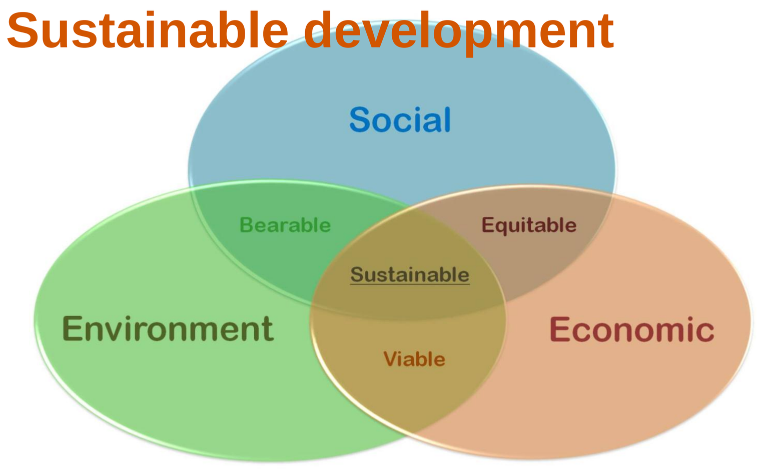
Use of Life Cycle Assessment to determine the environmental impact of thermochemical conversion routes of lignocellulosic biomass: state of the art

S. Gerbinet, A. Léonard

Laboratory of Chemical Engineering – Sustainable processes and development - University of Liège, Building B6 – Sart-Tilman, 4000 Liège, Belgium. Saicha.Gerbinet@ulg.ac.be

Introduction

Sustainable development



Biomass

- Limited fossil fuel resources
- Too much energy dependence

First generation:

- High waste
- Low yield

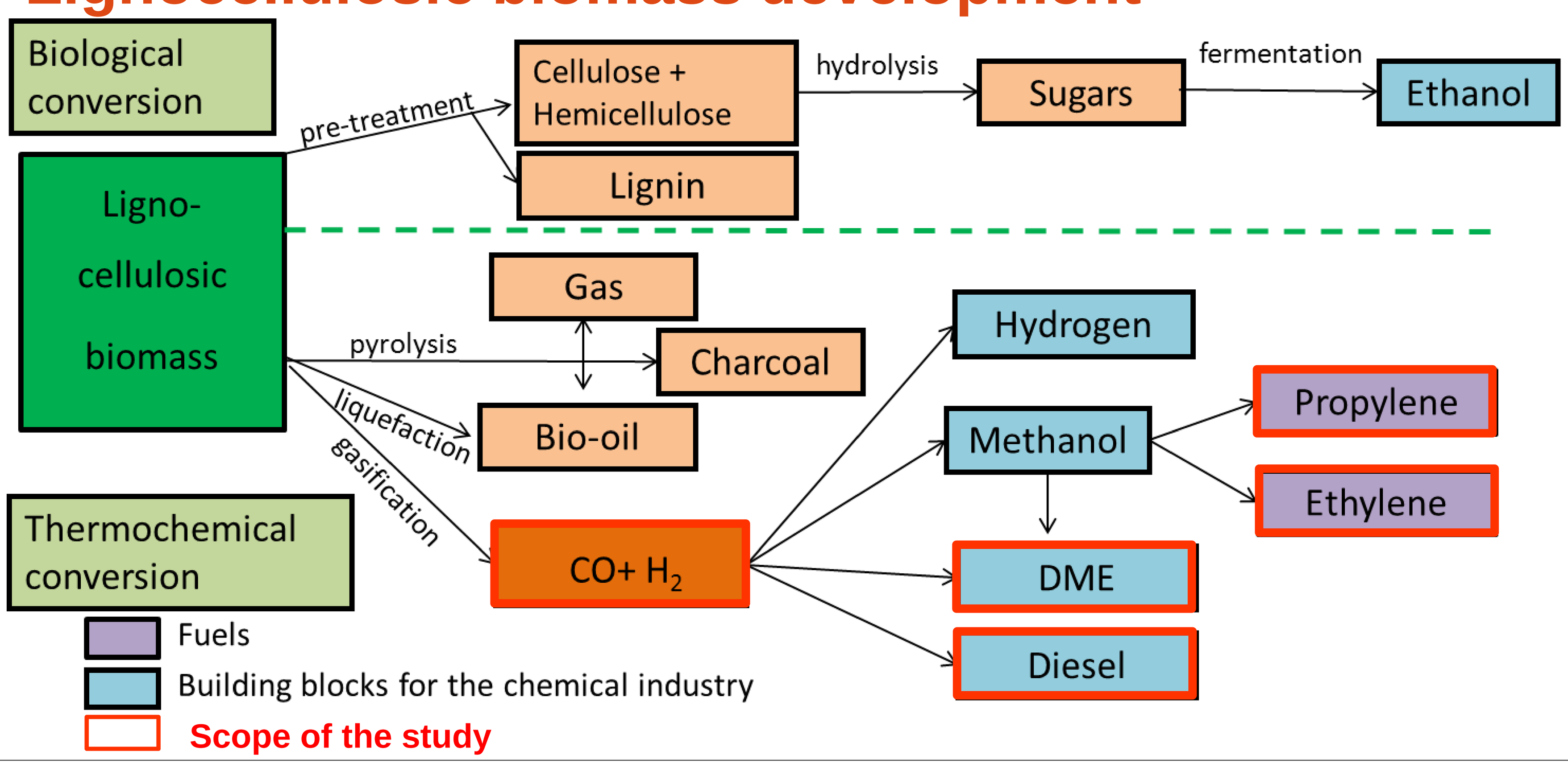
→ Competition for land / water with food crops

Lignocellulosic biomass (second generation technologies)

Abundant, cheap, and available in non-food plants: wood and energy crops such as miscanthus.

Environmental impact ? LCA (Life Cycle Assessment)

Lignocellulosic biomass development



Bibliography

Many studies on the technological aspects of lignocellulosic biomass, but few on the environmental aspects (LCA), presented here:

	Fuels type	Feedstock	dLUC	Well-to-wheel	Environmental impact	Eco	Comp. fossil	Comp biofuel	Sensi-tivity	Uncertainty	Results
1	FT-diesel	Switchgrass And/or coal	yes	well-to-tank	GWP	yes	no	no	no	no	GWP
2	FT-diesel	Biomass / coal / gas	no	yes	Energy Consumption (EC) GWP	yes	yes	no	yes	yes	EC GWP
3	FT-diesel	Biomass /coal / gas	no	well-to-tank	Energy consumption GWP Emissions	no	yes	no	no	no	EC GWP Emissions
4	FT-diesel	Biomass /coal	no	well-to-tank	Cumulative Energy Demand CED GWP	no	no	Green diesel	no	no	CED GWP
5	FT-diesel	Biomass	no	well-to-tank	Energy consumption GWP	yes	no	Green diesel	no	no	Cost GWP
6	Methanol	Bagasse	no	well-to-tank	CML and normalization	no	no	no	no	no	
7	Methanol	Wood	no	well-to-tank	CO_2	yes	yes	no	no	no	CO_2 if co-generation but Cost
8	Hydrogen Methanol	Biomass	no	well-to-tank	Energy Payback Time CO_2	yes	yes	yes	no	no	H_2 than methanol Biofuels than fossils
9	FT-diesel Ethanol DME	Switchgrass	no	yes	Fossil Energy Consumption Emission	no	yes	1st generation	no	no	FEC Emission
10	FT-diesel Ethanol Hydrogen	Biomass /natural gas /wind (H_2)		yes	Energy Consumption (EC) GWP	no	Diesel gasoil	1st generation	yes	no	EC : diesel ethanol GWP
11	1st and 2sd generation	Biomass	no	well-to-tank	Energy Consumption (EC) GWP	no	yes	yes	yes	no	2d generation than fossil fuel

eco = economic analysis; Comp. = comparison; Result: green environmental indicator : studied fuel better than the fuel (comparison(s) colon(s))

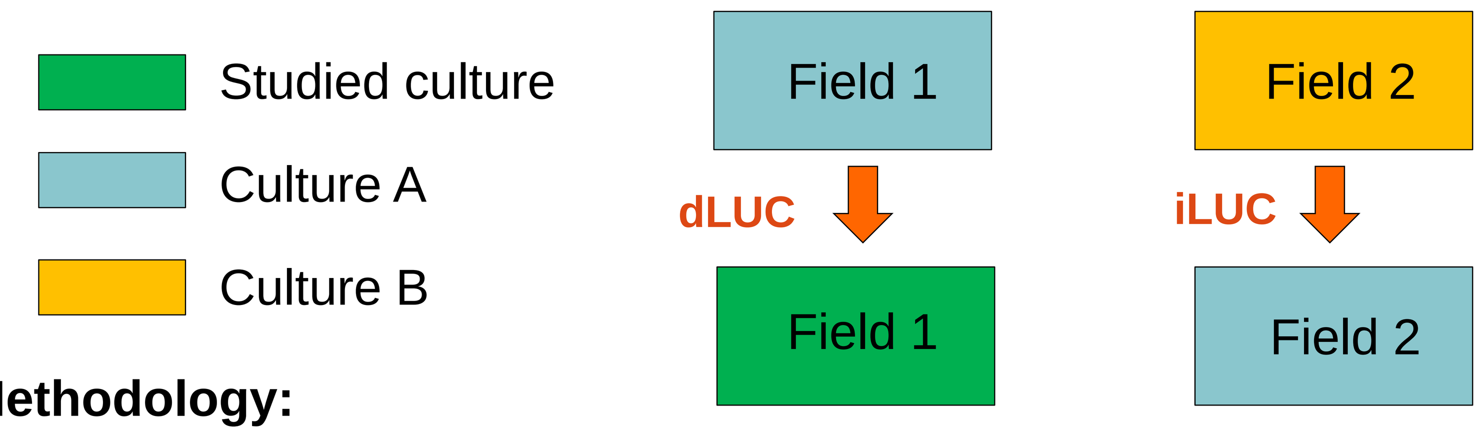
Studies not complete:

- all aspects never taken into account in one study
- dLUC generally not taken into account – iLUC, never

→ **New studies are necessary** → **Land Use Change Impact**
→ **Whole Life Cycle**

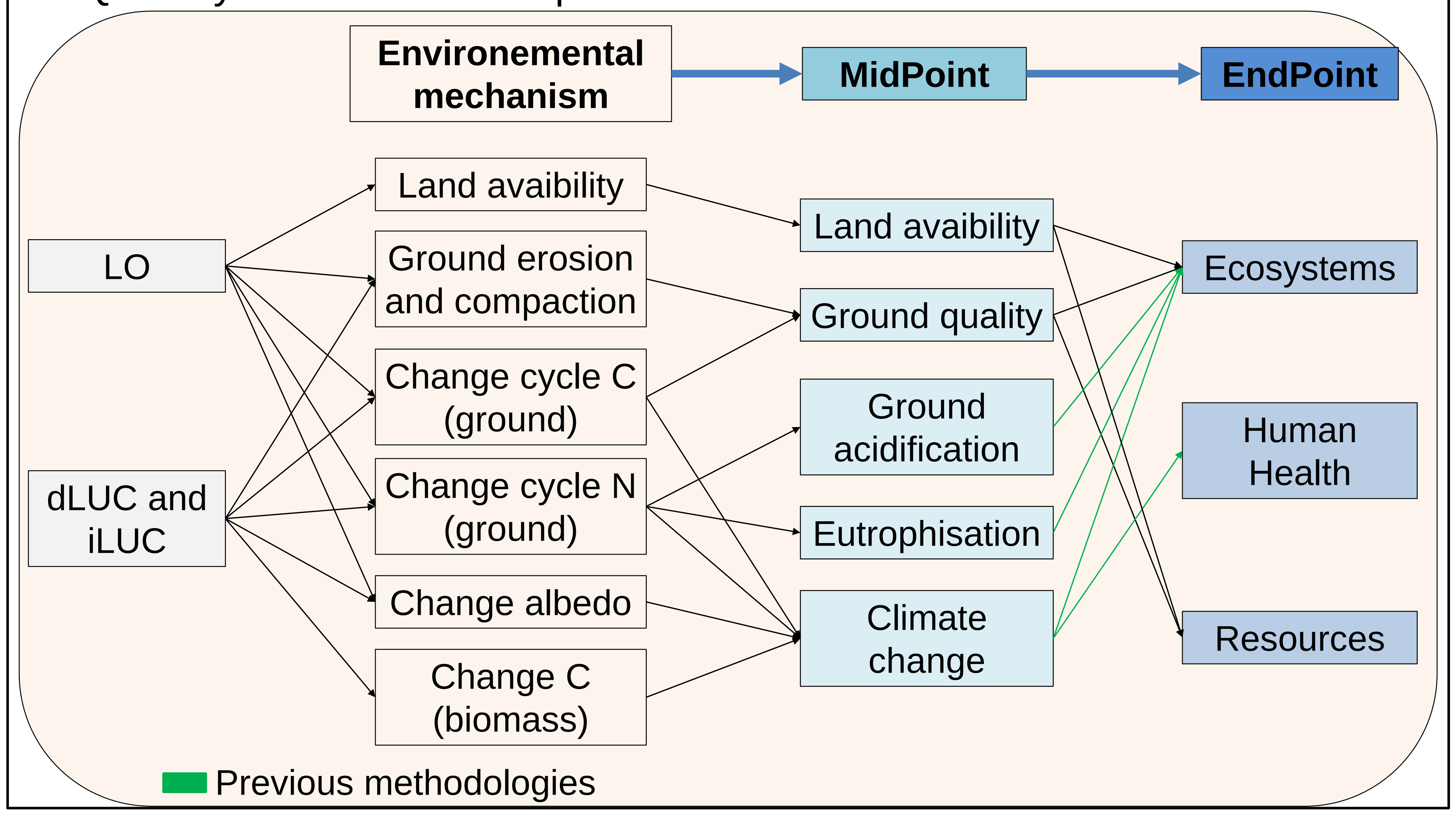
New methodological development for Land Use Change

3 Aspects: Land Occupation (LO) and Direct and Indirect Land Use Change (dLUC and iLUC).



Methodology:

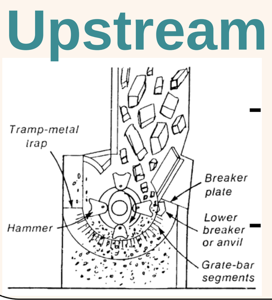
1. Determine required land and its properties (slope, fertility, etc.)
2. Determine dLUC and iLUC (most likely changes, yield improvement, etc. in a *regional* context)
3. Determine reference state, duration and final state. The reference state can be different than the initial state (most likely state, state before any human activity, etc.)
4. Quantify environmental impacts:



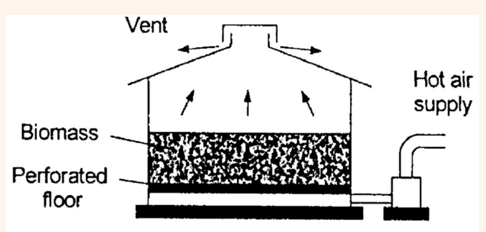
Process

Upstream process

Biomass pretreatment

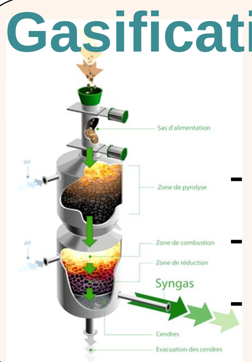


- Size reduction
- Drying



Gasification

Biomass + Oxidizing agent → **Syngaz**



- Air
- Oxygen
- Steam

1. T: 600 – 1000 °C
Heat supply: allothermal or autothermal
2. Oxidizing agent flow rate

Downstream process

Gas cleaning and reforming

- Nitrogen and sulfur compounds
- Particle removal
- Alkali removal
- Tar elimination
- Reforming

Methanol — T: 180 – 270 °C, P: 50 -100 bar, Catalyst: Cu/Zn

Methanol → Heavy olefins / Light olefins (MTO: methanol to olefins) → Ethylene / Propylene (Olefins cracking) → Chemical Industry

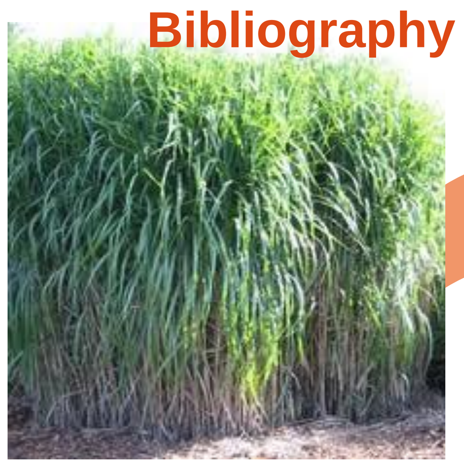
DME — From methanol: T: 250 → 365 °C - Catalyst: alumina; From gas: T: 240 °C - P >30 bar - Catalyst

Fischer- Tropsch synthesis → Lubricating oil and paraffin wax — T: 220 – 250°C, Catalyst: Co or Fe → Hydrocracking → Diesel

Fuel

Conclusions and perspectives:

Promising processes for substituting fossil fuels. Their environmental impact remains uncertains → LCA methodology
LCA adapted to include land use change effect.
Allow comparison beween biomass development and fossil technologies.



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