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Cost and CO_2-emission reduction of biomass cascading - Methodological aspects and case study of SRF poplar

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Biomass for GHG mitigation

- Biomass can play important role in GHG mitigation
- Use of biomass for materials and energy
- Resources are limited:
  - Total global potential of biomass about 50-200 EJ/yr in 2050 (primary energy consumption in 2001 about 420 EJ/yr).

Current biomass use

- Currently, low share of biomass for material and energy applications from dedicated crops (and forestry)
- In Europe, main reasons are:
  - high production costs
  - relative low availability of (agricultural) land

=> More competitive alternatives for the introduction of biomass are needed

The concept of cascading

- **Cascading:** sequential use of biomass for several applications ending with an energy production step => might improve the overall biomass system performance
- Methodological aspects are important for comparison of different chains
- Many different cascading chains from biomass possible

Efficiency

- Comparison of different systems
- Efficiency criteria:
  - GHG emission reductions
  - Agricultural land use
  - Costs of biomass systems
- Few studies explicitly address cascading of biomass

⇒ Potential benefits of cascading biomass still need to be proven in quantitative analyses.

Methodological issues

- Methods to account for GHG emission reductions are still in development

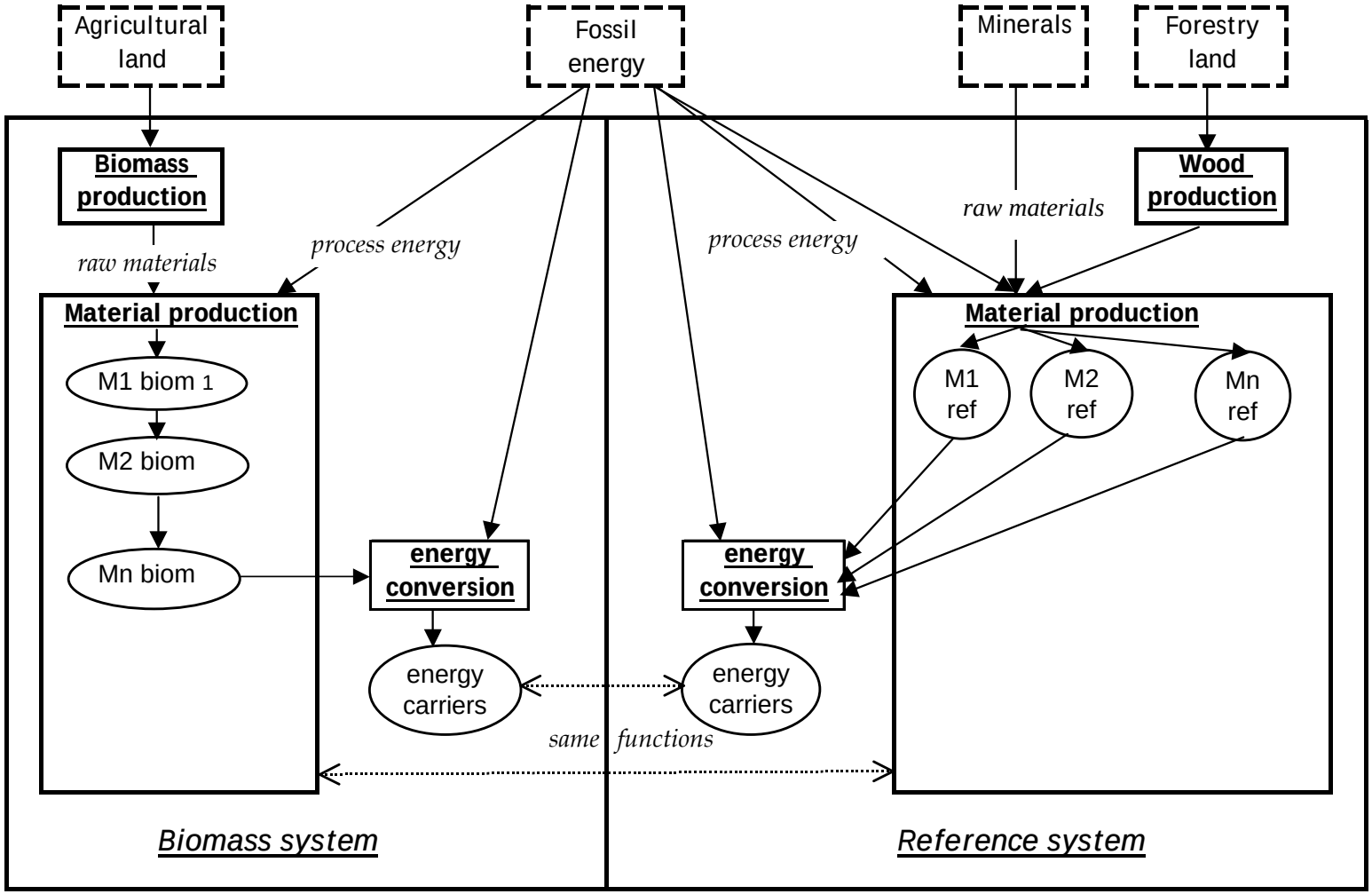
⇒ Adaptation or development of methodologies needed:

- Allocation to account for different products and land uses
- Accounting for time dimension in long-life cascading applications

Objective of this study

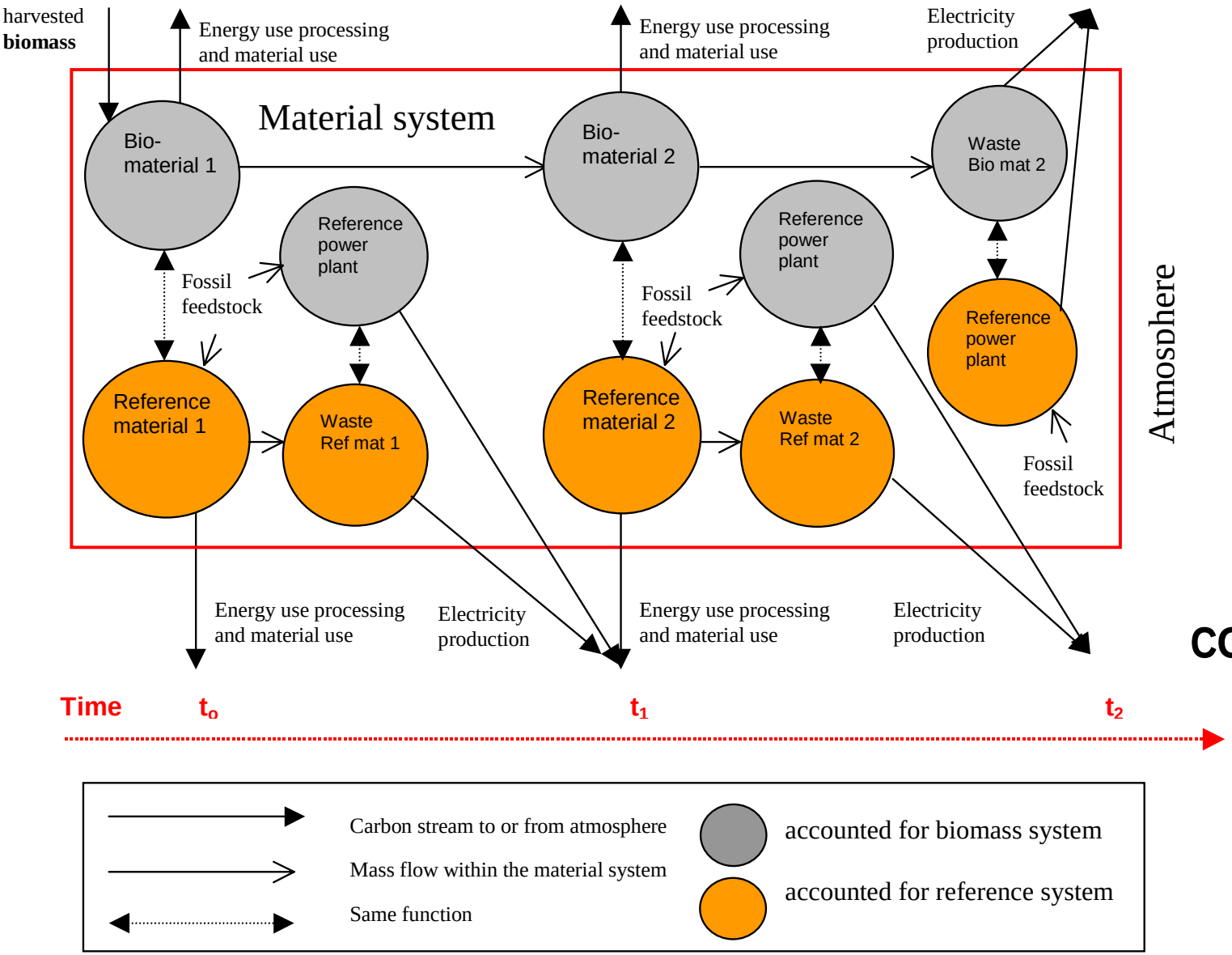
1. To select and **develop** a coherent **methodological framework** for the comparison of different biomass cascading chains in terms of costs, land demand and CO_2 emission reductions and
2. To **identify key parameters** and issues that influence the efficiency of biomass cascading chains

System boundaries



Land use

- Comparison on the basis of hectare land use in the biomass system (ha/yr)
- Occupation of 1 ha of medium quality agricultural land in NW-Europe for one year
- The land use of conventional forestry in the reference system converted to CO_2 emission reductions and cost reductions



(Avoided) CO_2 emissions over time

Time dimension

⇒Costs and CO_2 reductions are also calculated as present values

- Advantage: Effects of carbon sequestration in products become visible
- Disadvantage: Discount rates and future carbon prices uncertain

Case study of SRF poplar

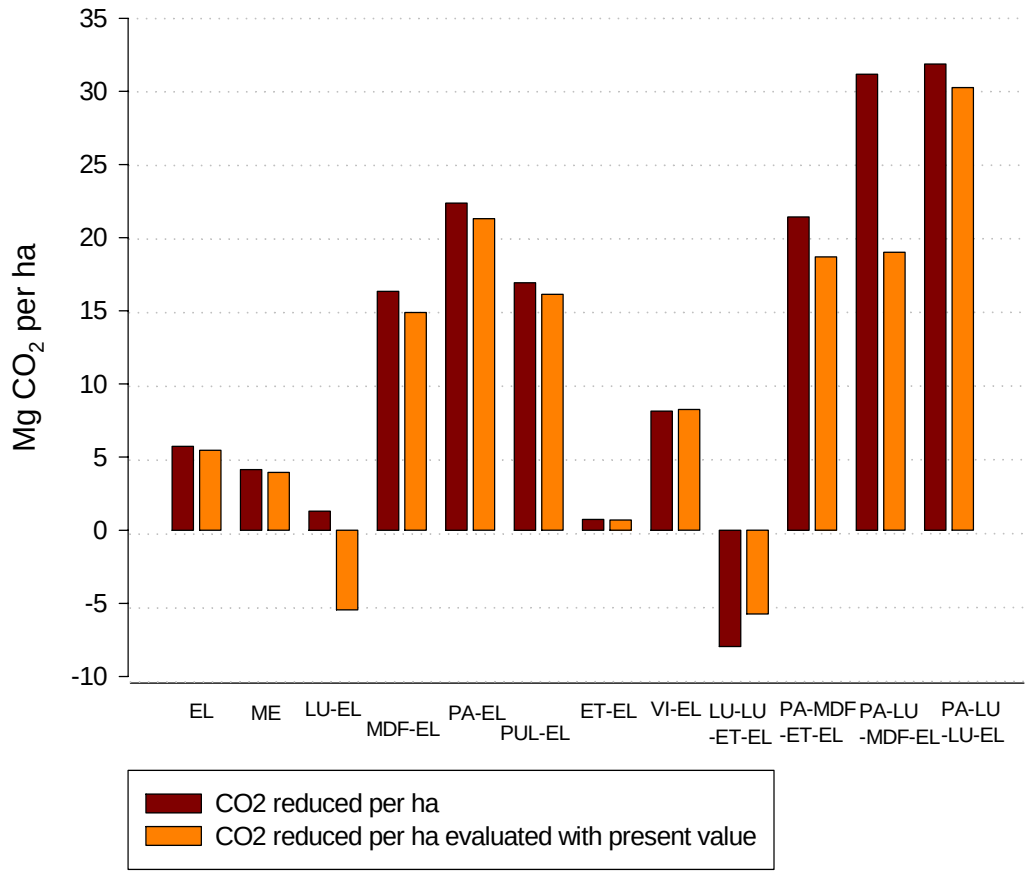
Applications of SR poplar wood and reference applications

Abb.	SR poplar application	Reference material	Substitution
LU	Particle lumber	Concrete	Fossil, mineral
MDF	MDF board	Plywood softwood	Wood
PA	Pallets	Pallets softwood	Wood
PUL	Chemical pulp	Chemical pulp softwood	Wood
ET	Ethylene	Ethylene from naphtha	Fossil
ME	Methanol	Gasoline	Fossil
VI	Viscose	PES fibre	Fossil
EL	Electricity, IG/CC	Electricity mix, WE	Fossil

⇒ Combined to cascading chains

Results

- Annual CO_2 emission reduction per ha of biomass production



EL: electricity

ME: methanol

LU: particle lumber

MDF: MDF board

PA: Pallet

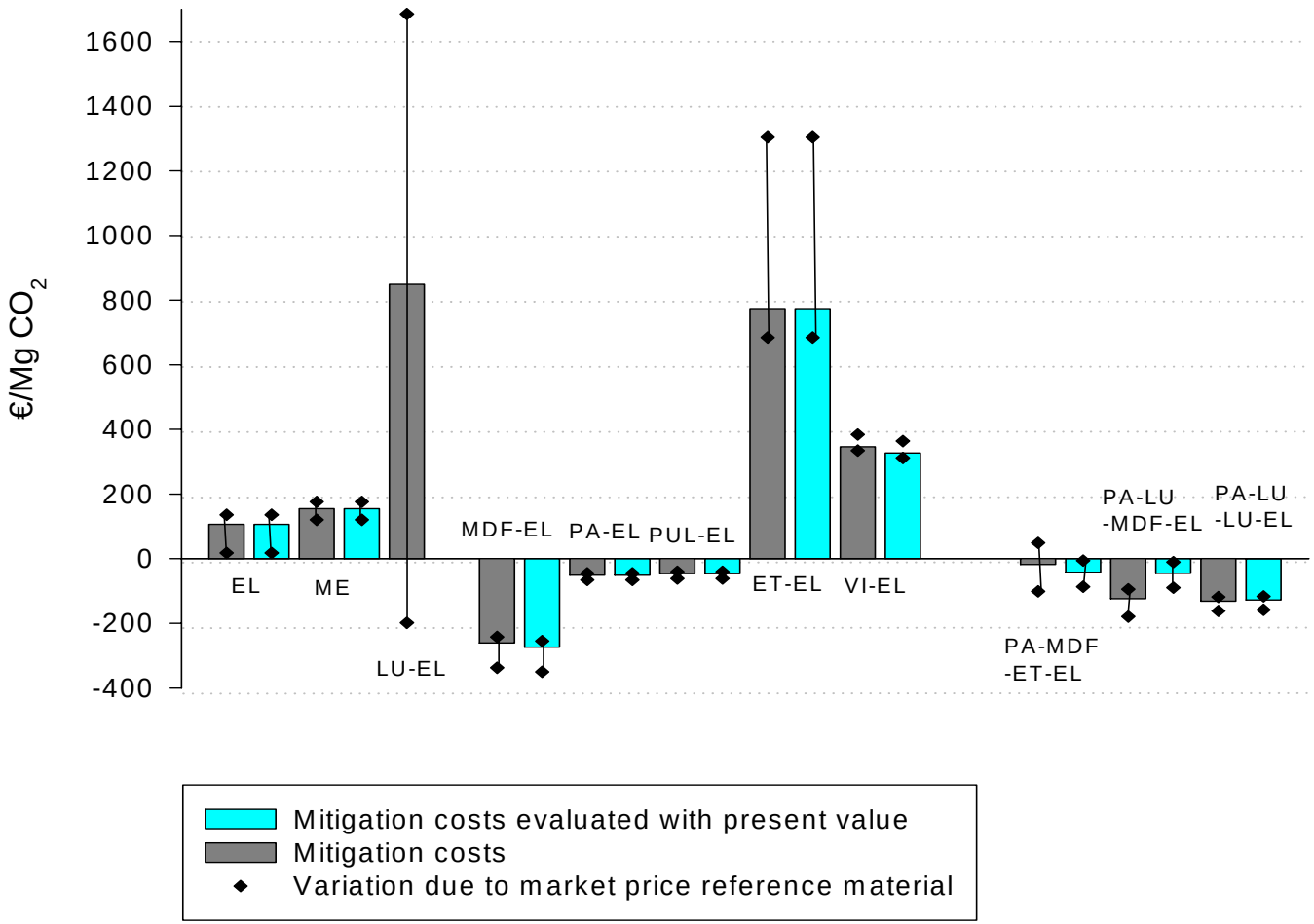
PUL: Pulp

ET: Ethylene

VI: Viscose

Results

- CO_2 mitigation costs



EL: electricity

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Conclusions - Cascading

- **Biomass cascading** has potential to improve CO_2 emission reductions per ha/yr and CO_2 mitigation costs.
- But a shorter cascading chain can be favourable to long chains depending on
  - **depreciation of CO_2 emission reductions** in time
  - kind of **biomass applications**
- Applications **substituting wood products** from conventional forestry very attractive from a cost and CO_2 reduction point of view

Conclusions - Quantitative benefits

- The performance of different chains varies
  - Net CO_2 emissions per ha: from reductions of 28 Mg CO_2/(ha*yr) (PA-MDF-ET-EL) to net emissions of 8 Mg CO_2/(ha*yr) (LU-LU-ET-EL).
  - CO_2 mitigation costs: from benefits of 200 €/Mg CO_2 (MDF-EL) to costs of 2200 €/Mg CO_2 (LU-EL)
- Results are strongly influenced by:
  - Market prices of material
  - Gross energy requirements of reference materials
  - Performance of material production
  - Reference energy systems
  - Yields of biomass cultivation

Conclusions - Method

- The method presented is suitable to quantify the CO_2 emission reductions, costs and land use of biomass cascading systems.
- Using the **present value method** affects the performance of long-term cascading chains significantly
- Accepted **methodology to evaluate time aspects** in CO_2 reduction by biomass material use needed
- Also **methodology to account for use of (forestry) land in the reference system** necessary

References

- Dornburg, V., *Multi-functional biomass systems*, Department of Science Technology and Society, PhD-thesis Utrecht University, 2004, 216 pp; http://www.chem.uu.nl/nws.

- Dornburg, V., Faaij, A., *Cost and CO_2-emission reduction of biomass cascading - Methodological aspects and case study of SRF poplar* (Climatic Change, in press).