
Land use change:

An essential aspect of Life Cycle Analysis of lignocellulosic biomass conversion processes

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LABORATORY of CHEMICAL ENGINEERING

Processes and Sustainable development

Agenda

1. Introduction
2. Lignocellulosic biomass conversion processes
3. Gasification
4. Life Cycle Analysis
5. Land Use Change
6. Conclusion

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Introduction

- Biomass
- Biofuels
 - 1st generation
 - 2nd generation



➔ **Lignocellulosic biomass**

http://www.lemonde.fr/planete/article/2013/01/08/la-production-d-agrocarburants-menace-la-qualite-de-l-air-en-europe_1813735_3244.html

Introduction

→ Lignocellulosic biomass

Wood



<http://www.bioenergie-promotion.fr/21906/7-septembre-2012-journee-technique-sur-la-qualite-du-bois-energie/>

Energy crops

Straw



<http://www.agriculteur-normand.com/reussir/public/impression.php?codeArticle=7774&idsite=14>

Miscanthus

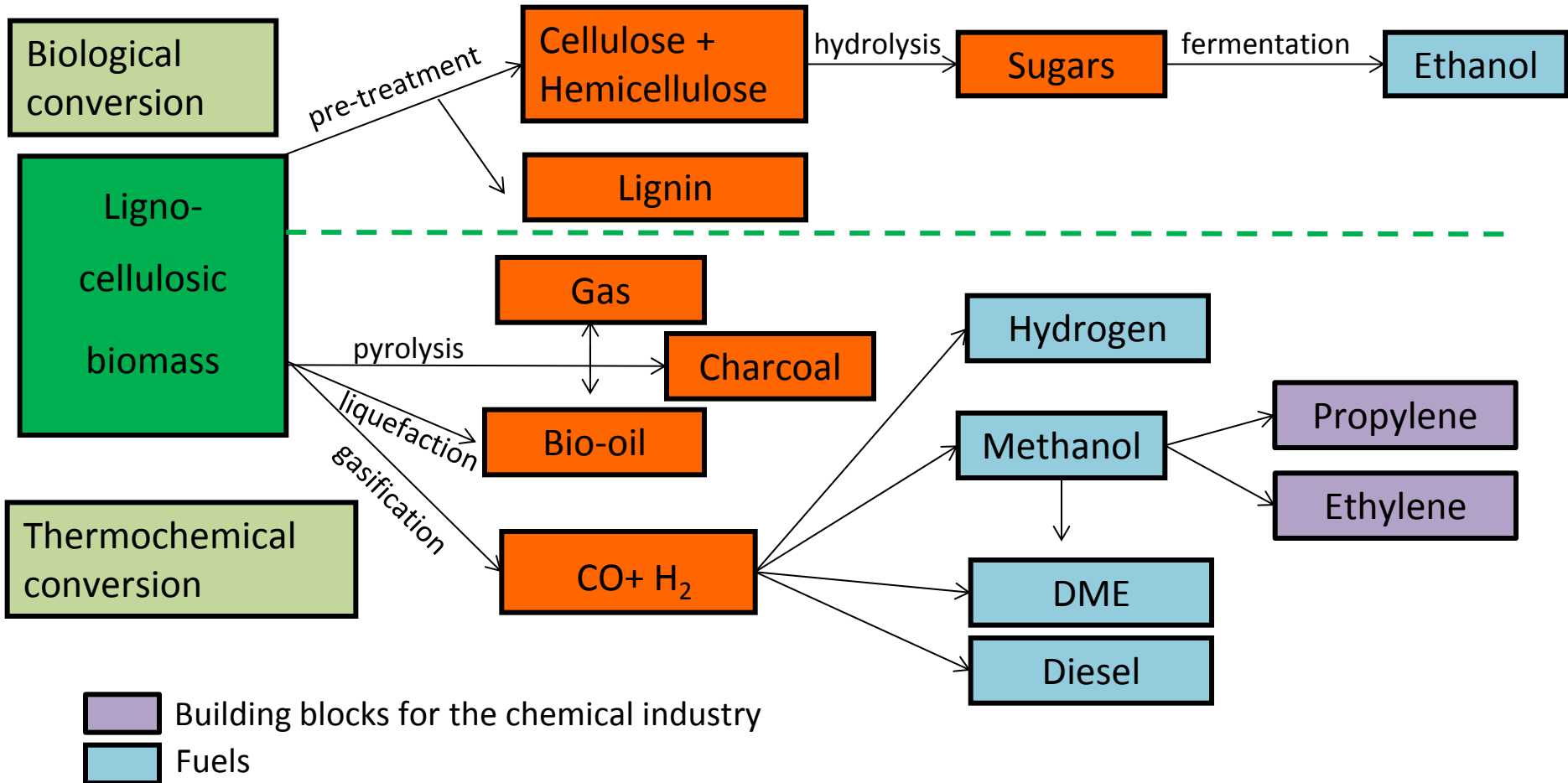


<http://missouribeginningfarming.blogspot.be/2012/02/giant-miscanthus-grass-good-or-bad.html>

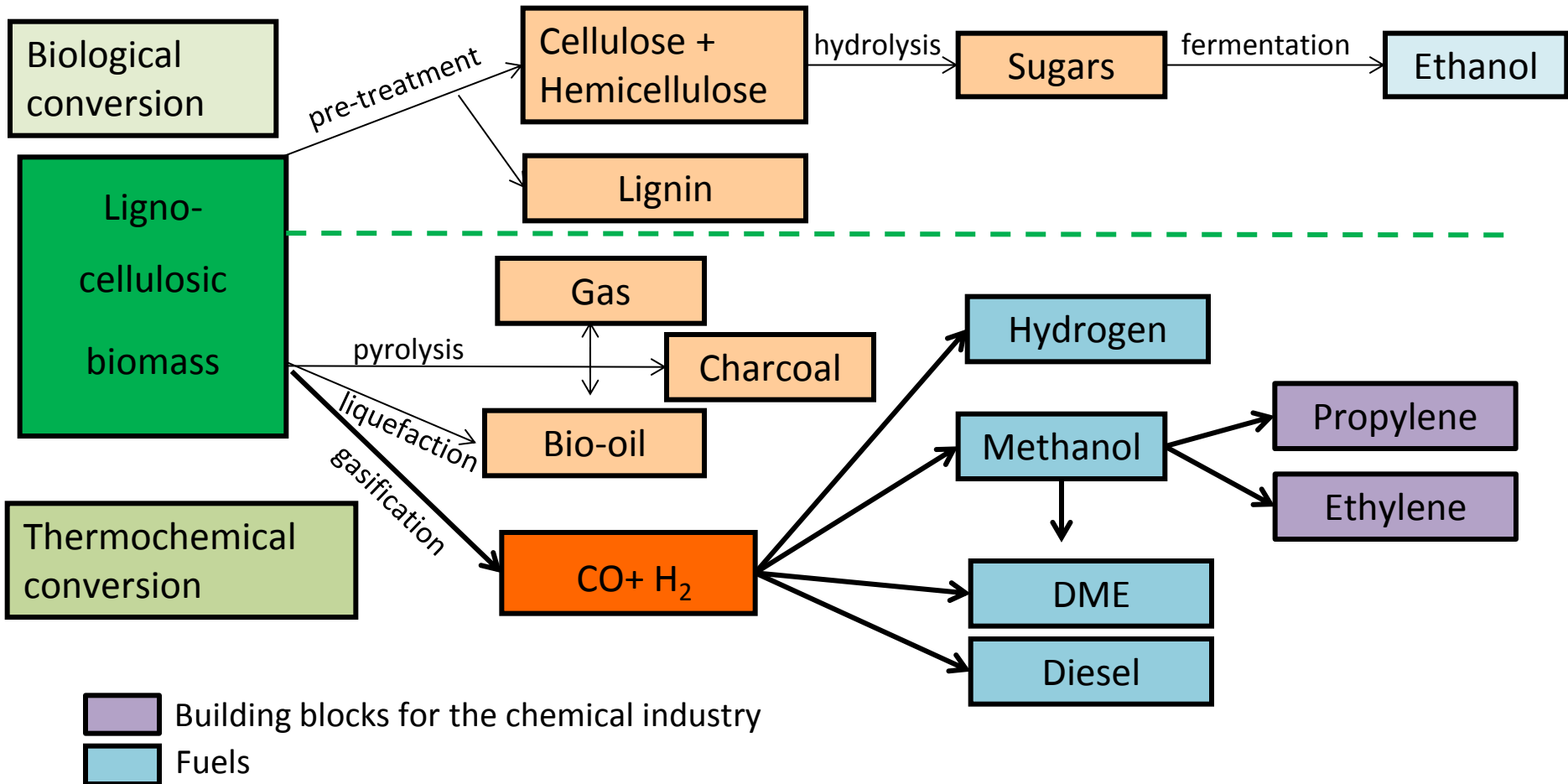
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Conversion processes



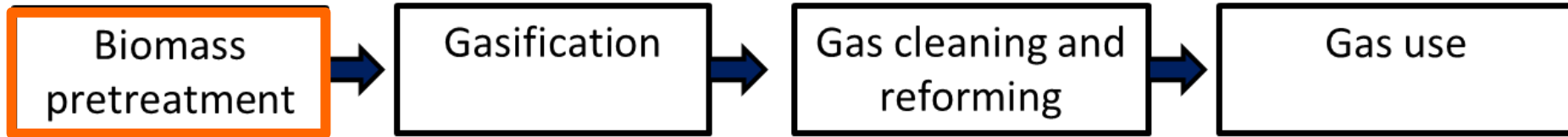
Conversion processes



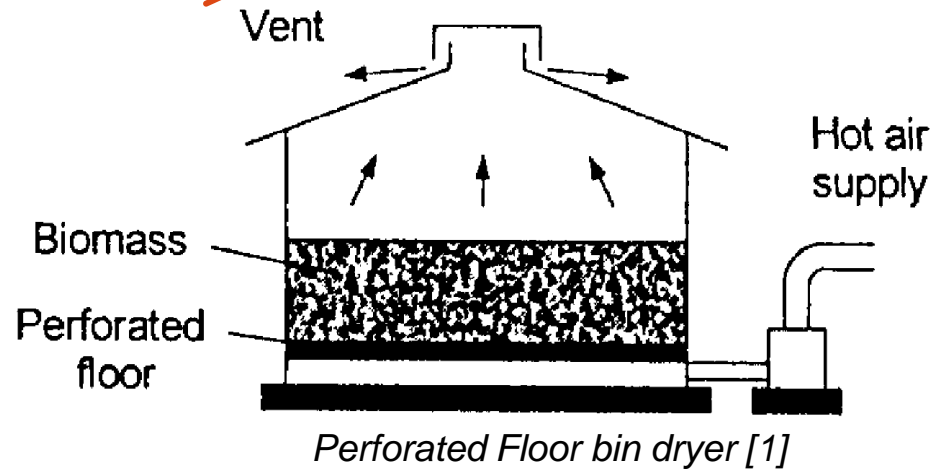
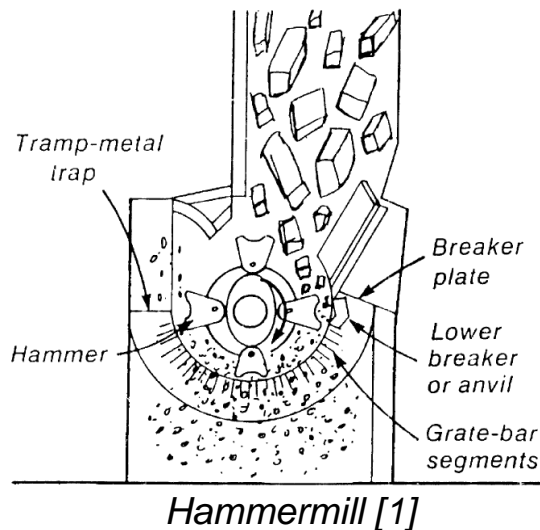
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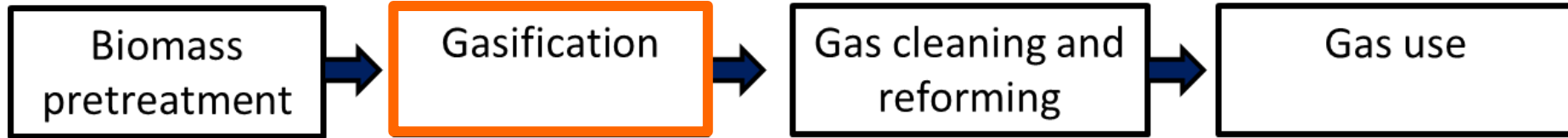
The Processes



→ Size reduction and drying

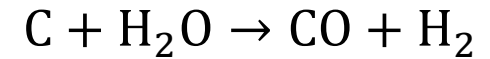
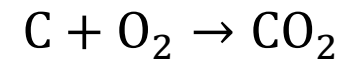
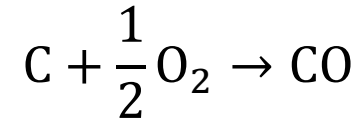


The Processes



Biomass + Oxidizing agent → Syngaz

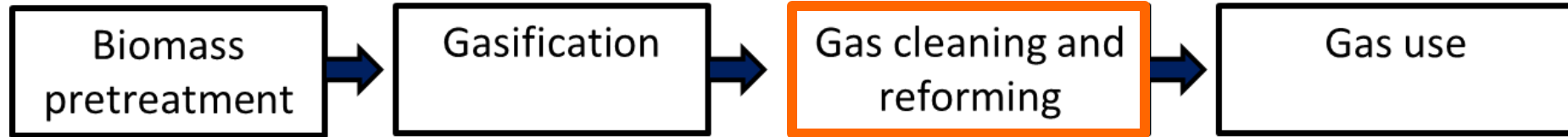
T: 600 – 1000 °C



- Air
- Oxygen
- Steam

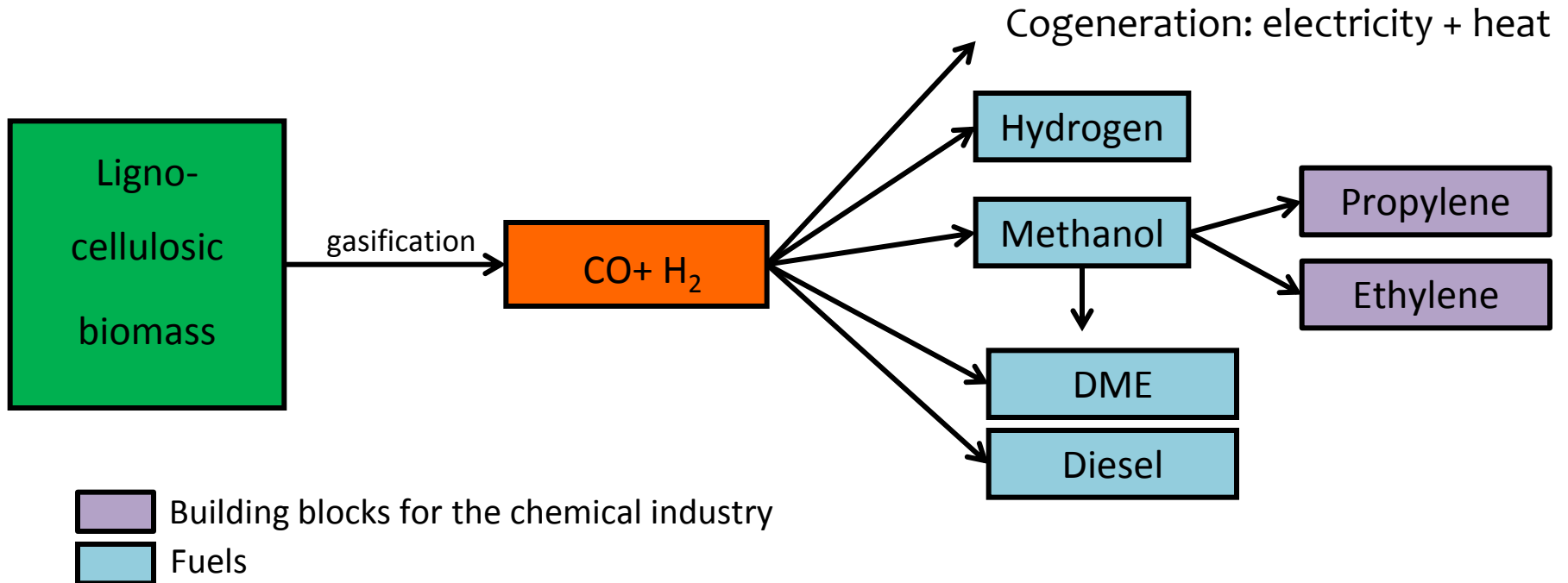
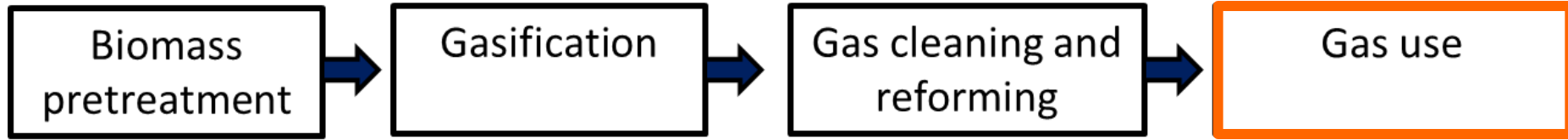
Component	% (volume)
CO	28-36
H ₂	22-32
CO ₂	21-30
CH ₄	8-11

The Processes



- Depends on the gas use

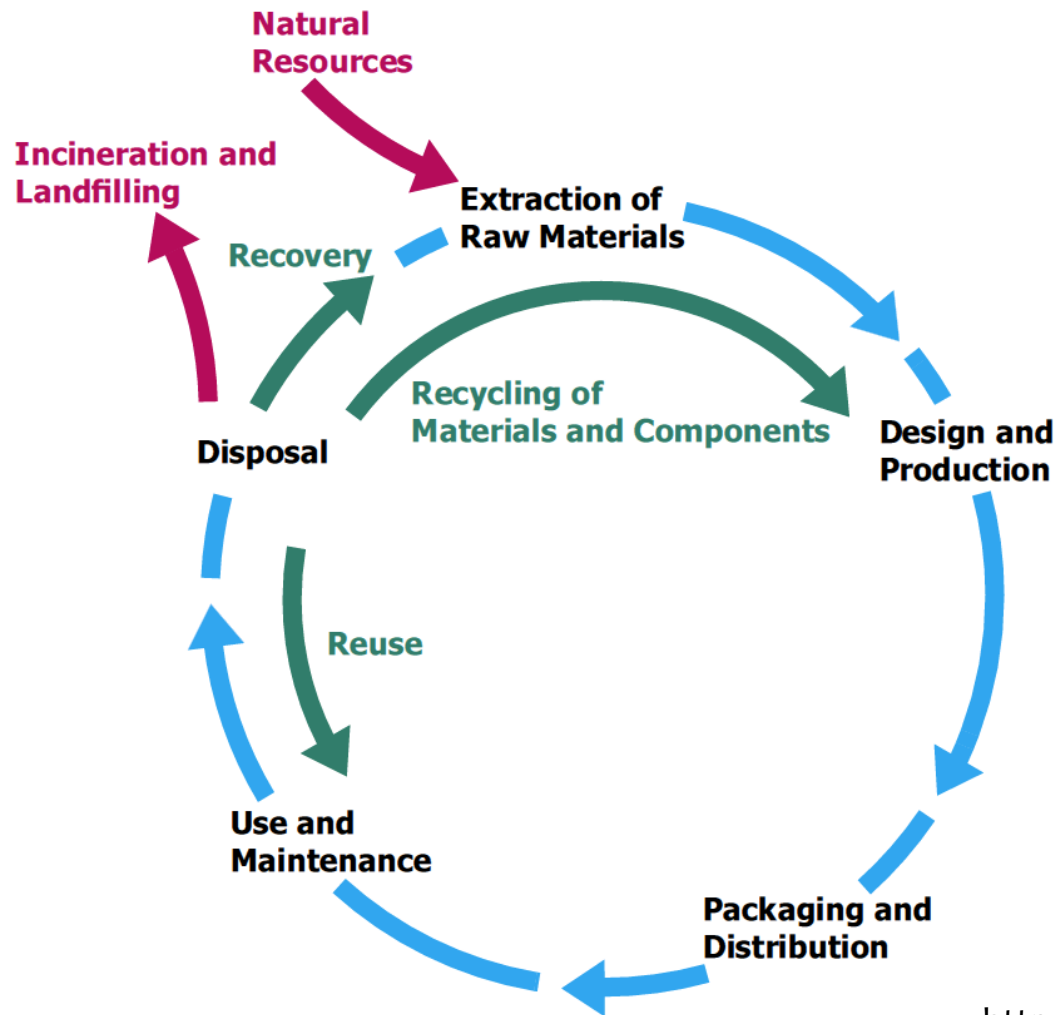
The Processes



Agenda

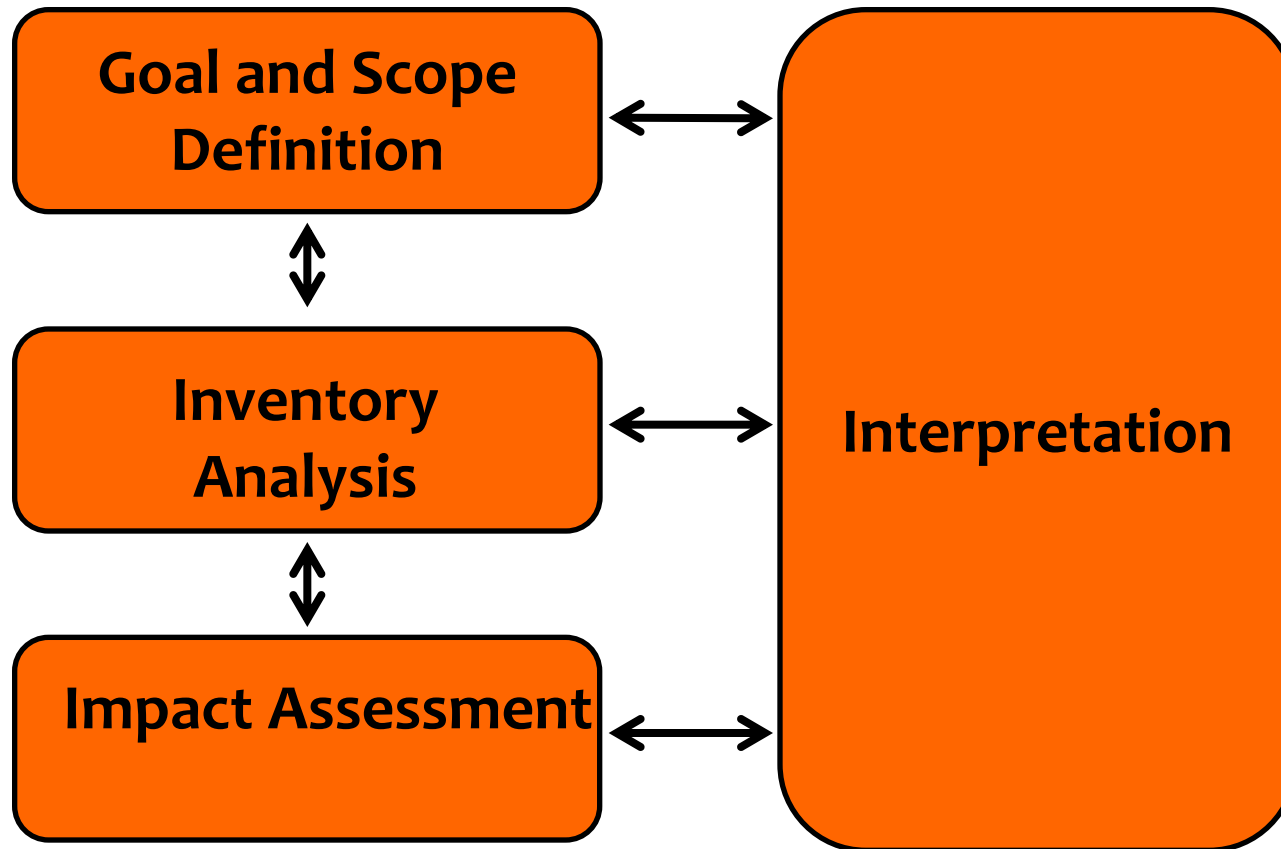
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The LCA methodology



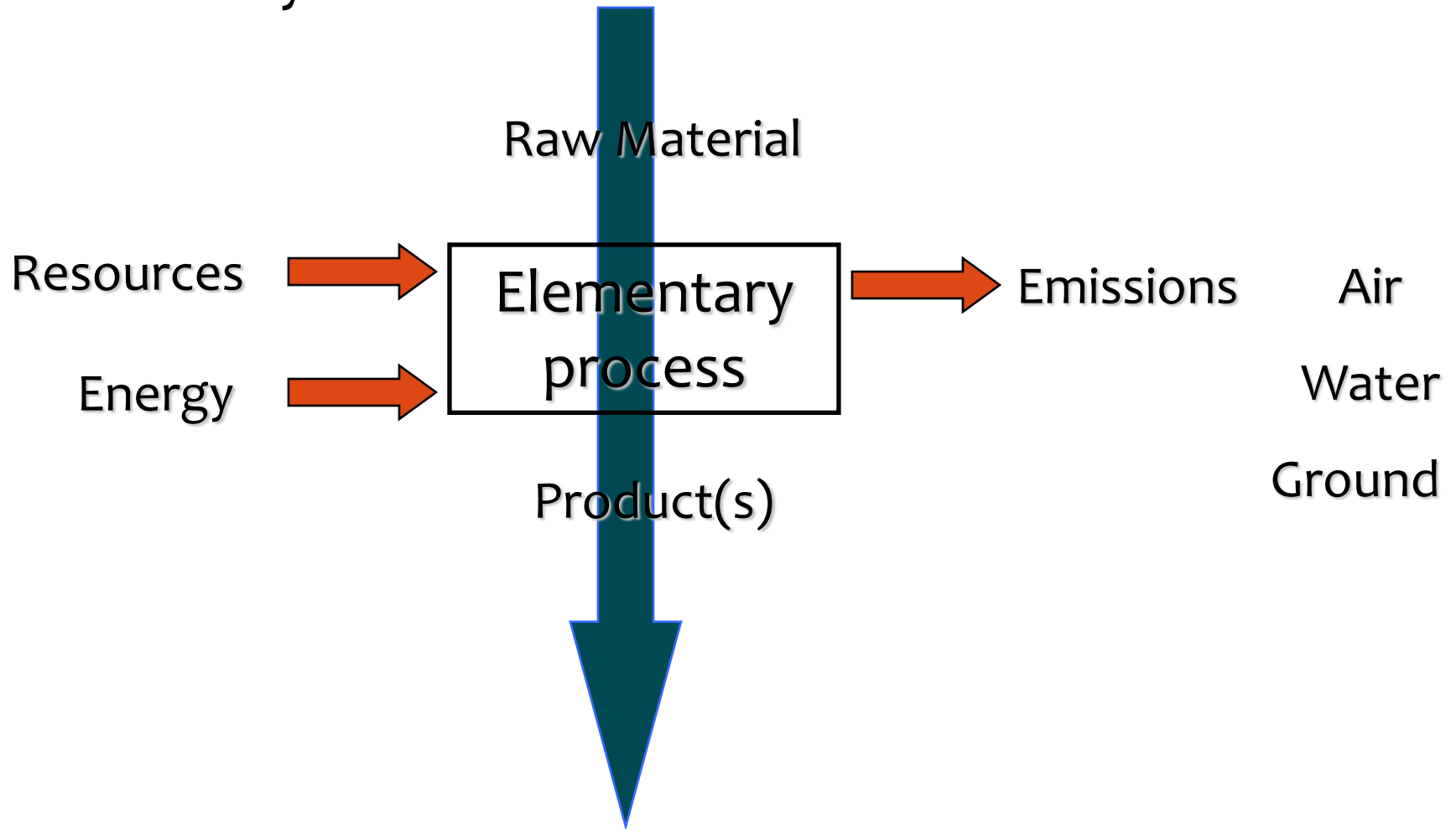
<http://www.unep.fr/scp/lifecycle/>

The LCA: four interdependent steps

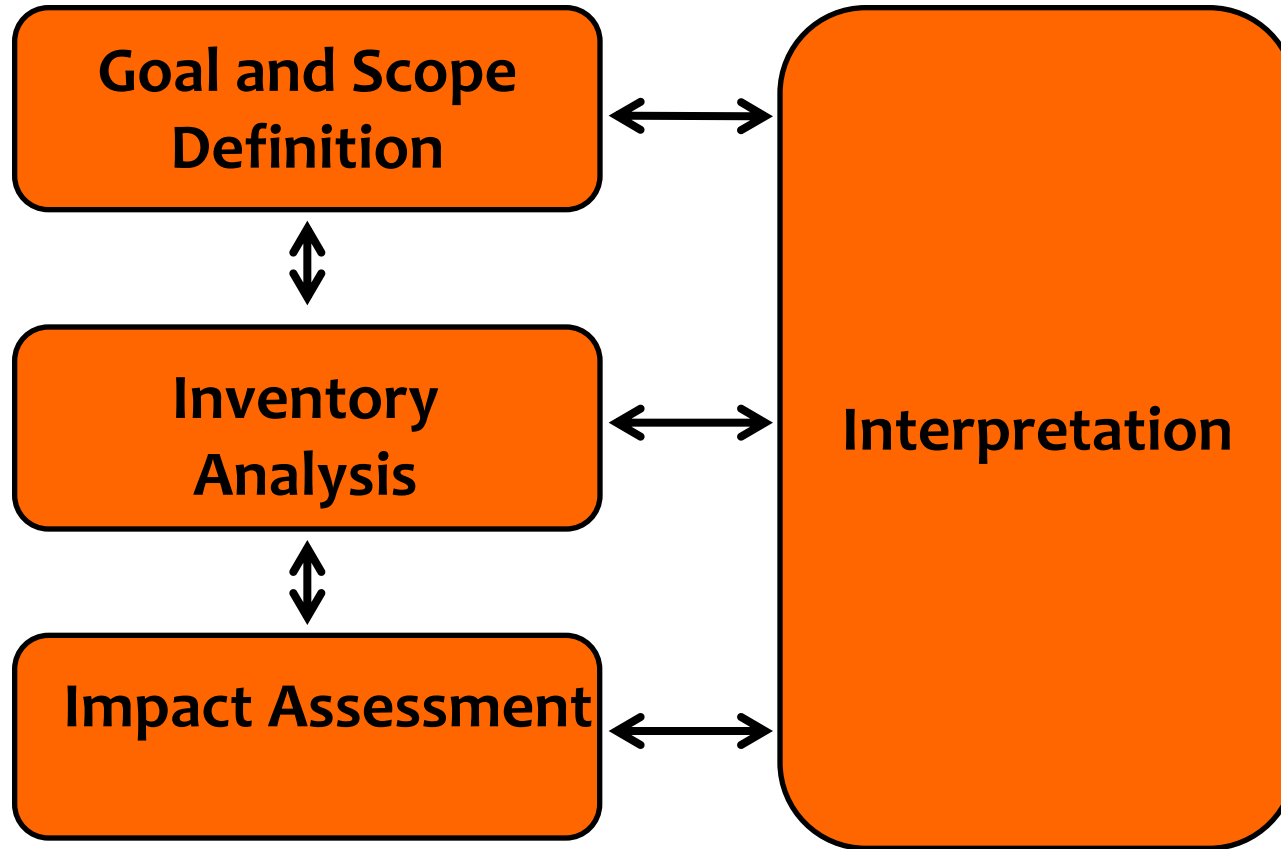


The LCA methodology

- Inventory



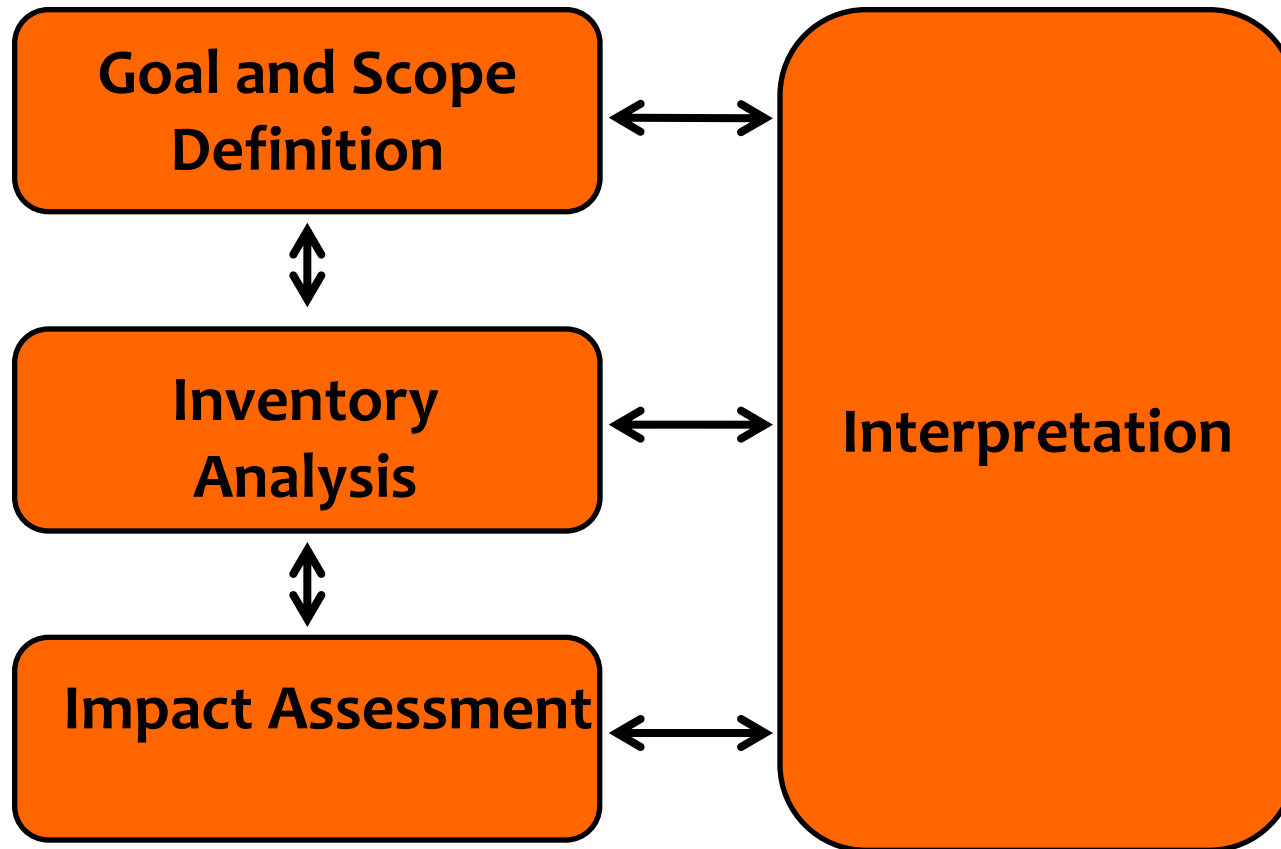
The LCA: four interdependent steps



Impact Assessment

- 2 levels
 - MidPoint
 - Impact categories such as climate change, eutrophication, acidification, etc.
 - EndPoint
 - Resulting impact on human health, ecosystem quality or resources depletion

The LCA: four interdependent steps



Previous studies

→ Many studies on the technological aspects of lignocellulosic biomass gasification, but **few on the environmental aspects** (LCA)

→ **Results:**

Lignocellulosic biomass $><$ fossil fuels

- **Better:** Global Warming Potential

Emissions

- **Worst:** Energy Consumption

Cost

→ But these studies are generally **not completed**

Previous studies

→ General shortcomings:

No study about propylene and ethylene

But also:

- ❑ **Impact of Land Use Change (direct or indirect)**
- ❑ Fuel type
- ❑ No Well-to-wheel
- ❑ Impact categories
- ❑ Comparison with fossil fuel or biofuel
- ❑ Sensitivity analysis
- ❑ Uncertainty analysis

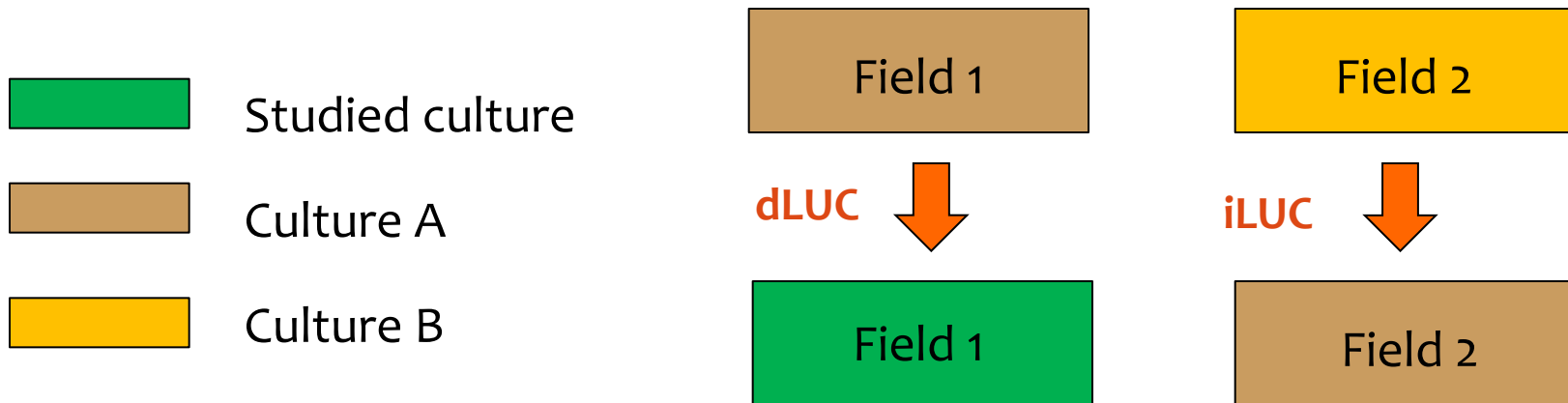
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Land Use Change (LUC)

3 Aspects:

- ❑ Land Occupation (LO)
- ❑ Direct Land Use Change (dLUC)
- ❑ Indirect Land Use Change (iLUC).



Land Use Change (LUC)

2 levels:

- ❑ Specific localization (example: rail localization)
- ❑ Unspecific localization (example : crops deployment)



http://commons.wikimedia.org/wiki/File:Voie_de_chemin_de_fer_avec_traverses_en_b%C3%A9ton_de_type_monobloc.jpg

<http://www.bien-voyager.com/preparer-son-voyage-en-ligne-etape-2-elaborer-son-itineraire-de-voyage/>

Land Use Change (LUC)

2 levels:

- ❑ Specific localization (example: rail localization)
- ❑ Unspecific localization (example : crops deployment)



<http://www.monde-diplomatique.fr/1994/02/BEAUGE/178>



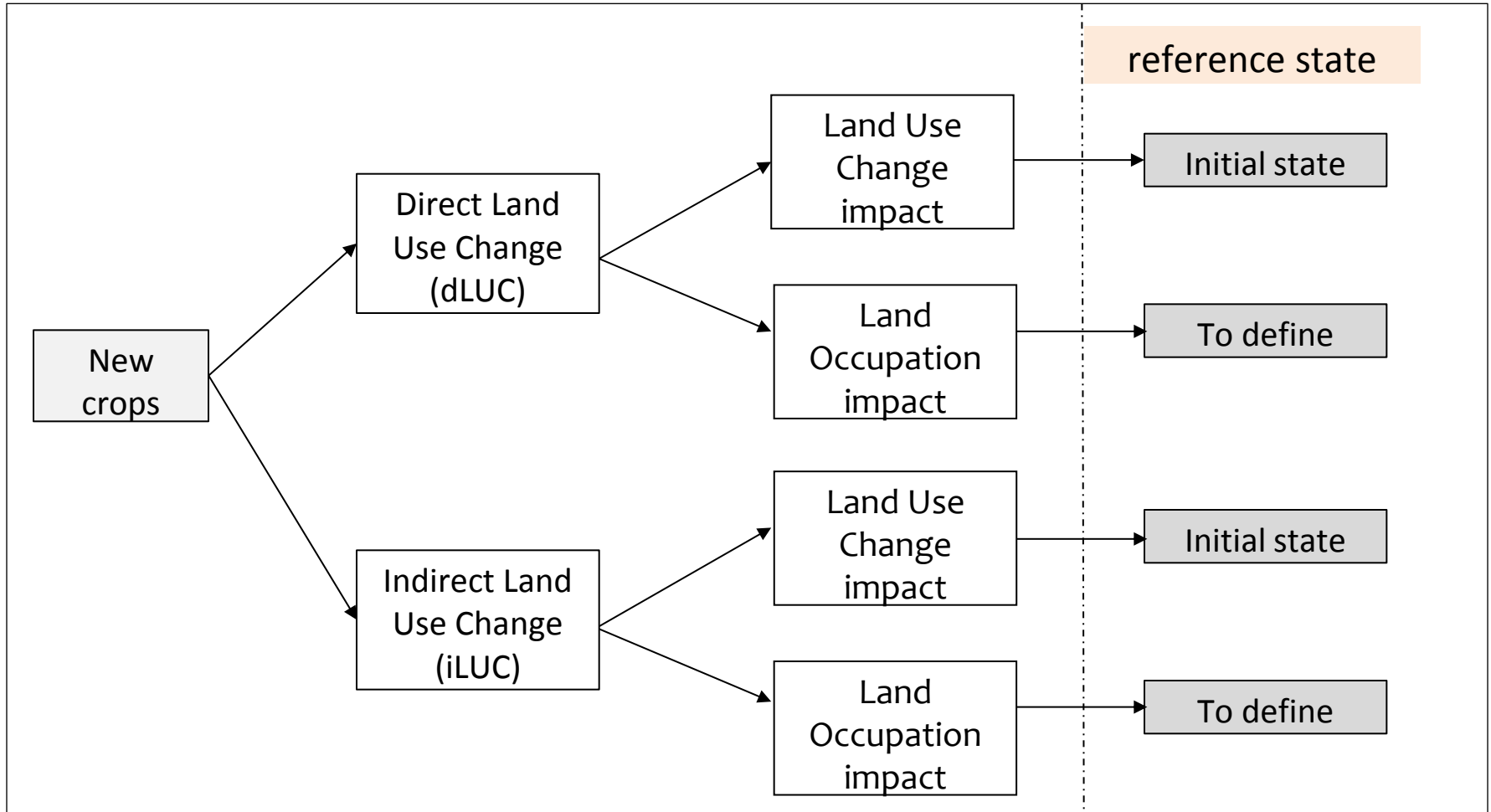
<http://missouribeginningfarming.blogspot.be/2012/02/giant-miscanthus-grass-good-or-bad.html>

➔ **Scenarios**

Land Use Change (LUC)

- Important aspects:
 - Surface
 - Time
 - Reference state

Land Use Change (LUC)



Land Use Change (LUC)

- LUC has an impact on
 - Carbon cycle
 - Physical properties of the ground
 - Nitrogen cycle
 - Hydraulic cycle
 - Pollutants flux (methane, COV, etc.)
 - Etc.
- ➔ Environmental impacts

Land Use Change (LUC)

- Global Warming Potential :
A lot of work already done
- Other indicators

Land Use Change (LUC)

- Global Warning Potential :
A lot of work already done
- Other indicators

Global Warning Potential

- European standards
 - **Handbook:** how to calculate the **impact of carbon stock change**
 - **Directive:** how to calculate **the carbon stock**

Global Warning Potential

- European standard
 - **Handbook:** how to calculate the **impact of carbon stock change**
 - **Directive:** how to calculate **the carbon stock**

Emission from carbon stock change

- Add for 20 years
- Divided by 20 (equal distribution for each year)

Global Warning Potential

- European standard
 - **Handbook:** how to calculate the **impact of carbon stock change**
 - **Directive:** how to calculate **the carbon stock**

$$C_{Si} = (SOC + C_{VEG}) \times A$$

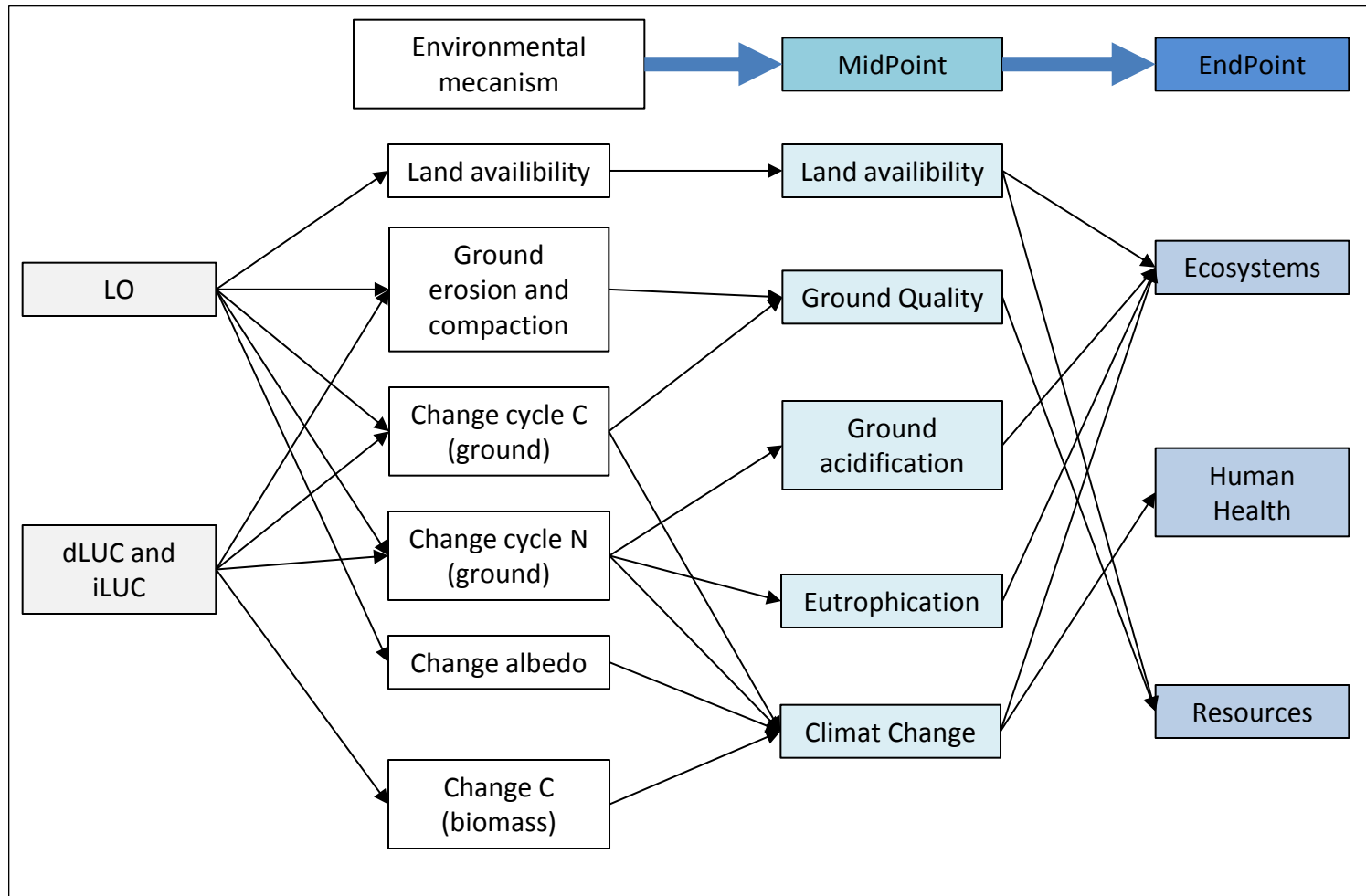
Carbon in the ground

Carbon in the biomass
(dead or living)

Land Use Change (LUC)

- Global Warning Potential :
A lot of work already done
- Other indicators

Land Use Change (LUC)



Land Use Change (LUC)

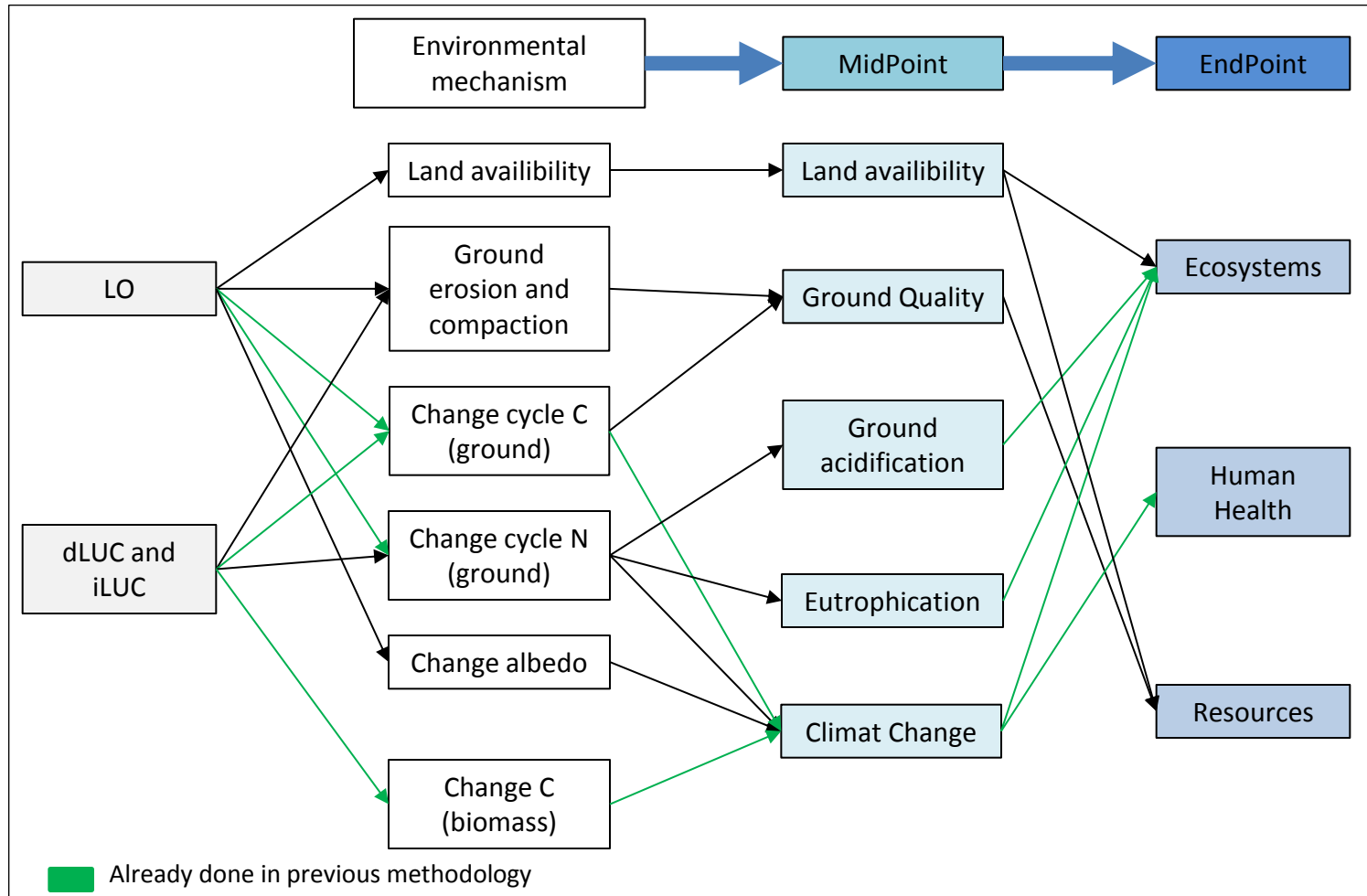
- Global Warning Potential :
A lot of work already done
- Other indicators

Example: Land availability

Land Use Change (LUC)

- Land availability: how to measure it?
 - In m^2 ?
BUT Independent of the intensity of the use, etc.
 - Yield? Productivity of biomass?
BUT only focuses on agricultural uses
- Difficult to express... How to quantify it?

Land Use Change (LUC)



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Conclusions and perspectives

- Promising processes for substituting fossil fuels. BUT their environmental impact remains uncertain → **LCA methodology**
- LCA has to be adapted to include **land use change** effect:
 - Impact of carbon stock change on Global Warming Potential: the European methodology
 - Other indicators: a lot of work still to do

Thank you for your attention

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