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Approach for the Integration of Biorefineries in the Existing Industrial Infrastructures

Gerfried Jungmeier
Workshop @i-SUP2014

“The role of industry in a transition towards the BioEconomy in relation to biorefinery”

September 3, 2014 Antwerp/Belgium
This is Biomass for Biorefineries in the BioEconomy

IEA Bioenergy
Task 42 Biorefining
There is Competition for Different Biomass Uses

**Bioenergy**
(heat, electricity, transportation fuels)

- **Food**
  (e.g. vegetables, meat)

- **Feed**

- **Biomaterials**
  (e.g. paper, construction material, chemicals, cotton, rubber, fertilizer)
A Statement

“There is no scientific evidence that the material use of biomass provides greater sustainability benefits than the energetic use, or vice versa.

BUT there is evidence that the combined energetic and material use ("biorefining") of biomass has the potential for large sustainability benefits"
The New Way in BioEconomy: From Competition to Integration
This is a Biorefinery

Biomass Resources
- oil
- starch
- sugar
- lignocellulose
- ....

Bioenergy
- liquid/gaseous transport biofuels
- electricity
- heat
- solid fuels

Bioproducts
- bulk chemicals
- fine chemicals
- animal feed
- food
- pulp&paper
- materials
- fertilizer
- gases
- ....

Based on different conversion processes
- Bio-chemical
- Thermo-chemical
- Physical-chemical
- Others

"Biorefinery is the sustainable processing of biomass into a spectrum of marketable products"
The 4 Features to Characterise A Biorefinery Systems

1. Platforms
2. Products
3. Feedstocks
4. Processes

Naming:
- Number platforms (Name of platforms)/Feedstock/Products/Processes
- e.g. 2-platform (electricity&heat, syngas) biorefinery/wood chips/FT-biofuels, electricity, heat, waxes/steam gasification
Application of Classification System

Generic System:
- Feedstock
  - Mechanical process
    - Chemical process
      - Platform
        - Biochemical process
          - Bioenergy
          - Bioproducts

Example:
- Oilseed crops
  - Pressing
    - Oil
      - Esterification
        - Distillation
          - Glycerin
          - Biodiesel
          - Feed
Classification System is Now in Use ....

Green building blocks for biobased plastics

Paulien Harren and Matthias Pachmann
14 Biofuel-driven Biorefineries for Biobased Economy in 2025

IEA Bioenergy
Task 42 Biorefining
Based on this first selection of most promising biorefinery concepts to produce large volumes of road transportation biofuels by 2025 the Task 42 is assessing the sustainability of these biorefinery concepts by analyzing economic, environmental and social aspects in comparison to conventional processes and products.

In a next step a “biorefinery fact sheet” for each of these selected “energy driven” biorefineries is developed, key characteristics for a specific production capacity of road transportation biofuel ……….
Purpose of the Biorefinery Fact Sheet

What are the facts & figures of different biorefineries?

Look here, you find facts & figures in our Biorefinery Fact Sheet

„Biorefinery Fact Sheets“ is linking element of Task 42 activities:

- **Market deployment aspects for biorefineries** (success factors, changing technologies, central/decentral processing, Biorefinery-Complexity-Index)
- **Stakeholder support for future BioEconomy** (integration in existing industrial infrastructures, Factsheets major biorefineries, National case-studies, added-value products)
- **Optimal sustainable biomass valorization** (supply chains, biomass demand, optimal biomass valorisation)
- **Policy&decision advice** (roadmap, policies, country reporting)
- **Dissemination&training activities** (task&stakeholder meetings, website incl. data-base biorefineries, newsletters, reports, brochures & leaflets, presentations, training course)
Overview Biorefinery Fact Sheet

Part A: Biorefinery Plant

Biorefinery FACT SHEET

"2-platform (electricity+heat, syngas) biorefinery using wood chips for FT-fuels, electricity, heat and waxes with steam gasification"

Part B: Value Chain Assessment

Annex:

Methodology of sustainability assessment and data with references
Part A: Biorefinery Plant
Mass and Energy Balance

"2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification"

Own calculations based on Austrian feasibility study (Hofbauer et al. 2008)
Part B: Value Chain Assessment
System Boundaries & Reference System

A 2-Platform (electricity & heat, syngas) Biorefinery Using Wood Chips for FT-biofuels, Heat and Waxes

Collection Forest Residues
  Transport
  Biorefinery
    FT-Diesel
    FT-Gasoline
    Heat
    Waxes
  Recycling / energy generation
  Distribution
    Use

Conventional Reference System

Fossil Resource
  Extraction
    Natural Oxidation
    Transport
    Refinery
      Diesel / Gasoline
      Heat
      Waxes
  Distribution
  Recycling / energy generation
  Use

*) incl. transportation

Product Services
Part B: Value Chain Assessment

Overview

“2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification”

<table>
<thead>
<tr>
<th>Whole value chain</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse gas emissions</td>
<td>range</td>
</tr>
<tr>
<td>biorefinery</td>
<td>70 (66 to 81) [kt CO₂-eq/a]</td>
</tr>
<tr>
<td>reference system</td>
<td>690 (640 to 790) [kt CO₂-eq/a]</td>
</tr>
<tr>
<td>saving</td>
<td>-90 (-87 to -92) [%]</td>
</tr>
<tr>
<td>Cumulated energy demand</td>
<td></td>
</tr>
<tr>
<td>fossil</td>
<td></td>
</tr>
<tr>
<td>biorefinery</td>
<td>0.6 (0.56 to 0.69) [PJ/a]</td>
</tr>
<tr>
<td>reference system</td>
<td>9.2 (8.5 to 11) [PJ/a]</td>
</tr>
<tr>
<td>saving</td>
<td>-93 (-92 to -95) [%]</td>
</tr>
<tr>
<td>total</td>
<td></td>
</tr>
<tr>
<td>biorefinery</td>
<td>14.9 (14 to 17) [PJ/a]</td>
</tr>
<tr>
<td>reference system</td>
<td>9.8 (9.1 to 11) [PJ/a]</td>
</tr>
<tr>
<td>change</td>
<td>52 (27 to 87) [%]</td>
</tr>
<tr>
<td>Agricultural area demand</td>
<td></td>
</tr>
<tr>
<td>feedstock</td>
<td>- (0 to 0) [ha/a]</td>
</tr>
<tr>
<td>Costs</td>
<td></td>
</tr>
<tr>
<td>annual costs</td>
<td>220 (200 to 250) [Mio €/a]</td>
</tr>
<tr>
<td>specific costs</td>
<td>1,200 (1100 to 1400) [€/t]</td>
</tr>
<tr>
<td>Revenues</td>
<td></td>
</tr>
<tr>
<td>annual revenues</td>
<td>224 (210 to 260) [Mio €/a]</td>
</tr>
<tr>
<td>specific revenues</td>
<td>1,200 (1100 to 1400) [€/t]</td>
</tr>
</tbody>
</table>

Communication in typical ranges & orders of magnitude!

Own calculations based on Austrian feasibility study (Hofbauer et al. 2008)
"2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification"

Own calculations based on Austrian feasibility study (Hofbauer et al. 2008)
"2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification"

Own calculations based on Austrian feasibility study (Hofbauer et al. 2008)
Introduction Biorefineries

Integration in industrial infrastructure

Examples for Integration

Outlook & summary
Upgrading Strategies Infrastructures to BioEconomy

Infrastructure

Integration

Biorefineries

THE INNOVATION COMPANY
Classification of Existing Industrial Infrastructure

1. Power and CHP plants
2. Biofuel plants
3. Oil refineries
4. Pulp and paper industry
5. Wood industry
6. Biogas/Biomethane plants
7. Chemical industry
8. Waste treatment plants
9. Food industry
10. Others

10 Main industry sectors with 31 subsectors
classified by
- feedstock
- platforms
- products
- processes
### Database of Existing Industrial Infrastructure

<table>
<thead>
<tr>
<th>1 Power and CHP plants</th>
<th>7 Chemical industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 heating plant</td>
<td>7.1 anorganic and organic chemicals</td>
</tr>
<tr>
<td>1.2 CHP plant</td>
<td>7.2 industrial gases</td>
</tr>
<tr>
<td></td>
<td>7.3 fertiliser</td>
</tr>
<tr>
<td>1.2.1 biomass</td>
<td>7.4 candles and waxes</td>
</tr>
<tr>
<td>1.2.2 fossil (oil, gas, coal)</td>
<td>7.5 synthetic material production</td>
</tr>
<tr>
<td>1.2.3 waste</td>
<td>7.6 food and animal feed additives</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2 Biofuel facilities</th>
<th>8 Waste treatment facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 biodiesel facilities</td>
<td>8.1 sewage treatment plants</td>
</tr>
<tr>
<td>2.2 bioethanol facilities</td>
<td>8.2 landfill gas facilities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3 Oil refineries</th>
<th>9. Food industry</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>4 Pulp and paper industry</th>
<th>9.1 breweries</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 pulp</td>
<td>9.2 sugar mills</td>
</tr>
<tr>
<td>4.2 paper</td>
<td>9.3 starch mills</td>
</tr>
<tr>
<td>4.3 pulp and paper</td>
<td>9.4 oil presses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5 Wood industry</th>
<th>9.6 fruit + vegetable processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 pellet facilities</td>
<td>9.7 creameries</td>
</tr>
<tr>
<td>5.2 wood based boards</td>
<td>9.8 bakeries</td>
</tr>
<tr>
<td>5.3 saw mill</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6 Biogas/Biomethane plants</th>
<th>10. Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 biogas CHP</td>
<td></td>
</tr>
<tr>
<td>6.2 biomethane</td>
<td></td>
</tr>
<tr>
<td>6.3 green refinery</td>
<td></td>
</tr>
</tbody>
</table>

feedstock, processes, platforms, products
Example Austria:
232 Sites in the 10 Main Industry Sectors

<table>
<thead>
<tr>
<th>Industry sector</th>
<th>Number of single sites Austria [-]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Power and CHP Plants</td>
<td>53</td>
</tr>
<tr>
<td>2 Biofuel And Bioethanol Facilities</td>
<td>11</td>
</tr>
<tr>
<td>3 Oil refineries</td>
<td>1</td>
</tr>
<tr>
<td>4 Pulp And Paper Industry</td>
<td>12</td>
</tr>
<tr>
<td>5 Wood Industries</td>
<td>25</td>
</tr>
<tr>
<td>6 Biogas/Biogas Plants</td>
<td>14</td>
</tr>
<tr>
<td>7 Chemical Industry</td>
<td>20</td>
</tr>
<tr>
<td>8 Waste Treatment Facilities</td>
<td>27</td>
</tr>
<tr>
<td>9. Food industry</td>
<td>60</td>
</tr>
<tr>
<td>10. Others</td>
<td>9</td>
</tr>
</tbody>
</table>
Example Austria:
Number of Sites in the 31 Industry Subsectors
Identifying Upgrading Opportunities Towards Biorefineries in the Biobased Industry

Integration opportunities:
same features in industrial infrastructure and the biorefineries

- Existing Industrial infrastructures are described based on 4 features
- Biorefineries are described based on 4 features

Result
High number of common features gives a high possibility for upgrading
Importance of Features for Integration

feedstocks&products ≥ platforms ≥ products

Feedstocks: very strong
Products: very strong
Platforms: strong
Processes: possible

Example Austria
10 industry sectors and 14 biofuel-driven biorefineries
Example I: How to Integrate this Biorefinery?

1-platform (oil) biorefinery using oil crops for biodiesel, glycerin and feed
Example I:
1 Biorefinery and 31 Industry Subsectors

1-platform (oil) biorefinery using oilseed crops for biodiesel, glycerin & feed
Example II: How to Integrate this Biorefinery?

5-platform (C6&C5 sugar, lignin&C6 sugar, electricity&heat) biorefinery using saw mill residues, wood chips and sulfite liquor for bioethanol, pulp&paper, electricity&heat
Example II:

1 Biorefinery and 31 Industry Subsectors

5-platform (C5&C6 sugars, lignin&C6 sugars, electricity&heat) biorefinery using saw mill residues, wood chips and sulphite liquor for bioethanol, pulp&papier, electricity and heat
How to Upgrade an existing Industrial Infrastructures to one of the 14 Biorefineries?

Infrastructure in 31 industry subsectors
Coverage:

14 Biorefineries and 31 Industry Subsectors
Coverage:
31 Industry Subsectors and 14 Biorefineries
Outlook

1. Discussion to further develop this approach

2. Apply to other countries and biorefineries

3. Extend “Biorefinery Fact Sheet” to the most promising integration options
Summary

Assist stakeholders in developing a BioEconomy to minimize technical, economic & financial risks

Integration opportunities: High number of common features in industrial infrastructure & biorefineries

Database of existing industrial infrastructure with 10 main industry sectors and 31 subsectors

Biorefinery integration in industrial infrastructure: feedstocks & products ≥ platforms ≥ processes

Biorefinery Fact Sheet gives facts & figures on biorefinery plant and value chain sustainability assessment

Selection of interesting “Biofuel-driven Biorefineries” for Biobased Economy 2025 by IEA Bioenergy Task 42 “Biorefinery”

Classification of biorefineries via 4 features: platforms, products, feedstocks, processes
Austrian Team Leader
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Challenges to be tackled
- Develop industry legitimacy and a level-playing field for sustainable biomass use
- Multi-sectoral stakeholder involvement in the development and implementation of sustainable value chains
- Technology development and biorefinery scale-up using best available practice and processes

Task 42 Biorefining: Sustainable processing of biomass into a spectrum of marketable food & feed ingredients, bio-based chemicals, materials,...