Memo: BUS-report on BUS-ticket B5
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# Quick-scan on the supply of biomass in China

**Formulation of the problem**
Studies by Koopmans and Koppejan (1998)[1] and Jingjing et al. (1998)[2] have estimated a large, unused biomass potential in China, mainly consisting of forestry and agricultural residues and municipal solid waste. However, it is unclear what the impact is of current agricultural practice, traditional uses of residues and the future demand for food, on the availability of these residues.

**Questions**
1. How large is the biomass potential in China, especially in the forestry and agro-sector for the main types of residues?
2. What is the current use of agricultural residues and how much of it can be sustainably used for bioenergy purposes? What problems are to be expected?
3. What are the characteristics of the current agricultural practice, how is it expected to change and what would be the influence on the future biomass supply?

## 1. Introduction

Biomass in China may be derived from (1) forestry and wood processing, (2) agricultural production and processing of agricultural products and (3) from municipal solid waste. A forth main source of biomass, manure from animal husbandry, is not taken into consideration in this quick-scan, because it requires a completely different conversion route (anaerobic fermentation producing biogas). Neither have we looked for information on dedicated energy crops, such as e.g bamboo. In a more thorough future assessment all these resources may be dealt with in greater detail. Furthermore, the current approach by means of a quick-scan, gives a rough overall picture, which does not do justice to the great regional variation which exists in China.

### 1.1 Forest resource assessment[3]

- Total land area 960 million ha ( 280x The Netherlands). Chinese total forest area is 164 million ha (i.e a 16.5% forest cover), of which 70% is designated for timber production (i.e.110 million ha). China's State Forestry Authority has set a target to increase forest coverage to 19% by 2010, which would imply an increase of 18 million ha of forests in the next 5 years. The current (2004) afforestation rate is 2.7 million ha/a. Forest cover is expected to reach 24% by 2030.
- Distribution of forests in China is extremely uneven due to large geographical differences: in the northwest provinces e.g there are very few forests. Consequently, there are large differences in regional timber supply, China's traditional timber base being the north-east of China.
- By the 1990's China's forests have been vastly overexploitated, resulting in disastrous floods which killed thousands. In response, the government has banned logging in some natural forest areas and implemented a huge tree planting programme.
- As a response to the major floodings of the Yangtze River, a natural forest resources protection program was implemented in 1998, which focuses on protection of the upper reaches of the Yangtze river, the Yellow River and parts of northern China and inner

[1] Koopmans, A. and Koppejan, J. 1998. Agricultural and forest residues – generation, utilization and availability. In: FAO 1998. regional Consultation on modern applications of biomasss energy, January 6-10, 1997, Kuala Lumpur, Malaysia
[2] Jingjing, L.I, Jinming, B.A.I and Overend, R. 1998. Assessment of biomass resource availability. Chinese Ministry of Agriculture and US Department of Energy, China Environmental Science Press, Beijing
[3] Anonymus 2001. China: timber trade and protection of forest resources. Chinese Academy of International Trade and Economic Cooperation

Mongolia. Due to this protection program the domestic timber supply has dropped dramatically.

- While the government is giving priority to protection of the natural environment, China is trying to compensate the shortfall in domestic timber production by vigorously speeding up to plant fast-growing, high yielding man-made plantation forests, especially in southern and southeastern regions of China, where water and climate conditions are more favourable and where trees are planted mostly for commercial purposes. In the north, northwest and northeast of China trees are planted mainly to form anti-desert shelterbelts[4].
- By 2003 the total tree plantation area was 46 million ha, with an annual increase of 2 million ha. Farms for fast growing trees covering 13 million ha will be set up over a period of 15 years (from 2000 to 2015) across the country, which are supposed to meet up to 40% of the countries future demand for timber[5].
- The expansion of commercial tree plantations is to be achieved largely through foreign investments and by joint ventures with companies such as Weyerhauser[6]. Government incentives to encourage foreign investments in tree plantations include low interest loans, fifty years leases on land, tax fee income from thinnings and allowing private forestry on public land. This policy has already resulted in half a million ha's of forest being planted[7]. There is a Fast-growing Timber Plantation Program and a Conversion of Forest to Cropland Program, with millions of ha's of cultivated land being converted back to forests each year to curb soil erosion and desertification. However, recently there have been conflicting demands on land by policies to increase agricultural crop production (especially the production of grain)[8].
- China's government even intents to rent overseas land such as in Malaysia for the planting of fast growing trees for wood fibre production

**Timber procurement**

- In 1999 China's total wood production was 280 million m3, of which the production of saw timber was 52 million m3. The national saw timber consumption was 92 million m3, far exceeding domestic supply. Annual saw timber supply is expected to decrease from 52 to 40 million m3/a by 2010, due to further logging restrictions in natural forests.
- Fast economic growth has boosted the demand for timber, especially for building and interior decorating, but also for furniture, charcoal an paper making. By 2010 China's timber supply will fall short of demand by 70 million m3.
- Imports of timber can help mitigate the shortage of domestic timber supply. China has already become the world's second largest importer of forest products after Japan and it is the top importing country worldwide of industrial roundwood.
- China is the largest buyer of stolen timber in the world: about 44% of all timber imports are from illegal sources[9].

**Fuel wood supply**

China is one of the world's largest wood producing countries, although two-thirds of its production is burned as fuel[10]. China's total annual fuel wood production was estimated 190 million m3 in 2002[11]. This amount includes all roundwood used for cooking, heating and power production. It includes wood harvested from main stems, branches and other parts of trees and wood intended for charcoal

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[4] William F. Hyde, Brian Belcher, Jintao Xu (eds.) 2003. China's Forests. Global Lessons from Market Reforms, 214 pp

[5] Xinhua News Agency, May 9, 2001

[6] Higgs, G. 2004. China's booming demand and it's impact on Canada. Taiga news 48, 2004

[7] According to the Tropical Forest Products Information and Consultation Center of China in 2001

[8] Zang Lei, 2004. Peoples Republic of China Solid wood products Annual 2004. USDA Foreign Agricultural Service, Global Agricultural Information network report CH4024.

[9] IEA 2004. The last Frontier. Illegal logging in Papua and China's massive timber theft. Report Environmental Investigation Agency

[10] Wood and paper product markets in China. Abare current issues 02.4, March 2002.

[11] Earth trends 2003: http://earthtrends.wri.org country profile China

production. However, it does not include biomass from indirect sources such as industrial residues derived from wood processing industries and recovered wood (wood waste from demolition, packaging, etc).

According to the resource study by Koopmans and Koppejan (1998), which presents somewhat outdated information, wood processing residues derived from saw milling and manufacturing plywood and particle board, may amount to 20 million m3/a (table 1 and 2). At present, the bulk of these residues remains unused. The amount of recovered wood in China is not known.

**Current uses of wood processing residues** in China are for instance:

- Internal heat supply (steam)
- Source of energy for manufacturing of bricks
- Small industrial applications
- Feedstock for blockboard and particle board
- Saw dusk may be briquetted and carbonised (high-grade charcoal)
- Used to cover charcoal mound kilns; used for insect repellents

As liquid propane gas and electricity are going to be distributed more widely throughout the country, some of the current fuel wood resource (190 million m3/a) may be used by the emerging bioenergy market or redirected towards wood panel and paper production, who rely on the same raw material. Given that two-third of China's wood resources are used for fuel, even a small percentage reduction in the traditional fuelwood demand could release a significant amount of wood for other uses. At present, wood chips for paper making are being imported mainly form Indonesia and Australia, wood pulp from Canada Indonesia and Chile and softwood logs mainly from the Russian Federation. If part of this very vast fuel wood resource is going to be used in more energy efficient ways, this will create substantial savings.

Table 1. Common recovery rates in forestry and wood processing
(percentage of inputs, usually logs)

| **Operations** | **Rec.Rate** | **residues** |
|---|---|---|
| Logging | 60% | 40% |
| Saw milling | 45-50% | 50% |
| Plywood production | 50-55% | 50% |
| Particle board prod. | 90%* | 10% |

* in which all types of wood are used and residues are partly being recycled.
Recovery rate

Table 2. Estimated amounts of forestry and wood processing residues in China in 1997

| **Residues from forestry and wood processing** | **Million tons/a** | **%** |
|---|---|---|
| Logging residues* | 46 | 66 |
| Saw milling | 15 | 22 |
| Plywood production | 5 | 7 |
| Particle board production | <1 | 5 |
| **Total** | **69** | **100** |

* excluding yields from conventional thinnings and clear cuts

**Conclusions on forest biomass**

1. China's forest resources are still under-utilised: the total annual increment is 485 million m3, of which only 280 million m3 is being harvested at present. This is a 58% utilisation rate. Most of the forest (73%) is natural forest, of which 90% is located in mountainous areas. Government policies discourage logging in natural forests. Therefore, the possibilities to significantly increase present-day harvest levels are limited. Yet even a small increase would mean a huge additional supply.

2. The government is actively stimulating the establishment of fast-growing tree plantations, but it will take some time before they reach maturity. In the mean time China will need substantial imports of wood products. However, imports of stolen wood from illegal logging and associated trade is a big problem, acknowledged by the Chinese government.
3. The traditional use of fuel wood is substantial. The introduction of modern, highly efficient conversion technologies will create large savings. Due to the increasing popularity of propane gas as the main household fuel, in some areas a substantial amount of fuel wood may become available for renewable energy. On the other hand e.g. the charcoal and paper industries are competing for the same raw material resources.
4. In a few decades the newly established tree plantations will yield a considerable amount of timber but also will produce large amounts of biomass for bioenergy. Because these tree plantations are still relatively young, at least half the volume of their annual increment (i.e. 10 m3/ha/a) could become available for bioenergy purposes. Assuming a tree plantation area of 60 million ha by 2010, half of which will then be 20 years old, the total annual yield will be about 150 million m3 of biomass (30 million ha x 5 m3/ha/a)
5. In the mean time, before these tree plantations are mature enough to be thinned commercially, and as the local fuel wood resources are becoming more and more depleted, imports of large amounts of fuel wood is conceivable, given the aggressive way in which China is importing other raw materials.
6. This could impact the international biomass trade, in which sustainability issues are considered crucial. However, at the moment it seems unlikely that sustainability aspects of biomass imports will rank high on the China's priority list.

### 1.2 Agricultural production

To a very large degree China's agriculture is characterised by relatively high-input cropping systems. The total area of cultivated cropland is about 130 million ha. Table 3 gives an overview of the main cops. In central, southeast and southwest China there is about as much irrigated land as dry land agriculture. In northern China the farming is mainly on dry land. In southern China rice, sugar cane and oil bearing crops are cultivated; in northern regions the main crops are corn, soybeans and tubers. Rice and wheat is grown in all regions of China.

Although China is rapidly changing into an urban and industrial society, 63 percent of China's population still live in rural areas. Currently, one third of the total energy consumption in rural areas comes from biomass. This corresponds with 200 million tons of coal equivalent.[12] 70 million people experience shortages of cooking fuel. In some areas, inappropriate utilisation of natural resources has caused environmental degradation and soil erosion.

**Bioenergy**

The Chinese Ministry of Agriculture has made bioenergy a priority area. However, much R&D still needs to be done on the commercialization of biomass resources, on conversion technologies and on market development. In 2006 a Chinese Renewable Energy Law will become effectuated[13], which, however, does not apply to the direct burning of straw and firewood in low-efficient stoves. The Renewable Energy Law encourages the conduction of resource surveys, the formulation of mid and long term targets en the preparation of a renewable energy development and utilisation plan. It will fund R&D and the establishment of demonstration projects. The Chinese government will encourage the development of dedicated energy crops, the production and utilisation of liquid biofuels and renewable energy in rural areas. There will be tax incentives and a renewable energy development fund to support research, pilot projects in rural areas, surveys and assessments of resources and the development of information systems. An example of a project funded by the Asian Development Bank to enhance the development of sustainable bioenergy systems in rural areas in China with special

[12] Jingjijng et al 1998
[13] www.renewableenergyaccess.com/assets/download/China

attention for the environment and poor farmers participation is the "Efficient utilisation of agricultural waste project", which was initiated in 2002 in the provinces of Henan, Hunei, Jianxi and Shanxi.[14] According to a recent assessment by the Chinese Biomass Development Center in Beijing by 1999, about 1.6 MTOE of energy consumption in China has come from biomass energy through energy-efficient technology and biomass energy conversion technology[15].

Table 3. Overview of the main agricultural crops in China in 2001

| **Crops** | **Area (M ha)** | **%** | **Production (M tons)** |
|---|---|---|---|
| Rice | 29 | 22 | 177 |
| Wheat | 25 | 19 | 94 |
| Corn (maize) | 24 | 18 | 114 |
| Veg. oil crops | 15 | 11 | 29 |
| Soybeans | 13 | 10 | 20 |
| Tubers | 10 | 8 | 35 |
| Cotton | 5 | 3 | 5 |
| Sugar cane | 1 | 1 | 75 |
| **Total** | **130** | **100** | |

(Source: National Bureau of Statistics of China)

Straw and stalks from agricultural crops are available in almost all regions of China. Koopmans and Koppejan (1998) estimated the total amount of residues from crops in the field 900 million tons/a (table 4). Note that these estimates were based on an assumed product/residue-ratio, which can vary considerable. A more thorough study by Jingjing et al (1998) estimates the total available amount of crop residues at 600 million tons/a, most of which (58%) is being used for cooking and heating in rural households. Other traditional uses include forage (24%), organic fertiliser (15%) and as raw material for paper production (3%).

Table 4. Estimated amounts of crop residues in the field in China (1997)
(Koopmans and Koppejan 1998)

| **Crop residues (in the field)** | **Million tons/a*** | **%** |
|---|---|---|
| Rice straw | 356 | 39 |
| Wheat straw | 216 | 24 |
| Maize stalks | 209 | 23 |
| Soybean straw & pods | 51 | 6 |
| Cotton stalks | 38 | 4 |
| Sugar cane tops | 24 | 3 |
| Others | 12 | 1 |
| **Total** | **900** | **100** |

* 15% moisture content on average

An important observation is that the present use of agricultural residues is at very low efficiency, which means that there is considerable scope for improvement. In many areas the traditional straw consumption is rapidly decreasing due to a combination of increasing incomes and the availability of fossil fuel resources such as coal, gas, oil and electricity (table 5 and 6). Jingjing (1998) estimate that the traditional use of straw as fuel has already reduced from 350 million tons to about 150 million tons/a in 1998.[16]. This would imply that about 200 million tons are available in a sustainable way for

[14] http://www.adb.org/Documents/RRPs/PRC/rrp_33443.pdf
[15] Z. Yuan, C.Z. Wu, H. Huang, G.F. Lin 2002. Research and development on biomass energy in China. International Journal of Energy Technology and Policy 2002 - Vol. 1, No.1/2 pp. 108-144
[16] Report of Sustainable Development Study in Rural Areas, Energy Consulting Program of the Chinese Science Academy of Engineering, in: Jingjing et al 1998.

more efficient bioenergy purposes and 150 million tons for traditional biofuel purposes (350 million tons in total).

Table 5. Energy consumption in China (2001)

| | % |
|---|---|
| Coal | 67 |
| Crude oil | 24 |
| Hydro | 7 |
| Natural gas | 3 |
| total | 100* |

(Source: National Bureau of Statistics of China)
* 100% corresponds with 1320 million tons of standard coal equivalents

Table 6. Consumption of electricity in 2000 (million GWh)

| | Million GWh |
|---|---|
| Total | 1.35 |
| Residential households | 0.18 |

Projections by 2010 indicate a total production of straw and stalks of 725 million tons/a. Excluding the straw used for forage, paper making, fertiliser and collection losses, the amount available for bioenergy use will be 375 million tons, which corresponds with approximately 170 million tons of coal equivalents or with 450 TWh of green electricity (assuming reasonable conversion efficiencies)[17]

In addition to residues derived from primary crop production, the processing of agricultural products too produces significant amounts of residues, which according to Koopmans and Koppejan (1998) may total about 150 million tons/a (table 7). Furthermore, woody residues from pruning plantation species (coconut, oil palm and rubber trees) in China amount to 2 million tons/a in total (mainly derived from rubber plantations).

Table 7. Estimated amounts of residues from processing agricultural products in China (1997) (from: Koopmans and Koppejan 1998)

| **Residues from processing** | **Million tons/a*** | **%** |
|---|---|---|
| Rice | 54 | 34 |
| Maize | 48 | 31 |
| Sugar cane | 24 | 15 |
| Groundnuts | 22 | 14 |
| Others | 7 | 6 |
| **Total** | **155** | **100** |

**Current uses of agricultural residues**
Residues usually are used for various purposes in the local community: the 6 F's: fuel, fodder, fertiliser, fibre, feedstock and further uses. Some residues have multiple uses: e.g rice straw used as medium for mushroom growing and for animal bedding and subsequently used in composting; rice husks are used as an insulator and as biofuel for power generation in large rice mills, with ashes used by the steel industry; crop residues are used as a source of energy for the brick industry, and they are widely used as a domestic fuel in areas where fuel wood is scarce. In other areas stalks and straw are simply left in the field or burned in the field (ash serves as fertiliser). Landless people are often allowed to collect residues on other people's lands. Trying to use these residues for renewable energy without offering compensation is asking for trouble. Thus a large proportion of agro-residues is used as fuel, fodder, animal bedding, paper making and building material.

[17] Jingjing et al (1998)

### 1.3 Organic fraction of municipal solid waste

With the growth of cities and continued urbanization by 1995 China had 640 large cities, ten of which with populations over 2 million. In 2001 the number of large cities had already increased to 662, twenty five of which with populations over 2 million (table 8). In 1995 these cities produced 107 million tons of residential solid waste and 30 million tons of excrements. More recent 2001data by the national Bureau of Statistics of China indicates a production of 135 million tons of municipal solid waste.

Table 8. Cities in 2001

| Population | Number of cities |
|---|---|
| < 200,000 | 37 |
| 200,000 – 500,000 | 180 |
| 500,000 – 1 million | 279 |
| 1 – 2 million | 141 |
| 2 – 4 million | 17 |
| > 4 million | 8 |
| Total | 662 |

Waste resource utilisation is still very low. In many small cities the economy is still comparatively backward. In cities where the rate of gas use for cooking is high, the amount of inorganic waste is low and consequently the organic content high. The applied measures of solid waste disposal are landfilling, composting and incineration. At present, sanitary landfill is the main method used in China accounting for 96% of all waste disposal. Waste incineration is less than 1% [18]. Forecasts predict that somewhere between 2010 and 2020 the urban population will outnumber the rural population (in 1995 70% of the population still lived in rural areas; in 2001 the rural population was 62%) and total population numbers will have increased to almost 1.5 billion (by 2001 total population was 1.27 billion).

As income increases and as consumption and lifestyle changes, the amount and composition of municipal solid waste also will change, i.e the higher the income the more refuse. By 2010 a total of 290 million tons of refuse is forecasted, which is more than a doubling compared with the 135 million tons in 2001. By 2020 the amount may even be 400 million tons. This demonstrates a rapid increase in the amount of municipal solid waste in China. In the near future China will face a huge task of determining how to dispose of increasing amounts of municipal solid waste and making use of these waste resources.

### Conclusion on MSW

There will be a rapid increase in the amount of municipal solid waste in China, part of which may be used as a resource. The recoverable fraction, however, is unknown.

## 2. Discussion

For a country with 1.3 billion consumers and limited natural resources, China is surprisingly self sufficient in food supply. It is even a net exporter of many food products, primarily to neighbouring Asian countries. China's agriculture has to feed 22% of the world's population on 7% of the world's arable land, 67% of which lies in remote mountainous areas. China has ten persons per hectare to feed from arable land, whereas the world's average is 4.4 people per ha.

[18] Kefa, C., Mingjiang, N., Jianhua, Y., Yong, C., and Xiaodong, L. The progress for the thermal treatment of municipal solid waste in China. Conference proceedings from the 4th International Symposium on Waste Treatment Technologies, 29 June - 2 July, 2003, Sheffield, UK. 5 pp.

China maintains its high level of food production by double cropping (planting winter wheat and summer corn), and by applying large quantities of fertilisers and pesticides to its limited land base[19]. In 2001 the use of chemical fertilisers totalled 42 million tons[20]. Furthermore, China has a relatively high share of its land irrigated (41%, i.e. 54 million ha). Due to the intense use of land, about 30% of China's arable land suffers from wind and water erosion, by which 5 billion tons of topsoil are washed away each year. About 27% of its total land area suffers from desertification, which affects over 400 million people.

China's annual grain production was about 466 million tons in 1995; peaked in 1998 with 512 million tons and dropped to 452 million tons in 2001, according to the National Bureau of Statistics of China[21]. Over the past 5 years (from 1999 to 2004 data) China's annual grain harvest has dropped 70 million tons, which is an amount that exceeds the entire grain harvest of Canada! (2004 grain harvest was 438 million tons). China's harvest shortfalls of recent years have been covered by drawing down its stocks of grain, which were filled up to the brim by record harvests in 1998 and 1999 (with 512 and 508 million tons respectively). However, these will soon be depleted, forcing the government to cover the shortfall with imports. The rice deficit is even more serious. Trying to cover a rice shortfall of 20 million tons in a world where annual rice exports total only 26 million tons will have an enormous impact on the world rice economy. And with a corn shortfall of 15 million tons China may soon have to import corn as well.

The fall in China's grain harvest is due largely to reduction of the area of arable land used for cereal production from 90 million hectares in 1998, via 82 million ha in 2001 to 76 million hectares in 2003.[22] Reduction of the grain area was caused by several factors: the loss of irrigation water, desert expansion, the conversion of cropland to non-farm uses, the shift to higher-value crops and a decline in double-cropping, which was partially due to the loss of farm labour in the more prosperous coastal provinces, as farmers have sought higher paying jobs elsewhere. Water shortages in important grain-producing regions in China may significantly affect its agricultural production potential. In the competition for scarce water, China 's cities and industry invariably get first claim, leaving farmers with a shrinking supply.

The high level of fertilizer and pesticides use on most arable land (fertiliser use is about the US average with 367 kg/ha) means that greater agricultural input use may not be sustainable. Water supplies are dwindling and pollution is worsening. More than half of China's rivers and lakes are already seriously contaminated. About 80% of discharged water is not effectively treated before release. The available area of arable land is further reduced because of China's policy to return ecologically fragile land to forest and grass cover. Because farms are increasingly remote from cities, inadequate storage and transportation networks are now responsible for 10% of China's grain losses and 33% of its fresh vegetable losses.

The agricultural sector will face the need to make more efficient use of its resources , e.g. by changing the mix of crops planted, adopting higher yielding varieties, improving land management and by achieving an economy of scale. China's farms are small and cultivated by family households. The average size is less than 1 ha. The inequality between rural and urban areas will create a significant income gap, which will be an important consideration in future rural development policies. Already the per capita income and living standards in cities are twice as high compared with rural areas. With three workers for every hectare of farm land, farming in China is very labour intensive and consequently income per worker is low. China is expected to see an exodus of labour from rural areas to urban areas.

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[19] http://www.ers.usda.gov/publications/aib775/aib775e.pdf
[20] National Bureau of Statistics of China
[21] http://www.stats.gov.cn/english/statisticaldata/yearlydata/YB2002e/ml/indexE.htm
[22] http://www.theglobalist.com/DBWeb/StoryId.aspx?StoryId=3827

All these examples illustrate that China's food supply comes from a decreasing land base, both in quantity and quality. The strong income growth and rapid urbanization are diversifying China's diet and creating demands for high value and speciality food products. When people move to cities they tend to eat more meat, processed food and restaurant meals and less grain. Urban residents consumed 70% more meat and eggs than rural residents, revealing a pattern in consumption growth in China in the coming years. Already in 1996 China has surpassed the USA in red meat consumption, eating five times more meat than 18 years earlier[23].

**Country in transition**

Since 1978 China has been in transition from a rural to an urban society and from a command economy to a market based one. Due to these transitions China has experienced one of the fastest agricultural growth rates, i.e. 6 percent per year for two full decades. Agriculture has played an important role in poverty reduction, lifting over 200 million people out of poverty[24]. Recently China has joined the World Trade Organisation, which will certainly affect the trade in agricultural products.

It is unlikely that WTO accession will threaten China's more or less self-sufficiency in grain production in the near term. In the longer term, however, market forces may bring about structural adjustments within the agricultural sector, such as more labour intensive crops that need less land. The prevailing small scale of farms makes producing high value crops (e.g fruits and vegetables) more profitable. The lifestock sector is expected to play a key role in reshaping China's agriculture in the coming years. The shift from backyard to modern feeding operations will expand the demand for feed ingredients, including grains and protein meals.
As the Chinese agricultural sector modernizes itself to face global competition, China's rural economy must reconsider the deployment of agricultural inputs. Rural policies continue to impede the free flow of land, labour and capital. Lack of land ownership and poor access to credit discourage investments that have long-term productivity payoffs, such as soil conservation measures.[25]

It is highly uncertain how these transitions towards a more efficient agricultural sector will affect the future availability of biomass. It will probably decrease. At the moment, the Chinese government is actively stimulating the afforestation of arable land. In due time these forest will yield considerable amounts of wood products. The fuel wood fraction will probably be as much as 150 million m3 of fuel wood per year. Traditionally, residues from primary agricultural production have been used in many ways. However, the growing urbanisation in the coastal provinces already has lead to shortages in labour in rural areas. Some of the traditional uses of residues will certainly decrease or even disappear and become available for alternative uses.

**Factors affecting the use of residues**

- Seasonality in supply
- Ownership and access
- Fraction economically recovered
- Environmental considerations
- Current and competing uses, which influence the availability and price
- Availability of appropriate equipment

Because of the increasing popularity of using liquefied propane gas by private households (table 9), it is very likely that fuel wood and crop stalks are going to present a huge unused biomass resource. Projections by 2010 indicate that perhaps as much as 376 million tons of residues per year could become available as biomass for energy purposes and as a raw material for bio-based products. How much of it will actually be deployed by the emerging bioenergy market will very much depend on the

[23] Jennifer Lin, 1996. Battle to satisfy awesome appetite: China's vast needs could disrupt the security of world food supplies, *South China Morning Post*, 22 November 1996, p.21.
[24] http://www.index-china.com/index-english/agr-s.html
[25] http://www.ers.usda.gov/publications/wrs012/wrs012a.pdf

state of commercialization of biomass resources, available conversion technologies and the demands made by other industrial users.

Table 9. Population numbers with access to gas (2001)

| Type of gas | Population in million |
|---|---|
| LPG | 140 |
| Coal gas | 43 |
| Natural gas | 32 |
| total | 215 |

(Source: National Bureau of Statistics of China)

**3. Conclusions on agricultural residues**

This quick-scan should be considered a first attempt to get an impression of the residue situation in China. Because of the very limited time-frame, the results can only be provisional. To get a more complete picture a more thorough assessment of the available sources of information will be needed, especially to do justice to the great regional variation in China. In many areas current economic developments are extremely fast. Consequently, the information will be quickly outdated. That is why it may be useful in a possible follow-up study to verify these findings with the views of a number of experts in the field of forestry, agronomy and waste management.

1. It seems that at present a considerable amount of agricultural residues are unused in China.
2. Even if they are used, the current residue-use is very inefficient, leaving much scope for savings and improvements
3. The large and complex local and regional differences which exist in China are not taken into account in this resource assessments yet, which results in an over-simplification of the actual situation. Region specific data are needed.
4. Unreliability of data is a big problem. Because most information is scattered, incomplete and often outdated and because of the limited time available for this quick-scan, data on actual use of residues were difficult to find, which e.g. could imply that much less residues are actually available than this study suggests.
5. Social impacts of a re-allocation of biomass sources are largely unknown, but will be very important for the actual implementation of bioenergy schemes.
6. It is of critical importance that he on-farm effects on soil conservation and soil fertility (affecting future crop growth), on income generation, on the local environment and on the livelihood of local communities (e.g differences in access to residues) are adequately addressed since they determine the social and environmental sustainability of the agro-residue resources.
7. The agricultural sector will feel the need to make more efficient use of its resources, as it modernizes itself to face global competition. In the longer term, market forces may bring about structural adjustments within the agricultural sector in which case the deployment of agricultural inputs and their environmental impacts will have to be reconsidered. This trend towards a more efficient agriculture will probably reduce the availability of residues in the long run.

## 4. Overall conclusions

1. Projections by 2010 indicate that 376 million tons of agricultural crop-residues per year could become available. Residues from forestry and wood processing may increase from 180 to 249 million m3 , the fast growing tree plantation will start to yield 150 million tons of fuel wood and the recoverable amount of municipal solid waste will more than double (table 10).

2. To utilize this vast biomass resource, totalling over 1 billion tons/a, the development and implementation of highly efficient conversion technologies will be urgently needed.

3. Thus it seems likely that at the short term China will not much impact the international trade in biomass. Much can be gained by energy savings and the application of energy-efficient technology.

4. It seems that in the biomass-scene the sleeping dragon has not awakened yet (but probably soon will…) .

Table 10: Current supply of residues and projections by 2010 (million tons)

| **Main sources of biomass** | **Current supply** | **2010 projections** |
|---|---|---|
| Forestry + wood processing | 180 | 249 |
| Fuel wood from tree plantations | - | 150 |
| Agricultural residues | 350 | 376 |
| Municipal solid waste* | 135 | 290 |
| **Total** | **665** | **1065** |

* of which the recoverable organic fraction, unfortunately, is unknown

## 5. Follow-up?

To get a more complete picture a more thorough assessment of the available sources of information will be needed, especially to do justice to the great regional variation in China. In a possible follow-up study it may be useful to verify these findings with the views of a number of experts in the field of forestry, agronomy and waste management.