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Life Cycle Assessment

Course Cleaner Production and the Water Cycle
Delft, May 12, 2011
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Contents

- Life Cycle Assessment
- Case study GHG calculator for bio-energy
- Classroom exercise

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Life Cycle Assessment

LCA: an important tool from the Industrial Ecology toolbox

Quantitative Environmental Life Cycle Assessment of Products / Services

- » Quantitative (as much as possible)
- » Environmental (thus not costs, safety, user friendliness, ...)
- » Life Cycle (from the cradle to the grave)
- » Products / Services: (with a central role for the function)

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Life Cycle Assessment

Core principles of LCA:

- Systems perspective
  - » all flows from the cradle to the grave
  - » related to the “functional unit”
  - » abstracted from time and location
- Complete picture of environmental impacts
  - » comparative and potential
  - » prevent problem shifting
- LCA methods and models: how to handle enormous amounts of data? Not complex, but still complicated

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Life Cycle Assessment

Why LCA?

- Increased attention for Product Policy
- Influence consumption and production patterns
- Less, better & different
- Prevent problem shifting

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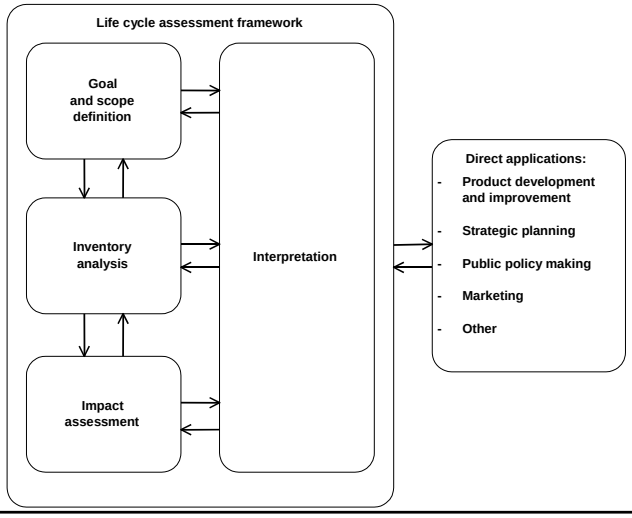
Life Cycle Assessment

ISO 14040 standard framework for LCA



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LCA: Goal and Scope

Functional Unit: Comparing "equivalent" products

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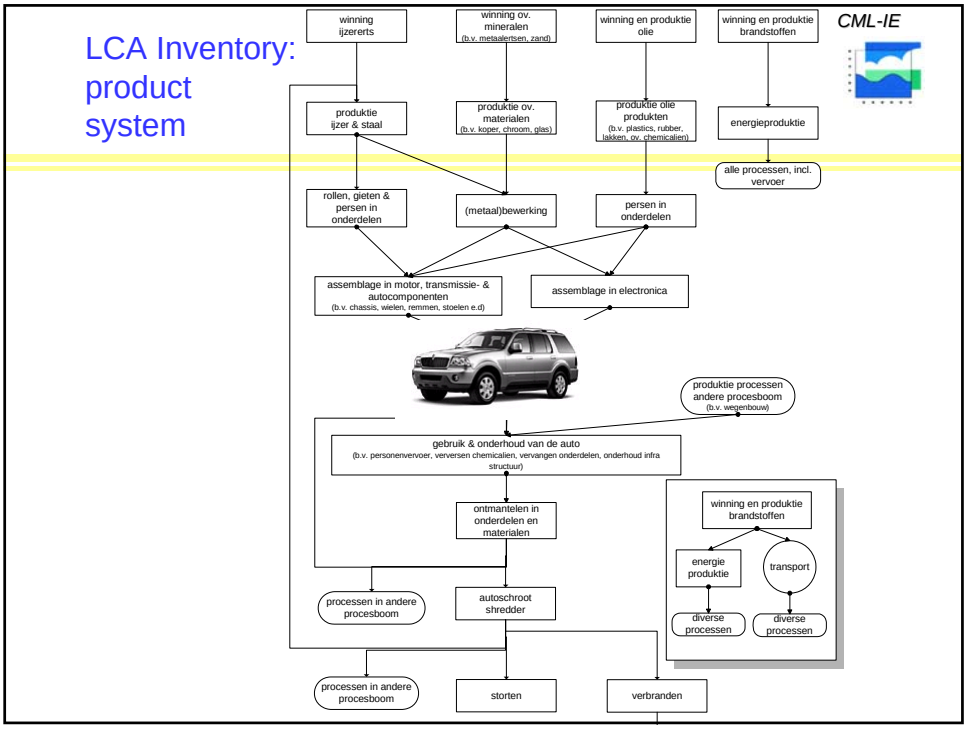
LCA: Goal and Scope

Functional Unit: not product, but service: km of transport

LCA Inventory: product system



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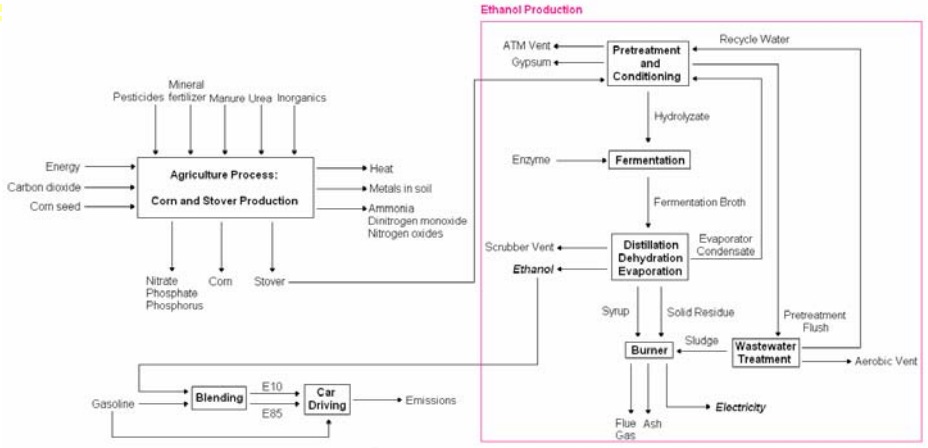
LCA Inventory: product system



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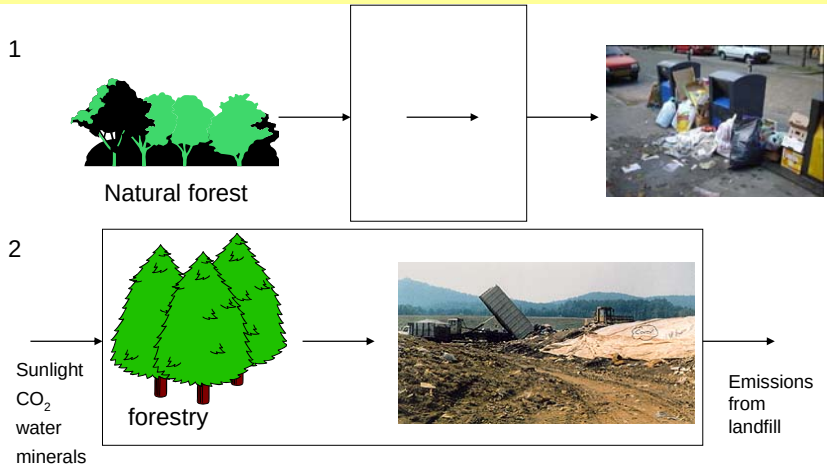
LCA Inventory: economy-environment border



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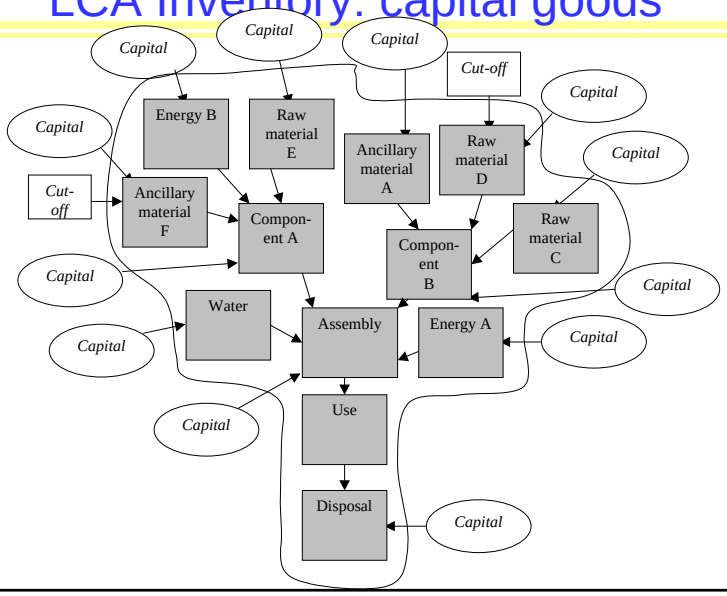
LCA Inventory: capital goods



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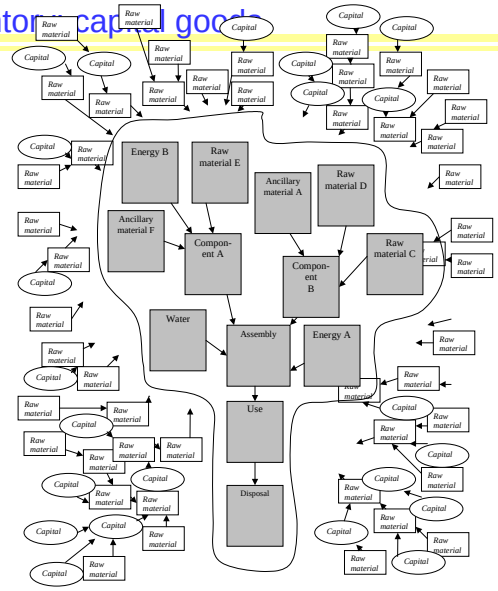
LCA Inventory: capital goods



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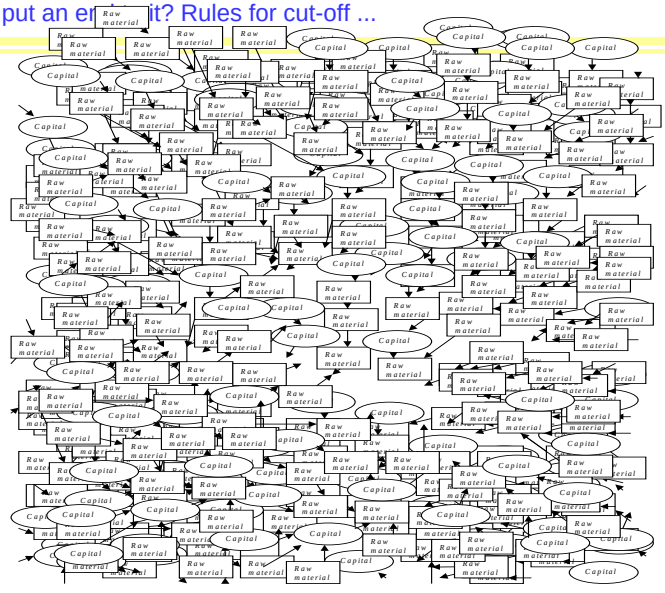
LCA Inventory: capital goods

where to put an end to it? Rules for cut-off ...



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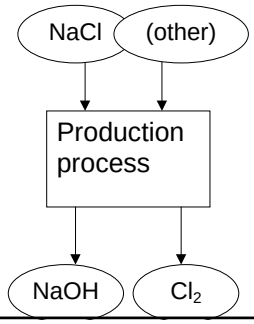
LCA Inventory

… and rules for allocation: in case of multi-output system

- Cut-off (waste)
- Mass / energy based allocation
- Economic allocation
- Systems expansion: double functional unit
- Substitution: subtracting “avoided processes”



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LCA Impact Assessment

- Potential:
  - » no “real” impacts (we don’t know and we don’t want to know)
  - » not time and location specific
  - » no thresholds: less is better
- Comparative:
  - » in terms of contribution to established environmental problems
  - » in relative terms per environmental problem (CO_2 equivalents)
  - » “midpoint” rather than “endpoint” of environmental cause-and-effect chain

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LCA Impact Assessment

- List of “impact categories”:
  - » climate change
  - » ozone depletion
  - » photo-oxidant formation
  - » acidification
  - » eutrophication
  - » toxicity
  - » land use
  - » abiotic resource depletion
  - » biotic resource depletion
  - » nuisance (odor)

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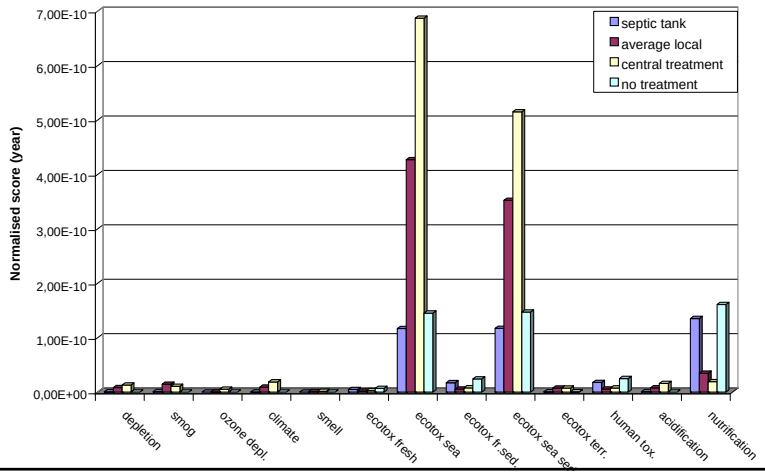
LCA Impact Assessment

Which alternative is best? Which is worst? Weighing between environmental problems is needed.



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LCA: Interpretation of results

- LCA methodology: dealing with “uncertainties”
- Uncertainties in data
  - » Process data: efficiencies, emissions, energy requirements ...
  - » Contribution analysis, sensitivity analyses, formalised uncertainty analysis
- Consequences of methodological choices
  - » Usually much more important
  - » Allocation and impact assessment
  - » Sensitivity analysis

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LCA: Applications

- LCA widely used in industry
  - » provides additional information to industrial process technology assessment ...
  - » ... and to risk-based permits
- Lately, some standardisation in “calculators”
  - » carbon footprinting, GHG calculators (development in advanced stage)
  - » water footprinting (development starting up)
- http://www.waterfootprint.org/

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LCA-based GHG calculators

- Bio-based energy: important part of renewable energy policies in Europe
- Lately, recognition of drawbacks >> development of sustainability criteria
- The Netherlands: Commissie Cramer criteria
  - » Large number of sustainability criteria, PPP
  - » Presently developed: greenhouse gas balance linked to improvement %

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LCA-based GHG calculators

- GHG calculators under development in UK, Germany, NL, ...?
  - » biofuels
  - » bio-electricity and heat
- International debate in EU
  - » methodological issues
  - » intended use of calculators
- Draft Directive EU
  - » Guidelines on data and methodology for GHG calculators

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LCA-based GHG calculators

- Dutch GHG calculator on bio-electricity and heat
- Feedstocks
  - » Pure plant oils (PPO: palm oil, rape seed oil and soybean oil):
  - » Wood residues (wood chips, wood pellets and waste wood from construction)
  - » Agricultural crops (maize, grass)
  - » Agricultural residues (manure, straw, potato remains)
  - » Waste from the food industry (swill, animal fat & bone meal)
  - » Municipal solid waste (MSW, GFT, landfill gas)
  - » Sewage sludge
- Conversion processes
  - » (co-)firing
  - » CHP
  - » digestion
  - » gasification
  - » green gas production

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LCA-based GHG calculators

- Uncertainties in GHG calculators:
  - » Process data: esp. Soil emissions
  - » Conservative, typical, best practice chains
- Methodological choices:
  - » Allocation!!!! In Dutch GHG calculators, energy-based allocation
  - » CO_2-neutrality of biomass

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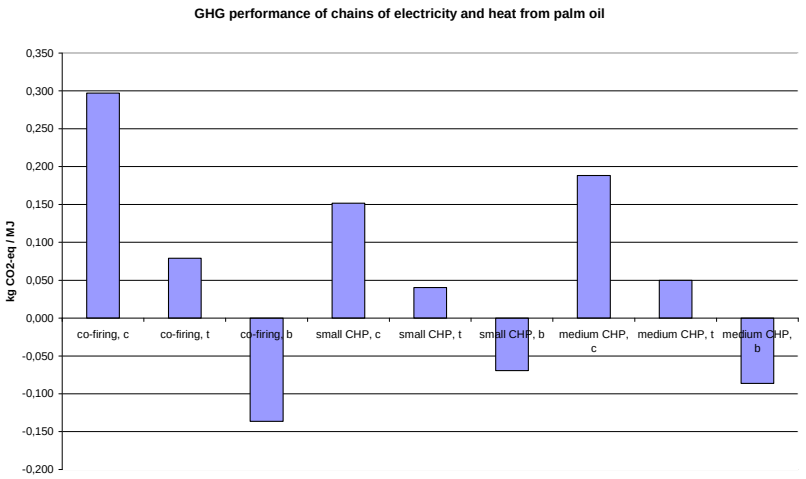
Some results: electricity and heat from palm oil



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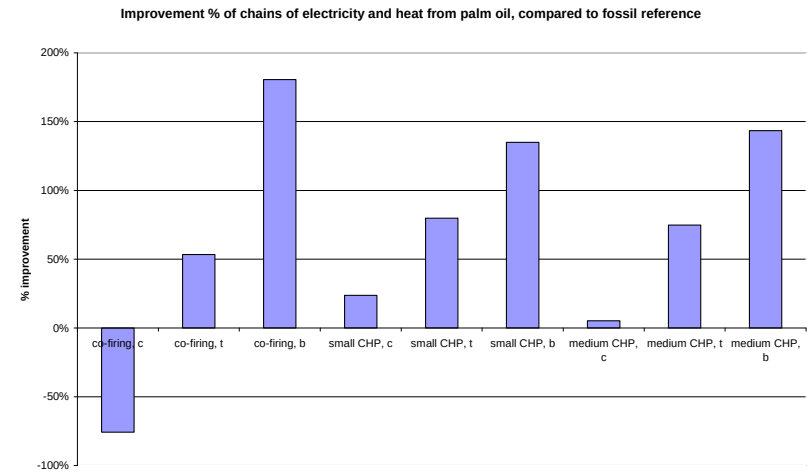

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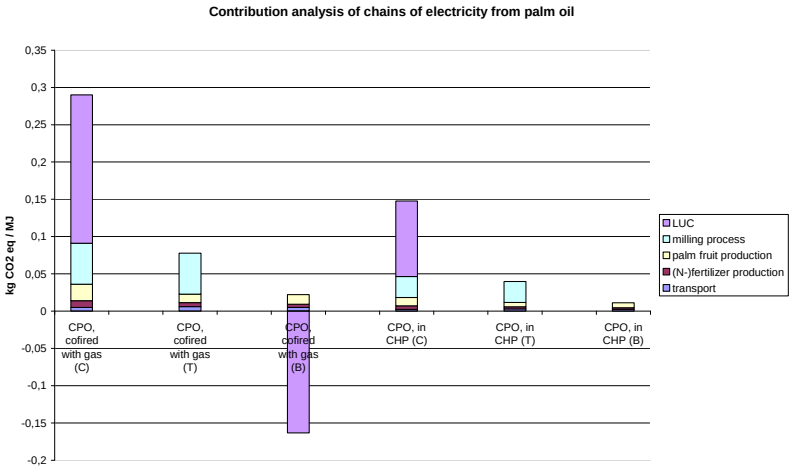

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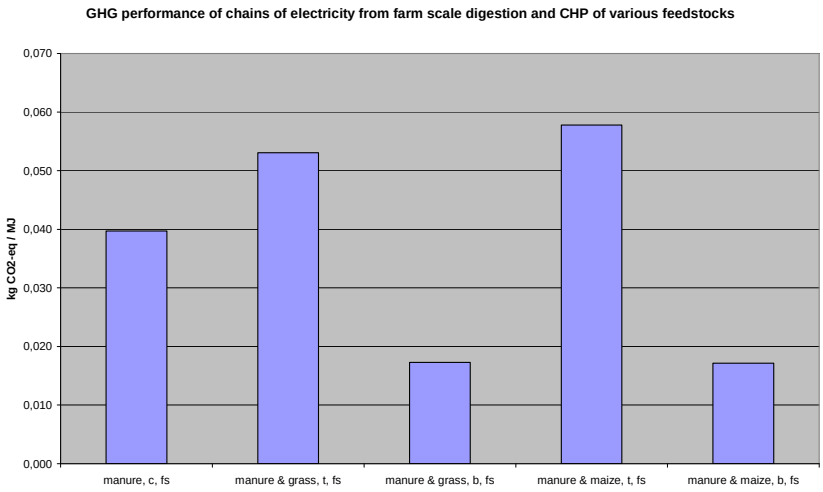
Some results: chains of digestion, farm scale



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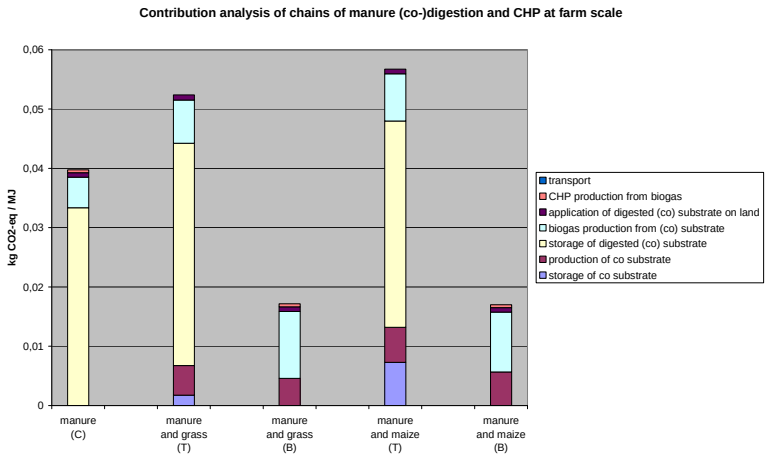

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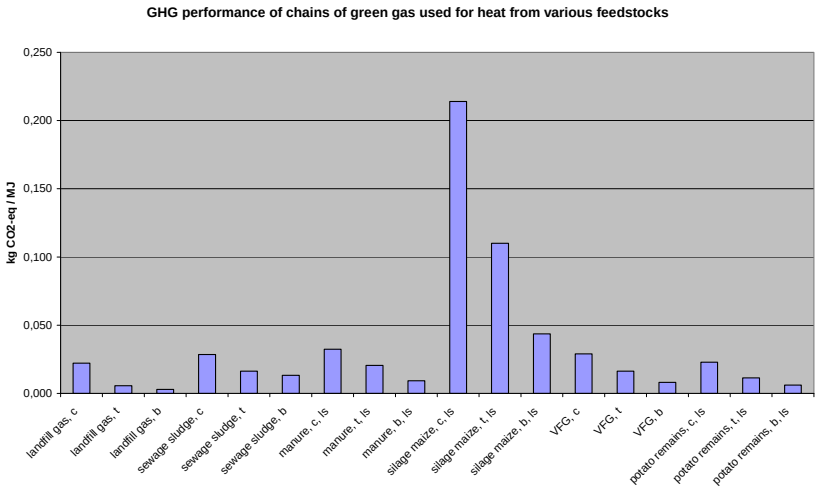
Some results: heat from green gas



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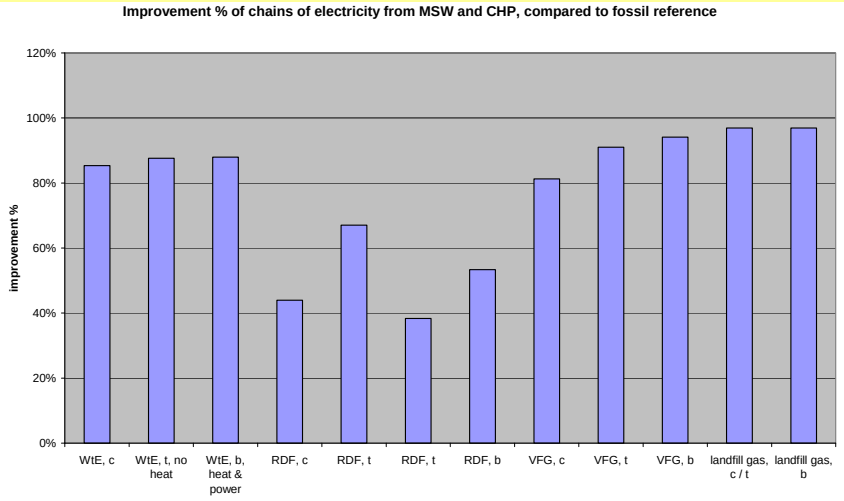
Some results: electricity from MSW



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Some results

- A lot depends on methodological choices, especially allocation in case of multi-output processes
  - » this can reverse results completely!

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Classroom assignment: biodiesel from rape seed

- Your assignment:
  - » calculate GHG emissions from chain of car transport using biodiesel from rape seed
  - » allocating for by-products
  - » calculating improvement % compared to fossil reference
  - » comment on outcomes

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Classroom assignment: biodiesel from rape seed

- biodiesel chain outputs
  - » transport by biodiesel (main product)
  - » electricity from rape seed straw (by-product)
  - » animal feed from rape seed meal (by-product)
- step-by-step
- all required data on data sheet

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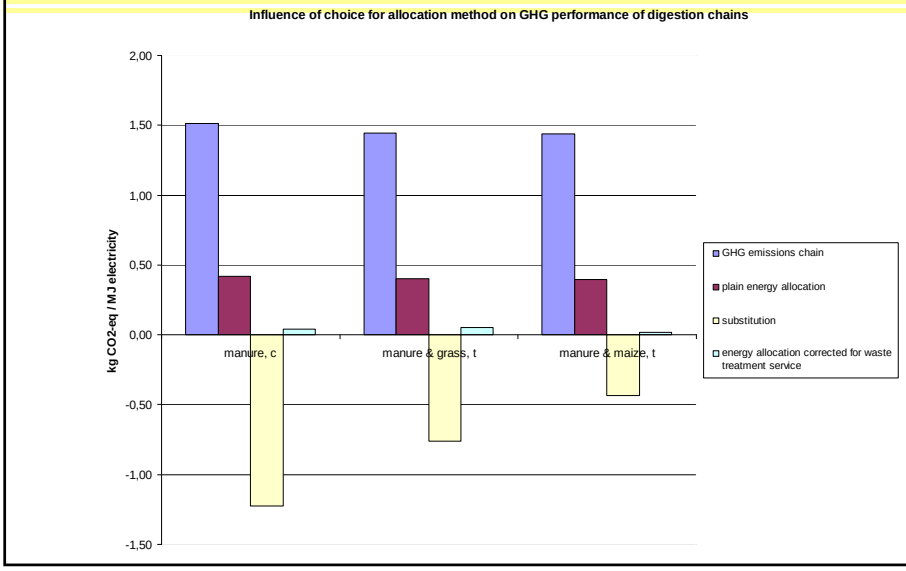
Methodological choices: influence of allocation



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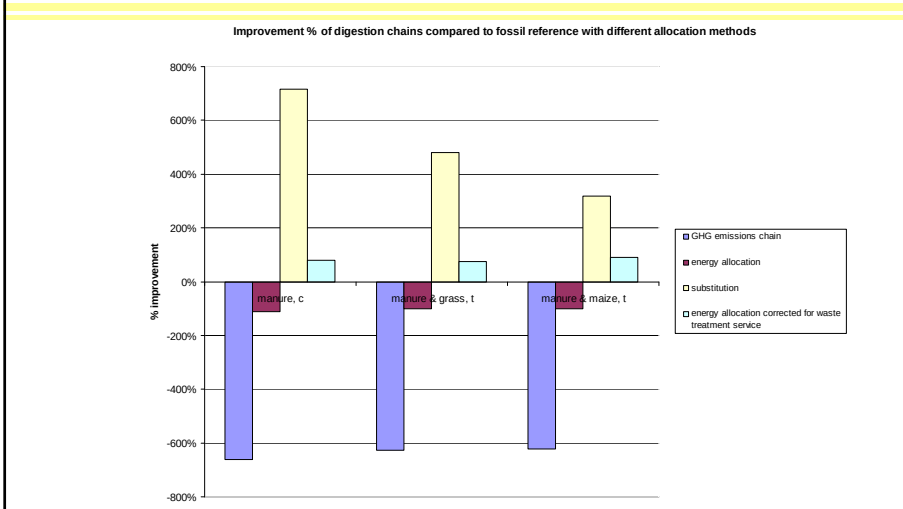
Methodological choices: influence of allocation



Consequences for policy supporting use

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- Allocation is a choice: no uncertainties to be reduced
- So far no generally accepted method
- Countries disagree
  - » UK: substitution “closest to reality”
  - » Germany: energy allocation “most robust”
  - » Netherlands: economic allocation “widest applicability and link with economic driving forces”
- EU followed Germany
  - » Intended use for subsidies does not allow variable outcomes
  - » Is alright for energy crops, first generation technology
  - » Is problematic for waste and residue feedstocks
  - » Solutions sought within the energy allocation framework: possible, but artificial
- International debate ongoing

Consequences for policy supporting use

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- Why is it important to include waste and residues in the EU Directive for biofuels?
- What to think of usefulness of LCA based greenhouse gas calculators?
- Will GHG calculators guarantee unproblematic biofuel production and use?