What is the right pathway to be sustainable? Case of biofuels and bioproducts in Europe

CHEMICAL ENGINEERING

Processes and Sustainable Development
Sandra Belboom & Angélique Léonard
15/5/2013 - Glasgow
1. Introduction

2. Production of biofuel

3. Production of HDPE

4. Results

5. Conclusions
1. Introduction

1.1. Worldwide energy context

What are the next challenges?

- Population increase
- Climate change
- Natural resources depletion

Worldwide energy context

Bioethanol

Bioethanol uses
1. Introduction

1.1. Worldwide energy context

What are the next challenges?

- Climate change
- Population increase
- Natural resources depletion

Projected population increase and climate change impacts.
1. Introduction

1.1. Worldwide energy context

What are the possible solutions?

For electricity production:

For transportation sector:

SUGAR CHAIN = BIOETHANOL

OIL CHAIN = BIODIESEL
1. Introduction

1.1. Worldwide energy context

What are the possible solutions?

For electricity production:

For transportation sector:

<table>
<thead>
<tr>
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</table>
1. Introduction

1.2. Bioethanol

What crops are used?

In America

North and Central America

In Europe

Worldwide energy context

Bioethanol

Bioethanol uses
1. Introduction

1.2. Bioethanol

What crops are used?

In America

- **North and Central America**
  - SUGAR BEET

- Brazil
  - WHEAT

In Europe

- SUGAR BEET

- WHEAT

Canada

18%

Worldwide energy context

Bioethanol

Bioethanol uses
1. Introduction

1.3 Bioethanol uses

What are the available bioethanol uses?

Most common use:
• Biofuels

Other possibility:
• Feedstock for chemical industry
  • Production of bioplastics

\[ C_2H_5OH \rightleftharpoons C_2H_4 + H_2O \]
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2. Production of biofuel

Systems boundaries

Cultivation Step → Crops

Crops → Ethanol production plant

Ethanol production plant → Hydrous ethanol

Hydrous ethanol → Dehydration step

Dehydration step → Biofuel

Biofuel → Gasoline

Gasoline → Combustion

Combustion → Crude oil

Crude oil → Refining

Refining → Hydrous ethanol
2. Production of biofuel

From biomass to biofuel

Cultivation Step

Seeds → Fuel → Fertilizers → Pesticides

Crops

Ethanol production plant

Hydrous ethanol

Dehydration step

Combustion

Biofuel

Gasoline

Refining

Crude oil

From oil to gasoline

Boundaries of systems

From biomass to biofuel
2. Production of biofuel

From oil to gasoline

Cultivation Step

Seeds → Fuel → Fertilizers → Pesticides

Crops

Ethanol production plant → Hydrous ethanol

Combustion

Biofuel Gasoline

Dehydration step

Crude oil

Refining

Boundaries of systems
From biomass to biofuel
From oil to gasoline
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3. Production of HDPE

**Systems boundaries**

- Seeds
- Fuel
- Fertilizers
- Pesticides

**Cultivation Step** → Crops

- ethanol production plant

**End of Life**

- (Bio) HDPE*

**Polymerization step**

- bioethylene
- ethylene

**Catalytic dehydration step**

- refining
- Crude oil

**HDPE = High Density PolyEthylene**
3. Production of HDPE

From biomass to ethylene

Seeds
Fuel
Fertilizers
Pesticides

Cultivation Step

Crops

Ethanol production plant

Hydrous ethanol

End of Life

(Bio) HDPE*

Polymerization step

Bioethylene

Ethylene

Refining

Crude oil

HDPE = High Density PolyEthylene

Boundaries of systems

From biomass to ethylene

From oil to ethylene
3. Production of HDPE

From oil to ethylene

- Seeds
- Fuel
- Fertilizers
- Pesticides

Cultivation Step ➔ Crops ➔ Ethanol production plant ➔ Hydrous ethanol

(Bio) HDPE* ➔ Polymerization step ➔ Bioethene

Catalytic dehydration step

End of Life

HDPE = High Density PolyEthylene

Boundaries of systems ➔ From biomass to ethylene ➔ From oil to ethylene
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4. Results

4.1. Climate change

<table>
<thead>
<tr>
<th></th>
<th>GHG difference per hectare (ton CO₂eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar beet</td>
<td>6.01</td>
</tr>
<tr>
<td>Wheat</td>
<td>2.96</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>7.73</td>
</tr>
<tr>
<td>HDPE</td>
<td>3.27</td>
</tr>
</tbody>
</table>

**Climate change**

- **Biofuel**
- **HDPE**
4. Results

4.2. Fossil fuel depletion

The bar chart illustrates the fossil fuel depletion per hectare (kg oil eq) for different biofuel and HDPE products:

- **Sugar beet Biofuel**: 1724 kg oil eq
- **Wheat Biofuel**: 1212 kg oil eq
- **Sugar beet HDPE**: 1942 kg oil eq
- **Wheat HDPE**: 1171 kg oil eq

This data is crucial for understanding the environmental impact of biofuel and HDPE production.
4. Results

4.3. Single score
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5.1. Conclusions

- Importance of yield:
  - Sugar beet allows more bioethanol per hectare than wheat
  - Belgian yields are very high in Europe

- When comparing biofuel and bioplastic:
  - Best score is obtained by sugar beet
  - Bioplastic allows more GHG and fossil fuel consumption reduction
5. Conclusions

5.2. Perspectives

- Complete LCA with all other environmental impact:
  - Human toxicity
  - Water depletion
  - Etc.

- Inclusion of consequential approach:
  - Effects on crops, plastics and biofuels markets

- Definition of a hierarchy for the land occupation:
  - Food
  - Feed
  - Material
  - Fuel
Thank you for your attention!