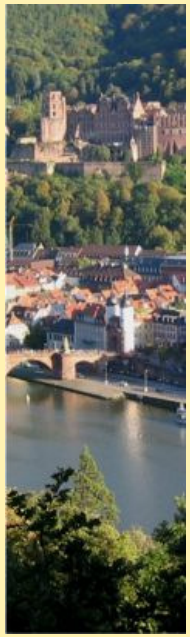
ifeu – Institute for Energy and
Environmental Research Heidelberg

# Presentation of IFEU

**Dr Guido Reinhardt**

4F Crops Kick-off meeting
Brussels, 1 July 2008

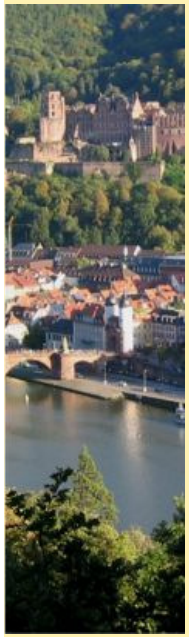
# Who we are - What we do



## 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



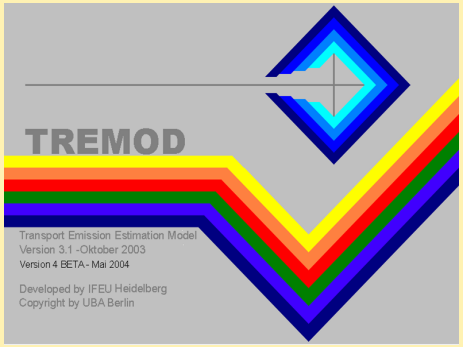
## IFEU focuses regarding the topic of biomass

- **Research / consulting on environmental aspects of**
  - **transport biofuels**
  - **biomass-based electricity and heat**
  - **biorefinery systems**
  - **biobased materials**
  - **agricultural goods and food**
  - **cultivation systems (conventional agriculture, organic farming, etc.)**
- **Potentials and future scenarios**
- **Technologies / technology comparisons**
- **$CO_2$ avoidance costs**
- **Sustainability aspects / valuation models**

# Who we are - What we do

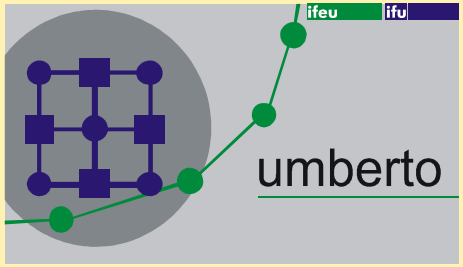
## TREMOD: Transport Emission Model

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

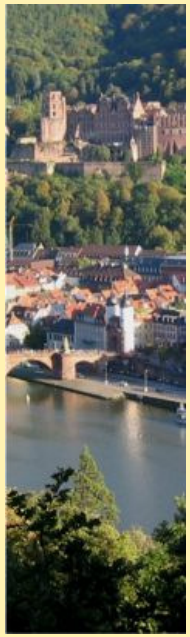



## Life cycle analyses (LCA) and technology impact assessments since 1990:

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



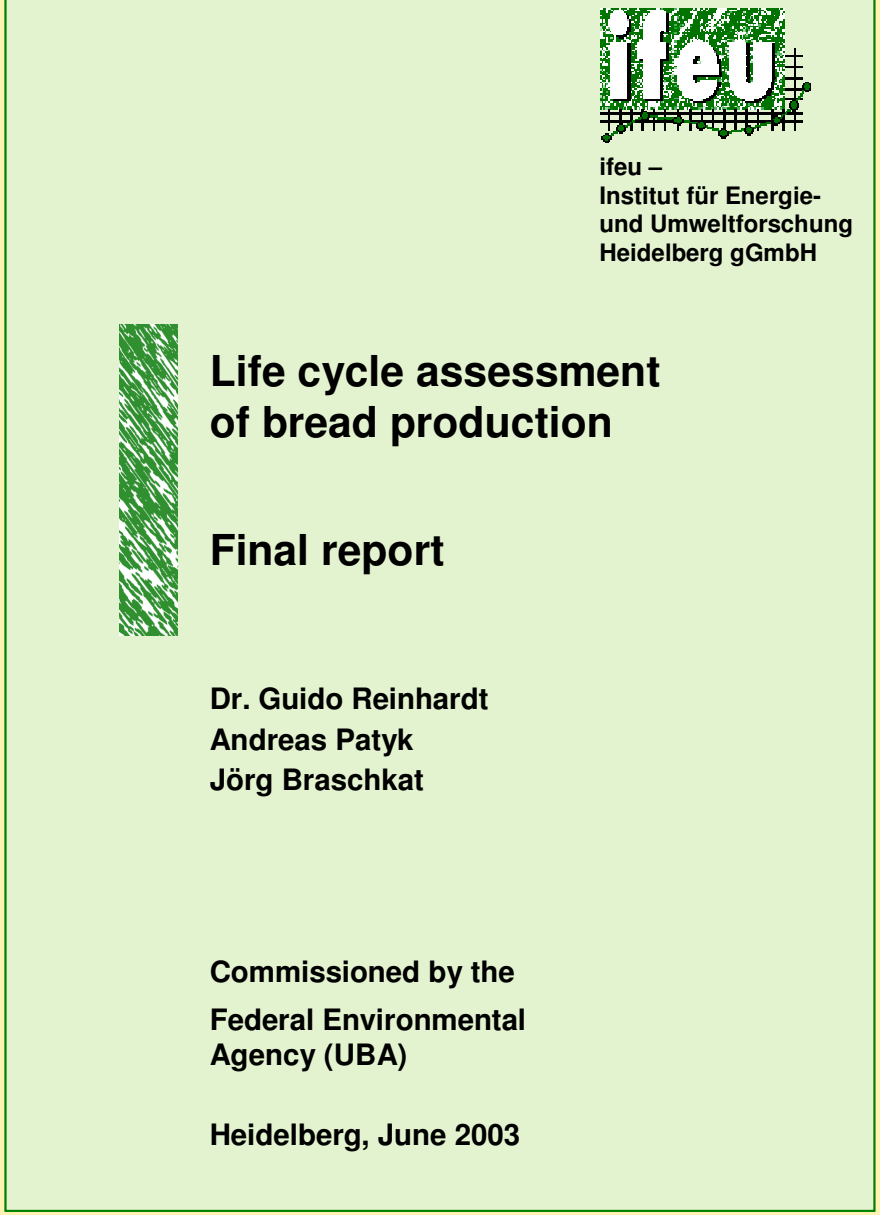
# Who we are - What we do



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

## Our clients (on biomass studies)

- World Bank
- UNEP, FAO, GTZ, etc.
- European Commission
- National and regional Ministries
- Associations (industrial, scientific)
- Local authorities
- WWF, Greenpeace, etc.
- Companies (Daimler, German Telecom, Shell etc.)
- Foundations (German Foundation on Environment, etc.)

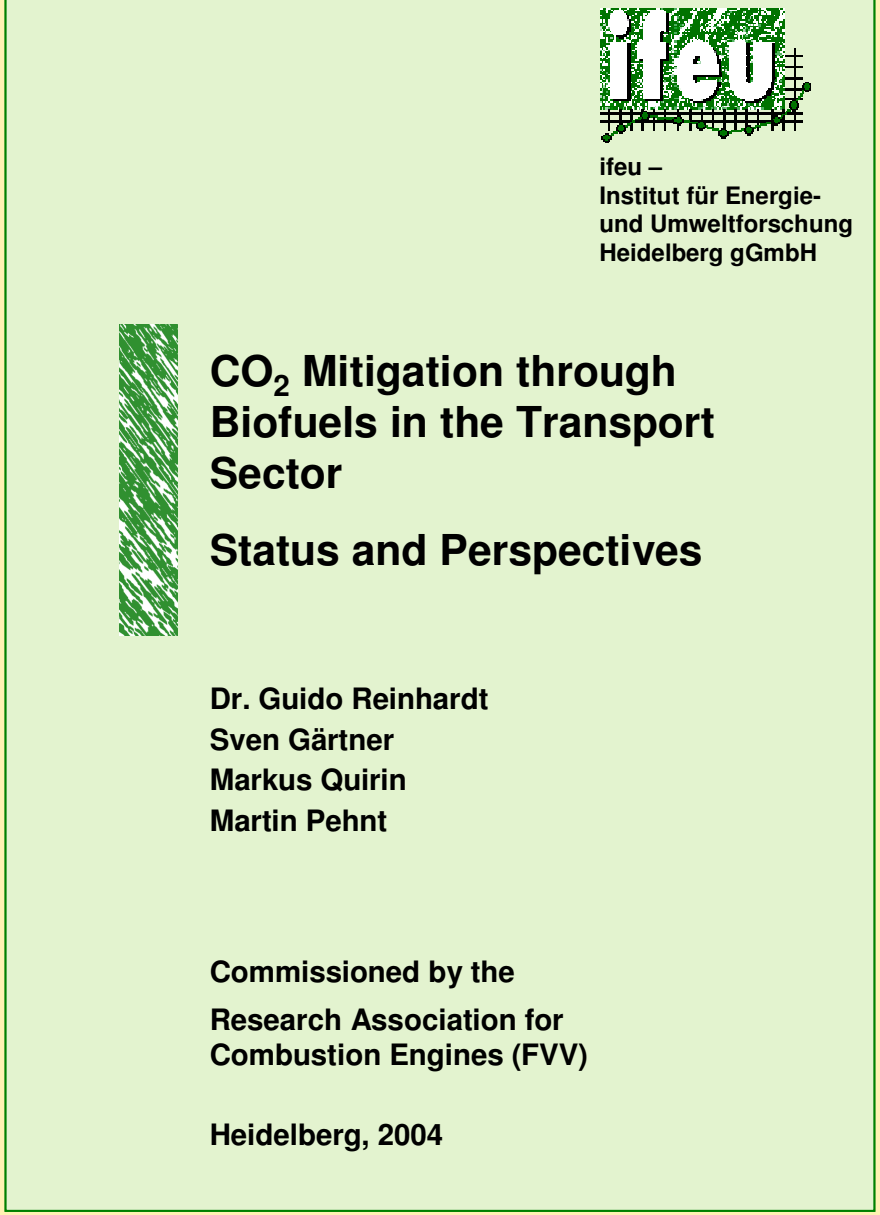



# „Life cycle assessment of bread production“

Utilisation and communication of the Cumulated Energy Demand (CED) as a practical decision parameter for sustainable products and services, commissioned by the Federal Environment Agency, Dessau

**Authors:**
Guido Reinhardt, Andreas Patyk, Jörg Braschkat

**Final report:**
June 2003

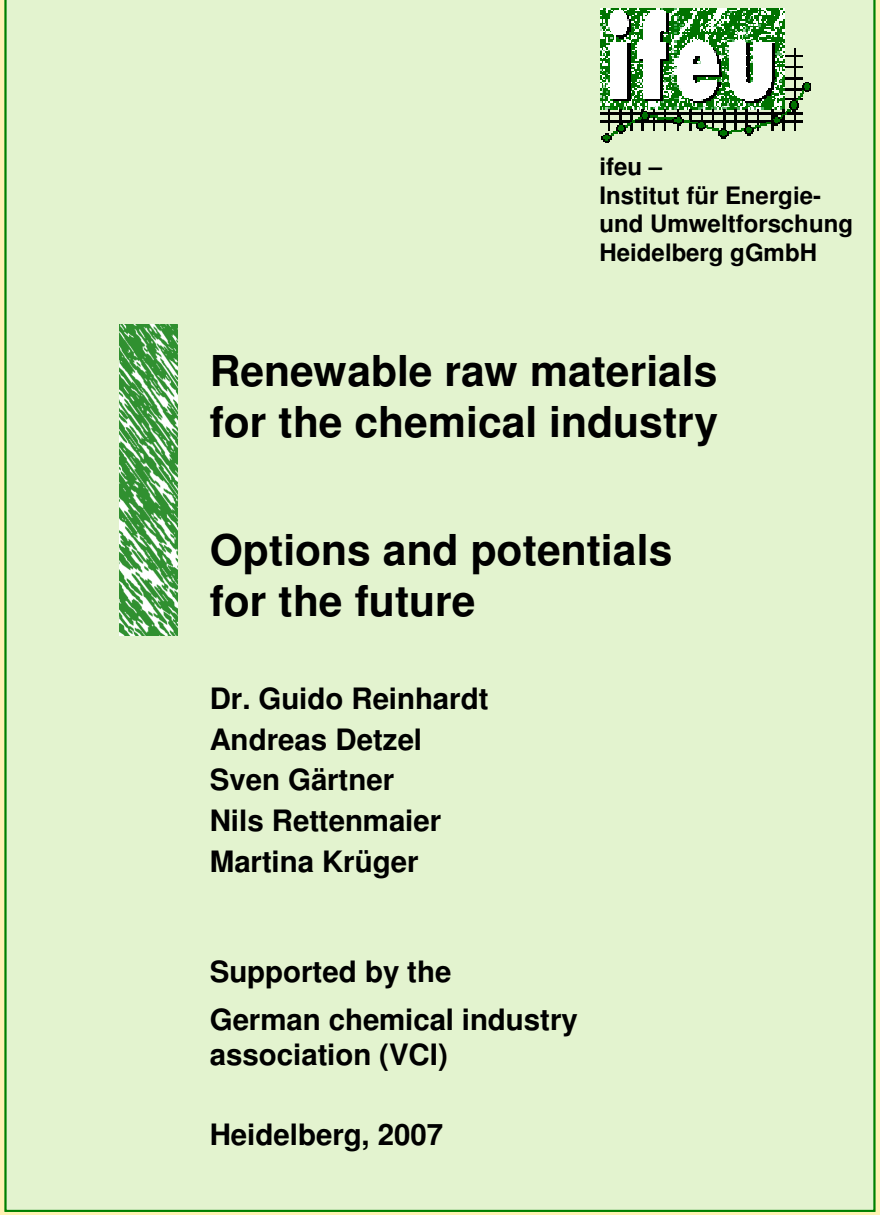



# „$CO_2$ Mitigation through Biofuels in the Transport Sector. Status and Perspectives“

Commissioned by the Research Association for Combustion Engines (FVV), Frankfurt

**Authors:**
Guido Reinhardt, Sven Gärtner, Markus Quirin & Martin Pehnt

**Project duration:**
2003 - 2004



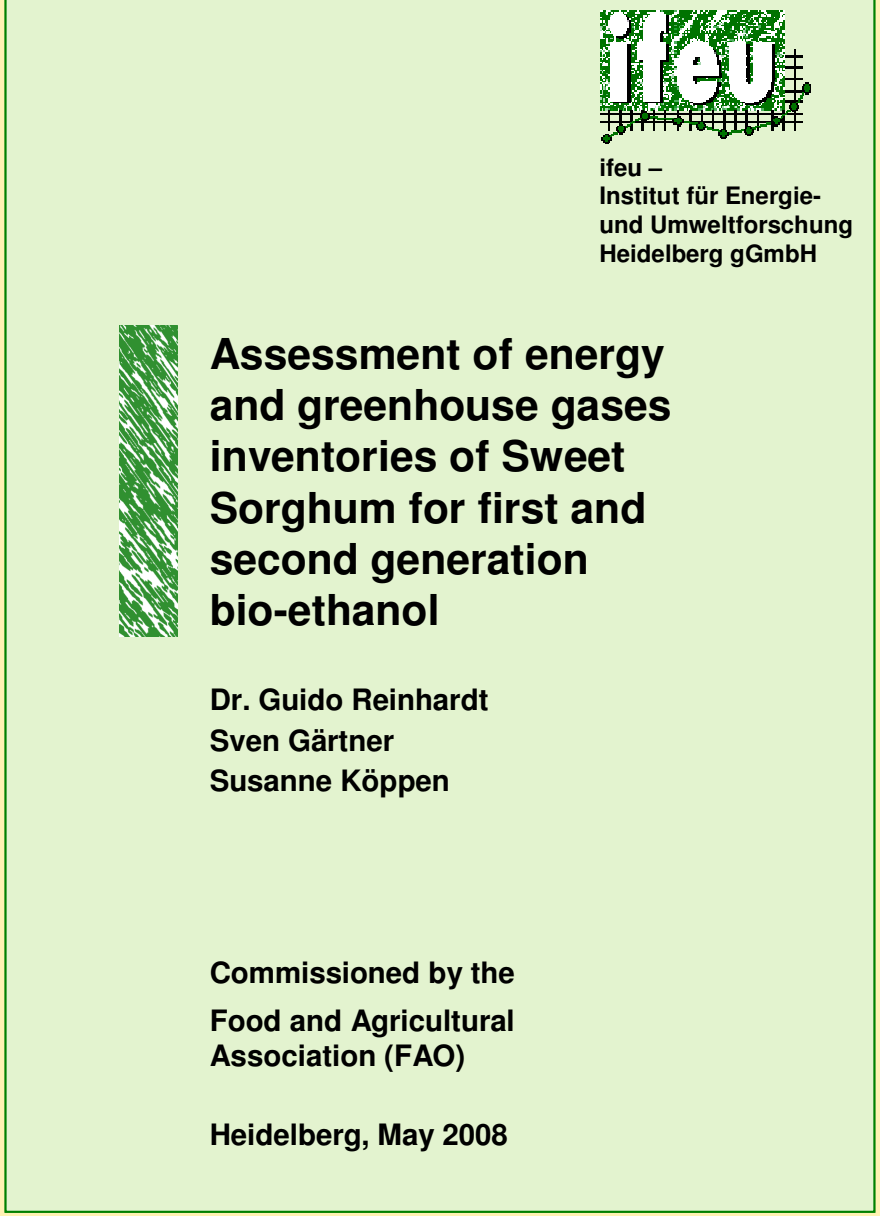

# „Renewable raw materials for the chemical industry – Options and potentials for the future“

Report prepared under support of the German chemical industry association (VCI), Frankfurt

**Authors:**
Guido Reinhardt, Andreas Detzel, Sven Gärtner, Nils Rettenmaier & Martina Krüger

**Project duration:**
Dec 2005 – Jan 2007

# Study on 5 F Crops




**„Assessment of energy and greenhouse gases inventories of Sweet Sorghum for first and second generation bio-ethanol“**

Report commissioned by the Food and Agricultural Association (FAO), Rome

**Authors:**
Guido Reinhardt, Sven Gärtner, Susanne Köppen

**Final report:**
May 2008


# „Industrial conversion of biomass“

Report prepared by the Office of Technology Assessment at the German Bundestag (TAB).

TAB author:
Dagmar Oertel

IFEU contribution:
**„Future component use of renewable raw materials“**
(Chapter IV)

IFEU Authors:
Guido Reinhardt, Sven Gärtner & Andreas Patyk

# IFEU's role

**IFEU: → WP leader of WP 4**

**→ Task leader of tasks 4.2, 4.3, 4.4**

**WP 4: Environmental analysis**

| | | |
|---|---|---|
| **Task 4.1** | **Environmental impact assessment** | **UniNOVA** |
| **Task 4.2** | **Life cycle analysis** | **IFEU** |
| **Task 4.3** | **Modeling of dependencies and sensibilities** | **IFEU** |
| **Task 4.4** | **Identification of best options** | **IFEU** |

# The Team

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**Downloads: www.ifeu.de**

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Environmental Research Heidelberg

# WP 4 Environmental analysis

# Overview & work plan

**Dr Guido Reinhardt**

4F Crops Kick-off meeting
Brussels, 1 July 2008

# WP 4: Environmental analysis

## Goal

**Assessment of environmental implications and identification of best options for each region or country.**

| | |
|---|---|
| **Task 4.1** | **Environmental impact assessment** |
| **Task 4.2** | **Life cycle analysis** |
| **Task 4.3** | **Modeling of dependencies and sensibilities** |
| **Task 4.4** | **Identification of best options** |

# Task 4.1 Impact assessment (EIA)

## Task description

- The local environmental impacts due to production of non-food crops will be evaluated, with focus on parameters like erosion, implications on water resources and supply, biodiversity, etc.
- Besides, the influence of the crops themselves and the choice of the farming location will be investigated.
- The results will account for specific country, crop and field conditions. Overall interactions and similarities or equalities will be pointed out.

# WP 4: Environmental analysis

## Goal

**Assessment of environmental implications and identification of best options for each region or country.**

| | | |
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| | **Task 4.1** | **Environmental impact assessment** |
| ➔ | **Task 4.2** | **Life cycle analysis** |
| | **Task 4.3** | **Modeling of dependencies and sensibilities** |
| | **Task 4.4** | **Identification of best options** |

# Task 4.2 Life cycle analysis

## Task description

- Using life cycle assessment (LCA) methodology according to the rules of ISO 14040/44, the environmental implications of all non-food crops under concern will be assessed by comparing the products from non-food crops to their fossil counterparts.
- The complete life cycles of all bio-products will be taken into account, whereas fuel = bioenergy and fiber = biobased materials. The whole production chain of each crop and resulting bio-product will be included as well as the agricultural reference systems, use of by-products and ashes, including all relevant conversion technologies under concern.
- Life cycle inventory parameters like primary energy demand, $CO_2$ or $NO_x$ will be used to describe resource demand, greenhouse effect, acidification, eutrophication, ozone depletion and human toxicity.

# WP 4: Environmental analysis

## Goal

**Assessment of environmental implications and identification of best options for each region or country.**

| | |
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| **Task 4.4** | **Identification of best options** |

# Task 4.3 Dependencies & sensibilities

## Task description

- For each comparison of a bio-product vs. its conventional counterpart, the basic scenarios will be transferred to “reference scenarios” which will incorporate correlations using functional dependencies.
- One or more reference scenarios for each non-food crop and relating bio-product describing all environmental implications will be produced.
- The scenarios include multi-functional dependencies as on yields, farming methods, fossil fuels to be substituted, country-specific conditions, etc. In addition, the timeframes of the project, 2020 and 2030 are taken into account by calculating separate sensitivity analyses.

# WP 4: Environmental analysis

## Goal

**Assessment of environmental implications and identification of best options for each region or country.**

| | |
|---|---|
| Task 4.1 | Environmental impact assessment |
| Task 4.2 | Life cycle analysis |
| Task 4.3 | Modeling of dependencies and sensibilities |
| ➔ Task 4.4 | Identification of best options |

# Task 4.4 Identification of best options

## Task description

**In this task, the best options for the production and use of a set of different non-food crops and resulting bio-products in the future will be assessed by using a multi-functional assessment tool. Four steps are necessary:**

- **All the reference scenarios will be combined**
- **The combinations will be optimized in terms of their environmental implications. Options with a high potential to save fossil energy carriers and to reduce the greenhouse effect will be preferred, following recommendations of the EU white paper and the Kyoto protocol.**

# Task 4.4 Identification of best options

## Task description (contin.)

- For all options, the overall potential on the environmental implications will be investigated. Basic data for the calculations will be assessed by the respective partners.
- All results will be compared with the results from the economic analysis (WP 3). Modifications will be made to ensure realistic options with an optimal combination of economic and environmental implications.

# WP 4: Environmental analysis

**IFEU: → WP leader of WP 4**

**Responsibilities**

| | | |
|---|---|---|
| **Task 4.1** | **Environmental impact assessment** | **UniNOVA** |
| **Task 4.2** | **Life cycle analysis** | **IFEU** |
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| **Task 4.4** | **Identification of best options** | **IFEU** |

# Deliverables WP 4

| | | Responsible | Month |
|---|---|---|---|
| D 12 | Environmental analyses | UniNOVA | 12 |
| D 13 | Life cycle analysis | IFEU | 12 |
| D 14 | Set of best options | IFEU | 21 |

# Milestones WP 4

| | | Responsible | Month |
|---|---|---|---|
| M 15 | Environmental impact assessment | UniNOVA | 6 & 12 |
| M 16 | Life cycle analysis | IFEU | 6 & 12 |
| M 17 | Modeling of depen-dencies and sensitivities | IFEU | 12 & 18 |
| M 17 | Identification of best options | IFEU | 15 & 21 |

# Time line of WP 4

| *WP 4* | Year 1 | | | | Year 2 | | | |
|---|---|---|---|---|---|---|---|---|
| **Months** | 1-3 | 4-6 | 7-9 | 10-12 | 13-15 | 16-18 | 19-21 | 21-24 |
| **4.1 Environmental impact assessm.** | | **M15** | | **D12 M15** | | | | |
| **4.2 Life cycle analysis** | | **M16** | | **D13 M16** | | | | |
| **4.3 Modeling of dependencies & sensibilities** | | | | **M17** | | **M17** | | |
| **4.4 Identification of best options** | | | | | **M18** | | **D14 M18** | |

**31 Dec 2008** ↑ **30 June 2009** ↑

**M = Milestone**
**D = Deliverable**

# Work plan

# Time line of WP 4

| *WP 4* | Year 1 | | | | Year 2 | | | |
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| **4.4 Identification of best options** | | | | | **M18** | | **D14 M18** | |

**31 Dec 2008** ↑ **30 June 2009** ↑

**M = Milestone**
**D = Deliverable**

➔ **Work plan in detail for the next 6 / 12 months related to task 4.1 and 4.2 only**

# WP 4: work plan

## How to start ?

**In order to fulfil the goal and scope of WP 4, it is necessary to define several system boundaries and pathways:**

- **General settings & definitions for the whole WP 4 (and other WPs like WP 3) like selection of crops and countries / regions**
  **→ wait for results from WP 1 (start after 6 months)**
- **Specific settings & definitions for task 4.1 (EIA)**
  **→ start now**
- **Specific settings & definitions for task 4.2 (LCA)**
  **→ start now**

# WP 4: Environmental analysis

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- The results will account for specific country, crop and field conditions. Overall interactions and similarities or equalities will be pointed out.

# Task 4.1: work plan

**Presentation from UniNOVA:**

**Ana Luísa Fernando, FCT / UNL**

# Task 4.1: work plan

**Definitions and specifications due after 6 months**

# Task 4.1: work plan

## Definitions and specifications due after 6 months

- **List of environmental parameters** (like water quality, soil quality, land use aspects et cetera)
- **Methodological details for EIA** (like different procedures for agricultural and industrial / conversion sites etc.)
- **System definitions applicable to the EIA** (like inclusion of nearby areas next to agricultural sites etc.).
- **All other definitions and specifications related to the EIA** (like time frame etc.)

# Task 4.1: What has to be done ?

| To-do list | responsible |
|---|---|
| ➢ First setup of definitions<br>➔ send to CRES / IFEU | UniNOVA |
| ➢ Comments<br>➔ send to UniNOVA | CRES/IFEU |
| ➢ Update<br>➔ send to all partners | UniNOVA |
| ➢ Comments<br>➔ send to UniNOVA | All partners |
| ➢ Finalize | UniNOVA |

g8

## Slide 35

**g8** guido; 14/5/2008

# Task 4.1: What has to be done ?

| To-do list | responsible | Schedule (proposal) |
|---|---|---|
| ➢ First setup of definitions<br>→ send to CRES / IFEU | UniNOVA | end Aug 2008 |
| ➢ Comments<br>→ send to UniNOVA | CRES/IFEU | end Sept 2008 |
| ➢ Update<br>→ send to all partners | UniNOVA | mid Oct 2008 |
| ➢ Comments<br>→ send to UniNOVA | All partners | mid Nov 2008 |
| ➢ Finalize | UniNOVA | end Dec 2008 |

= Milestone M15

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## Slide 36

**g9** guido; 14/5/2008

# Task 4.1: work plan

**Any comments ?**

# WP 4: Environmental analysis

## Goal

**Assessment of environmental implications and identification of best options for each region or country.**

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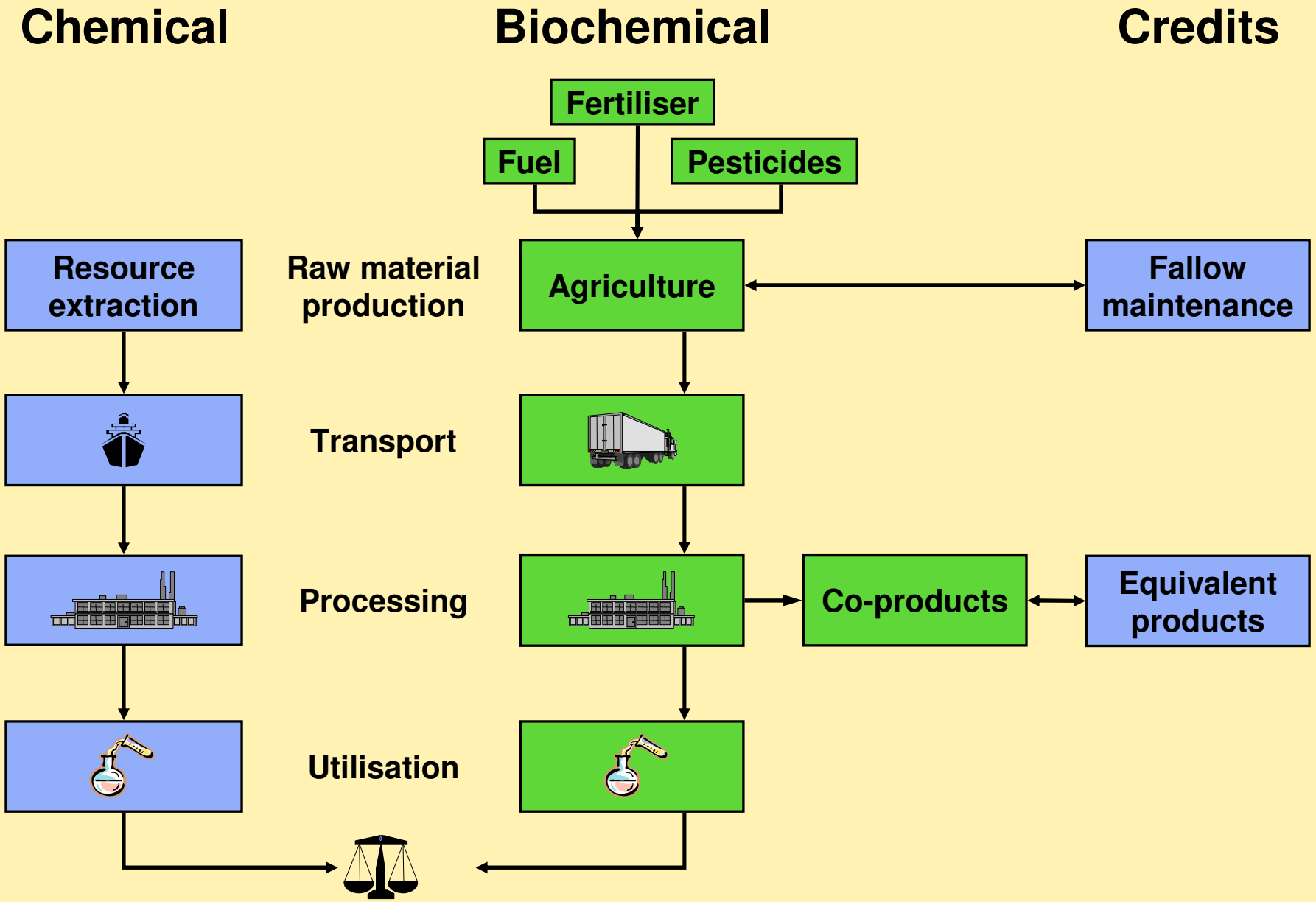
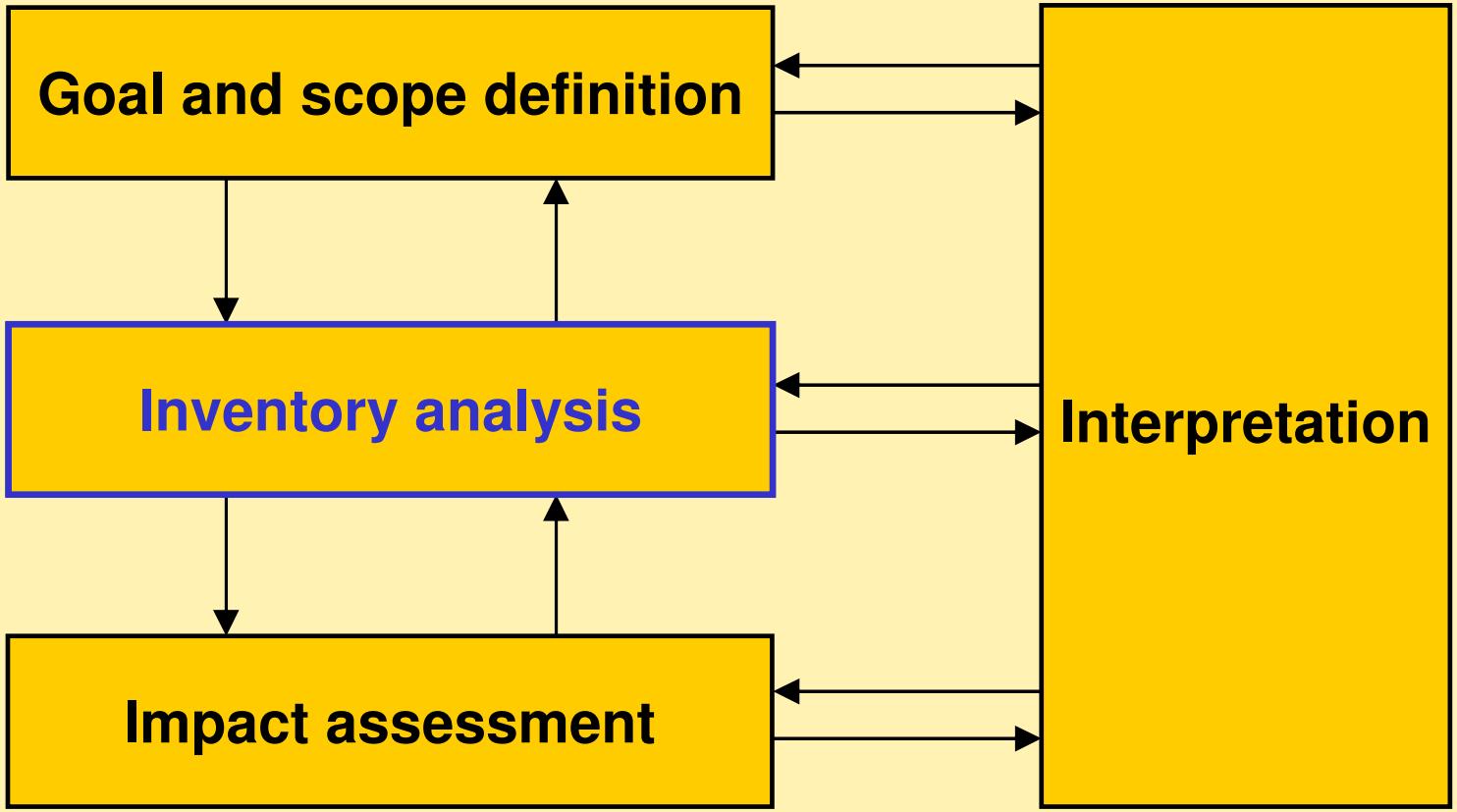
- Life cycle inventory parameters like primary energy demand, $CO_2$ or $NO_x$ will be used to describe resource demand, greenhouse effect, acidification, eutrophication, ozone depletion and human toxicity.

# LCA: Life cycle comparison



# Life cycle assessment (LCA)

## ISO 14040 & 14044

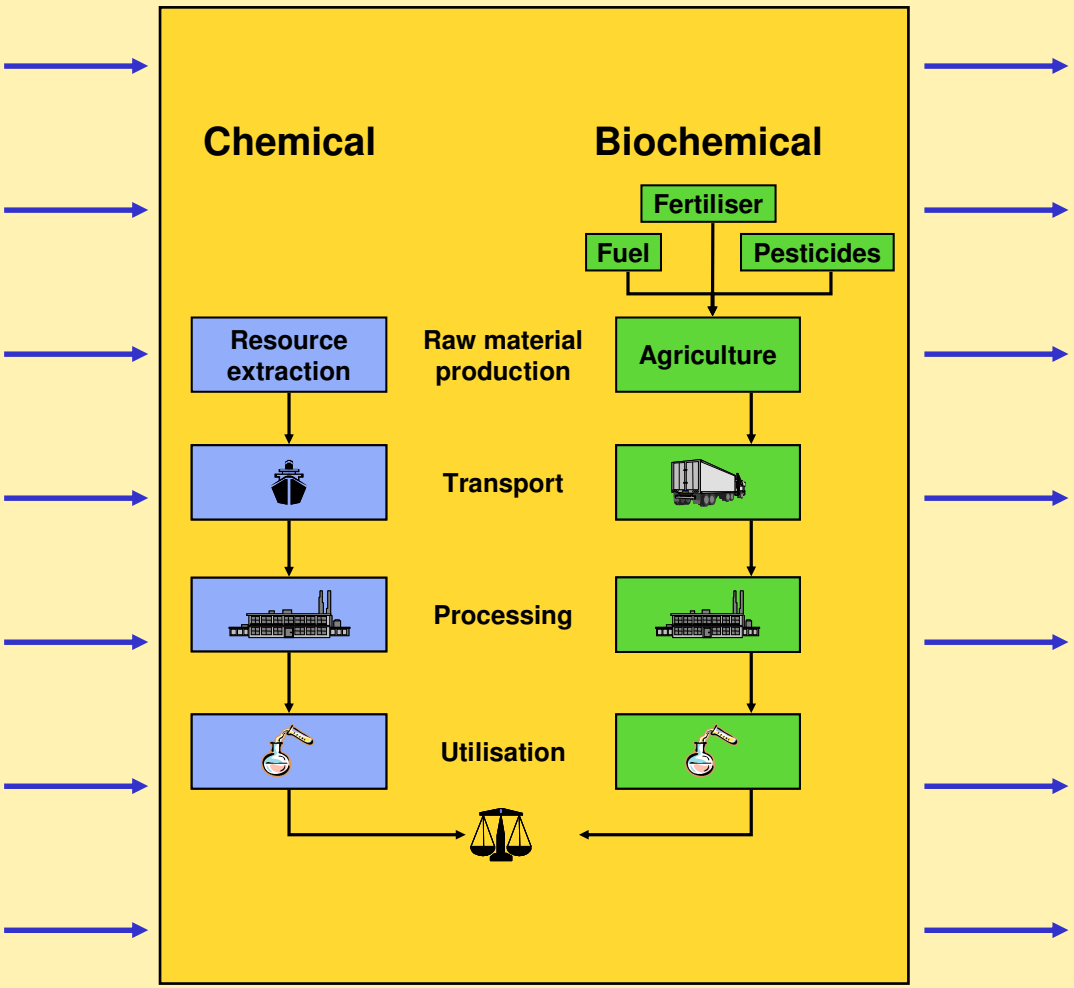


# LCA: Inventory Analysis

## Inputs

e.g.:

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



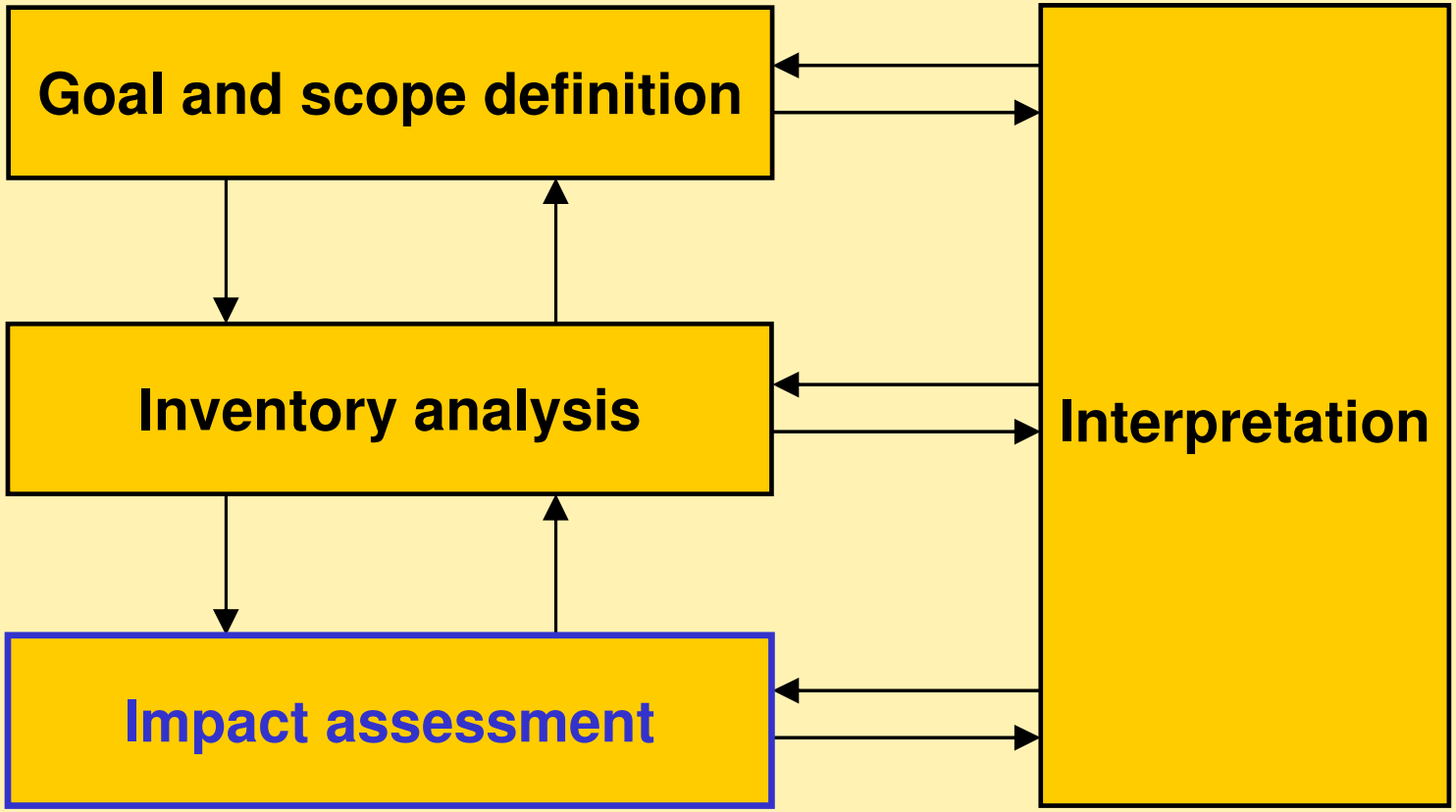

## Outputs

e.g.:

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

# Life cycle assessment (LCA)

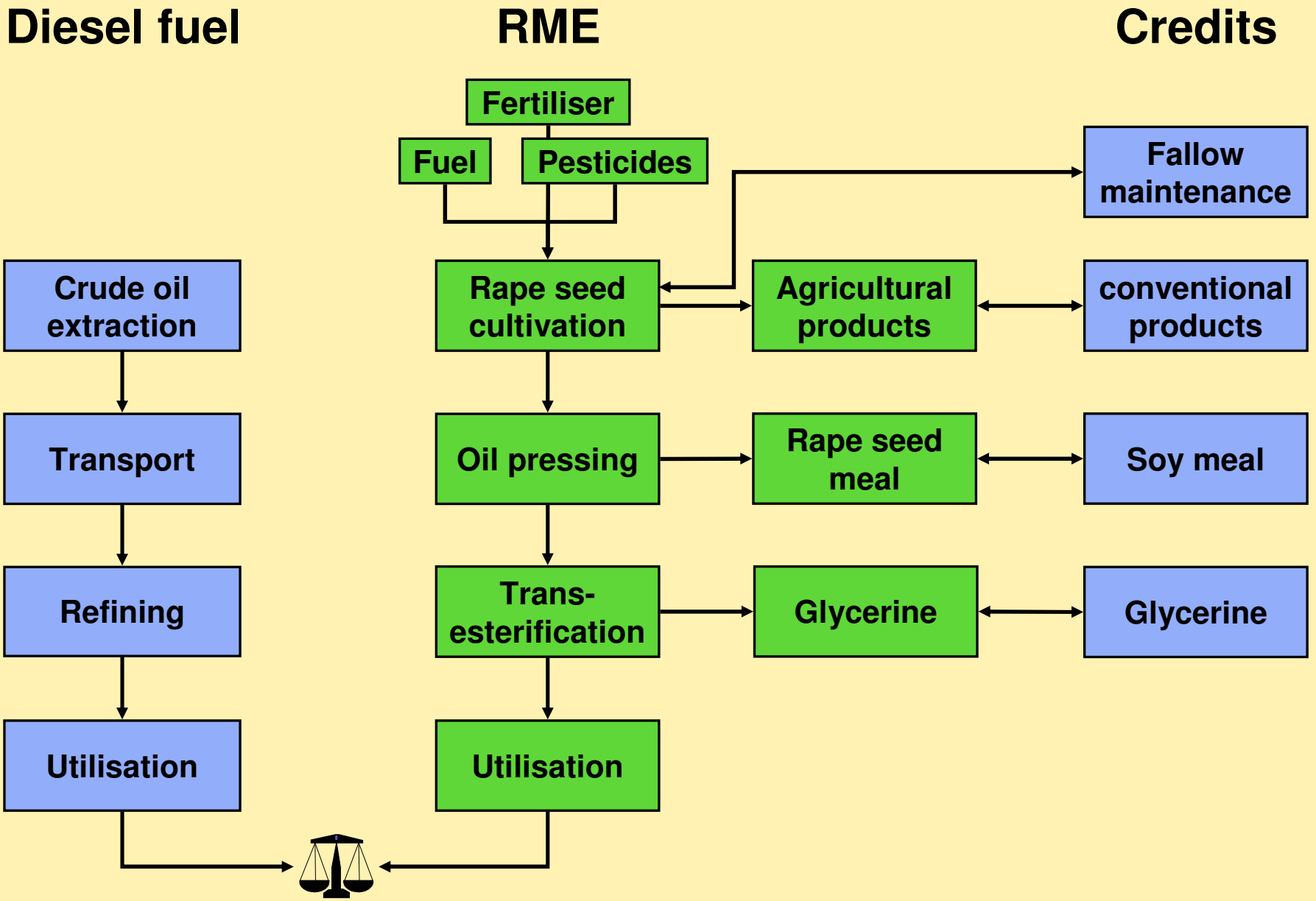
## ISO 14040 & 14044



# LCA: Impact assessment

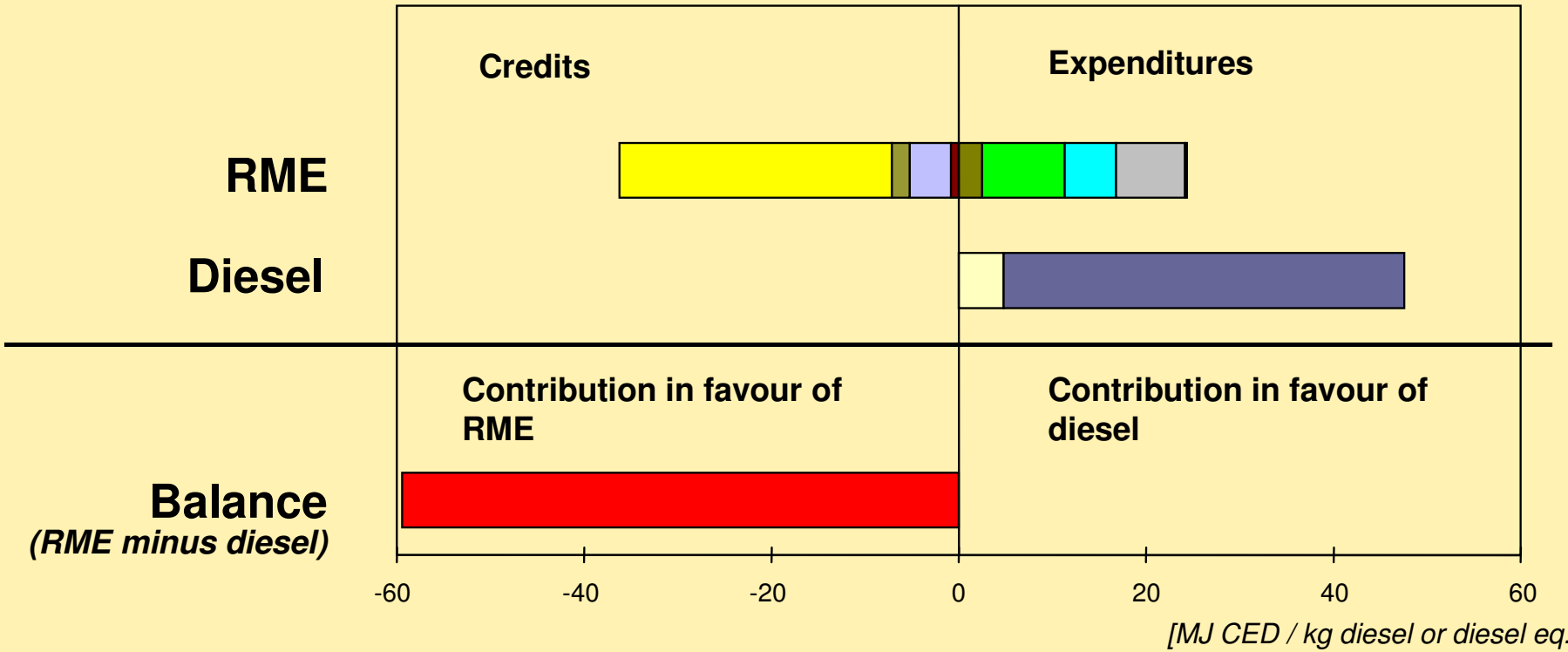
| Impact category | Parameter | Substances (LCI) |
|---|---|---|
| Resource demand | Sum of depletable primary energy carriers<br><br>Mineral resources | Crude oil, natural gas, coal, Uranium, …<br><br>Lime, clay, metal ores, salt, pyrite, … |
| Greenhouse effect | $CO_2$ equivalents | Carbon dioxide, 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), … |

# Example 1: Rapeseed oil biodiesel



# Results: RME versus diesel fuel

## Resource demand (energy balance)




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

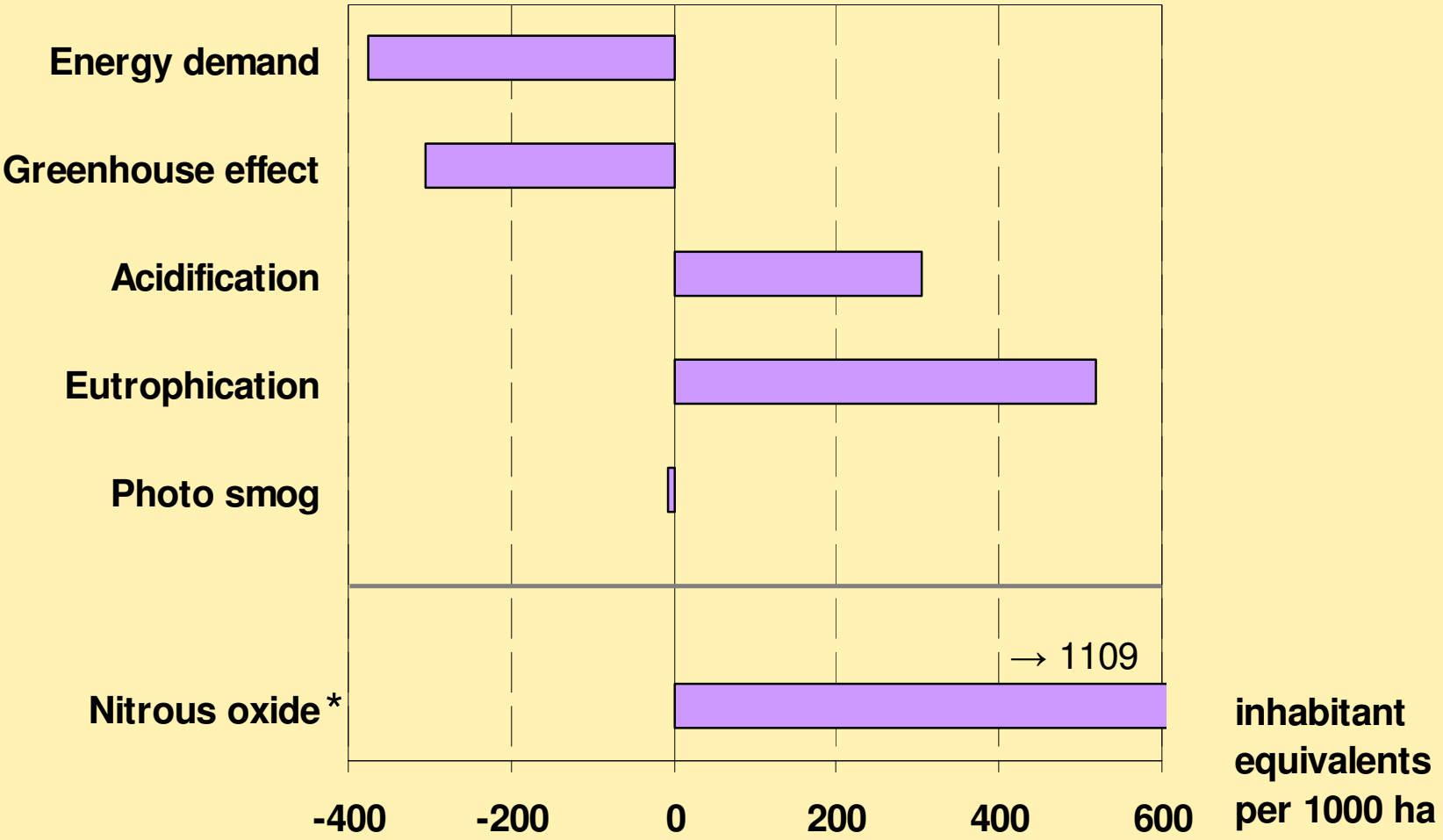
**Credits**
- Reference system
- Soy bean meal (agric.)
- Soy bean meal (transp.)
- Glycerine

**Diesel**
- Production
- Utilisation

**Source: IFEU 2006**

# Results: RME versus diesel fuel

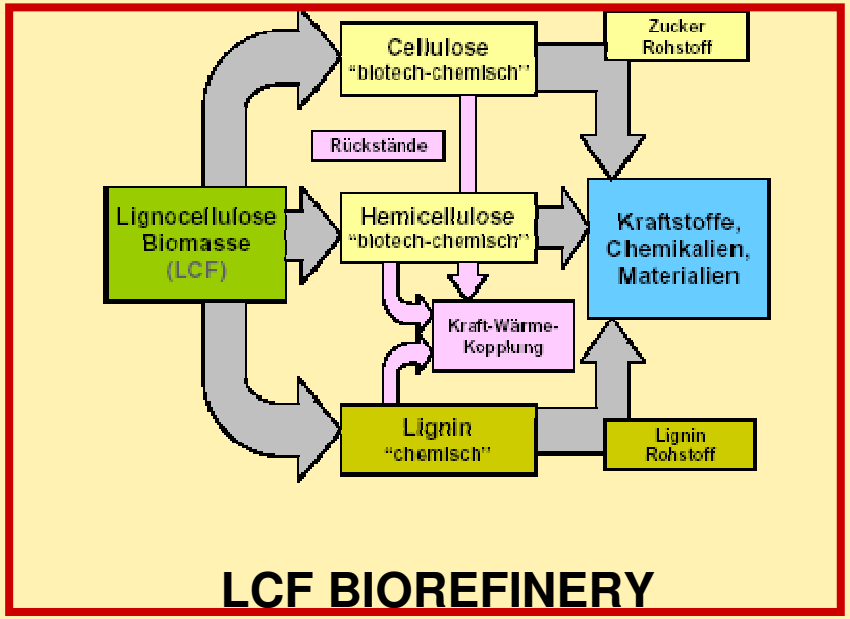
← Advantages for biodiesel  Advantages for diesel fuel →



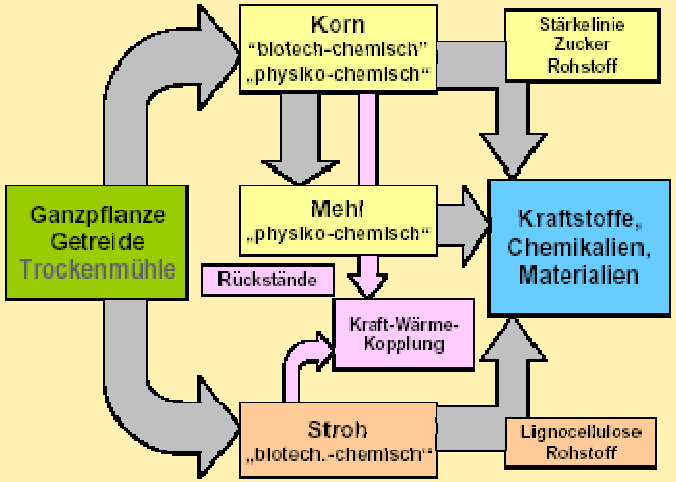

* one parameter for ozone depletion

Source: IFEU 2007

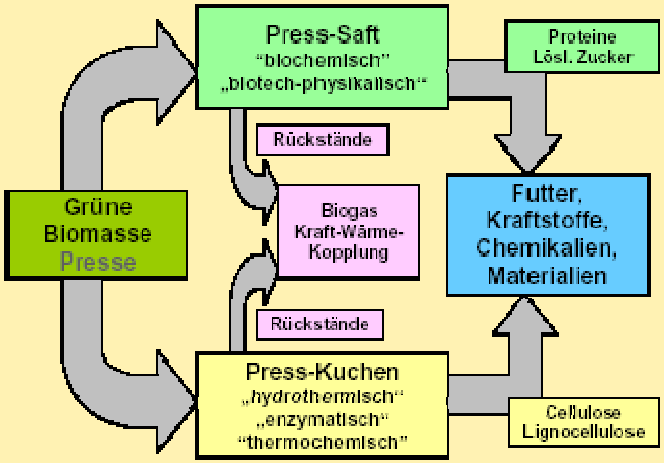
# Overview: Biorefineries



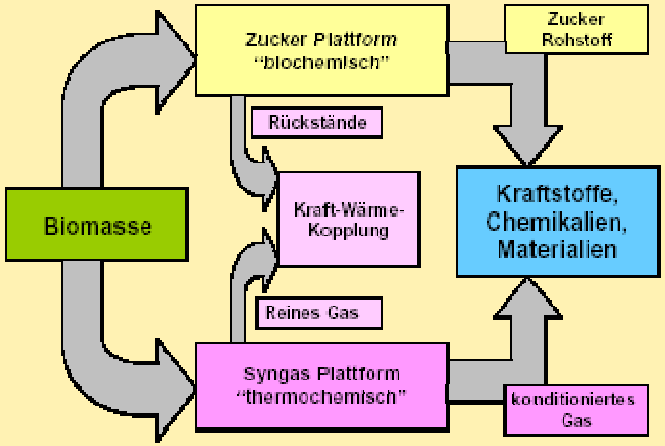

**LCF BIOREFINERY**




**WHOLE-CROP BIOREFINERY**

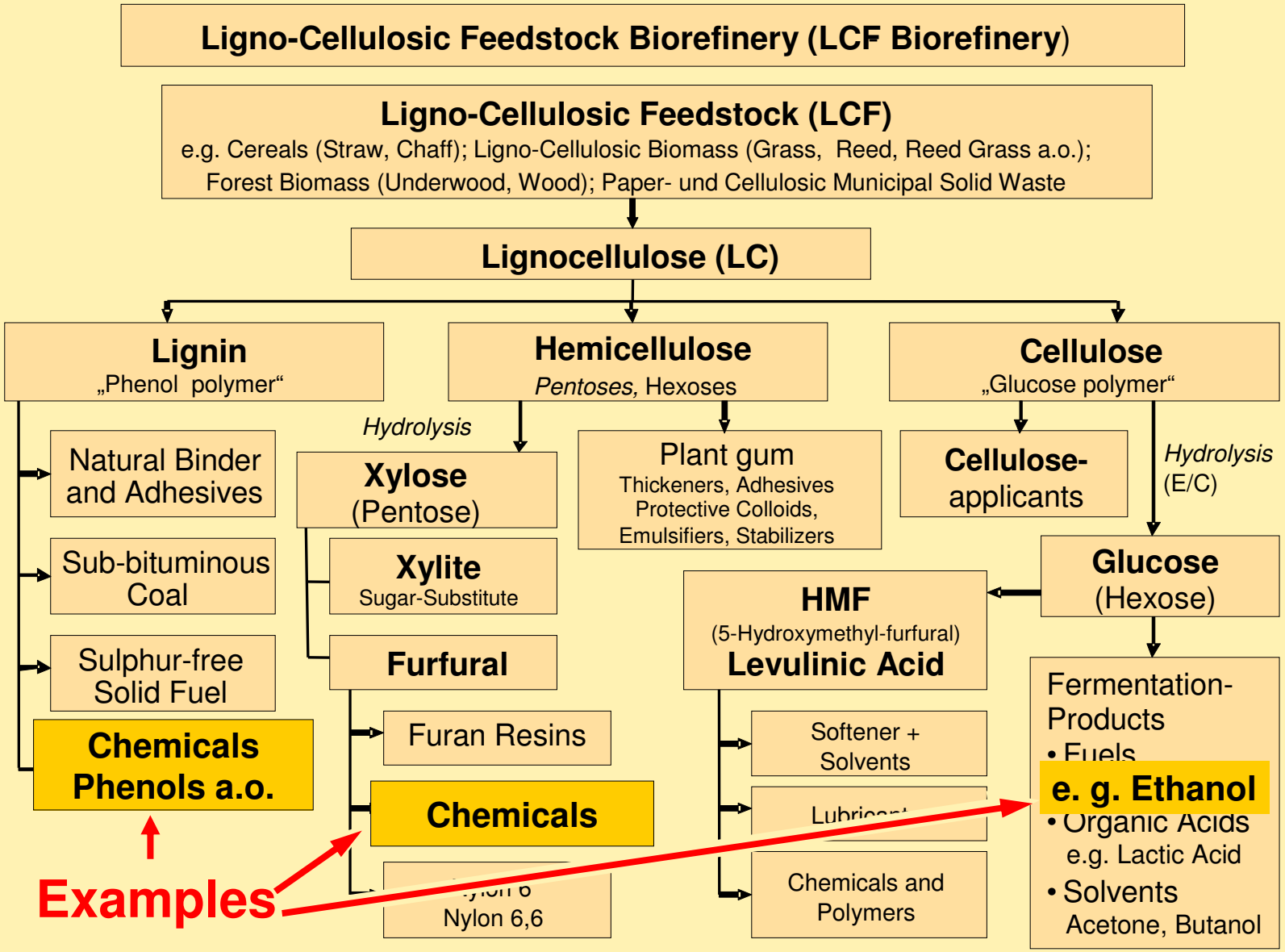



**GREEN BIOREFINERY**

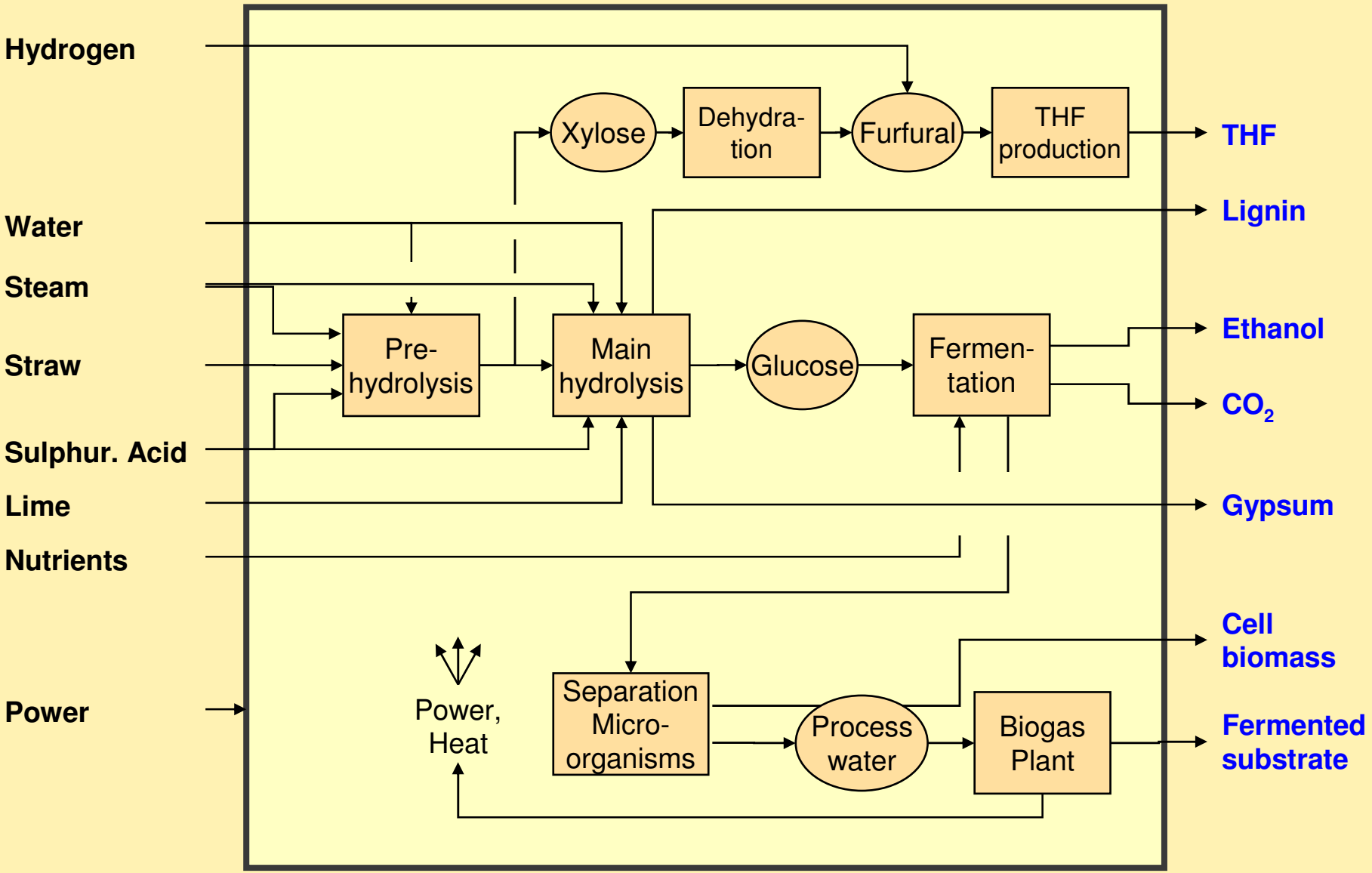



**TWO PLATFROM CONCEPT**

# Scheme of a LCF biorefinery

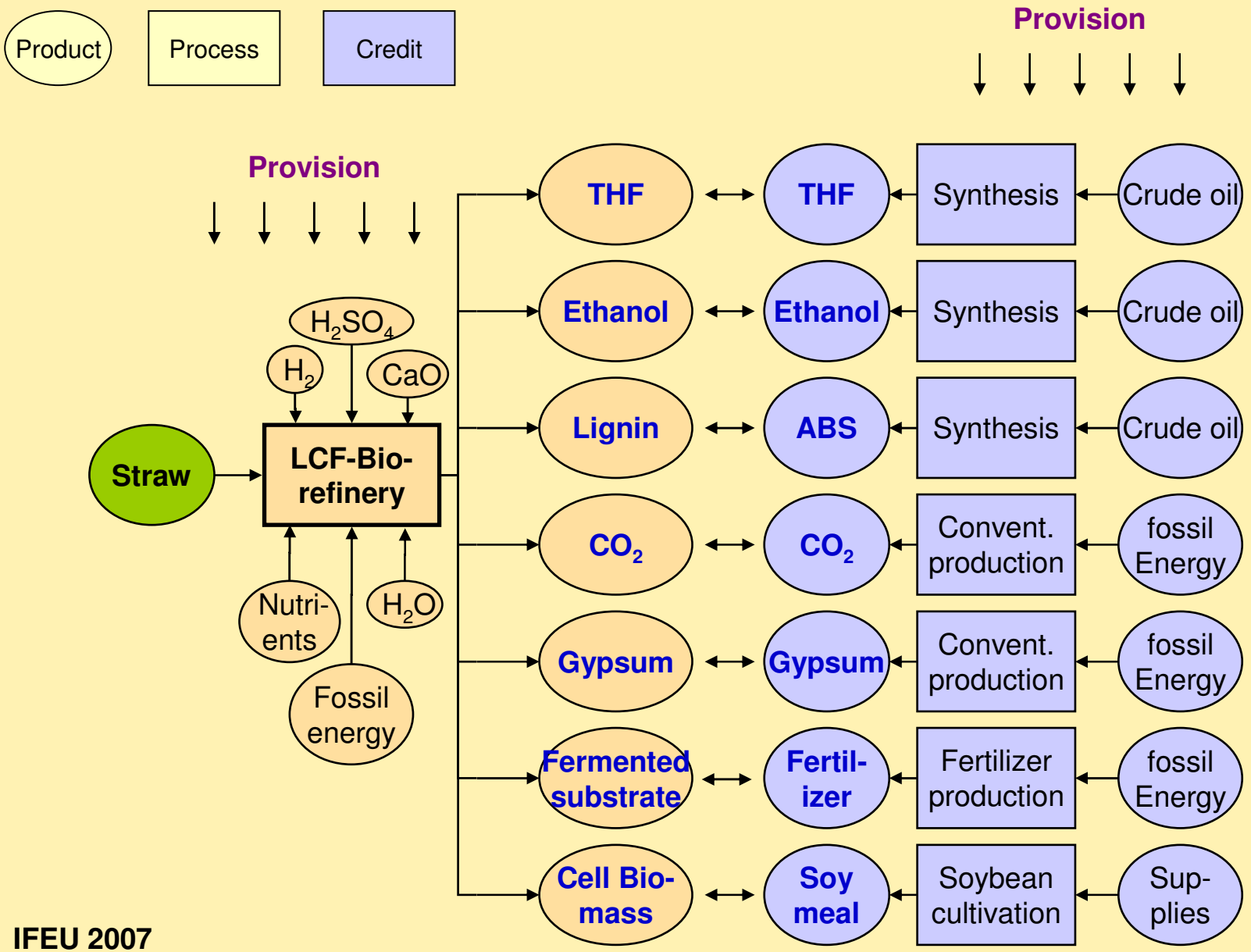


# Exemplary description of a LCF BR



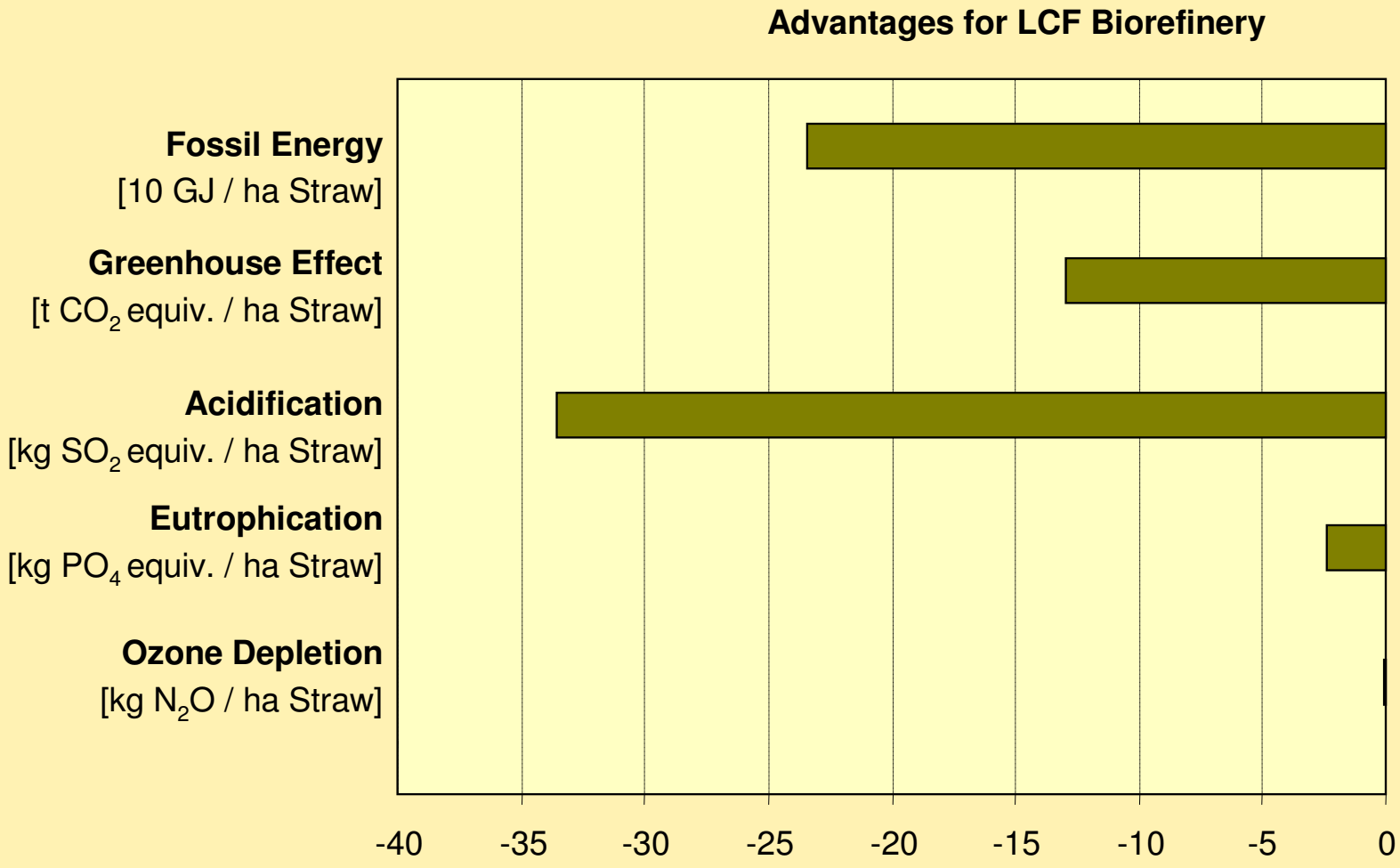

IFEU 2007

# Analyzed product paths: LCF BR

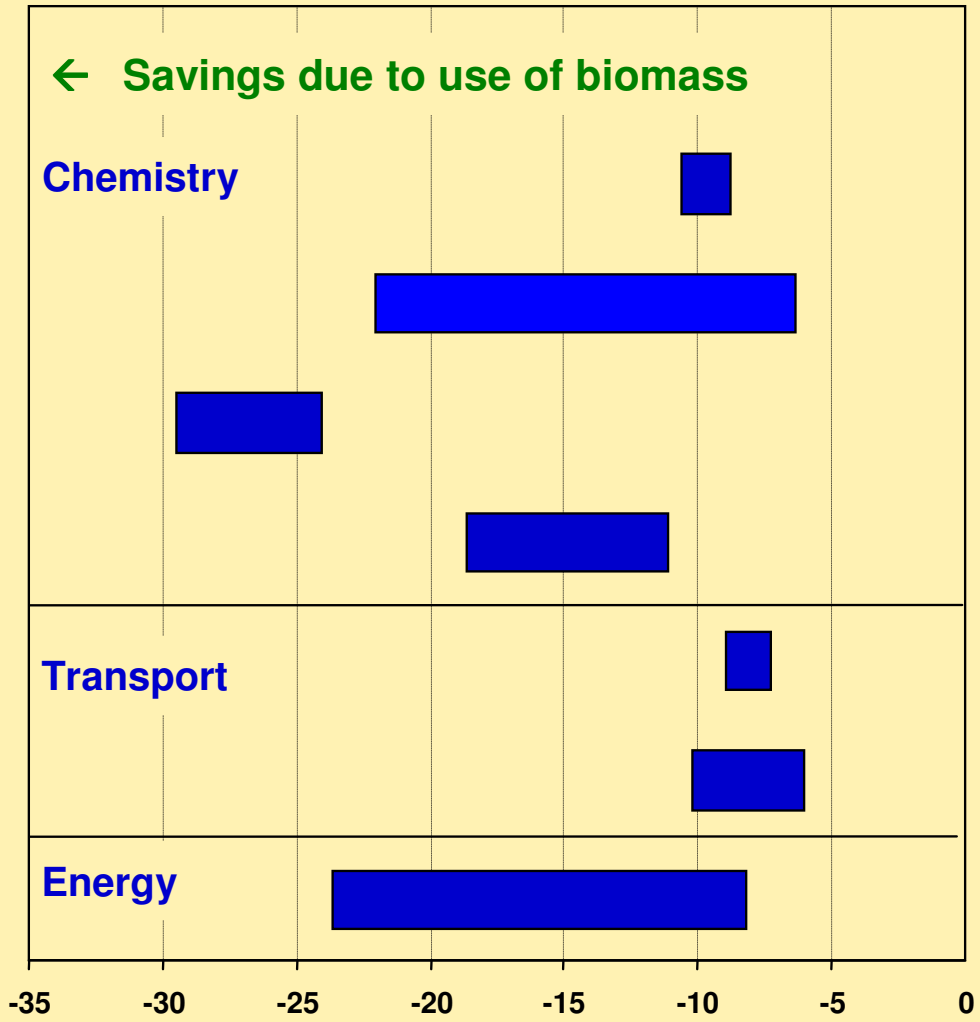



IFEU 2007

# Results: LCF biorefinery



# Results: Biomass uses compared




Greenhouse effect in t of $CO_2$ equiv. per hectare

**Biomass basis:**
**short rotation wood**

- EtOH (innovative fermentation)
- EtOH, THF, Phenol (biorefinery)
- Phenol (pyrolysis)
- EtOH/MeOH (gasification)
- EtOH (innovative fermentation)
- BTL (gasification)
- Power / Heat

# WP 4: work plan

## How to start ?

**In order to fulfil the goal and scope of WP 4, it is necessary to define several system boundaries and pathways:**

- **General settings & definitions for the whole WP 4 (and other WPs like WP 3)**
  **→ wait for results from WP 1 (start after 6 months)**
- **Specific settings & definitions for task 4.1 (EIA)**
  **→ start now**
- **Specific settings & definitions for task 4.2 (LCA)**
  **→ start now**

# Task 4.2: work plan

## Definitions and specifications due after 6 months

- **List of environmental impact categories** (like greenhouse effect, acidification et cetera)
- **Methodological details for life cycle inventory and life cycle impact assessment** (like aggregation of all greenhouse gases).
- **System definitions applicable to the environmental assessment** (like fossil and biogenic resource differentiations, direct / indirect land use).
- **All other definitions and specifications related to the environmental assessments** (like inclusion of infrastructure, time frame etc.)

# Task 4.2: What has to be done ?

| To-do list | responsible |
|---|---|
| ➢ First setup of definitions<br>➔ send to CRES | IFEU |
| ➢ Comments<br>➔ send to IFEU | CRES |
| ➢ Update<br>➔ send to all Partners | IFEU |
| ➢ Comments<br>➔ send to IFEU | All partners |
| ➢ Finalize | IFEU |

g2

**g2** guido; 14/5/2008

# Task 4.2: What has to be done ?

| To-do list | responsible | Schedule (proposal) |
|---|---|---|
| ➢ First setup of definitions<br>→ send to CRES | IFEU | end Aug 2008 |
| ➢ Comments<br>→ send to IFEU | CRES | end Sept 2008 |
| ➢ Update<br>→ send to all Partners | IFEU | mid Oct 2008 |
| ➢ Comments<br>→ send to IFEU | All partners | mid Nov 2008 |
| ➢ Finalize | IFEU | end Dec 2008 |

= Milestone M16

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# Task 4.3 and 4.4: work plan

**…. will follow later in the course of the project**

# WP 4 Environmental analysis

## Decisions

- **Work plan Task 4.1: as suggested ?**
- **Work plan Task 4.2: as suggested ?**

# The end