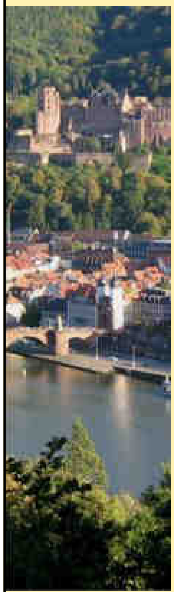
ifeu – Institute for Energy and
Environmental Research Heidelberg



GLYFINERY

Life cycle assessment of green chemicals and bioenergy from glycerol:

Environmental life cycle assessment

Dr Maria Müller-Lindenlauf

Brussels, 13 December 2011

Outline

- **Short introduction to LCA methodology**
- **Description of GLYFINERY pathways**
- **Results of environmental assessment**
  - **Comparison of innovative chemical pathways**
  - **Relevance for biodiesel LCA**
- **Conclusions**

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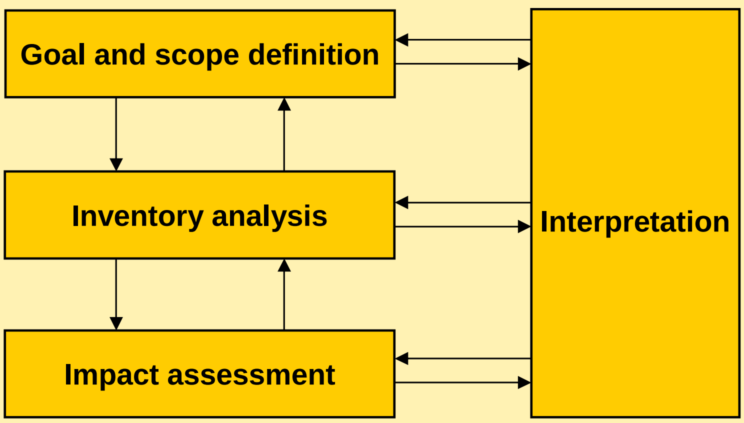
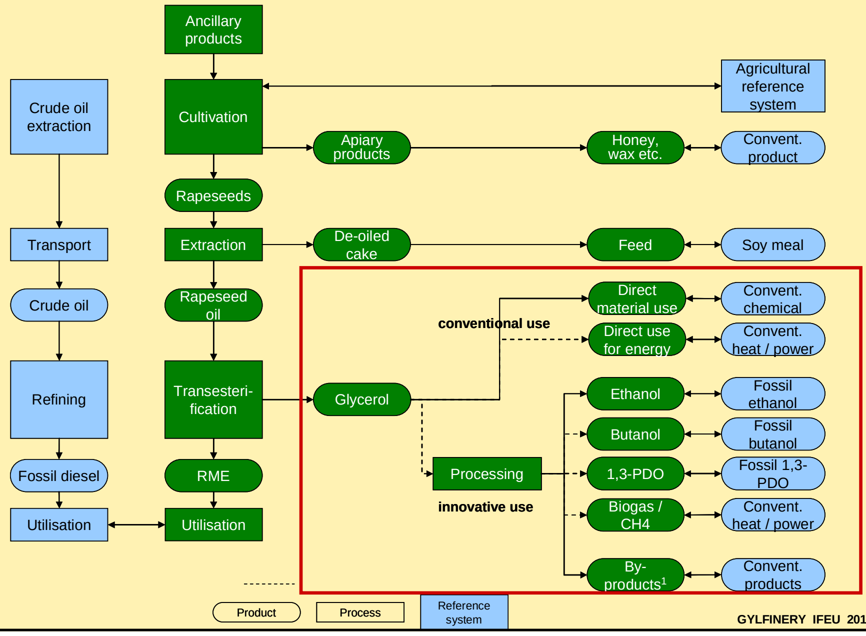
Life cycle assessment (LCA)

ISO 14040 - 14044



The LCA approach



LCA: general settings

Technical reference: mature technology

Time frame: 2020

Geographical coverage: EU27

Co-product handling: system expansion (main approach)

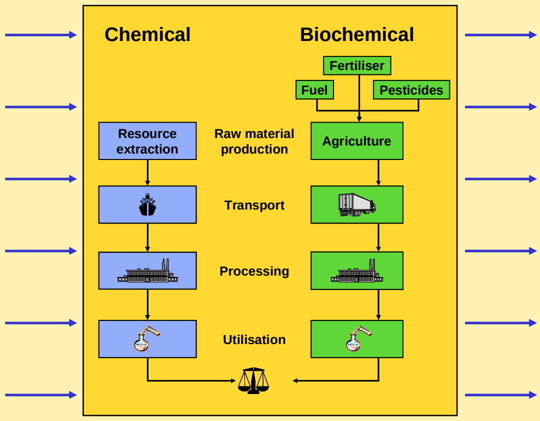
Infrastructure: excluded
(known from former studies: not relevant)

LCA: Inventory Analysis

Inputs

e.g.:

- natural gas
- nutrients
- solvents
- water
- electricity
- …



Outputs

e.g.:

- CO_2
- SO_2
- CH_4
- NO_X
- NH_3
- N_2O
- …

Date sources:

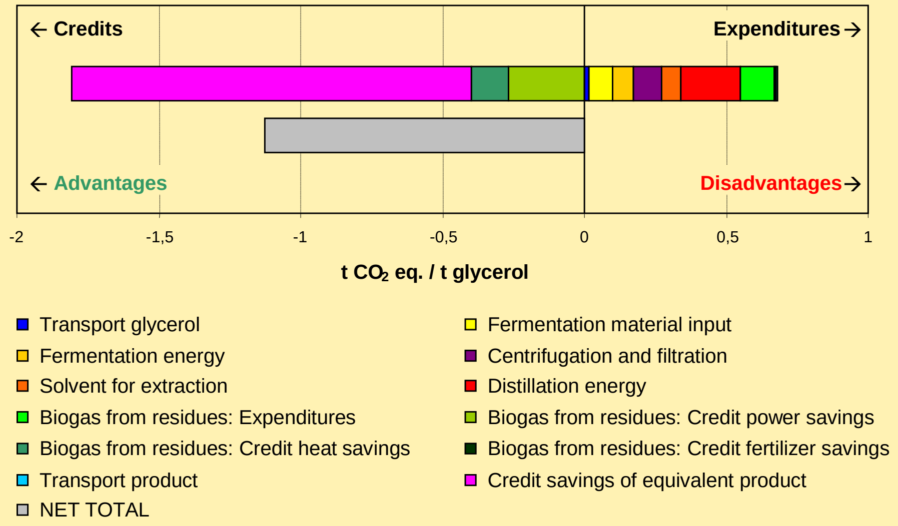
- Expert judgements from GLYFINERY partners
- LCA databases (ecoinvent, GEMIS, IFEU internal database etc.)

Impact assessment categories

Impact category	Parameter	Substances (LCI)
Energy demand	Sum of depletable primary energy carriers	Crude oil, natural gas, coal, Uranium, …
Greenhouse effect	CO_2 equivalents	Carbon dioxide, dinitrogen monoxide, methane, different CFCs, methyl bromide, …
Acidification	SO_2 equivalents	Sulphur dioxide, hydrogen chloride, nitrogen oxides, ammonia, …
Eutrophication	PO_4 equivalents	Nitrogen oxides, ammonia, phosphate, nitrate
Photosmog	Ethen equivalents	Hydrocarbons, nitrogen oxides, carbon monoxide, chlorinated hydrocarbons, …
Ozone depletion	´CFC11 equivalents	CFC, halone, methyl bromide, …

Example: Life cycle assessment

Greenhouse gas emissions: glyc. PDO vs. fossil PDO



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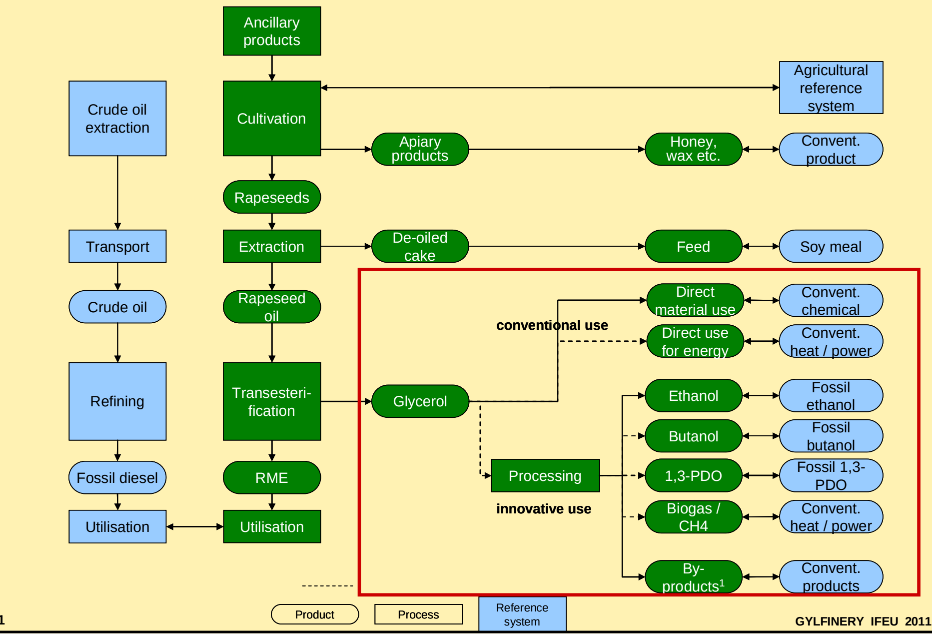
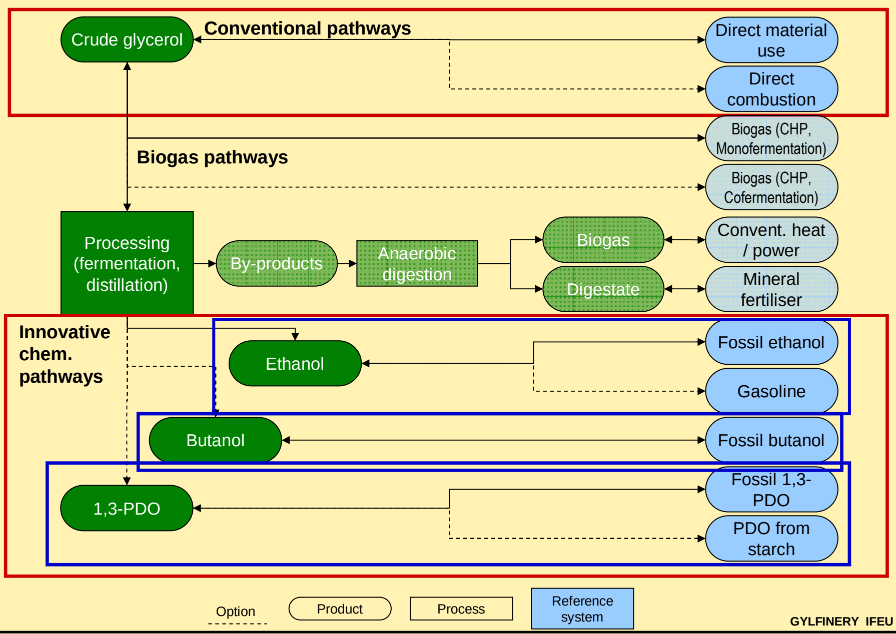
Glyfinery life cycles



GLYFINERY pathways



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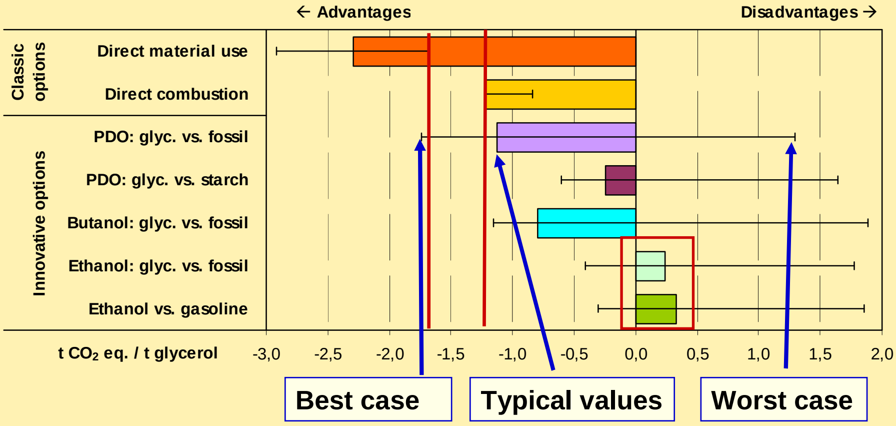
Results for chemical pathways

Greenhouse gas emissions



➡ High variances!

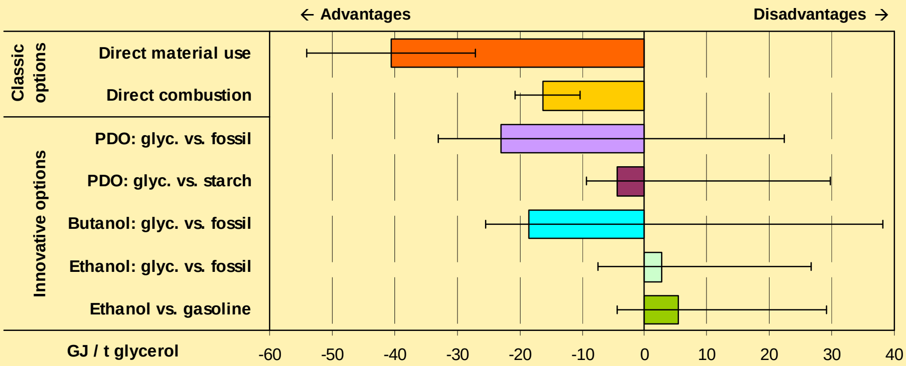
➡ Direct material use performs better than innovative pathways

➡ PDO as replacement of fossil PDO similar to direct combustion

➡ Ethanol shows disadvantages compared to fossil references

Results for chemical pathways

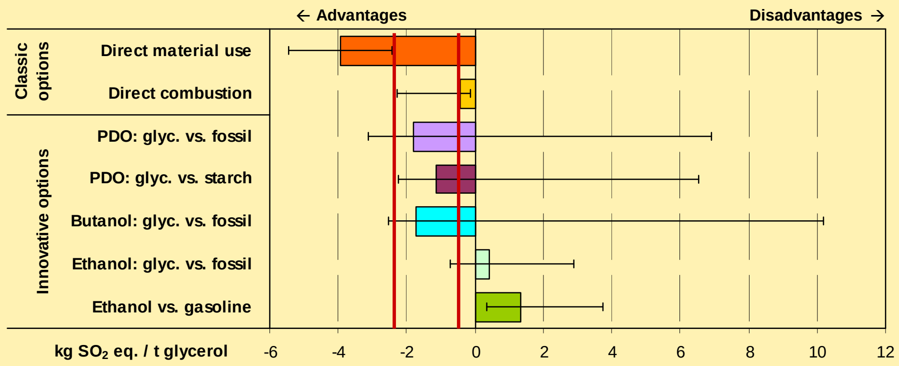
Energy demand



➡ Similar relative performance as for greenhouse gas emissions

Results for chemical pathways

Acidification

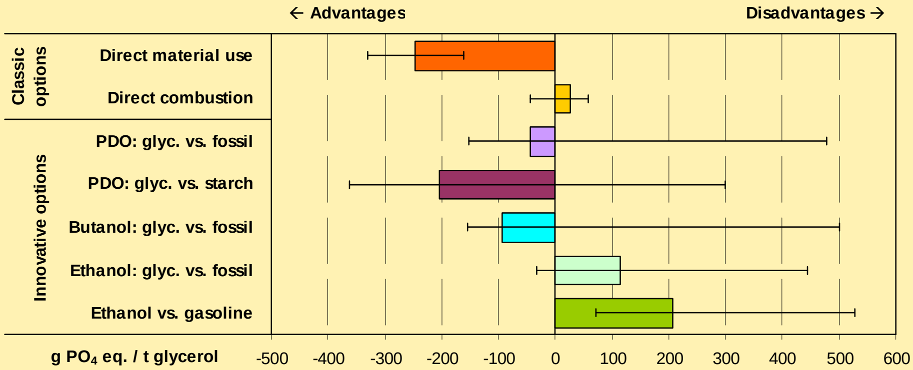


➡ **PDO and Butanol perform better than direct combustion in typical scenario but worse than direct material use**

➡ **Low emissions for all pathways**

Results for chemical pathways

Eutrophication



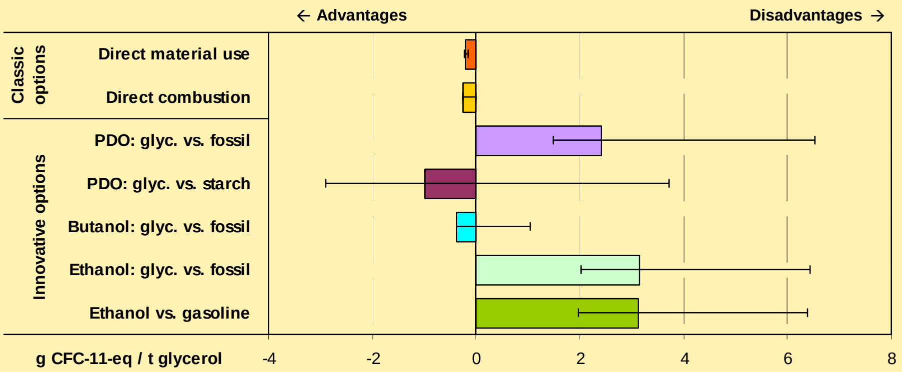
➡ **PDO vs. starch almost as good as direct material use (because of emissions from agriculture in starch production)**

➡ **PDO and Butanol from typical or good practice perform better than direct combustion**

➡ **Low emissions for all pathways**

Results for chemical pathways

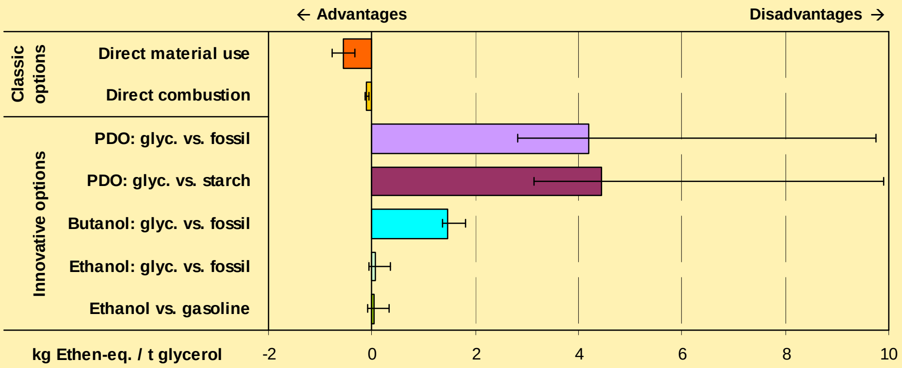
Ozone depletion



- ➡ Depend on fermentation inputs (nitrogen → N_2O)
- ➡ High data uncertainty
- ➡ Very low emissions for all innovative options (=no significance)

Results for chemical pathways

Photosmog



- ➡ Disadvantages mostly because of extraction solvent use
- ➡ Very low emissions for all innovative options (= no significance)

Inhabitant equivalents

Inhabitant equivalent (IE):

→ Instrument to compare environmental impact categories

Formular:

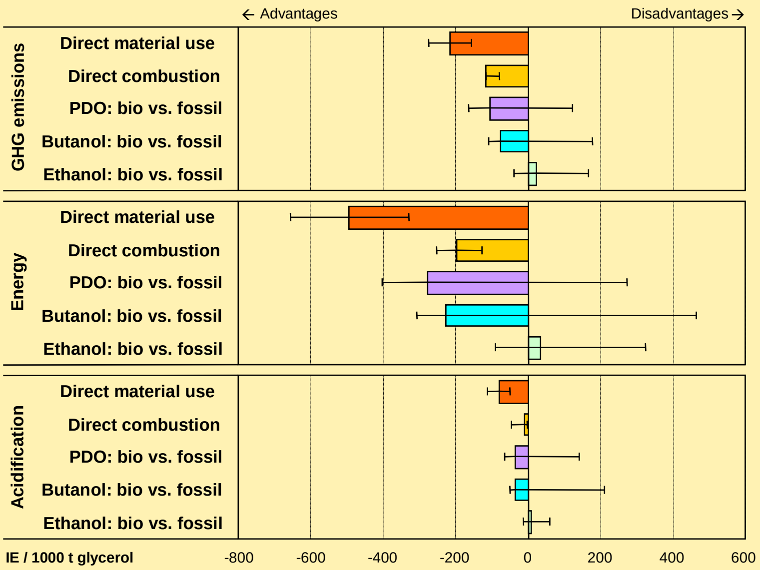
$$\frac{\text{Total environmental impact in EU in category A}}{\text{Number of inhabitants in EU}} = \text{IE (category A)}$$

Examples (for EU):

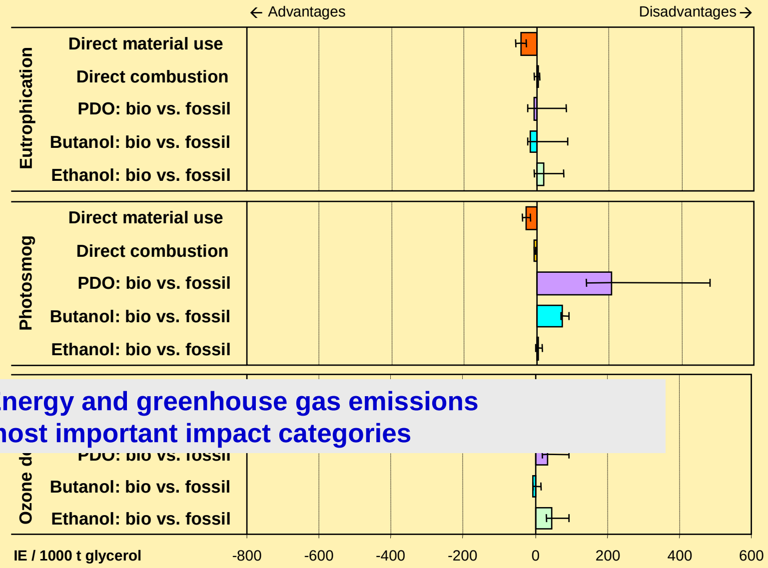
Energy demand: 1 IE = 82 GJ

Greenhouse gas emissions: 1 IE = 11 t CO_2-eq.

Inhabitant equivalents

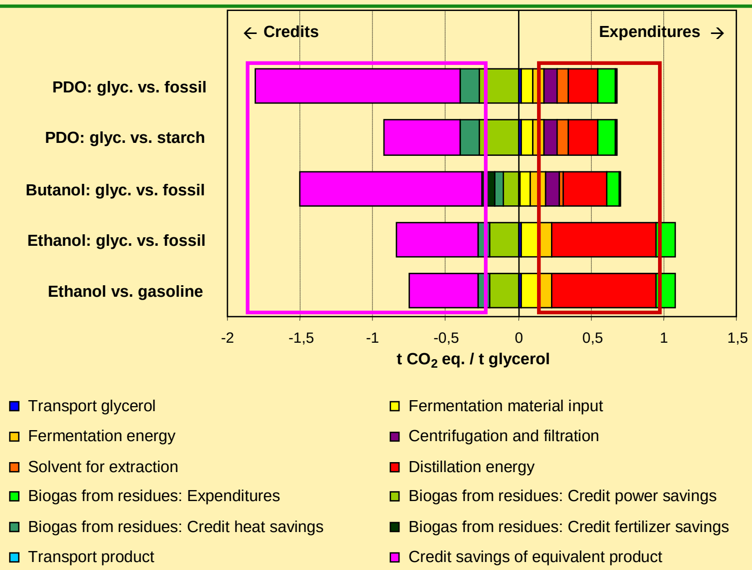


Inhabitant equivalents



➡ **Energy and greenhouse gas emissions most important impact categories**

Impact of life cycle stages



➡ **Credits for equivalent product and distillation energy are most important life cycle stages**

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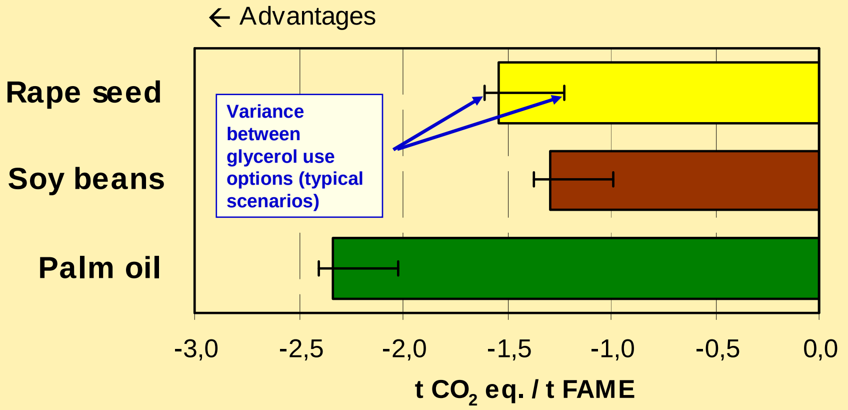
Entire biodiesel pathway

Comparison of feedstocks and glycerol use options

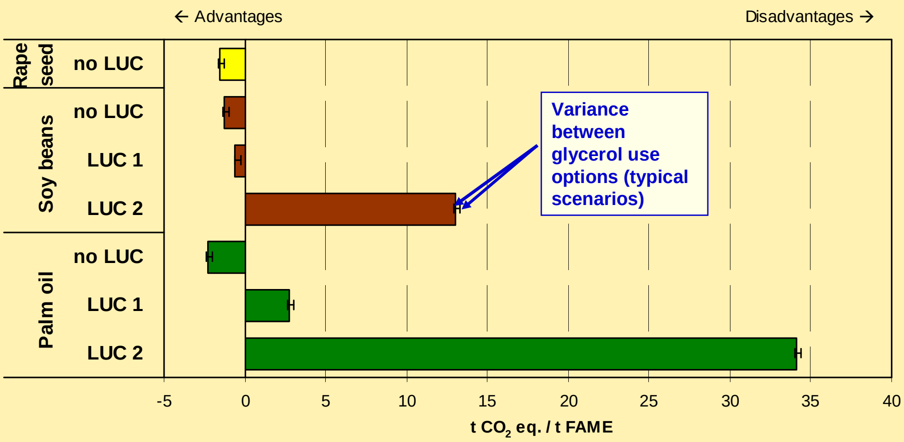


➡ Glycerol use affects biodiesel performance
(E.g. Soy + direct material use performs better than to rape seed + ethanol)

➡ Type of feedstock also very important

Land use change

Effects of land use change scenarios and glycerol use options



➡ **Land use change most important for biodiesel LCA**

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➔ **Conclusions**

Conclusions

From an environmental point of view:

- Direct material use remains best option
- PDO most promising innovative option:
  - comparable performance as direct combustions regarding GHG emissions and energy savings
- Optimization:
  - Reduction in distillation energy
  - Lowering emission of solvent for PDO extraction (to reduce photosmog)

Thank you for your attention!





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