11	24	3	35
11	United kingdom	88	1	11	38	180
12	USA	75	5	20	157	1369

Source: Shenzhen energy in tenth of 2000

3.3.1 Characteristic

As a developing country with numerous populations, China has special situation of country. The mature of developed country is not fully adapted to China.

- MSW classifying

The MSW classifying has been implemented in a few cities, which installed some classified dustbin in the important public. Based on survey, hardly classified dustbin can be useful. Furthermore, the living garbage is only classified in the bag, without absolute classifying.

- MSW component

The component of organic compound (combustible) is low in the garbage because of the low living standard of the municipal resident in China. The heating value of MSW is 900-1500kcal/kg. The reason inducing low heating value of MSW is that the garbage is not fully classified, excluding the living standard.

- Disposal fee for garbage

At present, the city resident paid the lower charge for garbage disposal, which only afford the garbage clean, and transportation. In the garbage disposal plant, the disposal cost of the garbage is mainly from financial payout of the local government. So the capital of building and operation in the garbage disposal plant is relatively lack.

3.3.2 Technology method

According to the situation of China, the combustion generating power technology should be enlarged. At the same time, when the landfill technology is adopted, the biogas output system should be prepared. These two methods will be mainstream of MSW disposal.

The compost technology of MSW was also demonstrated in some region, but the operation result is not satisfying. Beijing city imported a product line of high temperature compost from German, which can normally operate but the product has hardly market. Therefore, during selecting the technology flow, the technology feasibility should be fully considered.

Table 3-3-2 lists the compare of three disposal technologies. According to each characteristic, the technology selecting is as follows:

- In large and medium cities and some small cities with developed economy, the combustion technology can be selected.

- In small cities and large and medium cities with non-developed economy, the landfill technology can be selected.

- In impacted area, the combustion technology should be selected at the first. However, the landfill technology can be selected in the area with abundant land and low population.

Table 3-3-2 The compare of three MSW disposal methods

Content	Sanitation landfill	Combustion	Compost
Operation security	Fair ● Notice fireproofing	Good	Good
Occupy land	Large	Small	Medium

Select location	Difficult ● Considerer terrain, geologic condition ● Prevent surface and ground water pollination ● Build apart from city to increase the transportation distance	Easy ● Close to city ● The short distance of transportation	Easy ● Avoid impacted area ● The radius of smell infection need be below 200m ● The transportation distance is feasible.
Applying condition	● Mineral >60% ● Containing water<30% ● Density>0.5t/d	● In low heat value >3300kJ/kg, the assistant fuel nee not be used	● Considering innocuity, organic compound≥10% ● Considering fertilizer effect, organic compound >40%。
Last disposal	No	The residue need be filled, which accounts for 10% of the begging content	The residue need be filled, which accounts for 20~25% of the begging content
Product market	Reclaim biogas to generate electricity	Produce heat or electricity	It is difficult to build the stable compost market
Building investment	Relatively cheap	Relatively expensive	Medium
Pollution of surface water	Possible Take measure to reduce possibility	No pollution in the plant When the ash is filled, the pollutions lower than the landfill	At same as landfill
Pollution of ground water	Possible	The ash solidified can prevent pollution	Possible Heavy metal in compost product can pollute water
Air pollution	Have The cover and press can control the pollution	Have The Dioxin need be controlled	Have light odor
Soil pollution	Limit to the landfill area	Without	Need control heavy metal content in the compost product

4 Biomass energy available potential analysis

4.1 Agriculture and forest residue potential

The biomass generation power technology will have the large development potential in China. It is well known that this technology can save energy, protect environment, other tan it is an important factor that the biomass generation power will be promoted to become the most important industry in the renewable energy utilization.

Table 5-1 comes from *China Statistics Yearbook in 2004* by National Bureau of Statistics. The table shows that the total income per capita is 3582.4 RMB Yuan in rural, and net income per capita is 2622.2 Yuan in rural. Furthermore, the cash income per capita is only 2100.8, which accounts for 58.6% in total income. Based on calculating, the cash net income in the rural is only 1110.8 Yuan, which excluding cash payout for producing. In addition, there are 768.51 million populations in the rural of China, which accounts for 59.47% of total population in China. Such enormous population, the cash income per capita is below US$0.5.

Table 4-1-1 The income and expense per capita of the rural resident

Annual income per capita	**Sum (Yuan)**	**Annual expense per capita**	**Sum (Yuan)**
Total income	**2836.72**	**Total expense**	**2514.20**
Salary income	540.93	Family business expense	733.48
Family business income	2148.46	Purchase fixed asset for produce	113.10
Property income	41.85	Tax expense	49.14
Transfer income	105.49	Living expense	1524.22
		Transfer and property expense	94.27
Cash income	**2100.78**	**Cash expense**	**1918.62**
Salary income	540.42	Family business expense	548.21
Family business income	1430.80	Purchase fixed asset for produce	113.10
Property income	34.33	Tax expense	47.35
Transfer income	95.23	Living expense	1117.09
		Transfer and property expense	92.87
Annual net income per capita (Yuan)		**1936.01**	
Salary income		540.93	
Family business income		1276.60	
Property income		41.85	
Transfer income		76.64	
Annual net cash income per capita (Yuan)		**1110.79**	

Therefore, it is important for China government to increase the income in the rural, especially cash income. In 5th March 2005, State Department Premier Wen Jiabao declared that the agriculture tax would be exempted in the whole country next year. This measure will decrease 3.77 billion RMB Yuan payouts for the tax in the rural. (Based on the data in 2003)

The survey data indicates that the availability amount of crop straw, which is used as generating power, is about 247 million tons in China. (Shown in *Biomass Resource Report in China*). Based on the field survey, the collection cost of crop straw using as generation power is about 250-300 Yuan per tons, among which 100 Yuan is the cost of purchase straw. If 50% availability amount can be used, the cash income in the rural will increase 1.235 million Yuan every year.

As is stated above, the purchase agent is the farmer in the local area, who can collect 100 tons straw every year. Based on above calculation, the straw collection will provide 1.235 million employees for the rural. If the price of collection straw is 20 Yuan, each agent will acquire 200 Yuan net income, which is as 1.8 times as the net income per capita in the rural in 2003.

It is different form wind power and solar power that the biomass power, especially the crop straw generation power, can provide employees for the rural labor force and increase income of the farmer. Therefore, the biomass generation power will be regarded as the preferential industry developed by China government to solve the rural problem.

4.2 Animal excrement potential

Because the content of water is high and the solid is low in animal excrement, there is obstacle in using pyrogenation technology. However, the technology of biochemistry for producing biogas is very mature.

At present, the average scale of the husbandry is relative small. With the urbanization of country developing rapidly, the average scale of the husbandry will enlarge through resetting the husbandry, which will provide the good condition for the utilization for animal excrement.

There are above 1.3 billion populations in China, which is a large and stable market for protein consumption. Therefore, the animal husbandry development is an inevitable current. At present, the husbandry is lack of strict disposal for the excrement so as to pollute the environment around. Therefore, the control of waste discharge in husbandry should be enhanced. The generation power technology in husbandry is mature. At the same time, Renewable Energy Law provides the guarantee of economic benefit for this technology utilization. The technology of disposal excrement will be paid attention and widely used.

4.3 MSW potential

At present, the environment pollution from MSW has been more and more serious. National Environment Protection Bureau has explicitly put forward the request of disposal MSW, which is decreasing

production of garbage, reducing damage of garbage, and increasing utilization as energy of garbage. With reform deepening, the government has begun to change the function of government in China. The public project is more and more important in the government work. Therefore, the disposal technology for garbage will be enlarged in large scale. According to disposing 400 million tons MSW every year, the MSW generating power will become a new industry.

It is well know that there are largest populations of China in the word. The city with population above 4000 thousand people is about 11, 2000-4000 thousand people is about 22 cities, and 1000-2000 thousand people is about 141 cities (the data is from nation statistic bureau in 2003). In these cities, it will be a better choice to adopt the direct-fired technology to proposal MSW. Based on the statistic data form National environment protection department, the output of MSW is about 0.5tons per person every year. If there are 1000 thousand population in the city, the output of MSW will reach 500 thousand tons, which can supply MSW direct-fired generation power with 15MW installed capacity. Therefore, the direct-fired generation will have widely market in the disposal MSW of China.

5 Biomass energy policy suggestions

5.1 Biomass energy policy in China

5.1.1 Regulation about on-grid price of biomass generation

Related central government agencies, for example former Ministry of Electricity, former State Economy & Trade Commission, former State Development and Plan Commission, and Ministry of Science & Technology, have made regulations about the wind electricity interconnected with grid, but not clear regulation about biomass power generation. Many biomass power generation projects try to solve their grid connected problem following the regulation about the wind generation. The major contents about the grid connected regulation are to permit the generation connect into the grid with a suitable electricity price.

The general regulation about wind power is that the electric grid administration department should permit wind electricity into the nearby grid and purchase the whole power amount. The grid-connected wind electricity price will be determined according to reasonable profit, which is the cost of generating plus the cost of repaying the capital with interest. The additional price compare to the conventional electricity price will be shared equally in whole grid after the utility purchase wind generation. These rules have played very important roles to solve the problem of connection with wind generation and the grid. But because the problem of fixed electricity price has not been solved locally (it is separately handled by local government according to different situations), it is not sure how much the price difference between wind power and conventional power will be shared equally, and in addition there is no standard power purchasing agreement to rely on.

In 2003, the Notice of Electricity Price Reform (Guo Ban Fa [2003]62), printed and distributed by the State Council Office on July 3, 2003, clarify the regulation about renewable energy electricity price. The Notice ruled that: New energy resources and renewable energy, such as wind power and geothermal energy, do not currently take part in the competitive market. The grid enterprises have priority to purchase new and renewable electricity according to the price determined by the government or bidding. In the future, when the power market becomes matured, the government will determine the proportion of new and renewable energy in the power sector, and an industrial market of new and renewable energy resources with competition will then be set up. So the rules have been authoritatively fixed that renewable energy generation projects should not have to join in the competition of the electricity grid, which thereby removes a large obstacle in the development of renewable energy generation including biomass generation during the reform of power sector.

But, it does not exist a very clear standard price setting mechanisms or systems of RE. Price is set on a case-by-case basis with protracted negotiation between power producer and the grid or utility, thereby increasing the transaction costs, and discouraging RE industry. It is difficult to get reasonable price for biomass products, although some RE enterprises such as those based on wind power can do so.

5.1.2 Economy policy

5.1.2.1 Subsides

Subsidies, which are provided by the central and local governments, are one of the most popular economic incentives for biomass development in the PRC. The following are the major subsidy measures taken:

- Overhead: This mainly refers to operating expenses and other expenses of biomass managerial institutions in several commissions of the central government. There is about tens thousand staff at different levels for the management, R & D as well as training, equipment certification, inspection, etc for RE development, especially for the rural energy application. As the government reform, some institutions and organizations transfer to commercial management and operation, the subsidies from the government for the overhead became small and small.
- R&D: The central government subsidies R&D on key biomass technologies through NDRC and MOST.
- Capital investment subsidies for the interest: The subsidies normally provided by central government as a low-interest rate loan. For example, former Department of Resource Conservation and Utilization of SETC provided 120 billion RMB Yuan low interest loan each year on support the renewable energy development, and the Ministry of Water and Conservancy provides low-interest loans of about 300 million RMB Yuan for small hydropower development.
- Subsidies for projects: Central government has provided many kinds of subsides for renewable energy development through projects, especially for the biomass energy. In 1970s and 1980s, a large number of subsides are used in household biogas system, save-wood stove dissemination, small hydro power plants, and others. Besides the special funds, a part of central poverty fund, rural electric fund, and plantation and afforestation fund are used in biomass development.
- The rural biogas national debt project in 2003 and 2004: the subsidies standard is 1200 Yuan in northwest region and northeast region, 1000 Yuan in southwest region, and 800 Yuan for other regions, which will be given to rural household establishing the biogas system.
- Rural energy projects under rural small scale public establishment construct fund in 2001 and 2002: the subsides standard is 400 Yuan for each household biogas system, 100 thousand Yuan for each small scale biogas engineering project, and 200 thousands Yuan for each straw and stalk gasification and supply biogas engineering project.

- National ethanol gasoline for vehicle dissemination projects since 2002: Because the materials for ethanol is the dated corn, the national subsidies for dated food are also given to the ethanol plants as about 400 Yuan for each ton food. And, if the ethanol plant's profit is negative, the central government will also give the plants some subsidies. The subsides will be determined based on the principal of avoiding the negative profit and keeping a little profit.

5.1.2.2 Custom duties

According to the Notice about Adjustment of the Equipment Import Taxation (Guo Fa [1997] 37) issued by State Council on 1997, the custom duty and related VAT of the imported equipment for self use, which are listed in the Direction Catalog of Foreign Investment Industry, are exempted. The establish and management of new energy power plant, including solar energy, wind energy, magnetism, geothermal energy, tide energy and biomass energy, are listed in this Direction Catalog. However, Customs duty exemption depends on whether the equipment is considered high-tech and the need be clarify in each case.

The normal VAT for custom duty is 17%. According to the Notice about VAT and Consumption Tax of Imported Equipment (Guo Shui Fa [1993] 155) issued by SAT and Customs General Administration (CGA), the VAT for custom duty of imported biogas equipment is reduced to 13%.

5.1.2.3 VAT refund

The normal rate of VAT is 17% in China.

According to the regulation (Cai Sui [2001]198) issued by Ministry of Finance (MOF) and State Administration of Taxation(SAT) in December 2001, the VAT for municipal waste generated electricity will be refund totally since on January, 1, 2001. And, MOF and SAT issued a replenish notice in 2004 to clarify again that this VAT refund policy only be suitable for the municipal waste electricity in which more than 80% of fuel is municipal waste. This is a real good incentive policy for municipal waste generation.

Unfortunately, in these two documents, the VAT reduction and refund policy are only suitable for municipal waste generation and wind power generation. The VAT of wind power generation is reduced to 8.5% from 17%. Other biomass energy and renewable energy generation are very difficult to following this incentive policy.

In order to encourage ethanol productions and launch the national demonstration projects on ethanol gasoline for vehicle, the regulation (Guo Jing Mao Ji Shu [2002]147) issued by 8 national agencies, including State Economic and Trade Commission(SETC), State Development and Planning Commission, MOF and others in 2002. According to this regulation, a series incentive policy are determined, include that the VAT for ethanol production will be refund totally since Feb. 10, 2002.

5.1.2.4 Income tax

The normal rate of enterprises income tax is 33%. It is free for enterprises acknowledged by the State as in the new and high-tech industrial zones for the first two years and the 15% is applied in the following two years. Enterprises with wastes as main raw material are free from income tax within five years after operation. Staring from Jan. 1, 2000, for foreign funded enterprises in the middle and western areas of the country, the 15 % tax rate will be applied within three years after the current tax concession policy expires. If foreign-funded enterprises in eastern areas of China re-invest in the central and western areas of the country, they shall be regarded as foreign–funded enterprises if the investment proportion exceeds 25% and enjoy the corresponding treatment.

5.1.2.5 Consumption tax

In order to encourage ethanol productions, according to the regulation (Guo Jing Mao Ji Shu [2002]147) issued by 8 national agencies, the consumption tax for ethanol gasoline are exempted. The normal consumption tax is 5%.

5.1.3 Related environment policy published

5.1.3.1 Forbid burning directly and encouraging comprehensive utilization of the straw and stalk

Management Method on Forbidden Directly Burning the Straw and Stalk and Encourage Comprehensive Utilization is published on April 16, 1999 by General Administration of Environment Protection, Ministry of Agriculture, Ministry of Finance, Ministry of Railway and Road, Ministry of Communication, and General Administration of Civil Aviation of Chin, to forbid burning directly and encourage the comprehensive utilization of agriculture straw and stalk. According this Management Method, the regions, including the round regions in 15 km radius of the airport, the regions in 2 km width each side along the high speed road and the railway, and the regions in 1 km width each side along the provincial key roads, are forbidden to burn the agriculture straw and stalk directly. And, this notice also encourage the comprehensive utilization of agriculture utilization, for example, feed back the straw and stalk back to the field as fertilizer, develop straw and stalk fodder and materials for industrial use, and promoting straw and stalk gasification. The notice request that, the straw and stalk comprehensive utilization rate in capital cities of each province, and other important cities should reach 60% and 85% in 2002 and 2005 respectively.

5.1.3.2 Regulation on water pollution excrete and treatment

Water Pollution Prevention and Cure Law is updated on May 15, 1996, and Implementation Item for Water Pollution Protection Law is updated by State Council on March 20, 2000 to ensure the smooth implementation of the Law. According to the Law and the Implementation Items, the water environment quality standard and polluter emission standard are determined, water pollution protection supervisor management and pollution protection for the earth water and the water under the earth are regulated. And, the related waste water

emission control standards for different industries have also been published, and the standard system for waste water emission and treatment has been established. The related environment agencies have right to punish the enterprises with unqualified waste water emission.

5.1.3.3 Regulation on municipal waste treatment

Based on the Solid Waste Pollution Prevention and Cure Law, in 2002, Notice about Establish Charge Regulation on Municipal Waste Disposal and Promoting Waste Disposal Industrialization Development was published to ensure the implementation of the regulation in the Law. According to this document, the charge regulation on municipal waste disposal has been established to pay for the expenses on waste collection, transportation and disposal. The related municipal government agency should enhance the management and supervisor on waste disposal, if it can't meet the request, the government agency can ask the waste disposal station to submit their rebuild plan and promote their work. Each level of environment agency has the right to punish those waste stations that can't meet the regulation. This document has paid very important roles on promoting the waste disposal industrialization development.

5.2 Foreign biomass policy

On the whole, the main incentive policy of renewable energy includes feed-in tariffs, renewable portfolio standard, biding system, and assistant fiscal and financing policy. These assistant policies include RD&D investment, investment subsidies, exemption tax and financing policy. A country usually selects the feed-in tariffs or RPS as the main incentive policy for renewable energy and adds the other incentive policies to establish the whole renewable energy incentive policy system.

5.2.1 Feed-in tariffs

The term feed-in tariff is used both for a regulatory, minimum guaranteed price per unit of produced electricity to be paid to the producer, as well as for a premium in addition to market electricity prices. Regulatory measures are usually applied to impose an obligation on electricity utilities to pay the (independent) power producer a price as specified by the government. The tariff may be supplemented with subsidies from the state. The level of the tariff is commonly set for a number of years to give investors security on income for a substantial part of the project lifetime.

The feed-in tariff includes two methods. The one is confirming the lowest fixed price for the electricity from renewable energy, which is used in German, Italy, and Portugal. The other is adding to incentive price based on electricity price from fossil energy, which is used in Sweden and Denmark. Spain adopts these two methods.

Many counties confirm the electricity price on grid based on technology type, resource type, resource quantity, and project scale. Especially, the electricity price for biomass power generation is different to some degree because it has many technology type and different scale. Table 5-2-1 shows feed-in tariff for biomass electricity in different countries.

Normally, the real price for the biomass electricity is higher than the feed-in tariff published by government regulation because feed-in tariff is always implemented with other incentive policy, for example the tax incentive policy and investment subsidy, in many countries.

Table 5-2-1 Feed-in tariffs for biomass electricity in different countries.

Countries	Electricity price	Note
Austria	• Wood chips:€0.102/kWh to €0.16/kWh • Waste with high bio-share: €0.027/kWh to €0.128/kWh • Co-firing in fossil fuel plants: €0.03/kWh to €0.065/kWh • Biofuels: €0.1/kWh for plants>200 kW, €0.13/kWh for plants <200 kW • Biogas: €0.0725/kWh to €0.165/kWh • Landfill gas: €0.03/kWh for plants>1 MW, €0.06/kWh for plants < 1MW	The Act guarantees payment of feed-in tariffs for 13 years
Belgium	€0.2/kWh (fix price) + €0.25 /kWh (green certificates)	In Flanders, if the supplier does not comply with this obligation, they are fined €75 per missing certificate (1 MWh) in 2003, €100 in 2004 and €125 in 2005 In Wallonia, the supplier will be fined €100
Denmark	€0.081/kWh during 2001-2002	Feed-in tariff was launched in 1996. In anticipation of the start of the green certificate market, new tariffs were adopted in 2001. The support is generally lower than that in previous policies, the tariff set for electricity from new plants for the first period is nearly 30% lower than that for existing plants, but the tariff for biomass maintains the feed-in tariff of € 0.081/kWh since 1996.
Finland	Tax refund	Since 1997, biomass electricity generation became eligible for a refund of €0.042 per kWh on the electricity tax at distribution level. The refund was increased to €0.069 per kWh, and include logging chips, recycled fuels and biogas
France	• Bioenergy (<12MW): 7 ct/kWh • Biogas: from 4.5 ct/kWh (unit power above 6 MW level) to 5.72 ct/kWh (under 2 MW level) • Municipal solid wastes (<12 MW): from 1.74ct/kWh (summer) to 3.72ct/kWh (winter) in France (continental and Corsica), from 3.05 ct/kWh to 3.72ct/kWh in the overseas areas	Feed-in tariff adopted since 2001, a 15-year contract with guarantees rate

Germany	● Sewage gas, landfill gas and marsh gas: ✓ <0.5 MW, €0.0767/kWh ✓ >0.5MW, €0.0665/kWh ● Biomass: ✓ <0.5MW, €0.101/kWh ✓ 0.5-5MW, €0.089/kWh ✓ >5MW, €0.084/kWh	Adopted in 1991, and updated in 2000. From 2002 on, the remuneration paid for newly commissioned plants has been reduced annually to provide stronger incentives for cost reductions. The factor is 1% for biomass-fuelled plants.
Greece	In 2001, the average buy-back tariff was € 0.0616/kWh in interconnected system, and €0.0731/kWh (in 2001,IEA data)	Enacted in 1999. In the interconnected network, the Public Power Corporation (PPC) pays the generator a price which is composed of an energy and a capacity charge. The energy charge is 90% of the energy part of the medium-voltage domestic end-use tariff and the capacity charge is 50% of the capacity part of same tariff. In the non-interconnected islands, PPC pays only for energy not capacity. The price paid by PPC is 70% of the low-voltage end-use tariff.
Ireland	The price under AER VI (2003-2005): ✓ Biomass (8MW): 6.412ct/kWh ✓ Biomass –Anaerobic Digestion (2MW): 7 ct/kWh ✓ Biomass-CHP: 7ct/kWh	The Alternative Energy Requirement (AER), a bidding system, was launched in 1994. The AER VI have been conducted by 2003, and front weighting of the bid price was provided for, allowing a price increase of 35% for the first 7.5 years of the contract followed by an associated decrease of 35% for remaining 7.5 years.
Italy	Price for green certification is 6.7ct/kWh, plus the electricity price 5 ct/kWh, the total price for biomass electricity is 11.7ct/kWh (Wind 12 in China)	Feed-in tariff was launched in 1991, the fixed price was set. Green certification/quota system (GC) was launched in 1999, at least 2% of electricity should be produced from renewable sources. The RES producers that already benefit from the energy feed-in tariff provide could not obtain green certificates.
Korea	Landfill gas plant: ✓ <50 MW: KRW 61.8/kWh ✓ <20 MW: KRW 65.20/kWh	In 2002, the government set up a standard price for renewable energy power generation in order to support the use of new and renewable energy sources

Netherlands	9.7ct/kWh (6.8ct/kWh fix price + 2.9 ct/kWh tax exemption)	Since 2001, a Green certificate System has been used for the validation and monitoring of the production and sales of green electricity under the REB. The REB system was adapted with the enaction of Environment Quality of Electricity Production (MEP) in July 2003. The envisaged policy scheme combines a lower exemption level of taxation on consumption with a technology specific feed-in tariff (MEP). Green certificates will remain to be used. The MEP is a kWh subsidy that is paid to domestic producers for electricity from renewable sources and CHP who fee-in to the national grid. It is guaranteed for a maximum of ten years (not for CHP). The level of producer support is differentiated for technologies. In 2003, small stand-alone biomass installation has highest price (6.8ct/kWh), and small stand-alone biomass, landfill, and 100% biomass project have 2.9ct/kWh tax exemption. With this tax level, green electricity is on average as expensive as regular electricity.
Spain	• Fixed price: ✓ 6.85ct/kWh for energy crops electricity ✓ 6.05ct/kWh for other biomass electricity • Market electricity price + incentive price ✓ Incentive price – energy from biomass: €0.0279/kWh in 2002, and € 0.0332/kWh in 2003 – energy from livestock manure: €0.0271/kWh in 2002, and €0.0294/kWh in 2003	Projects can select between (1) a fixed contract price, and (2) a bonus incentive in addition to the market (pool) price, Tariffs are set as a percent of the average electricity rate.
Portugal	€0.06198/kWh in 2003	Since, the feed-in tariffs have been specified per technology.
Sweden	Market electricity price + €0.009/kWh incentive price	Feed-in tariff launched since 1997
Switzerland	CHF0.15/kWh	The tariff is adjusted to be higher during daily peak periods and lower in summer but the annual average must be met. Applied period: 1991-2008

Feed-in tariff in most countries give a guarantee period, most biomass electricity projects have 10-20 years guarantee period. In some cases, the tariff does change on a predictable schedule during the contract period. Table 5-2-2 shows some international examples of guarantee period for biomass project.

Table 5-2-2 International examples of guarantee period for biomass project

Country	Contract duration
Germany	20 years in virtually all cases
Austria	13 years for all RE
France	15 years for biomass and biogas from waste
Greece	10 years plus renewal option
Netherlands	10 years
Portugal	12 years
Spain:	Contract for life of facilities; tariff is variable
Denmark	10 - 20 years for fixed premium or tariff

In order to encourage the technology improvement and reducing the cost of renewable energy electricity, some countries ask for period evaluate the tariff, and some countries gave an automatic tariff reduction.

- In Germany, the automatic tariff reduction depends on the technology, solar (5%-6.5%), wind (2%), biomass (1.5%), larger hydro and geothermal (1%), small hydro (0%).
- In France, reduction rate in wind tariffs is 3.3% per year, but not reduction rate is asked for the biomass electricity.
- In Spain, the modification of renewable energy premiums has been introduced in the legislation that set the yearly electric tariffs in 2001. The premium for energy from biomass has been increased from €0.0279/kWh in 2002 to €0.0332/kWh in 2003, and also for the livestock manure management from €0.0271/kWh to €0.0294/kWh; conversely, the premium for wind energy has been reduced from €0.0290/kWh to €0.0266/kWh.

The incentive function of feed-in tariff on renewable energy power generation is very obvious and efficient. However, it has no incentive function on the other utilization of renewable energy. Furthermore, the heating utilization of biomass is also an important utilization method and field. Therefore, it is no enough for biomass energy development to adopt feed-in tariff. The other incentive

policy should be synthetically adopted to promote each technology developing.

5.2.2 Renewable portfolio standard (RPS)

RPS is a new incentive policy of renewable energy with electricity market reform. RPS prescribe that electricity producer or supplier should have some share of electricity in the producing or supplying from renewable energy, which will be realized through Green Electricity Certification and. Green Certification means the certification for sale the green electricity. When the power producer of renewable energy sells the electricity for the electricity market, they can acquire a Green Certification. The certification can be freely traded based on the Green certification trade system. If the electricity producer or supplier has not the electricity from renewable energy, they can purchase the Green Certification from the other renewable energy enterprise. At the same time, the renewable energy enterprise can acquire the additional income through selling the Green Certification to accelerate the renewable energy development.

The RPS can give the renewable energy investor economic subsidy through Green certification trade, and ensure the renewable energy development in the quota through penalty payment for non-compliance. The main characteristic of RPS is that the renewable energy can be developed based on the least cost in the market mechanism. But the RPS exists some limits, which is as follows. The market mechanism will bring on the uncertain electricity price of renewable energy, increase the investment risk of renewable energy, and induce the unjust competition among the renewable energy enterprise with the different scale and different technology.

In addition, the biomass heating utilization can be involved in the range of incentive policy by RPS in the theory. But the policy range need be decided by the policy maker. The first, the object type need be confirmed. There are two objects to be selected. The one is the share of renewable energy power generation in the total electricity consumption. The other is the share of renewable energy consumption in the total electricity consumption. Secondly, the measure of object need be confirmed whether biomass-heating utilization can be involved. At present, the electricity from renewable has been confirmed as the energy object of RPS in Australia. But the calculation method can be promulgated; such as the supply production of solar heating is converted into the electricity output. However, the RPS of other countries only pays attention to the renewable energy power generation.

Presently, some countries have begun to implement RPS, such as Australia, UK, Sweden, Italy, and some states of USA and so on.

- In Italy, Feed-in tariff was launched in 1991 and the fixed price was set, In 1999, Green certification/quota system (GC) was launched to meet the national renewable energy objective, which is at least 2% of electricity should be produced from renewable sources. Now, the price for green certification is 6.7ct/kWh, plus the market electricity price 5 ct/kWh, the total price for biomass electricity is 11.7ct/kWh. And, according to the national regulation, the RE source producers that already benefit from the energy feed-in tariff provide could not obtain green certificates.

- In Sweden, the electricity certificate trading system was established in May 2003. The objective is to achieve a 16.9% share of RES-E in electricity consumption in 2010 from 7.4% share in 2003. The price for Green certificate is estimated to be around 0.55ct/kWh. The certificate price will be set on the market. However, there is a minimum price and a penalty level.
    - The minimum price is the buy-out price at which the government promises to buy certificates from producers. This starts at 60 SEK/MWh (about 0.66 ct/kWh). The guaranteed price are: for 2004 €6.6152 per certificate, for 2005 €5.5127 per certificate, for 2006 €4.4101 per certificate, for 2007 €3.3076 per certificate and for 2008 €2.2051 per certificate.
    - A penalty for non-compliance is set at 175 SEK/MWh (1.93 ct/kWh) in 2003 and 240 SEK/MWh (2.63 ct/kWh) in 2004.
- In UK, the objective of UK is that the share of renewable energy electricity of total electricity consumption increases to 10% in 2010 from 2.8% in 2000. The Renewable Obligation was implemented on April 1, 2002 to replace the Non Fossil Fuel Obligation (NFFO) in order to meet this objective. The Renewable Obligation requires electricity companies to supply an increasing proportion of their production form renewable sources. In return, they will receive Renewable Energy obligation Certificates (ROCs), which can be traded domestically. A penalty is set for non-compliance: 30 GBP/MWh (about 4.5 ct/kWh). This penalty will be set annually in line with the retail prices.
- Australia: the Renewable Energy Act 2000 sets the framework for the Mandatory Renewable Energy Target (MRET). The government's renewable energy target seeks to raise the contribution of renewable energy sources in Australia's electricity mix by 9500 GWh per year by 2010 and maintain this requirement until 2020. Under this measure, tradable Renewable Energy Certificates (RECs) are used to demonstrate compliance with the objective. In order to meet their obligation, liable parties (wholesale purchasers) surrender Renewable Energy Certificate to the Renewable Energy Regulator. A Renewable Energy Certificates represents 1 MWh of electricity. The penalty payment for non-compliance is AUS$ 40 per MWh (non-tax deductible). The Office of the Renewable Energy Regulator administers the MRET.

Table 5-2-3 Information about RPS in selected countries

Country	Market electricity price	Green certificates price	Fine	Implementation time
Italy	€0.117/kWh	€0.067/kWh		1999
Sweden		2003: 60 SEK/MWh (about 0.66 ct/kWh) 2004: €6.6152/MWh 2005: €5.5127/MWh 2006: €4.4101/MWh 2007: €3.3076/MWh 2008: €2.2051/MWh	2003: 175 SEK/MWh (1.93 ct/kWh) 2004: 240 SEK/MWh (2.63 ct/kWh)	2003
UK	15-18 GBP/MWh in 2003-2004	45-48 GBP/MWh in 2003-2004	30 GBP/MWh (about 4.5 ct/kWh)	April 1, 2002
Australia			AUS$ 40 per MWh (non-tax deductible)	April 1, 2001

5.2.3 Bidding system

Bidding procedures can be used to select beneficiaries for investment support or production support (such as through heed-in tariffs), or for other limited rights such as sites for wind energy. Potential investors or producers have to compete through a competitive bidding system. The criteria for the evaluation of the bids are set before each bidding round. The government decides on the desired level of electricity from each of the renewable sources, their growth rate over time, and the level of long-term price security offered to producers over time. The bidding is accompanied by an obligation on the part of electricity providers to purchase a certain amount of electricity from renewable sources at a premium price. The difference between the premium and market price is reimbursed to the electricity provider, and is financed through a nondiscriminatory levy on all domestic electricity consumption. In each bidding round the most cost-effective offers will be selected to receive the subsidy. The mechanism therefore leads to the lowest cost options.

In order to maintain a differentiation in renewable energy sources, the bidding may be differentiated in bands of different technologies and energy sources. This means that biomass projects compete against other biomass projects but not against, for example, wind projects. The marginal accepted bid sets the price for the whole technology band.

Ireland is one of few countries using bidding system. The Alternative Energy Requirement (AER), a bidding system, was launched to promote renewable energy development combining with a corporate tax relief since 1994. The AER mechanism is the only dedicated subsidy system for production of renewable energies and it combines grant aid from the European Regional Development Fund (ERDP-subsidies) with price support above avoided fuel costs. The objective of an AER competition is to compete for rights to generated electricity and sell it to the ESB at agreed rates over a fifteen-year period. Prospective generators are invited to compete based on a price per unit of electricity. The six AERs have been conducted by 2003. Biomass/waste projects and Combined Heat and Power (CHP) projects are included in these six bidding projects. All these projects have 15 years operational period. According t to the results of AER VI (2003-2005), the electricity price for biomass (8MW) is 6.412ct/kWh, for biomass –Anaerobic Digestion (2MW) is 7 ct/kWh, for Biomass-CHP is 7ct/kWh.

5.2.4 Investment subsides

Investment subsides can help to overcome the barrier of a high initial investment. This type of subsidy is commonly used to stimulate investments in less economical renewable energy technologies. Investment subsidies are usually 20-50% of eligible investment costs, but in some case subsidy is given over the total eligible investment sum. The advantage of investment subsidies is effective to stimulate the activities of investors and enlarge the production scale, the disadvantage is that it can't promote technology improvement and reduce the cost since the subsidy has nothing to do with the operation of the enterprises.

Loans with a low interest rate are available for renewable energy including biomass, which is also very effective to reduce the total investment and the burden of the investment and interests for the enterprises. The disadvantage is that the government has to collect some money as discount or interest reduction subsidy.

For example, ***Sweden*** paid out €36 million from government budget to support biomass combustion and transfer technology since 1975, which is used in the RD&D and demonstration project in commercialization prophase. During 1997 to 2002, the share of investment subsidy for biomass CHP project was 25%, and the total subsidy was €48.67 million in five years. In addition, during 2004 to 2006, the government of Sweden provided the subsidy with €1350 per household for biomass supply heat system for resident living(use biomass solidified fuel).

Demark provides €4 million investment subsidy for biomass energy enterprise every year since 1981. At present, the electricity price of biomass on grid is only 8ct/kWh in Denmark.

During 1991 to 2001, federal government gave €295 million investment subsidy for biomass energy in German. Since 1990, KfW bank offered the loan with low interest for the private enterprise of biomass energy. The interest rate is 50% of the market interest. The farmer can acquire subsidy with DEM1000/ha for plant biodiesel feedstock (rapeseed). The enterprise producing biodiesel also can acquire the exemption form tax.

During 1991 to 1995, ***Italy*** provides 30% to 40% investment subsidy for biomass utilization project.

Japan supported the private enterprise to invest the renewable technology and utilization since 2003. The investment subsidy for biomass utilization project has accounted for 30% of investment cost and provided guarantee for 90% of total loan.

Europe provides subsidy with €45/ha. For the farmer planting energy crop to promote biofuel produce.

In ***Greece***, Law 2364/95, published in 1995, provided tax exemptions to households buying renewable equipment, 75% of the purchase value of renewable equipment can be deducted from taxable income. It has been estimated that this benefit can yield a real reduction in installation cost of up to 30%. Aid to Market penetration of Renewables - New Development Law 1998 provide a maximum 35% grant for investments in power generation and maximum 75% deduction form taxable income for the residential and service sectors.

In ***Portugal***, the subsidies are provided to public and private organizations for investments projects in four categories: renewables for electricity generation, energy management measure and co-generations, green fuels for transport fleets, fuel switching to natural gas. Subsidies vary according to renewable-type and projects economic feasibility, but in general correspond to approximately 40% of the investment.

Spain plans to increase ethanol production and to expand biodiesel plant capacity. Both national and regional governments provide subsidies for plant construction and for promoting ethanol use. Spain is the largest producer of fuel ethanol in the EU. Total biofuel production in 2001 was 80 000 tones and it s estimated to have increased to 187 000 tones in 2002.

5.2.5 Tax incentive policy

Tax incentive policy is a very important measure for promoting renewable energy development in the United States, EU and other developed countries. Incentive tax policy includes two types. One type is to give a favorable tax rate for renewable energy industry including reduce tax rate or exempt part taxes of custom tax, capital investment tax, VAT and income tax (both for enterprise and residents). Another type is to undertake force tax on non-renewable energy such as consumption tax and environment tax, which will increase the cost of non-renewable energy and increase the competition of renewable energy. It is proved by practices in many countries that the carbon tax, especially with high standard and high rate, is a perfect way to accelerate the clear energy development and application and encourage the enterprises to apply advanced technology and improve technical level.

The countries in EU levy the higher tax for energy consumption. The tax type includes energy tax, carbon tax and sulfur tax, especially the tax on oil consumption with higher levy, which accounts for tow third of gasoline and diesel price. Each country in EU exempts renewable energy utilization from all kinds energy tax.

Expect for proposing definite quota, the main policy measure to support biomass liquid fuel is exemption form fuel tax in EU. At present, the oil price is about €1/litre in EU, among which two third is fuel tax. However, using biomass ethanol will be exempt from fuel tax. Though the cost of ethanol fuel was twice as high as the gasoline cost, the biomass ethanol rapidly developed through this tax policy.

In ***Sweden***, there is high-energy tax. The tax includes fuel tax, energy tax, carbon tax, and sulfur tax. If all energy tax are exempted from, the electricity price can be provided €2/kWh preferential price. Therefore, the tax incentive policy is main policy in Sweden for promoting the biomass development and utilization. Namely, the biomass energy project is exempt form all kinds of energy tax.

In Germany, the federal government promotes the use of liquid biofuels for use in motor vehicles through tax exemption amounting to Euro 0.77/litre for rapeseed methyl ester. In November 2003, the government proposed changes to the tax law in accordance with a new EU Directive. The Change would entail a 100% tax exemption for biofuels for petrol taxes for a period of six years. The exemption would be granted to blends of up to 5% bio-ethanol, and exclusively for undenatured alcohol. According to the Eco-tax reform, the biofuels were exempt from the oil tax until the end of 2008.

In UK**, t**he Climate Change Levy is designed to promote energy efficiency and stimulate investment in new energy technologies and applied since 2001. The levy is a tax on energy use in industry, commerce, agriculture and the public sector. It applies to gas, electricity, LPG and coal. The levy is based on the primary energy content of the various fuels, not the carbon content. Levy rates are £0.43/kWh for electricity; £0.15/kWh for gas, £1.17/kg for coal; and £0.96/kg for LPG. In 2002, VAT rates on the biofuel have been reduced from 17.5% to 5% to correspond to the rate for domestic fuels.。

In Portugal**, t**he reduced VAT rate for renewable energy technology is 5% (compared to the normal VAT rate of 17%). Due to European fiscal harmonization this measure was revised in 2001 to the present rate of 12%.

Sweden**:** Sweden levies three different taxes on energy products: an energy tax, a CO2 tax and sulphur tax. **T**he small-scaled renewable energy based electricity production is partially or totally exempt from the energy tax levied on households and the service sector, this gives a tax benefit of 10-20 ct/kWh. Furthermore, producers and consumers of biomass-based electricity are exempt from various environmental taxes, such as the CO2 tax, sulphur tax and NOx levy.

Spain: The Law 24/2001 on Fiscal, Administrative and Social Measures offered corporate tax deductions for investment in renewable energy. Eligible investments entitle firms to a 10% tax deduction on installations or equipment using biomass form agricultural or forestry waste, solid municipal waste and biofuels. All ethanol and biodiesel producers are exempt from the hydrocanban tax. The percentage of ETBE in gasoline is exempt from the tax.

Dutch government set up regulating energy tax in 1997. In 2003, the energy tax on fossil electricity for small consumers (<10 000 kWh) was further raised to 6.39ct/kWh, with a partial exemption of 2.9ct/kWh for renewables. With this tax level, green electricity is on average as expensive as regular electricity.

5.2.6 RD&D budgets

The developed countries pay a lot of attentions on renewable energy RD&D. IEA countries' renewable energy RD&D budgets totaled about US$ 23.55 billion, some 8% of total energy RD&D funding from 1974 to 2002, renewable energy RD&D was US$ 65 million. Expenditures for renewables RD&D grew rapidly in the late 1970s and peaked in 1980 at just under US$ 2 billion. Expenditures declined by about two-thirds in the early 1980s but have been relatively stable since the late 1980s, in the range of US$550 million to US$ 700 million. Annual expenditures on renewables RD&D for all IEA countries averaged about US$ 650 million from 1990 to 2002, 7.7% of total government energy RD&D budgets.

The United States, Japan and Germany accounted for about 66% of total renewables RD&D funding period 1990 to 2002. Italy, the Netherlands and Switzerland accounted for an additional 15%. These six countries combined invested US$ 531 million per year on average for renewable energy RD&D. The United States had the highest average renewables RD&D budget of US$ 236.9 million per year. The average annual budget in Japan was US$ 110.9 million and in Germany US$82.8 million during 1990 to 2002.

Renewable Energy RD&D funding priorities usually reflect resource endowments. In Austria, Canada, Finland, Hungary and Sweden, biomass accounts for more than 40% of the renewable energy RD&D.

United States and the Netherlands have highest biomass RD&D input in the world. The average biomass RD&D budget during 1990 to 2002 reached US$ 60.3 million and US$ 7.7 million, and accounted for 25.5% and 23.4% of total national renewables RD&D budget in United States and the Netherlands respectively.

There have been many recent efforts to enhance the biofuel (including biomass ethanol and biodiesel) RD&D in IEA countries. Most IEA countries set up special biofuel RD&D projects to promote the research and utilizations of biofuel. In the United States, Biomass Research and Development Act was launched in 2000 with US$ 49 million budget for biofuel and biomass RD&D during 2000 to 2005; and also in 2000, Funding for the Development of Ethanol announced to award a one year US$7 million grant for developing enzymes to convert wood chips, corn stalks and other biomass waste to ethanol.

5.2.7 National protection measures

For protecting the farmer's benefit in USA and EU, these countries adopt the limitative measure for the import of biofuel because the developing countries in tropic area have obvious advantage of

competition in producing biofuel. For example, USA levies the tariff with 50 cent/ gallons on the import of ethanol from Brazil. The trade protectionism of developed country is of no avail for the development of biofuel.

5.3 The suggest for Renewable Energy Law detail rule

Renewable Energy Law has been promulgated by Standing Committee of the National People's Congress in February 28, 2005 and enacted in January 1, 2006. The law proposed the legal frame for supporting the development of renewable energy industry. For implementing the law in effect, the main department of national government, such as energy, price, finance, construction and standardization, establishes the matched regulation in administration and technology standard, which will implement in company with Renewable Energy Law in January 1, 2006.

At present, the following policies, management regulations and technical standards are being developed by central governments in order to ensure the smooth implementation of Renewable Energy Law:

- National Long & Medium Planning of Renewable Energy Development in China (2020), by Energy Bureau, NDRC
- National Guide Catalogue of Renewable Energy Industry Development, by Energy Bureau, NDRC
- Management Regulation of Electricity Price and Additional Price Sharing System for Renewable Energy, by Department of Price, NDRC
- Management Regulation of Renewable Energy Electricity on Gird
- Management Regulation of Renewable Energy Fund
- Loan and Subsidy Incentive Regulation for Renewable Energy
- Technical Code of Solar Water Heating System in Civil Buildings

Consulting biomass utilization experience from the other countries, and combining our status of economical and social development, the comments and suggestions for establishing these policies and management regulations are proposed to promote the biomass utilization and development in China, which is shown as follows.

5.3.1 Enhance the recognition of biomass utilization and development, and establish definite long& medium targets for biomass development

With the increasingly serious environmental problem from using fossil energy and gradually exhausted resource, the biomass energy is more and more important. Compared with traditional biomass utilization, the advance biomass technology has essential difference. The advance biomass technology is transferring the biomass to electricity, oil and gas. The utilization effect is the same as fossil energy. Therefore, on a long view and strategic development, it is very important to develop and

utilize the biomass. The targets and detail demand need be confirmed for biomass development and utilization. For example, EU claims the share of biomass liquid fuel, including biodiesel and ethanol, in fuel for vehicle should reach 2% in 2005, 5.57% in 2010, and 8% in 2015.

We suggest:

- The biomass development target, including the target for biomass generation, biomass heating, and biomass fuel respectively, should be identified in National Long & Medium Development Planning of Renewable Energy in China. Especially, the target of biomass heating, which is easy to be ignored, should not be missed in the national target.
- The target of biomass development in National Long & Medium Development Planning of Renewable Energy Development in China (2020) is suggested to set as:
  - In 2020, the installed biomass generation capacity will account for 5% of the total installed generation capacity, which is about 50 GW; the production of biomass solidified fuel will be about 200 million tons (about 100 million tce); the biomass liquid fuel will account for 10% of the transportation fuel.

5.3.2 Enhance biomass energy technology RD&R, pilot, and demonstration

The biomass utilization has many types and different degree. For realizing biomass energy utilization, the government of each country devotes a lot of technology RD&R budgets to overcoming the problem and obstacle in the biomass utilization based on the resource status and technology and economy situation. At the same time, the government of each country provides the investment subsidy (usually account for 20%-30% of total investment), tax incentive policy for pilot, demonstration project of biomass technology, and support united utilities, private enterprise and residential household utilizing the biomass energy.

Through effort for many years, in view of the technology capacity in the world, these technologies are mature, which including biomass solidified technology, biomass direct-fired generation power, ethanol and diesel using energy crop.

At present, small biogas digester for resident, large & medium scale biogas project, landfill gas utilization, bagasse CHP, and biomass liquid fuel has some experience and foundation in China. Furthermore, crop straw generation power, biomass solidified technology and fuel technology is beginning just now.

Because R&D, pilot and demonstration are foundation and ensure for the dissemination and wide utilization, the input on R&D, pilot projects and demonstration projects are very important Chinese biomass, which is just launched. For biomass technology R&D, pilot and demonstration, the report suggest:

- In National Guide Catalogue of Renewable Energy Industry Development, the following technology should be listed in the priority technology:

- Small biogas digester for resident
- Large & medium scale biogas project
- Landfill gas utilization
- Bagasse CHP
- Crop straw generation power
- Biomass solidified fuel
- Biomass ethanol and biodiesel technology

- In Management Regulation of Renewable Energy Fund, the following issues should be identified:
  - Clarify the support and input for biomass development, especially for the support and input for biomass technology R&D and demonstration projects.
  - Constitute to provide the financial support for biomass project in the rural area
  - Enhance the demonstration work to lay the good foundation of biomass technology utilization and spread in the large scale.
  - Expend the existing subsidy for domestic biogas digester and large scale biogas project in the rural area to more other biomass utilization

5.3.3 Constitute and embody feed-in tariff to accelerate biomass generation power development

Based on the implementing experience of incentive policy in the foreign country for ten years, the feed-in tariff, compared with the other incentive policy, is very adapted to the development of renewable energy in initial stages. The policy can effectively stabilize the market, reduce the risk of investor, and enhance the confidence of investor. At present, the feed-in tariff of renewable energy has been mature and recognized.

The biomass generation power has many types of technology, including agriculture and forest residues direct-fired and gasification generation power, MSW combustion and landfill gas generation power, and biogas generation power. Because the biomass generation power has different resource availability, technology type and development standard, the tariff of biomass power is different in the power project with different type and scale. The classified tariff will effectively promote all kinds of biomass generation power project in proportion.

The Renewable Energy Law has confirmed that the regulation of feed-in tariff, fixed price and full purchase should be implementing for renewable energy power. At the same time, the law defined that the electricity price of renewable power project should be confirmed according to different type of renewable power and different region status to promote renewable energy development and ensure the project benefit, and be adjusted with the development of renewable energy technology. Through effort

and communication, the department of government has been in accord with each other on the fixed price of biomass generation power. It need be paid attention to how to calculate the electricity price. Because there is little experience of biomass generation power in China, the all cost and risk need be fully considered when calculating the electricity price. The fixed price confirmed at the start should promote the development of biomass energy. The electricity price should been check termly to promote technology progress and reduce the cost.

In theory, the fixed price of biomass generation power should be confirmed according to the different technology, installed capacity. However, in view of little experience of biomass generation power project in China, it is relatively difficult to confirm the fixed price according technology type. Therefore, the electricity price with preferential benefit can be confirmed at the beginning to accelerate the development and utilization of biomass energy. Through the practice for one or two years, after having some experience and data, the price can be evaluated and checked to establish the detail the price catalogue of biomass generation power.

At present, Management Regulation of Renewable Energy Electricity Price and Additional Price Sharing System is being developed by Department of Price, NDRC. The regulation will very affect on the renewable energy generation power. The report suggests that the following content should be described in the management regulation.

- The feed-in tariff and price sharing system of renewable energy generation power should be determined based on the principle of promoting development, advancing efficiency, enhancing management, and fair burden.
- The investment return rate of renewable energy generation power should be higher than the average return rate of normal power plant.
- The electricity price of biomass generation power can adopt the market price plus incentive price.
  - The market price is the normal price on grid of coal power plant in each province.
  - The incentive price should be established according to the incentive principle. Because of limited experience on biomass generation, each cost and risk should be fully considered. The report suggests that the incentive price can be 0.25Yuan/kWh temporarily.
- The guarantee period for biomass incentive price should be 15 years since the operation. The incentive price will be cancelled after 15 years of operation.
- The incentive price catalogue of biomass generation power should be evaluated and published every two years. The initial annual decrease rate of biomass electricity price is set as 2%.

- For the co-fired biomass generation project, the share of biomass feedstock in total fuel should meet a proportion to gain the incentive price. The report suggests that the biomass generation project, which proportion of biomass in total fuel should be more than 80%, is the eligible project to gain the incentive price.
- According to relative regulation in China, the renewable energy project, which confirms the investor through bidding, will implement the direction price of government. The bidding price formed by market competition should be less than the published biomass electricity price in the local region.
- For public generation power system off gird of renewable energy, the sale price for user will adopt the average sale price in the local electricity grid. If the maintenance cost of the system is higher than the average sale price in the local grid, the margin of cost can be acquired by the electricity additional price of renewable energy form user.

5.3.4 Provide investment subsidy to accelerate the development of biomass gas fuel and supply heating

There is widely utilization of biomass supply heating in some countries of Europe. For example, the heat from biomass solidified fuel accounts for 50% of total supply heat in the region. Most of countries support the biomass gas fuel and supply heat through providing investment subsidy, exempting from tax.

Renewable Energy Law of China regulates the gas fuel and heat form biomass energy should be compulsively purchase according to feasible price with economical benefit. However, the price of gas fuel and heat is all audited and approved by the local government, at the same time, the market price and acceptability of user is very different in each city. Therefore, it is very difficult that the national government enacts the price catalogue for biomass gas fuel and heat and implement the compulsive purchase.

Therefore, compared with biomass generation power, the government need pay more attention to the development and utilization of biomass gas fuel and heat. The technology isn't only regarded, supported and supervised by the national government, but also managed and implemented in detail by the local government.

The suggestion is as follows:

- The central government should establish the special renewable energy fund to provide investment subsidy for renewable energy project, especially non-power renewable energy project, including biomass solidified fuel and biogas utilization.
- The local government should enact the implementing regulation of compulsive purchase and price catalogue for biomass gas fuel and heating.

5.3.5 Enlarge the range of pilot and demonstration to promote biomass liquid fuel development

As replacing oil, biomass liquid fuel has been regarded and supported by the government of each country in recent years. The government of each country adopts the all kinds of method to solve the technology problem, decrease the investment risk, reduce the production cost and develop market. The methods include providing RD&R fund and investment subsidy, exempting from tax, and compulsively using etc.

The government of China began to build the pilot project of using ethanol of vehicle in Henan and Heilongjiang in 2002. In 2004, the range of pilot was enlarged into nine provinces, including Heilongjiang, Jilin, Liaoning, Henan, Anhui, nine cities of Hubei, seven cities of Shandong, six cities of Hebei and five cities of Jiangsu. In the pilot region, a series of incentive policies and measures were implemented, including compulsively using, investment subsidy, exempting from tax, confirming the bargain price and retail price of ethanol, which promotes the vehicle ethanol production, utilization, development. But these policies and measures are limited in the pilot enterprise and region.

As a result, the report suggest:

- Increase the investment for technology R&D, especially the biomass ethanol from non-grain production, to exploit a suitable technology roadmap for China
- Increase the investment for the technology R&D of vehicle using biomass liquid fuel to enlarge utilization range of biomass ethanol and biodiesel.
- Expand the pilot and demonstration range and applicable range of incentive policy and measure to attract the more investor and expand the market.

5.3.6 Research RPS and implement RPS in small range and suitable time

As a very effective incentive policy of renewable energy, RPS can develop the renewable energy with the least cost under the market mechanism. Because of without the relative RPS articles in Renewable Energy Law, it is impossible to implement RPS in the whole country recently. But because the RPS has strong restriction for the enterprise, China Government hope to enact the RPS for the large power companies at suitable time to supervise the large power companies investing renewable energy project.

Therefore, the suggestion is as follows:

- Continue to research the feasibility and implementing scheme of RPS, and carry out the pilot and demonstration project in small range to make ready for implementing RPS in the whole country.

5.3.7 Reduce and exempt the taxation to support biomass energy development

The tax reduction and exemption is an effective incentive policy widely adopted by many countries. The tax exemption covers income tax, fixed asset tax and VAT. Furthermore, Environment tax in Europe, which has a high rate for fossil fuel and exempt for renewable energy, is also a very useful incentive policy to encourage the development and utilization of clean energy, as while as to promote enterprise using the advance technology and improving the technology standard.

China has adopted some tax incentive policies for some biomass technology utilization, including landfill gas utilization (full refund all of VAT), biogas project (13% VAT rate), biomass ethanol in pilot provinces and cities (full rebate all of VAT, exemption of consumption tax). But, the applicable range of these incentive policies is limited to demonstration regions and enterprises, and limited technologies are beneficial from these tax policy.

Therefore, the report suggests that the Loan and Subsidy Incentive Regulation for Renewable Energy should be identified:

- Consulting VAT rate of wind power, the VAT of biomass project can be levied on 8.5%, including biomass heat supply and generation power; and for some special biomass projects, which is well contributed for environmental protection, such as landfill gas utilization, large & medium scale biogas project, and biomass liquid fuel, the VAT should full refund.
- The VAT refunds policy for biomass liquid fuel should be extending the whole country and whole related enterprises. The consumption tax for biofuel will be exempted.
- Research the feasibility and scheme of levying carbon tax in order to enact the carbon tax in suitable time. The fossil energy will be levied upon the carbon, but the carbon tax of renewable energy, including biomass energy, will be exempted from.

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