DEVELOPMENT OF ECO-EFFICIENCY INDICATORS FOR A BIOREFINERY

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Introduction

- **“Biorefining: the sustainable processing of biomass into a spectrum of marketable products and energy.”**

Source: IEA Bioenergy Task 42

- **Multiple biorefinery products**
- **→ Which to produce?**

More fuel or more chemical?

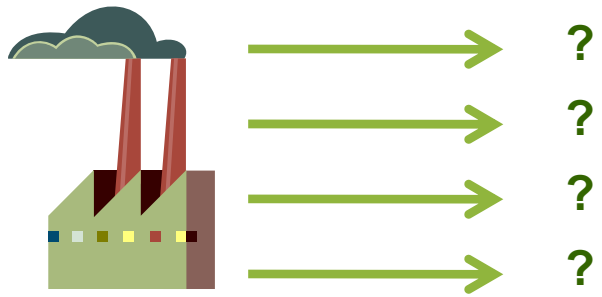
→ Which configuration?

feedstock-based or energy-driven biorefinery?

→ Which level of integration?

fully-integrated= biorefinery plant

+crop farm + livestock farm?



How to make the decision?

Introduction

Eco-efficiency

- **World Business Council for Sustainable Development Definition: Creating more value with less environmental impact**
- **Integration of environmental influence and economic value allows decision makers to weigh and compare products and technologies**
- **Helps to set measurable eco-efficiency targets and facilitate comparisons between companies and business sectors.**

$$\text{Eco-efficiency indicator (EEI)} = \frac{\text{Production value}}{\text{Environmental influence}}$$

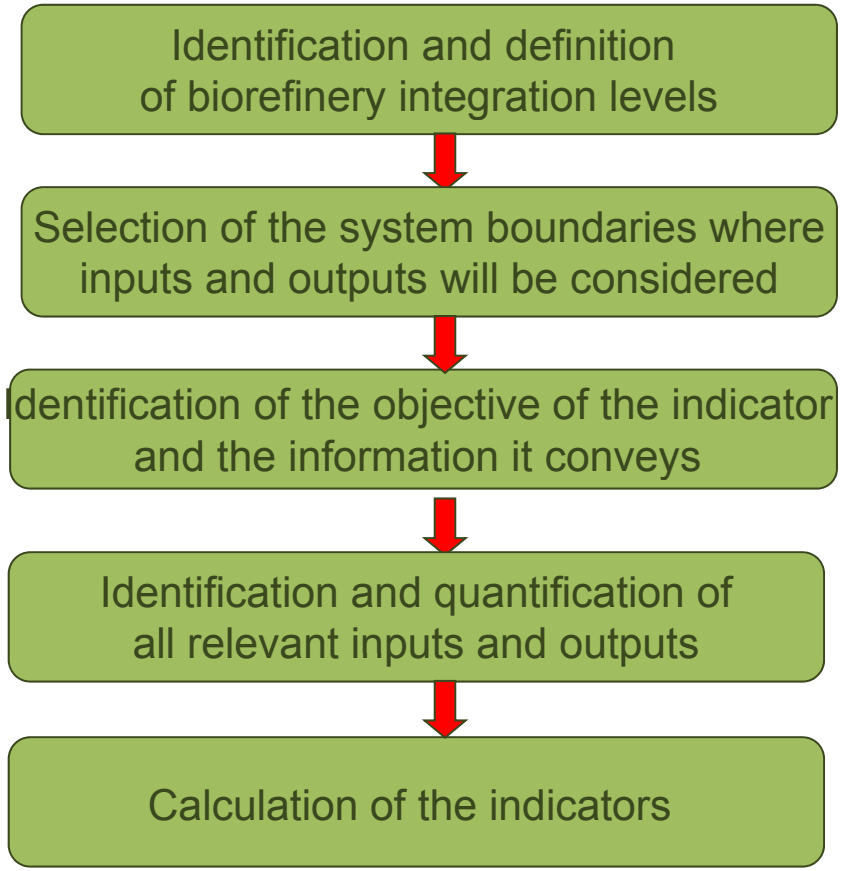
Source: National Round Table on the Environment and the Economy (NRTEE)

Objectives 

- **Aids in decision-making process for stakeholders, biorefinery business owners, etc**
- **Understanding of eco-efficiency of biorefinery products**
- **Understanding of eco-efficiency of biorefinery type and integration level**
- **To achieve the above,**
  We develop the eco-efficiency indicators specifically for biorefinery

Approach

- **Physical flows of material and energy**
- **Includes only the biorefinery business / operations areas**



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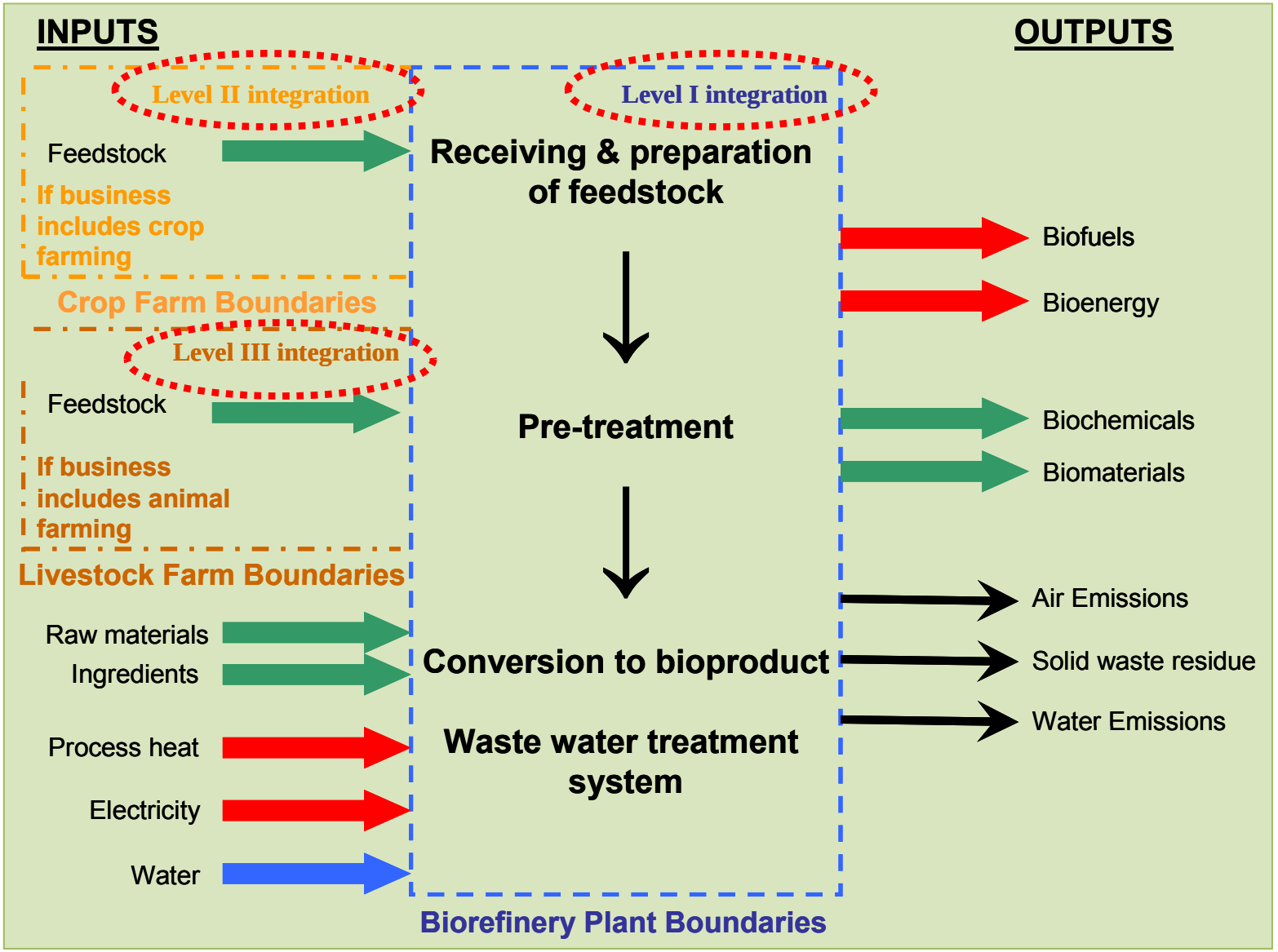
Biorefinery Integration level



Environmental Issues of biorefinery

- **Energy analysis**
- **Global Warming potential resulted from Greenhouse Gas (GHG) emissions**
- **Eutrophication resulted from Nitrogen and Phosphrous-based compounds at the crop farm**
- **Acidification**

ENVIRONMENTAL INFLUENCES

- Main environmental influences of a biorefinery:
- Energy Consumption
- Material Consumption
- GHG emissions (kg CO_2-equivalent)
- Acidification (kg SO_2-equivalent)
- Eutrophication (kg PO_4-equivalent)

Centrum voor Millieukunden Leiden (CML) 2001, impact assessment methodology

CHOOSING PRODUCTION VALUE

Generally Applicable Value Indicators (GAVIs):

- **Quantity of product**
- **Net Sales**
- **Net Profit (PR) as defined in Generally Accepted Accounting principles (GAAP)** ✓

Eco-Efficiency indicator (EEI) example

Product Energy consumption eco-efficiency indicator

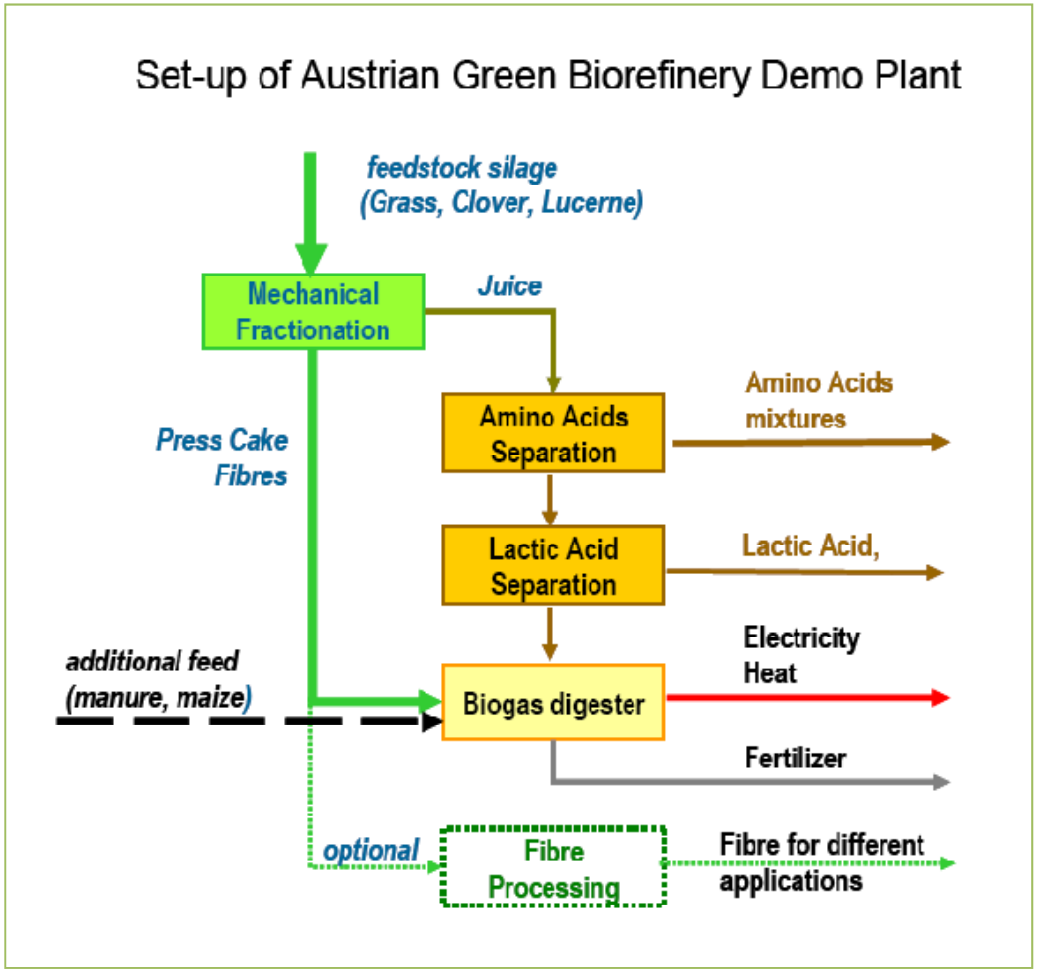
$$\text{Energy consumption EEI } (EE_{TEC;ij}) = \frac{PR_{ij}}{\sum TEC_{ij}}$$

Biorefinery Energy consumption eco-efficiency indicator

$$\text{Energy consumption EEI } (EE_{TEC,i}) = \frac{PR_{i}}{\sum TEC_{i}}$$

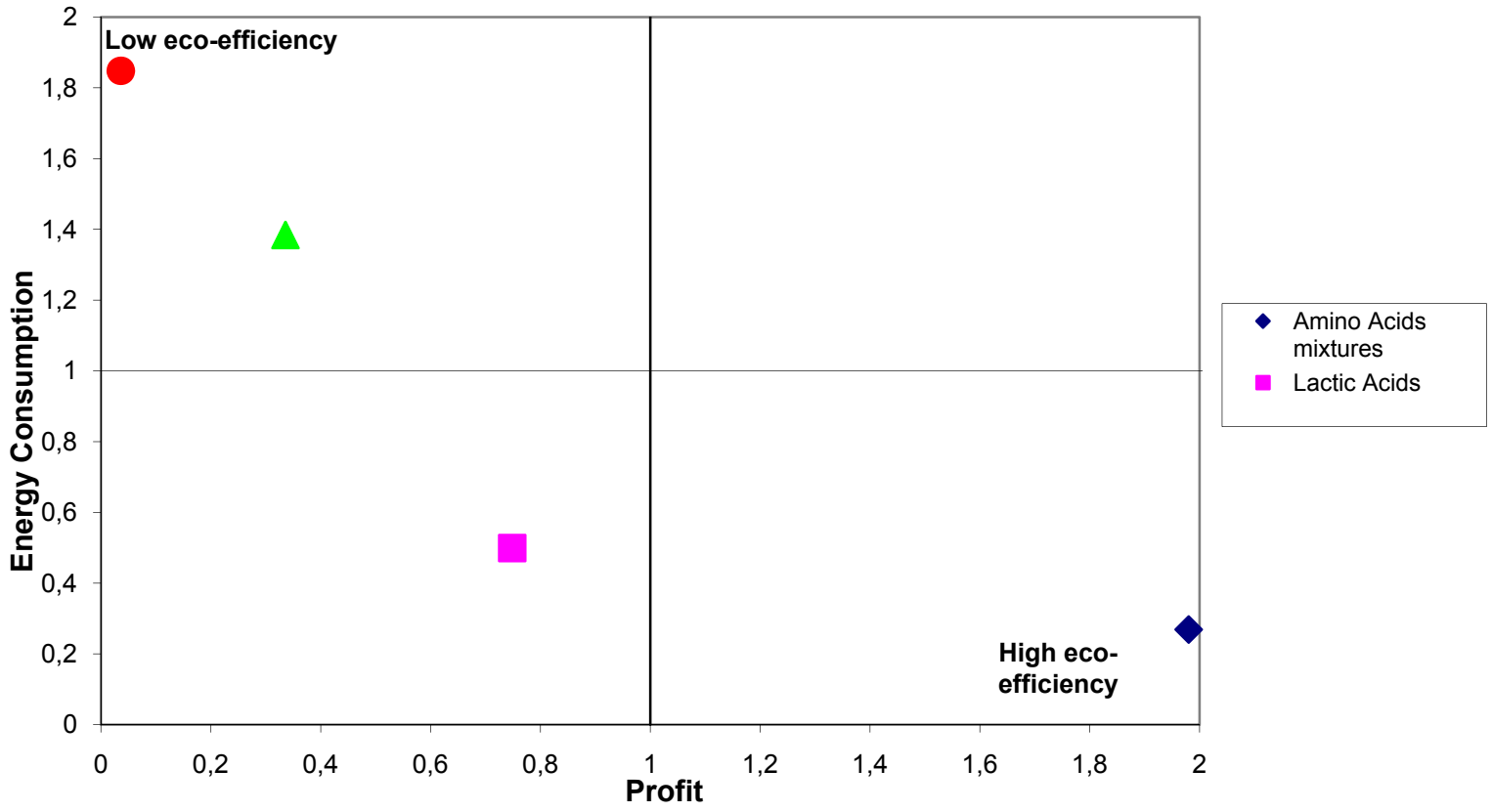
Notations: i refers to the level of integration of the biorefinery; j refers to the product

Biorefinery case study



Source: National Round Table on the Environment and the Economy (NRTEE)

BIOREFINING PRODUCT ECO-EFFICIENCY COMPARISON



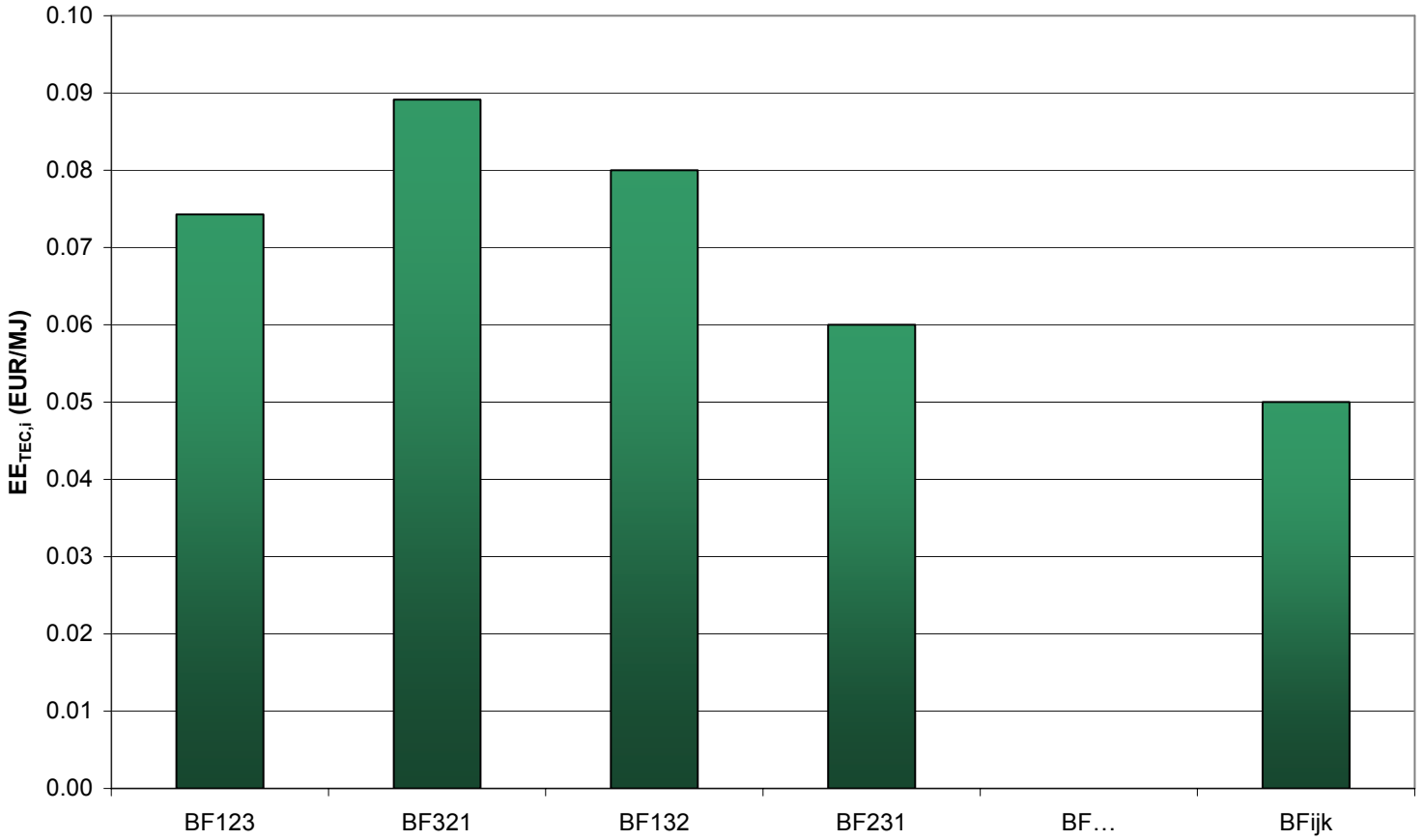
Biorefinery Comparison

Biorefinery overall eco-efficiency score = **€**

How much "weight" to each impact?

- **Energy consumption**
- **Material consumption**
- **Acidification**
- **Eutrophication**
- **Greenhouse gases**

Biorefinery Comparison



Notations: i refers to the level of integration of the biorefinery; j refers to the product; k refers to the feedstock

Conclusion

o The framework of the eco-efficiency indicators is developed for a biorefinery.

o Develop more and better indicators to be reflect the eco-efficiency.

o “Give” the “weight” of each environmental impact for effective comparison of biorefinery.

o Hope to obtain actual data from a commercial biorefinery

Danke für die Aufmerksamkeit !

Kontakt

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