Institute for Global Environmental Strategies

Biofuels in Asia: Case Studies and Implications

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Outline

Part 1: ***Why this "biofuel" hype comes***

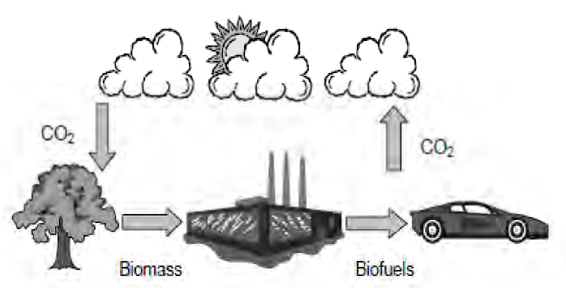
- What is biofuel? How are they produced and used?
- Potential advantages of biofuel utilization
- Current status of biofuel introduction
- Life cycle of biofuel utilization

Part-2 ***Case Studies in Asia***

- Challenges of biofuel utilization
- Possible responses (domestic & international)

Part-3 ***What do we learn?***

- Implications



Definition: What is biofuel?

- **Fuels made from biomass such as plants and other organic materials/wastes**
- **Various forms with various uses**

Examples:

Gas

- **Methane from livestock wastes (manure) for heat/power generation**
- **"Syngas" (CO, H_2) synthesized through the gasification process of organic materials used for power generation and other purposes**

Solid

- **Chips and pellets made of waste timber/residues for heat/power generation**

Liquid

- **Bioethanol/biodiesel made from plants and other organic materials/wastes for transportation fuels, commonly referred to as "biofuels"**
- **Synthetic diesel-like fuels made from syngas through the Fischer-Tropsch process**

Feedstock and technologies used for biofuels

Bioethanol

- **Fermentation of saccharide from plants such as Sugar cane, Corn, Wheat, etc. So-called the "First Generation" of biofuels**
- **Fermentation of saccharide from cellulosic materials (pre-treatment required) from rice straw, waste timber/residues. So-called the "Second Generation" of biofuels**
- **ETBE（ethyl tertiary butyl ether): A gasoline additive synthesized from ethanol and isobutylene**

Biodiesel

- **FAME (Fatty Acid Methyl Ester): Diesel-like fuel produced from methyl esterification of vegetable oil from—**
  - **Edible oil crops (such as Palm Oil, Soybeans, rapeseeds), inedible oil crops (such as jatropha and pongamia), or recycled cooking oil. So-called the "Second Generation" of biofuels**
  - **Microalgae (including *Euglena*). So-called the "Third generation" (by the USDA)**
- **Bio Hydrofined Diesel (BHD）from vegetable oil (≈ synthetic diesel) and others**

source：http://www.biol.tsukuba.ac.jp

Purpose of biofuels

Used in the transport sector

- Bioethanol and ETBE are blended into gasoline
  - In Japan, E3 (gasoline blended with 3% bioethanol) sold in Osaka and Miyako Island (Okinawa); ETBE (3% blended in gasoline) partially in the Tokyo metropolitan area. No Special engine required. Blending upper limit: 3% in Japan for safety reasons
  - Outside Japan, E10-E100 (Brazil). Special engine or modification required.

Biodiesel is blended into diesel fuel

- In Japan, B5 (diesel fuel blended with 5% biodiesel) is the upper limit. Used for garbage collection trucks and municipal buses in Kyoto.
- Outside Japan, B20-B100 (the United States, Europe, etc.)

Biodiesel can be used for power generation

Potential advantages of biofuel utilization

Reduction of GHG emissions and improvement of air quality: A cleaner production option

- Fewer CO_2 emissions (more "carbon neutral")
- Fewer SOx(Sulfur oxides) and PM(particle matter) emissions
- In the transport sector, it is a quicker and easier response compared to the introduction of the next generation vehicles such as electric vehicles

Reduction of dependency on fossil fuels

- Contribution to energy production, responding to increased demand for energy
- Renewable energy

Rural and agricultural development

- Contribution to increased agricultural production/income
- Job creation
- Reducing 'Indoor air pollution'

Realization of resource recycle-based society

- Reduction of wastes and increase in material recycling
- Preserving local biodiversity

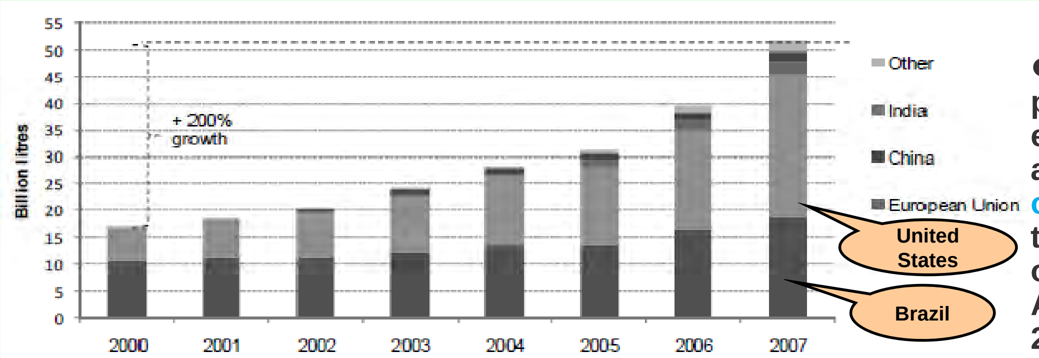
A cassava grower in Guangxi province in China (October 2009)

Biofuel impact on GHG reduction

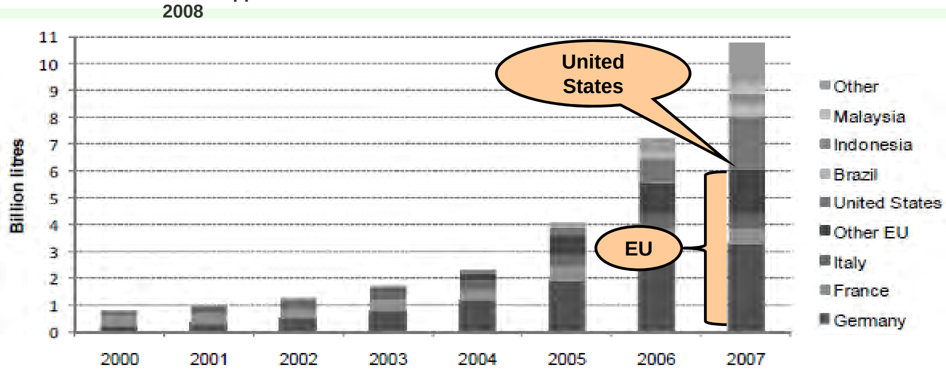
Fuel	Country	CO_2 (% reduction)	Source
Corn ethanol	US	2 (for E10) to 23 (for E85)	(Wang 2005)
Corn ethanol	US	-30	(Pimentel 2001) as quoted by International Energy Agency (2004)
Cassava	Thailand	63	(Nguyen et al. 2007)
Sugarcane	Brazil	80	(International Energy Agency 2004)
Oil palm	Malaysia	60	(Zutphen 2007)
Jatropha	India	80	(Hooda and Rawat 2006)
Coconut	Philippines	60	(Pascual and Tan 2004)

Source: IGES White Paper (2008) Chapter 5

Biofuel production in the world



Source: Biofuel Support Policies: An Economic Assessment. OECD 2008



Source：Biofuel Support Policies: An Economic Assessment. OECD 2008

- **Total biofuel production is equivalent to approximately 1% of transport fuels in the world (The State of Food and Agriculture, FAO, 2008)**
- **Bioethanol production doubled in the past seven years.**
- **Biodiesel production is smaller scale than bioethanol, but has been rapidly increasing.**

Biofuel production in Asia

Biofuel production by country, 2007

COUNTRY/COUNTRY GROUPING	ETHANOL		BIODIESEL		TOTAL	
	(Million litres)	(Mtoe)	(Million litres)	(Mtoe)	(Million litres)	(Mtoe)
Brazil	19 000	10.44	227	0.17	19 227	10.60
Canada	1 000	0.55	97	0.07	1 097	0.62
China	1 840	1.01	114	0.08	1 954	1.09
India	400	0.22	45	0.03	445	0.25
Indonesia	0	0.00	409	0.30	409	0.30
Malaysia	0	0.00	330	0.24	330	0.24
United States of America	26 500	14.55	1 688	1.25	28 188	15.80
European Union	2 253	1.24	6 109	4.52	8 361	5.76
Others	1 017	0.56	1 186	0.88	2 203	1.44
World	**52 009**	**28.57**	**10 204**	**7.56**	**62 213**	**36.12**

Note: Data presented are subject to rounding.

Source: The State of Food and Agriculture, FAO, 2008

- **China is the largest producer of bioethanol in the region and the third largest in the world.**
- **Indonesia and Malaysia are the top two biodiesel producers (palm oil) in the world.**

Biofuel Policy in Asia

Country	Numerical targets	Blending mandate	Economic measures
China	Biofuel share 15% of transportation energy by 2020.	Ethanol: trial period of 10% blending mandates in some regions.	Ethanol: Incentives, subsidies and tax exemption for production. Diesel: Tax exemption for biodiesel from animal fat or vegetable oil.
India	E10	Ethanol: Blending 20% in gasoline by 2017 Diesel: 20% blending by 2017	Ethanol: Excise duty concession. Ethanol and Diesel: Fixed prices for purchase by marketing companies.
Malaysia	No target identified.	Diesel: Blending of 5% palm olein in diesel.	Diesel: Plans to subsidise prices for blended diesel.
Indonesia	E1-5 B1	Ethanol: Blending 15% in gasoline by 2025 Diesel: 20% blending by 2025	Diesel: Subsidies (at the same level as fossil fuels).
Thailand	Plan to replace 20% of vehicle fuel consumption with biofuels and natural gas by 2012.	Diesel: 2% palm oil for all diesel vehicles from April 2008.	Ethanol: Price incentives through tax exemptions.

Biofuel Policy in Asia (Cont'd)

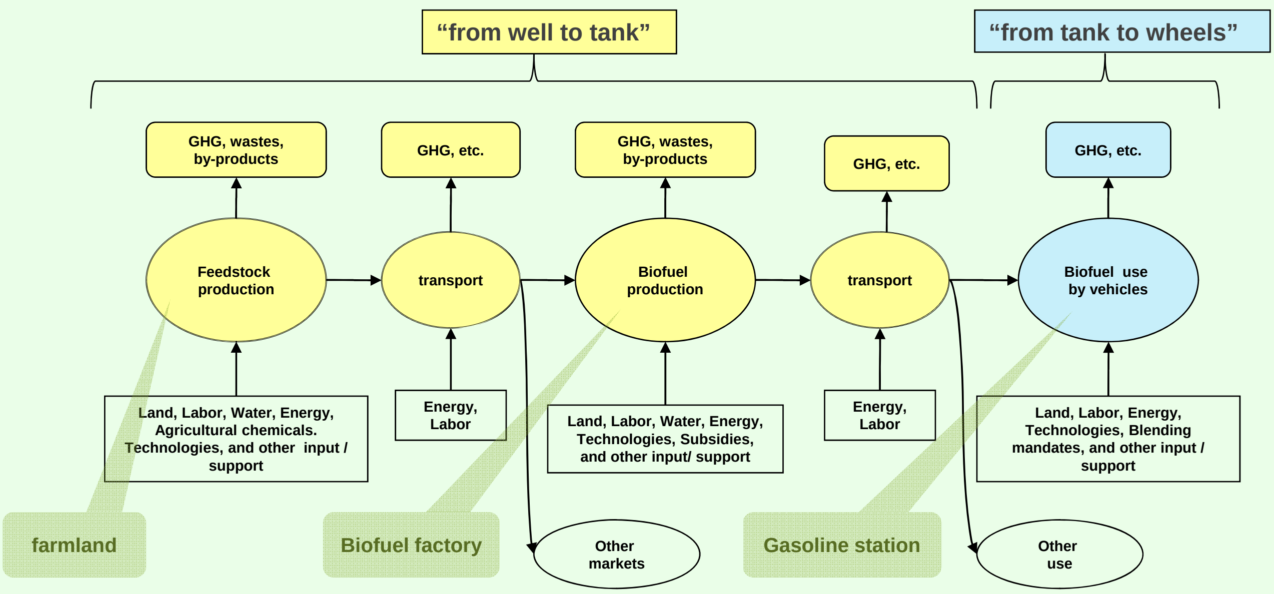
Country	Numerical targets	Blending mandate	Economic measures
Philippines	No target identified.	Ethanol: 5% by 2009, 10% by 2011. Diesel: 1% coconut blend, 2% by 2009 .	Ethanol and Diesel: Tax exemptions and priority in financing.
Republic of Korea	No target identified.	Diesel: 0.5% biodiesel blend to be increased to 3% by 2012.	Biodiesel: Tax exemptions.
Japan	Plan to replace 500 ML/year of transportation petrol with liquid biofuels by 2010.	No blending mandate. Upper limits for blending are 3% for ethanol and 5% for biodiesel.	Ethanol: Subsidies for production. Tax exemptions are being planned.
Singapore	No target identified.	No blending mandate identified.	Promoting investment in biodiesel plants.

Source: IGES 2008 and USAID 2009

Q: How does the blending mandate affect biofuel market and society?

Life cycle of biofuel production

- Biofuel's life cycle assessment



- Biofuels are a cleaner production option when entire cost is concerned.
- However, are they so in the whole life cycle?

Challenges of biofuels

1. Uncertainties regarding the potentials of GHG emissions reduction or air quality improvement when life cycle of biofuels is concerned
   - Life Cycle Assessment (LCA) of biofuels: assessment of GHG or energy balance from "well to wheel"
   - Ranges of GHG emissions reduction potential from biofuels
     - Corn (bioethanol): 0-20%
     - Soy bean (biodiesel): 40-80%
     - Sugarcane (bioethanol), recycled cooking oil (biodiesel), or the second generation bioethanol: 80-90% or above
     - However, the estimates vary greatly depending on the production conditions ("well to tank")
       - Fertilizer use, soil conditions
       - Energy/machine use
       - Technologies used for bioethanol or vegetable oil production

Challenges of biofuels

- More importantly, GHG emissions balance is subject to land use changes
  - If tropical forests or peat land is replaced with biofuel feedstock plants (such as palm), the net balance of GHG emissions become negative – an opposite effect
- Some reports indicates an increase in NOx (nitrogen oxide) from biofuel use
- Many available LCA results are from experiments conducted in developed countries (the United States, European countries)
- More LCA is needed conducted in various conditions

Challenges of biofuels

2. Limitation of available resources (land, water, labor, capital, technologies) used as inputs of biofuel feedstock production

- Even all the farmlands are dedicated to grow biofuel feedstock plants, only 57% of total demand for fossil fuels would be met by biofuels (IGES 2008 White Paper).
- Food- fuel conflict
  - Price hike of food products warned in the reports by the OECD and FAO
  - Negative **impacts** on food security or other social impacts on the economically vulnerable

Challenges of biofuels

3. Possible negative impacts by the introduction of large-scale monoculture

- Deforestation, loss of biodiversity: adding environmental problems rather than solving
- Possible negative social impacts
  - unclear land tenure/legal system, land-less farmers
  - Threatened traditional/indigenous lifestyles, etc.

Source: Friends of the Earth et al.

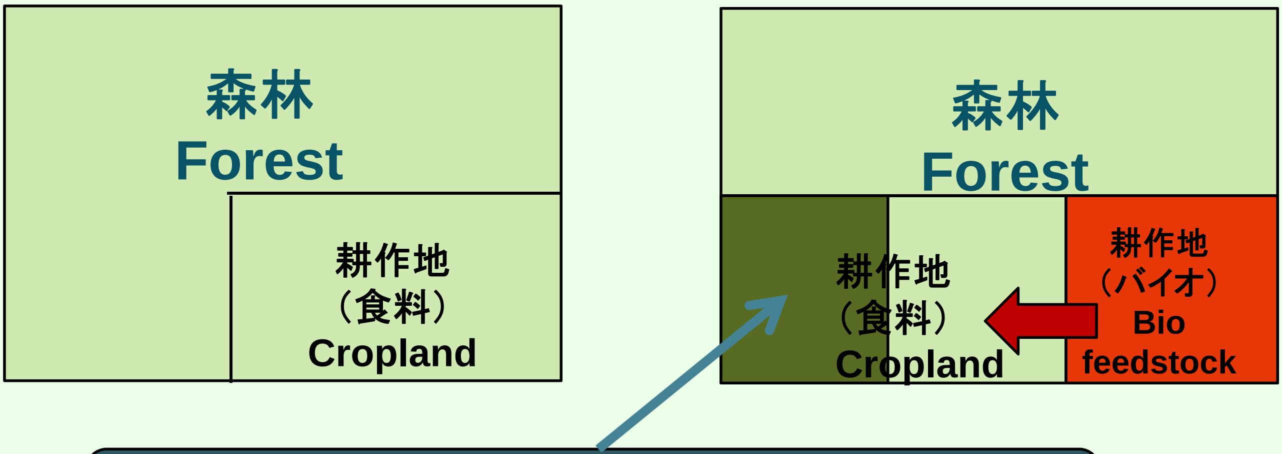
4. Biofuels production is often not economically viable without government’s subsidies

- Necessary support for infant industry
- Ministries’ desire to control/possess power

Challenges of biofuels

5. Impact of Indirect land use change

*** Expansion of biofuel production compresses existing cropland and “indirectly” induces deforestation.**



Cropland directly deforests; nonetheless, it was caused by expansion of biofuel production.

Biofuel policies in Japan

Focus on bioethanol

- Target of 500,000 kl of transport fuels in 2010 (including biodiesel)
- Domestic production in 2007: about 30 kl
- Construction waste timber, food waste, sugarcane, unmarketable wheat, non-food purpose rice, etc.
- Aim to expand to 31,000 kl by large-scale pilot projects
- Subsidies for installation of bioethanol plants, etc.
- Majority of the target will be achieved by imported ETBE
- Upper limit for ethanol blending for safety reasons (3%)

A number of small-scale biodiesel projects by municipal governments or NGOs

- Domestic production: about 5,000 kl
- Recycled cooking oil
- Rape seed project
- Upper limit for biodiesel blending for safety reasons (5%)

Source: Kyoto city

Goals and Challanges of Biofuel policies in Japan

Contribution to GHG emissions reduction

- In the short-run, to the promised degree under the Kyoto Protocol
- A low-hanging fruit
- In the long-run, depending on the development of the second generation and next generation vehicles
- E3 (Ministry of the Environment) vs. ETBE (Petroleum Association of Japan)

Contribution to energy security

- Limited as domestic production capacity is limited
- Under an optimistic technology development scenario, biofuel's contribution to the total energy consumption would be as big as 5% in 2030.

In general, expectation for the second generation is high

- Facilitating factors: Eco Towns and recycling laws found to play important roles
- Challenges: fluctuating supply of construction timber and economic viability, collection from small scale waste generators
- Harmonizing policies needed related to subsidies, stakeholder cooperation and awareness raising, revisiting exemption conditions in the law, streamlining ethanol blending policies

China: Case study- Biofuel policy

Utilization of gas and solid biomass is popular

- Comprehensive renewable energy promotion plan
- Biogas micro-digester (household), biogas digester (pig farms)
- Contribution to heat /power generation in rural

Focus on bioethanol

- Third largest in the world
- Originally started with recycling stale grains
- Operated and controlled by the state-owned bioethanol companies
- Since 2007 "no fuel from food" due to concerns about food price
- Increased demand for gasoline from rapid increase in vehicle ownership
- Seeking for alternative feedstocks
- Bioethanol production from cassava (non-food feedstock) in Guangxi province

Cassava field in Guangxi province (October 2009)

China: IGES field study

A number of small-scale biodiesel plants

- Recycled cooking oil
- Jatropha production by the state-owned petroleum companies or foreign inventers in the Southwest region

Jatropha production in Yunnan province

- As an afforestation effort managed by the forestry department
- Planted on unutilized hillside (not on farmland or existing forests)
- Side business/extra income for farmers
- “Wait and see” attitude of farmers because of great uncertainties of future jatropha market price
- Observed labor shortage in harvest time
- Policies to give economic incentive for producers

Jatropha seedlings in Yunnan province (December 2008)

India: Case study –Biofuel Policy

High blending mandate and export promotion of biofuel cause food-fuel conflict (Sugar-Bioethanol)

Non-food crop (Jatropha) as an alternative

- Jatrophagrows on wasteland with little water
- However, low yield & high cost

Using irrigation water & fertilizer

- More production costs
- Reduces greenhouse gas benefits
- Competes with food and other crops for scarce resources, water, fertiliser

Analytical Result

- Multipurpose feedstocks such as sweet sorghum could be considered rather than non-food feedstocks.
- Consider sustainability standards to reduce potential negative effects.

Indonesia: Case study- Biofuel policy

A net petroleum importer and the largest palm oil producer

High expectation for biofuel production

- "Middle-east of biofuels"
- Long-term diesel blending mandate plans

Serious environmental impacts reported

- Deforestation
- Unclear land tenure system

Economic development lagging in remote areas

- Too much centralization in Java
- Biofuels as a possible measure for rural electrification (energy-sufficient village project) – a good example of local benefit
- Technology transfer is not so easy

Harvested palm fruits in Indonesia (2008)

Indonesia: IGES field study -Jatropha and Cassava-

Possibility of Small scale biofuel program:

- **Conducted survey to measure reduction of black carbon from indoor cooking by using biogas from jatropha waste.**
  - Farmers in Way Isem, an ESSV in Lampung, utilize jatropha waste to produce biogas for cooking, which mitigate climate change and improve the health of villagers

Survey/interview with farmers in Purtowono

- **Analysis of data from the household survey conducted in two ESSV villages on March 2010**
  - established socio-economic baseline data of farmers engaged in biofuel production
  - identified farmers' need for capacity training esp. with new feedstock (sweet sorghum) and other barriers
- **Analytical result**
  - Observed yield improvement and no need for expansion for large scale palm oil plantation . **To achieve the goal, need to provide practical guidance on small scale village level biofuel development based on our research and results from surveys**

Survey/interview with farmers in Kendeng

Expansion of land and water use using 2017 projection

Agricultural Production of major feedstocks and Biofuel energy yields						
Biofuel Type	Bioethanol				Biodiesel	
Crop	Maize		Sugarcane		Oil Palm	
Country	US	China	Brazil	India	Malaysia	Indonesia
Estimated Crop Area (Million ha) 2010	9.8	3.1	0.4	0.4	0.1	0.2
Projected Biofuel Production (Million Liter) 2017#	52400	10200	40500	3570	1140	2990
Estimated Crop Area Expansion (Million ha) 2017	13.4	4.8	6.9	0.7	0.23	0.76
Irrigation withdrawal of biofuel crops 2008 (km^3)**	5.44	9.43	1.31	6.48	0.6	0.91
% of total withdrawal of Blending biofuels 2008	2.7	2.2	3.5	1.2	1.0	1.2
Estimated Irrigation Withdrawal 2017 (km^3)*	7.42	14.4	2.4	12.1	0	3.6

* Biofuel Feedstock Assessment for Selected Countries (2008), Freitas (2009), Hoogeveen et al. (2009)
**Fraiture et al. (2008)
OECD/FAO (2008)

•Using OECD/FAO production projection, estimated ratio of land and water requirement in 2017
• For China and India, strong demand of irrigation withdrawal will be constraint.
• For Malaysia and Indonesia, shortage of land available will be challenge.
• High blending mandate and export promotion cause shortage of land and water use in the Asian countries.

Need for international policy coordination

Trade policies

- Lowered tariffs could encourage export of unsustainable biofuels
- Should not become non tariff barrier

Sustainable criteria

- Various initiatives launched (examples)
  - *Global Bioenergy Partnership (GBEP)*：G8, Brazil, China, India, etc.
  - *Roundtable on Sustainable Palm Oil (RSPO)*：Palm oil industry
  - *Roundtable on Sustainable Biofuels (RSB)*: Focus on liquid form of biofuels, version one of the "*Principles & Criteria*"
- Implications on international biofuel trade rules
- Compliance and participation

Sustainable principles and criteria: RSB

Sustainability Assurance

- Standards & Certification to ensure maximization of positive impacts and minimization of negative impacts
- "**Roundtable on Sustainable Biofuels**" (RSB) is developing a global standard for biofuels
- Use of multi-stakeholder processes
- All stakeholders are welcome to participate in the process
- Harmonizing interests of various stakeholders is challenging

  e.g. European Biodiesel Board (EBB) and European Bioethanol Fuel Association (eBIO) left RSB early 2010

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

How is the RSB(international voluntary multi-stakeholder initiative developing principles and criteria for sustainable biofuels production)organized?

- **Governance structure** and open membership starting in 2009, with 'chambers' divided along the following lines: trade unions, small and large farmers, producers, financial institutions, petroleum and transportation industry, food security NGOs, indigenous people's groups, conservation NGOs, etc.
- One **Secretariat** based at EPFL (École polytechnique fédérale de Lausanne).
- Nov. 12, 2010, Version 2.0 of Principles and Criteria was issued, after extensive public stakeholder consultation.
  - Despite debate over the structure, multi-stakeholder approach was maintained
  - Methodology for calculating GHG emissions is finalized
  - How to address indirect impacts is still uncertain
  - Pilot testing on supply chains worldwide is being conducted in 2010
  - 2 tier certification structure implemented: 1) Entry Level 2) Full Compliance with RSB Principles and Criteria
  - 2 boards system (management, certification) was newly introduced

Proposed solutions and their feasibility 1

1. Use of biofuel feedstocks of non-food origin

- Inedible oil crops such as jatropha, pongamia, etc.
- Use of marginal/waste land to grow
- Avoid food-fuel conflict

× Low productivity of marginal/waste land
- Farming methods not established
- Lower harvest, lower economic viability
- More fertilizers, more GHG emissions

× Definition of "waste" land
- Often these lands are not exactly "wasted"
- Possible encroachment of non-food plants to farmland

× Other constraints may indirectly cause food-fuel conflict
- Labor, water

Jatropha plants in Yunnan province (December 2008)

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Proposed solutions and their feasibility 2

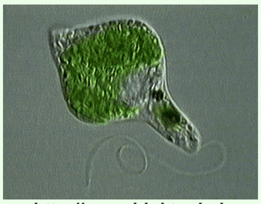
2. The second generation biofuels (or even third generation)

- Avoid food-fuel conflict
- Better net GHG emissions reduction in theory
- Wide varieties of possible feedstock choices
  - Timber waste/residues (cellulose), food wastes, etc.
  - High-yields grass ("soft-cellulose")
  - Micro algae ("third generation," biodiesel)

× Technologies not developed for a commercial production yet
- Technologies for pre-treatment of cellulosic materials
- High transportation costs (bulky materials in the mountains)

× Effects of land use and water use still unknown
- Same issues as other agricultural crops

× Overall LCA results still unknown
- High-yields grass needs fertilizers to grow



source：http://www.biol.tsukuba.ac.jp

Needs further R&D

Ex）Japan's future biofuel production largely depends focuses on the second/third generation

Proposed solutions and their feasibility 3

3-1. Is self-sufficient biofuel production/consumption feasible?

- Limitation of biofuel production factors
- Blending mandate is too demanding
- Mass production of biofuel is not profitable at this point
- Local micro production can be feasible, nevertheless, it cannot supply for domestic consumption

3-2. If not, is importing biofuel consistently achievable?

- For ethanol, Brazil is an only potential exporter
- For biodiesel, Indonesia and Malaysia can be exporters
- Nonetheless, strong import demand causes price increase and environmental damage

Proposed solutions and their feasibility 4

4. Choice of biofuel feedstocks and scale of the production

- Multi-purpose feedstocks such as sweet sorghum could be considered rather than non-food feedstocks. Jatropha is not a miracle plant.
- Nonetheless, Jatropha and its waste can be feasible for small scale biofuel production and consumption. (e.g. Indonesia ESSVs)
- Biofuels may have more potential for small scale development or rural electrification rather than large scale
- Even in successful cases, implementing sustainability standards to reduce potential negative effects is crucial

Questions: How do you find optimal solution?

Please consider to give related actors (such as governments, NGOs, research Institutions, biofuel industry, etc.) policy recommendations for promotion of sustainable biofuels considering these factors;

- **Energy use / Environmental context**
- **Economic / Local development context**
- **Sustainability context**