Importance of LUC and ILUC on the carbon footprint of bio-product: case of bio-HDPE

CHEMICAL ENGINEERING

Processes and Sustainable Development

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Université de Liège

LGC CHEMICAL ENGINEERING

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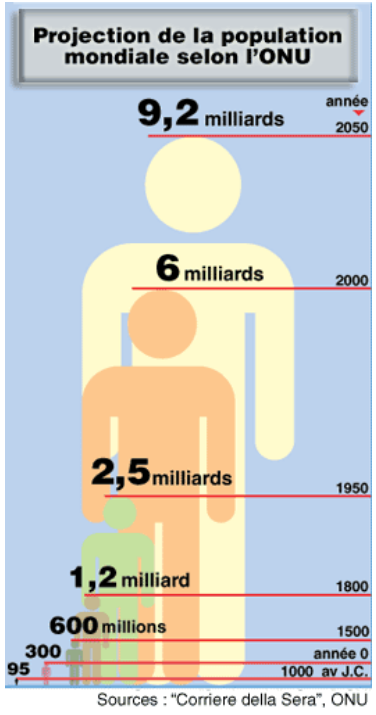
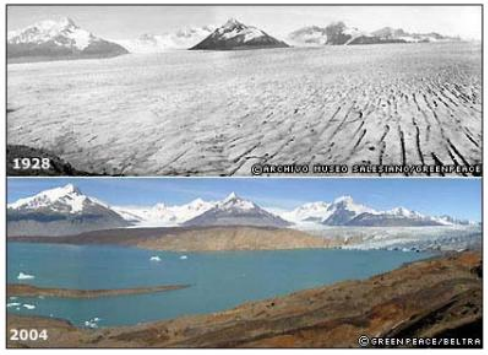
1.1. Worldwide energy context

What are the next challenges?



Population increase



Climate change

Natural ressources depletion

1. Introduction

1.1. Worldwide energy context

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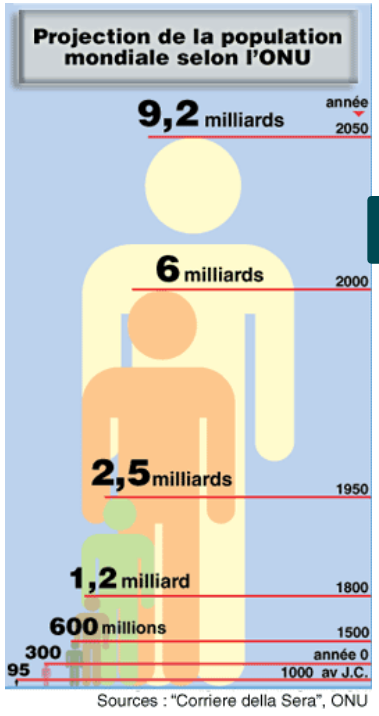

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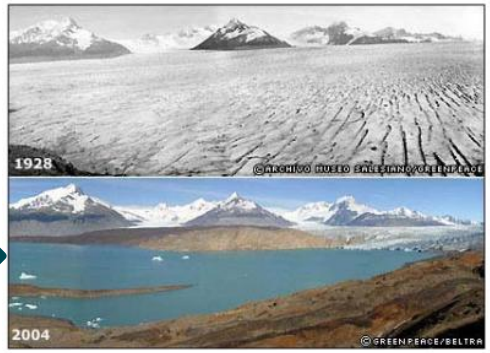


Climate change

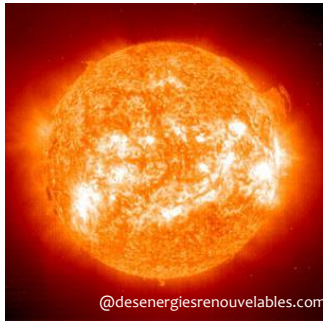
Natural ressources depletion

1. Introduction

1.1. Worldwide energy context

What are the possible solutions?

For electricity production:



For transportation sector:

SUGAR CHAIN =
BIOETHANOL

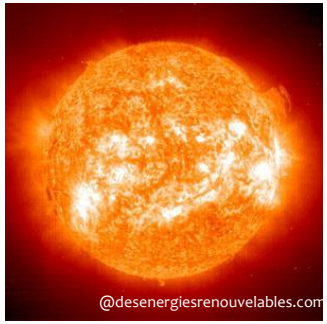
OIL CHAIN =
BIODIESEL

1. Introduction

1.1. Worldwide energy context

What are the possible solutions?

For electricity production:



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SUGAR CHAIN = BIOETHANOL

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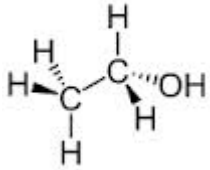
1. Introduction

1.2. Bioethanol



What crops are used?

In America

North and Central America

Brazil

Canada

In Europe

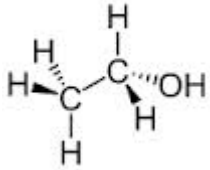
25%

23%

18%

1. Introduction

1.2. Bioethanol



What crops are used?

In America

North and Central America

SUGAR CANE

Canada

In Europe

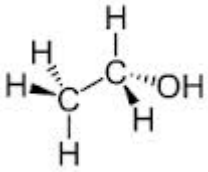
SUGAR BEET

23%

18%

1. Introduction

1.3 Bioethanol uses



What are the available bioethanol uses?

Most common use:

- Biofuels

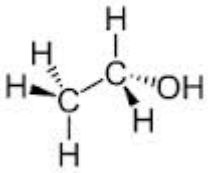
Other possibility:

- Feedstock for chemical industry
  - Production of bioplastics

$$C_2H_5OH \rightleftharpoons C_2H_4 + H_2O$$

1. Introduction

1.3 Bioethanol uses



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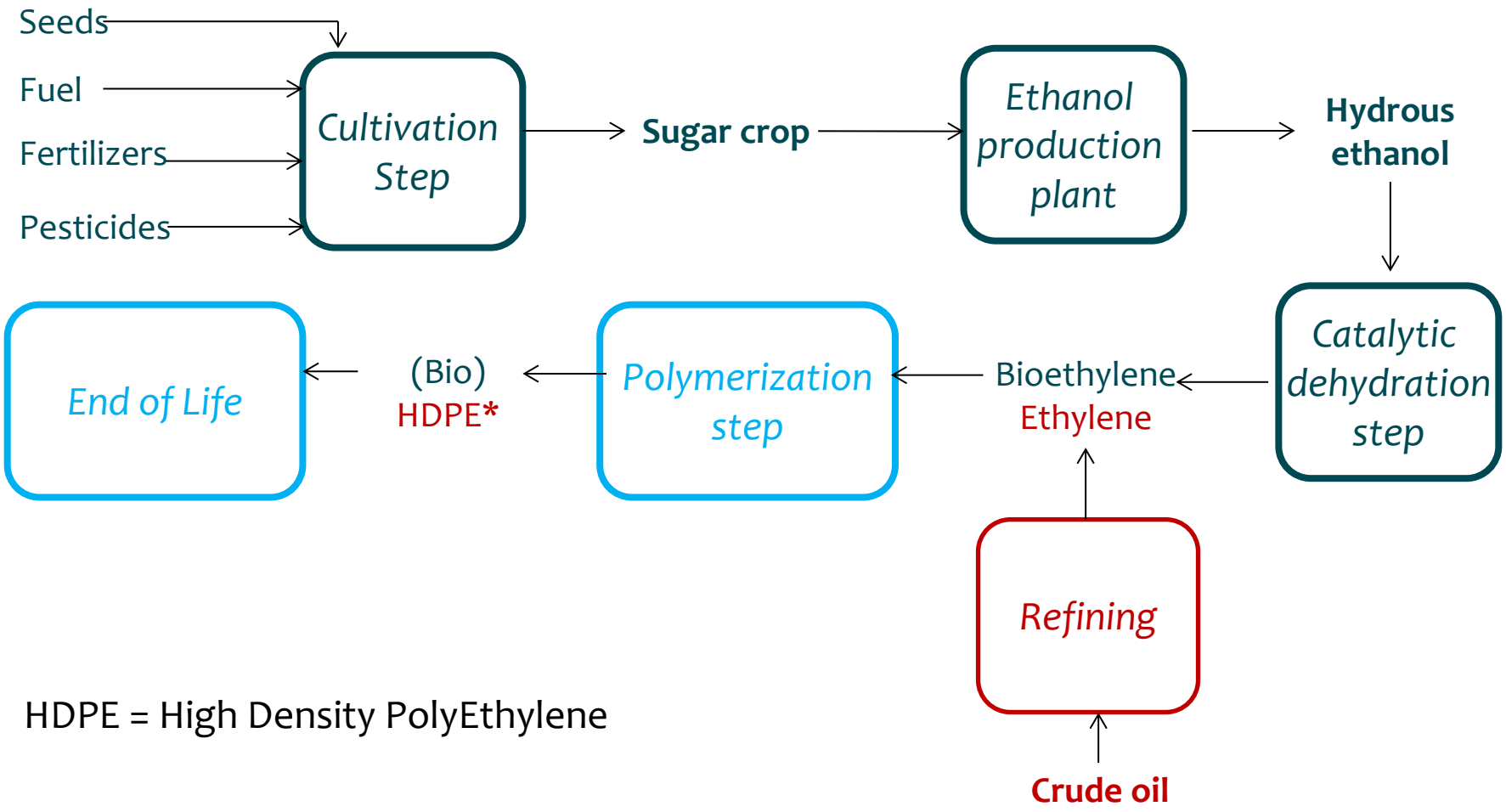
2. Production of HDPE

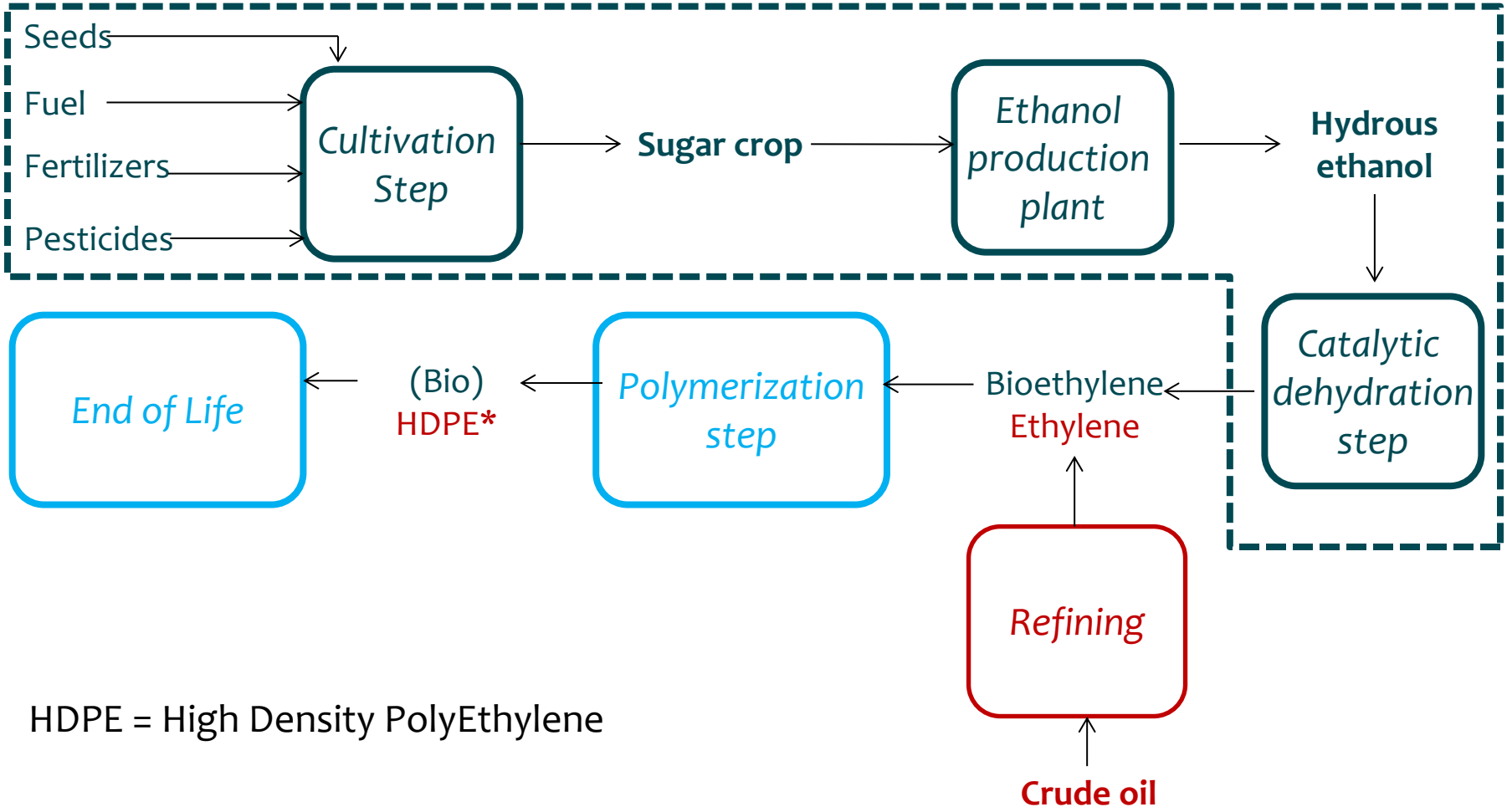
Systems boundaries



HDPE = High Density PolyEthylene

2. Production of HDPE

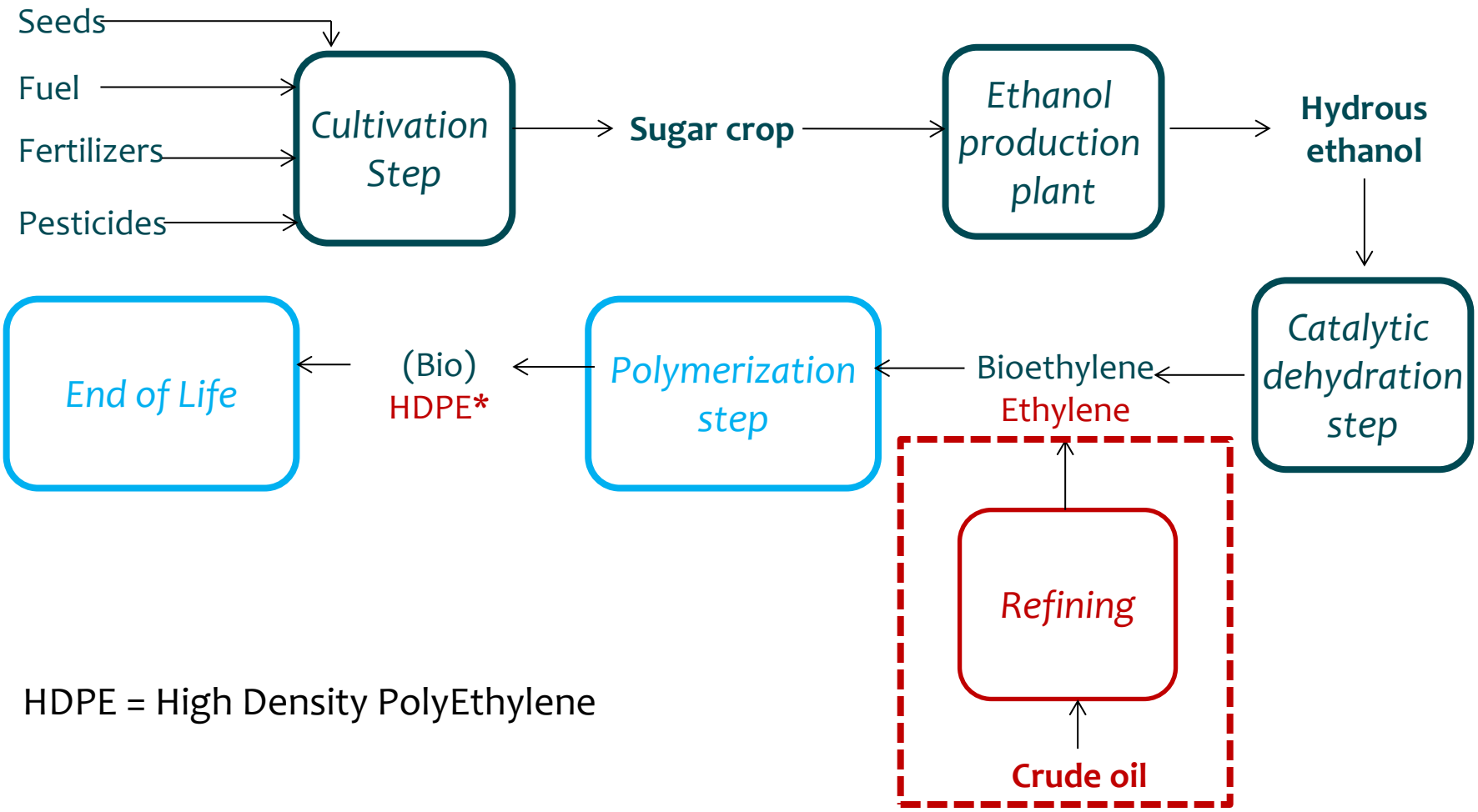
From biomass to ethylene



HDPE = High Density PolyEthylene

2. Production of HDPE

From oil to ethylene



HDPE = High Density PolyEthylene

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3. Land use change assumptions

3.1. Direct land use change

- Sugar cane

PASTURES | SUGAR CANE

- Carbon stocks modification

$$\Delta C_{expansion\ (kg)} = C_{pastures\ (kg)} - C_{sugar\ cane\ (kg)}$$

- Changes in carbon stocks converted in CO_2 emissions, spread over 20 years

$$Emissions\ of\ CO_{2\ (kg)} = \frac{\Delta C_{expansion\ (kg)}}{20} \times \frac{44}{12}$$

- Sugar beet
  - No LUC because of small available areas ➔ importation with ILUC

3. Land use change assumptions

3.1. Direct land use change

- From pastures to sugar cane fields – CO_2 calculations

Scenario – Sugar cane	Emissions of CO_2 (t CO2/t HDPE) LUC*
Best: Degraded pasture➔ field without tillage	-0.27
Average: Pasture with minimal management ➔ field with reduced tillage	1.8
Worst: Well-maintained pasture ➔ field with high tillage	3.15

3. Land use change assumptions

3.2. Indirect land use change

- Sugar cane

FOREST

PASTURE

From 16 to 100% of deforestation

- Sugar beet

PASTURE

SUGAR BEET

In the Netherlands

3. Land use change assumptions

3.2. Indirect land use change

- From pastures to sugar cane fields – CO_2 calculations

Scenario	Direct LUC	Indirect LUC	
	Sugar cane	Sugar cane	Sugar beet
Best ($t CO_2/t$ HDPE)	-0.27	16%: 2.04 100%: 12.76	-1.47
Average ($t CO_2/t$ HDPE)	1.8	16%: 2.21 100%: 13.78	0.8
Worst ($t CO_2/t$ HDPE)	3.15	16%: 2.37 100%: 14.81	2.84

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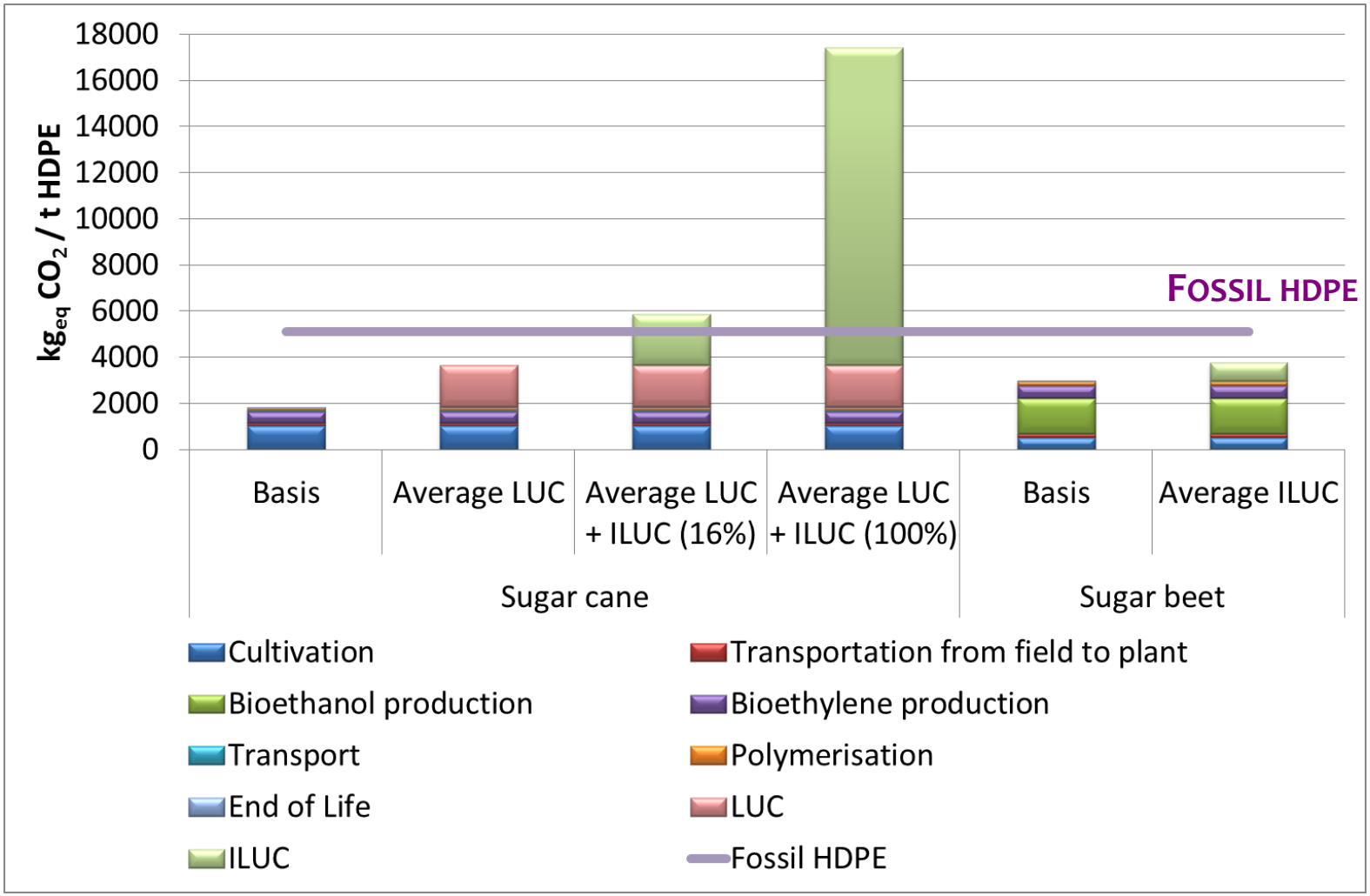
4. Results

4.1. Important stages



4. Results

4.2. Payback time

Payback time = time needed to recover an environmental gain after LUC emissions

Crop	HDPE	
	Scenario	Payback time (years)
Sugar cane	LUC	12
	LUC + ILUC (16%)	26
	LUC + ILUC (100%)	101
Sugar beet	ILUC (Belgique)	8

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5. Conclusions

5.1. Conclusions

- Importance of different steps:
  - Sugar cane → cultivation
  - Sugar beet → bioethanol production and cultivation

- Without LUC/ILUC, climate change impact is highest for fossil HDPE

- Importance of LUC/ILUC
  - Results can be reversed
  - Important payback time

5. Conclusions

5.2. Perspectives

- Other feedstock:
  - Wheat → 1st generation
  - Wood residues → 2nd generation
  - Algae → 3rd generation

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

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

Thank you for your attention!

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