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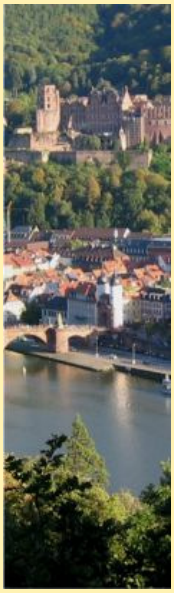
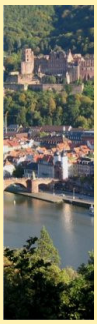


Ensuring the Environmental Sustainability of Jatropha Production and Use

Dr Guido Reinhardt

International Workshop
"Bioenergy Policies for Sustainable Development in Africa"
Bamako, Mali, 25 – 27 November 2008

Who we are - What we do



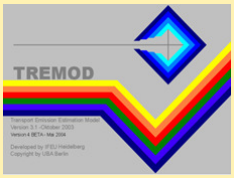
IFEU - Institute for Energy and Environmental Research Heidelberg, since 1978

- **Independent scientific research institute**
- **organised as a private non profit company with currently about 40 employees**
- **Research / consulting on environmental aspects of**
  - **Energy (including Renewable Energy)**
  - **Transport**
  - **Waste Management**
  - **Life Cycle Analyses**
  - **Environmental Impact Assessment**
  - **Renewable Resources**
  - **Environmental Education**

Who we are - What we do

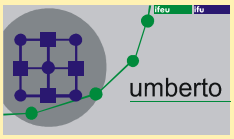
TREMOD: Transport Emission Model

- Modelling emissions of road vehicles, trains, ships and airplanes
- Official database of the German Ministries for emission reporting

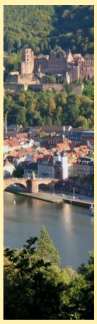


Life cycle analyses (LCA) and technology impact assessments since 1990:

- Biofuels (all biofuels, all applications)
- Alternative transportation modes
- Renewable Energy



Who we are - What we do



IFEU - Institute for Energy and Environmental Research Heidelberg, since 1978

Our clients (on biofuel studies)

- World Bank
- UNEP, FAO, GTZ, etc.
- European Commission
- National and regional Ministries
- Associations (industrial, Life Cycle Analyses)
- Local authorities
- WWF, Greenpeace, etc.
- Companies (DaimlerChrysler, German Telecom, etc.)
- Foundations (German Foundation on Environment, British Foundation on Transport, etc.)

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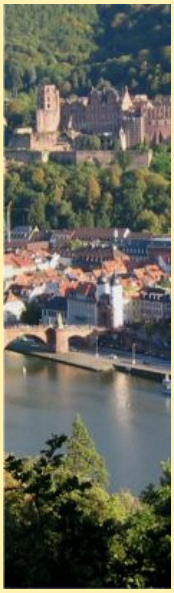

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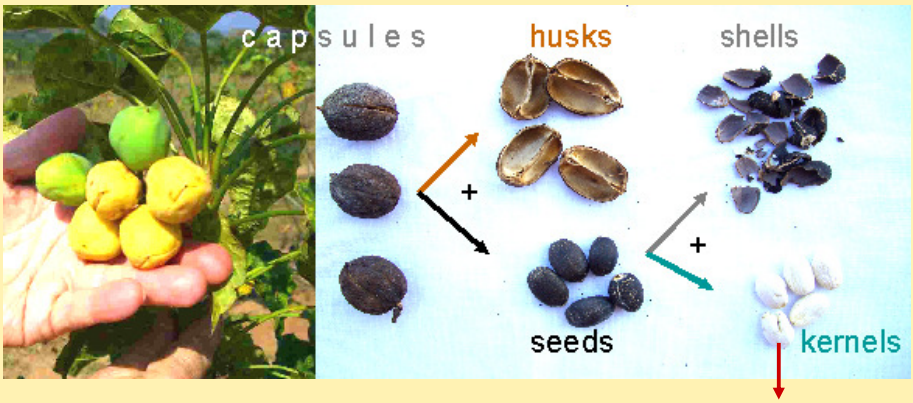
Jatropha curcas L.

Jatropha curcas L.




Jatropha curcas: Miracle plant ?



Cultivation scenario	Yield fruits [kg / (ha*yr)]	Yield seeds [kg / (ha*yr)]	Yield oil [kg / (ha*yr)]
Today	2,270	1,418	402
Optimised	3,811	2,382	676
Best	6,572	4,436	1381

Reinhardt et al. 2007

Jatropha: Miracle plant ?

- **Traditional uses:**
  - Whole plant: enclosure fences, medicine (seeds, leaves, bark, latex)
  - Husks (and shells): fertiliser
  - Oil (toxic): soap, purgative
  - Press cake (toxic): fertiliser
- **Future uses:**
  - Whole plant: erosion control, carbon sequestration
  - Husks (and shells): fuel
  - Oil (toxic): biofuel (pure plant oil or biodiesel)
  - Press cake (toxic): fuel or animal feed (detoxified!)

➔ **Vision: Low-input biofuel from the "green desert" for the benefit of the rural population**

Agenda

- Environmental implications
- Optimization by using byproducts
- Use of the oil
- Land use issues
- Water demand
- Conclusions & recommendations

Biofuels

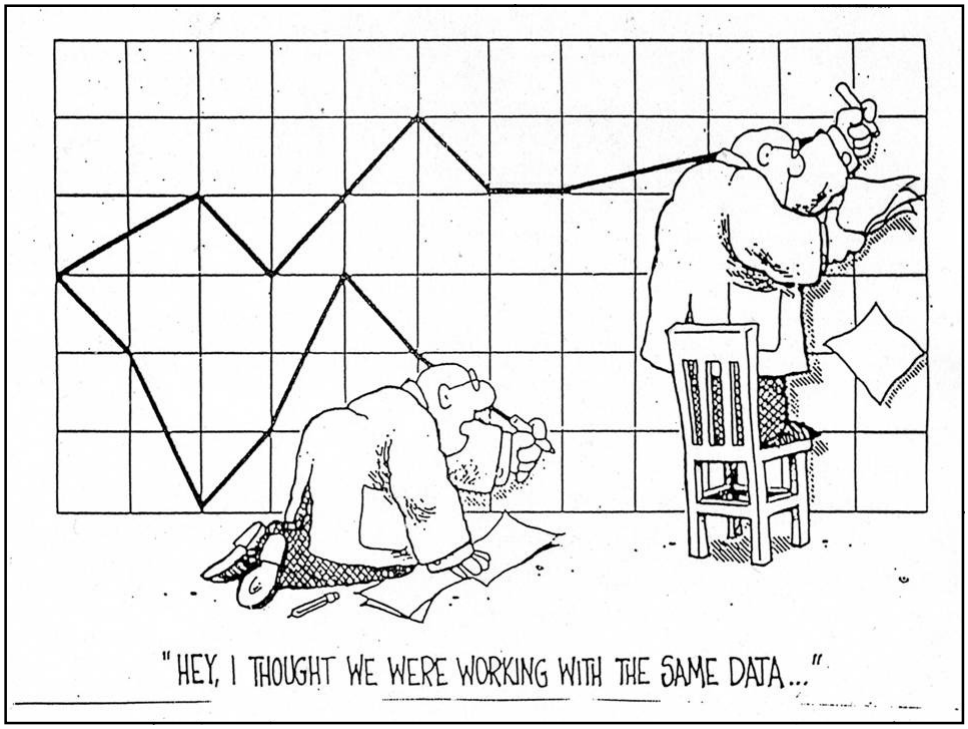
Environmental advantages and disadvantages:

+	–
• CO_2 neutral	• Land use
• Save energetic resources	• Eutrophication of surface water
• Organic waste reduction	• Water pollution by pesticides
• Less transport	• Energy intensive production
• etc.	• etc.

Total:

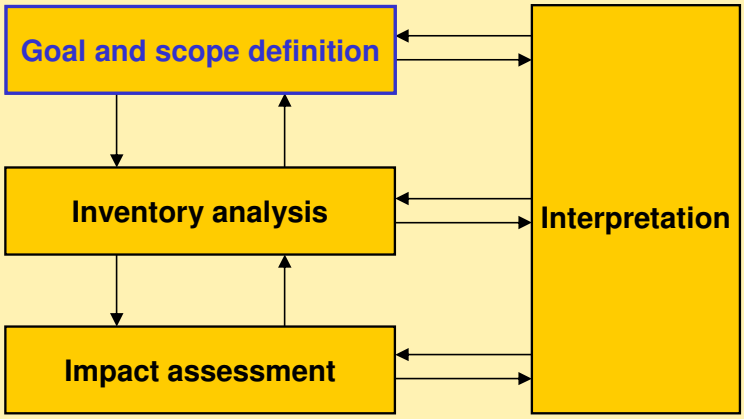
positive or negative

?

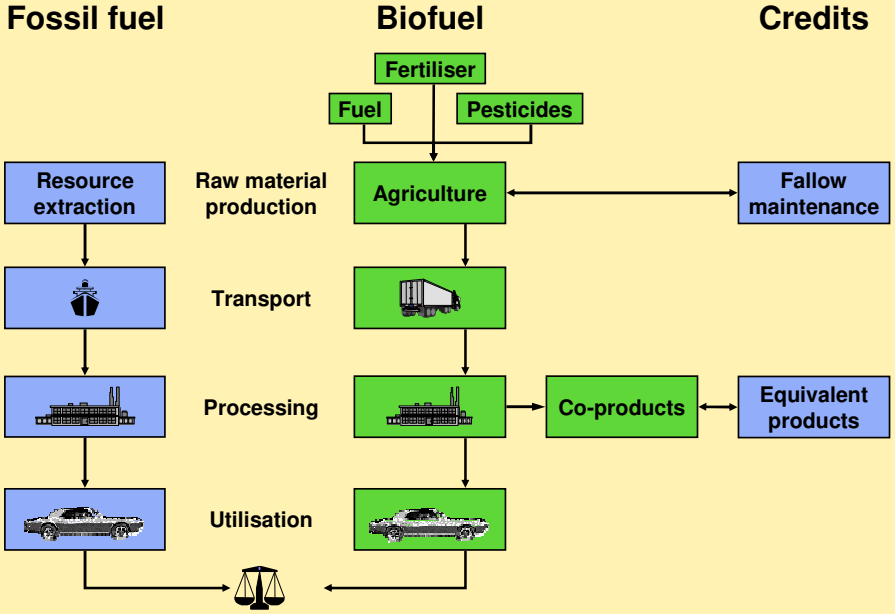


Life cycle analysis (LCA)

ISO 14040 & 14044

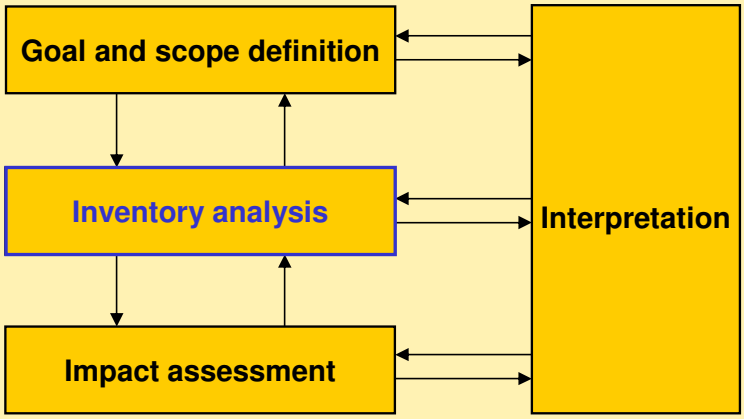


LCA: Life cycle comparison



Life cycle analysis (LCA)

ISO 14040 & 14044

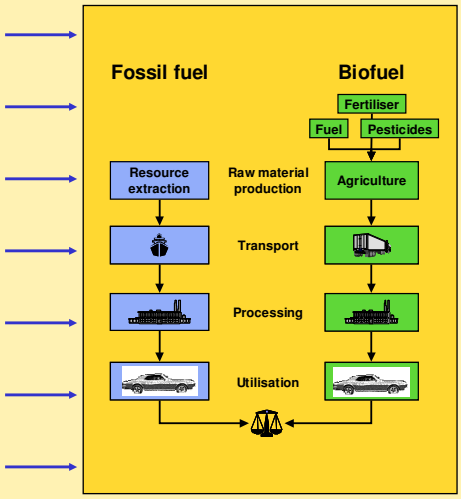


LCA: Inventory Analysis

Inputs

e.g.:

- natural gas
- crude oil
- brown coal
- hard coal
- uranium
- water



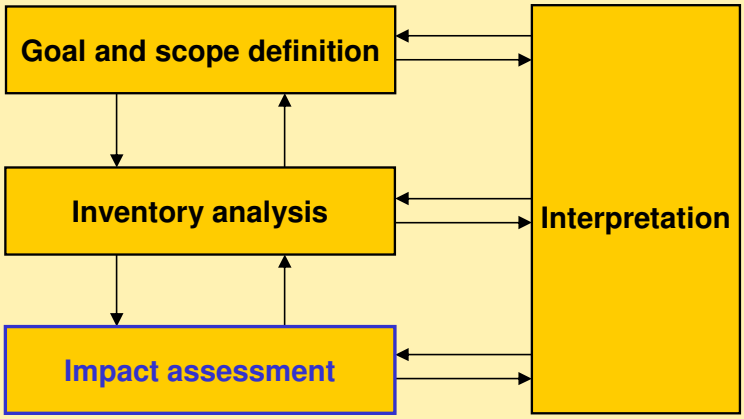
Outputs

e.g.:

- CO_2
- SO_2
- CH_4
- NO_X
- NH_3
- N_2O
- HCl
- CO
- C_6H_6
- VOC

Life cycle analysis (LCA)

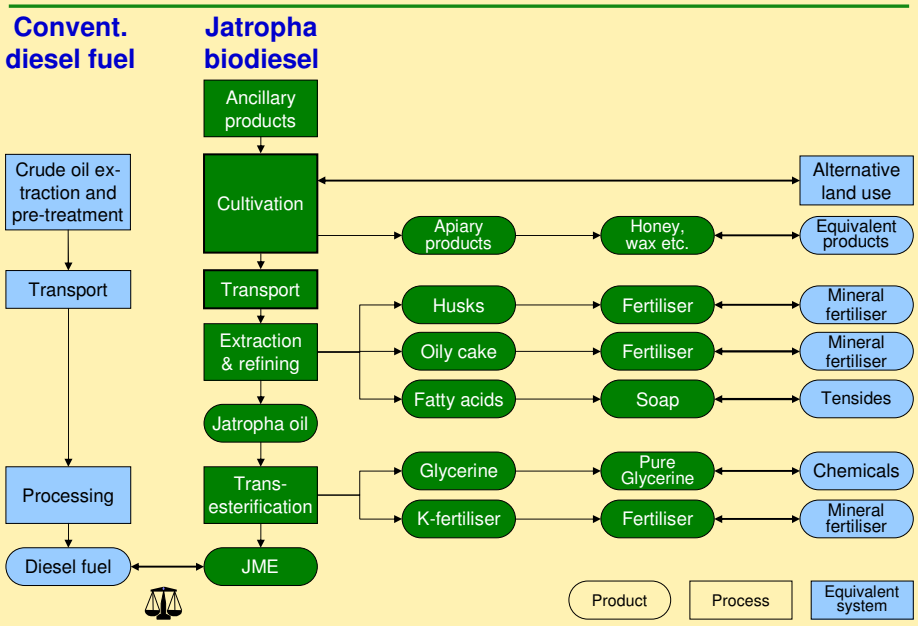
ISO 14040 & 14044



LCA: Impact assessment

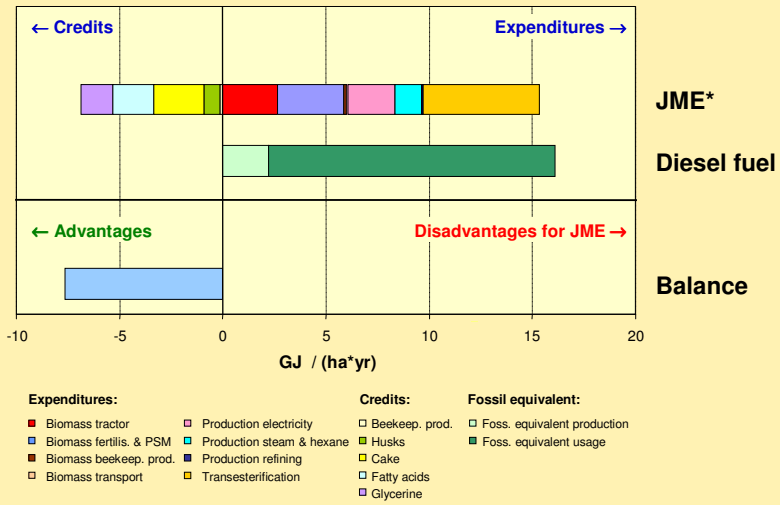
Impact category	Parameter	Substances (LCI)
Resource demand	Sum of depletable primary energy carriers Mineral resources	Crude oil, natural gas, coal, Uranium, … Lime, clay, metal ores, salt, pyrite, …
Greenhouse effect	CO_2 equivalents	Carbon dioxide, dinitrogen monoxide, methane, different CFCs, methyl bromide, …
Ozone depletion	F11 equivalents, (Nitrous oxide)	CFC, halone, methyl bromide, …
Acidification	SO_2 equivalents	Sulphur dioxide, hydrogen chloride, nitrogen oxides, ammonia, …
Eutrophication	PO_4 equivalents	Nitrogen oxides, ammonia, phosphate, nitrate
Photosmog	Ethylene equivalents	Hydrocarbons, nitrogen oxides, carbon monoxide, chlorinated hydrocarbons, …
Human and Ecotoxicity		Nitrogen oxides, carbon monoxide, hydrogen chloride, diesel particles, dust, ammonia, benzene, benzo(a)pyrene, sulphur dioxide, dioxines (TCDD), …

JME: Life cycle comparison



Results: JME versus diesel fuel

Energy savings

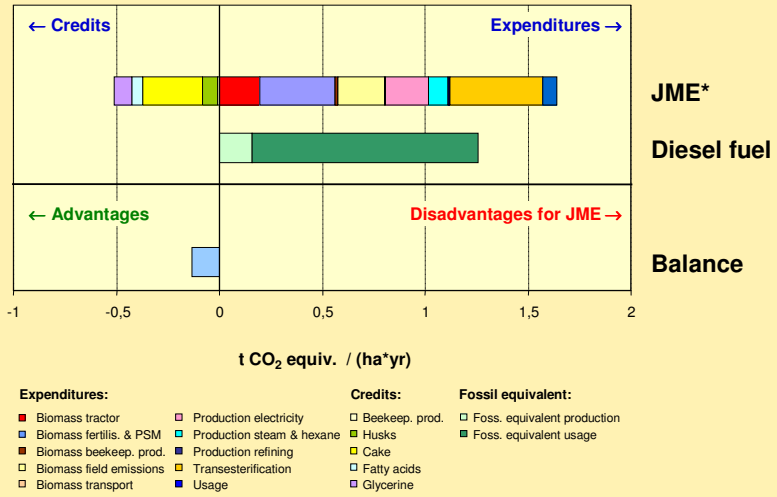


* JME = Jatropha oil methyl ester = Jatropha oil biodiesel

Source: IFEU 2007

Results: JME versus diesel fuel

Greenhouse effect

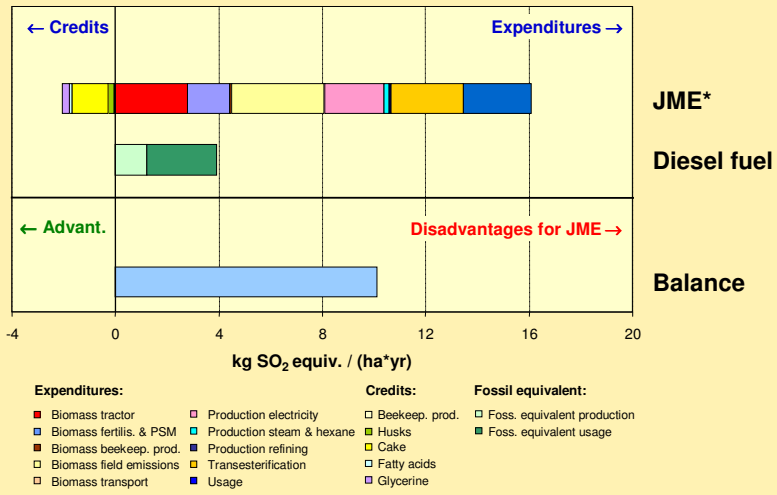


* JME = Jatropha oil methyl ester = Jatropha oil biodiesel

Source: IFEU 2007

Results: JME versus diesel fuel

Acidification

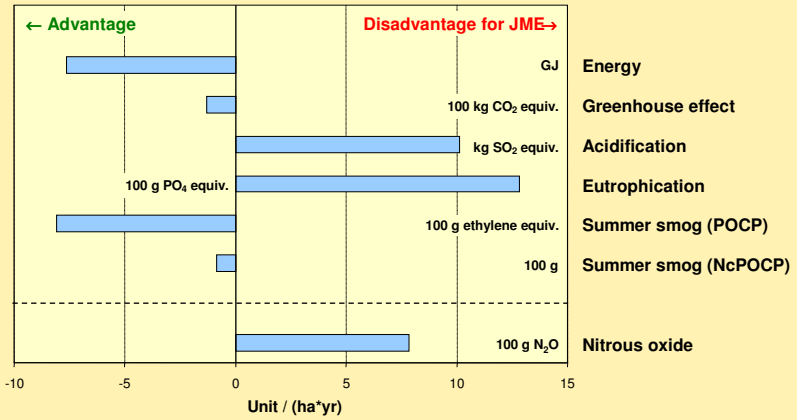


* JME = Jatropha oil methyl ester = Jatropha oil biodiesel

Source: IFEU 2007

Results: JME versus diesel fuel

All environmental impact categories



➔ **Advantageous (e.g. energy), disadvantageous (e.g. acidification) and ambiguous results (summer smog)**

Source: IFEU 2007

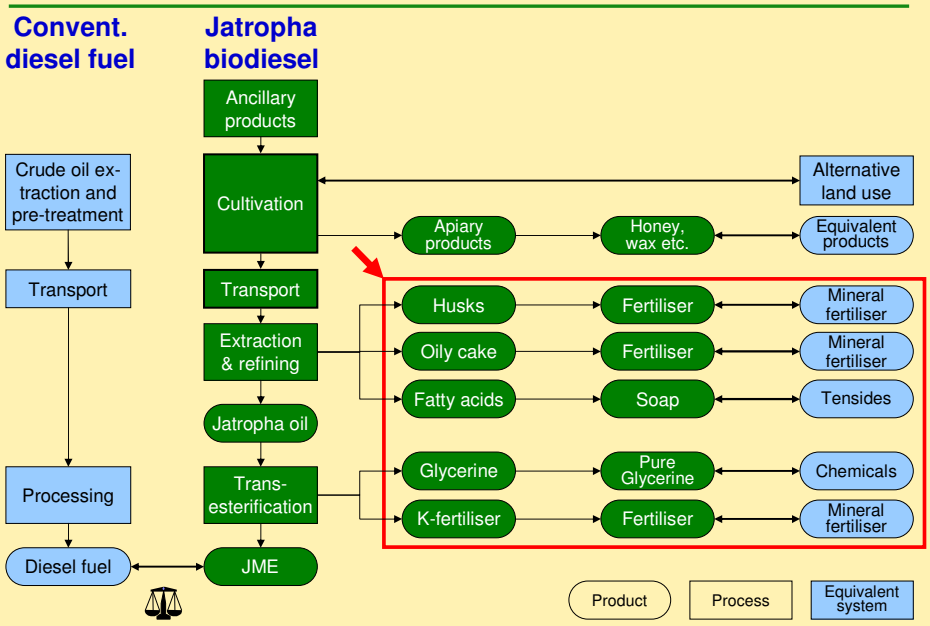
Synopsis of environmental impacts

- Jatropha biodiesel shows both environmental advantages (e.g. saving of non-renewable energy carriers) and disadvantages (e.g. acidification and eutrophication) compared to fossil diesel fuel
- An objective decision for or against a particular fuel cannot be taken. However, based on a subjective value system a decision is possible.
- If, for example, saving of non-renewable energy carriers and greenhouse gases is given the highest priority, Jatropha biodiesel performs better than fossil diesel fuel

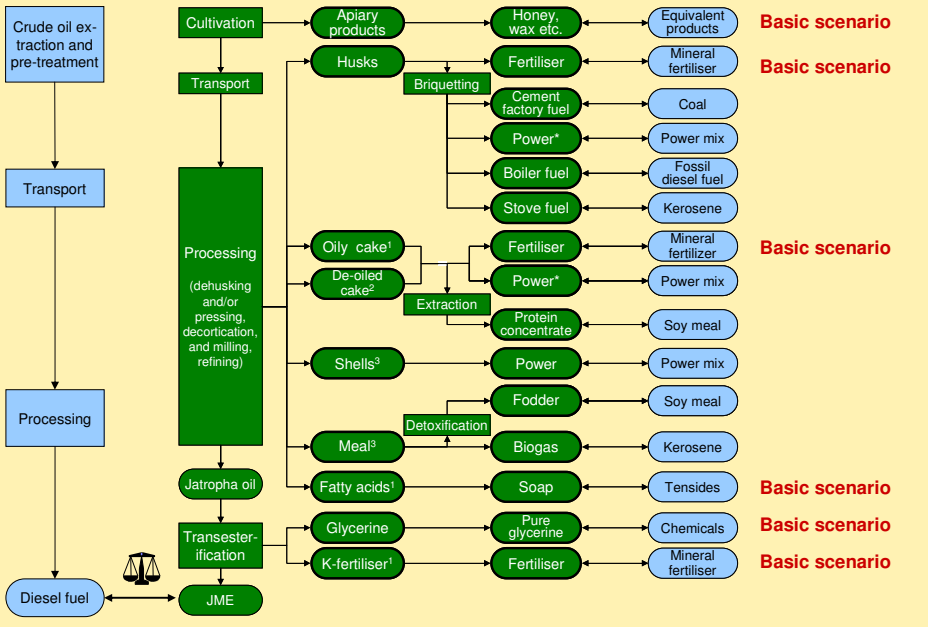
➔ **Trends and patterns also known for other biofuels**

➔ **Let's minimize the negative implications and optimize the positive ones !**

JME: Optimisation potentials

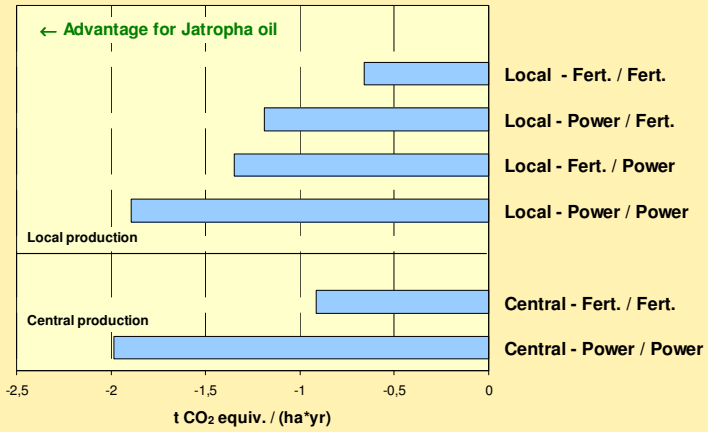


Optimisation: By-product utilisation



Results: By-product utilisation

Greenhouse effect



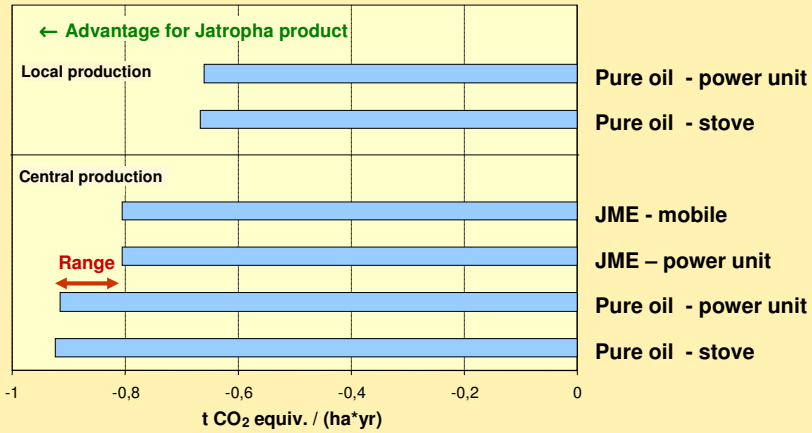
➔ **Best results, if by-products are used for bioenergy**

➔ **Huge optimization potential**

Source: IFEU 2007

Results: Product utilisation

Greenhouse effect



➔ **Local production not as effective as central production**

➔ **No big difference of pure oil to JME use**

Source: IFEU 2007

Agenda

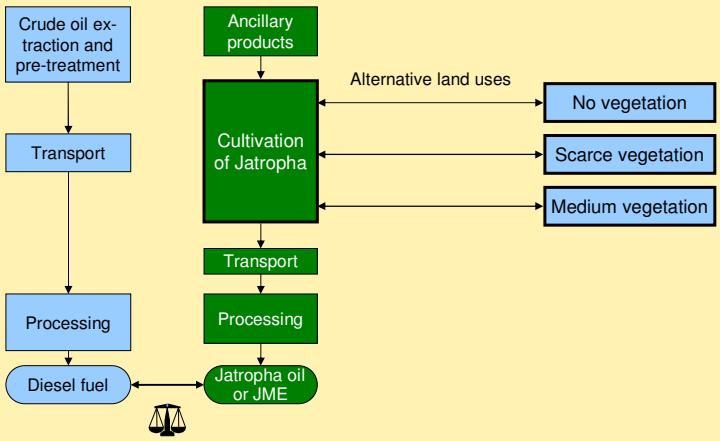
- Environmental implications
- Optimization by using byproducts
- Use of the oil
- Land use issues
- Water demand
- Conclusions & recommendations

Land use change / C stock change




Optimisation: Land use change

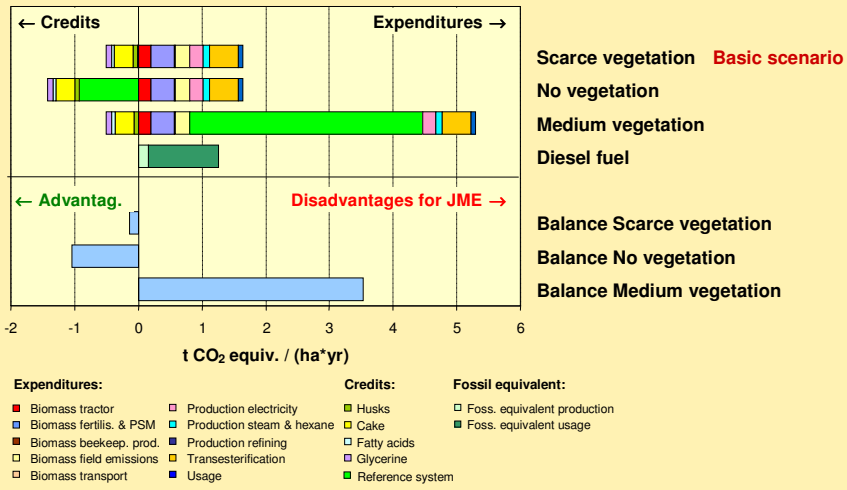
Carbon stock changes



Source: IFEU 2007

Results: Land use change

Greenhouse effect



➔ **Carbon stock changes decisive for GHG balance**

Source: IFEU 2007

Water demand

Rainfall per year

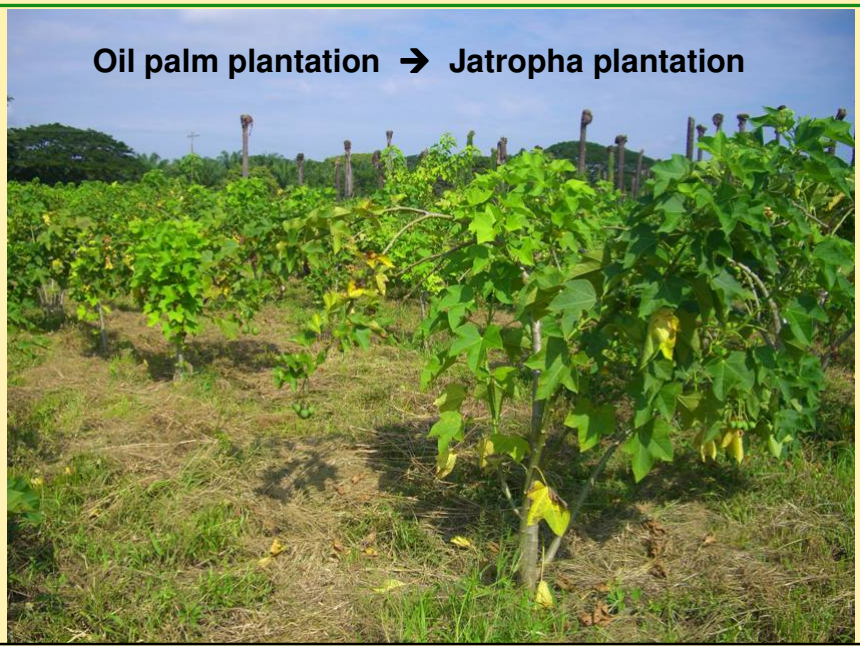
… after 2 years

50-100 mm

> 2000 mm

Land use change

Oil palm plantation → Jatropha plantation



Jatropha and water demand

Water issue can be a big threat:

- High yields if much water available
- Competition on land use especially when big investors are involved and large plantations are planned
- Food versus fuel debate

Agenda

- Environmental implications
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Conclusions

- **Main results:**
  - Jatropha biodiesel shows both environmental advantages and disadvantages compared to fossil diesel
  - If saving of fossil energy carriers and greenhouse gases is given the highest priority, the use of JME is advantageous…
  - … but results point at a great optimisation potential
- **Detailed results:**
  - Land use change: large influence of carbon loss / gain
  - By-products / credits for bioenergy: bioenergy leads to higher savings depending on energy carrier replaced
  - Conversion: centralised production more beneficial than decentralised
  - Primary products: Jatropha oil and JME from centralised production perform eqally.

Recommendations

- **Establishment of new plantations**
  - Reduction of carbon stock must be prevented: plantations on poor, sparsely vegetated soils, e.g. degraded land, is best solution
  - This also avoids land use competition with food production and minimizes risk of water
- **System optimisation**
  - Full potential of optimisation measures should be tapped: e.g. use of by-products for bioenergy generation
- **Jatropha production & use can be sustainable**
  - High potential for a sustainable low-input production and use of Jatropha oil especially for rural population

Thank you for your attention

Dr Guido Reinhardt

Any questions ?

……. Don't hesitate to ask.

Assistance to calculate energy / CO_2 balances or to process certification issues ?

……. guido.reinhardt@ifeu.de

Downdloads: www.ifeu.de

Further reading

Ifeu
Institut für Energie- und Umweltforschung Heidelberg GmbH

Screening Life Cycle Assessment of Jatropha Biodiesel

Final Report

Commissioned by
Daimler AG, Stuttgart

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Heidelberg, 11 December 2007

ifeu - Institute for Energy and Environmental Research Heidelberg GmbH

CSMCRI - Central Salt & Marine Chemicals Research Institute, Bhavnagar

University of Hohenheim Institute of Animal Production in the Tropics and Subtropics

Basic Data for Jatropha Production and Use

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Updated version – June 2008

Jatropha: Quo vadis ?