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# Life Cycle Assessment: a key decision tool for biomass valorization

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CHEMICAL ENGINEERING

*Processes and Sustainable Development*

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1. Context of research
2. Life Cycle Assessment methodology
3. Environmental evaluation of biomass utilization
4. Perspectives in biomass and bioenergy field

# Context

- Environmental consciousness of politics, industrials and consumers
- “20/20/20” European goal
- 13% of renewable energy in Belgium in 2020



# Context

- Belgian renewable energy availability
  - Wind
  - Solar (PV)
  - Hydroelectricity
  - Biomass
- Support tools for politics decisions
  - Need of “sustainable” tools



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# Life Cycle Assessment – Methodology

- LCA (Life Cycle Assessment)
  - Environmental Management tool
  - Standardized tool (Standards ISO 14040 – 14044)
  - Still in development (methodology – methods – context)

# Life Cycle Assessment – Definition

- “ LCA describes environmental aspects and potential impacts throughout a product’s life cycle, i.e. raw material acquisition, production, use and disposal” ISO 14040
- Product = material product or service
- “Cradle to grave” approach

# Life Cycle Assessment – Uses

**Internal**

## Strategy

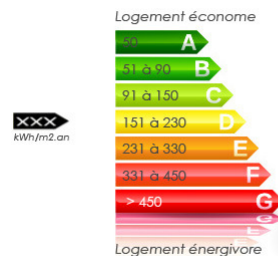
- Potential impacts of products on environment
- Investments decision support

## R & D products/process

- Early identification of problems/opportunities
- Assistance in projects selection
- Assistance in defining objectives

**External**

## Marketing

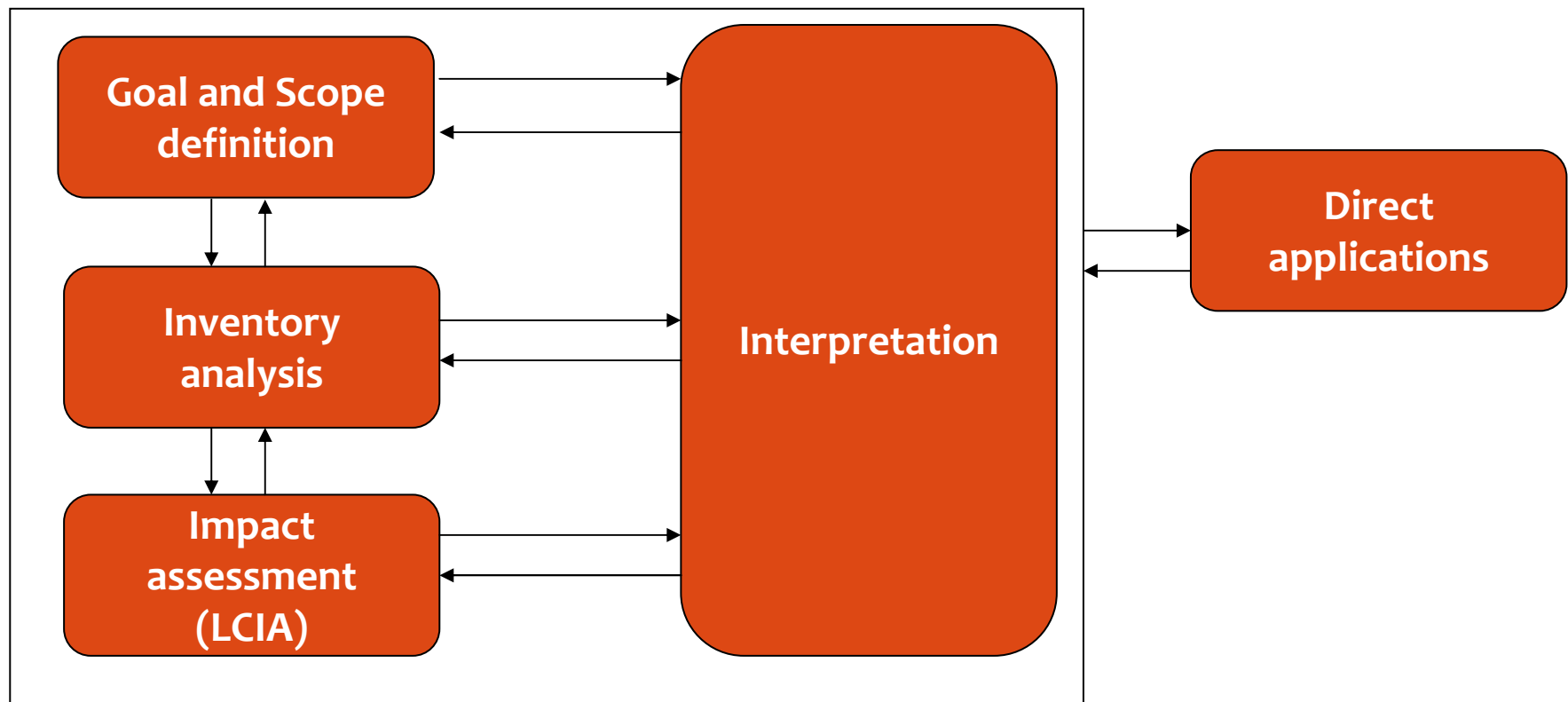


## Policy

- Best information of authorities, consumers, etc. (legislation/regulation, eco-labels ...)
- Comparative analyses

# Life Cycle Assessment – Steps

- Four stages described in ISO 14040



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# Biomass utilization

- Belgian biomass

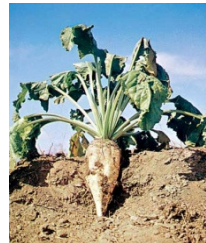
- Wood

- Used as pellets, chips by individuals or industries

- Energy crops

- “First generation”

- Rapeseed
      - Wheat
      - Sugar beet



- “Second generation”

- Still in technological development

# Biomass utilization

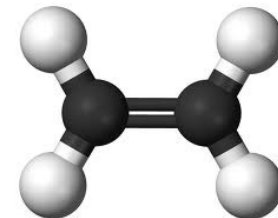
- Sugar beet

- Transformation in bioethanol via fermentation of sugars



- → Proved fuel potential
- → Chemical potential as bioethylene?

**Best sustainable choice ?**



# Biomass utilization – LCA

## ■ Goals of study

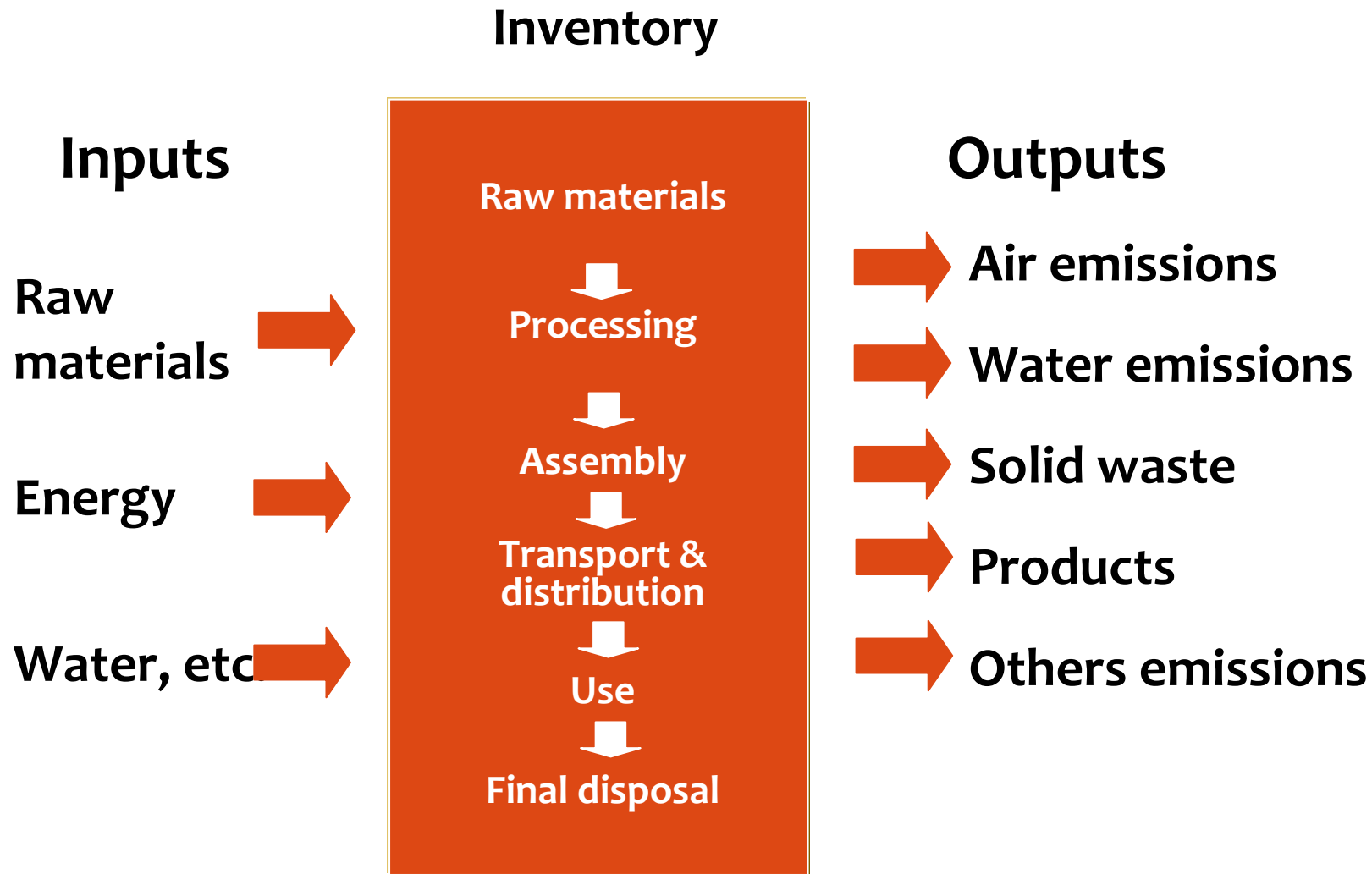
- ❑ To compare production of ethylene from bioethanol or from fossil fuels: ‘bioethylene’ vs. ethylene
- ❑ To allow debate on the use of bioethanol

## ■ Functional unit

- ❑ Bioethylene production with the cultivation of one ha of arable land



# Biomass utilization – Life Cycle Inventory

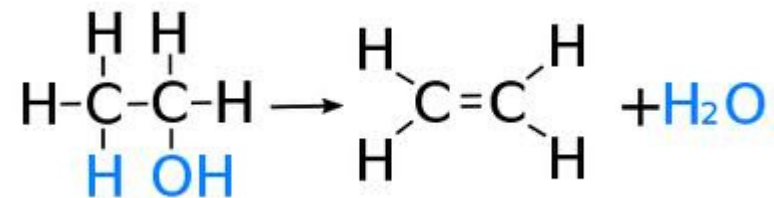


# Biomass utilization – Life Cycle Inventory

- Steps for bioethanol production
  - Cultivation of one ha
    - Production of seeds, fertilizers production, cultivation, harvest, etc.
  - Transportation
    - From agricultural land to factory
  - Production of bioethanol
    - Fermentation, pasteurization, distillation, drying of byproducts, etc.

# Biomass utilization – Life Cycle Inventory

- Steps for bioethylene production
  - Bioethanol production
    - All steps described before
  - Dehydration of bioethanol into bioethylene



- Production of ethylene
  - Use of database

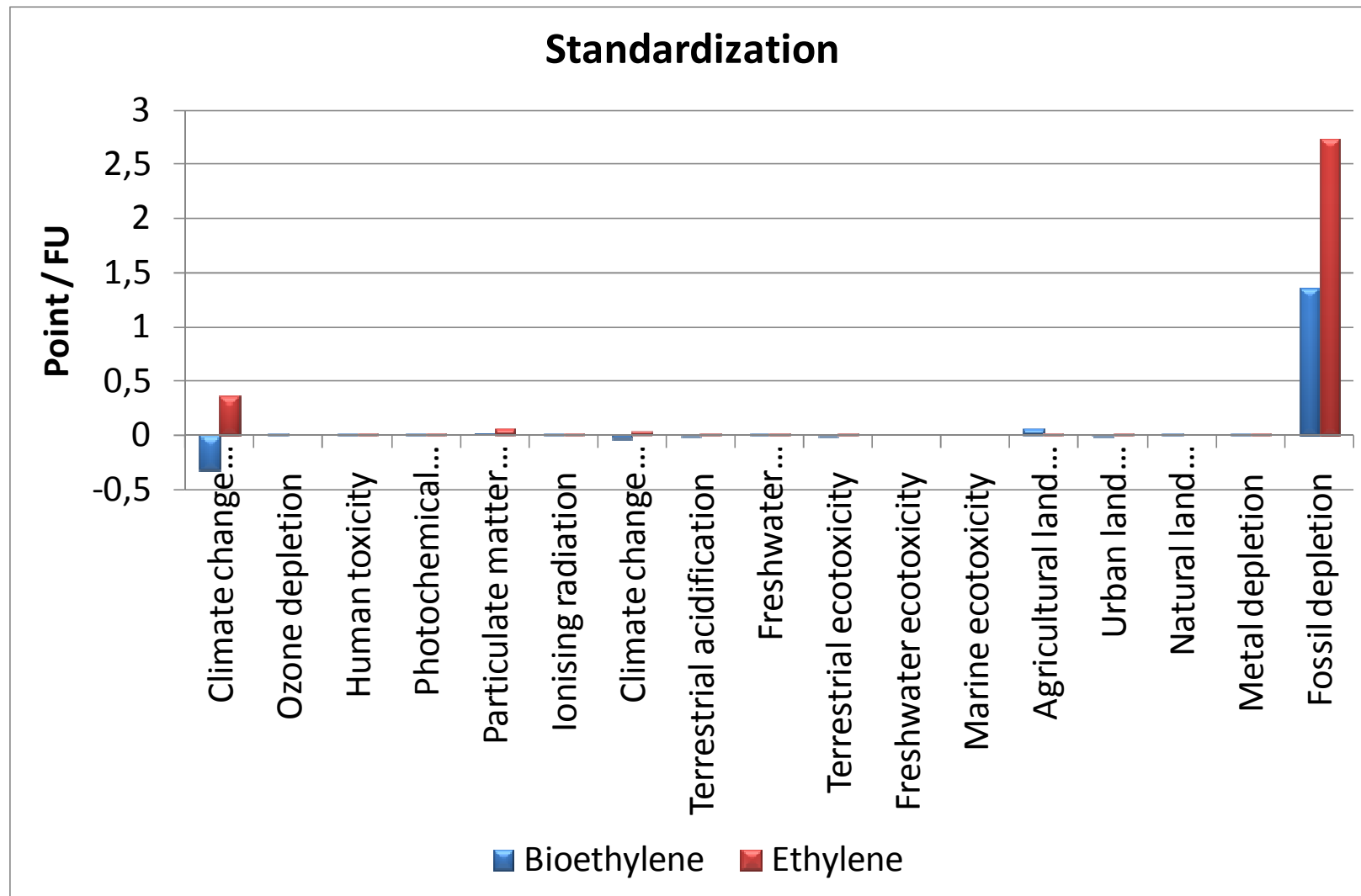
# Biomass utilization – Impact assessment

- Estimate the potential environmental impacts using the results of the inventory
- Provide elements of information for the interpretation phase of the life cycle
- Existence of different methods

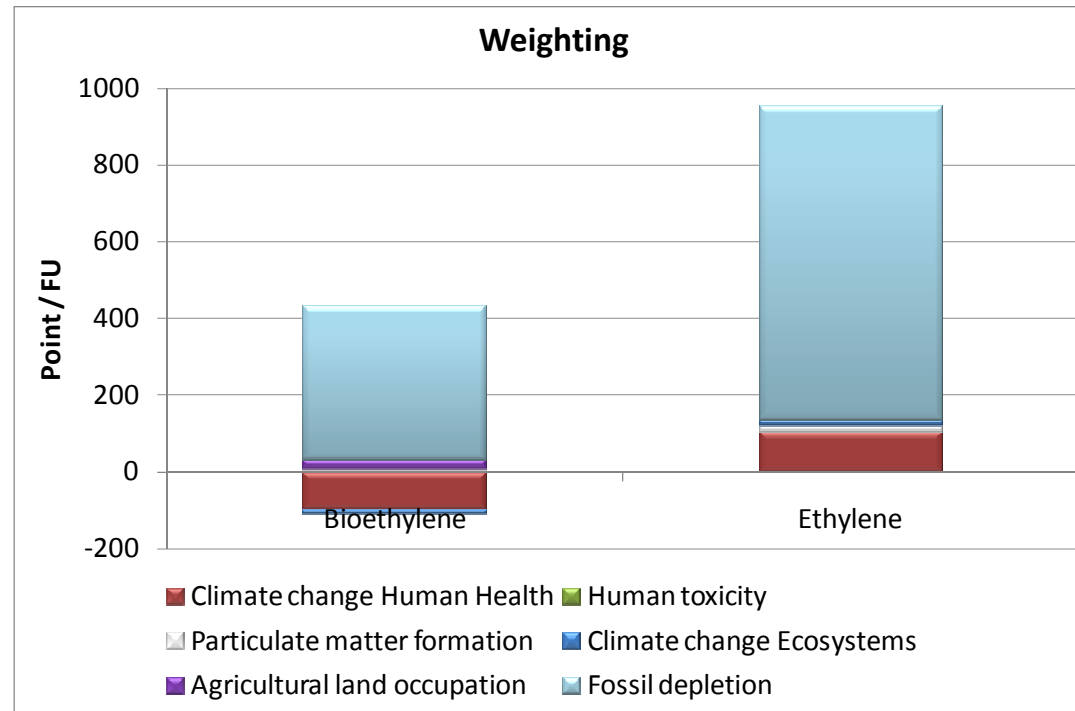
# Biomass utilization – Impact assessment

- Methods depending on the desired response
  - Midpoint (e.g. Climate Change)
    - Impact 2002+
    - CML
    - ReCiPe
  - Endpoint (e.g. Human Health)
    - ReCiPe

# Biomass utilization – Impact assessment

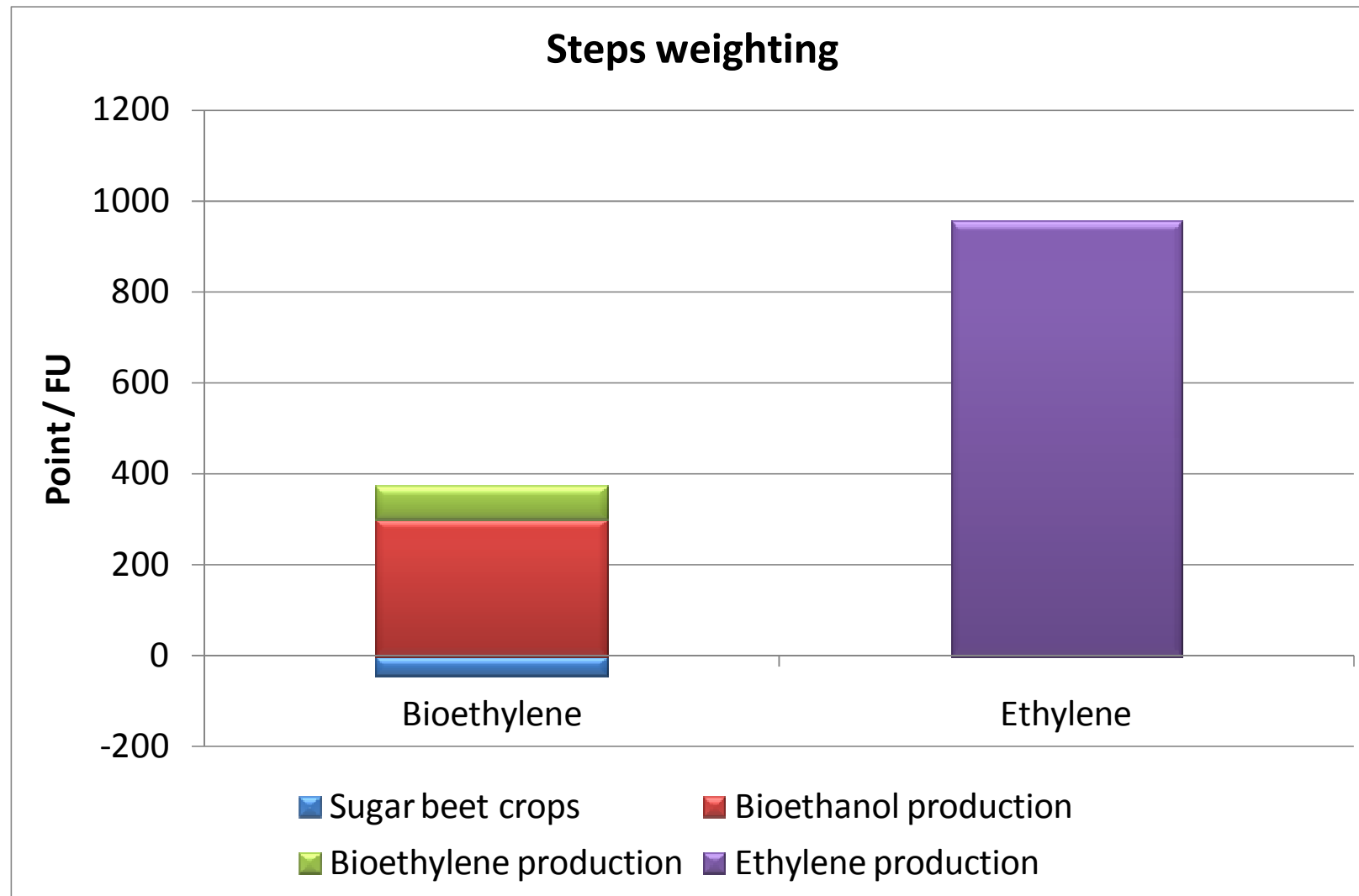


# Biomass utilization – Impact assessment



Impact	Unit	Bioethylene	Ethylene	Economy (Eth – Bioeth)
Climate change	kg CO <sub>2</sub> eq	-3082	3350	6432
Fossil depletion	kg oil eq	1833	3726	1893

# Biomass utilization – Impact assessment



# Biomass utilization – Interpretation

- Bioethylene reaches a less important impact than ethylene for
  - Climate change
  - Fossil fuel depletion
- Limitation of the study
  - Soil transformation (pastures or forests to arable land → lost of carbon)



OR



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# Perspectives – Biomass

- Life Cycle Assessment = environmental management tool
  - Decision support tool
  - Need of methodological developments for soil uses
  - Need of others tools for economic and sociological aspects → 3 pillars of sustainable development
- Biomass
  - Part of solution with good farmer management
  - Not only usable for energy → need to find the best way to use it

# Perspectives – Biomass

- Use of LCA approach for other biomass-related topics
  - Biomass combustion, biomethanation or gasification
  - 2<sup>nd</sup> generation biofuels
  - 3<sup>rd</sup> generation biofuels
- Questions to answer
  - What is the best way to use energy crops?
  - Is better to produce energy or chemical components?
  - How can we valorize waste?

# Perspectives – Biomass

And you, what's your opinion?

