

10/07/2009

Bio-energy

Fuelling a sustainable future?

Amsterdam, April 20th 2009



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In cooperation with UAntwerp (Prof. Roeland Samson & Prof. Jan Kretzschmar) and K.U.Leuven (Prof. Bart Muys)

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Introduction

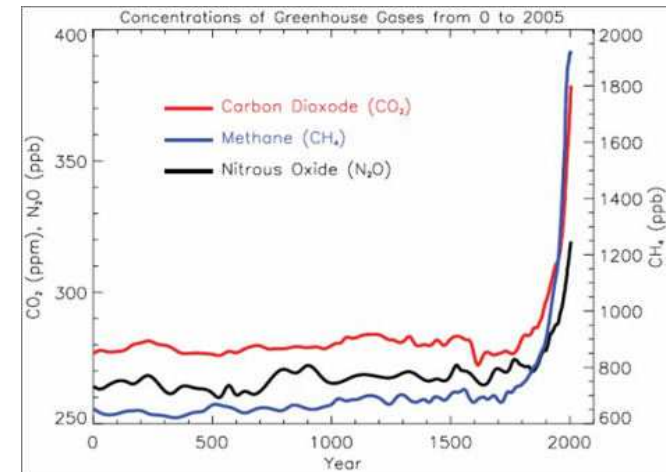
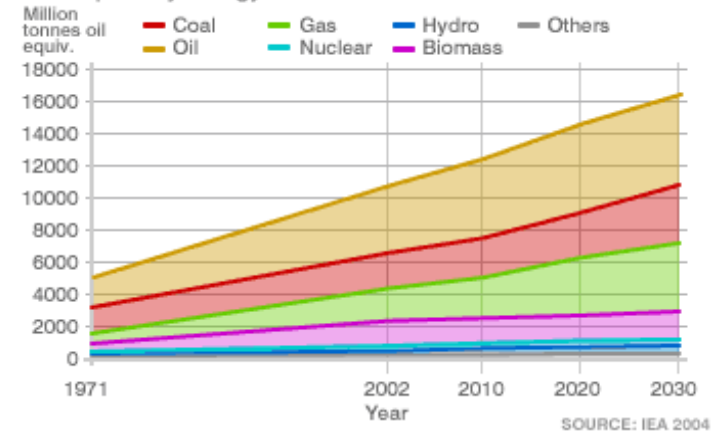
Energy Transition

- Growing global energy demand: projected to increase by 60% in the next 25 to 30 years [IEA]
- Climate change caused by increased greenhouse gas (GHG) concentrations in the atmosphere
- Security of energy supply



Increased interest in alternative energy production such as bio-energy

World primary energy demand



SOURCE: IPCC

Introduction

• Targets of the EU

2010

- 12% renewable energy
- 5,75% biofuels
- 21% renewable electricity

2006

- 9,2% renewable energy
- 1,8% biofuels (2007/2008: 2,5%)
- 14,5% renewable electricity

2020

- 20% renewable energy
- 10% ~~biofuels~~ **6% biofuels**
- **10% renewables in transport**

• Targets of the Netherlands

2010

- 5,75% biofuels
- 9% renewable electricity

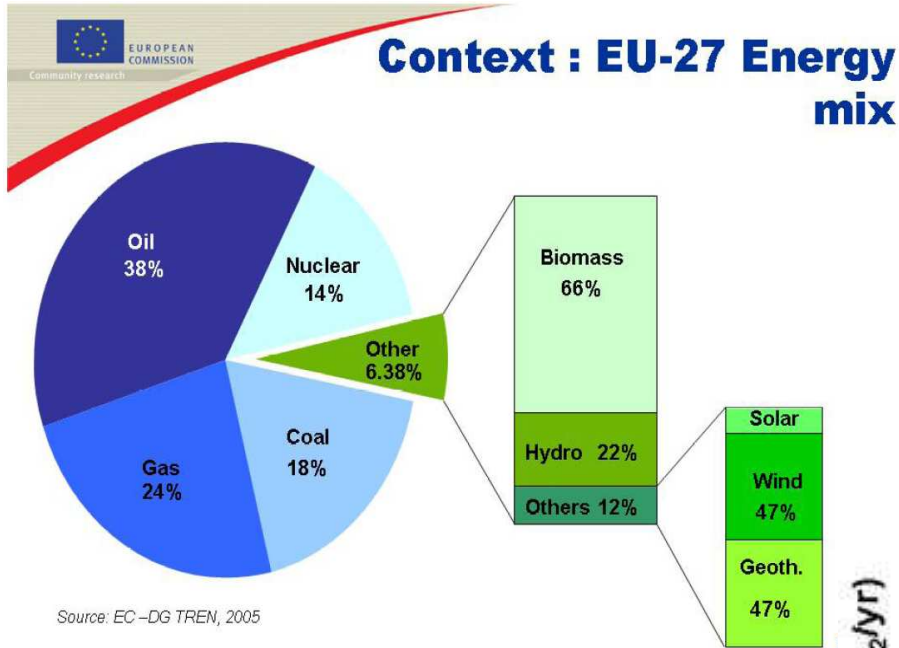
2006

- 2,3% biofuels (2007)
- 7,9% renewable electricity
- 2,7% renewable energy

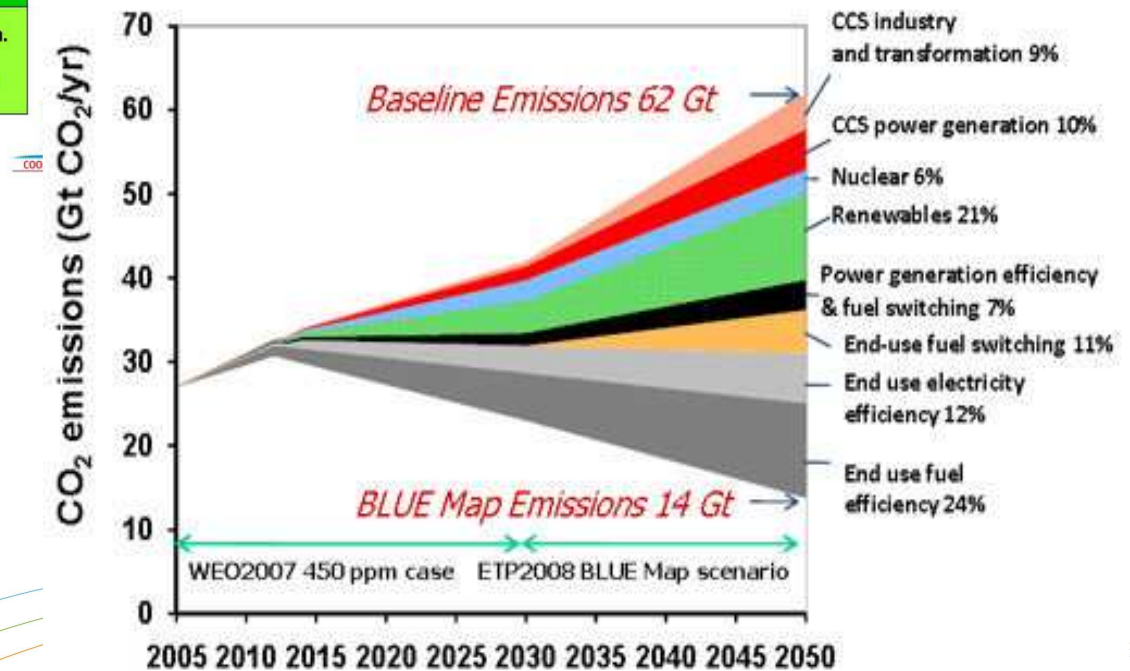
2020

- 14% renewable energy

Introduction



- Substantial contribution of biomass to the share of renewable energy in the EU and to reduce carbon emissions



Introduction

Video

EU: 20% renewable energy by 2020

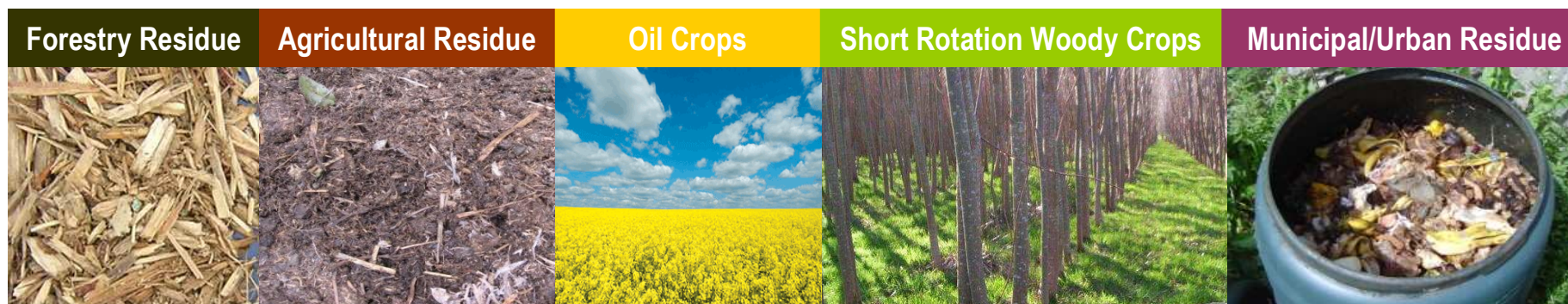
3'52"

(www.our-energy.com/videos/eu_20_percent_of_renewable_energy_by_2020.html)

What is bio-energy?

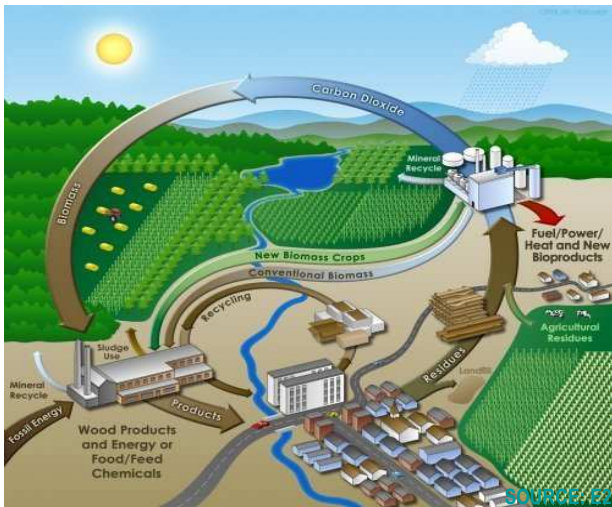
Bio-energy = common denominator for all forms of energy that are derived from biomass (transport fuels, electricity, heating & cooling).

Biomass = any organic material, of plant and animal origin, derived from agricultural and forestry production and resulting by-products, and industrial and urban wastes.



What is bio-energy?

Processing chain:



Photosynthesis



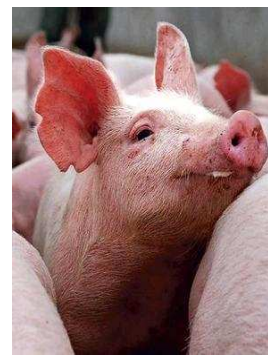
Closed carbon cycle?

- ⇒ Additional GHG emissions related to crop growing (land management practices, use of fertilizer/pesticides), transport, conversion, distribution,..
- ⇒ Difference 1st generation \longleftrightarrow 2nd generation

Feedstock, Types and Technologies

- Oils & fats** → **Biodiesel**
- **Pure Plant Oil**
- **Hydrogen.Veg.Oil**

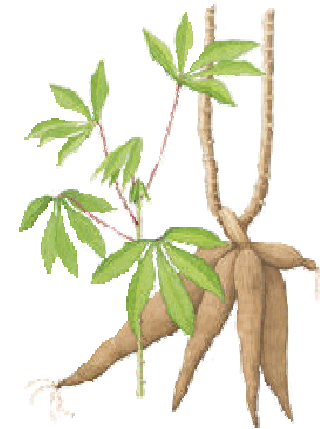
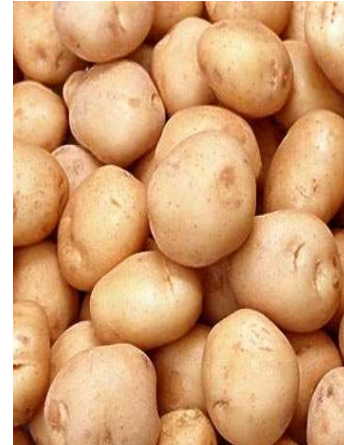
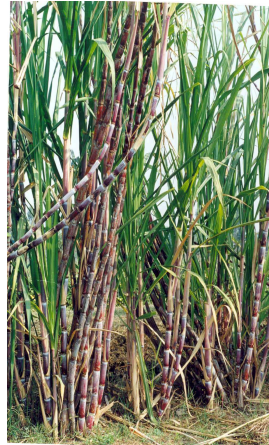
- rapeseed oil
- palm oil
- sunflower oil
- soybean oil
- jatropha oil
- micro-algae
- animal fats
- used frying oils



Feedstock, Types and Technologies

Sugars & starch → Ethanol
→ Butanol

sugarcane
sugar beet
wheat / barley
maize (corn)
potato
cassava



Feedstock, Types and Technologies

Digestible products

→ Bio-methane

maize/sugarcane residue

sewage sludge

agricultural waste

industrial organic waste
(e.g. from food industry)

organic municipal waste

dry manure

liquid manure



Feedstock, Types and Technologies

- Cellulose** → FT (synthetic) biodiesel / BTL
- Bio-DME
- Cellulose ethanol
- Bio-methanol

“2nd generation”



fast growing grasses
(miscanthus, bamboe, cane)

farmed wood / short rotation coppice
(willow, poplar)
residues of agricultural crops
(straw, stalks)



black liquor (from paper pulp industry)

wood residues / waste wood

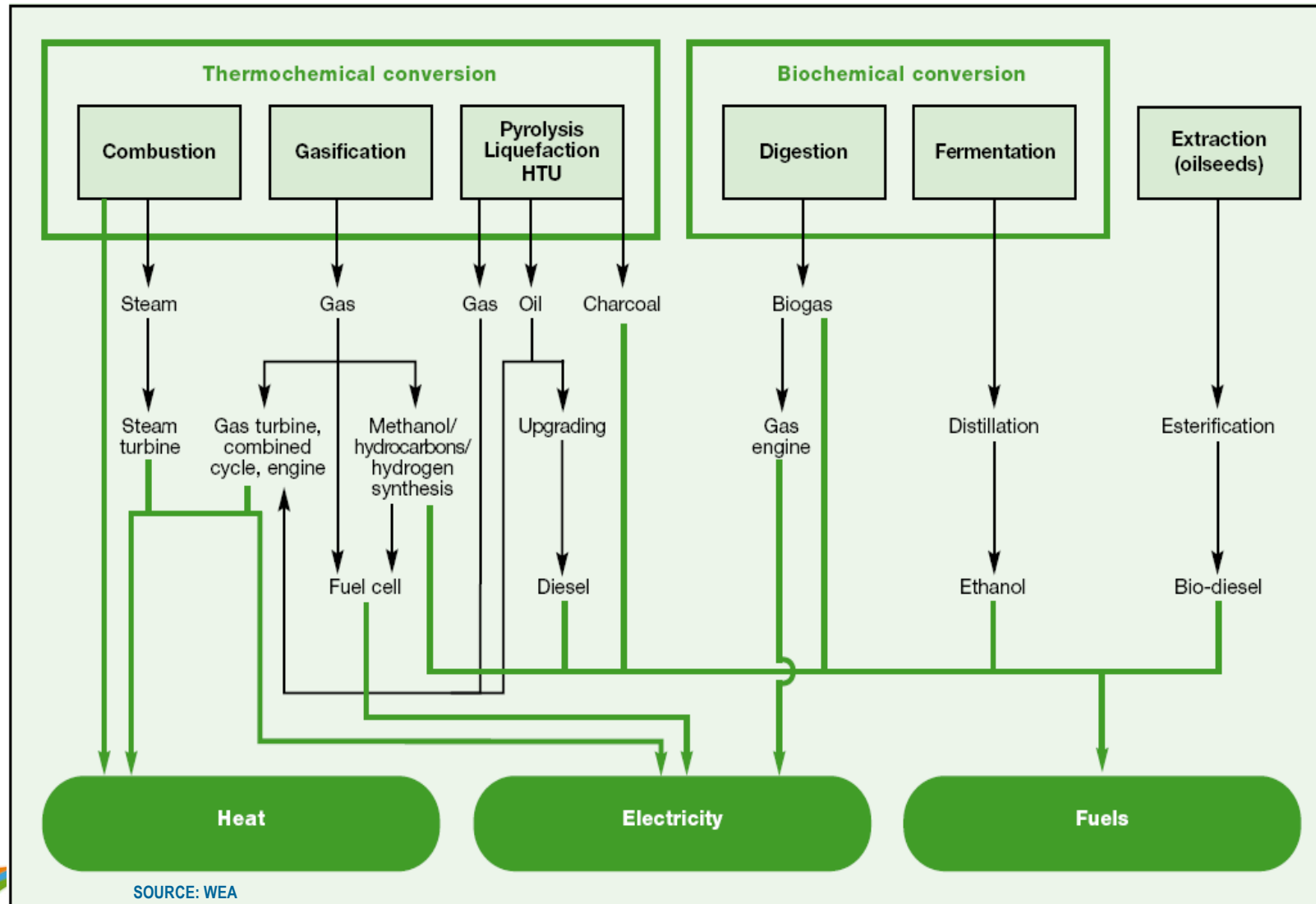
organic waste

microalgae



Conversion Technologies

Main conversion options for biomass to secondary energy carriers



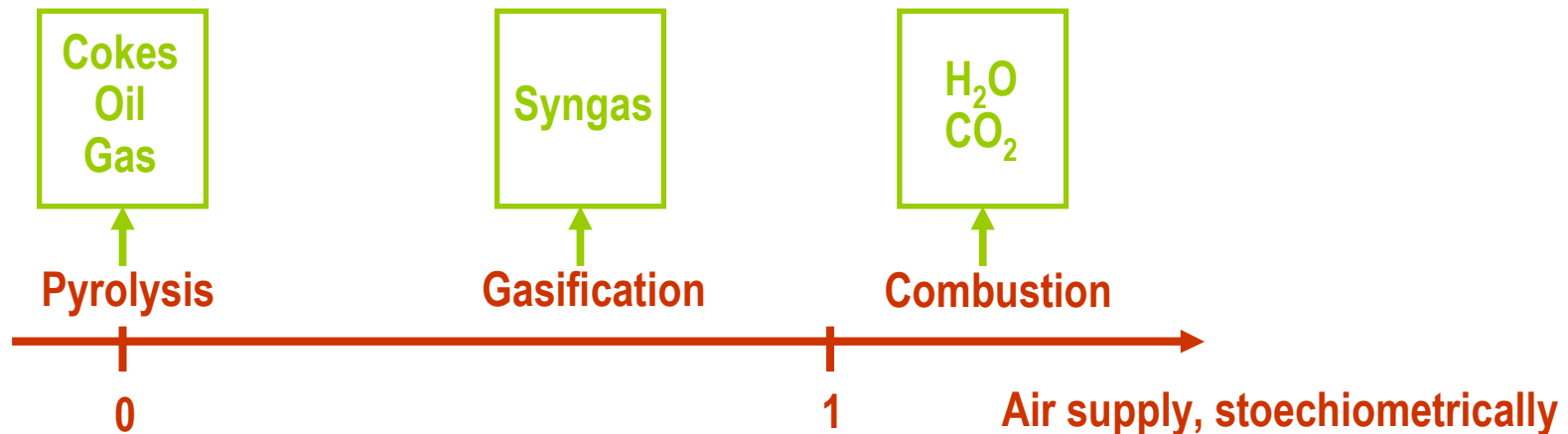
Conversion Technologies

Thermochemical conversion technologies

- Dry Matter Content $\geq 30\%$
- Burning = oxidation



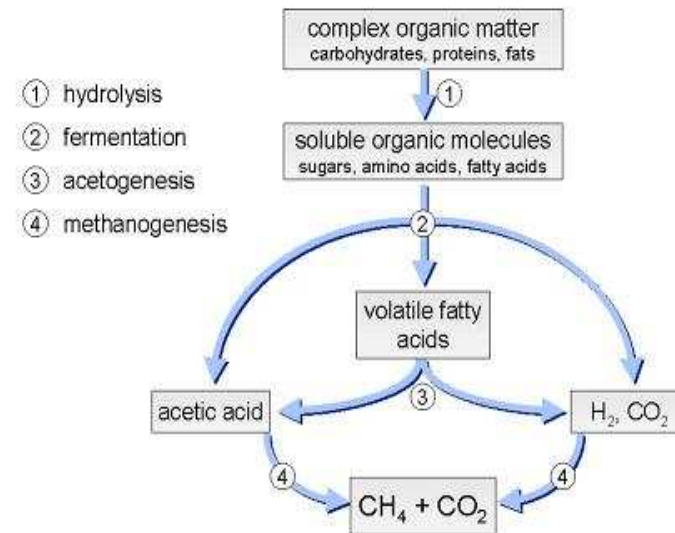
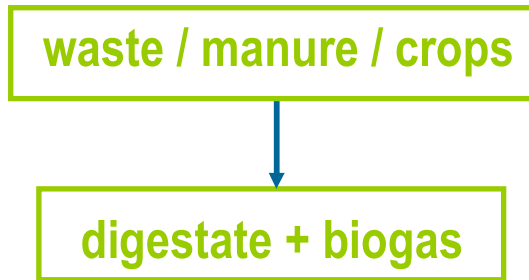
x, y in mol



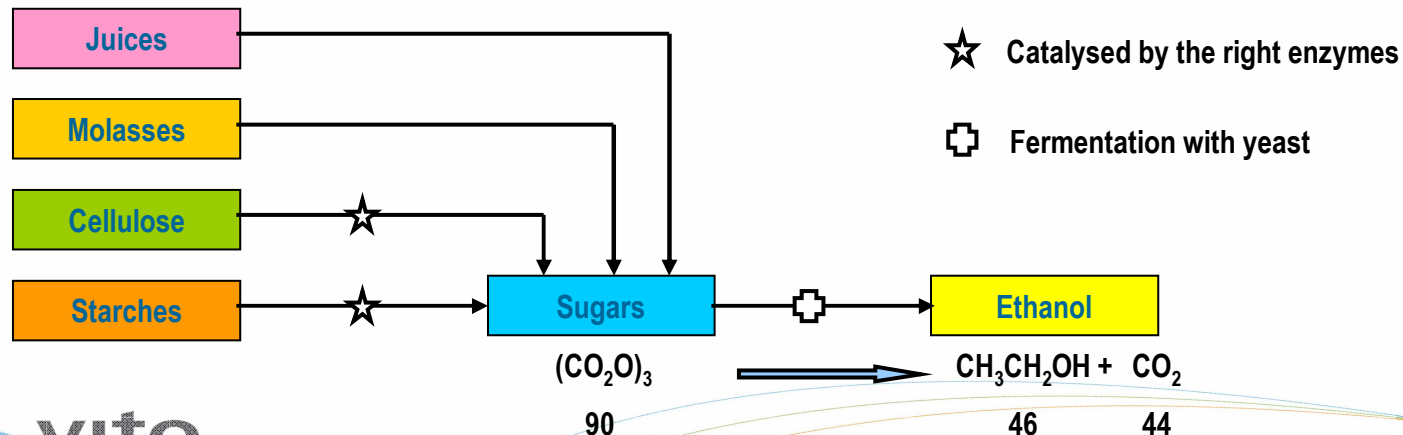
Conversion Technologies

Biochemical conversion technologies

• Anaerobic digestion:



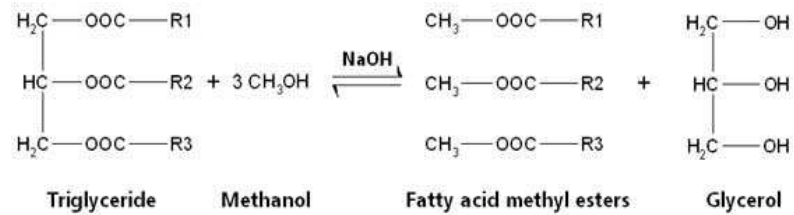
• Ethanolic fermentation:



Conversion Technologies

Transesterification of oil

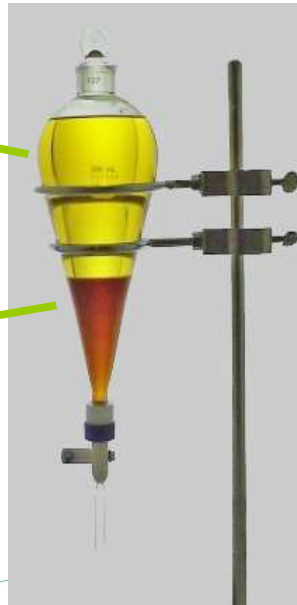
- Use of methanol + catalyst (strong base)



- Result

Biodiesel (80-90%)

Glycerin (10-20%)



Profits and constraints



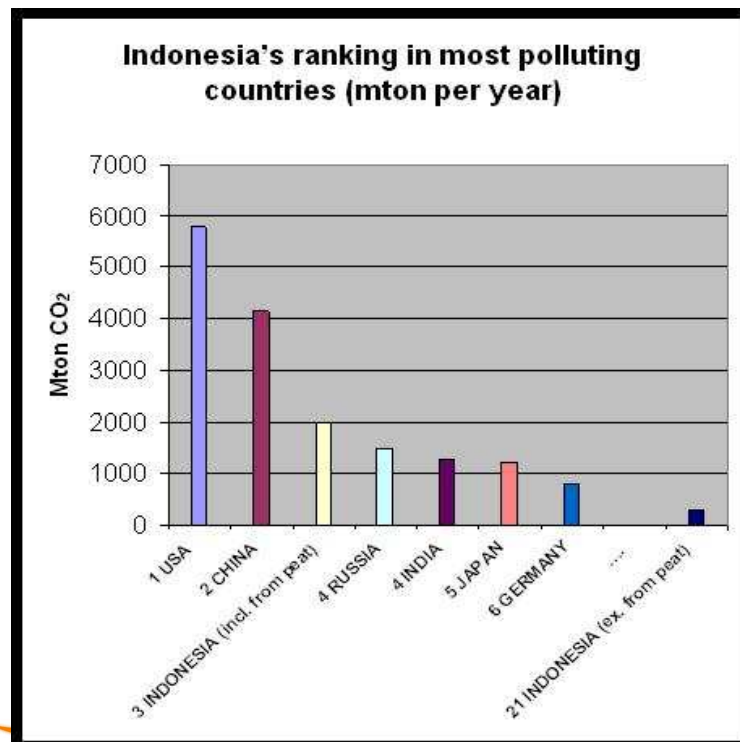
Profits and Constraints

CONSTRAINTS

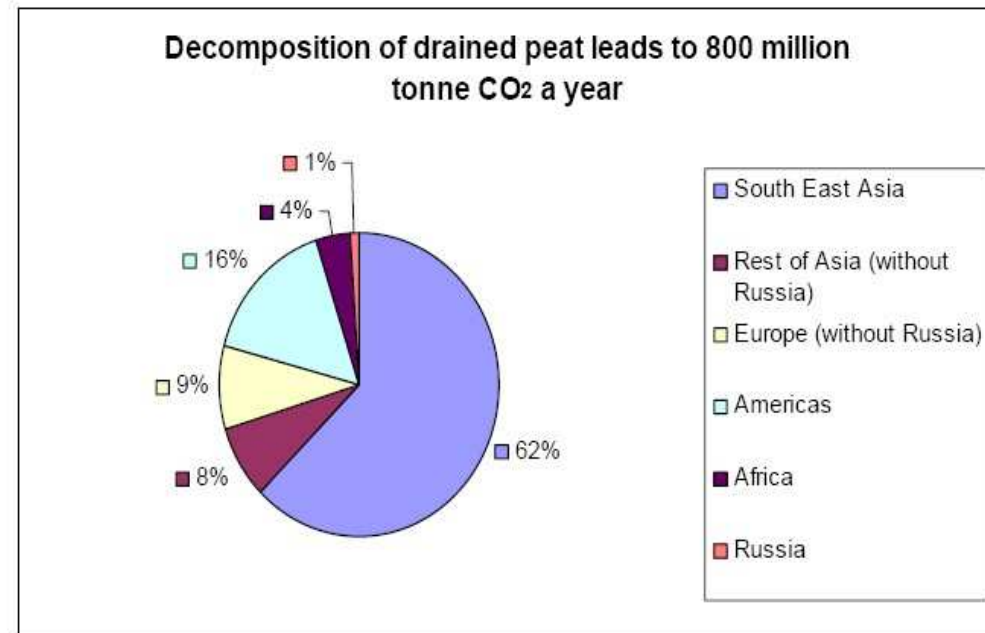
Deforestation

→ Brazil: soy (and sugarcane)

→ Indonesia/Malaysia: oil palm



vision on technology



Source: Wetlands International and DeltR Hydraulics



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Profits and Constraints

Video

Palm Oil: Profit with great losses

10'

(http://www.milieudefensie.nl/english/forests/videos/palmolie_eng.htm/)

Profits and Constraints

CONSTRAINTS

- Deforestation
- Environmental degradation
 - soil / water / air
 - biodiversity



Profits and Constraints

CONSTRAINTS

- Deforestation
- Environmental degradation
- Social injustice:
 - land rights
 - working conditions



Profits and Constraints

Video

FIAN: Sugar Cane for Ethanol in Brazil

10'

Profits and Constraints

CONSTRAINTS

- Deforestation
- Environmental degradation
- Social injustice
- Competition with food (?)



→ very depending on the place/situation

→ food availability/capita is higher then ever before

→ much land not in use (or not suitable for food crops)

→ rise in food prices: increasing meat consumption (65%), lower harvests in 2006-2007 due to drought, declined stocks, higher energy costs, speculation in feedstock, ...

Sustainability

- **Precautions are needed**

- to avoid that nature conservation areas, rain forests, ... (areas with high biodiversity and carbon storage) are used
- to make sure that bio-energy / biofuels are creating opportunities for local communities (socio-economic conditions), not only multinationals
- to achieve optimum GHG reduction (e.g. coal powered ethanol facilities in the US have negative GHG balance)

⇒ **Worldwide agreements / sustainability requirements / certification**

- **Support 2nd generation biofuels**

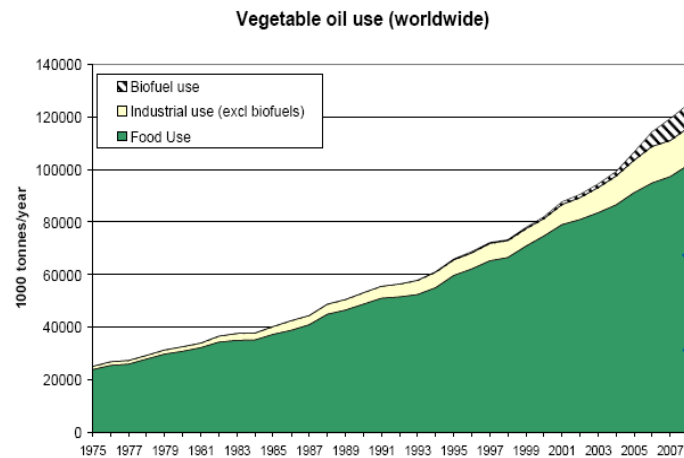
- Increase yield per hectare and use of rest streams through the use of cellulose
- Also diminishes tension with food production

- **Energy savings remain priority**

Sustainability

Some important remarks:

- constraints not only for bio-energy, but for all bio-based products



Food

Cosmetics

Chemicals



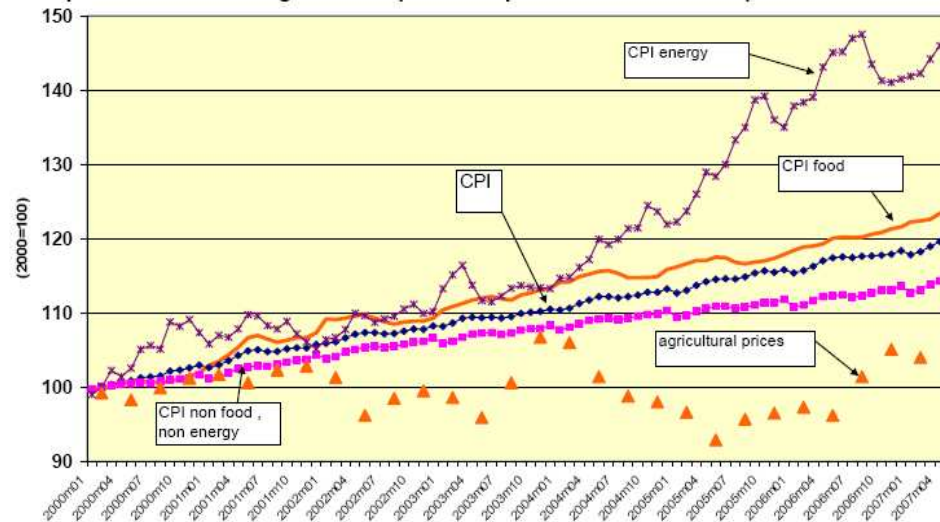
- current deforestation mainly happens for timber and food purposes!
- also fossil fuels cause a lot of social, economic, ecological and political trouble

Sustainability

Some important remarks:

- commodity prices keep on rising although agricultural prices decrease again

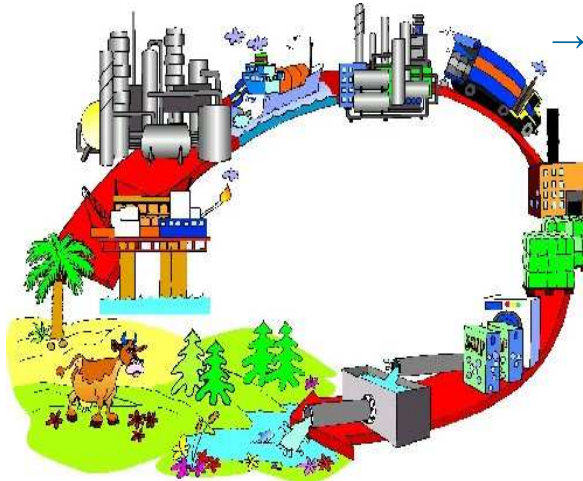
Development of nominal agricultural producer prices and consumer prices in the EU27 (Jan. 2000=100)



- Need for structural approach in worldwide agriculture to fulfill increased food demand (even without introduction of biofuels).
- Moratorium on biofuels is not likely to reduce food prices significantly.
- With higher biofuel shares, the impact on commodity prices may become more important.
 - ⇒ food supply should always be priority,
 - ⇒ focus on use of marginal land, co-production of food and energy (in bio-refineries) & cellulose based biofuels in the long term

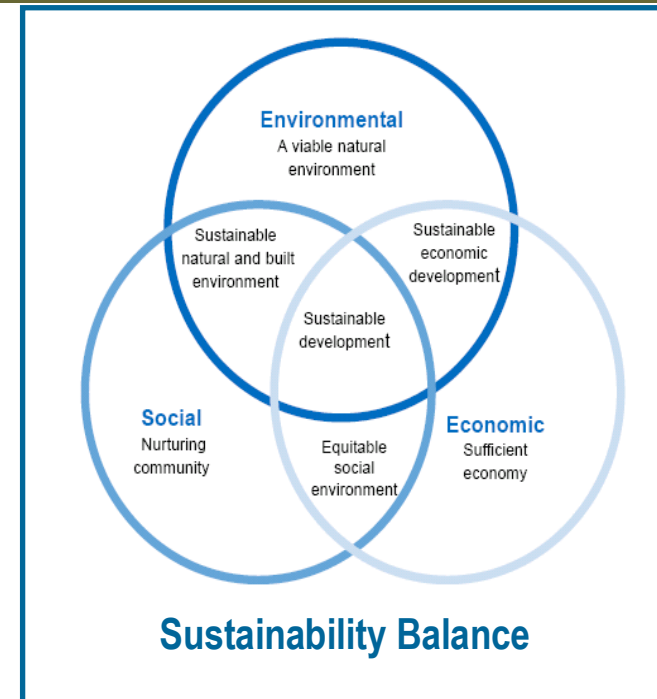
Measuring Sustainability

- **Life Cycle Assessment (LCA)** → **GHG balance** (CO₂ equivalents)
→ **energy balance**



Through whole production chain:

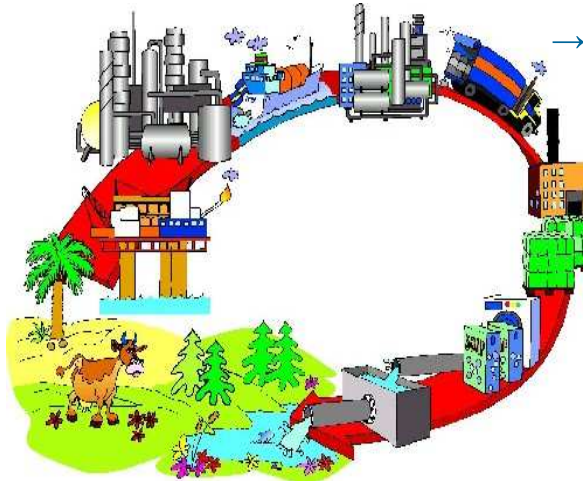
- Production/harvesting raw material
- Pre-treatment (densification, drying, chopping, etc.)
- Storage
- Transportation
- Conversion to energy carrier



“People - Planet - Profit”

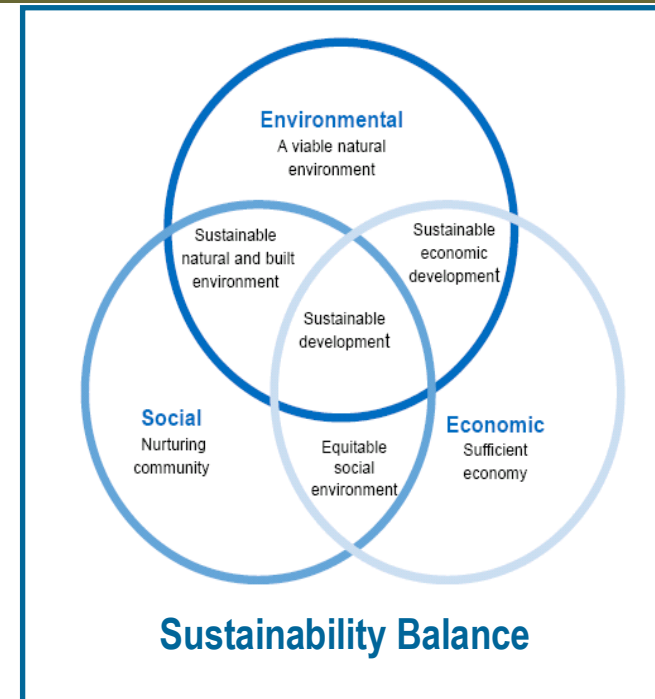
Measuring Sustainability

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“People - Planet - Profit”

Measuring Sustainability

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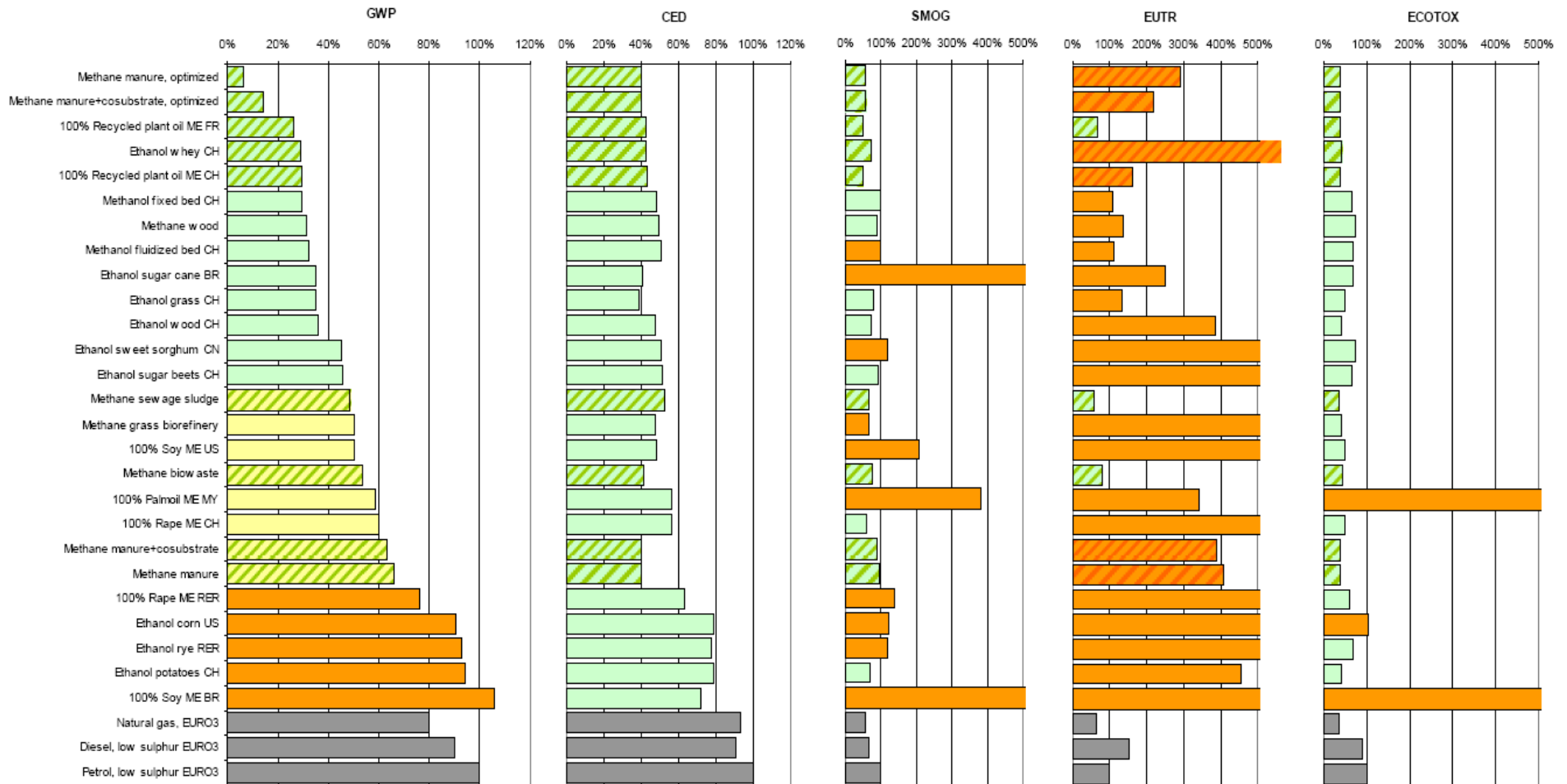
GWP: Greenhouse Warming Potential

CED: Cumulated non-renewable Energy Demand

SMOG: Summer Smog Potential

EUTR: Excessive Fertilizer Use

ECOTOX: Ecotoxicity



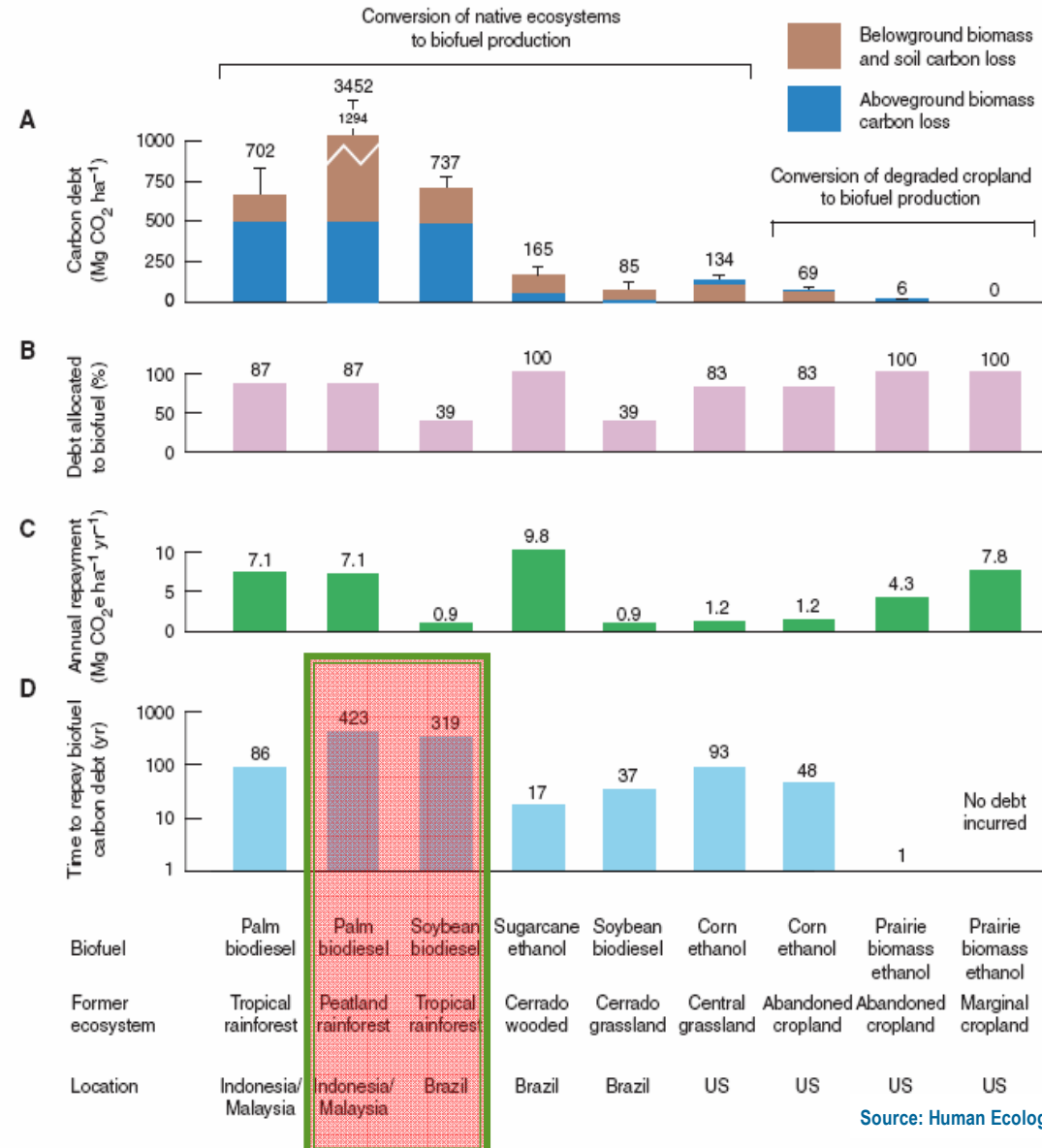
Measuring Sustainability

Carbon debt

- Caused by land conversion
- Can be paid back by carbon savings (but takes a very long time)



vision on technology

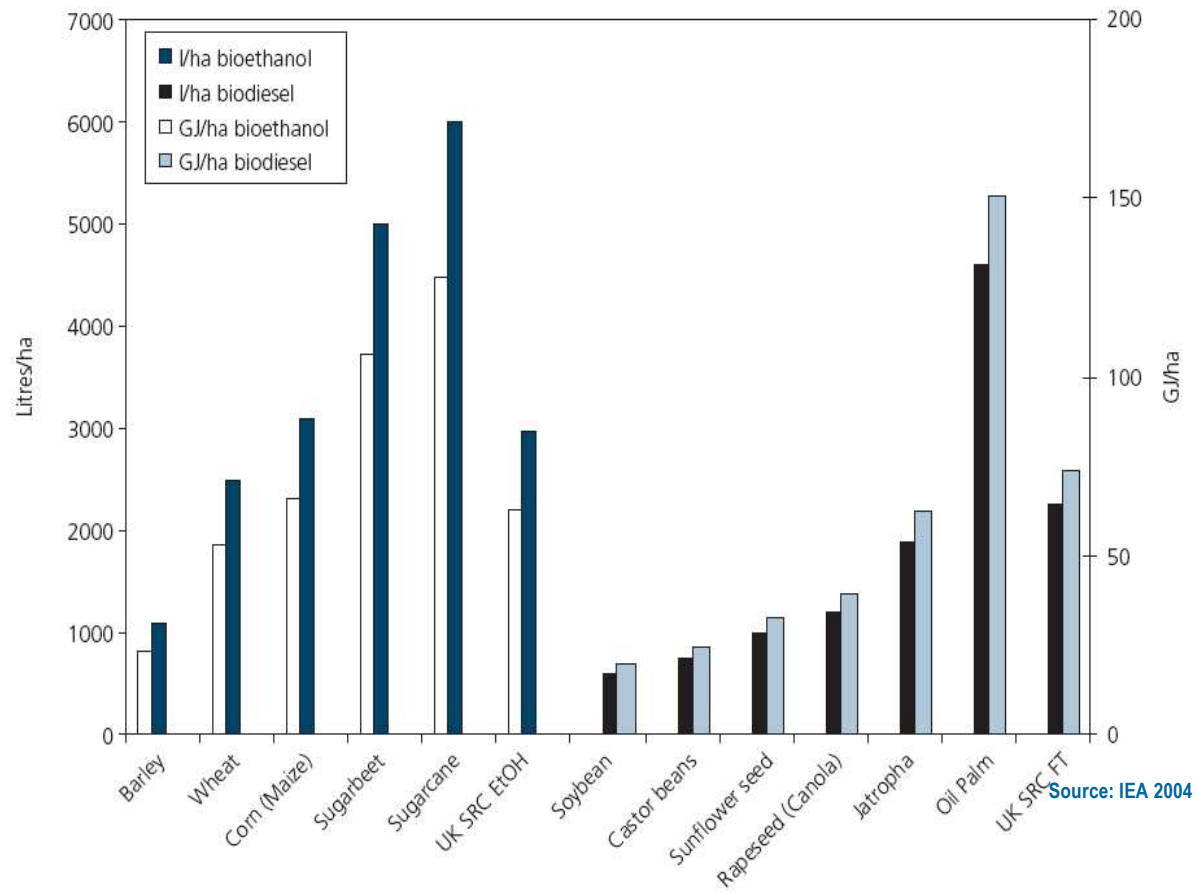


Source: Human Ecology

Measuring Sustainability

- Land Use

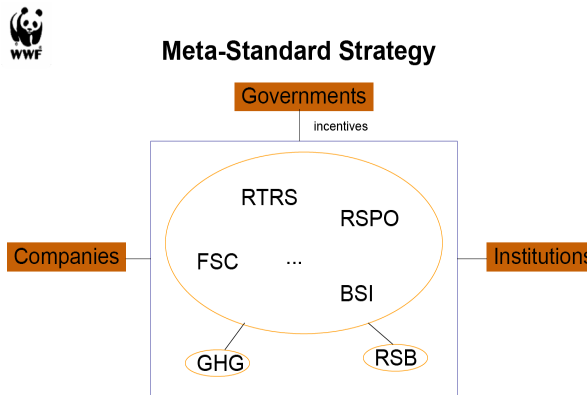
Biofuel yield per hectare



Measuring Sustainability

Standards and certification

- Voluntary commodity Initiatives such as FSC, RSPO, RTSS, BSI, Basel criteria, ..
- WWF: Meta-Standard



Criteria in European Renewable Energy Directive and Fuel Quality Directive

- ✓ GHG savings: min. 35% (2010), min. 60% (2017)
- ✓ Biofuels must respect “cross compliance” rules (only in case of European biomass)
- ✓ Biodiversity: no-go areas (primary forests, protected areas, highly biodiverse grasslands)
- ✓ Conversion of high carbon stock areas prohibited (wetlands, continuously forested areas, peatlands)
- ✓ Reporting obligations on indirect land use change and on environmental, social and economic issues

Good start but not sufficient to ensure a sustainable development of bio-energy

Future Potential

Overview of the global potential of biomass for energy to 2050 for a number of categories



Biomass category	Main assumptions and remarks	Energy potential in biomass up to 2050
Energy farming on current agricultural land	Potential land surplus: 0-4 Gha (average: 1-2 Gha). A large surplus requires structural adaptation towards more efficient agricultural production systems. When this is not feasible, the bioenergy potential could be reduced to zero. On average higher yields are likely because of better soil quality: 8-12 dry tonne/ha/yr* is assumed.	0 – 700 EJ (more average development: 100 – 300 EJ)
Biomass production on marginal lands.	On a global scale a maximum land surface of 1.7 Gha could be involved. Low productivity of 2-5 dry tonne/ha/yr.* The net supplies could be low due to poor economics or competition with food production.	<60 – 110 EJ
Residues from agriculture	Potential depends on yield/product ratios and the total agricultural land area as well as type of production system. Extensive production systems require re-use of residues for maintaining soil fertility. Intensive systems allow for higher utilisation rates of residues.	15 – 70 EJ
Forest residues	The sustainable energy potential of the world's forests is unclear – some natural forests are protected. Low value: includes limitations with respect to logistics and strict standards for removal of forest material. High value: technical potential. Figures include processing residues	30 - 150 EJ
Dung	Use of dried dung. Low estimate based on global current use. High estimate: technical potential. Utilisation (collection) in the longer term is uncertain	5 – 55 EJ
Organic wastes	Estimate on basis of literature values. Strongly dependent on economic development, consumption and the use of bio-materials. Figures include the organic fraction of MSW and waste wood. Higher values possible by more intensive use of bio-materials.	5 – 50 EJ
Combined potential	Most pessimistic scenario: no land available for energy farming; only utilisation of residues. Most optimistic scenario: intensive agriculture concentrated on the better quality soils. In parentheses: average potential in a world aiming for large-scale deployment of bioenergy.	40 – 1100 EJ (200 - 400 EJ)

* Heating value: 19 GJ/tonne dry matter.

Source: IEA Bioenergy

Future Potential

Overview of current use, and the technical and theoretical potentials of different renewable energy options:

Resource	Current use (EJ)	Technical Potential (EJ)	Theoretical potential (EJ)
Biomass energy	~50	200-400 (+)	2,900
Hydropower	9	50	147
Solar energy	0.1	>1,500	3,900,000
Wind energy	0.12	640	6,000
Geothermal energy	0.6	5,000	140,000,000
Ocean energy	NA	NA	>140,000,000
Total	56	>7,600	>144,000,000

Source: IEA Bioenergy

Cost ranges for production electricity, heat, and fuel from various renewable energy options:

Technology	Current energy cost	Potential long-term future energy cost (2050)
Biomass energy (based on energy crops as feedstock)		
• electricity	€ _{ct} 5-15/kWh electricity	€ _{ct} 4-10/kWh electricity
• heat	€ _{ct} 1-5/kWh _{fuel}	€ _{ct} 1-5/kWh
• biofuels	€8-25/GJ _{fuel}	€6-10/GJ
Wind electricity	€ _{ct} 5-13/kWh	€ _{ct} 3-10/kWh
Solar PV electricity	€ _{ct} 25-125 _y /kWh	€ _{ct} 5-25/kWh
Solar thermal electricity	€ _{ct} 12-18/kWh	€ _{ct} 4-10/kWh
Low temperature solar heat	€ _{ct} 3-20/kWh	€ _{ct} 2-20/kWh
Hydroelectricity	€ _{ct} 2-10/kWh	€ _{ct} 2-10/kWh
Geothermal energy		
• electricity	€ _{ct} 2-10/kWh	€ _{ct} 1-10/kWh
• heat	€ _{ct} 0.5-5/kWh	€ _{ct} 0.5-5/kWh

Source: IEA Bioenergy

Future Potential

Estimated costs of biofuels compared with the prices of oil and oil products (biofuels exclusive of taxes)

Biofuel	2006 (US cents/litre)	Long-term about 2030 (US cents/litre)
1 Price of oil, US\$/barrel	50–80	
2 Corresponding pre-tax price of petroleum products US cents/litre	35–60 ^a	
3 Corresponding price of petroleum products with taxes included, US cents/litre (retail price)	150–200 in Europe ^b About 80 in USA	
4 Ethanol from sugar cane	25–50	25–35
5 Ethanol from corn	60–80	35–55
6 Ethanol from beet	60–80	40–60
7 Ethanol from wheat	70–95	45–65
8 Ethanol from lignocellulose	80–110	25–65
9 Bio-diesel from animal fats	40–55	40–50
10 Bio-diesel from vegetable oils	70–100	40–75
11 Fischer-Tropsch synthesis liquids	90–110	70–85

Source: IEA 2006

Future Potential

Video

Ghent Bio-Energy Valley: Towards a Bio-based Economy

8'58"

(<http://www.youtube.com/watch?v=hSwnSW5308U>)

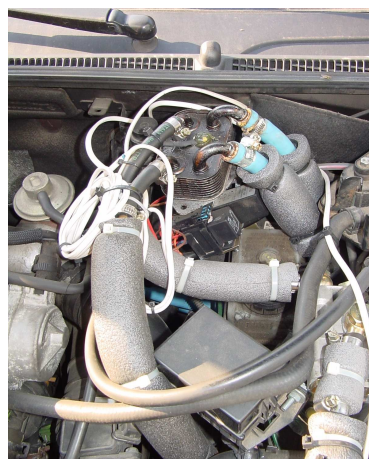
Future Potential

Handicaps in the development of the bio-based economy

- **Technological handicap:** The used technologies are still at the beginning of their development ↔ mature petrochemistry
- **Investment handicap:** most biorefineries still need to be built ↔ existing petrochemical factories
- **Scale handicap:** most biorefineries still have a relatively small scale ↔ economies of scale of large petroleum refineries

Practical Examples

Rapeseed → biodiesel



Practical Examples

Wood Pellet Burner - Glasshouse Sector



- 1,2 MW
- 1.000 tons of pellets
- Investment: € 250.000
- Return Time: 5 years



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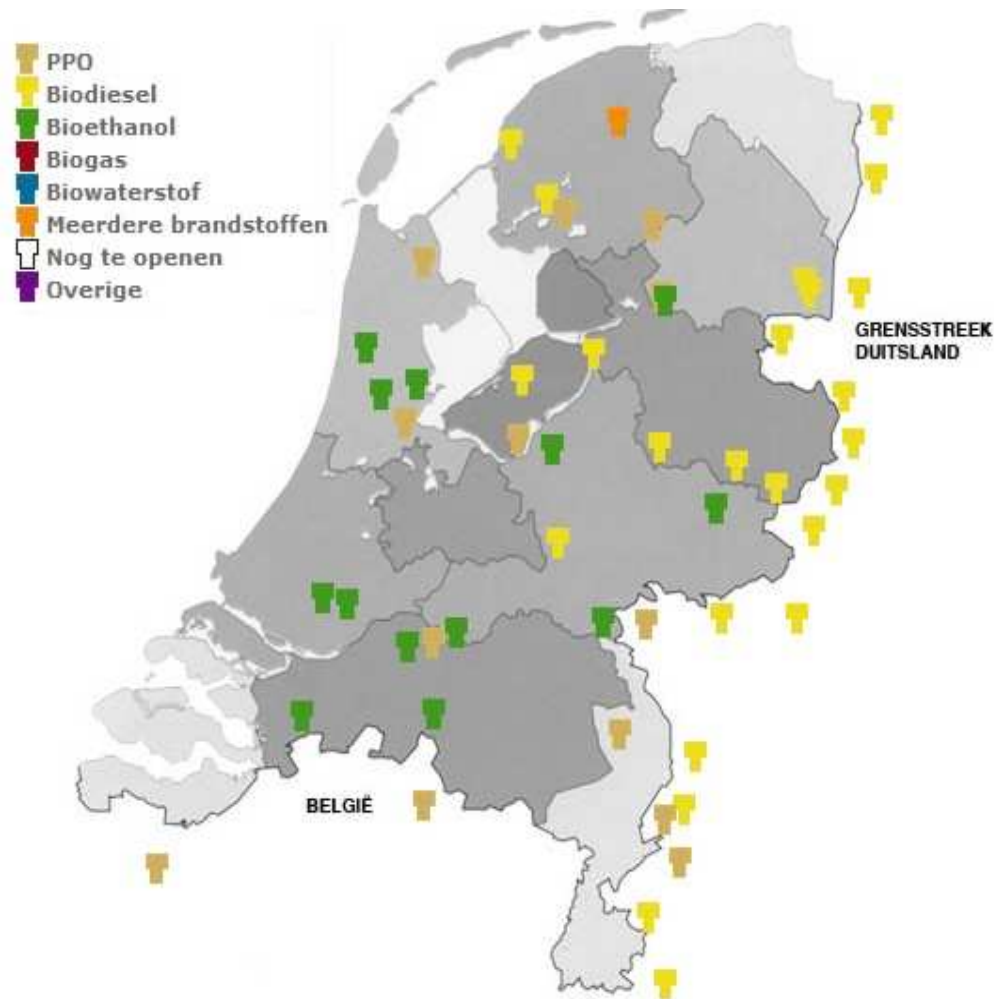
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Practical Examples



Practical Examples

Filling Locations for biofuel in the Netherlands



Source: <http://www.biotanken.nl/>

Examples

Video

Fuelling the future

8'14"

(http://ec.europa.eu/avservices/video/video_prod_en.cfm?type=detail&prodid=4835&src=1)

Examples

Video

Jämtland County

8'42"

(http://ec.europa.eu/dgs/energy_transport/videos/energy/2005_11_jamtland_en.htm)

Conclusions

- **There is a huge potential for bio-energy to make a significant contribution to the development of a sustainable energy future.**
- **But bio-energy alone cannot deliver the solution towards a sustainable energy future. It should be part of an integrated package of measures.**
 - 1) Avoidance of energy consumption
 - 2) Use of renewable energy
 - 3) Efficient use of fossil energy
- **Existing policy frameworks and targets for bio-energy are sometimes based on doubtful evidence and may miss important opportunities to deliver greenhouse gas emissions reductions.**
- **There are a significant number of social, economic and environmental uncertainties associated with bio-energy and policy frameworks must ensure that such issues are addressed.**
- **New opportunities are present, but mostly only feasible with subventions. Further research, principally on second generation bio-energy, is highly needed.**



Thank you for your attention!





Thank you for your attention!

Questions?

