ifeu – Institute for Energy and Environmental
Research Heidelberg, Germany

# Greenhouse gas balances of biofuels

**Horst Fehrenbach and Dr. Guido Reinhardt**

**Sustainable Bioenergy –
Challenges and Opportunities**

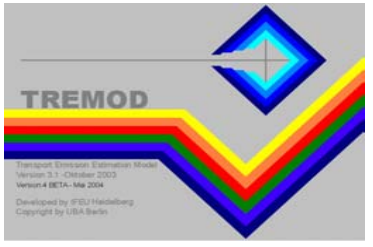
Bonn, 12-13 October 2006

# 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 (Fuel cells, FFV, etc.)
- Renewable Energy
- Waste-to-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, GTZ etc.
  - European Commission
  - National and regional Ministries
  - Associations (national and international)
  - Local authorities
  - WWF, Greenpeace etc.
  - Companies (DaimlerChrysler, German Telekom, etc.)
  - Foundations (German Foundation on Environment, British Foundation on Transport etc.)

# Biofuels for transportation

## Environmental advantages and disadvantages:

**+**

- $CO_2$ neutral
- Save energetic resources
- Organic waste reduction
- Less transport
- etc.

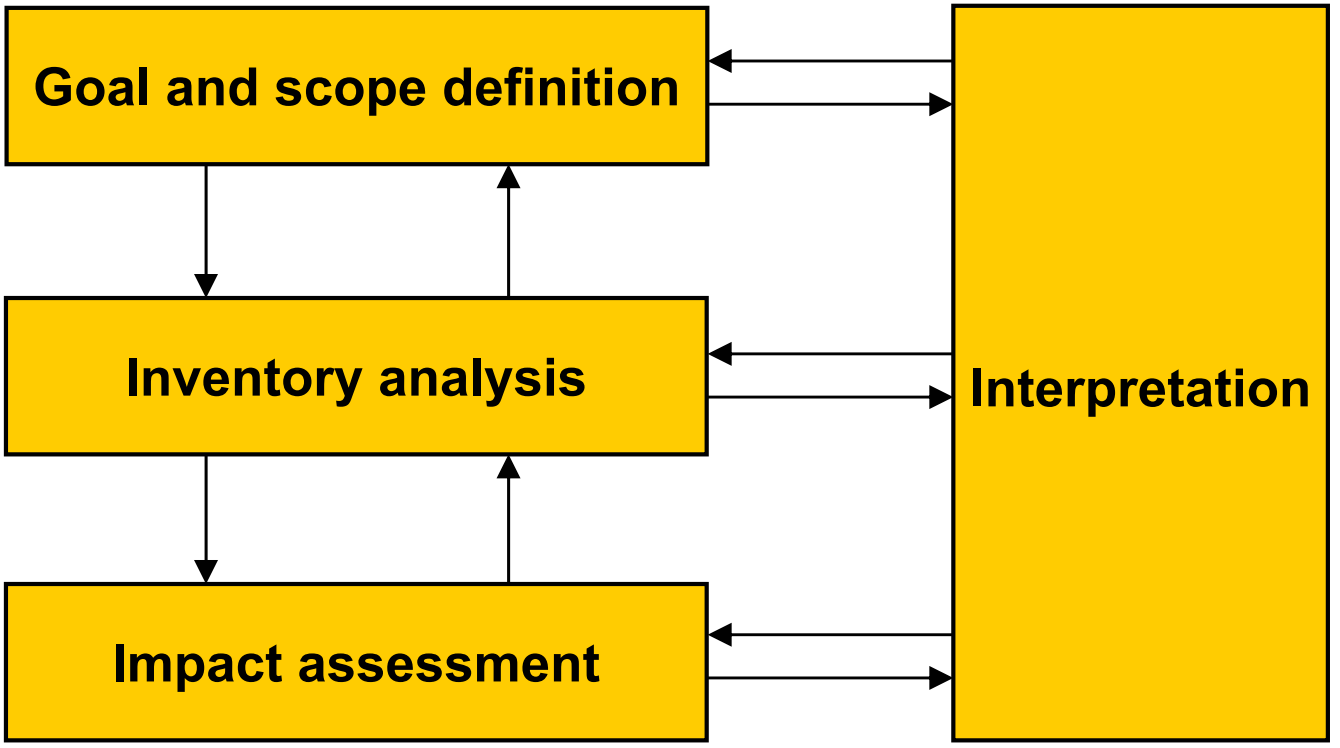
**–**

- Land use
- Eutrophication of surface water
- Water pollution by pesticides
- Energy intensive production
- etc.

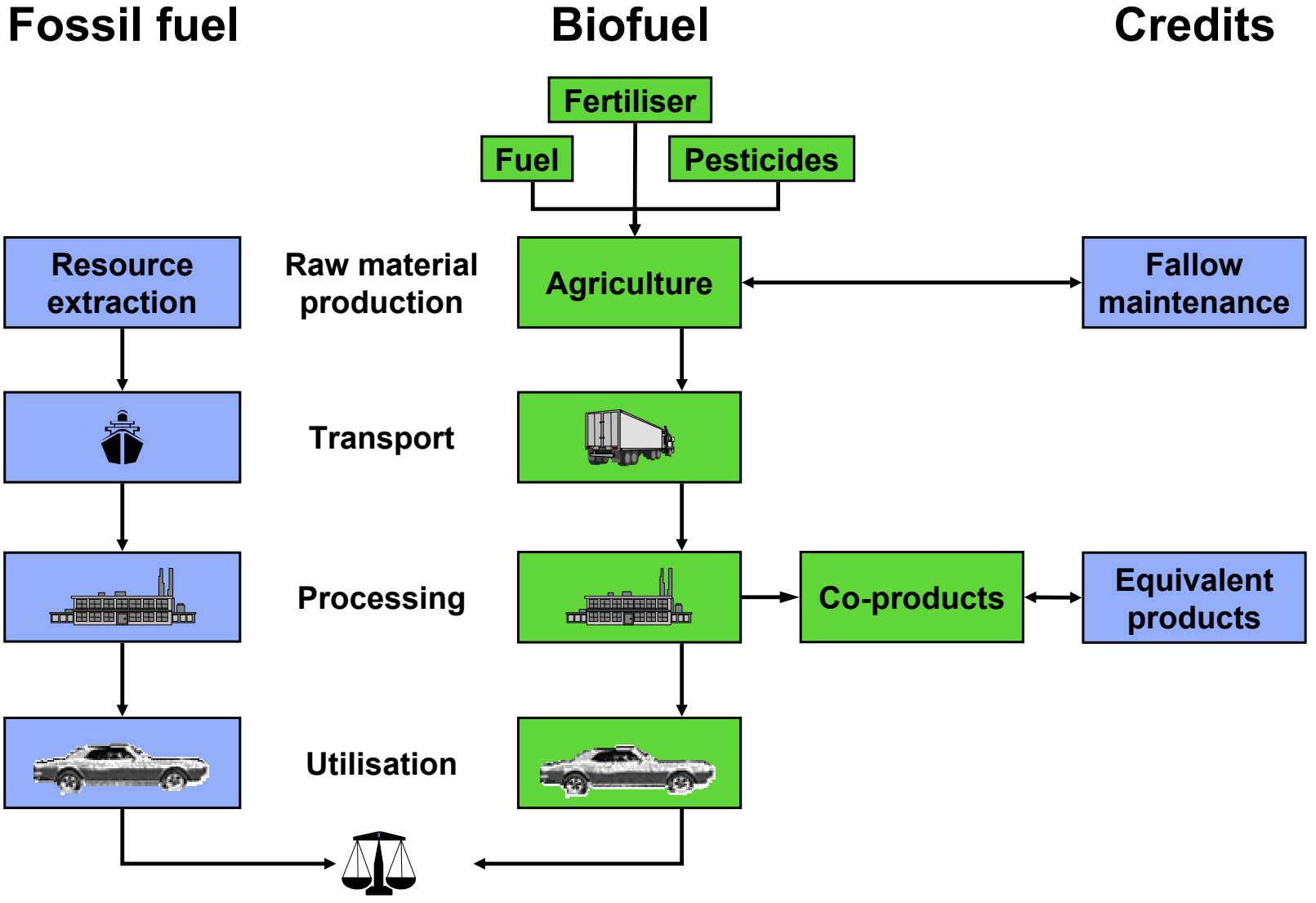
**Total:**
**positive or negative**
**?**

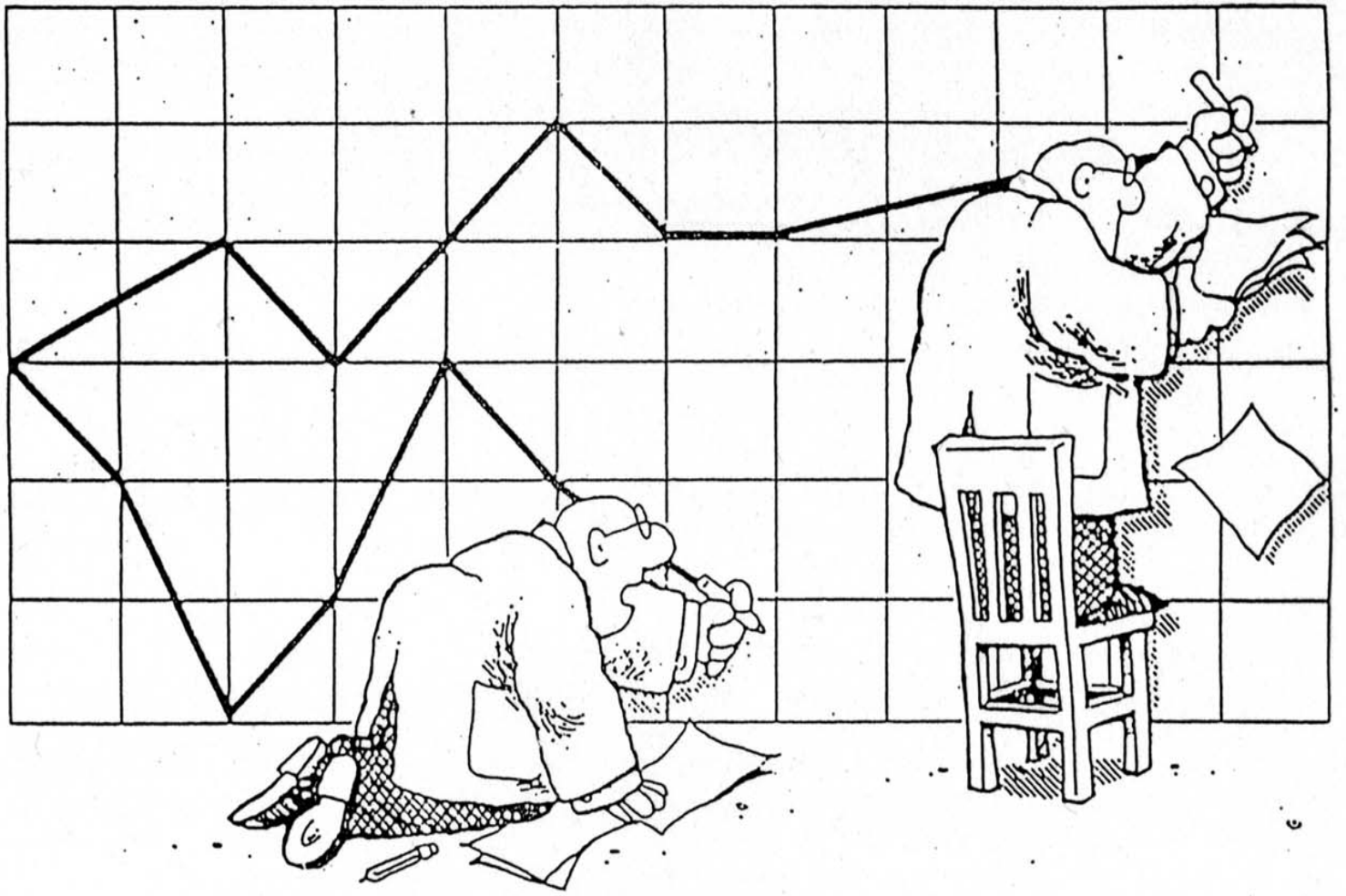
# Life cycle analysis (LCA)

## ISO 14040-43



# Life cycle comparison





"HEY, I THOUGHT WE WERE WORKING WITH THE SAME DATA..."

# IFEU 2004, continuous updates

## $CO_2$ Mitigation through Biofuels in the Transport Sector

## – Status and Perspectives –

- **Analysis of all LCAs world wide published on current and innovative biofuels for transportation.**
- **Analysis of literature regarding costs and potentials.**
- **Conclusions including necessities for research.**

Download available from: **www.ifeu.de**

# Literature review

**Analysis of all world-wide published LCAs about current and innovative biofuels for transportation**

**Procedure:**

- **Literature compilation world wide by involving external experts: more than 800 publications.**
- **Screening of the studies concerning state of the art data and fulfilment of ISO 14040/43 norms (Life cycle assessment).**

# Analysed biofuels for transportation

| | Number |
|---|---|
| **Bioethanol** | |
| — Bioethanol from sugar cane | 1 |
| — Bioethanol from corn | 7 |
| — Bioethanol from wheat | 9 |
| — Bioethanol from sugar-beet | 8 |
| — Bioethanol from lignocellulose | 8 |
| — Bioethanol from potato | 1 |
| — Bioethanol from molasses | 2 |
| **ETBE** | |
| — ETBE from wheat | 2 |
| — ETBE aus sugar-beet | 8 |
| — ETBE from lignocellulose | 2 |
| — ETBE from potato | 1 |
| **Biodiesel** | |
| — Biodiesel from rapeseed | 17 |
| — Biodiesel from sunflower | 7 |
| — Biodiesel from soybean | 3 |
| — Biodiesel from Canola | 2 |
| — Biodiesel from coconut oil | 1 |
| — Biodiesel from recycled plant oil | 1 |
| — Biodiesel from animal grease | 1 |
| — Biodiesel from used cooking oil | 1 |
| **Plant oil** | |
| — Plant oil from rapeseed | 4 |
| — Plant oil from sunflower | 1 |

| | Number |
|---|---|
| **Biomethanol** | |
| — Biomethanol from lignocellulose | 5 |
| **MTBE** | |
| — MTBE from lignocellulose | 1 |
| **DME** | |
| — DME from lignocellulose | 3 |
| **BTL** | |
| — Sunfuels from lignocellulose | 4 |
| **Pyrolysis oil** | |
| — Pyrolysis oil from lignocellulose | 0 |
| **HTU Diesel** | |
| — HTU diesel from lignocellulose | 0 |
| **Biogas** | |
| — Biogas from org. residues | 3 |
| **Hydrogen** | |
| — GH2 from lignocellulose | 5 |
| — GH2 from org. residues | 1 |
| — LH2 from lignocellulose | 3 |

**Analyses regarding energy and $CO_2$ balances: 112**

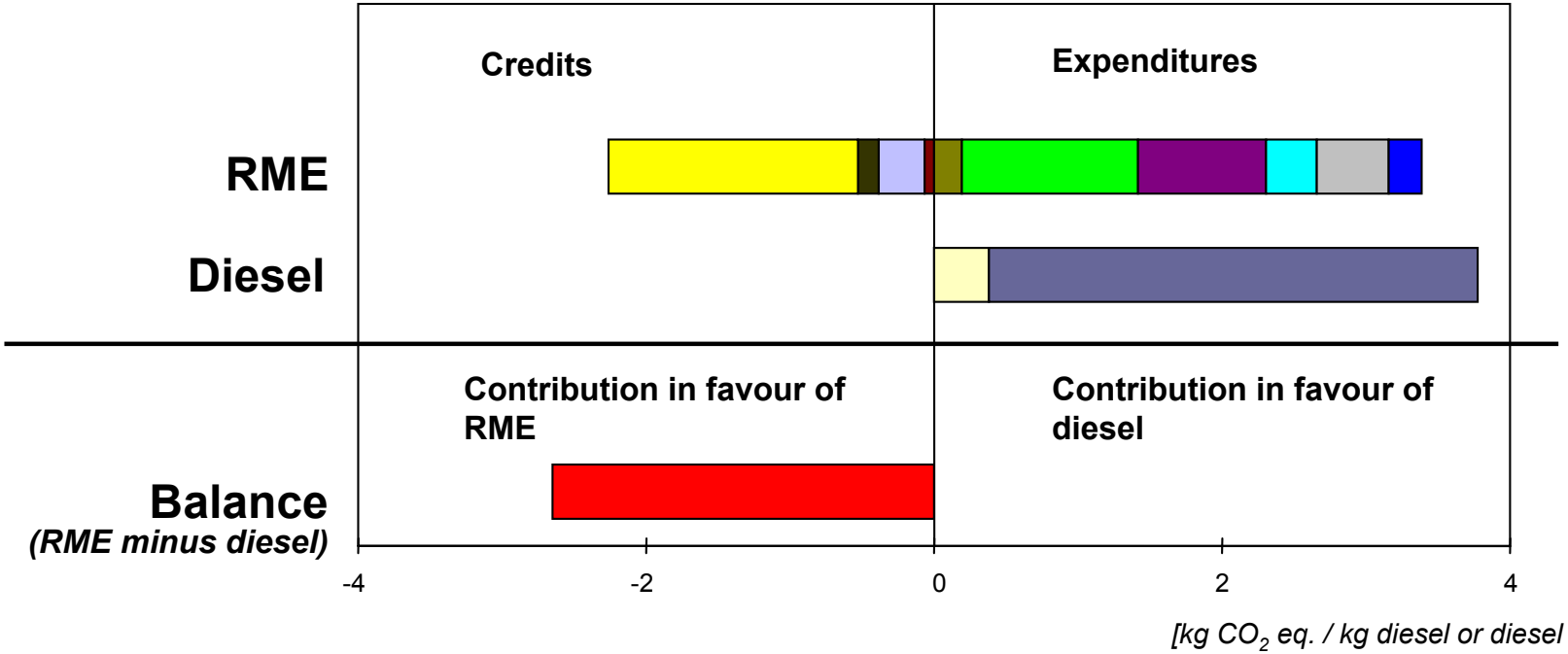
# Energy and greenhouse gases

**Result:**

**Not all LCA studies can be regarded to be representative: for this reason, deduction of bandwidths necessary**

# Example: RME versus diesel

## Greenhouse effect



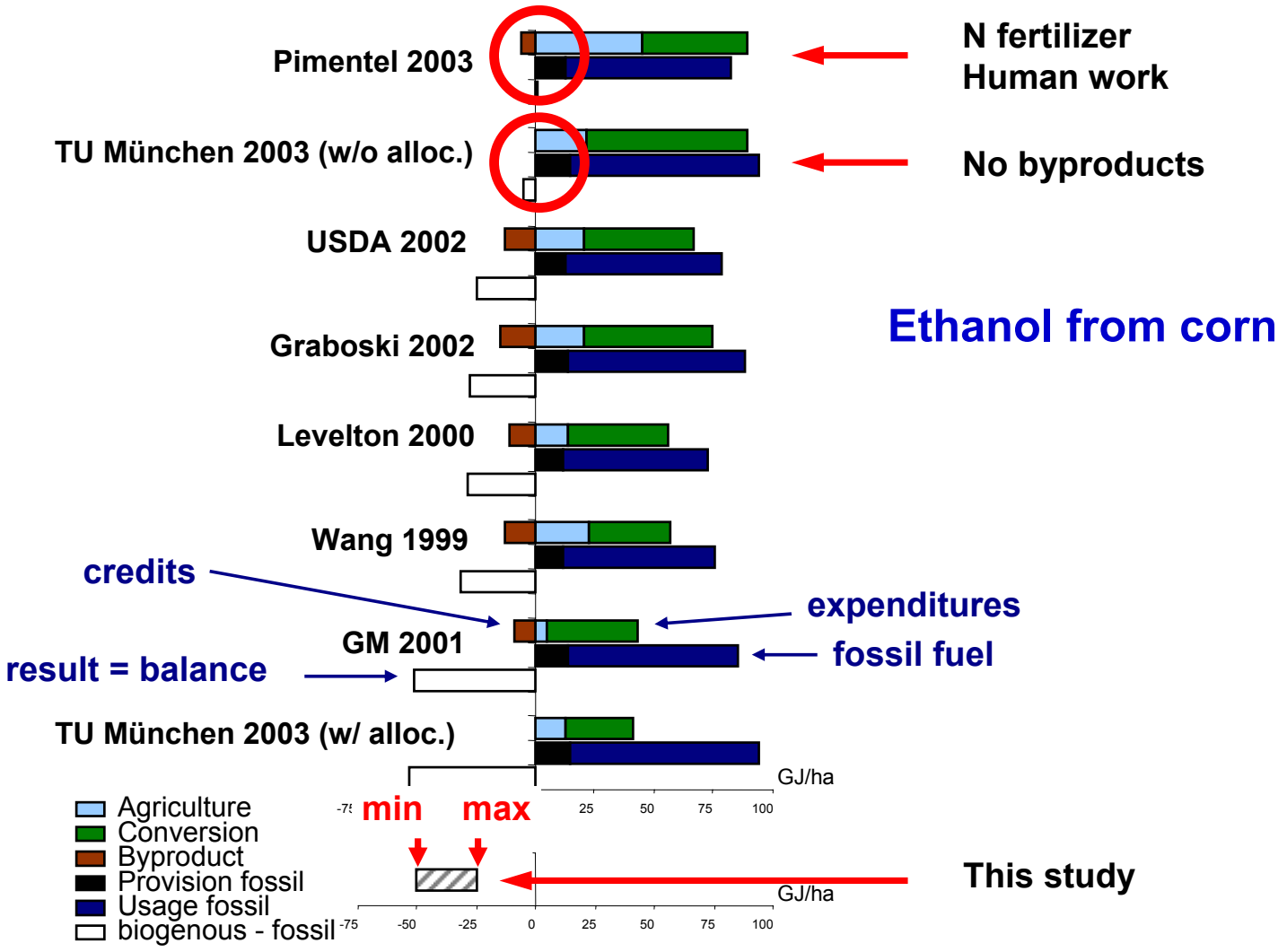

*[kg $CO_2$ eq. / kg diesel or diesel eq.]*

**RME**
- Machine work
- Material inputs
- Oil pressing
- Transesterification
- Utilisation

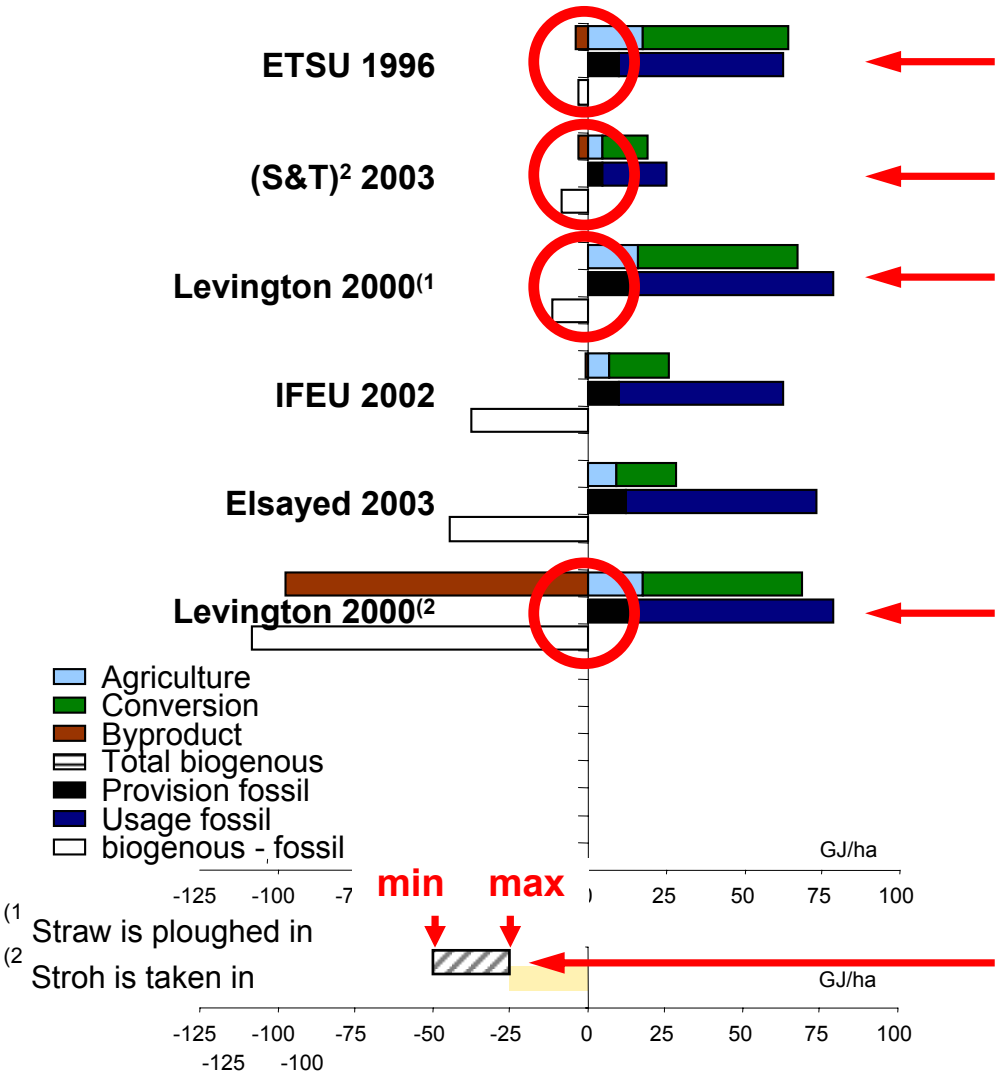
**Credits**
- Reference system
- Soy bean meal (agric.)
- Soy bean meal (transp.)
- Glycerine

**Diesel**
- Production
- Utilisation

# Deduction of bandwidths



# Deduction of bandwidths




Basis data

Yield 27 dt/ha

No byproducts

Straw credit

**Ethanol from wheat**

This study

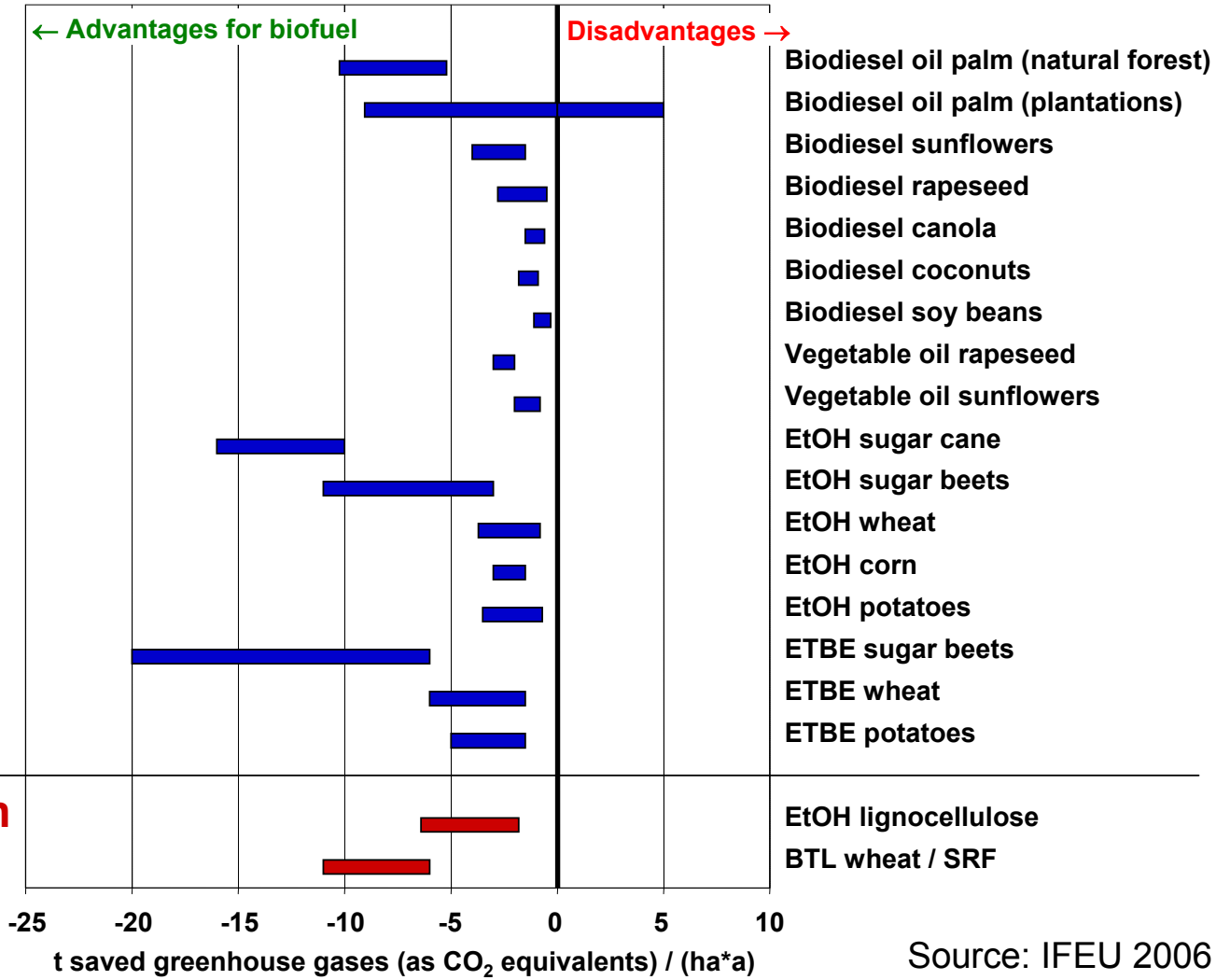

Oil palm plantation through
cutting of tropical forests


Oil palm plantation instead
of existing plantations


Oil palm plantation instead of existing plantations

# $CO_2$ balance of biofuels

**1st generation biofuels**

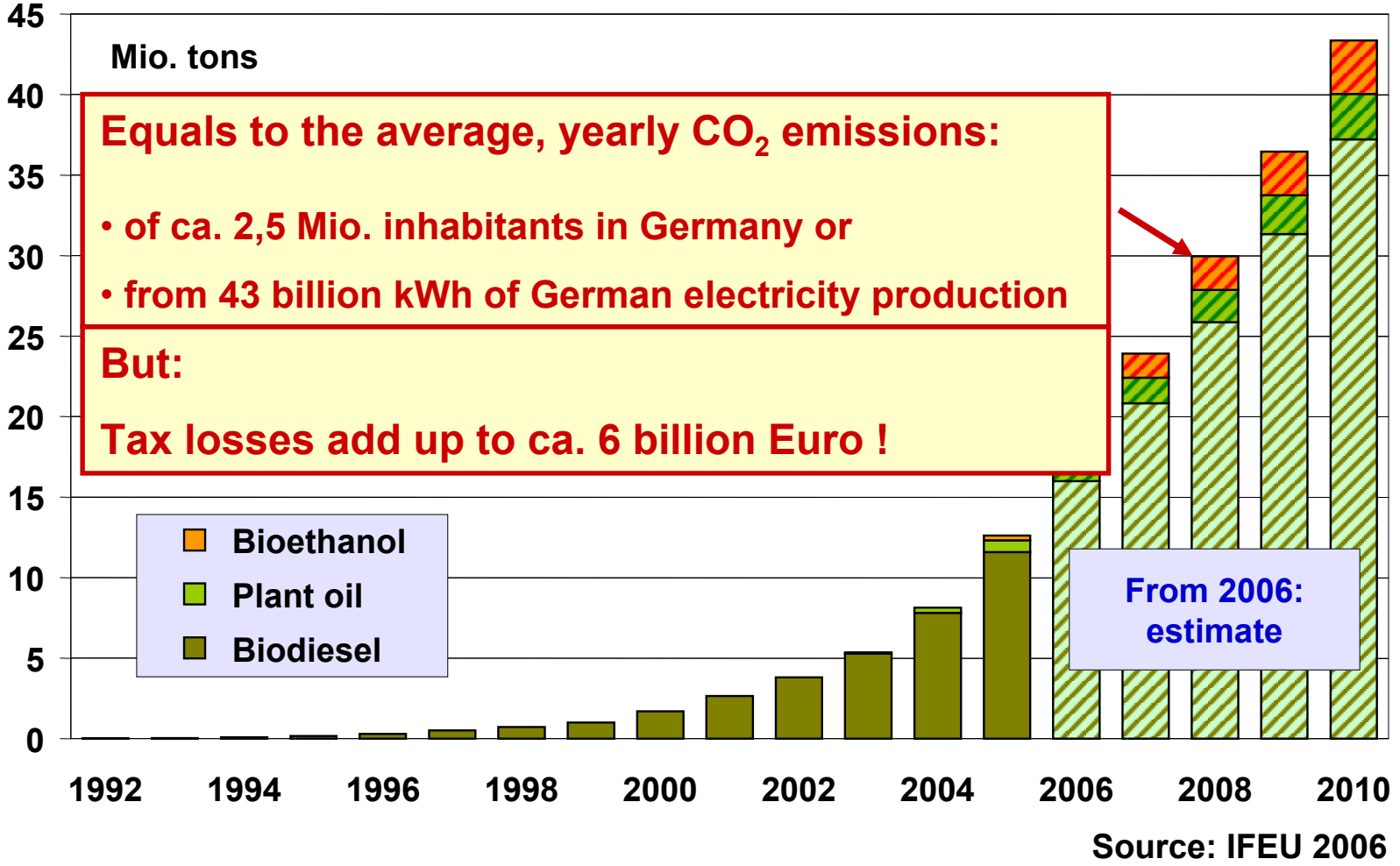



**2nd generation biofuels**

Source: IFEU 2006

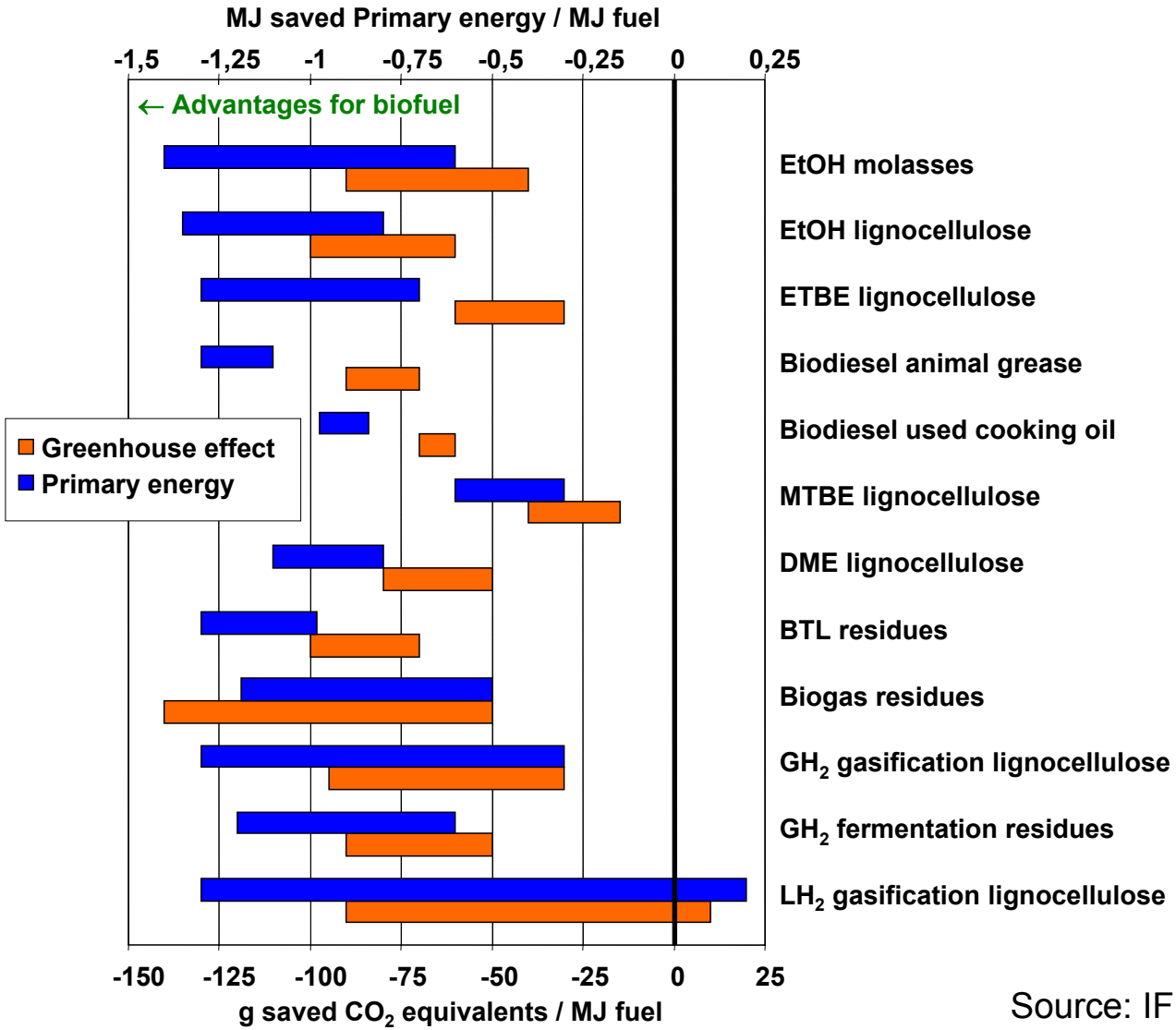
# $CO_2$ savings in Germany

## Cumulated savings of greenhouse gases through first generation biofuels in Germany



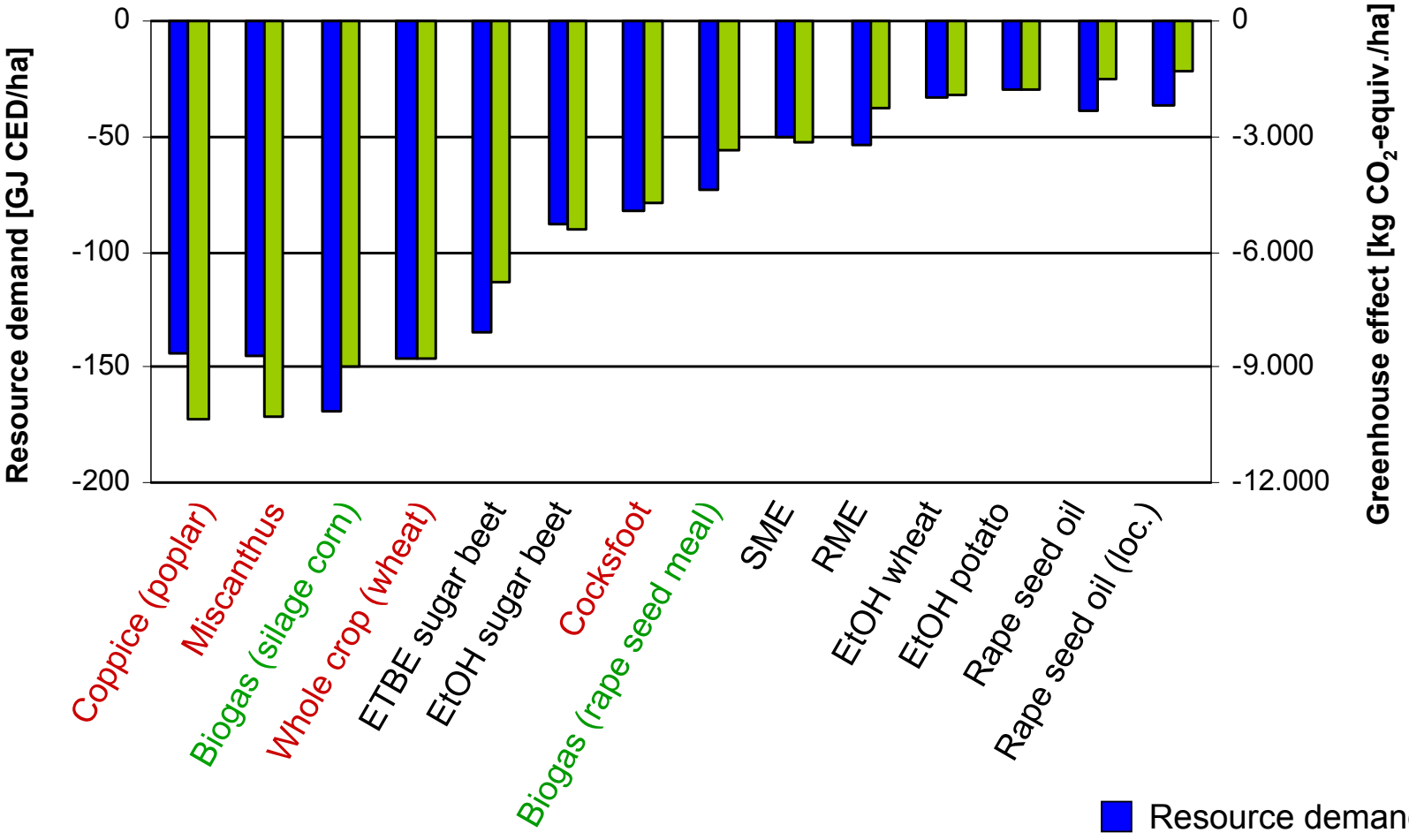

Source: IFEU 2006

# Results: biofuels from residues




Source: IFEU 2006

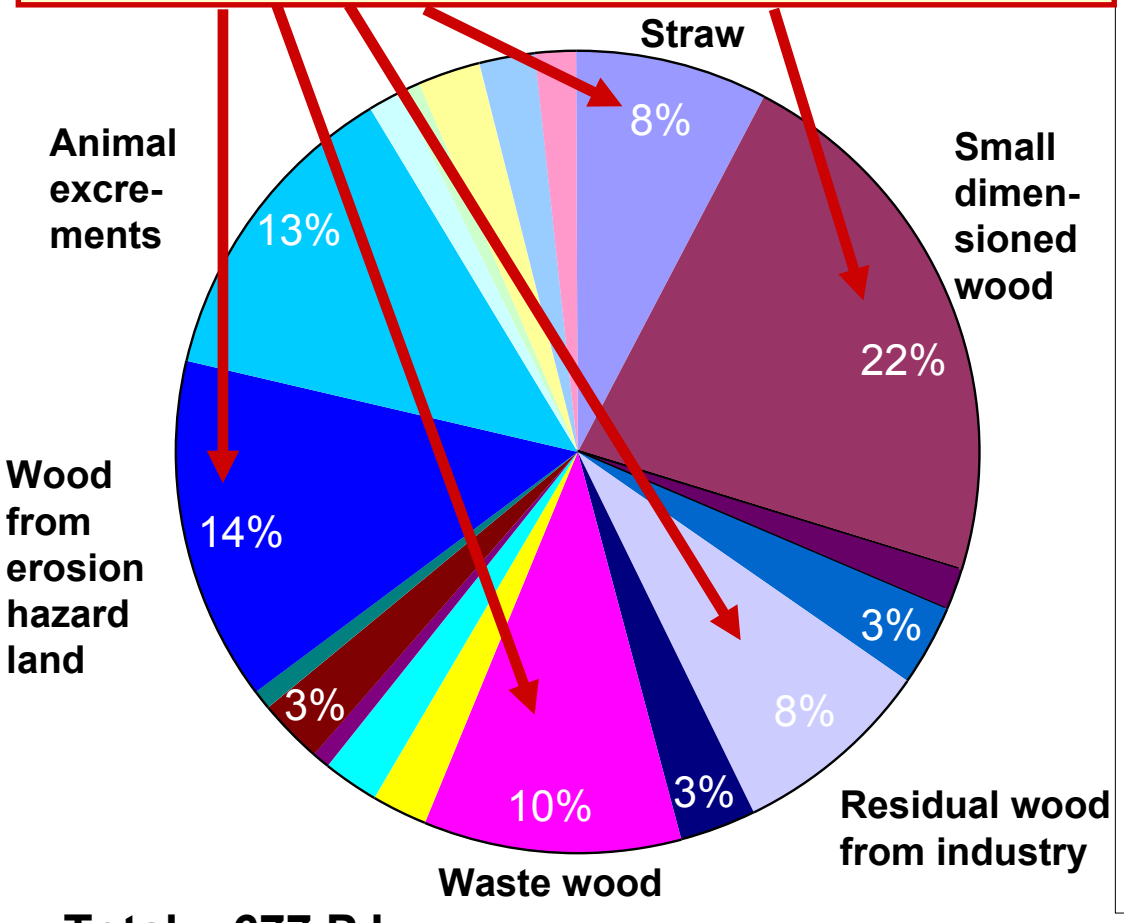
# Results: biofuels versus biofuels




Source: IFEU 2006

# Germany: Sustainable biomass potentials 2010

**Lignocellulose (wood and straw): > 60 %**




- Straw
- Small dimensioned wood
- Forest border development
- Open land
- Residual wood from industry
- Wood fraction in household waste
- Waste wood
- Sewage sludge
- Zoo mass
- Green biomass compensation area
- Biotope network: arable land
- Extensive grassland
- Energy crops: erosion hazard land
- Animal excrements and litter
- Harvest residuals from agriculture
- Waste from trade and industry
- Organic municipal solid waste
- Sewage gas
- Landfill gas

**Total = 677 PJ**

**Source: DLR / IFEU / WI 2005**

# Key findings & conclusions

- **Environmental assessment**

  ➔ **In general, biofuels save fossil energy and GHG compared to conventional energy supply. Exemptions exist and explanations can be given.**

  ➔ **Solid biofuels usually perform better than liquid biofuels from energy crops.**

  ➔ **Biogas options based on energy crops lie within the range of liquid and solid biofuels. Detailed analyses are necessary to determine their impacts. Some biogas options have quite a high potential to save GHG.**

# Key findings & conclusions

- **Sustainable potentials**

  ➔ **Because of competition for land and competition in the usage of biomass the potentials for energy crops are limited.**

  ➔ **If energy crops are used for biofuels, biggest greenhouse gas savings are associated with high yield crops like SRF, sugar beet or wheat.**

  ➔ **Lignocellulose has by far the biggest sustainable mass potential (energy crops and residues). This comes along with very effective greenhouse gas savings.**

# Key findings & conclusions

- **Sustainable development**

  ➔ **There is a great potential to save GHG using biofuels for both, transportation and green energy / green heat.**

  **But they should be developed in accordance with other goals towards a sustainable development including alternative use of biomass for industry and chemistry.**

# The IFEU biofuel team

www.ifeu.de

## Thank you for your attention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