Balancing Biofuels Developments with Feedstock Concerns

- Analysing Biodiesel Growth in China -

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China biofuel for transport

Private vehicle ownership increased six-fold in 10 years, expanding fossil gasoline and diesel use. The facts:

- Total fossil diesel consumption in 2004: 95.5 Mio t/a,
- Total fossil diesel consumption in 2006: 116.0 Mio t/a
- Total fossil gasoline consumption in 2004: 45 Mio t/a
- In 2020, the fossil fuel demand only by motor vehicles will range about 256 Mio t: **85 Mio t of gasoline** and **171 Mio t of diesel**.
- If 10% of bioethanol (E10) is added to gasoline, the demand for bio-ethanol (E100) in 2020 will reach **8.5 Mio t.**
- If 5% of diesel demand is met by biodiesel (B5), the demand for bio-diesel (B100) in 2020 will reach **8.2 Mio t.**

Forecast of China's dependence, oil import	**2010**	**2020**
Crude oil import forecast Mio t/year	228	422
Dependence on import	61 %	76.9 %

2007
160

PRC Governmental biofuel policies, incentives and standards

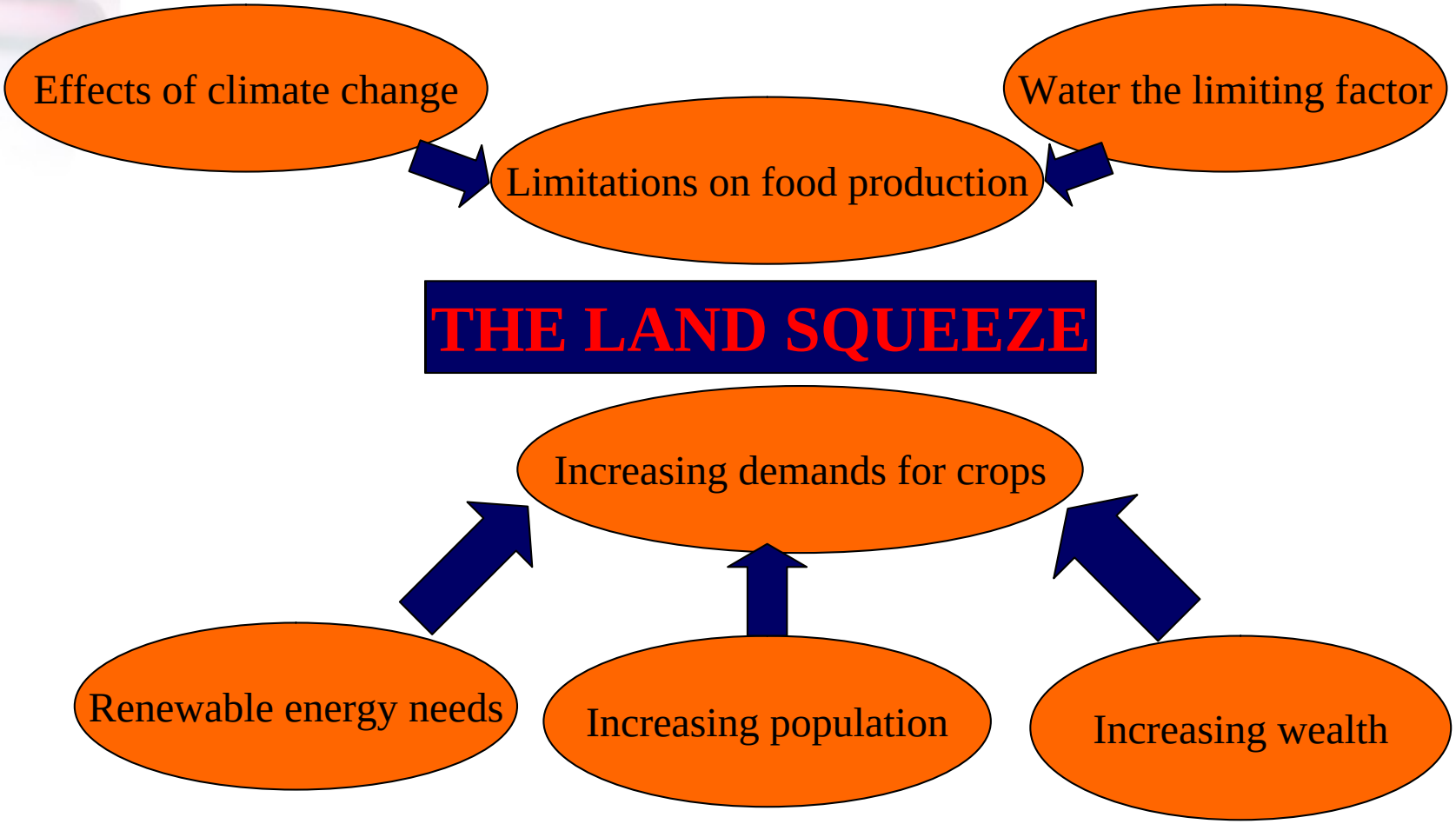
"Biofuels will meet 15 % of China's transportation energy needs by 2020"

- Successful private commercial engagements are still limited by
  - Chinese energy market monopolization,
  - the low degree of law and regulation implementation,
  - the lack of technological, social and ecological standards.
    - *Strict fuel ethanol production standards are in place but there are no equivalent standards for biodiesel or biogas for transport.*
- Economic incentives, practical and economical technology and professional personnel are still missing in the Chinese biodiesel sector – but not in the bioethanol sector -, thus characterizing the biodiesel energy business currently as a risk business where most of the involved firms are operating at marginal profit, but with huge perspectives.

How biofuels fit in the renewable energy policy

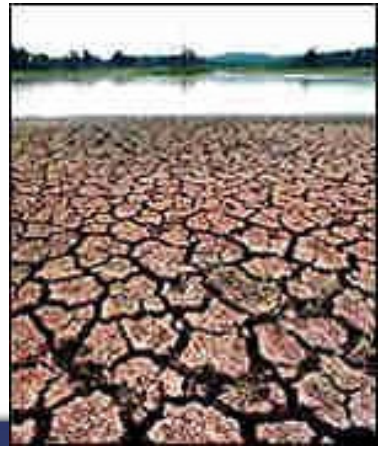
- Chinese policies regarding the bioenergy sector development are relatively new. Although a Renewable Energy Law is established, the system of regulations is incomplete.
- China's biomass potential is based on residues from agriculture, forestry, related industries, municipal biological waste, organic wastewater, energy crops, Tree Borne Oil (TBO) and green land management.
- Biomass assessment and data collection system for biomass energy started recently in late 2006.
- Biofuel development will impact on food self-sufficiency and food security - therefore Chinese government's support for the development of the biofuel sector is limited or at least very slow.

Demand For Land



Energy or Food?

- Little conflict potential between energy-oriented infields and foodstuff plantations
  - *according to studies on Chinese food supply the potential output per ha can meet most of the increased demand for food – also in future.*
  - *27% of China's territory is desert*
  - *Over the past 25 years, China has made great strides in improving agricultural productivity and reducing hunger and poverty levels*
  - *Competition will always exist for both the biomass for liquid biofuel production and the requisite land resource to grow it: the four "f" of biomass usage: food, feed, fibre, and fuel*
- In the Chinese context energy-oriented agriculture with at least some valued dual use or co-product derived from the crop are now promoted.



Bioethanol

- Two reactions are key to understanding how biomass is converted to bioethanol:

Hydrolysis is the chemical reaction that converts the complex polysaccharides in the raw feedstock to simple sugars. In the biomass-to-bioethanol process, acids and enzymes are used to catalyze this reaction.

Fermentation is a series of chemical reactions that convert sugars to ethanol. The fermentation reaction is caused by yeast or bacteria, which feed on the sugars. Ethanol and carbon dioxide are produced as the sugar is consumed.

- There are three groups of feedstock for ethanol production:

1. Grains: corn, wheat, rice …
2. Non-grains (NGB): cassava (tapioca), sugar (beats and cane), sorghum, potatoes, sweet potatoes …
3. Cellulose: any organic matter like agricultural waste, grasses, sewage, sludge, grass, plant stalks, trees …

Bioethanol production

Year	Production Quantity
2002 and before	Official fuel ethanol production began in 2004. There is little recorded fuel ethanol production before this time.
2003	>20,000 MT/year
2004	300,000 MT/year
2005	920,000 MT/year
Aggregate	~1,220,000 MT/year

China Ethanol Export in 2001-2005 in 1,000 LTR

HTS#	Description	2001	2002	2003	2004	2005
	Total Ethanol	249,422	115,248	284,101	96,912	162,204
220710	Undenatured	234,323	99,748	276,084	91,596	158,654
220720	Denatured	15,099	15,500	8,017	5,316	3,550

China Ethanol Import 2001-2005 in 1,000 LTR

HTS#	Description	2001	2002	2003	2004	2005
	Total Ethanol	455	3,558	4,316	4,253	19,590
220710	Undenatured	137	1,435	2,258	2,021	15,936
220720	Denatured	318	2,122	2,058	2,232	3,654

2005: about 920,000 MT; production capacity of 1,020,000 MT.
2010: increase to nearly 4 Mio MT

Bioethanol outlook – corn based

- widely popular feedstock: can be planted nearly all over China
- not considered by the Ministry of Agriculture as future energy crop for bioethanol because energy corn needs similar land conditions as for food production.
- 2006: more than 23 Mio t of corn processed for industrial use, an increase of 84% from 2001, while output of corn only grew by 21.9% over the same period.
- in December 2006: NDRC ordered local governments to stop approving new projects that process corn for industrial uses, and to promote use of non-grain feedstock to produce biofuels (e.g., cellulose based ethanol from biomass).
- 2006: 6.8 % rise in the price of corn due to industrial demand, increasing need for corn by livestock production, and the reluctance of corn growers to sell in expectation for higher prices

Bioethanol outlook – wheat based

- Wheat is currently the principal feedstock source for only one fuel bioethanol factory in Henan province.

- There are three reasons why wheat will not become a large component in China's biofuel production:

1. high domestic demand for food;
2. relatively low efficiency rate in ethanol production;
3. government policies away from the use of grain-based feedstock in ethanol production.

Bioethanol outlook – sorghum based

- *Sorghum bicolor L.* can be used in decentralized or centralized processing units.
- Best yield of sorghum is reported within a collection limit of 25 km.
- Generally, centralized production of bioethanol from *Saccharum officenarum* L. juice is not feasible, due to rapid decrease of sugar content in the harvested stalks.

bio-ethanol production unit based on sweet sorghum

multistage yeast fermentation plant

Bioethanol outlook – cassava based

- *Manihot esculenta Crantz:* less expensive starch source for commercial manufacture of bioethanol for transport fuel production.
- 2004: 72% of the cassava used only for biofuel; 78.000 t/y imported from South East Asia; biggest share in chips or starch has Vietnam and Thailand.
- 2006: Henan's Tian Guan Group by contract with the Government of Laos, leasing 15 km² of land for the production of cassava-based ethanol - import of fuel bioethanol to China.
- Cassava could supply up to 4 Mio MT of fuel ethanol.

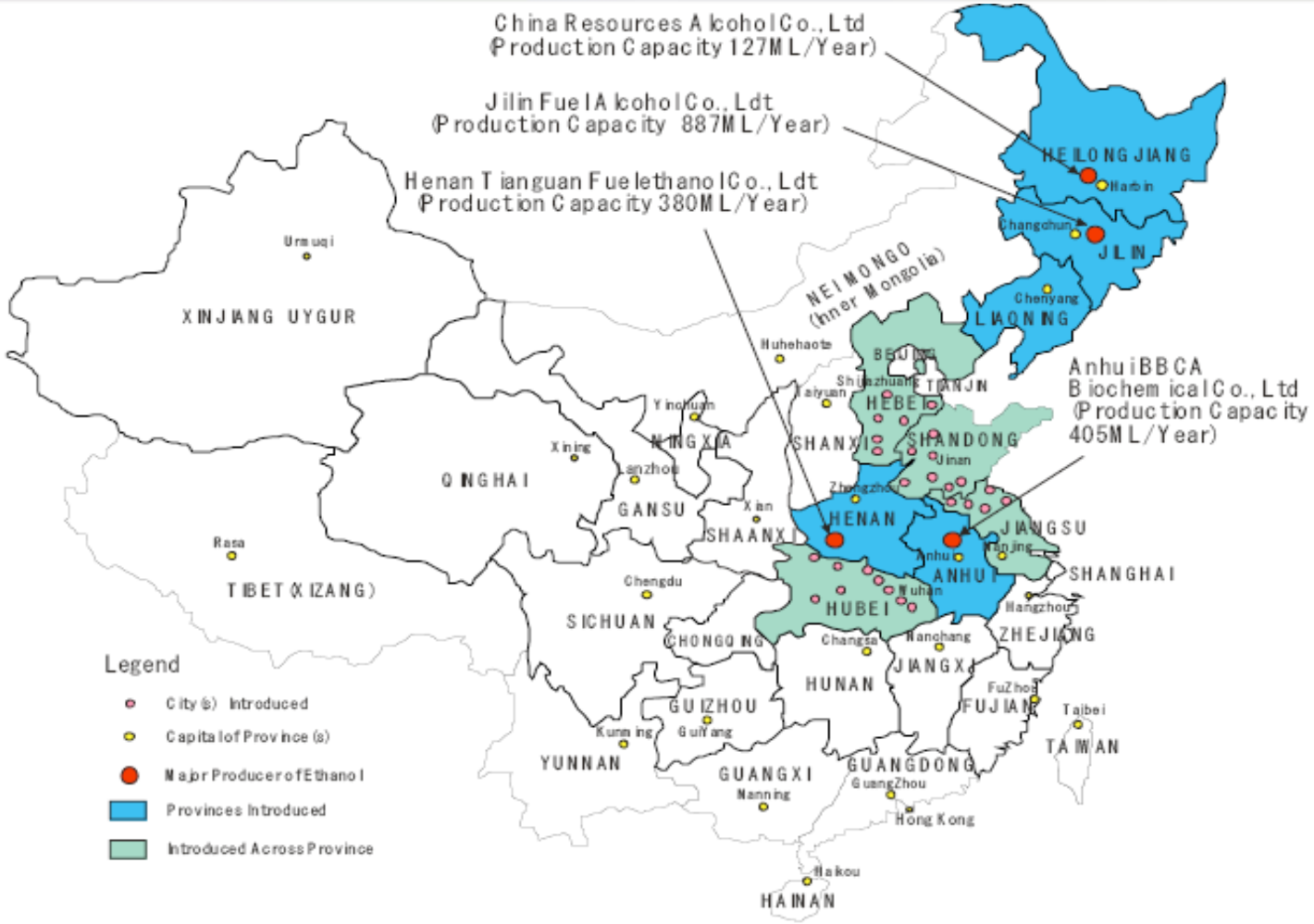
Bioethanol outlook – sugar cane based

- grows well in Guangdong and Guangxi Province in Southern China
- Guangxi Academy of Agricultural Sciences promotes bioethanol production program by expanding sugar cane cultivation to neighbouring regions
- Sugar manufacturing industry is not positive about constructing bioethanol production plants based on sugar cane because of high domestic demand for sugar; imports of sugar about 1 Mio t/y
- Currently 10% of bioethanol is produced from sugar industry residues.
- State Environmental Protection Agency (SEPA) carried out environmental impact assessments for all ethanol production technologies: due to inefficient and wasteful production technologies, sugar as raw material for fuel ethanol production is not accepted.

Commitment to the introduction of E10

1. 1986: R&D subsidies were granted to the technology development efforts and a number of trials were carried out under the *"National High Technology Research and Development Initiative"* (also known as "863 Plan")
2. 2001: legislative support by announcing standards for *"Denatured fuel ethanol" (GB18350-2001)* and *"Bio-Ethanol gasoline for automobiles" (GB18351-2001)* to specify the production of E10.
3. 2002: the government enforced the *"Law Concerning Testing for the Use of Bio-Ethanol Gasoline for Automobiles"* and launched a business model for the introduction of E10 in specified areas.
4. 2004: bridgehead toward the full-scale ethanol use by announcing the *"Law Concerning Testing for the Extensive Use of Ethanol Blended Gasoline for Automobiles and the Regulations Concerning the Conduct of Testing for the Extensive Use of Ethanol Blended Gasoline for Automobiles"*

E10 manufacturer in China



Bioethanol market development

- China's food-grade ethanol industry comprises over 200 production facilities in 11 provinces, capable of producing more than 10 Mio t of bioethanol each year, but only 4 Mio t have been produced in 2005.
- As ¾ of the overall ethanol production is still for drinks and industrial purpose, only 25% of the capacity is used for biofuel ethanol.
- The government does not regulate food-grade ethanol production as it does for fuel-grade ethanol. Undenatured food-grade ethanol plants are far too numerous for government regulation.
- As food security is a great concern, China have also made investments in Brazil, from where the country will probably import considerable quantities of bioethanol in the future.

Bioethanol market subsidies

- Since 2005: market price for bioethanol about 360 EUR/t, supported by governmental subsidies – about 137 EUR/t
  - *Although resource restriction of "overtime grain" and high price of fresh corn increase the cost of bioethanol, the current (subsidized) market price of bioethanol is less than fossil gasoline.*
- The processing costs of 100% bioethanol are about 101 EUR/t, not considering the purchase costs for feedstock. Even if production will be running at full scale, about 137 Mio EUR/a will be requested as subsidies. Ethanol subsidy has already been reduced from 183 EUR/t to 137 EUR/t, and will further gradually decrease to 0 in 2010.
- Companies producing bioethanol enjoy interest support for loans and favorable tax policies, and several provinces are obliged to sell ethanol fuel.
- Fuel bioethanol is profitable when oil prices approach 6 RMB/l. However, content requirements and the influence of state owned purchasers of biofuel will define demand.

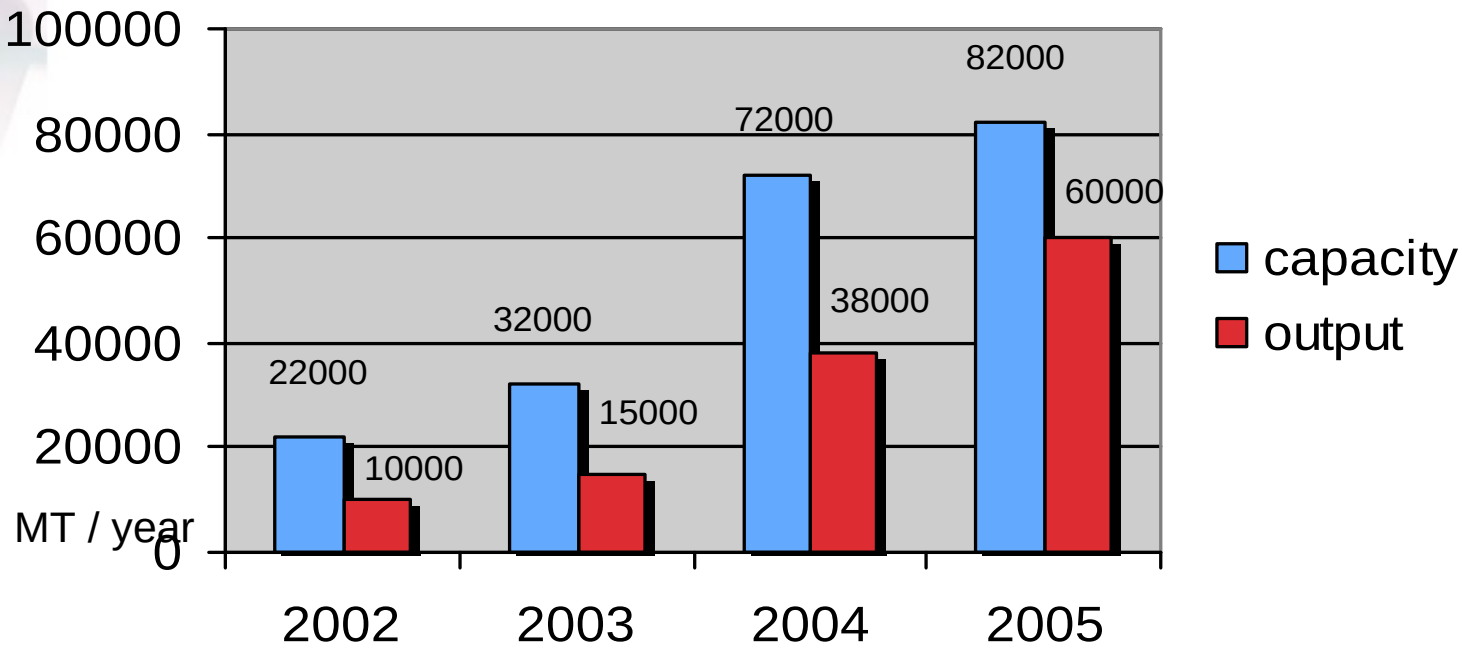
Biodiesel

- … a mixture of long-chain fatty acid esters, conventionally manufactured through trans-esterification of triacylglycerol with methanol, catalyzed by inorganic bases or acids.
- … blended with diesel (or used directly in a diesel engine); common blending rates exist: B5, B10, B85, and B100.
- … production is technologically more complex than ethanol production.
- … produced from waste oil & grease, vegetable or animal fat, waste acidified oil, plant oil and wood plant oil, any oil-based/fatty organic matter.
- … byproduct from production: large amounts of glycerol.
  - *Glycerol can be used for four purposes:*
    - *plastics and fiber production*
    - *thermal biomass combustion,*
    - *biogas production booster*
    - *biomethanol production*

Biodiesel market - development

- rising demand since the diesel market is twice that of the gasoline market.
- main difficulty: lack of feedstock for production.
  - *China is the largest importer in the world for all major edible vegetable oils.*
- May of 2006: preliminary steps towards biodiesel promotion by setting up a special development fund to encourage research, development, and production.
- 2005: purchase of nearly 3 Mio t or 75 % of its total palm oil needs from Malaysia.
- Various Chinese firms have approached the Malaysian External Trade Development Corporation to purchase palm oil waste for bio diesel production.
- In search of long-term contracts, they were willing to pay $200-250 / t.

Biodiesel production for market supply



- 2006: 100,000 to 200,000 MT
- 2007: 2.3 Mio MT *(estimation based on installed capacity)*
- 2020: 10 Mio MT

No secured information about real number of factories, operation capacity and actual output!

Biodiesel feedstock

Palm
5136 kg/hectare

Peanut
1263 kg/hectare

Rapeseed
1000 kg/hectare

Sunflower
672 kg/hectare

Soy
375 kg/hectare

Biodiesel feedstock

Chinese Dwarf Cherry

Castor
1271 kg/hectare

Neem Tree

Wilson's Dogwood

Yellowhorn

Jatropha curcas L. □□□□□□

Shrub or tree up to 2-5 m tall. Service life: 30-50 years

□□□□□□□50-68% Seeds oil: 50-68%

Chinese biodiesel news

- 2004: A survey conducted by the Chinese Academy of Forestry identified 151 families of oil-bearing woody plants, with 697 genera and 1,553 species, which can be tapped for biodiesel production. Of these, 154 species have an oil content of more than 40 %, while nearly 30 species of trees or shrubs have a comparatively centralized distribution that can be used as convenient raw materials for biodiesel.

- 2006: United Nations Development Program (UNDP) and China's Ministry of Science and Technology are co-funding since a 4-year project in Guizhou, Sichuan, and Yunnan provinces to encourage local farmers to grow *Jatropha curcas* trees for biodiesel production.

  - *In addition to producing biofuel, the project aims to eliminate poverty and improve fragile ecosystems.*

Biodiesel feedstock: Tree born oil

Aleurites fordii *Pistacia chinensis* *Sapium sebiferum* *Rhus succedanea* ***Xanthoceras sorbif olia*** *Ldesia polycarpa* *Jatropha curcas* *Cornus wilsoniana* *Euphorbia tirucalli*

The successful experience on artificial planting of these plants was obtained, and it is expected that the development of these resources should be promising and valuable.

AIeurites fordii □□(□□)

□□□□□□48-50 % Oil content of the seed is 48-50 %

表 2 不同海拔高度油桐坐果率(李书县,1989 年)

海拔高度(m)	400	500	600	700	800	900	1000
坐果率(%)	89.3	88.9	89.1	89.5	86.2	78.5	76.9

Rhus succedanea L

40-60 % Oil content of the dry fruit is 40-60 %

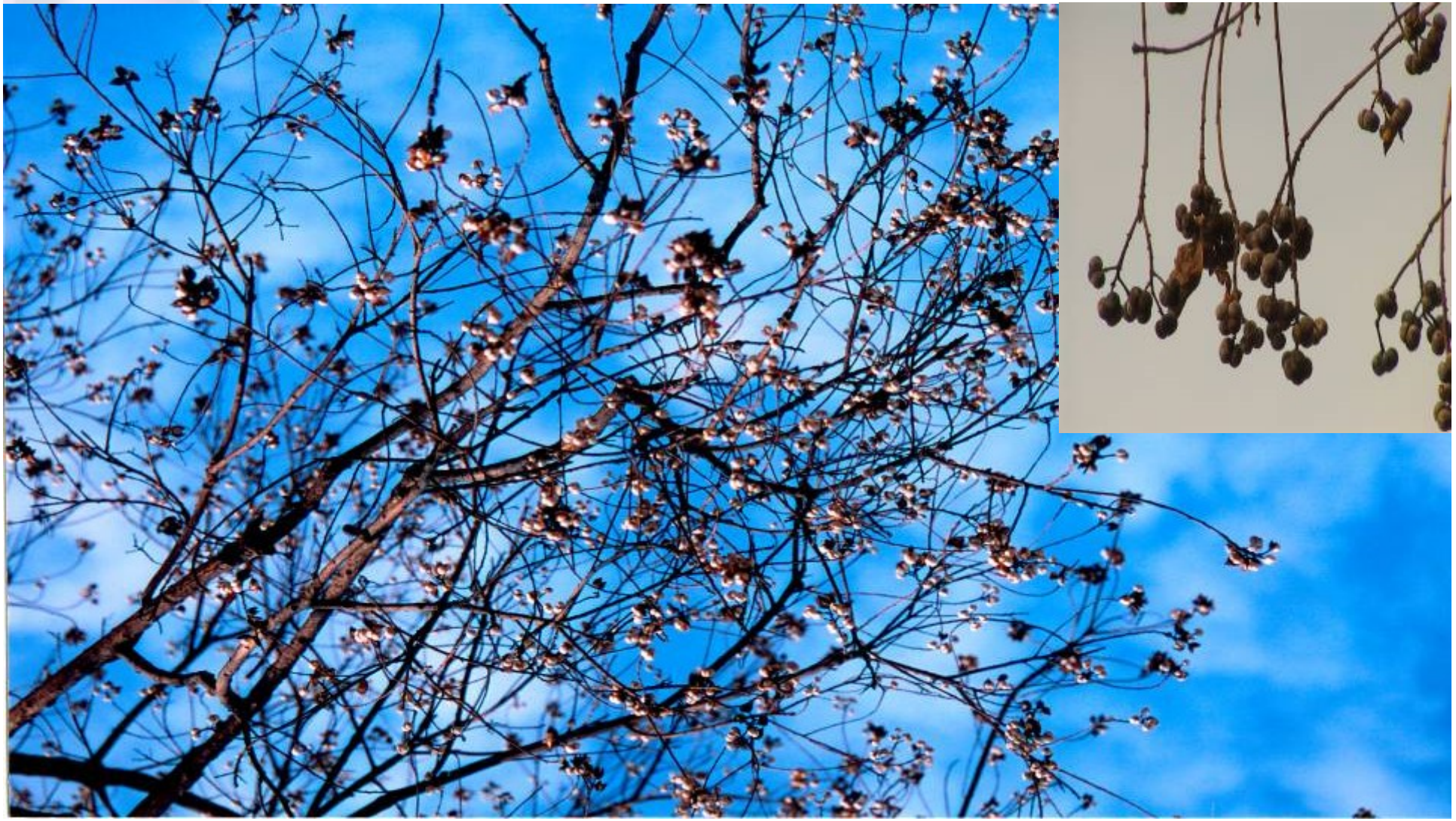
170 45

There are 1.7 Mha of Rhus Succedanea. L in China with the annual growing rate of 0.45 Mha. Excepting the lacquer harvested, the seeds are wasted.

Sapium sebiferum □□ (□□□)

□□□□□□Oil content of the seed is 64% , dry fruit is 35 %.

□□□□200□□□□5000□□□□□□□□□□□□□□□□□□□□



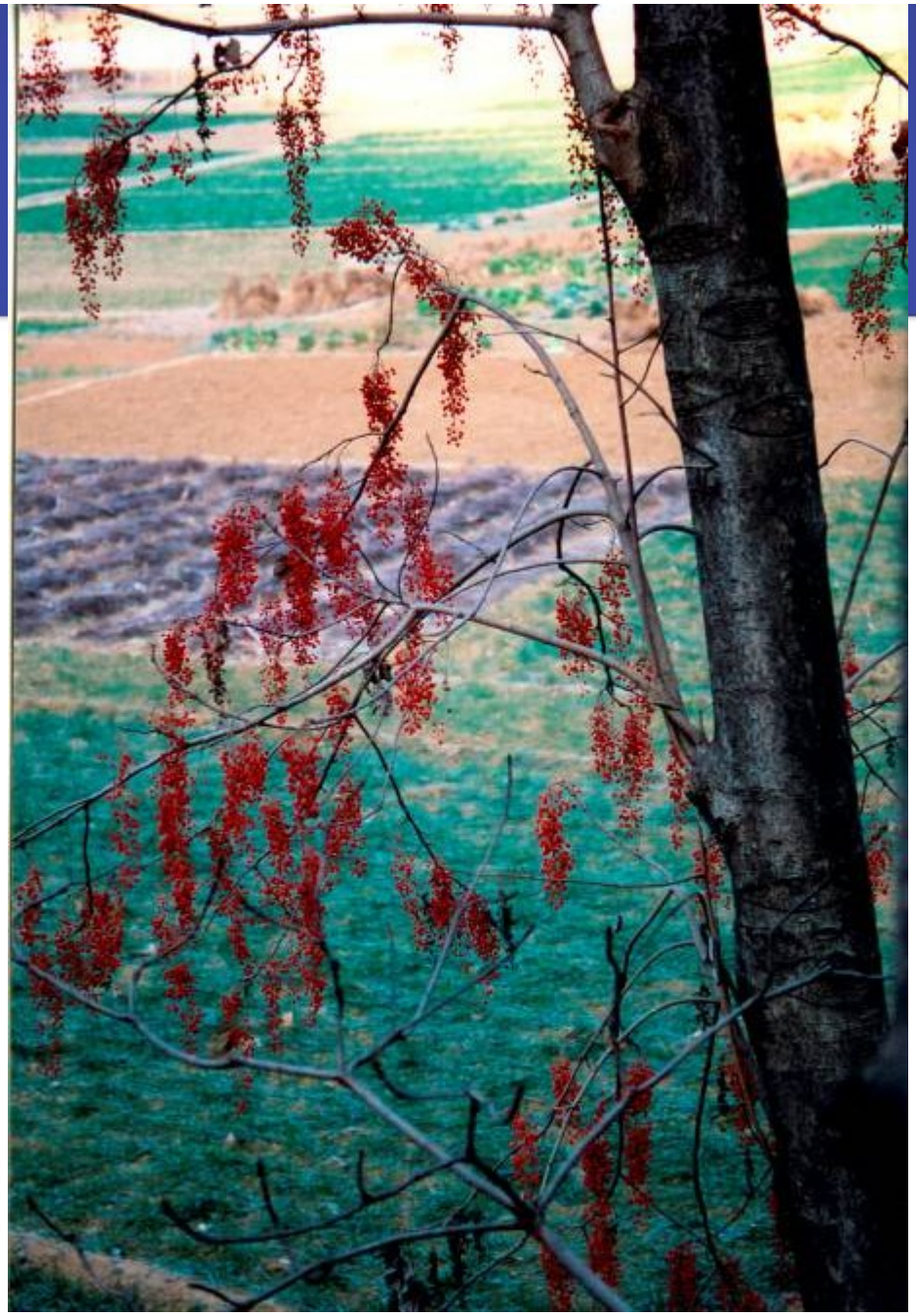
Ldesia polycarpa Maxim

□□□□□□□□

□□□□□□□28 % □□□56%

Oil content of the seed is 28%
Dry fruit is 56%

□□□□800-1500MM□□□□□□□□□



Cornus wilsoniana □□□ (□□□□)

Shrub or tree, period: 50 years. Grows fast.

□□□□□: 33-36%. Oil content of the dry fruit is 33-36%.

Xanthoceras sorbif olia Bunge.□□□□□□□□

□□□□□□45 %

Oil content of the seed is 45%

Pistacia chinensis Bunge □□□(□□)

Deciduous arbour tree up to 30 m tall□more than 300 years;

□□□□□Oil content of the seed is 42% ,

Unique Chinese Feedstock

Unique Chinese Feedstock

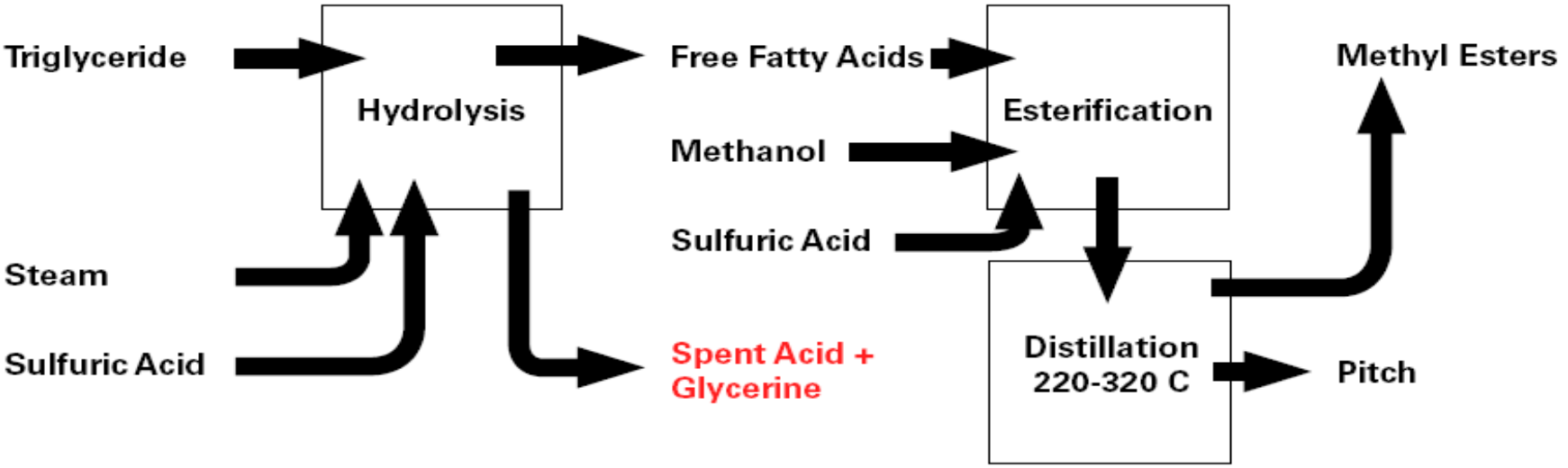
Cobra Feedstock library

Cobra Feedstock library

Cobra Feedstock library

Chinese Biodiesel Production Technology Development

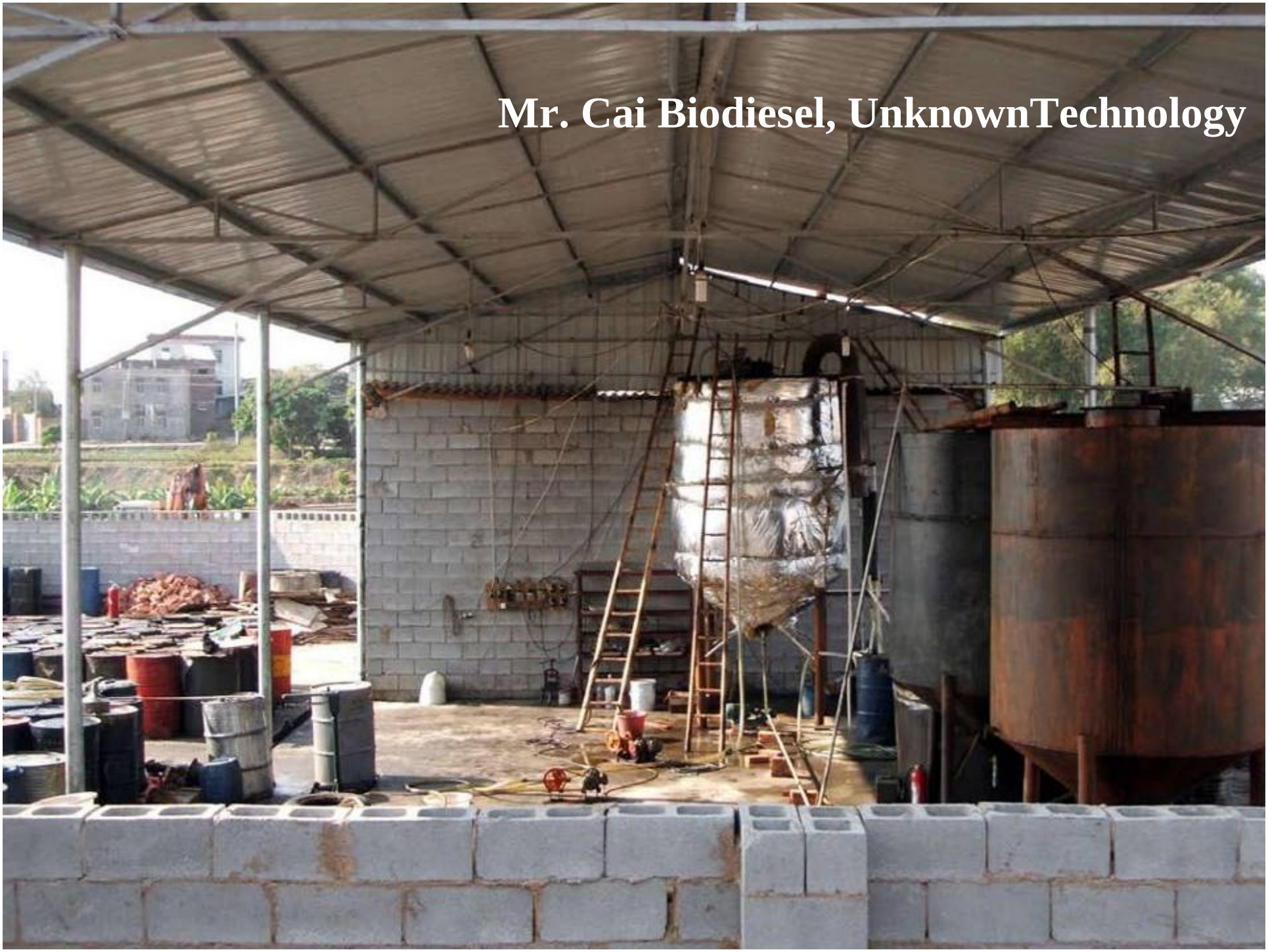
Popular Chinese Production Technology, High Acid System



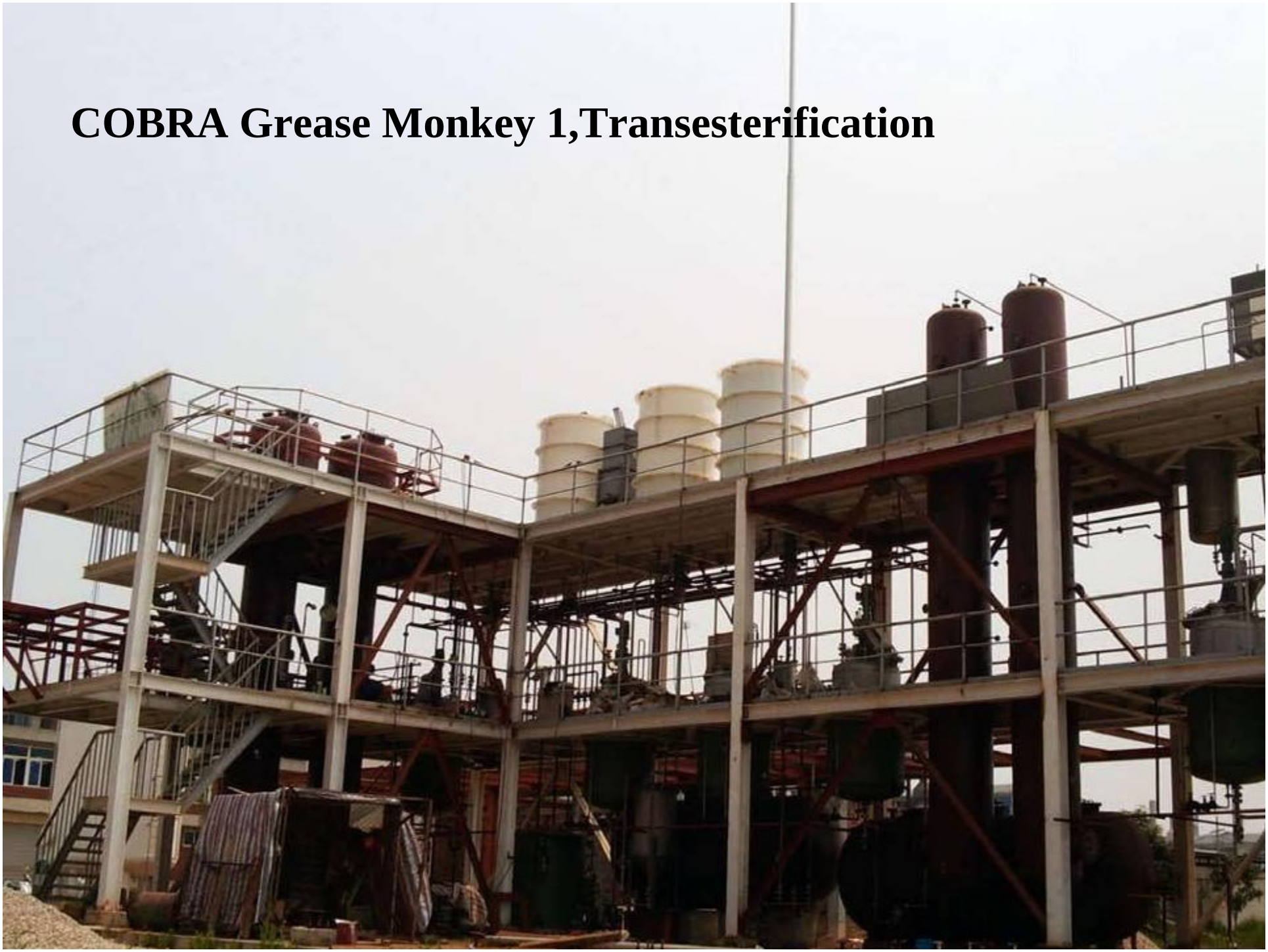
Advantages:
Biodiesel quality guaranteed
Not sensitive to feedstock quality

Disadvantage:
Energy Intensive, high acid environments
Waste water issues, no by-products
High capital costs, high operating costs

Longyan Zhuoyue New Energy, High Acid System


Mr. Cai Biodiesel, UnknownTechnology

COBRA Grease Monkey 1,Transesterification



Biodiesel in China

History of Biodiesel in China (1)

- Begun with Professor Din, Fuzhou University. Technology is an extended application of Fatty Acid distillation and purifi- cation plants
- 2001, Hainan Zhenghe operational
- 2002, Hebei Zhenghe begins construction 2002, Sichuan Gushan operational
- 2003, Longyan New Energy Zhuoyue operational
- 2003 Summer, Power shortage caused rush on diesel. Brown out still continue in Guandong Province
- 2004, Fujian Gushan begins construction
- 2005, SinoPec and China Petroleum forms a pact, 'Diesel Inverse Pricing' policy begins. Wholesale price higher than retail price. Wholesalers turn to biodiesel to retain profit

History of Biodiesel in China (2)

- **2005, A flood of 100,000+ T/year projects are proposed across China**
- **2005, Diesel hoarding begins**
- **2005 Summer,Typhoon caused diesel suppy shortage in the southern provinces.**
- **2006 January, Gutter oil at RMB 1800/T**
- **2006 March 26, China retail diesel price increased from RMB 4.05/L to RMB 4.19/L. Pricing inverse worsen, wholesale demand for biodiesel increase**
- **2006 April, International oil price reaches USD 70 per barrel**
- **2006 May 26, China retail diesel price increased from RMB 4.19/L to RMB 4.64/L**

History of Biodiesel in China (3)

- 2006 July, International oil price reached all time high USD 78 per barrel. Biodiesel wholesale price at all time high RMB 5100/T
- 2006 September, Gutter oil priced at RMB 3200/T
- 2006 September, International oil price drops below USD 70 per barrel
- 2006 October, International oil price at USD 62 per barrel, smuggled diesel enters Chinese market
- 2006 October 15, biodiesel market crashing, smuggled diesel price RMB 4900/T, non-spec diesel is even cheaper. Biodiesel is no longer favored due to density, use and profit considerations
- 2006 October 30, biodiesel wholesale price RMB 4700/T
- 2006 December, Sinopec and China Petrolem breaks pact, wholesale price falls below retail price
- 2006 December, many plants are closed due to market and winter issues

History of Biodiesel in China (4)

- **2007 March, many new plants begin production**
- **2007 March 26, British sailors were seized by Iran, rise in Middle East tension cause sharp rise in international oil price, Biodiesel demand increased**
- **2007 April 4, British sailors released, international oil price drops to USD 64.38 per barrel, demand for Biodiesel de- creased**
- **But more 250,000+T per year are proposed 2007**

Biodiesel market - policy

- Biodiesel's future relies on three key factors:
  1. Government support and NDRC defining a clear plan for expansion, not only for biodiesel production, but also for the harvesting of non-grain based crops.
  2. Research and development to solidify feedstock and technologies for production:
     - *new kind of hybrid rapeseed was developed by the Chinese Academy of Agricultural Sciences with an oil content of 54.7 %.*
  3. Defining and obtaining key organic sources for production.

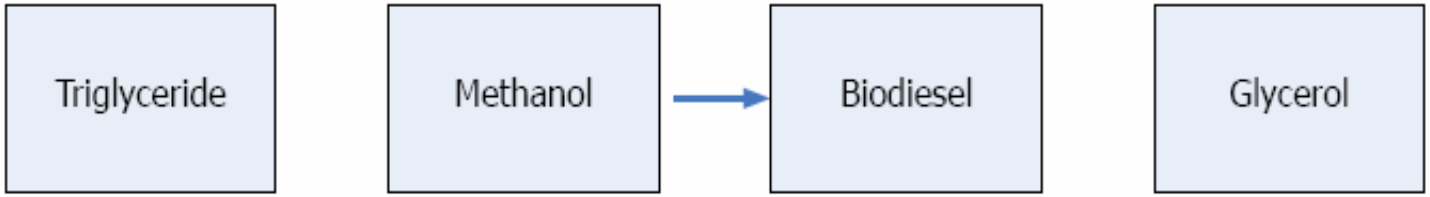
But Biodiesel is not Diesel

	Diesel	Biodiesel
Mass (kg)	1000	1000
Unit Price (RMB/L)	4.63*	4.63*
Density	0.85	0.88
Volume (L)	1176	1136

RMB 5216/1000 kg, MAX !!!

*RMB 4.63/L is #0 Diesel pump price at Xiamen City

Taxation without Representation



Mass (kg)	1111*	216	1000	327
Unit Price (RMB/1000 kg)	3200	2750	4700	0
Cost (RMB)	3555.20	594	4700	0
VAT (17%)	0	86.30	682.91	0

Gross Profit RMB -45.81

*90% Yield

What‘s going on now?

Fujian Longyan Zhuoyue New Energy	30,000 T/year
Xiamen Haizhou Clean Energy	10,000 T/year
Fuzhou Gushan Biodiesel	30,000 T/year
Jianyan Jiafu Lipid Chemicals	2000 T/year
Fujian Genesis Bioenergy	30,000 T/year
Fuzhou Dongzhi Energy	6000 T/year
Sanming Eifu Lipid Process	20,000 T/year
Guandong Jlanuo Chemical	20,000 T/year
Zhuhai Green Bioenergy	10,000 T/year
Hebei Jlnhai Bioenergy	15,000 T/year
Henan Zumadian Yixiang Lipid	10,000 T/year

*This list contains Biodiesel Producer COBRA has first hand contact with