BIOFUELS - AT WHAT COST ?

Government support for ethanol and biodiesel in China

November 2008

Prepared by:
the Global Subsidies Initiative
of the International Institute for Sustainable Development

Based on a report commissioned by the GSI from the Energy Research Institute
of the National Development and Reform Commission

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Where values in Chinese yuan renminbi (CNY or RMB) have been converted into U. S. dollar values, the exchange rate used was from www.xe.com in July 2008, where 1 CNY equals US$ 0.146. U. S. dollar values have been rounded.

Abbreviations and acronyms

CNPC	China National Petroleum Corporation
CNOOC	China National Offshore Oil Corporation
CNY	Chinese yuan
DDGS	Distillers dried grains with solubles
FAO	Food and Agriculture Organization
FAS	Foreign Agricultural Service (of the United States Department of Agriculture)
E10	A blended fuel comprised of approximately 10 percent ethanol and 90 percent gasoline
GHG	Greenhouse gas
GSI	Global Subsidies Initiative
IEA	International Energy Agency
IISD	International Institute for Sustainable Development
IMF	International Monetary Fund
MBD	Million barrels per day
MTOE	Million tonnes of oil equivalent
NDRC	National Development Reform Commission
NOx	Nitrogen oxides
OECD	Organisation for Economic Co-operation and Development
PM 10	the concentration of particulate matter of 10 microns or greater diameter
RIRDC	Rural Industries Research and Development Council (Australia)
RMB	renminbi
SOx	Sulphur oxides
TCE	Tonnes of coal equivalent
UNDP	United Nations Development Program
USDA	U. S. Department of Agriculture
USGC	U. S. Grains Council
US$	U. S. dollars

Executive summary

In recent years, the governments of a growing number of countries have promoted industrial-scale production and use of liquid biofuels—fuel-grade ethanol and biodiesel[1]—and backed that commitment with financial support. This report, one of a series of country studies undertaken by or for the Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (IISD), examines the types and magnitude of support to biofuels in China.

Maintaining a reliable and secure energy supply to power China's economic boom is one of the Chinese Government's top priorities. With oil imports surging, private car use soaring and the costs of environmental pollution mounting, a domestic biofuels industry seemed an attractive option to Beijing. The Chinese Government also saw a biofuels industry as a means of building a "new socialist countryside" by providing alternative markets for grain and improving incomes and employment opportunities in China's impoverished rural areas. China is now an enthusiastic supporter and promoter of biofuels for transport.

According to government data commissioned by the GSI, China provided a total of RMB 780 million (US$ 115 million, roughly US$ 0.40 a litre) in biofuel subsidies in 2006 (table below). These comprised support for ethanol in the form of direct output-linked subsidies paid to the five licensed producers, as well as tax exemptions and low-interest loans for capital investment. Further support is provided through mandatory consumption of ethanol-blended fuel in ten provinces (a ten per cent blend with gasoline, E10).

No official subsidies are currently available for biodiesel, although this is likely to change in the near future, with direct subsidies expected to be introduced before 2010. Ethanol and biodiesel industries are also likely to benefit from subsidies for feedstock production and soft-loans for research and development. A lack of publicly available data prevented the quantification of these forms of support.

Total support for ethanol and biodiesel is expected to reach approximately RMB 8 billion (US$ 1.2 billion) by 2020, according to official estimates. This is likely to be a significant underestimate, as it does not include support to feedstocks such as the RMB 3000 (US$ 437) per hectare per year available from 2007 for farmers growing feedstock on marginal land.

Official data on biofuel production and subsidies in China

		Ethanol					**Biodiesel**				
	Units	2004	2005	2006	2010^e	2020^e	2004	2005	2006	2010^e	2020^e
Production capacity	million tonnes	1.14	1.34	1.56	2.00	10.00	0.06	0.13	0.19	0.20	2.00
Subsidies[1]	million RMB	680	730	780	940	4220	–	–	–	370	3680
	million US$	100	107	115	135	615	–	–	–	55	540

Notes: e = estimate; 1. Subsidies comprise direct payments, tax exemptions and low-interest loans.

Source: National Development and Reform Commission, 2008.

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[1] "Biofuel" refers to liquid renewable fuels such as ethanol (an alcohol fermented from plant materials) and biodiesel (fuels made from vegetable oils and animal fats) that can substitute for petroleum-based fuels.

China launched its Ethanol Promotion Program in 2002. The programme has steadily expanded over time, with the provision of support shifting from direct subsidies to tax-breaks and low-interest loans. China now produces around 1.6 million tonnes of fuel ethanol a year, with maize constituting about 80 per cent of the feedstock in 2007. One large, state-owned enterprise owns or has a significant stake in four of the five plants that are licensed to provide ethanol to state-owned petrol stations for blending and distribution. The sector is heavily regulated, with new ethanol plants requiring central government approval. All transport fuel prices in China are controlled by the government and the ethanol price is set at 0.911 times the ex-factory price of gasoline (research octane 90) with a sales price within RMB 4000–5000 (US$ 584–730) per metric tonne. However, following the government's decision to lift petrol prices in June 2008, the ethanol price reportedly rose to RMB 5890 (US$ 859) per tonne (China Chemical Reporter, 2008).

China's Medium and Long-Term Development Plan for Renewable Energy nominates biomass energy as a priority sector and sets targets of 2 million tonnes by 2010 and 10 million tonnes by 2020 for non-grain fuel ethanol use.

As China is a net importer of vegetable oils, the government has not promoted biodiesel use as a transport fuel. At present, biodiesel is not officially distributed through petrol stations in China, nor is there a national biodiesel standard. Producers sell it directly to users, without taxation or direct fuel subsidies. According to Chinese Government sources, total Chinese biodiesel output in 2006 was 190 000 tonnes. Press and other reports indicate that the figure now is much higher, with estimates of recent production in the range of 200 000 to 300 000 tonnes. The absence of taxation on this level of biodiesel consumption provides an unofficial subsidy of around RM 65 million (US$ 9.4 million) per year (foregone consumption- and value-added tax revenue on 200 000 tonnes of biodiesel consumption).

A target for biodiesel use has been set for 200 000 tonnes by 2010 and 2 million tonnes by 2020. To help reach the 2020 target, it has been reported that the Chinese biodiesel industry expects a comprehensive development plan to be released by the end of 2008, with direct production subsidies to be awarded this year.

China's biodiesel industry is dominated by small-scale operators using animal fats or waste cooking oil as feedstock. However, the prospect of government support is attracting larger market entrants as well as foreign investment. There are now at least eleven operational biodiesel plants with at least another twenty-eight planned or under construction, including some with an annual production capacity of over 100 000 tonnes. Compared with the ethanol sector, the biodiesel industry is largely unregulated and there is significant involvement from the private sector.

The high cost of feedstock in 2007 and the first half of 2008 eroded profitability of both fuel ethanol and biodiesel production in China. High maize and cassava prices and the fixed ethanol price means Chinese ethanol producers rely on government subsidies to turn a profit. Ethanol producers have called for more government subsidies and a more flexible pricing formula to take into account rising feedstock prices. Waste oil prices have also risen significantly and, with Chinese fossil diesel prices capped by the state and remaining relatively flat compared with international diesel prices, profitability for biodiesel has been significantly eroded. In the absence of subsidies, biodiesel producers survive by either switching to production of alternative products for the chemicals industry or taking advantage of localized fossil-diesel shortages by charging users a premium for biodiesel. Little of either fuel is imported or exported.

The Chinese Government now realizes the inherent conflict between biofuels and food production in China. China's Ethanol Promotion Program was originally envisaged as a means of using up stockpiles of maize that had gone stale. It was not until these stockpiles were depleted, and ethanol producers turned to fresh maize, pushing domestic prices to record highs, that the government became aware of the potential for biofuels to compete with food crops for land and undermine China's food security policy. China is experiencing a sustained period of inflation with rising food prices, underpinned by domestic and international biofuels production. Rising vegetable oil prices as a result of international biodiesel production in particular have hit China hard. The government responded by halting the construction of new maize-based ethanol plants and promulgating policies to encourage the production of biofuels from non-grain feedstocks grown on marginal land.

The lack of available land on which feedstock crops can be produced is the most significant constraint on the expansion of China's biofuels production. China already endeavours to feed its 1.3 billion people, around 20 per cent of the world's population, with less than seven per cent of the world's arable land. Land and water resources have been stretched to the limits of sustainability (if not beyond) to achieve food security.

Chinese officials themselves have noted that an increase in ethanol production would depend on whether enough land could be found to plant feedstock crops and that, given the shortage of suitable land, it would be very difficult to achieve the large-scale production targets laid out in the Medium and Long-term Plan. The authors estimate that, at the very least, 2.23 million hectares would be used for the production of biofuels in China next decade if production and planting targets are met.

The government has identified 35 to 75 million hectares of marginal land that might be suitable for biofuel feedstock crops. There is no set definition of "marginal" land but it appears to include saline land, steep hillsides and may also refer to land that is not currently being used for any obvious productive purpose. The economic, social and environmental impacts of using these lands for biofuel production will depend on local circumstances.

From an economic perspective, the extent to which marginal land could viably support biofuel crops is uncertain. Yields from sub-optimal lands may be insufficient to make cultivation profitable. Also, there have been no analyses to determine whether growing feedstock crops is the most economically valuable allocation of China's land resources.

The use of marginal land for feedstock production may provide opportunities for poor farmers. Biofuel crops could provide a source of cash income for farmers in some of China's poorest regions, particularly if farmers are able to contract directly with energy companies. However, there is evidence that small landholders can be at risk of displacement due to illegal or unjust land acquisitions, as local government and investors establish large-scale biofuel developments. Many of the potential non-grain feedstocks identified by the Chinese government (such as cassava and sweet potatoes) could in fact be directed towards food production or animal fodder, helping to alleviate high food prices. If biofuel crops divert water and fertilizer from food crops, that also could affect food availability and prices.

From an environmental perspective, the cultivation of feedstock crops such as sweet sorghum on degraded saline or arid lands could be beneficial for erosion control and improvement of soil health. Where forest, grassland or vegetated hillsides are converted for feedstock production, there will be consequential carbon dioxide emissions from vegetation and soil, potential loss of biodiversity, erosion risk and impacts water quality due to pesticide and fertilizer run-off.

The National Development Reform Commission (NDRC) has identified Southwest China as a key area for the production of *Jatropha curcus* as a biodiesel feedstock, and provincial governments have set ambitious acreage targets for the establishment of jatropha plantations. Southwest China is one of China's most ecologically important regions, containing most of China's remaining natural forests as well as the headwaters of the Yangtze and the Mekong rivers. The development of large-scale jatropha plantations could threaten biodiversity and harm important waterways, through erosion and agricultural run-off. Subsidies available to farmers for the cultivation of biofuel crops on marginal land are significantly higher than those paid to farmers to set aside marginal land for conservation purposes, so withdrawals from China's environmental set-aside program (Grain for Green) are possible.

These area payments could also be become expensive for the government if farmers and agro-industries are able to access generous per hectare payments for growing small quantities of biofuel feedstocks on infertile land. Such an outcome would deliver little biofuel per subsidy-dollar. On the other hand, putting in place minimum yield or land quality requirements would risk encouraging the cultivation of arable land for feedstocks.

Even under the most optimistic scenarios for Chinese biofuel production (if production targets are met) soaring private vehicle ownership means domestic production of biofuels would have a negligible effect in reducing China's oil consumption or increasing energy security. China is projected to use 800 million tonnes of oil equivalent in 2030, according to the International Energy Agency. By 2020, the government target of 12 million tonnes of biofuel production would be equivalent to less than two percent of total oil consumption (taking into account the lower energy content of biofuels compared with petroleum).

Pollution benefits are likely to be marginal, also. Analysis by the Chinese government found significant reductions in sulphur, carbon monoxide and greenhouse gas emissions from vehicles using E10 compared with running the same vehicles on gasoline. Once all stages of the production of the biofuels were taken into account, however, the reductions were found to be minor, and some pollutants actually increased using E10 in place of pure gasoline.

Maize farmers in China have benefited from increased prices as a result of fuel ethanol production. Some jobs have been created in impoverished rural areas. However, these localized benefits would seem to be outweighed by more widespread negative effects of higher food prices, which hit China's poor hard in 2007 and 2008. Small-scale farmers face increased risk of displacement and land seizures as a result of provincial government and investor enthusiasm to expand large-scale biofuel feedstock production into new areas.

Government support for biofuels in China does not appear to be delivering the hoped-for benefits for energy security, pollution control and rural development that motivated the development of its biofuel policies. There is also the potential for unintended negative consequences that could actually undermine the government's economic, social and environmental goals.

On this basis, the authors recommend that:

- direct production-linked subsidies for fuel ethanol production be eliminated and direct subsidies for biodiesel production should not be introduced; and
- government support for biofuels demonstration projects should be limited to those that can clearly avoid competition with food or feed production to encourage greater research and development of genuinely non-food biofuels feedstock sources, particularly lingo-cellulosic sources.

Remaining conflicts between biofuels and food production, and between biofuels and the environment, require further consideration. In particular:

- any subsidies paid to farmers for conservation set-aside programs should be brought into line with those paid to farmers to produce biofuels (or the latter subsidies reduced);
- the survey of marginal land currently being conducted should investigate the likely impacts of biofuels production on marginal land on food production, the environment and local livelihoods; and
- site-specific assessments ensure that biofuel development on marginal land is appropriate under local circumstances.

More generally, China should hasten the liberalization of transport fuel prices. China's current price caps serve to undermine the government's energy-efficiency goals. If improving energy security and reducing urban pollution are genuine priorities, then allowing domestic fuel prices to rise to those established in international markets would be the most effective step that China could take to curb demand, particularly if such action is accompanied by policies to improve vehicle efficiency and slow growth in car ownership.

1 Introduction

This report examines the historical development and current status of the biofuel industry in China, focusing on government policies to support production and consumption. The analysis forms part of a multi-country effort by the Global Subsidies Initiative (GSI) to characterize and quantify (to the extent possible) government subsidies and other support for biofuel production, distribution and consumption, including support provided for the production of key inputs. The report also assesses the environmental and social impacts of biofuel production in China.

Statistics and information commissioned by the GSI from the Chinese Government's National Development and Reform Commission (NDRC) have formed the basis of this report. In some cases, however, it has been necessary to supplement or augment this information with that from other sources, including the U.S. Department of Agriculture's Foreign Agricultural Service (FAS), and a number of academic and press reports. In particular, there is a great degree of variation in Chinese production statistics for both fuel ethanol and biodiesel. In most cases, data from the NDRC was used unless a more up-to-date source that can be corroborated ws available.

1.1 Biofuels in China

Two biofuels for transport are produced and used, to varying degrees, in China: ethanol, mainly produced from maize, and biodiesel, mainly produced from waste cooking oil and fat residues (Box 1.1). A 10 per cent ethanol blend with gasoline (E10) is used in ten provinces in China as part of a mandated consumption program. Biodiesel is not officially distributed throughout petrol stations in China but is bought by users directly from producers. Virtually all ethanol and biodiesel produced in China is consumed domestically. With domestic demand for transport fuels skyrocketing, there are minimal exports of biofuels.

The Chinese government has been an enthusiastic promoter of biofuels, which were seen as part of the answer to China's energy security, rural-development and pollution problems. However, with grain prices rising rapidly, the government has become concerned that promotion of biofuels, particularly ethanol, may contribute to food-price inflation and erode China's food security. The government is now endeavouring to engineer a shift away from the use of grains a feedstock for biofuels, and is promoting feedstocks grown on agriculturally marginal land. The key question China now faces is whether there is sufficient (and adequate) marginal land on which to grow the feedstocks necessary to meet both production targets and satisfy mandated consumption demand. If not, these targets and mandate programmes may need to be drastically revised.

1.2 Outline of the report

Chapter 2 provides a broad overview of China's energy policies and government bodies responsible for energy policy-making. There is a brief discussion of China's petroleum pricing policies and then a detailed outline of China's biofuels policies and programs.

Chapter 3 provides details of China's fuel-ethanol and biodiesel industries, including production estimates, industry structure and cost structures. The key issues of land availability for feedstock production and biofuels production outlook are discussed in this chapter.

Chapter 4 provides an overview of support to the biofuel production chain, including intermediate inputs and output-linked support. Chapters 5 and 6 look at the environmental and social impacts of biofuel production in China. Conclusions and recommendations are provided in Chapter 7.

1.3 Framework of the analysis

Figure 1.1 illustrates the framework used in the report to assess the scale of subsidies provided at different points of the supply chain for biofuels in China, from the production of feedstock crops through to the final consumption of the product. The framework of analysis is adapted from that developed by the Global Subsidies Initiative (first published in Koplow, 2006). In this analysis, the report has focused on subsidies and taxes that affect production components—those components that have a significant effect on the cost structure of biofuels.

Box 1.1 Biodiesel and ethanol production processes

Liquid transport biofuels are most commonly produced as either biodiesel or ethanol. Biodiesel is typically produced from vegetable oil or animal fat. In a process known as transesterification, the fat or oil is reacted with an alcohol (usually methanol synthesized from natural gas) in the presence of a catalyst to yield mono-alkyl esters (biodiesel) and glycerine. Other by-products can include fatty acids, fertilizer and oilseed meal. Many of these by-products have a value, particularly the glycerine and oilseed meal (e.g. soybean meal is used for both human and animal food). The energy content of biodiesel varies between 88 per cent and 99 per cent of the energy content of diesel, depending on the feedstock and esterification process used (Love and Cuevas-Cubria, 2007).

Biodiesel is used to replace fossil diesel. It can be used pure or in a blend (commonly B5 or B20, which contain 5 per cent or 20 per cent, respectively, biodiesel mixed with fossil diesel).

Over 50 plant species produce extractable oils. All have potential for use as fuel, but most are prohibitively expensive. The main oils used for fuel are derived from rapeseed (canola), soybeans, oil-palm fruit or kernels, coconut, sunflower seed, and physic nut (*Jatropha curcas*). Another possible source of lipids is oil-rich microalgal feedstocks. Producing biodiesel from algae is still at the research and demonstration phase.

Several alternative technologies are vying to replace transesterification. The costs of these technologies are highly sensitive to increases in the prices of oils and fats. One new process uses existing equipment normally found in oil refineries to create a diesel substitute (called "renewable diesel") using animal fats or vegetable oils. Longer term, diesel substitutes may be synthesized from almost any type of low-moisture biomass using the Fischer-Tropsch (F-T) process. Although the F-T process is well-developed and has been used to make liquid fuels from fossil-fuel feedstocks such as coal, production from biomass is still at the research and demonstration stage.

Ethanol is a clear alcohol that can be used as a fuel in spark-ignition engines, either neat or blended with gasoline. The energy content of fuel ethanol is around two-thirds that of gasoline (regardless of the feedstock used), but it has a significantly higher octane rating.

Fuel ethanol can be either hydrous (also called "hydrated") or anhydrous. Hydrous ethanol typically has a purity of about 95 per cent and has been used in Brazil since the late 1970s as a fuel in motor vehicles with modified engines. Further processing to remove any residual water produces a high-purity anhydrous ethanol that is typically blended with petrol for use in unmodified engines.

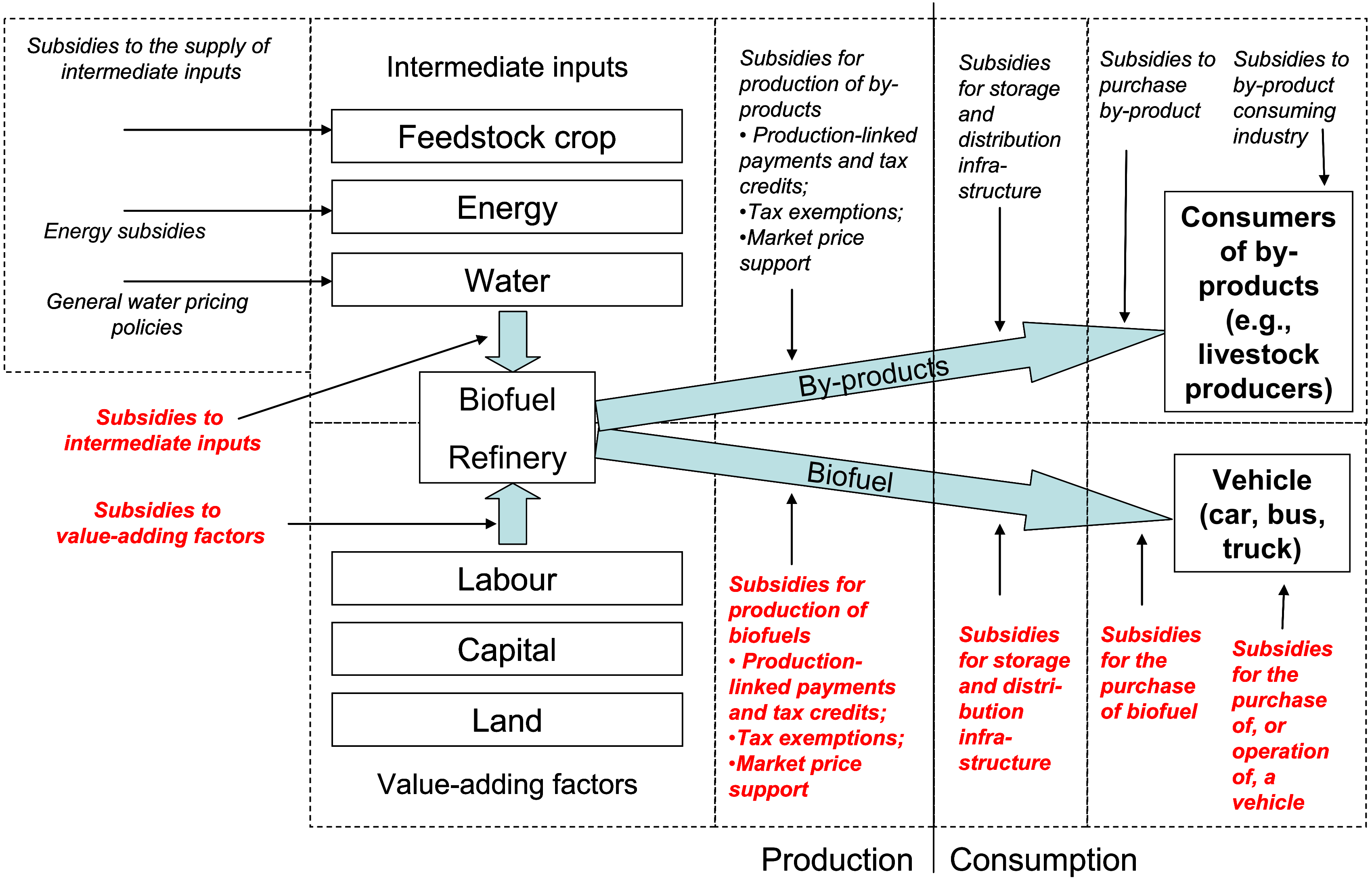
More than 95 per cent of the world's ethanol is produced by fermenting plant-derived matter, mainly sugars and starches. The rest is produced synthetically, from petroleum or coal. Less than 25 per cent of total ethanol produced is used for beverage or industrial purposes (Berg, 2001).

Production from sugar and starch is referred to as a *first-generation* technology. *Second-generation* technologies are under development to commercialize production of ethanol from cellulosic material, such as crop waste, wood and grasses. In second-generation ethanol manufacturing plants, the cellulose and hemi-cellulose constituents of the biomass are typically converted into simple sugars either biologically, using enzymes, or chemically, using acids and high temperatures, prior to fermentation.

Thermo-chemical processes can potentially produce petroleum substitutes by converting methanol-to-olefins followed by olefins-to-gasoline or methanol-to-dimethyl ether (DME). Synthetic gasoline from biomass will be identical to regular gasoline and there will be no issues for compatibility. DME is being developed as a synthetic biofuel, which can be manufactured from lignocellulosic biomass. It is a promising fuel for both gasoline and diesel engines. China’s production of dimethyl ester (from coal) is expected to double this year, and in time China could turn to biomass-to-dimethyl ester.

Sources: Berg (2001), Love and Cuevas-Cubria (2007), Steenblik (2007).

Figure 1.1 Subsidies provided at different points in the biofuel supply chain



2 China’s energy and biofuels policies

2.1 Energy policy

China’s booming economic growth of the past two decades has driven rapid increases in its energy demand. China is now the world’s second largest (and fastest growing) energy market. China’s energy demand will continue to soar, driven by heavy industry and increasingly by residential and transport use as urbanization and incomes increase. The International Energy Agency (IEA) estimates that China’s primary energy needs will expand from 1 742 million tonnes of oil equivalent (Mtoe) in 2005 to 3 819 mtoe in 2030, implying an average annual rate of increase of 3.2 per cent (IEA, 2007). The IEA also predicts that China will account for almost 30 per cent of the increase in world oil consumption between 2005 and 2030.

Until around 2001, China was able to meet much of its energy requirements from domestic sources, but since then it has become increasingly reliant on imports of energy. China is now the world’s third largest importer of oil (despite also being the sixth largest producer). Government concerns over the need to ensure sufficient energy supplies to maintain China’s rapid economic growth, as well as the geopolitical implications of dependence on overseas sources of energy, underpin China’s energy policy. The environmental consequences of China’s growing energy use (especially given the dominance of coal in China’s total energy demand) are also key policy drivers. These imperatives are forcing China to increase its energy efficiency and increase its use of alternative, domestically-produced (and cleaner) sources of energy. It has looked to biofuels to achieve some of these objectives.

While economic liberalization has increased the role of the market in many sectors of China’s economy, the strategic importance of energy means that the state retains a significant degree of control in that sector. The pricing of energy is a highly politically sensitive issue and the government controls almost all downstream energy prices. However, price caps serve to undermine the government’s energy-efficiency goals, and the government has acknowledged that it will need eventually to liberalize its energy prices. But it has said it will proceed cautiously.[2]

China abolished its Ministry of Energy in 1993 and responsibility for different aspects of energy policy were divided between different central government agencies. Until 2008, the NDRC, China’s powerful economic coordination agency, and the Energy Leading Group (a supra-ministerial coordinating body set up in 2005 by the State Council and headed by China’s Premier Wen Jiabao) were the lead agencies responsible for energy policy. In 2008, the Leading Group was abolished and the National Energy Administration (NEA) was set up to assume the roles of the Leading Group and the Energy Department of the NDRC. The NEA sits under the NDRC in China’s bureaucratic hierarchy. The NEA is responsible for overall energy policy, as well as specific energy sectors (oil, gas, coal, electricity, nuclear and renewable energy), management of China’s strategic oil reserves, and approval of large

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[2] Zhang Guobao, head of the NDRC Energy Bureau said in June 2008 that China is committed to liberalizing fuel prices eventually but that this has been delayed by sharp rise in global oil prices. See also State Council White Paper on Energy Hhttp://www.china.org.cn/english/environment/236955.htm#2H.

energy projects and overseas energy investments. The NEA shares responsibility for energy pricing with the NDRC.

China's Five Year Plans set out the framework for China's medium-term energy policy. The (current) 11th Five Year Plan (2006–2010) focuses on increasing China's energy efficiency and expanding domestic supplies. A key goal of the plan is to decrease China's energy intensity (i.e. the amount of energy required to produce a unit of GDP) from 2005 levels by 20 per cent by 2010. China passed a Renewable Energy Law in 2005 (discussed below). A new energy law, expected to call for more environmentally-friendly energy policies and market-based pricing mechanisms, has yet to be passed.

2.2 Petroleum prices and subsidies

With domestic oil supplies dwindling, China has become a net oil importer in order to meet surging domestic demand. China's net oil imports reached 3.5 million barrels per day (mbd)—almost half its 7.1 mbd of oil consumption—in 2006, making it the world's third largest oil importer (IEA, 2007). Demand is expected to increase by an annual average rate of 5.2 per cent between 2005 and 2015, with total Chinese oil consumption more than doubling between 2005 and 2030, driven largely by demand in the transport sector (IEA, 2007). Growth in demand is largely driven by the exponential rise in private-vehicle ownership. The IEA expects that by 2017 the number of new car sales in China will overtake new car sales in the United States, with over 10 million new cars sold a year. In 2006, 4.4 million new cars were sold in China (IEA, 2007). Energy demand from cars is projected to rise by 10 per cent per year between 2005 and 2015 (IEA, 2007).

The Chinese government, keen to avoid inflation-related public discontent, tightly controls all retail petrol and diesel prices. While downstream prices are capped, upstream prices are largely liberalized, so China's oil refiners pay global market prices for oil while being forced to sell to Chinese consumers at capped prices. In mid-2008 China's two key state-owned oil companies, Sinopec and CNPC,[3] cut refinery production in response to rising international prices in order to minimize their losses, prompting nation-wide fuel shortages. With increasing public anger at the lack of fuel and the prospect of China's road freight system shutting down, on 19 June 2008 the government raised petrol prices by 16.7 per cent and diesel prices by 18.1 per cent (the first price rise since November 2007).[4] As of June 2008, Chinese drivers were paying around RMB 6.2 per litre (US$ 0.90 per litre) for petrol (PR Newswire, 2008). However, even after these price increases, Chinese petrol and diesel prices were, respectively, 31 per cent and 38 per cent below international prices in June 2008 (*South China Morning Post*, 2008).

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[3] China's petroleum industry is dominated by three state-owned enterprises: China National Petroleum Corporation (CNPC), China Petroleum, Chemical Corporation (Sinopec) and China National Offshore Oil Corporation (CNOOC). CNOOC focuses on offshore exploration and production while Sinopec and CNPC handle domestic production, refining and distribution. Sinopec and CNPC operate almost all of China's oil refineries and the domestic pipeline network. All three companies carried out Initial Public Offerings between 2000 and 2002 with the Chinese government maintaining a majority stake in each of them.

[4] In order to minimize the impact on vulnerable sectors, subsidies will be paid to farmers and taxi drivers (Reuters, 2008c).

2.3 Diesel

Diesel is currently the predominant transport fuel consumed in China. Consumption of diesel in China has grown faster than of petrol, and the IEA expects that trend to continue over the next decade (IEA, 2007). Demand for diesel has been driven by the widespread adoption of mechanized farm equipment and increased use of commercial vehicles. One hundred and twenty million tonnes (around 150 billion litres) were consumed in 2006 (U.S. Department of Agriculture, 2007). With the alleviation of rural hardship a key government priority, diesel prices, like petrol prices, remain capped.

2.4 Ethanol Promotion Pilot Programme

China initiated its first fuel ethanol production early this decade, spurred by energy security concerns and enormous grain stockpiles that were becoming increasingly expensive to administer and maintain.[5] A 200 000 tonne capacity trial ethanol production plant was established in 2001—the Tianguan Ethanol Plant, in Henan province. This led to the NDRC launching a pilot scheme promoting the use of E10 in three cities in Henan: Zhangzhou, Luoyang and Nanyang. The policy aims behind the pilot program were the alleviation of fuel shortages, improved urban air quality and promotion of agricultural development (by creating a market for surplus grain and thus lifting stagnant rural incomes).

In 2001, China enacted legislation setting out fuel ethanol standards.[6] The legislation sets quality control standards for ethanol to be used as fuel, as well as criteria for its testing, packaging, transportation and storage.

With standards now in place, the Henan pilot program was expanded in 2002 to Harbin and Zhaodong in the northeastern province of Heilongjiang, and a maize-based ethanol plant was built in that province. The pilot was further expanded in 2004 to include seven additional provinces (Jilin, Hubei, Hebei, Anhui, Shandong, Jiangsu and Liaoning), mandating the phased-in use of E10 in selected cities in those provinces and nominating four “nationally approved” ethanol plants. Under the pilot program, all producers of fuel ethanol must only sell their product to either CNPC or Sinopec. CNPC and Sinopec then blend the ethanol with gasoline and distribute E10 through their petrol stations in the nominated cities. Virtually all petrol stations in China are owned by either Sinopec or CNPC.

The legislation that establishes this pilot program (the Pilot Plan for Extensive Utilisation of Ethanol Blended Gasoline for Automobiles and the Regulations for Extensive Utilisation of Ethanol Blended Gasoline for Automobiles) set out the financial policies that apply to ethanol use in China (including incentives and pricing formulae). The 2004 pilot plan

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[5] China maintains a policy of around 96 per cent grain self-sufficiency. Under this policy, China has a national grain reserve system under which a certain proportion of grain produced each year is allocated to grain reserves. Large grain harvests in the late 1990s led to bulging and aging grain reserves. Dong (2007) estimates the central government was paying around 2.8 billion yuan (US$ 410 million) a year to administer and maintain these reserves at this time.

[6] The Denatured Fuel Ethanol Standard (GB18350-2001). This legislation sets out standards for fuel ethanol composition, testing, packaging, transportation, storage and the National Standard of Ethanol Gasoline for Automobiles (GB18351-2001), which sets out the technical requirements for fuel ethanol to be used in motor-ignited internal combustion engines. Standards are contained in Appendix I.

legislation also establishes a National Ethanol Promotion Team, led by the NDRC with Sinopec and CNPC as subgroup leaders. By 2005, all vehicles in the nominated pilot cities were required to use E10.

The pilot scheme was later expanded to include the southern province of Guangxi. Table 2-1 shows the supply range of ethanol throughout China.

Table 2.1 Fuel ethanol supply in China

Location of production	Province where ethanol is consumed	Supply capacity (10 000 tonnes, NDRC figures)	Note
Heilongjiang	Heilongjiang	10	Whole province
Jilin	Jilin	10	Whole province
	Liaoning	20	Whole province
Henan	Henan	13	Whole province
	Hubei	17	9 cities
	Hebei	n.a.	4 cities
Anhui	Anhui	10	Whole province
	Shandong	22	7 cities
	Jiangsu		5 cities
	Hebei		2 cities
Guangxi	Guangxi	10	Whole province

Source: NDRC (2008); press reports.

In early 2006 (before the government began to take note of rapidly rising grain prices), the NDRC declared that the ethanol pilot was a success and that China was well-suited to ethanol production and use, and that its use resulted in economic, environmental and social benefits (Li, 2007).

2.5 Renewable Energy Law

The increasing importance China is according biofuels is reflected in the Renewable Energy Law, which came into effect in January 2006. The law sets out definitions of biofuels and confirms China's commitment to encouraging the use of biomass fuels (Article 16). Most importantly it establishes a Renewable Energy Fund (Article 24) specifically to assist with "biofuel technology research and development, standards development and demonstration projects and support biofuel investigation and assessment of raw materials resources and information dissemination and domestic related equipment manufacturing." It also includes biofuels in the National Renewable Energy Industry Development Guide Directory so that discounted loans and tax incentives can be obtained for equipment manufacturing and cultivation of energy crops (Article 25). The Regulation of the Renewable Energy Fund nominates the development of bioethanol and biodiesel as key priorities, and specifies the types of biofuel-related activities that should be supported. These include science and technology research, demonstration projects and local manufacture of equipment for biofuel development.

2.6 The shift away from grain-based ethanol production

By 2006, it became apparent that soaring global and domestic grain prices required a re-evaluation of China's fuel ethanol program. In 2006, maize constituted around 90 per cent of the feedstock for China's fuel ethanol production and with stale grain reserves exhausted, ethanol producers had begun to use fresh maize. In addition, the area of land under grain production decreased due to a number of factors (urbanization, development and changes in the grain subsidy regime in particular) leading to a decline in food production. At the same time, food-price inflation in China was growing rapidly and leading to growing public discontent. With China's growing ethanol production threatening to undermine its food security and exacerbate food price inflation, the NDRC issued an urgent notice,[7] which effectively halted the construction of new maize-based ethanol plants. The NDRC and Ministry of Finance subsequently issued a joint notice raising concern about the number of provinces proposing to construct ethanol plants without regard to market demand or possible impacts. The joint notice requires that all new ethanol plants must be approved by the NDRC. Since that time, only two new ethanol plants have been approved, a cassava-based ethanol plant in Guangxi, which became operational in late 2007, and a 300 000-tonne capacity sweet potato-based plant in Hebei, which is expected to become operational in 2008. The notice also prohibited the existing four approved ethanol plants from expanding capacity without NDRC approval.

With the government concerned about the effect on grain security of using maize as the predominant ethanol feedstock, China's ethanol policy was adjusted to favour non-grain feedstocks, in particular sweet potato, cassava and sweet sorghum, grown on non-arable "marginal" land. In December 2007, the Ministry of Finance issued policies promoting the use of non-food sources for biofuels through subsidies for projects producing ethanol from cellulose, sweet sorghum and cassava or making biodiesel from forest products. The Ministry of Agriculture Agricultural Biofuel Industry Plan, released in July 2007, outlines the government's aims to develop new crop bases for biofuel production by 2010, including sweet sorghum and cassava. It is predicted that the proportion of maize used in ethanol production will fall from 80 per cent in 2007 to around 70 per cent after 2009 (Cao Zhi, qtd. in Biopact, 2007). China's four large grain-based ethanol plants are reportedly in the process of undergoing conversion to production based on non-grain feedstocks (Ethanol and Biodiesel News, 2008).

A key plank in the Government's efforts to ensure that biofuel production does not affect China's food security is its emphasis on the use of marginal land to produce biofuel crops. There appears to be no set definition of "marginal" land but it appears to include saline land, steep hillsides and may even more broadly be used to refer to land that is not currently being used for any obvious productive purpose. See Chapter 3 for more discussion of the use of marginal land for producing biofuel feedstocks.

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[7] Urgent Notification on Regulating Corn Processing Project Construction and Management [2006] No. 2781.

2.7 Medium and Long-Term Development Plan for Renewable Energy

Despite concerns about food security, China remains committed to rising domestic ethanol production and use—although not perhaps to the extent it may have earlier envisaged. A draft five-year renewable energy plan issued by the NDRC in 2006 as part of the overall 11th Five Year Plan proposed ambitious goals for ethanol production: by 2010, China's biofuel production would amount to 5.2 million tonnes, a 400 per cent increase in fuel ethanol production from 2006 (U.S. Department of Agriculture, 2007). However, the State Council did not approve the plan due to concern about rising grain prices. Instead, the NDRC issued a Medium and Long-Term Development Plan for Renewable Energy in August 2007. The Plan states that by 2010, China will aim to raise the share of renewable energy in total primary energy consumption to 10 per cent and 15 per cent by 2020 (NDRC, 2007). The plan nominates biomass energy as a priority sector and sets targets of 2 million tonnes for national annual use of non-grain fuel ethanol and 200 000 tonnes for biodiesel by 2010. By 2020, under the plan, China will be using 10 million tonnes of fuel ethanol and 2 million tonnes of biodiesel per year.

2.8 Biodiesel policies

Biodiesel production in China commenced in 2001 using waste food oil and residues from fat refining as feedstock. In 2003 the government began to focus more attention on biodiesel research and industrial development. However as China is a net importer of vegetable oils, the government has not promoted biodiesel as a transport fuel.

At present, there are no specific policies or schemes analogous to the ethanol pilot scheme for the promotion of the use of biodiesel as a transport fuel. The Chinese government announced a voluntary biodiesel standard (for 100 per cent biodiesel) in July 2007 but there is currently no mandatory national biodiesel standard. This means biodiesel is not currently distributed through petrol stations in China. A target for biodiesel use has been included in the government's Medium and Long-Term Development Plan for Renewable Energy: 200 000 tonnes (225 million litres) by 2010 and 2 million tonnes (2.25 billion litres) by 2020. It has been reported that the Chinese biodiesel industry expects a comprehensive biodiesel development plan will be released in 2008 and that biodiesel production subsidies will be awarded for the first time this year (Speckman, 2008).

The NDRC plans to develop domestically-grown biodiesel feedstocks that do not compete with food crops for land or water resources. *Jatropha curcus*, an oil-nut bearing tree, is considered the most likely and trials of jatropha cultivation have been underway in Southwest China. The NDRC has designated South-west China as the official target area for jatropha cultivation and envisions around 600 000 hectares of jatropha plantations in each of China's Southwestern provinces (Weyerhaeuser *et al.*, 2007).

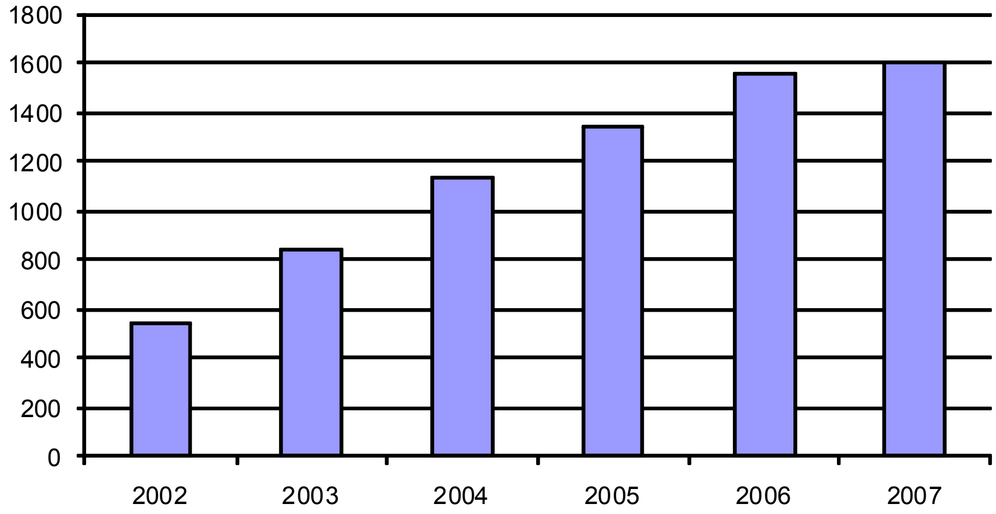
3 Status of the Chinese biofuels industry

3.1 Ethanol

3.1.1 Current production levels and planned capacity

In 2006 and 2007 respectively, China produced 1.56 million tonnes and 1.6 million tonnes of fuel ethanol.[8] Fuel ethanol production expanded rapidly between 2002 and 2006, but with rising grain prices and a shift in policy towards non-grain feedstocks, production growth has tapered off (Figure 3.1).

Figure 3.1 Chinese fuel ethanol production 2002–2007 ('000 tonnes)



Source: 2002 to 2006: NDRC (2008); 2007: Research and Markets Biofuels Report (2008).

Maize constitutes around 80 per cent of the feedstock of China's fuel ethanol production with the remainder being produced from wheat and cassava (Table 3.1).

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[8] Differing figures for Chinese fuel ethanol production exist. For 2006, the NDRC (2008) cited production of 1.56 million tonnes, while U.S. Department of Agriculture (2008) said 1.3 million tonnes. The NDRC did not provide a figure for 2007, while the U.S. Department of Agriculture (2008) estimated 2007 production at 1.4 million tonnes and the Research and Markets Biofuels Report (2008) estimated 1.6 million tonnes for the same year.

Table 3.1 Estimated feedstock use in China 2007

Feedstock	% of fuel ethanol production 2007 (estimate)	Quantity used for fuel ethanol production (estimate)
Maize	80	4.2 million tonnes
Wheat	15	840 000 tonnes
Cassava	5	56 000 tonnes

Source: NDRC (2008)

The bulk of China' s fuel ethanol is produced by the five NDRC-approved operational ethanol plants: Jilin Fuel Ethanol Co. Ltd, Henan Tianguan Fuel Ethanol Co., Anhui Fengyuan Biochemical Co., Heilongjiang Huarun Alcohol Co. and the New Tiande cassava-based ethanol plant in Beihai, Guangxi. According to the NDRC, there is also a trial sweet sorghum-based ethanol plant in Heilongjiang (Heilongjiang Siyi Alcohol Co.). The combined capacity of these plants, according to the NDRC, is around 1.12 million tonnes per annum. Output figures for individual plants are not available.

Actual production may be significantly higher than official statistics suggest. The discrepancy between the NDRC production *capacity* figures and its total production estimates is 400 000 tonnes of additional ethanol production. Press reports and U.S. Department of Agriculture (2008) indicate that some plants have larger capacity than indicated by the NDRC.[9] Additional fuel ethanol may also be produced by smaller, non-licensed operators (for example a Chongqing plant that commenced operations in 2006, which has a capacity of 100 000 tonnes) (Schwartz*,* 2008) or from plants that produce hydrous ethanol (for food or pharmaceutical use) and on-sell it unofficially to fuel ethanol plants for conversion. Food-grade ethanol producers are also reportedly supplying ethanol to oil companies. A sugar cane glut in southern china has encouraged some alcohol producers to increase their cane-based production and sell ethanol to be blended with gasoline (Reuters, 15 June 2008).

An anomaly in Chinese maize feed and food, seed and industrial (FSI) use would suggest that Chinese fuel ethanol production is even higher. Figure 3.2 shows a sharp uptick in otherwise flat FSI use of maize at around the same time that Chinese ethanol promotion policies were launched. Maize use for FSI purposes jumped almost 10 million tonnes between 2006 and 2008. This is equivalent to approximately 3 million tonnes of ethanol production—double the official estimates.[10]

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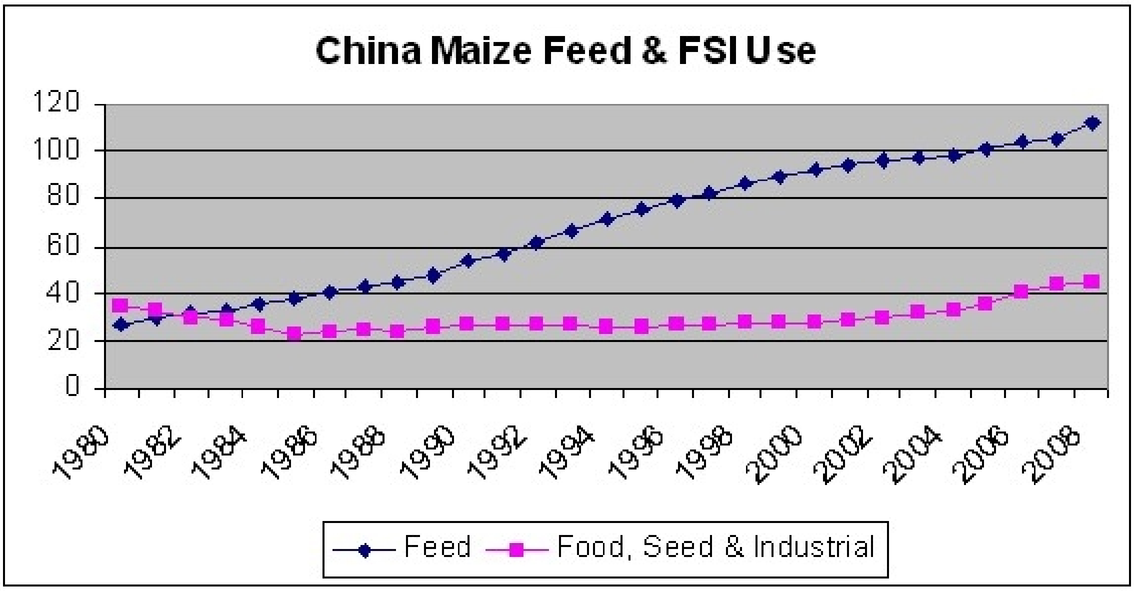
[9] See for example U.S. Department of Agriculture (2008), also Xinhua Oil, Gas and Petrochemicals, 25 May 2008, and Speckman, 2008.

[10] Assuming 3.3 tonnes of maize: 1 tonne ethanol (NDRC, 2008).

Figure 3.2 Chinese maize feed and food, seed and industrial (FSI) use 1980–2008 (million tonnes)



Source: U.S. Department of Agriculture.

With a moratorium on approvals for new maize-based ethanol plants, new production is focussed on plants processing sorghum, cassava and sweet potato. A new plant using cassava as feedstock commenced operations in Beihai, Guangxi in 2007. The plant will have a capacity of 200 000 tonnes in 2008 (Reuters, 2008a). The NDRC also approved in mid-2007 the construction of a new 300 000 tonne capacity plant using sweet potato as feedstock in Hebei province (Reuters, 2008d). New plants are planned (but not yet approved) for Guangdong (300 000 tonne capacity using cassava) and Hubei (100 000 tonne capacity using rice). China's biggest ethanol producer, ChinaAgri, announced in March it planned to build a second phase at its Guangxi plant this year with a capacity of 300 000 tonnes (Reuters, 2008a). With this amount of production potentially coming on line by the end of the decade, Chinese fuel ethanol production could reach 2.15 million tonnes by 2010.

In addition, in April 2008, the NDRC endorsed proposed plans by 5 provinces (Hubei, Jiangsu, Jiangxi and Hebei and Chongqing) to build ethanol plants using sweet potato, cassava or sorghum (Reuters, 2008d). No specific plans were approved but provinces were invited to make formal proposals.

While there are currently no commercially operational second-generation ethanol feedstock plants in China, various investors have plans to build pilot cellulosic ethanol plants. ChinaAgri is reportedly teaming up with Danish company Novozymes to research cellulosic ethanol production and has started building a 5000 tonne pilot plant in Heilongjiang while another plant is planned for Shandong province (Durfee, 2007; Millbrandt and Overend, 2008).

3.1.2 Structure of the industry

The state dominates the fuel ethanol industry in China: all five approved plants are state-owned. China's largest fuel ethanol producer is ChinaAgri, the listed arm of China's state-owned agricultural group COFCO (COFCO owns 57 per cent of ChinaAgri). ChinaAgri has stakes in Jilin Fuel Ethanol Co., Heilonjiang Huarun Alcohol Co., Anhui Fengyuan Biochemical Co. and owns the Guangxi cassava plant and is the major investor in proposed plants in Hebei and Hubei. China's state-owned oil companies, CNPC and Sinopec, also own stakes in a number of the ethanol plants. Private domestic investment in ethanol plants is not restricted but the larger energy and agriculture companies, which are more likely to build or invest in ethanol plants, tend to be state-owned in China. Foreign investors can only invest in ethanol production in China as a minority joint-venture partner. Table 3.1 lists China's operational and approved ethanol plants as well as those proposed by provincial governments and investors that have not yet been approved.

Table 3.2 Fuel ethanol production in China

Location	Company name or major investor	Feedstock	Production capacity (source)	Estimated 2008 production (source)	Notes
Operational					
Jilin, Jilin	Jilin Fuel Ethanol Co. Ltd (PetroChina 55%, Jilin Grain Group 25%, COFCO 20%)	Maize	300 000 (NDRC) 500 000 (Xinhua and USDA) 600 000 (Speckman)	420 000 (USDA)	
Nanyang, Henan	Henan Tianguan Fuel Ethanol Co. (PetroChina 60%, Sinopec 20%, Henan Investment Group 20%)	Wheat, maize	300 000 (NDRC) 200 000 (USDA) 470 000 (Xinhua) 500 000 (Speckman)	450 000 (USDA)	
Bengbu, Anhui	Anhui Fengyuan Biochemical Co. (COFCO 20.74%)	Maize, cassava	320 000 (NDRC 340 000 (Xinhua) 440 000 (USDA and Speckman)	400 000 (USDA)	
Heilongjiang	Huarun Alcohol Co. (COFCO 100%)	Maize	100 000 (NDRC) 380 000 (Xinhua) 180 000 (USDA)	180 000 (USDA)	
Heilongjiang	Huazhuan Siyi Ethanol Co. Ltd	Sweet sorghum	50 000 (NDRC)	n.a.	Possibly operational on a trial basis. May be part of Huarun Alcohol Co.
Guangxi	New Tiande Company	Cassava	100 000 (NDRC, USDA)	200 000	Operational, possibly owned by China Resources Alcohol Co
Beihai, Guangxi	ChinaAgri, Sinopec	Cassava	200 000		Operational Dec. 2007

Location	**Company name or major investor**	**Feedstock**	**Production capacity (source)**	**Estimated 2008 production (source)**	**Notes**
Chongqing	Chongqing Huanqiu Petrochemical Co.	Cassava	100 000	n.a.	Operational but awaiting government approval and licence
Planned					
Guangdong	China Grain Group and CNPC	Cassava	300 000		
Hebei	China Resources Alcohol Co.	Sweet potato and rice	230 000		
Hubei	TianGuan Ethanol Co. Ltd	Rice	100 000		
Nanchong, Sichuan	(PetroChina)	Sweet potato	100 000		Feasibility study completed
Kunming	PetroChina	Potato	100 000		Cooperative agreement signed with Yunnan government in Aug. 2006. Feasibility study completed
Yancheng, Jiangsu	PetroChina	Potato and sweet sorghum	200 000		Agreement signed in Oct. 2007 and feasibility study approved by PetroChina
Binzhou, Shandong	PetroChina	Sweet potato	200 000		PetoChina and Shandong province signed framework agreement to develop biomass energy
JIng'gangshan, Hubei	Sinopec	Cassava	100 000		Sinpec and JIng'gangshan City signed cooperative agreement in July 2007
Zhijiang, Hubei	Sinopec	Potato	300 000		
Chengde, Hebei	Sinopec	Sweet potato			Sinpoec and Chengde City signed agreement in Oct 2007
Wuzhou, Guangxi	ChinaAgri, Sinopec	Cassava	300 000		Cooperation agreement signed in April 2008 between ChinaAgri, Sinopec, and Guangxi COFCO Biomass Energy Co.
Jingmen, Hubei	ChinaAgri	Potato	200 000		COFCO and Hubei Jinlongquan Group Co. signed cooperative deal

Location	**Company name or major investor**	**Feedstock**	**Production capacity (source)**	**Estimated 2008 production (source)**	**Notes**
Hengshui, Hebei	ChinaAgri	Cassava	300 000		COFCO and Hebei province signed cooperative deal in June 2006
Zhaodong, Heilongjiang	ChinaAgri, Novozymes	Ligno-cellulose	5000		

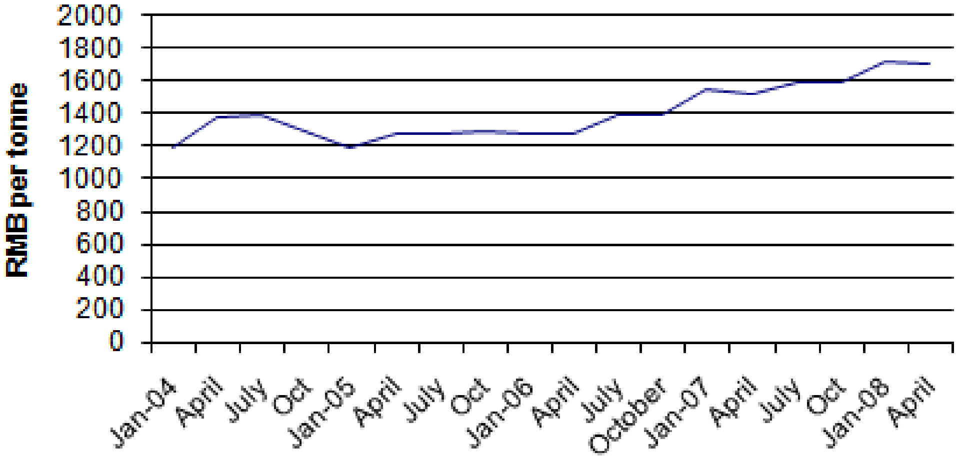
Source: NDRC (2008), Speckman (2008), U.S. Department of Agriculture (2007 and 2008), Xinhua (2008), press reports (where not stated).

3.1.3 Cost structure of production

The price of maize is the key determinant of Chinese ethanol production costs. Maize constitutes 80 per cent of the feedstock used in ethanol production in China and the price of maize accounts for around 70 per cent of the variable cost of producing fuel ethanol (NDRC, 2008). The NDRC estimates that the actual cost of fuel ethanol produced from maize is RMB 3221 (US$ 470) per tonne. It is not known what maize price this estimate is based on. The U.S. Department of Agriculture estimated in 2007 that the maize ethanol production cost was RMB 5000 (US$ 730) per tonne.

In its early stages, China's ethanol production used stale maize stocks as feedstock. However, by 2006 these reserves had been exhausted and facilities were forced to use fresh maize, pushing up maize prices further at a time of rising grain prices worldwide. Having averaged around RMB 1 300 between the first quarter 2004 and the second quarter of 2006, domestic prices for maize in China rose 30 per cent over the following year (Figure 3.2).

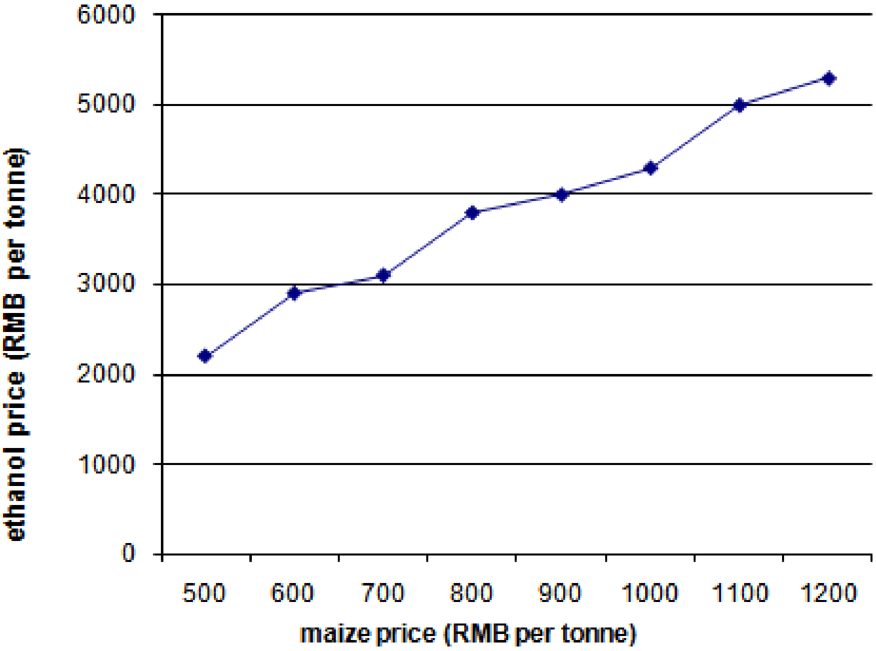
Figure 3.2 Maize price in China 2004–2007 (RMB per tonne)



Source: Chinafeed (2008)

Based on NDRC analysis, if the ethanol price in China were to keep track with rising maize prices, the fuel ethanol price should have been over RMB 5500 (US$ 803) per tonne in mid-2008 (Figure 3.3).

Figure 3.3 Relationship between maize price and ethanol price in China



Source: NDRC (2008)

However, the price of fuel ethanol (like all transportation fuels in China) is controlled by the government. China regulates the price of fuel-ethanol gasoline at 0.911 times the ex-factory price of RON (research octane number) 90 gasoline. Applying that standard, its sales price should be within RMB 4000–5000 (US$ 584–730) suggesting that profitable maize-based fuel ethanol production is not possible without government subsidies. Chinese ethanol producers were granted some relief, however, following the government's decision to lift petrol prices in June 2008, which led to the ethanol price reportedly rising to RMB 5890 (US$ 859 per tonne) (China Chemical Reporter, 2008).

Rising maize prices as well as government policy have pushed Chinese ethanol producers towards non-grain feedstocks, mainly cassava, sweet potatoes and, to a lesser extent, sweet sorghum. These feedstocks initially had significant cost advantages over maize (for a more detailed analysis of feedstock attributes see Appendix II). Table 3.2 sets out NDRC estimates of the cost of ethanol production for non-grain feedstocks compared with maize.

Table 3.2 Ethanol production costs—selected non-grain feedstocks

	Unit	Sweet sorghum	Cassava	Sweet potato
Starch content	Per cent	15%	27–33%	15–25%
Planting costs	RMB (or US$) per tonne	150 (US$ 21.9)	303–373 (US$ 44–54)	193–228 (US$ 28–33)
Feedstock/ethanol yield	Tonnes per tonne of ethanol produced	15	7	10
Raw material cost	RMB (or US$) per tonne of ethanol produced	2250 (US$ 328)	2610 (US$ 381)	2280 (US$ 332)
Production cost	RMB (or US$) per tonne ethanol	4000 (US$ 584)	4000–4500 (US$ 584–657)	4000–4500 (US$ 584–657)

Source: NDRC (2008), USDA (2008)

However, non-grain feedstock prices are rising sharply and the cost advantage appears to have eroded significantly. The price of cassava increased from RMB 300 (US$ 44) per tonne in 2006 to RMB 600–700 (US$ 88–102) per tonne in 2008 (Schwartz, 2008) and the imported price of cassava averaged around US$ 200 per tonne in the first quarter of 2008, a 50 per cent increase on the same in 2007 (U.S. Department of Agriculture, 2008). Ethanol producers in China have noted that rising feedstock prices are squeezing already thin profit margins and estimate that without larger government subsidies, projects will be "doomed" (Bezlova, 2008). Producers have also called for a more flexible pricing formula that could take into account rising feedstock prices (Durfee, 2007).

3.1.4 Trade in ethanol

Most Chinese imports and exports of ethanol are undenatured, mainly for alcohol production for human consumption. China exports a very small amount of denatured, or fuel-grade ethanol. The volume of all ethanol exports jumped in 2006 due to rising global fuel and grain prices (see Table 3.3) and then slumped by 88 per cent in 2007 after the government removed a 13 per cent value-added tax rebate on ethanol exports in order to discourage expansion of the grain-processing sector.

Table 3.3 China's ethanol exports 2002–2007 (‘000 litres)

	2002	2003	2004	2005	2006	2007
Total ethanol	115 248	284 101	96 912	162 204	1 017 779	129 973
Undenatured	99 748	276 084	91 596	158 654	970 721	110 718
Denatured (fuel)	15 500	8017	5316	3550	47 058	19 256

Source: U.S. Department of Agriculture, 2008.

Table 3.4 China's ethanol imports 2002–2007 (‘000 litres)

	2002	2003	2004	2005	2006	2007
Total ethanol	3558	4316	4253	19 590	7972	678
Undenatured	1435	2258	2021	15 936	5930	n.a.
Denatured (fuel)	2122	2058	2232	3654	2042	n.a.

Source: U.S. Department of Agriculture, 2008.

3.2 Biodiesel

3.2.1 Current production levels and planned capacity

Total Chinese biodiesel output in 2006 according to the NDRC was 190 000 tonnes, although press and other reports indicate that the figure now is much higher. The U.S. Department of Agriculture (2008) estimates that 2007 production was around 300 000 tonnes. According to a 2008 Energy Business Report on China’s biofuels, Chinese biodiesel maker Gushan Environmental Energy alone produces 200 000 tonnes of biodiesel from several facilities across China. With a large number of small-scale producers, it is difficult to obtain accurate production figures.

3.2.2 Structure of the industry

China’s biodiesel industry is dominated by small-scale operators using animal fats or waste cooking oil as feedstock. The Hainan Zhenghe Bio-Energy Co. Ltd in Hebei, the Sichuan Gushan Oil and Fat Chemical Company and the Fujian Zhuoyue New Energy were the first industrialized biodiesel production enterprises in China. From 2005 to 2006 China’s biodiesel industry grew quickly. There are now at least 12 operational biodiesel plants with at least another 26 planned or under construction, including some with annual production capacity over 100 000 tonnes. There has been increasing involvement by overseas-listed private Chinese companies, the largest of which are Gushan Environmental Energy, China Biodiesel International Holdings and China Clean Energy. There is also some foreign investment in the biodiesel sector. D1 Oils Plc, a global producer of biodiesel based in the United Kingdom, is reportedly investigating developing jatropha crops in China (Energy Business Reports, 2008), the United Kingdom-based Sunshine Technology Group is investing in a proposed jatropha-based biodiesel plant in Yunnan and Biolux International Austria has invested in a plant using imported rapeseed in Jiangsu (see Table 3.5).

Compared to the ethanol sector, the biodiesel industry is largely unregulated. Biodiesel plants do not need to be licensed by the NDRC. Because biodiesel plants tend to be much smaller than ethanol plants and do not require the same degree of regulatory oversight, there is significant involvement from the private sector. However, the large state-owned petroleum companies such as CNOOC and CNPC are attracted by the potential of jatropha and are starting to invest in proposed biodiesel plants and plantations.

Table 3.5 Biodiesel production status in China

Province	Company	Operating year	Feedstock	Production capacity (tonnes)
Constructed				
Hebei	Zhenghe Bio-energy Ltd.	2002	Acidified oil, fatty acid distillates, *Pistacia chinensis* Bunge fruit	10 000
Sichuan	Gushan Oil & Fat Chemical Company	2002	Grease waste, Rapeseed oil	12 000
Fujian	Longyuan Zhuoyue New Energy Company	2003	Grease waste	10 000
Hebei	Gushan Oil & Fat Chemical Company	2003	Grease waste	30 000
Henan	Xinghuo Bioengineering Company	2004	Waste oil	50 000
Fujian	Yuanhua Energy Technology Company	2004	n.a.	30 000
Shandong	Lunuo New Energy company	2004	n.a.	20 000
Fujian	Yuanhua Energy Science Company	2005	Grease waste	30 000
Fujian	China Clean Energy	2005	Waste oil	10 000
Henan	Xinyang Hongchang Group,	2006	Local wood plant oil, grease waste	30 000
Guizhou	Jintongfu Biodiesel	2006	n.a.	10 000
Shandong	Huawu Group	2006	Waste cottonseed oil	100 000
Gansu	Gansu Huacheng Biofuel	2006	Waste oil	200 000
Operational in 2008 (date of commencement not known)				
Hunan	Zhonghe Energy	2008	n.a.	500 000
Beijing	Gushan Environmental	2008	Waste oil	100 000
Hunan	Gushan Environmental	2008	Waste oil	30 000
Fujian	China Clean Energy	2008	Waste oil	100 000

Province	Company	Operating year	Feedstock	Production capacity (tonnes)
Inner Mongolia	Tianhong (Tongliao) Bioenergy Scientific Development Co. Ltd	2008	n.a.	25 000
Fujian	China Biodiesel Holding	2008	Waste oil	50 000
Henan	Luoyang Tianchang Biological Engineering Co. Ltd	2008	n.a.	10 000
Shanghai	Shanghai Zongshenghua Energy Scientific Co. Ltd	2008	n.a.	15 000
Hebei	Hebei Zhongtianming Biodiesel Co. Ltd	2008	n.a.	10 000
Henan	JiYuan Zhongyi Petro Utility Co. Ltd	2008	n.a.	10 000
Planned				
Jiangsu	Nantong Biolux	2009	Rapeseed oil (70% imported)	250 000
Shanghai	Gushan Environmental	2009	Waste oil	50 000
Chongqing	Gushan Environmental	2009	Waste oil	30 000
Guangxi	Guangxi Liuzhou Minghui Biofuel Co. Ltd	2009	n.a.	20 000
Sichuan	CNOOC	2010	Jatropha	100 000
Henan	Luoshan Jingding Chemical Co. Ltd	2010	n.a.	10 000
Hainan	CNOOC	n.a.	Palm oil and jatropha	43 000
Guizhou	Zhongshui Energy	n.a.	Waste oil, tung tree oil.	20 000
Sichuan	Sinopec	n.a.	Woody biomass	80 000
Hebei	Sinopec	n.a.	Waste oil	2000
Guizhou	Zhongshui Energy	n.a.	n.a.	20 000
Yunnan	Yunnan Shengyu New Energy	n.a.	Jatropha	100 000
Jiangsu	Nanjing Qingjiang Bioenergy Tech	n.a.	Vegetable oil	750 000
Sichuan	PetroChina	n.a.	Jatropha	60 000
Guizhou	SinoPec	n.a.	Jatropha	50 000
Total 38				

Source: NDRC (2008); Weyerhaeuser *et al.* (2007); Speckman (2008).

The biodiesel from China's biodiesel companies established before 2006 is generally of low quality and used principally as a solvent or as an additive to coal in thermal power plants or rural industrial cafeterias where coal is typically used for cooking (U.S. Department of Agriculture, 2007). However, newer and larger entrants are producing biodiesel that can be used as a transport fuel (Energy Business Reports, 2008). It is generally sold directly to users in the local area as there are no official distribution channels. Because there is no mandatory national biodiesel standard in China, it cannot be blended by the CNPC and SINOPEC and sold in petrol stations. However, despite this, it has been reported that at least one of the larger biodiesel makers, Gushan Environmental Energy, is selling biodiesel to retail petrol stations (Energy Business Reports, 2008).

3.2.3 Cost structure of production

Biodiesel production is constrained by lack of feedstock. Rising vegetable oil prices have all but ruled out biodiesel production from virgin vegetable oil feedstocks at present. China is a net importer of vegetable oils. While some vegetable-oil based biodiesel plants have been constructed, shortages of cooking oil and rising palm oil prices mean many plants have shifted to used cooking oil as feedstock. But even the prices for cooking used oil increased in the first half of 2008, as rising vegetable oil costs forced restaurants to re-use oil for cooking (Biofuels International, 2008). At least one biodiesel plant, China Clean Energy, has halted production due to rising feedstock prices.

Because Chinese diesel prices are capped by the state and remaining relatively flat compared to international diesel prices, the profitability of biodiesel producers that produce only transport biodiesel has been significantly eroded.

Some producers, such as China Biodiesel International, have remained profitable by switching from transport biodiesel (also known as B1) to B2 or B3 production (that is lower grade fatty acid methyl esters used as solvents in the chemical industry) (Hobson, 2008). As there is no official formula for the calculation of the biodiesel price relative to the fossil diesel price (as there is with ethanol relative to petrol), biodiesel suppliers can take advantage of localized fossil diesel shortages to charge a premium for biodiesel (for example, Gushan Environmental, sells biodiesel at a premium direct to users) (Seeking Alpha, 2008). Detailed data for the cost structure of biodiesel production from waste oil is not available.

In order to increase the supply of Chinese biodiesel production, the State Forestry Administration, in conjunction with the NDRC, has plans to develop 800 000 hectares of oil-bearing tree nut plantations in Southwest China. *Jatropha curcus* is considered a high-potential biodiesel feedstock because it can grow in a variety of climates and soils with relatively little chemical inputs or water. The NDRC considers that it is particularly suited to cultivation in southwest China, where a large proportion of China's marginal land is located. In 2006, the CNPC provided RMB 5 million (US$ 730 000) for demonstration projects in Yunnan for trial jatropha cultivation (Weyerhaeuser *et al.*, 2007). In response to this interest from the central government, the Yunnan provincial government has proposed building 14 biodiesel plants with a total output of 3.2 million tonnes per year (Weyerhaeuser *et al.*, 2007). No further details of these plans are available. With jatropha plantations still in the trial stage and with jatropha yields on sub-optimal land uncertain, any commercially viable large scale biodiesel production is at least five years away (Weyerhaeuser *et al.*, 2007).

The NDRC calculated the cost structure of biodiesel production using jatropha in 2006 at RM 3910 (US$ 570) per tonne. Information is not available as to the yields, irrigation levels or fertilizer use assumed in the NDRC's calculations. Other studies give cost estimates that are significantly higher than those of the NDRC (see Chapter 5 for further discussion).

3.3 Land availability for biofuel production

Lack of available land on which to produce feedstock crops is the most significant constraint on the expansion of China's biofuels production. China already endeavours to feed its 1.3 billion people with less than 7 per cent of the world's arable land and has stretched existing land and water resources to the limits of sustainability (if not beyond) to achieve food security (Lohmar and Gale, 2008). Very little arable land remains to produce non-food crops. Reliance on imported feedstock would be expensive and potentially disrupt food supplies.

To avoid competing with food crops, central government policy states that biofuel crops are to be grown on "marginal land," a term which in Chinese forestry and agriculture includes steep hillsides, saline and alkaline soils as well as land not being used for conventional agricultural purposes.

The NDRC estimates that China has around 35–76 million hectares of land that could be used for the cultivation of biofuels crops. This figure seems high and actually includes some categories of arable land: 7.34–9.37 million hectares of "reserve arable land"; 8.66 million hectares of fallow rice fields in southern China that can be used for the cultivation of rapeseed in winter; and 16 million to 57 million hectares of reserve forest land. The NDRC estimates that 36 million hectares of this land has the potential to produce 3.1 million tonnes (3.9 billion litres) of ethanol and 3.8 million tonnes (4.5 billion litres) of biodiesel per year.

However, caveats should be applied to these projections—and it is highly unlikely that this level of output is achievable. A large proportion of marginal land may be ecologically fragile or too degraded or arid to make cultivation profitable. In addition, plots of marginal land may not necessarily be contiguous, which would prevent large-scale commercial cultivation. Current estimates of marginal land reported by provincial officials may be exaggerated in order to benefit from central government financial incentives for the use of marginal land. Also, given the shortage of arable land, some marginal land is already being used for agricultural production in China.[11]

Even for crops that can grow on marginal land, output will depend on temperature, water availability, nutrients and plant condition. Jatropha*,* for example, is widely believed to be capable of growing on poor, degraded lands that are not otherwise capable of producing food crops or supporting healthy natural ecosystems. However, studies have shown that yields from low-productive, un-irrigated lands can be low (Jatropha World, 2008). Seed production ranges from about two tonnes per hectare per year (un-irrigated) to over 12.5 tonnes per hectare per year, after five years of growth. Hence, jatropha yields may be too low for jatropha-based biodiesel oil to be profitable or, if it is to be profitable, could lead to competition with food crops for arable land, water or fertilizers.

Without a definitive survey of the amount, location and quality of China's "marginal land" and to what extent it can support the growing of biofuels crops, it is uncertain how much biofuels crop production China can support. The Chinese Ministry of Agriculture is currently conducting an investigation into these questions (Niu, 2007).

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[11] Wang Zhongying, Director of the NDRC Centre for Renewable Energy Development has been reported as saying that on a recent visit to Lijiang in South-west Yunnan he was surprised to see mountaintous land, assumed unused, being cultivated (Speckman, 2008)

Lack of locally available feedstock is already forcing some ethanol producers to import feedstock. The cassava-based ethanol plant in Guangxi reportedly expects to import around 30 per cent of its feedstock in 2008, mostly from Thailand and Vietnam.[12] Other ethanol producers are buying land overseas to plant biofuel crops or investing in existing biofuel feedstock farms. Henan TianGuan has purchased 180 000 hectares in Laos to plant cassava (Wang, 2006). Others have gone offshore, investing in biofuel plantations and ethanol plants in the Philippines.[13]

3.4 Biofuels production outlook

With the variability in data for Chinese ethanol production and plant capacity, it is difficult to make an assessment of the production outlook for ethanol.[14] The U.S. Department of Agriculture (2008) estimates 2008 total ethanol production capacity at 1.8 million tonnes and the additional ethanol production capacity being built or proposed means China could potentially meet or even exceed its target of 2 million tonnes of ethanol before 2010.

However, the lack of available land on which to produce ethanol feedstock crops—as well as high feedstock prices, water scarcity, limited import availability, and difficulties in scaling up crop production—will act to constrain growth in Chinese ethanol use. The IEA cites these reasons for doubting whether China will meet its annual production target of 2 million tonnes (2.5 billion litres) of ethanol by 2010 (IEA, 2007). Chinese officials themselves have noted that an increase in ethanol production would depend on whether enough land could be found to plant feedstock crops and that, given the shortage of suitable land, it would be very difficult to achieve the large-scale production targets laid out in the Medium and Long-term Plan (China Daily, 2008).

According to the GSI's estimates, China currently uses 1.03 million hectares of its 130 million hectares of arable land to grow fuel ethanol feedstocks. This would increase to 1.2 million hectares in 2010 and 4.7 million hectares in 2020 if production targets are to be met without resorting to imports (Table 3.7). This does not take into account smaller and lower quality yields for crops grown on marginal land, and so the actual amount of land required could be significantly higher. The number could be higher still if production plans for ethanol plants not yet approved are taken into account.

In addition to ethanol feedstocks, provincial governments in southwest China plan to establish an additional 1.03 million hectares of jatropha plantations to fuel biodiesel production within the next decade (Weyerhaueuser *et al.*, 2007), bringing the total land required for biofuel production to at least 2.23 million hectares by 2020.

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[12] There is also reportedly a thriving black market in Guangxi and Guangdong for fuel ethanol produced from cassava leading to a surge in imports of tapioca chips from Thailand (Reuters, 2006).

[13] Two Chinese companies, Beidahuang and China CAMC Engineering have invested in ethanol plants in the Philippines (Javier, 2007). A Chinese delegation also reportedly visited Fiji in February 2008 to investigate opportunities for cassava ethanol production there (Fiji Times, 27 February 2008).

[14] However, ChinaAgri expects to produce around 700 000 tonnes of fuel ethanol from its 3 ethanol plants in 2008. It also predicts that the Jilin ethanol plant (in which it holds a 20% stake) will produce 500 000 tonnes this year. (Reuters, 2008a). Production plans for other plants are not available.

It may even be the case that current fuel ethanol production does not ensure sufficient supply of E10 in the ten provinces where its use is mandated. Petrol stations throughout Guangxi started selling E10 in mid-March 2008 and were required to stop selling pure petrol by the end of that month (Sinocast, 2008) However, by April, rising cassava prices made the mandatory phase in of universal E10 use in Guangxi uneconomic and it was suspended (Schwartz, 2008).

China has a large ethanol industry producing for the food, beverage and pharmaceutical markets, which produced around 4.5 million tonnes of hydrous ethanol in 2007. There is the possibility that producers of hydrous ethanol could sell their product to the five licensed fuel ethanol producers for conversion into anhydrous ethanol for fuel use. This, however, could have the effect of driving up food, beverage and surgical alcohol prices, given current conditions of land and feedstock scarcity. The Chinese Government already seeks to shield makers of food- and beverage- grade ethanol from competition for feedstock in some parts of China: sugar cane (the main feedstock for food ethanol production in southern China) is banned from being used as a feedstock for fuel ethanol production (Reuters, 2008b).[15]

There is a similar level of variability in biodiesel production figures. It appears, however, that biodiesel may be approaching, if it has not already exceeded, the annual production target of 200 000 tonnes by 2010 in the renewable energy plan. Some long-term forecasts estimate that China could produce around 6 million tonnes (seven billion litres) of biodiesel a year from jatropha (Speckman, 2008). This would appear to be an overly optimistic target given the significant uncertainties about the amount and suitability of land available for jatropha cultivation and the yields from crops grown on marginal land.

Production of biofuels from ligno-cellulosic materials could overcome many of the problems of limited land availability. The technology of so-called second generation biofuels is still in the trial stage, however, and any large-scale production of these biofuels in China is some years away.

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[15] There may already be some unofficial diversion of hydrous ethanol to fuel ethanol plants, which could help explain the discrepancies in fuel ethanol production figures.

Table 3.7 Estimated land used in fuel ethanol production in China to 2020

Feedstock	Total area 2007 (million ha)	Production 2007	Quantity used for biofuel 2007 (million tonnes)	Land used for biofuel 2007 (million hectares)	Quantity used for biofuel 2010	Land used for biofuel 2010	Quantity used for biofuel 2020	Land used for biofuel 2020
Maize	28	137	4.2	0.84	4.62	0.924	4.62	0.924
Wheat	23	106	0.84	0.153	0.35	0.063	0.35	0.35
Cassava	0.6	11	0.56	0.035	2.1	0.131	28	1.75
Sweet potato	7	150	0	0	2	0.087	35	1.52
Sweet sorghum	n.a.	n.a.	Neg.	Neg.	0		31	0.44
Total				1.027		1.205		4.7

Notes: Neg. = Negligible

The calculations underlying Table 3.7 were based on the assumption that maize would constitute 70 per cent of ethanol feedstock in 2010, wheat 5 per cent, cassava 15 per cent and sweet potato 10 per cent. This assumption is based on the production plans of approved, future ethanol plants and the gradual conversion of existing grain-based plants to alternative feedstocks. Feedstock ratios for 2020 are estimated at maize: 14 per cent; wheat: 1 per cent (these rates assume actual wheat and maize volumes used for fuel ethanol will remain steady from 2010); cassava: 40 per cent; sweet potato: 35 per cent and sweet sorghum: 10 per cent. Land use figures are calculated using Chinese tonne per hectare rates from a number of sources: maize: 5 tonnes per hectare (U.S. Grains Council, 2008); wheat: 5.5 tonnes per hectare (NDRC, 2007); cassava: 16 tonnes per hectare (FAO, 2002); sweet potatoes: 23 tonnes per hectare (RIRDC, 2006). A yield of 70 tonnes millable stalk per hectare for sweet sorghum in India is used (ICRISTAT, 2004). The following ethanol conversion rates are used: 3.3 tonnes of maize: 1 tonne ethanol (NDRC, 2008); 3.5 tonnes wheat: 1 tonne ethanol (Wang *et al.*, 2007); 7 tonnes of cassava (fresh roots): 1 tonnes ethanol (NDRC, 2008); 10 tonnes cassava (fresh tubers): 1 tonne ethanol (NDRC, 2008) and 31 tonne sweet sorghum: 1 tonne ethanol (ICRISTAT, 2004).

Sources: FAO (2002); NDRC (2007 and 2008); USDA (2007 and 2008); U.S. Grains Council (2008); RIRDC (2006); ICRISTAT, (2004); Wang *et al.* (2007); author's calculations.

4 Government support for biofuels

The Chinese government provides large range of subsidies, tax exemptions and soft loans for biofuels production. The total value of support for ethanol has been rising since 2002, with the provision of support shifting from direct subsidies to tax breaks and low interest loans. Government support policy changed in 2006 away from subsidising producers to use grain reserves to produce ethanol towards encouraging the use of non-grain feedstocks for both ethanol and biodiesel production.

No direct subsidies are currently provided for biodiesel. However, because biodiesel is sold directly from the factories to end users, those end-users do not pay consumption- or value-added tax on that fuel. The NDRC estimates that these tax breaks will be valued at around RM 65 million (US$ 9.4 million) per year when production reaches 200 000 tonnes in 2010 (Table 4.1). Given that production has already reached this level, the lack of tax collection can be considered an existing subsidy. The NDRC plans to introduce an official support package by 2010, as evidenced by their forecast estimates for support in 2010 and 2020.

Table 4.1 Government subsidy estimates for biofuel development in China (millions of RMB and of US$)

	Ethanol					Biodiesel				
	2004	2005	2006	2010	2020	2004	2005	2006	2010	2020
Biofuel total capacity (million tonnes)	1.14	1.34	1.56	2.00	10.00	0.06	0.13	0.19	0.20	2.00
Output-linked Support										
Consumption tax exemption	256.5 ($ 37)	301.5 ($ 44)	351 ($ 51)	450 ($ 66)	2250 ($ 328)	/	/	/	45 ($ 6.6)	450 ($ 66)
VAT exemption	204 ($ 30)	240 ($ 35)	279 ($ 40)	358 ($ 52)	1790 ($ 261)	/	/	/	19.8 ($ 2.8)	197.9 ($ 28)
Direct (“loss”) subsidies	214	181	140	119	119	/	/	/	300 ($ 43.8)	3000 ($ 438)
Factors of Production – Capital										
Low interest loans	6.94 ($ 1.01)	8.16 ($ 1.2)	9.50 ($ 1.4)	12.18 ($ 1.8)	60.90 ($ 8.9)	/	/	/	3.3 ($ 0.48)	33.1 ($ 4.8)
Total	682 ($ 100)	731 ($ 107)	780 ($ 114)	939 ($ 137)	4220 ($ 616)	/	/	/	368 ($ 53.7)	3683 ($ 537)

Note: Numbers have been rounded.

Source: NDRC (2008)

Using the Global Subsidies Initiative’s framework, an analysis of government support in the production of biofuels in China is set out below.

4.1 Assistance to intermediate inputs

The inputs for biofuel production are classified as either a) raw materials, such as maize, cassava and jatropha; or b) chemicals and water used in the processing of raw materials into ethanol or biodiesel.

China's biofuels policy was originally driven, in part, by the need to reduce excess grain stocks. The legislation that established the pilot program promoting ethanol use provides for a subsidy to be paid to ethanol producers for stale grain purchased from grain reserves for use in ethanol production. The policy imperatives behind this subsidy no longer apply. Grain reserves have been run down to an extent that stale grain is not widely used in ethanol production.

A range of agricultural subsidies support the production of crops that are used in biofuel production. In 2005, Chinese farmers benefited from RMB 70 billion (US$ 8.5 billion) in subsidies the form of tax reductions, direct payments to grain producers and assistance for upgrading seed stock and machinery (OECD, 2007). It is difficult to verify actual government expenditure on agricultural support as funding is provided through many government agencies, each with a different system of allocating funds to farmers and villages (OECD, 2007).

Grain producer subsidies were introduced nationally in 2004 as well. While the rate of the subsidy was determined by the provincial government, the most prevalent rate was RMB 10 (US$ 1.2 at the time) per mu[16] (RMB 150 or US$ 18 per hectare), including for maize and wheat. Total funds for the programme were RMB 13.2 billion (US$ 1.6 billion) and RMB 14.2 billion (US$ 1.8 billion) in 2005 and 2006, respectively.

Measures have been put in place to lower the prices of chemical fertilizers. In 2002, for example, fertilizer producers paid between 10 and 30 per cent less per kilowatt hour than other industrial enterprises (OECD, 2007). In 2005, export taxes on fertilizers were raised in order to protect the domestic market and fertilizer producers were temporarily exempted from value-added tax.

Chinese farmers benefit, like residential consumers, from capped electricity prices. At times, the agriculture sector may also be exempt from nation-wide government-mandated electricity price rises. Farmers are also subsidised to compensate them for rises in the price of diesel fuel.

As of December 2007, China's Ministry of Finance provides farmers with a subsidy of RMB 3000 (US$ 438) per hectare per year for forestry plantations to grow biofuels feedstock (such as jatropha) and RMB 2700 (US$ 394) per hectare per year for non-grain biofuels crops (such as cassava) (China View, December 2007). There are no data available on the quantity of subsidies paid out under this scheme or if the subsidies have had an impact on production levels. While the payment might be a strong incentive for planting these crops, the current subsidy cost to the government is likely to be small given the small amounts of jatropha and cassava being produced for fuel.

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[16] A mu is a Chinese unit of land area equivalent to 1/15 hectare.

There appears to be growing business interest in investing in jatropha plantations in Yunnan Province, including from CNPC and Sinopec. In addition, the Yunnan provincial government is allocating subsidies of RMB 160 per mu (US$ 350 per hectare) to district forestry officials who then distribute subsidies to farmers (Weyerhaeuser *et al.* 2007).

These area payments could be become expensive for government if farmers and agro-industries are able to access large per hectare payments for growing meagre feedstock harvests on infertile land. Such an outcome would deliver little biofuel per subsidy dollar. On the other hand, imposing minimum land quality or yield requirements would risk encouraging the use of arable land for feedstocks.

This study was not able to identify any specific policies providing government support for biofuels production relating to non-feedstock material inputs (such as chemicals used in the production process).

4.2 Assistance to value-adding factors

China's Renewable Energy Law of 2006 establishes a Renewable Energy Special Fund. This fund is designed to support demonstration projects for non-grain biofuels production and the domestic manufacture equipment used for the production of biofuels. Under the Catalogue of Renewable Energy Industry Guidance, preferential loans can be provided to biofuels projects that use non-grain feedstocks. In addition, the Ministry of Finance will subsidize demonstration projects producing ethanol from cellulose, sorghum or cassava or making biodiesel from forest products. Projects that meet China's industrial standards would receive 20 to 40 per cent of the total investment. The GSI was unable to find any data that would have enabled it to quantify the value of grants or loans provided under these schemes.

4.3 Assistance to outputs

The Chinese government provides direct output-linked subsidies to the five licensed ethanol plants (including, since late 2007, the Guangxi cassava-based ethanol plant). Under the 2004 legislation, licensed ethanol producers receive a subsidy to compensate for losses incurred in ethanol production, blending and distribution and a subsidy for the use of stale grain in ethanol production. These subsidies were previously provided based on production *capacity* but since 2007 have been based on actual production, with producers being provided a flat RMB 1373 (US$ 200) per tonne of ethanol produced (Table 4.2) (International Energy Agency, 2008). From 2008, subsidies will become more targeted. There will no longer be a fixed subsidy but a subsidy based on an evaluation, conducted in November each year, of each individual plant's performance.

Table 4.2 Direct subsidies to compensate for losses paid to licensed ethanol plants 2005–2007

(RMB and US$ per tonne)

Company name	2005	2006	2007
Jilin Fuel Ethanol Co	2395 (US$ 350)	2055 (US$ 300)	1375 (US$ 200)
Henan Tianguan Group	1720 (US$ 251)	1375 (US$ 200)	1375 (US$ 200)
Anhui Fengyuan Biochemical Co.	1885 (US$ 275)	1630 (US$ 238)	1375 (US$ 200)
Heilongjiang Huarun Alcohol Co. Ltd	2395 (US$ 350)	2055 (US$ 300)	1375 (US$ 200)
Average subsidy	**2100** **(US$ 306)**	**1775** **(US$ 249)**	**1375** **(US$ 200)**

Note: Numbers have been rounded.

Source: NDRC, 2008

The five licensed ethanol producers also receive an exemption from the 5 per cent consumption tax and from the 17 per cent VAT. The NDRC's calculation of the total value of these subsidies between 2004 and 2006 is set out in Table 4.3.

Table 4.3 Total subsidies for ethanol development in China (million RMB)

Subsidy	2004	2005	2006
Exemption of 5% consumption tax	255 (US$ 37)	300 (US$ 44)	350 (US$ 51)
VAT reduction for ethanol mixed with gasoline	205 (US$ 28)	240 (US$ 35)	280 (US$ 41)
Direct subsidy for loss	215 (US$ 31)	180 (US$ 26)	140 (US$ 19)
Total subsidies	**675** **(US$ 98)**	**720** **(US$ 105)**	**770** **(US$ 112)**

Note: Numbers have been rounded.

Source: NDRC (2008)

In addition, NDRC policy provides for a government subsidy to be paid to ethanol producers at times of sustained low oil prices.

The mandated use of E10 in ten provinces also acts as a form of market price support for the licenced ethanol producers, by guaranteeing demand regardless of the price of the product. Further, the government's tight control on entry into the ethanol production market ensures limited competition for existing producers. Each producer has a dedicated supply region so is virtually guaranteed to have a 100 per cent market share of the fuel-ethanol consumed within its respective geographic boundaries.

There are currently no official subsidies for biodiesel. The NDRC expects tax exemptions for biodiesel producers to total around RMB 65 million (US$ 9.5 million) by 2010. As mentioned above, this subsidy is effectively in place now, given that biodiesel is sold directly from producers to consumers, and therefore is untaxed.

The profitability of Chinese biodiesel producers appears to depend on their ability to produce alternative products or ability to take advantage of localized diesel shortages to sell direct to users at a premium. However, the NDRC is considering introducing direct production subsidies for biodiesel and formalizing the tax exemptions. China will be paying RMB 1500 (US$ 219) per tonne in 2010 to biodiesel producers (Table 4.1). This amount appears to be based on 2006 NDRC calculations of jatropha biodiesel production costs of RMB 3900 (US$ 570) and a profitable sale price of RMB 6017 (US$ 878) per tonne. With the 2006 diesel price in China at around RMB 4500 (US$ 657) per tonne, the NDRC calculates that a subsidy of RMB 1500 is necessary to support commercial production. However, according to other studies, this calculation may be based on estimates of jatropha yields and production costs that are overly optimistic (Weyerhaeuser *et al.*, 2007).

4.4 Assistance for research and development

Support from the Renewable Energy Fund, in the form of interest-free or discounted loans, is available for a number of research and development activities in relation to biofuels. These include R&D into the use of non-food crops and forest wood biomass for the production of biofuels; the trial cultivation of non-food crops for biofuels production on barren hills, wasteland and sandy and alkaline soils; science and technology research for biofuels development; demonstration projects for biofuels development and use; and development and evaluation of biofuels feedstocks. Insufficient information was available to quantify the value of these forms of support.

5 Social impacts of biofuels production and use

Raising rural incomes and alleviating rural hardship is a key policy priority for the Chinese government. While around two thirds of China's population lives in rural areas, the benefits of the country's economic boom have largely been concentrated in urban, coastal areas while the countryside has languished. Rural incomes are about one third of those of urban residents. Rural underemployment is also a significant problem. The Chinese government sees strong potential for biofuels to help build a "new socialist countryside" by providing rural development opportunities that will help lift incomes, absorb the surplus rural labour force and alleviate hardship for China's rural poor.

5.1 Employment in the biofuels sector

Given the fact that many Chinese biofuels plants operate or are expected to operate in more remote, rural provinces away from the major coastal cities and provinces, the biofuels sector in China could offer considerable employment opportunities where they are most needed. Data is not available for the number of people employed in biofuels production in China. The NDRC estimates, however, that a 100 000 tonne (127 million litre) per year fuel ethanol plant employs around 1 000 people. This number seems high. In other countries, a biofuel facility of around 100 000 tonnes capacity would generally employ 20 to 25 people directly. The NDRC estimate may refer to total employment generation, including employment in feedstock production, transportation and possibly downstream activities. The high number may also be an aspirational target reflecting the Chinese government's policy aim of fuel ethanol production alleviating rural unemployment or absorbing laid off state sector workers in rust belt provinces such as Jilin. Employment data or targets for the biodiesel sector are not available.

5.2 Biofuels and rural incomes

Early this decade, the Chinese government saw an opportunity to use reserves of stale grain for biofuel feedstock by creating an alternative market for grain and by lifting prices. A series of bumper grain harvests in the late 1990s led to a sharp drop in the maize price. In Jilin province for example, a key maize-growing province in China, the price of maize by the end of the last decade had fallen to its lowest level in 25 years (Dong, 2007). This led to sharp decline in rural incomes in maize-growing regions (Dong, 2007).

Farmers benefited, however, once maize prices rose significantly as a result of increased ethanol use. The extent to which the use of non-grain feedstocks will lift farmer incomes is uncertain. The NDRC estimates that if cassava ethanol production reaches 1 million tonnes and the fresh cassava price is RMB 470 per tonne, household income for those cultivating cassava could increase by RMB 940 (US$ 137) per year (this figure is based on 2.7 million households each cultivating 2 mu (0.13 ha) cassava). Rising cassava prices mean Chinese cassava farmers (mainly in the poor rural province of Guangxi) will benefit from higher incomes. Higher prices for cassava will also mean that for the many impoverished rural households that consume home-grown cassava as a staple, money will be available to purchase more nutritious and varied foods. However, the effects would be highly detrimental to those who *purchase* cassava as a staple (for example, poor urban households in southern China).

There is also the potential for jatropha to become a valuable cash crop for farmers in Southwest China, but this will depend largely on farmers being able to contract directly with jatropha processors and energy companies to sell jatropha grown on their land allocation. The appropriation by local governments of marginal land currently worked or occupied by farmers in order to sell it to companies for jatropha plantations would, of course, result in significant negative impacts on farmers. (For more discussion, see the section on land acquisitions below).

5.3 Biofuels and food prices

In 2008, China experienced its highest rate of inflation in 12 years. This inflation, according to China's National Bureau of Statistics, is almost entirely attributable to rising food prices, which increased 21 per cent in the first quarter of 2008 from the same period a year earlier (Harmsen, 2008). While there are a number of factors behind the food-price increases, biofuels production, both domestically and internationally, are partly responsible. In the nine months preceding June 2007, domestic maize prices on the Dalian Commodities Exchange increased 30 per cent as a result of more maize being processed into ethanol by Chinese fuel ethanol plants (Dong, 2007). This contributed to a 43 per cent increase in the price of pork. (A disease that killed hundreds of thousands of pigs was also responsible.)

There is the potential for Chinese fuel-ethanol production to continue to put upward pressure on food prices. Although Chinese biofuel policies are now attempting to engineer a move towards non-grain feedstocks, the reality is that the majority (up to 80 per cent) of the feedstock for ethanol production will be maize or wheat for the near future. The limited availability of cassava feedstock and high prices of imported cassava will continue to limit the use of that feedstock. The use of sweet sorghum and sweet potato is still in the trial stage. This means there is potential for ethanol production to place increased pressure on food prices through increased demand for maize.

In addition, biofuel policies in other countries have been cited as a major contributor to rising world food prices and shortages (FAO, 2008; Mitchell, 2008) that have impacted on China. Agricultural commodity prices have risen sharply since 2006, and the prices of major staples such as grains and oil seeds have doubled in the past year (FAO, 2008). The FAO's food price index rose, on average, 8 per cent in 2006 compared with 2005, and 24 per cent in 2007 when compared with the previous year. In the quarter of 2008, prices rose 53 per cent when compared with the final quarter of 2007 (FAO, 2008). And prices are expected to stay high (OECD-FAO, 2008).

The IMF (2008) estimated that biofuels accounted for almost half of the increase demand in major food crops in 2007, while the OECD (2008) estimated that around 60 per cent of the increase in consumption of cereals and vegetable oils was due to biofuels. Mitchell (2008) calculated that biofuels contributed to 70 to 75 per cent of the recent food price increases. The conversion of vegetable oils to produce the world's 9 billion litres of biodiesel last year has contributed to the dramatic rise in palm oil demand and prices. According to Oil World, a forecasting service in Germany, biofuels accounted for almost half the increase in worldwide demand for vegetable oils in 2007, and represented seven per cent of total consumption of the oils (cited in Bradsher, 2008).

The higher food prices have undermined the purchasing power of the poor, including in China (Ivanic and Martin, 2008). Poor households may spend up to 75 per cent of their income on food, and when prices rise many sacrifice education or medical care in order to afford basic foods; and some simply can no longer afford sufficient food (Ivanic and Martin, 2008). Higher food prices affect urban and rural poor alike, as most rural households are net consumers rather than producers of food (Ivanic and Martin, 2008). Oxfam (2008) has estimated that the livelihoods of at least 290 million people around the world are immediately threatened because of it. The World Bank estimated that 100 million people have already fallen into poverty because of the food crisis (Ivanic and Martin, 2008). Depending on the estimate (OECD, IMF or World Bank all have different numbers), biofuels have caused between 30 and 75 million people to fall into poverty.

Although China maintains a grain self-sufficiency policy of around 95 per cent (and is in fact a net food exporter, according to Huang *et al.*, 2008), its increasing integration into the global economy means there is a close alignment between domestic and international grain prices. Chinese grain prices have increased as Chinese farmers have exported more of their product. Chinese farmers, once closed-off from international markets, today have immediate access to international pricing information and this is reflected in domestic prices.

Rising international vegetable oil prices in particular have been keenly felt in China. China's focus on maintaining grain self-sufficiency means farmers, attracted by subsidies, have switched from growing soybeans and rapeseed to grains. China is the world's largest consumer of vegetable oils, but with declining domestic production, it is also now the world's largest importer of vegetable oil (in 2007 China produced 9 million tonnes of vegetable oil but consumed 22.5 million tonnes) (Flex News, 2008). It is the world's largest importer of palm oil (which is blended in China with other vegetable oils to produce cheap cooking oil). Vegetable oil prices in China rose by around 40 per cent in 2007 and have been a key source of popular discontent, particularly among the urban poor. Three people were killed and 31 injured in November 2007 in a stampede for discounted cooking oil at a supermarket in Chongqing as people sought to stockpile supplies against rising prices (Anderlini, 2007).

Many of the potential "non-staple" biofuel feedstocks that the Chinese government has identified can also be directed towards food production or animal feed. Cassava is consumed as a staple in the poorer areas of southern China and is used in starch-making and in animal feed. Higher cassava prices could translate into higher prices for some processed foods and meat products. The NDRC has identified winter crops of rapeseed as a potential biodiesel feedstock but winter rape could just as well be used for food production and could help ease cooking oil shortages and price rises.

Given the current volatility in international and domestic markets for food commodities, a thorough investigation of the uses of marginal land in China for food or feed production (or other more economically valuable purposes) rather than biofuel crops would seem warranted. For example, government efforts to alleviate food-price increases might be better served by the cultivation of fodder crops, such as saltbush on arid saline soil, rather than dedicating such land to biofuels production. The government's nomination of marginal land as land to be prioritized for biofuels production may not represent the most economically valuable allocation of China's land resources (particularly when there has been little assessment of the suitability of that land for that purpose).

5.4 Potential displacement of livelihoods by cultivating "marginal" land

The use of marginal land for feedstock production raises questions about the impacts on local farmers. In some cases, it may provide opportunities for poor farmers but it may also result in displacement. There is growing evidence that land perceived to be marginal may be vital to the livelihoods of some poor rural groups—for example for herding of livestock or gathering of wild products (Cotula *et al.,* 2008). In Southwest China for example, most marginal land, around 76 per cent (Weyerhaeuser *et al.*, 2007), is owned by village collectives. The small scale cultivation of jatropha by farmers on marginal land in Southwest China could deliver significant benefits. Guizhou, Sichuan and Yunnan are among China's poorest provinces; Guizhou has China's lowest rural per capita net income of RMB 1877 (US$ 274) per year (Weyerhaeuser *et al.*, 2007). Jatropha seeds could provide a source of new cash income for these farmers, however, as explained earlier, jatropha yields on marginal land are still highly uncertain. A study conducted by the UN Development Programme and China's Ministry of Science and Technology estimated that households could generate a net annual income of RMB 250–400 per mu (US$ 36–58) from jatropha after three to five years. According to Weyerhaeuser *et al.* (2007), however, this estimate assumes much higher yields than may be realistic on marginal land or implies subsidized inputs for farmers. Weyerhaeuser also cites Yunnan Forestry Department estimates of additional farm incomes of RMB 100 (US$ 14.6) per person per year.

The greatest risk for local farmers arises if investors in jatropha plantations seek to consolidate marginal land plots to achieve economies of scale. Farmers in China have very weak land tenure and even the rights they do have are often poorly enforced. Rural land is owned by village collectives (that is, the local government), which allocate farmers in the village a "land use right" of a plot of land for a period of thirty years. Plots are allocated on a household basis and are usually very small (on average around 0.4 hectares). The land use right does not confer the right to sell the land, nor can the land be used as collateral for a loan.

With China's industrialization and economic boom, land values have soared, creating incentives for local governments to sell rural collective land to property developers. Forced land acquisitions by corrupt local officials with inadequate or no compensation for farmers has become a serious problem in China. The Ministry of Land and Resources estimates that at least 20 per cent of land acquisitions across China were illegal, with the figure up to 80 per cent in some regions. Land seizures by corrupt local governments have become the main cause of protests in recent years (Business Week, March 24, 2008).

The growing interest of investors, both foreign and from large Chinese energy companies, in developing jatropha plantations and the eagerness of local governments to develop biofuels as a pillar industry in Southwest China, places farmers at risk of displacement from illegal or unjust land acquisitions.

As discussed further in the following chapter, the long-term sustainability, including socio-economic, implications of large-scale jatropha plantations are unknown. Some impacts are already being felt by some communities however. In India, for example, government promotion of jatropha plantations is said to be occurring at the expense of arable land and farmers. One study found that farmers have been forced by local governments to replace food crops with jatropha or risk losing their land or even going to prison (Navdanya, 2008). Farmers were also reported to have been promised subsidies for growing jatropha, which never materialized leaving the farmer financially disadvantaged. Jatropha is not currently used for purposes other than biodiesel production and therefore farmers growing the crop would have no alternative markets or use for jatropha if the market for biodiesel collapsed (for example, due to a change in government support policies).

6 Environmental issues

6.1 Atmospheric pollution and greenhouse gas emissions

One of the initial drivers behind China's promotion of biofuel use was to combat rising atmospheric pollution. Many of China's cities suffer from some of the highest levels of particulate matter, sulphur dioxide (SOx) and nitrogen oxides (NOx) in the world (World Bank, 2007). These emissions result in a large number of premature deaths each year as well as serious environmental problems including acid rain. While the predominance of coal in China's energy mix is a key cause of this pollution, China's growing use of petrol and diesel is contributing to harmful emissions. The use of biofuels can lead to a reduction in harmful pollutants, although this does depend on the vehicle in which they are used. The NDRC (2008) show a 46 per cent reduction in SOx emissions from vehicles using E10 compared with when the same vehicles are run on gasoline, and a 36 per cent reduction in carbon monoxide (CO) and a 12 per cent reduction in greenhouse gas (GHG) emissions (Table 5.1). Using a life cycle analysis, reductions are not as dramatic, and for some, emissions are even greater for E10 (Table 5.2).

Table 6.1 E10 and pure gasoline on-road vehicle emission comparison (grams per kilometre)

Item	CO	NOx	PM10	SOx	GHGs
Conventional gasoline	5.517	0.275	0.033	0.085	400
Gasoline mixed with 10% ethanol (E10)	3.531	0.275	0.033	0.046	351
Increment (±)	-36%	0%	0%	-46%	-12%

Source: NDRC (2008)

Table 6.2 E10 and pure gasoline emission comparison: life cycle analysis (grams per kilometre)

Item	Volatile organic compounds	Carbon monoxide	Nitrogen oxide	Particulate matters	Sulphur oxide	Greenhouse gas emissions
Conventional gasoline	0.167	3.483	0.262	0.025	0.079	238.599
E10 mixed gasoline ethanol is 10%	0.146	2.629	0.265	0.023	0.094	233.827
Increment (±)	-13%	-25	+1%	-10%	+18	-2%

Source: NDRC (2008)

Specific data on emissions from biodiesel use in China are not available. Other analyses show that, when compared with fossil diesel, particulate emissions of biodiesel can be 20 to 39 per cent lower, S0x emissions 80 per cent lower, carbon monoxide 43 per cent lower and

CO_2 78 per cent lower (e.g. Wang, 2006). However analysis from the U.S. Environmental Protection Agency found NOx emissions from biodiesel to be 10 per cent higher than from fossil diesel (Union of Concerned Scientists, October 24, 2008).

Assessments that measure GHGs over the entire process of biofuel feedstock production, processing and use (life cycle analysis) indicate a wide divergence in carbon balances depending on the feedstock, technologies used and production methods (FAO, 2008). The NDRC studies above show a reduction in GHG emissions from ethanol use. However, it is not known whether this analysis is based on the use of stale maize reserves as a feedstock or envisages the cultivation of previously marginal land with a non-grain feedstock such as cassava.

A full life cycle analysis of the total GHG emissions inherent in ethanol or biodiesel production and use in China is not possible without a detailed assessment of the specific characteristics of the biofuel including the regional context, feedstock and its methods of cultivation and processing methods. However, we can expect that any expanded biofuel production in China, even on marginal land, could result in the conversion of forest, grassland and vegetated hillsides into land cultivated for feedstock production.

Cultivation of forest and grassland results in a significant release of carbon dioxide as a result of either burning or decay of organic matter in plant biomass or soils (Fargione *et al.,* 2008). The resulting "carbon debt" of land conversion can be repaid by biofuel use over time, but until that time net GHG emissions will be higher than that for fossil fuels. The carbon debt, for example, resulting from jatropha production in Southwest China may be relatively small if eroded, unvegetated hillsides are cultivated.[17] If forested areas are converted to jatropha cultivation, a significant carbon debt could result, analogous to the 86 years Fargione *et al.* (2008) found it would take to repay the carbon debt incurred by converting tropical forest in Malaysia or Indonesia to palm oil production for biodiesel. And while Chinese government policy forbids expanded ethanol production using maize, pressure on maize prices from existing ethanol production could encourage farmers to cultivate maize on grassland previously set aside under conservation programs. Searchinger *et al.* (2008) found that when land use change was taken into account, net GHG emissions from ethanol made using maize grown on converted grassland resulted in 93 per cent more GHG emissions than from gasoline.

6.2 Impact of converting marginal land to biofuel feedstock production

For the period that Chinese ethanol production concentrated on the use of stale grain reserves for ethanol production (roughly 2000–2006), the environmental impacts of China's biofuels production remained relatively small (compared with that in South East Asian

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[17] Weyerhaueser *et al.* (2007) estimate a small increase in China's forest cover (around 1.2 per cent, assuming that plantation area targets can be met) from jatropha plantations in South-west China that would result in a 0.9 – 5.6 million reduction in China's carbon dioxide emissions—a tiny percentage of China's total annual carbon dioxide emissions (more than 5 000 million tonnes).

countries for example). Now that government policy stipulates that biofuel feedstocks are to be cultivated on marginal land, the environmental implications are far less certain.

The exact amount, location and condition of marginal land in China is unknown (see Chapter 3) so it is difficult to assess the potential extent of environmental consequences of its use. There appears to be little research or investigation into the environmental impact of large scale conversion of marginal land in China to biofuels feedstock production. Potential negative impacts could include biodiversity loss, increased pest and fire risk, erosion, and water-quality impacts due to pesticide and fertilizer runoff (cultivation of marginal land often requires large inputs of chemical fertilizers) (e.g. see Oxfam, 2008, and Wakker, 2005, for an analysis of environmental impacts of oil palm plantation establishment in Southeast Asia). However, depending on the crop and the land being cultivated, potential positive impacts could include erosion control and increased forest cover.

6.2.1 Jatropha cultivation on marginal land in Southwest China

It is estimated that there are around 23 million hectares of marginal land in the steep slopes of Southwest China (Naylor *et al.*, 2007). This region, with its large areas of marginal land and climactic suitability to oil-bearing tree nut cultivation, has been selected by the central government as the key Chinese region for biodiesel feedstock production, particularly jatropha. Provincial governments have responded enthusiastically and have set targets for jatropha plantations in Southwestern China totalling around 1.03 million hectares (Weyerhaeuser *et al.*, 2007).[18] This area is greater than the 800 000 hectares of jatropha envisaged by the NDRC.

Southwest China is one of China's most ecologically important regions. Most of China's remaining natural forests are in Yunnan.[19] The area is home to sensitive mountain ecosystems as well as the headwaters of major rivers such as the Yangtze and the Mekong. Chinese experts have documented the significant ecological value even of land in this region classified as "marginal" with degraded forests in the region playing a role in ensuring biodiversity (Jia, 2008). The rapid growth of a single species such as jatropha in these ecosystems could jeopardize the region's significant biodiversity. The European Union-China Biodiversity Programme has recommended that environmental assessment be carried out to distinguish high biodiversity areas from low biodiversity areas in Southwest China that could be suitable for jatropha or other biodiesel feedstock cultivation.

The long-term sustainability implications of large-scale jatropha plantations are not yet known, due to its recent emergence as a bioenergy crop. Achten *et al.* (2007) found in a qualitative sustainability assessment, focusing on environmental impacts and some socio-economic issues, that jatropha plantations could have overall favourable benefits for

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[18] This amount comprises: 26 667 ha in Guizhou, 333 333 ha in Sichuan and 666 667 ha in Yunnan. These targets are handed down from the provincial level to local forestry bureaus, which are responsible for implementation. As of 2006, exisiting jatropha plantations amounted to 71 300 ha in the three provinces: 1300 ha in Guizhou, 20 000 ha in Sichuan and 50 000 ha in Yunnan.

[19] About forty per cent or 12.9 million hectares of the province is classified as "forest." Of this about nine million hectares is considered virgin forest. (U.S. Embassy, 2008).

sustainable development, as long as only wastelands or degraded grounds were converted for jatropha cultivation.

6.2.2 Sweet sorghum production on marginal land in northern China

"Marginal land" in northern China is likely to be sandy, degraded land heavily affected by desertification. The production of potential feedstocks such as sweet sorghum, which is drought resistant and can grow in saline-alkaline soils (FAO, 2002), could benefit the environment by controlling erosion, storing carbon and helping to reverse desertification. The added advantage of sweet sorghum is that only its stalks are used for ethanol production while the seeds can be used for human consumption or animal feed. It has been estimated there are around 24 million hectares of land with saline soil across thirteen provinces in northern China (Dong, 2007). According to China's Ministry of Agriculture, around 16–18 tonnes of sweet sorghum stalks can produce 1 tonne of ethanol. It would require two thirds of a hectare to produce this amount of sweet sorghum in northern China; the source for this estimate does not specify whether this is the yield from saline or other marginal land (Dong, 2007). Production of sweet sorghum for ethanol production in China is still at the trial stage with a pilot plant in Heilongjiang province currently producing 5 000 tonnes of ethanol from sorghum a year.

Severe water scarcity in northern China is a significant issue. It is possible that the marginal land in northern or western China may be too arid even for sorghum. Yields under sub-optimal conditions are questionable and may not be commercially viable.

6.3 Industrial pollution

The potential environmental impacts of a large number of biofuel plants close to ecologically sensitive areas and waterways (such as in Southwest China) is a concern. While China has environmental protection laws and regulations controlling industrial pollution, enforcement can be a problem, particularly where corrupt local officials may be involved in shielding polluters. By-products of biodiesel production include oil and glycerine, which, if they leak or are dumped into waterways, quickly deplete the water of oxygen and kill fish and other aquatic species.[20] Ethanol production involves the production of large amounts of waste water that can pose a risk to waterways. The production of ethanol has been found to have led to serious instances of water and air pollution in the United States (Beeman, 2007).

6.4 Key government policies on environmental protection

Following China's devastating 1998 floods, the central government launched the National Forests Protection Program, which prohibited the commercial logging of natural forests in the upper reaches of the Yangtze River and the upper- and middle-reaches of the Yellow River and reduced commercial logging of natural forest in China's northeast and Inner

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[20] In 2006, a biodiesel refinery in Missouri was convicted of deliberately dumping glycerine into a waterway, resulting in the deaths of 25 000 fish and wiping out a population of endangered mussels (Goodman, 2008).

Mongolia.[21] China claims 98 million hectares of natural forest has been protected under this program (State Forestry Administration, 2007).

The Grain for Green Program (or Land Conversion Program) was implemented in 1999 as a cropland set-aside program to increase forest cover and prevent soil erosion on sloping land.[22] Under the program, farmers are provided with subsidies and free seedlings to plant trees on land set aside for the purpose. By 2007, China claims that 24.3 million hectares of cropland had been converted to forest under the program, increasing total forest cover by more than two percentage points. Steeply sloping and eroded land are the main targets of the program. In Southwest China a steepness criterion for inclusion in the program is a slope of 25 degrees or more while in northern China the criterion is a slope of 15 degrees or more (Naylor *et al.*, 2007).

China also has shelterbelt and desertification control programs across the country that have resulted in the planting of almost 50 million hectares of plantations. The Desertification Control Program targeting areas in the vicinity of Beijing and Tianjian aims to stem the rapid rate of desertification (as high as 3 400 square kilometres a year) that is claiming arable land in northern China.

How China's policy of promoting the cultivation of biofuel crops and plantations fits in with these environmental policies as well as agricultural policies has not been articulated by the government. Biofuel feedstock production may complement shelterbelt and anti-desertification and erosion programs. However, certain biofuels policies may undermine environmental policies which seek to remove sloping agricultural land from cultivation.

Subsidies paid to farmers to set aside land for conservation purposes under the Grain for Green Program are significantly lower than those available to farmers to cultivate marginal land for biofuel crop production. Chinese farmers are eligible for a RMB 300 (US$ 44) per hectare subsidy per year for up to eight years to set aside grassland or forest (Li, 2002) compared to RMB 2700–3000 (US$ 394–440) per hectare per year (with no time limit) for growing biofuels crops on marginal land. This may encourage farmers to withdraw from the Grain for Green program and grow biofuels crops on environmentally sensitive land.

In the United States, for example, there has been a wide-scale withdrawal from a similar set-aside program, the U.S. Department of Agriculture's Conservation Reserve Programme (CRP)(National Academy of Sciences, 2008). The CRP makes annual rental payments to farmers to convert environmentally sensitive or highly erodible land to native grasses, wildlife plantings, trees, filter strips, and riparian buffers. CRP contracts last for 10 to 15 years. As in the U.S., high rates of withdrawal from the Grain for Green program in favour

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[21] The severity of the 1998 floods, which killed more than 3 000 people and caused around US$ 20 billion damage was attributed to deforestation in the headwaters of the Yangtze.

[22] At the same time, China is also seeking to halt the decrease in the amount of arable land by placing stricter controls on the development of farm land for industrial or residential purposes. A property boom and increasing urbanisation has seen the conversion of an increasing amount of Chinese farmland to commercial or housing development. In some cases, inadequate or no compensation has been provided to displaced farmers by local governments who have, in turn, profited significantly from deals with developers.

of growing biomass will have the effect of converting lands that may be helping to ameliorate water pollution into lands that are additional sources of water pollution.

6.5 Forest management and illegal logging

Government subsidies for biofuels crop production and interest in non-staple feedstocks in general has created great interest in jatropha plantations and refineries in Southwest china. CNPC and Sinopec have both begun to develop jatropha plantations in Southwest China in conjunction with the State Forestry Administration and provincial governments. Forestry companies are also becoming interested as they see subsidies for jatropha and land planted with biofuels plantations are subject to less stringent forestry management practices than other tree plantations. Hong Kong-based China Grand Forestry Resources Group announced in late 2007 that it would acquire Yunnan Shenyu New Energy, a company that is engaged in developing a "demonstration production base" for growing jatropha and building a biodiesel plant with a production capacity of 100 000 tonnes. China Grand Forestry representatives have noted that they will receive preferential treatment in forestry land auctions because of their involvement in renewable energy. China Grand Forestry have also noted that they would double their forestry land in China, which would be subject to fewer restrictions if the land was logged of existing trees and planted with jatropha as well as receiving a subsidy for each hectare of jatropha planted (Speckman, 2008).

Policies promoting biofuels production could also further increase opportunities for rent-seeking behaviour by local officials[23] and create incentives for illegal clearing of land (particularly with the collusion of corrupt local officials). Allegations of illegal logging in China's protected forests in Yunnan surface regularly (Liu, 2006). Singapore-based Asia Pulp and Paper (APP) has been accused of illegal logging of protected rainforest in Yunnan. According to Greenpeace, APP signed a contract in 2002 with the Yunnan provincial government to plant fast-growing eucalyptus plantations over 2 million hectares of "barren land" in the provinces. Environmental groups claimed the land in fact was virgin rainforest. Following an investigation, China's State Forestry Administration confirmed in 2005 that APP was suspected of illegal logging in Yunnan and that the local government responsible was also acting in collusion with APP (Rui, 2005).

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[23] Incentives are high for local and provincial governments in China to encourage rapid development. High provincial economic growth figures result in increased fiscal transfers from the central government as well as increased promotion opportunities for government officials. These incentives continue despite increased government focus on provinces' environmental achievements.

7 Conclusions and recommendations

7.1 Assessment of success of biofuels policies in achieving wider policy objectives

China initially looked to biofuels to help it achieve three major policy objectives: increase energy security, increase rural income opportunities and reduce environmental pollution. It is questionable whether China's biofuels policies have advanced—or have the potential to advance—any of these objectives. Given the sheer volume of China's oil imports and rate of growth, it is hard to see how policies to promote ethanol use, particularly E10 mandates, have had any impact on improving China's energy security by creating a secure, alternative source of supply. Even if production were to be ramped up sufficiently for ethanol use to perceptibly reduce dependence on overseas oil imports, it is likely that the majority of the feedstock would have to be imported, given China's land constraints. Such an approach would undermine any self-reliance achieved by domestic ethanol production.

Studies also question whether use of fuel ethanol and biodiesel consumption results in lower emissions of harmful atmospheric pollutants (such as sulphur- and nitrogen oxides, and particulate matter) compared with the use of fossil fuels. NDRC analysis indicates that greenhouse gas emissions from biofuels production and consumption could be greater than those from fossil fuels when land use change is taken into account. Additional negative environmental impacts from expanded biofuels production in China are possible, even likely. Conversion of environmentally significant marginal land into cropland and withdrawal from conservation set-aside programs could result in loss of biodiversity, increased erosion and harm to waterways. Incentives for illegal logging could also increase.

Maize farmers in China have benefited from increased prices as a result of fuel ethanol production. Some jobs have been created in impoverished rural areas. However, these localized benefits would seem to be outweighed by more widespread negative effects of higher food prices, which hit China's poor hard in 2007 and the first half of 2008. Small-scale farmers face increased risk of displacement and land seizures as a result of provincial government and investor enthusiasm to expand large-scale biofuel feedstock production into new areas.

Soaring private vehicle ownership in China means domestic production of biofuels, even if production targets are met, would have a negligible effect in reducing China's oil consumption or increasing energy security. With increasing car ownership driving demand, China's oil need is projected to be 800 million tonnes of oil equivalent in 2030 compared with 350 million tonnes of oil equivalent in 2005, according to the International Energy Agency. Ethanol and biodiesel can only meet a very small fraction of China's surging demand for transport fuels.

Some differential in tax might be appropriate in order to reflect the lower emissions of atmospheric pollutants produced from biofuels, and their (generally) lower life-cycle emissions of greenhouse gases compared with unleaded petrol and low-sulphur diesel. But the differential is likely to be small—especially if permanent vegetation is removed in order to plant feedstocks crops, and if direct and indirect land-use effects are taken into account.

However, determining the actual benefits has proved to be no easy task, even in countries with well-developed agricultural monitoring systems (like in the United States and Switzerland). The life-cycle GHG emissions of biofuels differ enormously, depending on the kind of feedstock used, how it is produced, and how it is processed. Biodiesel produced from used cooking oil can have 80 per cent reductions in GHG emissions compared with petroleum diesel. But facilities such as those that use grain as a feedstock and coal for process heat, yield much smaller GHG emission reductions. The net impacts of biofuels made from diverse feedstocks grown on different types of marginal land require careful analysis before these fuels are indiscriminately granted financial support based on assumed environmental or other benefits.

7.2 Domestic economic impacts of ethanol subsidies

Given current cost structures, biofuels production in China is not profitable without government support. China's five licensed fuel ethanol producers rely on government subsidies to remain viable, particularly given rising feedstock prices and a set government price for fuel ethanol. Government subsidization of ethanol production appears set to continue. The NDRC expects China will be paying around RMB 939 million (US$ 137 million) a year in 2010 in total subsidies to ethanol producers (including tax exemptions, subsidies for losses incurred and low interest loans). This estimate is based on China reaching its production target of 2 million tonnes of ethanol by 2010. It does not include R&D subsidies or market price support from mandates.

At present, the majority (four out of five) of the subsidized ethanol plants are grain-based. China is in the awkward position of seeking to discourage the use of staple crops for biofuels production yet at the same time paying production subsidies predominantly to ethanol producers using maize and wheat as feedstocks. Subsidies will be paid to the cassava-based plant in Guangxi this year (under the new scheme that replaces the fixed subsidy rate of RMB 1373 per US$ 200 per tonne with an amount based on the individual plant's performance). With only one additional non-grain feedstock ethanol plant currently approved, this subsidy bias will continue (and in fact will most likely be essential if China continues to maintain an ethanol production target of 2 million tonnes by 2010 and also continues its programme of mandated ethanol use across ten provinces). The grain-based ethanol plants are reportedly undergoing conversion to processing non-grain feedstocks. It is not known whether the new subsidy scheme based on an assessment's of a plant's performance is in any way based on its progress in making that conversion.

The Chinese Government policy of only allowing licensed ethanol producers to receive subsidies is aimed at eliminating ill-conceived and *ad hoc* construction of ethanol plants by provincial governments. However, this policy may also have the effect of blocking entry to potentially more efficient private investors and therefore funnelling subsidies towards inefficient producers. Restricting foreign investment in the fuel ethanol sector may have a similar effect. China Agri, a state-owned enterprise, has a virtual monopoly on ethanol production, removing the opportunity for competition to improve efficiency and reduce dependence on subsidies.

The total amount of subsidies paid to ethanol producers is not large in terms of China's fiscal position. China provides a large amount of financial support to a range of renewable energy technologies and projects. However, it is questionable whether fuel ethanol subsidies and policies are the most cost-effective means of achieving the policy outcomes to which they were intended, and whether the benefits outweigh the costs.

The long-term viability of the industry can also be questioned. In all countries except Brazil, which has unique access to vast land areas capable of growing sugar cane (currently the most efficient biofuel feedstock), biofuel industries remain dependent on subsidies, even after decades of support. Biofuel industries have graduated from being "infant industries" to welfare-dependent adults. In some countries, even high levels of support have not been able to save biofuel industries from decline in the face of rising feedstock expenditure. For example, many Australian biodiesel industries closed operations in 2007 and 2008, despite high rates of subsidies (Quirke *et al.,* 2008).

Government caps on petrol (and diesel) prices make it even harder for biofuel producers to operate without subsidies. Nonetheless, even in countries that allow the retail price of transport fuels to follow the international market price, such as in most OECD countries, the subsidies are still needed for biofuels in many the United States. In fact, biofuels remain uneconomic even the countries that heavily tax petroleum fuel, which elevates its price relative to alternatives (in the European Union, for example—see Kutas *et al.,* 2007).

7.3 Domestic economic impacts of proposed biodiesel subsidies

China does not currently give direct subsidies for biodiesel production. However, there is a widespread industry expectation in China that it will do so soon, even by the end of 2008. Given rising vegetable oil and waste oil prices, jatropha is being viewed in China as the key to the future of a successful biodiesel industry and provincial and central governments continue to promote jatropha biodiesel production. However, the prospects of jatropha biodiesel production in China are uncertain, as born out in the range in the estimates of jatropha oil production costs: RMB 3500–12 000 (US$ 511–$ 1752) due to the uncertainty in extractable oil content, particularly from feedstock grown on marginal land. According to Weyerhaeuser *et al.* (2007), refining costs add another RMB 4500 to RMB 13 000 (US$ 657 to $ 1898) per tonne of biodiesel. These estimated costs are significantly higher than the NDRC estimate of production cost of RMB 3900 (US$ 569) per tonne outlined in Chapter 3.

The NDRC appears to be envisaging a subsidy for biodiesel production of around RMB 1500 per tonne by 2010. However, as discussed in Chapter 4, this calculation may be based on unrealistic estimates of jatropha production costs and may not be sufficient to ensure profitability. Nor will jatropha biodiesel production necessarily reduce the subsidy burden. Peters and Thielmann (2008) found the estimated cost of production for jatropha-based biodiesel in Tanzania was about five times the cost of fossil diesel. They estimated that a 10 per cent biofuel blend would require around 10 per cent of Tanzania's total tax revenue in subsidies. In India, a 10 per cent blending target was estimated to cost between 0.3 and 3.9 per cent of the country's total tax revenues.

This has not deterred potential investors, however, and there is a great deal of proposed investment in both jatropha plantations and refineries in China. It is unknown whether the government will seek to control haphazard or uneconomic biodiesel investment through a centrally-administered licensing system in the same way that it has done with ethanol producers.

Many other details of how the biodiesel market would function, including how biodiesel would be distributed, are not yet clear. These are important factors which will determine how government regulation and support for the biodiesel industry will impact on China's domestic economy.

7.4 Recommendations

Given the potentially high economic, social and environmental costs of biofuel production in China, and the limited gains in energy security and pollution control, continued government support of biofuels in China in the manner being currently provided seems unjustified. On this basis, the authors recommend that:

- direct production-linked subsidies for fuel ethanol production be eliminated and direct subsidies for biodiesel production should not be introduced; and
- government support for biofuels demonstration projects should be limited to those that can be demonstrated to avoid competition with food or feed production to encourage greater research and development of genuinely non-food biofuels feedstock sources, particularly lingo-cellulosic sources.

Remaining conflicts between biofuels and food production, and between biofuels and the environment, require further consideration. In particular:

- any subsidies paid to farmers for conservation set-aside programs should be brought into line with those paid to farmers to produce biofuels (or the latter subsidies reduced); and
- the survey of marginal land currently being conducted should investigate the likely impacts of biofuels production on marginal land on food production, the environment and local livelihoods; and
- site-specific assessments ensure that biofuel development on marginal land is appropriate under local circumstances.

More generally, China should hasten the liberalization of transport fuel prices. China's current price caps serve to undermine the government's energy-efficiency goals. If improving energy security and reducing urban pollution are genuine priories, then allowing domestic fuel prices to rise to those established in international markets would be the most effective step that China could take to curb demand, particularly if such action is accompanied by policies to improve vehicle efficiency and slow growth in car ownership.

Appendix I Chinese fuel ethanol standards

All tables included in these appendices were produced by the NDRC and are reproduced here verbatim.

Table I. 1 Denatured fuel ethanol index

Item	Index
Performance	Light lipid liquid without visible suspension and deposit
Ethanol, % (V/V) ≥	92.1
Methanol, % (V/V) ≤	0.5
Actual gelatin, mg/100mL ≤	5.0
Water, % (V/V) ≤	0.8
Fabio-chlorine (Cal), mg/L ≤	32
Acidity (acetic acid), mg/L ≤	56
Copper, mg/L ≤	0.08
pH value*	6.5–9.0
*pH value should be between 5.7 ~ 9.0 when executed before April 1, 2002	

Note: The effective metal corrosion inhibitor should be added to meet motor ethanol gasoline copper corrosion requirements.

Table I. 2 Ethanol gasoline for automobiles national standard (GB1835102004)

Item	**Quality Parameter**				**Standard**
	90#	93#	95#	97#	
Counter-explosion quality：					
Investigate octane number (RON) ≥	90	93	95	97	GB/T 5487
Counter-explosion index (RON+MON)/2 ≥	85	88	90	-	GB/T 503
Lead content/(g/L) ≤	0.005				GB/T 8020
Distillation					GB/T 6536
10 % evaporation temperature /℃ ≤	70				
50 % evaporation temperature /℃ ≤	120				
90 % evaporation temperature /℃ ≤	190				
Final Boiling Point /℃ ≤	205				
Residue (volume fraction)/% ≤	2				
Vapor Pressure /kPa					GB/T 8017
From September 16 to March 15 ≤	88				
From March 16 to September 15 ≤	74				

Item	Quality Parameter				Standard
	90#	93#	95#	97#	
Actual glial /(mg/100mL) ≤	5				GB/T 8019
Induction period [b]/min ≥	480				GB/T 8018
Sulfur content (mass)/% ≤	0.08				GB/T 380 GB/T 11140 GB/T 17040 SH/T 0253 SH/T 0689 SH/T 0742
Mercaptan (one of the following requirements to be met) : Dr. Test Mercaptan sulfur content (mass)/% ≤	 Pass 0.001				 SH/T 0174 GB/T 1792
Copper corrosion (50 ° C, 3 h) ≤	1				GB/T 5096
Water-soluble acid or alkali	None				GB/T 259
Mechanical impurities	None				Observation
Moisture (mass) /% ≤	0.20				SH/T 0246
Ethanol content (volume fraction)/%	10.0±2.0				SH/T 0663
Other oxygen-containing compounds (mass)/% ≤	0.1[e]				SH/T 0663
Benzene content f (volume fraction)/% ≤	2.5				SH/T 0693 SH/T 0713
Hydrocarbon content g (volume fraction)/% ≤	40				GB/T 11132 SH/T 0741
Olefin content g (volume fraction) /% ≤	35				GB/T 11132 SH/T 0741
Manganese content (g/L) ≤	0.018				SH/T 0711
Iron content [i]/(g/L) ≤	0.010				SH/T 0712

Source: NDRC (2008)

Appendix II. Analysis of potential and existing biofuels feedstocks in China

(Source: NDRC, 2008)

Ethanol feedstocks

Sugar cane

Sugar cane is a technically ethanol feedstock as the saccharification process of amylum and fibres biomass can be omitted. In 2005, the cultivation area in China was about 20.31 million mu and the yield over 86 million tonnes. Most of the sugar cane produced in China was used to produce sugar. Molasses, the main by-product is used in the production of ethanol. Sugar cane is grown in Guangxi, Guangdong, Yunnan, Hainan, Fujian, Sichuan, Jiangxi and Hunan and other southern provinces in China. Guangxi is the largest sugar cane producing area, with output accounting for more than half of the total national yield. Detailed data for different provinces is shown found at Table II.1.

The NDRC considers 600 000–800 000 hectares of marginal land suitable for planting sugar cane from which an annual output of 50 million tonnes of sugar cane can be produced (however, sugar cane is a water-intensive crop and any marginal land designated for sugar production would need high rainfall or irrigation). This amount could potentially produce 4 million tonnes fuel ethanol assuming the production capacity exists. While sugar cane will continue to be used for sugar production, in China's near future it could be an important reserve energy feedstock, particularly given the saturation of demand and the decrease of prices in the international and domestic sugar market.

NDRC analysis of planting costs for energy sugar cane and sweet sugar cane is given in Table II.1 (Wang, 2006).

Table II. 1 Planting costs of different kinds of sugar cane

Crop	Yields (t/ha)	Cost (RMB/t)
Energy sugar cane	210	180 (US$ 26.30)
Sugar cane for sugar production	75	250 (US$ 36.50)

Sweet sorghum

The NDRC considers sweet sorghum one of the most attractive energy crops. It could be grown from Heilongjiang in the far northeast to tropical Hainan Island in the south, but the most suitable areas for cultivation include the northeast of China, North China, northwest of China and the Huanghuai River basin. The seed yield is about 200 to 400 kg per mu and stem yield is about 5 000 kg per mu. Its stem is rich in sugar and the content is about 17 to 21 per cent, which can used to produce ethanol and sugar and can be used for animal fodder after processing. Other parts of sweet sorghum, such as seeds, are also used as food.

The NDRC considers sweet sorghum to be the most likely energy crop to be successful on barren and saline-alkaline land in the longer term (2015 to 2030). Sweet sorghum has not been planted on a commercially large scale so the NDRC estimates the planting cost based on those for sorghum:

Table II. 2 Planting cost of sweet sorghum

Item	Cost RMB per ha
Machinery	30 (US$ 4.40)
Fertilizer	110 (US$ 16)
Seeds	10 (US$ 1.46)
Pesticide	10 (US$ 1.46)
Manpower	70 (US$ 10.20)
Irrigation and electricity	20 (US$ 2.92)
Total	250 (US$ 36.50)

Cassava

Cassava has a strong adaptability, high yield per unit area and high starch content (22 to 33 per cent.). In the drier parts of southern China, cassava yields are 45 tonnes per ha, and can produce 0.43 tons fuel ethanol.

In 2005, China's cassava cultivation area was about 9 million mu, and the total output was 11 million tonnes, mainly located at Guangxi, Guangdong, Hainan, Yunnan, Guizhou and Sichuan. Guangxi is the largest area for cassava cultivation, with 6 million mu under cultivation and a yield of 8 million tonnes. Planting area and yield account for more than 66 per cent out of the national total. Most is used for processing starch and feed. It is also traditionally processed into alcohol (blending liquor).

However, cultivating cassava is labour-intensive, storage technology is poor and involves high starch loss, it uses a lot of energy to process and can result in serious pollution. These problems need to be improved through pilot demonstrations to accelerate its industrialization process. It is worth noting that Brazil encountered great difficulties in achieving large-scale cassava production, largely due to the susceptibility of the crops to pests and diseases.

Cassava planting costs are based on the field survey and interviews with local households in Guangxi province. Because the cassava has been planted in poor regions, the planting and harvesting is mostly done by hand so rural manpower is the main cost factor.

Table II. 3 Cost analysis for cassava planting

Item	Cost RMB per ha
Machinery	0
Fertilizer	90 (US$ 13.14)
Seeds	375 (US$ 54.75)
Pesticide	30 (US$ 4.38)
Manpower	1440 (US$ 210)
Irrigation and electricity	0
Total	2745 (US$ 400)

Sweet potato

Sweet potato is a tuberous root crop, important in China as a source of food, animal feed, industrial raw materials and, now, energy. It has high and stable yields, strong adaptability, rich nutrient content, and multiple uses. China is the world's largest sweet potato-producing country, with total plantings each year constituting about 7 million ha, about 65.4 per cent of the global total. Annual yield is about 150 million tons, accounting for 85.9 per cent of the world's sweet potato output. Production by provinces can be found at Table 1-3. Starch content of fresh sweet potato is around 20 per cent, and about 64–68 per cent for dry potato. Sweet potato is not included in China's grain purchasing and selling systems, and is included in China's grain security calculations. Currently, sweet potato processing is relatively extensive and varieties are limited. More than 45 per cent of sweet potato produced is used by households for free-range livestock feed. About 18 per cent is used for processing starch and noodles. Sweet potato is not highly commercialized (<30 per cent) with almost no large-scale processing industries. Therefore, the NDRC considers sweet potato a rich resource for the biomass energy industry.

Table II. 4 Yield of sweet potato in the main production areas in China

Province(Region)	Area (thousand ha)	Unit production (ton/ha)	Total (100 000 tonne)
Hebei	250	22	55
Jiangsu	160	30	48
Anhui	400	25	100
Shandong	450	28	126
Henan	550	23	127
Zhejiang	110	28	31
Fujian	220	25	55

Province(Region)	Area (thousand ha)	Unit production (ton/ha)	Total (100 000 tonne)
Jiangxi	150	22	33
Hubei	180	21	38
Hunan	250	21	53
Guangdong	300	24	72
Guangxi	250	18	45
Chongqing	500	20	100
Sichuan	900	20	180

Biodiesel feedstocks

Jatropha curcas

Jatropha originates in the tropical Americas. It is easy to propagate and can grown in dry tropical valleys and barren wasteland. There are wild and cultivated jatropha plants in Guangdong, Guangxi, Yunnan, Guizhou and Sichuan.

There are a number of small-scale demonstration jatropha plantations in Southwest China. Based on these plantations, the NDRC estimates jatropha planting cost will be RMB 418.6 (US$ 61)/mu.

Table II. 5 Jatropha planting costs

Item	Cost RMB/mu	Note
Seeds	55 (US$ 8)	
Plant	275 (US$ 40.15)	
Management after planting	88 (US$ 12.80)	4 years management
Harvest of seeds	0.6 (US$ 0.08)	Harvest during third to fifth years
Total	418.6 (US$ 61)	

Pistacia chinensis Bunge

Pistacia chinensis Bunge is a shade-tolerant and drought-resistant deciduous tree and can live for up to 300 years or more. The oil content of seed kernels is 56.7 per cent and can be used for soap and lubricant production. *Pistacia chinensis* Bunge oil has yet not been used as feedstock for biodiesel, but the NDRC feels it offers good potential for this purpose.

Pistacia chinensis Bunge occurs naturally throughout 23 provinces and autonomous regions in north, central and south China. This tree grows on mountains and hills, and also occurs in large pure or mixed forests. With 40 trees planted per mu, each can produce 20 kg fruit, with a potential biodiesel per-mu yield of about 200 kg.

Other oil plants

Table II. 5 Main woody oil plants in China

Type	**Distribution**	**Ratio of oil contents**	**Yield of seeds (Kg/ha**	**Current areas (1 000 ha)**
Jatropha curcas	Sichuan, Yunnan, Guizhou, Chongqing, Guangxi, Hainan, Fujian	30%–60%	3000–7500	21
Pistacia chinensis Bunge	From Hebei, Shandong, to Guangdong, Guangxi, From Taiwan, to Sichuan, Yunnan. Hebei, Henan, Shanxi, Shaanxi's distributions are the most.	35%–40%	1500–9000	87
shiny-leaved yellow horn	Ningxia, Gansu, Inner Mongolia, Shaanxi, etc	30%–40%	3000–9000	5
C.wilsoniana Wanger	Mainly at the Yangtze River basin and the cornbrash region at the South-west of China. Also at the south region of Yellow River	30%–36%	4500–10500	4.5
Sapium	Mainly at the Yangtze river basin, and Zhejiang, Hubei, Sichuan	35%–50%	2250–7500	48
Tung tree	Gansu, Shaanxi, Yunnan, Guizhou, Sichuan, Henan, Hubei, Hunan, Guangdong, Guangxi, Anhui, Jiangsu, Zhejiang, Fujian, Jiangxi, etc	40%–50%	3000–12000	1188
Total		-	-	1354

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The Global Subsidies Initiative (GSI)
of the International Institute for Sustainable Development (IISD)

The International Institute for Sustainable Development's Global Subsidies Initiative shines a spotlight on subsidies – transfers of public money to private interests – and the ways in which they can undermine efforts to put the world on a path toward sustainable development.

Subsidies have profound and long-lasting effects on economies, the distribution of income in society, and the environment, both at home and abroad. Subsidies have shaped the pattern and methods of agricultural production, even in countries that now provide few or no farm subsidies. They have encouraged fishing fleets to search farther and deeper than ever before, aggravating the problem of over-fishing. They have fueled unsustainable energy production and wasteful consumption patterns.

While subsidies can play a legitimate role in securing public goods that would otherwise remain beyond reach, they can also be easily subverted. Special interest lobbies and electoral ambitions can hijack public policy. When subsidies result in a fundamentally unfair trading system, and lie at the root of serious environmental degradation, the question has to be asked: Is this how taxpayers want their money spent?

The GSI starts from the premise that full transparency and public accountability for the stated aims of public expenditure must be the cornerstones of any subsidy program. In cooperation with a growing international network of research and media partners, the GSI is endeavouring to lay bare just what good or harm public subsidies are doing; to encourage public debate and awareness of the options that are available; and to help provide policy-makers with the tools they need to secure sustainable outcomes for our societies and our planet.

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