

# **Part 1**

## **Resource Overview**

# Biomass Resources and Utilization

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## I. Brief Introduction

- Types of resources
- Main technologies
- Final products

## Types of Biomass Resources

### Mainly include

- \* Organic wastes from agricultural and industrial sectors: crop residues, animal dung, waste water or residues from industrial and agricultural processing plants, such as slaughters, breweries, sugar makers, paper mills etc.
- \* Forestry wastes: wastes from wood processing
- \* Energy crops: forestry, oily plants etc.
- \* Municipal solid waste (MSW)

## Biomass Utilization Technologies

- Direct combustion
  - stove combustion technology
  - boilers/burners
  - briquetting
  - garbage combustion
- Physical conversion technology
  - wood carbonization
  - hydrogenation gasification
  - oil making by hydrogenation
- Chemical conversion technology
  - landfill and composting
  - small-scaled biogas fermentation
  - large/medium scaled anaerobic fermentation
  - ethanol making technology
- Energy-plant oil making technology

### Final Products Produced by Biomass Conversion

- \* Gaseous products: such as biogas, producer gas
- \* Liquid products: biofuels such as bio-ethanol, bio-diesel,
- \* Solid products: briquettes, pellets, bio-charcoal
- \* Electricity: one-stage conversion such as biomass combustion power generation, two-stage conversion such as biogas power generation

### II. Biomass Resources

- Crop residues
- Forestry wastes
- Firewood
- Animal wastes
- Organic industrial waste water
- Oily plants
- Material used for bio-ethanol production

### Crop Residues

- \* It's estimated, based on the planting area and ratio of grain to stalk of the main grains in 2000 in China, about 526 Mt of stalks was produced totally in that year, of which, the stalks produced from the five major crops including rice, maize, wheat, rape, and cotton was 477 Mt.

### Crop Residues

production amount (10 000 t/a)	provinces
< 1000	Beijing, Tianjin, Shanxi, Shanghai, Fujian, Hainan, Chongqing, Gansu, Qinghai, Ningxia
1000 - 2000	Inner Mongolia, Liaoning, Jilin, Zhejiang, Jiangsu, Guangdong, Guangxi, Guizhou, Yunnan, Shanxi, Xinjiang
2000 - 3000	Heilongjiang, Anhui, Hubei, Hunan, Sichuan
3000 - 4000	Hebei, Jiangsu
> 4000	Shandong, Henan

### Wastes from Wood Processing

- \* It's estimated, based on the production of timber in whole country in 2000, about 31.34 M t of wastes was produced from wood processing.

### Firewood Resources

In 1994, firewood forestry covered about 4.29 Mhm<sup>2</sup>, taking up to 3.34% of the total national forestry land. In 1998, 1999, and 2000, the firewood assumption was 4.10 Mm<sup>3</sup>, 3.88 Mm<sup>3</sup> and 3.28 Mm<sup>3</sup>.

### Firewood Resources

area of firewoods (1000 hm <sup>2</sup> )	provinces
< 100	Beijing, Tianjin, Shanxi, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Shandong, Hainan, Tibet, Gansu, Qinghai, Ningxia, Xinjiang
100 ~200	Henan, Guangxi
200 ~ 300	Hebei, Inner Mongolia, Jiangsu, Hunan, Guangdong, Guizhou
> 300	Liaoning, Jiangxi, Hubei, Yunnan, Shanxi

### Solid Wastes from Animal Husbandry

- \* In 2002, totally about 1.5 Bt of dung was produced from animal husbandry sector, of which, 334 Mt, 997 Mt, and 137 Mt from pig, cattle, chicken breeding respectively.
- \* In 2002, there were 8 241 intensive livestock farms that emitted 30.66 Mt of dung and 213.32 Mt of waste water totally in a year.
- \* About 19.46 Mt of dung was discharged from specialized animal breeding households at the same year.

### Definition on Scale of Intensive Livestock Farms

Types	Pig farm ( Annual output, heads)	Egg chicken farm (in stock, 10000 pcs)	Meat chicken farm (in stock, 10000 pcs)	Dairy farm (in stock, heads)	Beef farm (in stock, heads)
Middle scale farms	3 000 ~10 000	5 ~ 20	10 ~ 40	200 ~ 600	500 ~ 1 200
Large scale farms	> 10 000	> 20	> 40	> 600	> 1 200

### Definition on Scale of Intensive Livestock Farms

Types	Pig farm ( Annual output, heads)	Egg chicken farm (in stock, 1000 pcs)	Meat chicken farm (in stock, 1000 pcs)	Dairy farm (in stock, )	Beef farm (in stock, heads)
Scale	500 ~ 2 000	1 ~ 40 000	1 ~ 99 999	20 ~ 100	50 ~ 400

### Solid Waste Discharged from Intensive Livestock Farms in 2002

Solid waste discharge	Province
Over 2 Mt/a	Guangdong, Jilin, Beijing, Hebei
1M ~ 2 Mt/a	Heilongjiang, Liaoning, Fujian, Shandong, Henan, Zhejiang, Shanghai
Less than 500 000 t/a	Shanxi, Tianjin, Anhui, Hainan, Sichuan, Chongqing, Guizhou, Yunnan, Shanxi, Gansu, Qinghai, Ningxia

### Resources on Industrial Organic Waste Water

Annual production of industrial organic waste water: 2.51 Gt, solid residues: 73.78 Mt, of which,

**Light industries**

alcohol, sugar refinery, distillery, amylum,

monosodium glutamate, drink, paper mill and so on

846 Mt (solid wastes 24.44 Mt)

**Non-light industries**

medicine, slaughter, flour,

1.674 Gt (solid wastes 49.34 Mt)

oil, sauce, food , petrification, rubber, aldose

### Oily Plants

- \* Extending through warm and semi-tropical zones, China possesses plenty of crop diversities, 1 159 of which grow organs with 10% of oil.
- \* There are over 400 species with rich oil in China.
  - ① eucalypt; ② euphorbia; ③ C16-C18 trees with high content of unsaturated acid;
  - ④ herbaceous plants with high naphtha;
  - ⑤ oil plants.

### Starch-type Material for Bio-ethanol Production

- \* Potato: sweet potato, potato, cassava and so on.
- \* Grain Material: com, grain sorghum, barley, wheat, rain and so on.
- \* In 2001 - 2003, about 30 - 35 Mt of potato-typed products was produced averagely in a year.
- \* During the same period, 1.75 Gt of grain was produced averagely in a year.

### Sugar-type Material for Bio-ethanol Production

- \* Sweet sorghum: mainly trial plantation at present
- \* Sugar cane: average annual production during 2000 - 2003 was 75 Mt. Production from Guangxi takes nearly 50% of the total national production. 14 Mt and 12 Mt from Yunnan and Guangdong Provinces. The plantation of sugar cane is widely distributed in area southern to Yellow River.

### III. Biomass Development Status

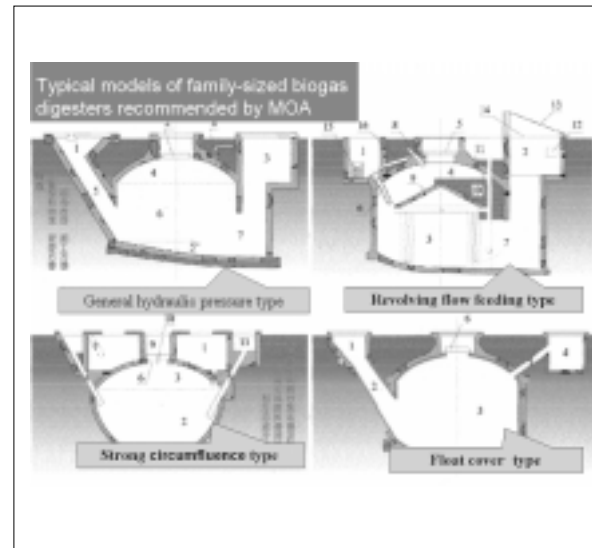
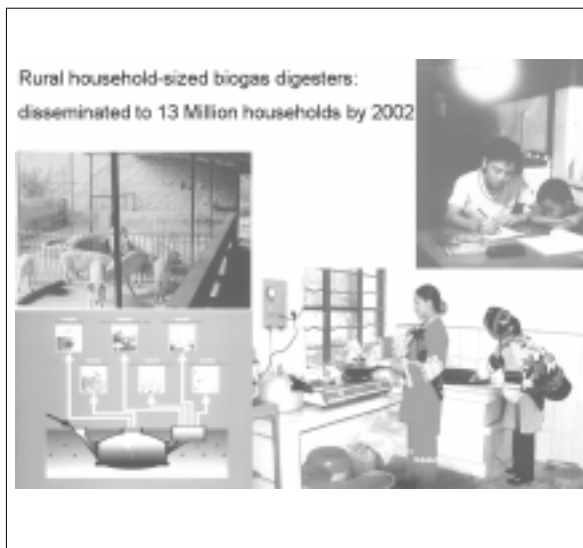
- \* Biogas from animal wastes
- \* Biogas from industrial organic waste water
- \* Biomass-fueled power generation and district heating
- \* Centralized gas supply by biomass gasification
- \* Production of bio-fuels

### Biogas Production from Animal Wastes

- Household-scaled biogas digesters
- Biogas plants at intensive livestock farms

### Biogas Production from Animal Wastes

- \* By 2003, there were over 13 M household-scaled biogas digesters all over China, which produce 3.9 Gm<sup>3</sup> of biogas in a year.
- \* By 2003, about 1 351 medium/large scale biogas plants which treat 22.86 Mt of wastes and produce 50.63 Mm<sup>3</sup> of biogas in a year.



By 2002,  
Large/medium biogas plants at  
intensive livestock farms: 1351 plants



## Industrial Organic Waste Water Biogas Plants

\* By 2003, there were over 600 biogas plants with fermentation volume of 200 m<sup>3</sup>. Total volume reached 1.5 Mm<sup>3</sup> that treat 150 Mt of industrial organic waste water and produce 1 Gm<sup>3</sup> of biogas in a year. Shandong owns 105 plants out of the 600 plants. Plants in Shandong, Sichuan, Jiangsu, Henan, Anhui, Guangdong, and Zhejiang Provinces take up to 61.3 % of the total.

## Power Generation and District Heating

- \* Until now, the installed capacity of biomass-fueled power generation plants reaches 2 000 MW, of which 1 700 MW is fueled by bagasse, the rest by agri/forestry wastes.
- \* Practice of power generation and district heating abroad
  - CHP: North Europe, Sweden, Austria and Finland. Biomass CHP for heat have reached 50% of the whole area.
  - District heating only

## Central gas supply system with biomass gasification



## Fuel Bio-ethanol

- \* Strategic measures to promote the development of bio-ethanol production
- Since June 2002, started to implement a one-year demonstrative projects in five cities including Zhengzhou, Luoyang, and Nanyang in Henan Province, Haerbin and Zhaodong in Heilongjiang Province.
- In February, NDPC and other eight ministries decided to spread the pilot plants gradually in Heilongjiang, Jinlin, Liaoning, Henan, Anhui province and some cities.

## Fuel Bio-ethanol

- \* Implementation
  - Currently, Heilongjiang, Jilin, and Liaoning Province begin to extend the use of bio-ethanol gasoline market will cover above 80% of the whole market in the provinces;
  - Henan will begin by Dec. 1, 2004;
  - Hubei, Hebei will spread the pilot plants in cities in the near future;
- \* Production
  - Until now, ethanol production reaches nearly 1 Mt, mainly using starch-typed grain as raw material such as over-time maize.

## Bio-diesel

- There are several small-scale plants to produce bio-diesel using oil from plants like colza and cottonseed, and using oil from kitchen waste. However, recently, in order not to compete for the same raw material resource of cook oil and industry oil, the bio-diesel technology was developed which use the fruit and seed of newly imported special trees and plants as raw material. A new market is going to be shaped gradually. Bio-diesel plant has been constructed in Sichuan Province with a capacity of 100000 tons of bio-diesel production using the special tree fruits. The company production standard has been set up. The current productivity is 20000 tons per year.
- The factor restricting bio-diesel development is the price. A 133.4 hm<sup>2</sup> of seedling farm for this tree has been set up in Panzhihua, Xichan and Liangshan in Sichuan province in 2001, aiming to populating 20010 hm<sup>2</sup> of this trees. This oily tree has been planted 3335 hm<sup>2</sup> and 6670 hm<sup>2</sup> in Sichuan Province in 2003 and 2004 respectively.

## IV. National Plan on Biomass Development

### National Plan on Biomass Development

- By 2020, renewable energy power generation will take up to 10% of and the fourth biggest sector in the power generation of the whole state. Wind power, small hydropower, and biomass fueled power will be 20 GW, 50 GW, and 20 GW respectively.
- By 2020, annual bio-fuel production capacity will reach 11 M tons of oil on the market.
- Aiming at commercialization, the integrated system of biomass gasification and power generation on a basis of the village and small town, to supply commercial energy as much as equivalent to 100 million standard coal.

### National Plan on Biomass Development

#### Biomass fueled power generation

- By 2020, the installed capacity of biomass fueled power generation: 20 GW, of which
- Biomass gasification/combustion for electricity: 17160MW
- Middle and large scale biogas for electricity: 1280MW
- garbage combustion for electricity: 2050MW
- Landfill gas for electricity: 500MW

#### Bio-fuel

- Production capacity of bio-ethanol: 10 Mt per year
- Production capacity of bio-diesel: 1 Mt per year

## V. Feasibility Analysis on Plan's Implementation

Biogas power generation

Bio-fuels

Biomass-fueled power generation

Power generation of MSW

## Biogas Power Generation

- The biogas production potential will reach 21.5 B m<sup>3</sup> in 2020, double of that in 2001.
- Count as availability of 60% by 2020, industry organic wastewater can produce biogas of 12.9 billion m<sup>3</sup>, power generation of 22.22 billion kWh, installed capacity of biogas for generating power can be 1 744MW.
- So, intensive livestock waste biogas engineering and industry organic wastewater biogas engineering can generate power of 969 MW.
- So, consider from the supply of the resource, under the appropriate law, the planed quantity of 1 280MW can be fulfilled.

## Biogas Power Generation

- The annual manure discharge is estimated to be nearly 1.5 billion tons according to the in stock pigs, cattle and poultries in 2002. The manure discharge is predicted to be 4 426 billion tons. It can produce 157.5 billion m<sup>3</sup> biogas which can generate 283.45 billion kWh of electricity.
- Considering the restricting factors such as scale of the livestock farms, manure collection coefficient, investment and utilization efficiency of the plants, biogas production from manure can generate 28.35 Billion kWh if we make use of 10% of the manure resource, the power capacity will be 28.345 billion kWh by 2020, and 2225 MkW power installation using biogas could be achieved. (base on electricity generation of 1.8 kWh per m<sup>3</sup> biogas. One kW installed capacity generates 6,000 kWh electricity a year)

## Bio-fuels

- As forecasted, if maintaining the existing mobile structure and fuel assumption of each vehicle, about 1 M vehicles will be used and 228 M tons of gasoline and diesel will be assumed in China in 2020.
- Blinding 10% of bio-fuels in fossil gasoline and diesel in 2020, then the bio-fuel demand will reach 22.80 M tons.
- That is, the targeted production capacity at the national development plan will satisfy about 50% of the total assumption (when blinding 10% in all the used fuels).

## Bio-fuels

### Pre-conditions and assumptions

Use corn to produce bio-ethanol

- 3.3 tons of corn can produce 1 ton of bio-ethanol.
- Plantation of 6 mu of corn outputs 3.3 tons of maize.
- Therefore, assuming fully use corn for the 10 M tons of bio-ethanol production, about one fifth of the total corn's plantation areas in 2000 should be needed.

## Bio-fuels

### Pre-conditions and assumptions

use sweet sorghum to produce bio-ethanol

- 16 tons of sweet sorghum's stalks can produce 1 ton of bio-ethanol.
- Plantation of 4 mu of sweet sorghum outputs 16 tons of stalks.
- Therefore, assuming fully use sweet sorghum for the 10 M tons of bio-ethanol production, about 60% of the total sorghum's plantation areas should be shifted to plant the needed sweet sorghum.



## Bio-fuels

Considering the food security, better use non-food related crops as the material for bio-ethanol production.

According to the local concrete situation, nationally to set up a bio-ethanol production structure with multiple types of raw materials.

To promote the bio-fuel production in a greater efforts, such as enlarge the planed target on bio-ethanol production (80% even 100% use of the blinded gasoline).

## Power Generation Fueled with Agri/forestry Wastes

### Pre-conditions and assumptions

- Totally, about 526 M tons of crop residues was produced in 2000 in whole country.
- There would be no tremendous change on grain production structure in China until 2020.
- About 30% of the total crop residue is available for energy use.
- Considering the factors on practical feasibility of collection, transportation, investment scale etc., the real utilization rate of the crop residue is around 20%.
- Taking the residue combustion as the technique, 1 MW installed capacity of the system consumes about 5500 tons of residues.

## Power Generation Fueled with Agri/forestry Wastes

Therefore, the total installed capacity practically is about 5.8 GW.

Similarly, assuming that the real utilization rate of the forestry wastes is around 50% as energy use, the total installed capacity on forestry waste conversion is about 3.0 GW practically.

## VI. Several Considerations

Priorities on Biomass Development  
&  
Governmental Support

## Priorities on Biomass Development

- Solid biomass power generation
- Promotion of bagasse, rice husk, woody waste power generation
- To construct demo combustion/gasification cogeneration plants or district heating systems, e.g., on large state-owned farms, where there is plenty of organic resources.
- Mixed combustion technologies, such as co-combustion of biomass with coal, crop residues with rice husks.
- Demo on village-scaled biomass power plants

## Priorities on Biomass Development

- **Biogas technology**
- Industrial organic waste water with higher gas productivity.
- Pig manure derived biogas plant.
- Demo projects of central biogas plants consuming / treating animal waste.
- R & D of biogas power generators and controlling systems

## Priorities on Biomass Development

- **Bio-fuels**

Crops with less relevancy to national food security

- Bio-ethanol, such as sweet sorghum
- Bio-diesel, such as oily plants, crop residues

## Capacity building

- Evaluation of biomass resources at provincial level
- Evaluation and feasibility study on biomass conversion technologies
- Methodology study on biomass CDM projects and their development
- Fostering and training on equipment manufactures and project developers

## Governmental Support

- Launch of the Law on Renewable Energy Promotion
- Construction of pilot/demonstrative biogas plants
- Research and development of key technologies
- Promotion of international exchange and cooperation in the necessary fields

Thank You !