Assessment of combined renewable power, heat and fuels production in the context of time-dependent supply and demand

Moritz Raab
Dr. Ralph-Uwe Dietrich, Felix Habermeyer
DLR – Research Group for Techno-economic assessments

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Agenda

1. Background and motivation

2. Project FlexCHx

3. Techno-economic and ecologic assessment

4. Summary and Outlook
1. **Background and motivation**

- State of the art – e.g. combined power and heat production in gas plants

![Diagram showing the processes](image)

- Process can be driven by electricity demand or heat demand
1. **Background and motivation**

- New concept - combined renewable power, heat and fuels production

- Biomass as an exemplary “low grade” energy and carbon source for the process
- Stationary BtL process published in [1] - No time-depended aspect of demand is taken into account
  - Hardly no reaction to volatile electricity production and price possible - only reduction possible

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1. Background and motivation

- Creating a process that is capable of producing power, heat and fuels
- Participates in the electricity market – positive and negative reserve capacity

- Increasing share of renewables increases demand for flexible plants

Charts from [www.energy-charts.de](http://www.energy-charts.de)
1. Background and motivation

- No leapfrogging from stationary production processes towards plants of short-term flexibility
- First technical experience with production plants operating in different seasonal modes
- Technical challenges can be addressed for further research projects
- Simulation data obtained from different seasonal modes can be used to outline the potential of flexible production processes
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2. Project FlexCHx

www.flexchx.eu

High heat demand & Low renewable electricity availability

Low heat demand & High renewable electricity availability

Seasonal solar irradiation and heating demand for a typical Northern European country


2. Project FlexCHx

Gas clean-up
- Replacement of conventional gas cleaning processes (Rectisol/Selexol) by a cost-effective sorbent based cleaning process
- Testing of the cleaning process in conjunction with the SXB gasifier

Process highlights:
- Large range of possible feedstock
- Tar removal in the gasifier
- No gas cooling for the filter required
- Flexible electrolyzer with oxygen storage
- Autothermal reforming
- Cost-efficient gas clean-up
- FT By-pass for high heat demand

Techno-economic & ecologic analysis

Feedstock → SXB Gasifier → Filter → Reformer → Gas Clean-up → Fischer-Tropsch Synthesis → Product Upgrading

CHP Integration
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3. Techno-economic and ecological assessment (TEEA)

DLR’s Techno economic process evaluation tool

- Efficiencies (X-to-Liquid, Overall)
- Carbon conversion
- Specific feedstock demand
- Exergy analysis

- CAPEX, OPEX, NPC
- Sensitivity analysis
- Identification of most economic feasible process design

- GHG-footprint
- GHG-abatement costs
3. Techno-economic and ecological assessment (TEEA)

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Technical evaluation

Life-cycle assessment (LCA)

Alternative fuel

Economic/techno-ecological evaluation

Economic assessment

Ecological evaluation

Figure 1: DLR’s Techno economic process evaluation tool (TEEPET)
3. Techno-economic and ecological assessment (TEEA)

- Adapted from best-practice chem. eng. methodology
- Meets AACE class 3-4, Accuracy: +/- 30 %
- Year specific using annual CEPCI Index

- Automated interface for seamless integration
- Easy sensitivity studies for every parameter
- Learning curves, economy of scale, ...

**Process simulation results**

**Capital costs**
- Equipment costs
- Piping and installation
- Service facilities
- Engineering

**Operational costs**
- Raw materials
- Utilities
- Maintenance
- Labor

**Unit sizes**

**Energy/ Material flows**

**Net production costs (NPC) [€/kg]**
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**GHG footprint of products**
- Electricity
- Heat
- Fuel

**Application efficiency**
- Car

**GHG abatement costs**
\[
\frac{\text{€}}{\text{tCO}_2\text{eq.}} = \frac{\text{Difference in production costs}}{\text{GHG abatement}}
\]

- Electricity footprint
- Biomass footprint

Car - http://aktionberlinerallee.de/
Wind turbine: http://clipartbarn.com/wind-turbine-clipart_15864/
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• “Gate to gate” Techno-economic and ecological assessment of two operating modes are assessed
• With (future) data for electricity supply and demand more flexible operating modes can be evaluated
• Results of “Gate to gate” assessment can be used in a model with larger perspective
  o Influence of several plants on an electric grid
  o Fuel production capacity as a function on electricity supply and demand
• Including the usage of the products and the corresponding efficiencies different optimizations can be carried out
  o What is the most economic running mode for the plants
  o What running mode has the least GHG emissions
Thank you for your attention

Moritz Raab
Dr. Ralph-Uwe Dietrich, Felix Habermeyer
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