Comparative Live Cycle Assessment of multiple bioenergy technologies based on the feedstock wheat straw

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Energieinstitut an der
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Netzwerk für Forschung, Lehre und Praxis

Background

- Lignocellulose biomass: potential for biorefining
- Avoid food versus fuel dilemma
- Biomass conversion technologies:
  - Direct combustion
  - Thermo-chemical (example: Gasification)
  - Bio-chemical (example: Fermentation)
  - Physico-chemical (example: Fischer-Tropsch)

Which process has the best "environmental performance"?

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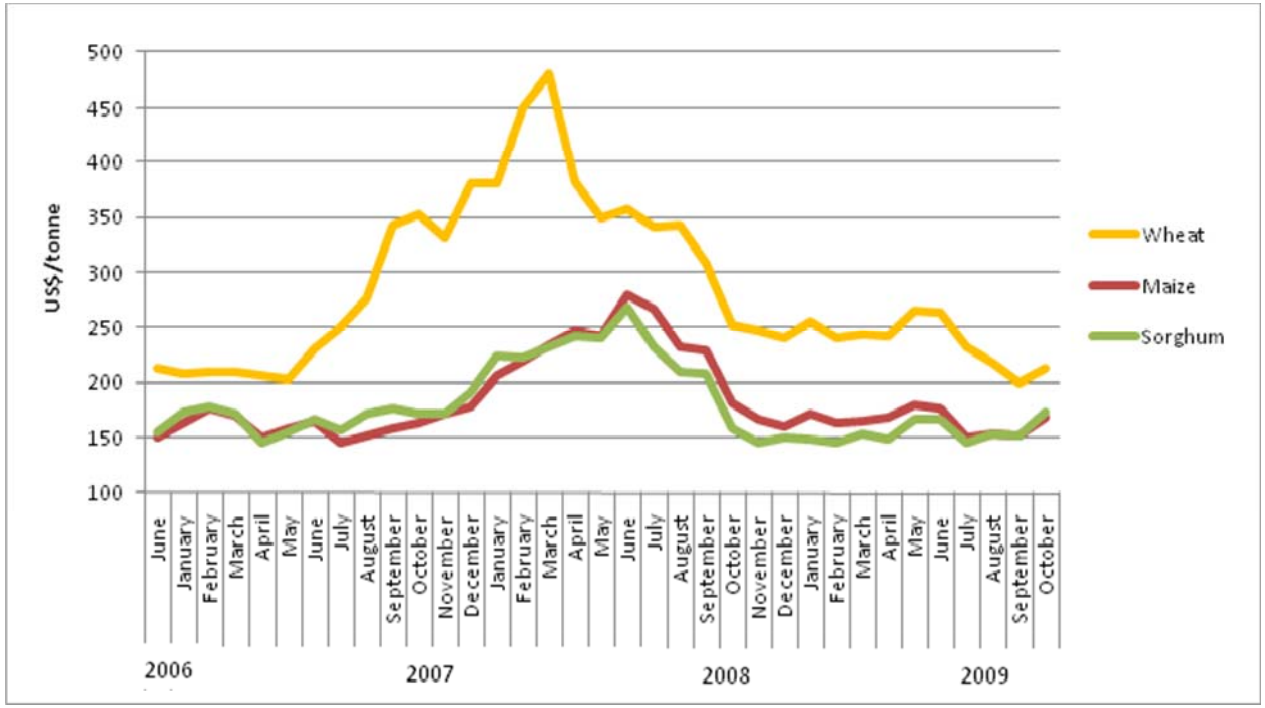
Bioenergy – diversification of feedstock required



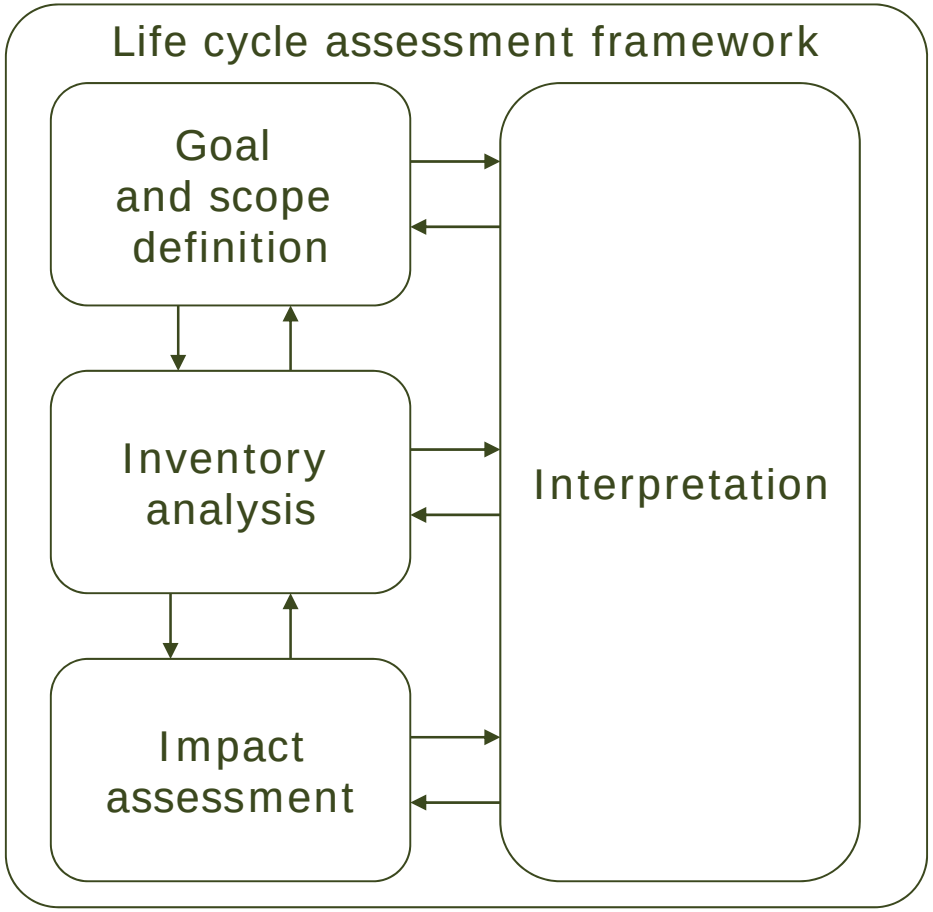
Wheat: *US No.2 Hard Red Winter Prd. Prot.1*
Maize: *US No.2 Yellow*
Sorghum: *US No.2 Yellow*
Source: own representation, FAO (2008), Crop Prospects and Food Situation', No.4 November 2009.

International development of selected grain prices

Complex structures and interferences in utilisation

Ecologic, economic, technical, social criterias

The method of choice – Life Cycle Assessment (LCA)



Source: own representation according ISO 14000 ff

according ISO 14040/14044

Goal and scope definition:
- aim & scope of the study
- process units
- system boundaries
- assessed flows

Inventory analysis:
- data collection
- data validation
- assignment to processes
- allokation

Impact assessment:
- effect model
- impact categories

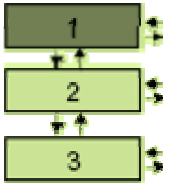
Interpretation:
- Evaluation der Ergebnisse
- Analyse der Ergebnisse

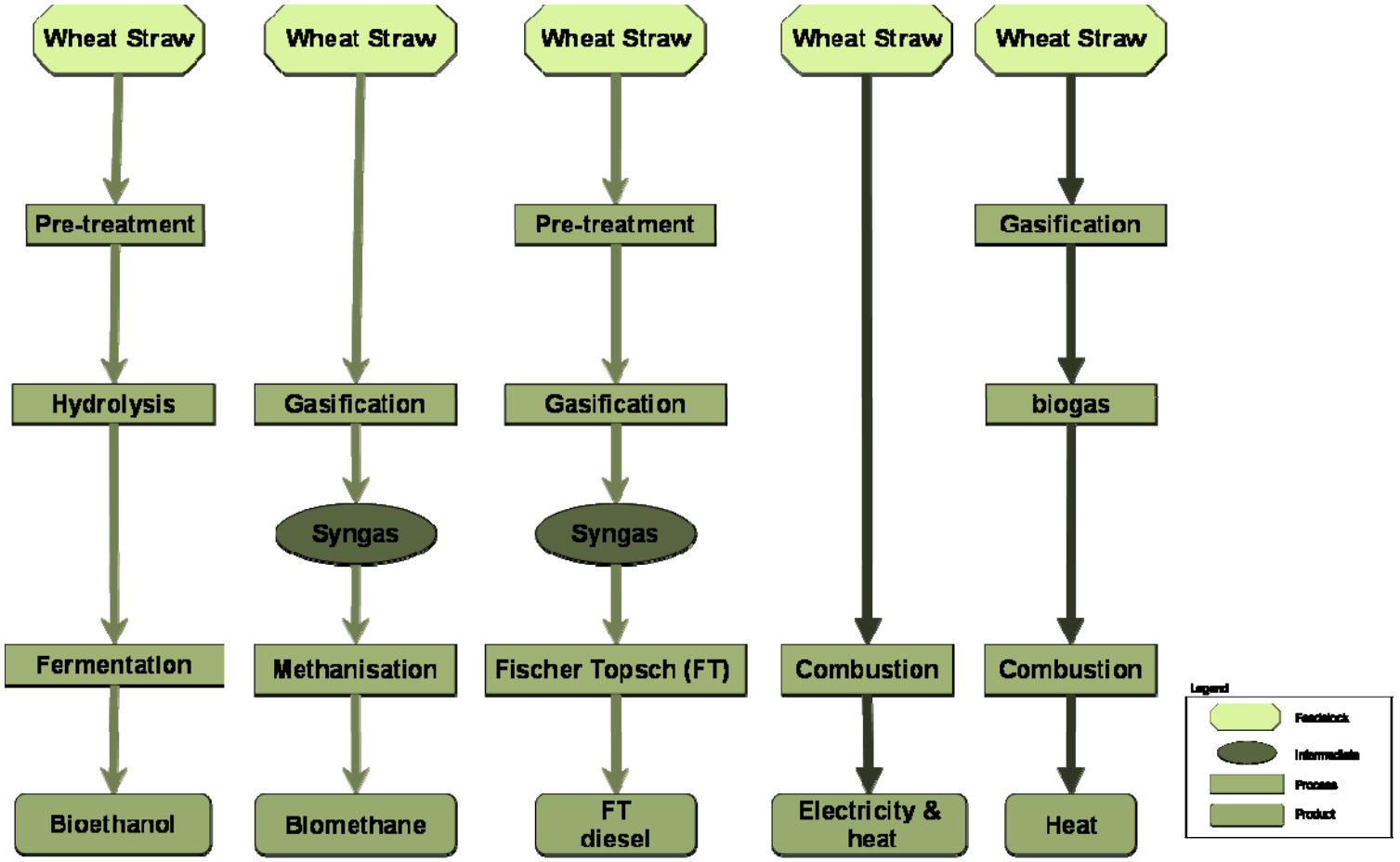
Aim & Scope

- Comparative study of bioelectricity, bioheat and biofuel production from wheat straw in terms of environmental performance

- Functional unit: 1 TJ (lower heating value) of dry wheat straw

System Boundaries





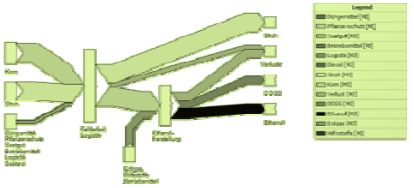
Source: own representation

Inventory analysis

Basic framework

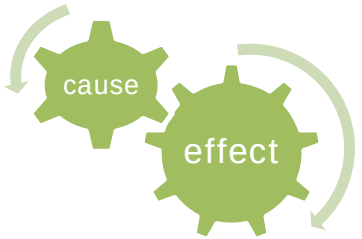
- Life cycle inventory of wheat straw generation & provision **not included**
- Process of construction of buildings and machinery **not included**
- Allocation based on net calorific value
- Germany as regional system boundary
- Main inventory data source:
  Global Emission Model for Integrated System (GEMIS) version 4.5

Systems Description



Type of conversion	Description	Products Category
Wheat straw to bioelectricity and bioheat	Direct combustion	Bioenergy
Wheat straw to bioheat	Gasification + combustion	Bioenergy
Wheat straw to bioethanol	Hydrolysis + Fermentation + Distillation	Biofuel
Wheat straw to biogas	Gasification	Bioenergy/ Biofuel
Wheat straw to Fisher Tropsch diesel	Gasification + Fisher Tropsch	Biofuel

Impact Assessment methodology



Centrum voor Millieukunden Leiden (CML) 2001

Impact categories:

- **Ozone layer Depletion Potential (ODP)**
- **Abiotic Depletion (ADP)**
- **Global Warming Potential 100 years ($GWP_{100years}$)**
- **Photochemical Oxidant Creation Potential (POCP)**
- **Acidification Potential (AP)**
- **Eutrophication Potential (EP)**
- **Radioactive Radiation (RAD)**

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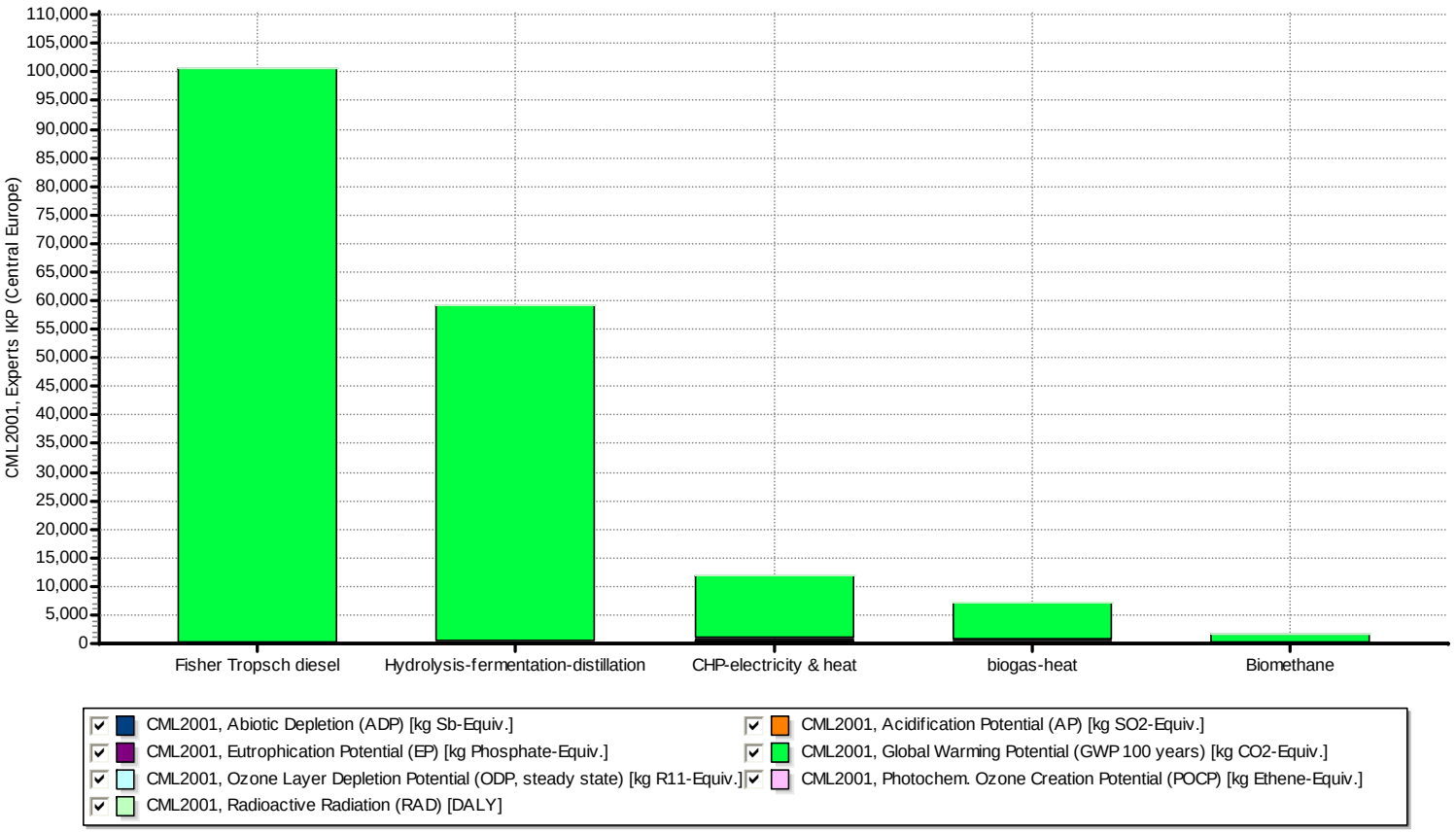
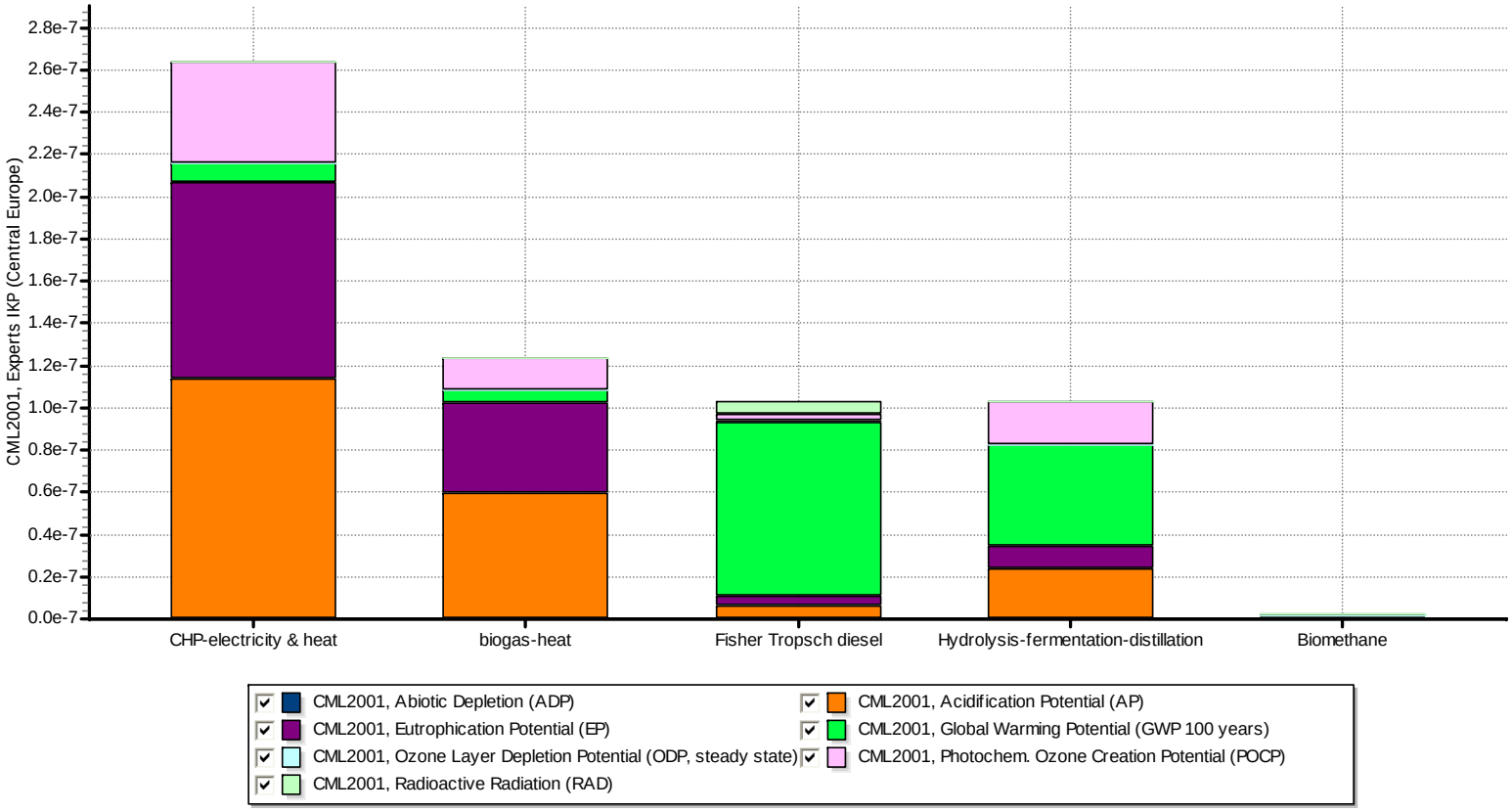
Results & Discussion (1)



Source: own representation

Environmental performance of biomass conversion technologies before normalisation

Results & Discussion (2)

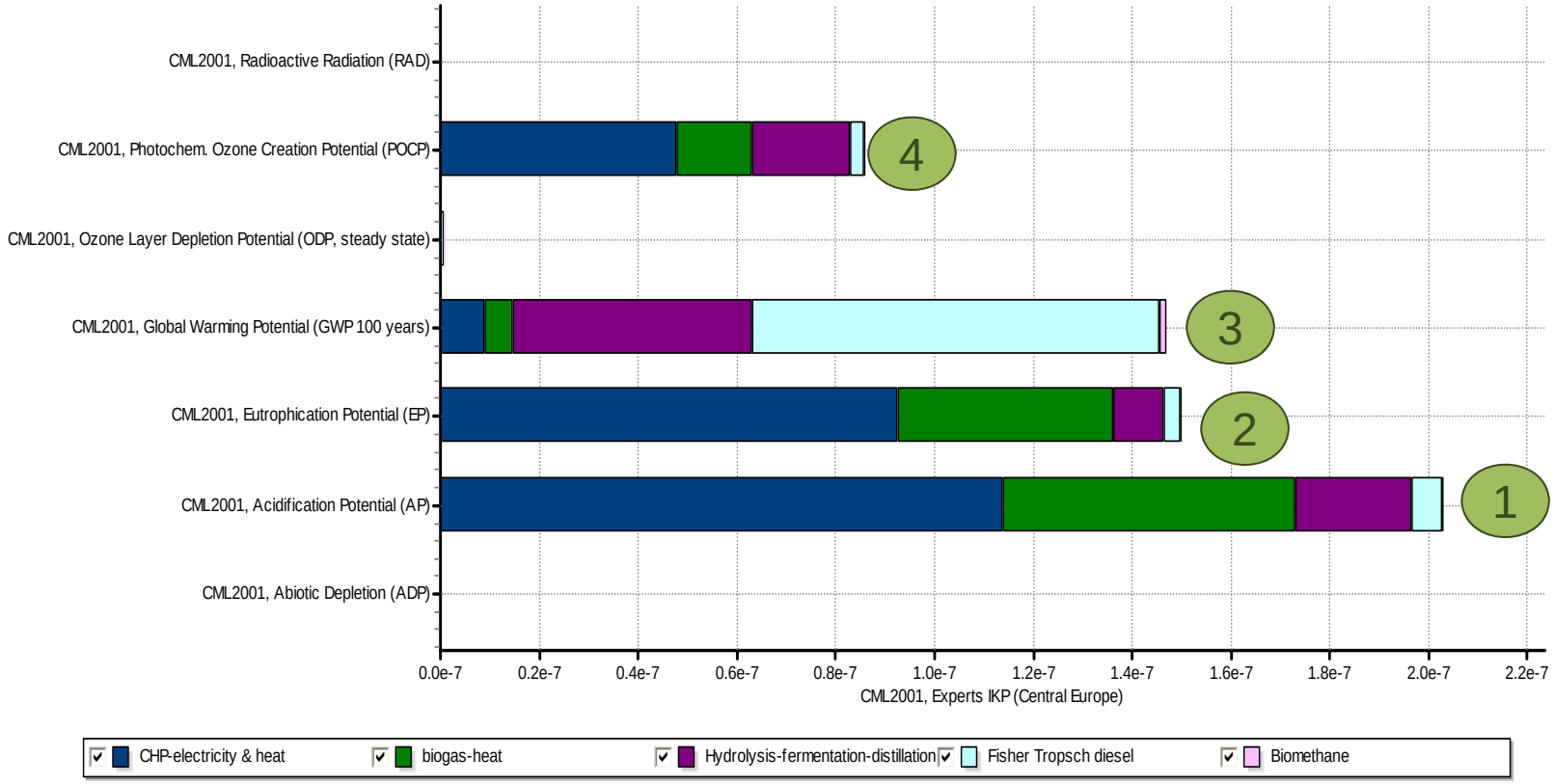


Source: own representation

Environmental performance of biomass conversion technologies

(after normalization using CML2001, Germany)

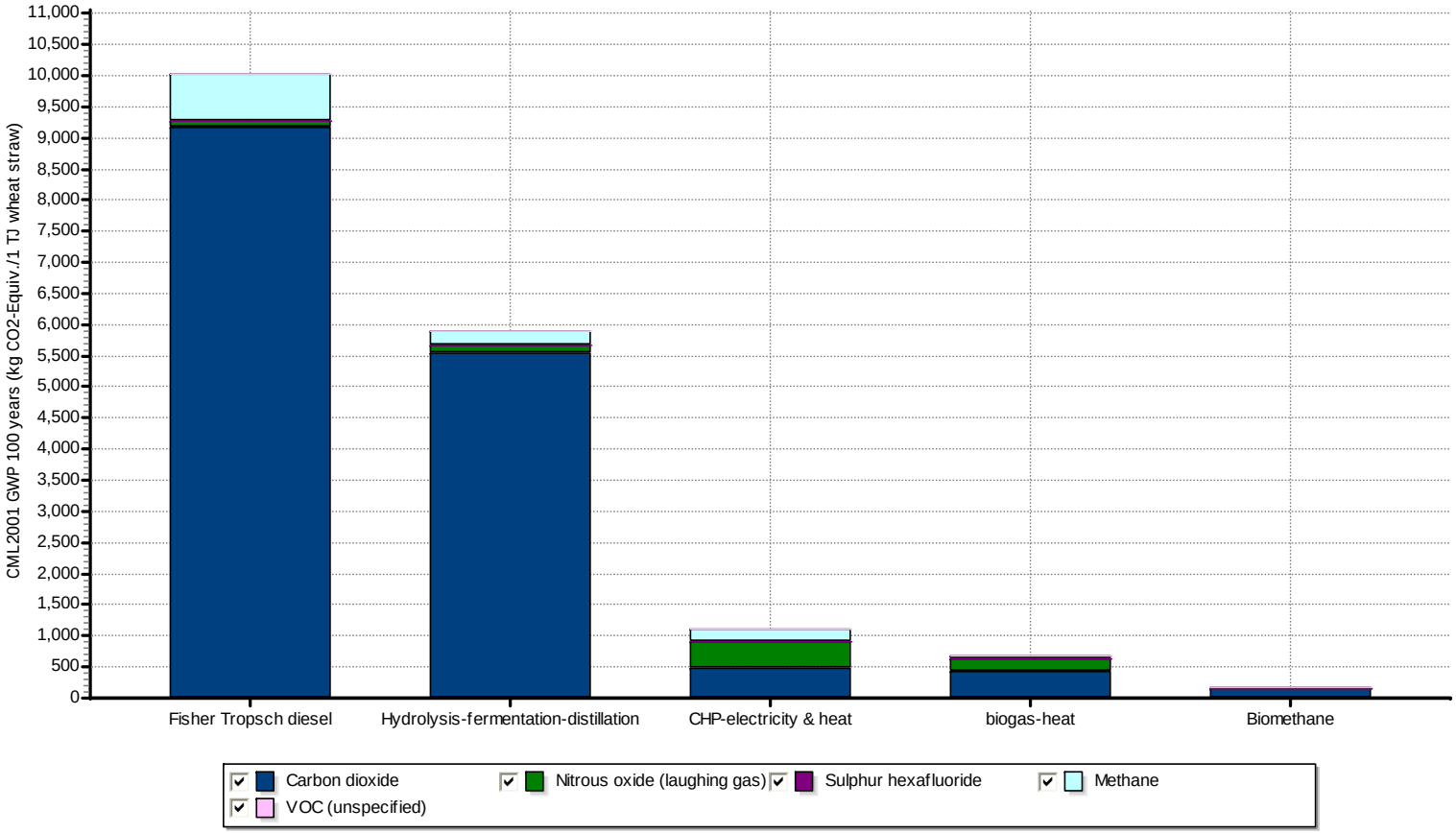
Results & Discussion (3)



Source: own representation

Impact categories contribution (after normalization using CML2001, Germany)

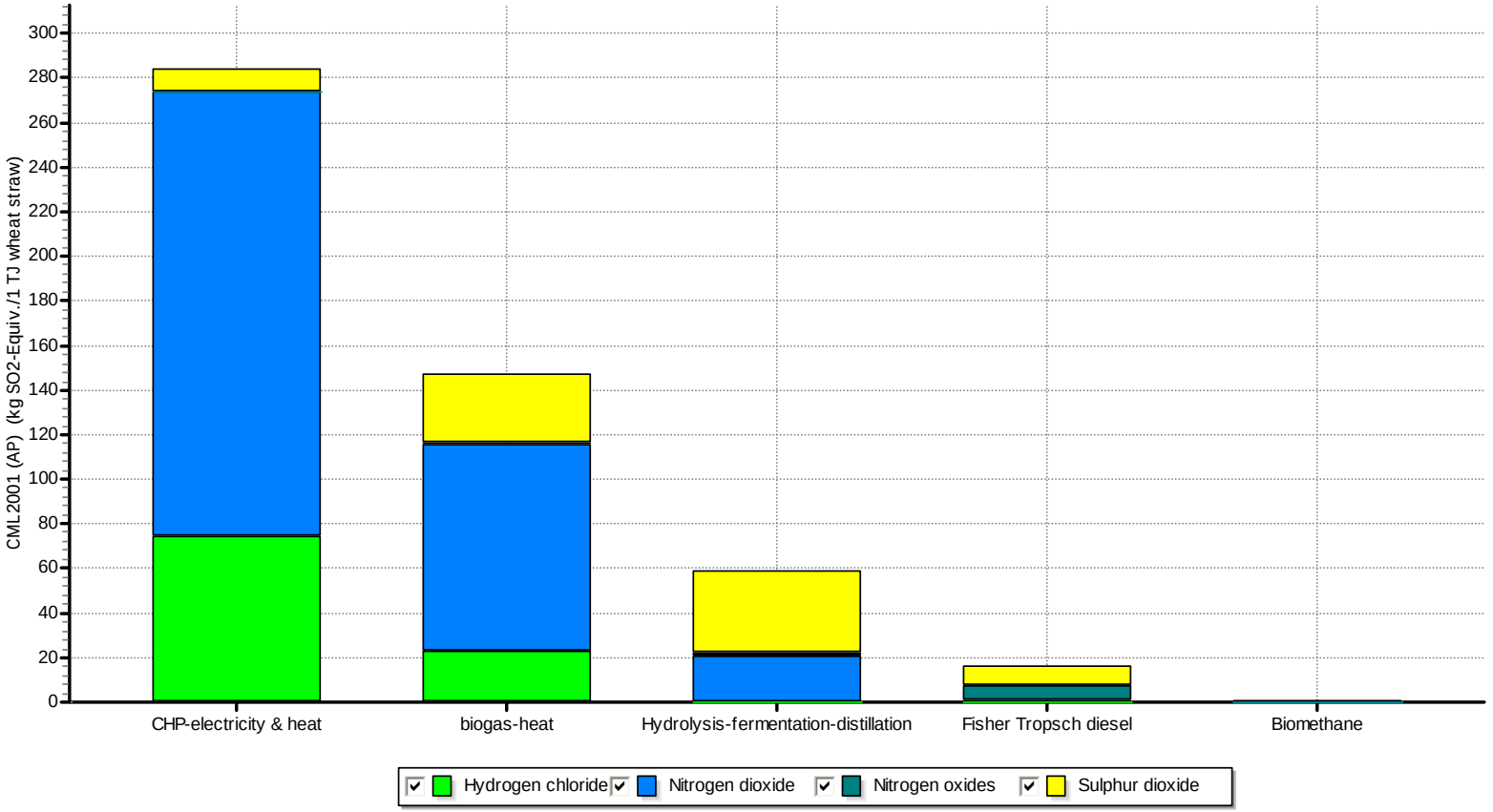
Results & Discussion (4)



Source: own representation

Contribution analysis for GWP *100 years*

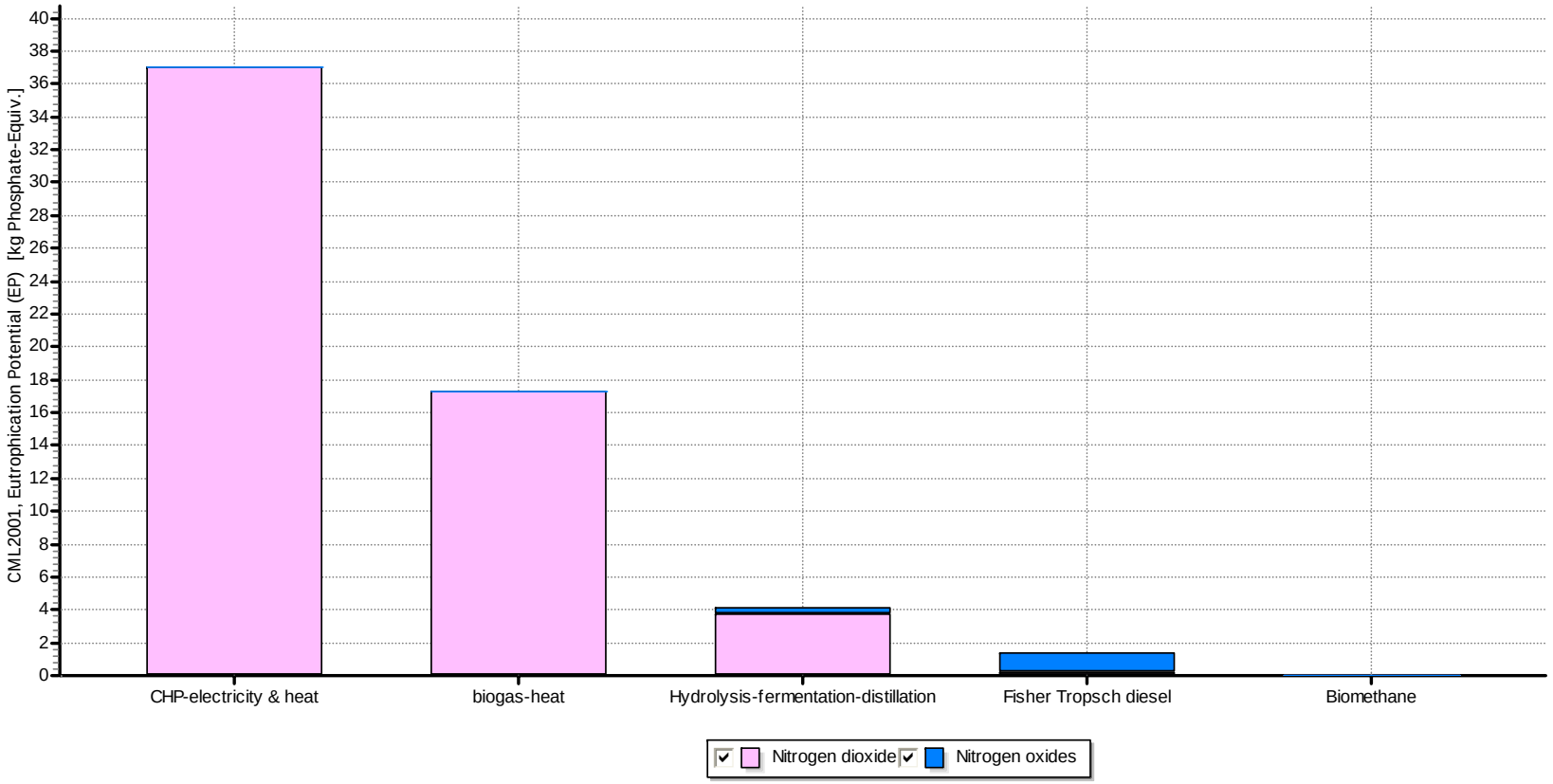
Results & Discussion (5)



Source: own representation

Contribution analysis for Acidification potential

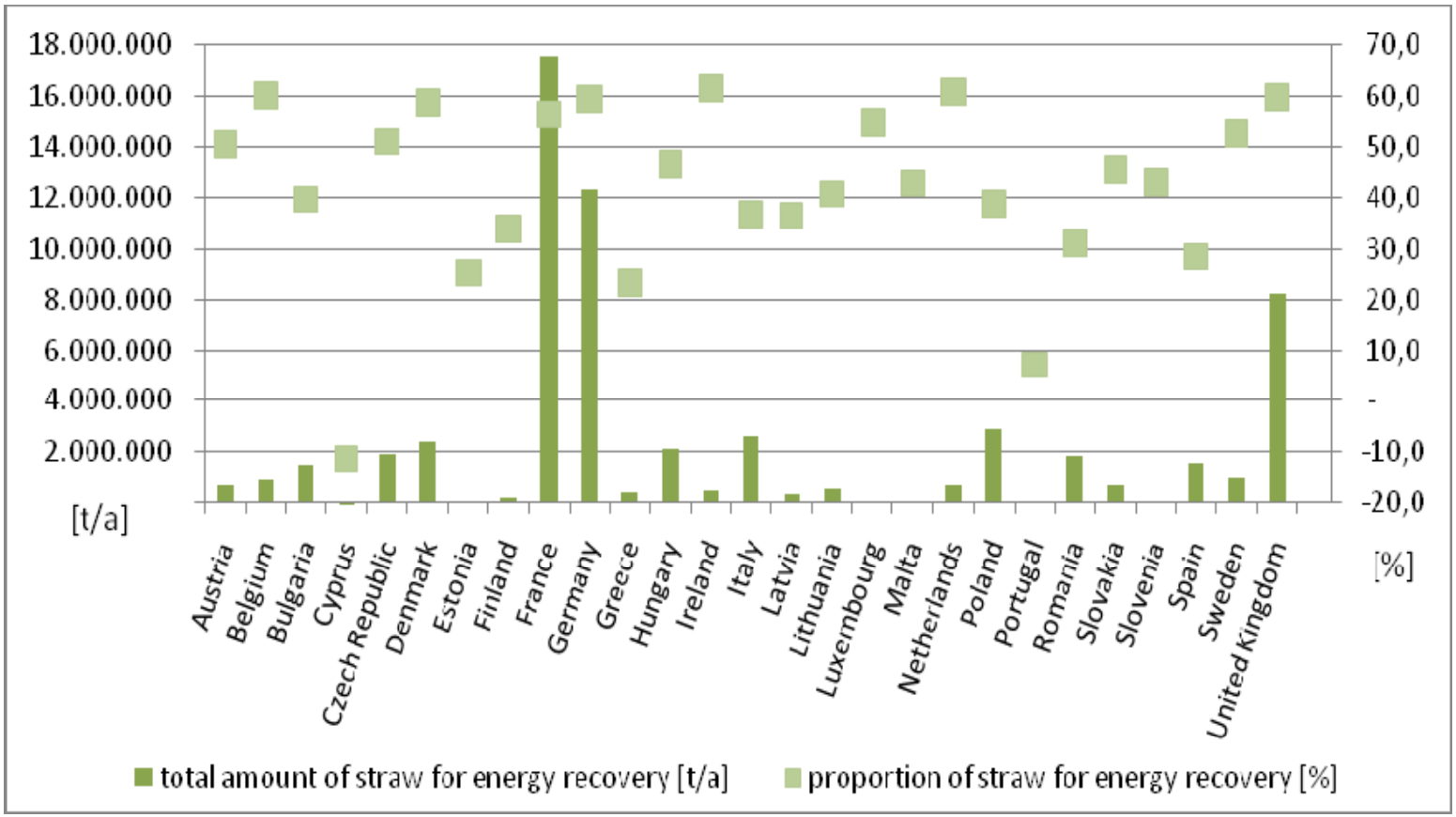
Results & Discussion (6)



Source: own representation

Contribution analysis for Eutrophication potential

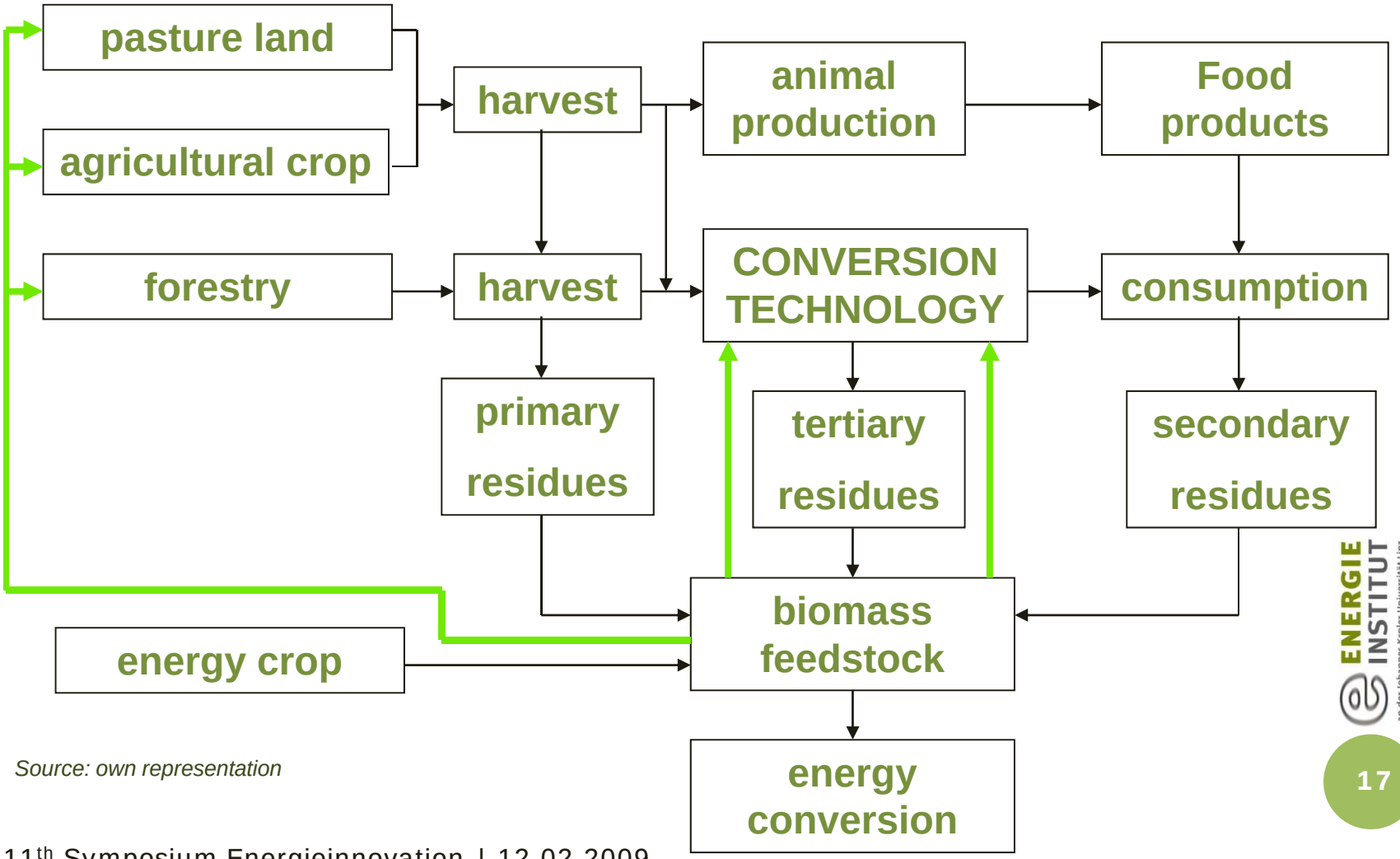
Chances and potential of energy recovery from wheat straw in Europe



Source: own representation, based on data from http://faostat.fao.org, for the year 2008

Profile of wheat straw quantities in the countries of the European Union

Biomass utilisation – potential for improvement



Source: own representation

Conclusion

- **Bioenergy and bioheat production seems to dominate the impact categories of Acidification and Eutrophication while biofuel production seems to dominate the impact categories of Global warming potential.**
- **Other biomass conversion technologies producing biomaterials and/or biochemicals added in future studies.**
- **Expansion of system boundaries to resource provision and utilization phases**
- **comparative LCCA – Life Cycle Cost Analysis**

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Danke für die Aufmerksamkeit !

Kontakt

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