Biomass in Industry
- How, When and Why?

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Biomass in Industry

Traditional Use:
• Replacing fossil fuels for industrial heating
• Biomass-based industrial combined heat and Power (CHP)

Biorefinery concepts:
• Advanced biomass-based CHP
• Products from biomass (biofuels, materials, chemicals)
Biomass

Existing plant
Industry or Power Plant

New processes

Process integration

Thermochemical conversion of biomass

Chemical and biochemical conversion of biomass

Conversion to products

Fuels

Electricity

Materials for further refinement

Chemicals for further refinement

ENERGY COMBINE
Biorefinery - definition

"A wide range of technologies able to separate biomass resources (wood, grasses, corn, etc.) into their building blocks (carbohydrates, proteins, fats, etc.) which can be converted into value-added products such as biofuels and bio-chemicals".


Example of biofuels and conversion processes

- **Cellulose & Lignin**
  - Wood, black liquor, grass

- **Starch**
  - Wheat, corn, potatoes

- **Sugar**

- **Oil**
  - Rapeseed, palm oil, soy

- **Rest flows**
  - From agriculture, forestry, industries, societal waste, etc., e.g., straw, sawdust, manure, sludge, food waste.

Conversion Processes:

- **Combustion**
- **Gasification to syngas (CO and H2)**
- **Fermentation of sugar**
- **Aerobic digestion**
- **Biogas**
- **Pressing and esterification**
- **Cracking Bio-oils treated with hydrogen**

Energy Carriers:

- **Electricity**
- **Hydrogen**
- **Fischer-Tropsch Diesel**
- **DME (Dimehtyleter)**
- **Methanol**
- **Methane**
- **Ethanol**
- **FAME**
- **HVO**
Two Types, in Principle, of Biorefineries

Non-Bulk Products
Normally small- or medium-scale size
High-value products
Reduction of CO2 emissions? Our knowledge for different products limited
Typically limited market

Bulk Products
Economy possible due to large-scale processes (economy of scale)
Biobased transport fuels, materials, chemicals, green power, heat
Important advantages through integration with e. g. process industries
Reduction of CO2 emissions vary, but is in many cases considerable
Generally speaking, carbon footprints directly dependent on what is replaced, i. e. coal, oil or natural gas
The pulp mill biorefinery – Studied products

Energy
- DME
- Ethanol
- FT-diesel
- Biooil
- Heat
- Electricity
- Pellets
- Lignin

Chemicals/Materials
- Phenols
- Carbon fiber
- Binders
- Dispersants
- Activated carbon
- Fiber additives
- Barriers
- Hydrogels
- Fibers
- Derivatives
- Nanocellulose

Extractives
- Functional polymers
- Bioactive compounds

Lignin
Cellulose
Bark
Forestry residues

Lignin
Hemi-cellulose
Cellulose
Some Major Processes

• Biomass gasification
• Black liqour gasification (in chemical pulp and paper industry)
• Fermentation (to ethanol and more advanced end products)
• Torrefaction and pyrolysis
• Fractionation
Examples of Bulk Type Biorefineries in Process Industries

**Pulp and Paper Industry**
- Black Liquor Gasification: Green Power, DME
- Biomass Gasification: Green Power, Methanol, FT-diesel, SNG
- Fermentation: Ethanol
- Dissolving Pulp: Ethanol from hemicellulose
- Lignin Precipitation: Carbon fibre, etc

**Iron and Steel Industry**
- Biomass for replacement of coal/char

**Chemical and Petrochemical Industry**
- Biomass Gasification replacing cracker gas: Methanol, polyethylene, etc
- Fermentation: Polyethylene

**Oil Refineries**
- Biomass Gasification: Hydrogen, FT-diesel, SNG
Only a few biorefinery concepts are available in a short time perspective.

For many concepts pilot and demo plants are needed.

Demo plants for bulk products normally expensive (10-50 million Euros).

Strong policy instruments are needed for many concepts (40-70 Euros/ton CO2?).

Decisions on large scale concepts are normally strategic and must be taken against a very uncertain future regarding policy instruments, energy and biomass prices, etc.

In e.g. integrated large-scale biorefinery concepts, several stake holders must cooperate, making decisions and business models complicated.
## Output ENPAC - New policies and 450 PPM

<table>
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<th>SCENARIOS</th>
<th>2020 New</th>
<th>2020 450</th>
<th>2030 New</th>
<th>2030 450</th>
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<td>856</td>
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<td>761</td>
<td>246</td>
<td>733</td>
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The time perspective is important for several reasons, e.g.:

- policy instrument and energy/product price development (sensitivity analysis important)
- sustainability of a biorefinery product (time dependent and must consider policy instrument development)
- Two parameters of highest importance for climatic sustainability is what fuel/raw material the biomass replaces and the future build margin for grid power production
3 gasification based biorefinery concepts were considered

- Biomass residues corresponding to 94 MW\textsubscript{LHV}
- In addition, about 1.55 TWh (177 MW\textsubscript{LHV}) of forest residues is available within a 100 km radius.
Carbon balances incl comparison with stand-alone concepts

CO₂ emissions reduction [kg CO₂/AMWh biomass]

Marginal electricity production technology

- Coal
- Coal, CCS
- NGCC
- Co-firing

- Gas turbine
- Gas turbine stand-alone
- Methanol
- Methanol stand-alone
- FT liquids
- FT liquids stand-alone
Biomass and Industrial CCS

• In the future, CCS will probably be used in industry (from 2030-2040, depending on carbon charge development)
• BECCS (Biomass-based CCS) in industry will have an important role
• Several biorefinery concepts have CO2-rich bystreams, making CCS cheap
• BECCS gives the same carbon footprint as fossil-based CCS (not more, not less)
What Product(s) for Sustainable Use?

Power
If the build margin grid power production is e.g. coal condensing plants, high efficiency power production with biomass means low GHG emissions (hence more short term)

Materials and Chemicals
With lower grid GHG emissions, production of materials and chemicals is more sustainable. Recycling always important but in most cases no carbon footprint advantage with biomass origin compared with a fossil one

Biofuels
Carbon footprint comparison with materials and chemicals depends on process routes for different products. No general conclusion can be made.

For economic sustainability, the economic performance for the different types of product depends totally on future carbon charge development (level, product specific, etc)
Median and range of the potential from three major sources of biomass for energy in Europe. Source: Biotechnology for Biofuels 2012, 5:25
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