



RUB

RUHR-UNIVERSITÄT BOCHUM

GREEN METHANOL PRODUCTION

Computer-aided Process Design



Advantages and Disadvantages Power-to-X

Advantages:

- **Integration of renewable energy:** PtX enables the efficient storage and use of surplus renewable energy
- **Energy storage:** PtX can serve as a form of long-term energy storage
- **Flexibility:** PtX technology can be adapted to different forms of energy, such as synthetic natural gas, methanol, etc...

Disadvantages:

- **Energy losses:** The conversion of electrical energy into chemical energy takes place in several steps
- **Infrastructure and costs:** The implementation of PtX projects on a large scale requires considerable investment in infrastructure

Beispielprozess Power to Methanol

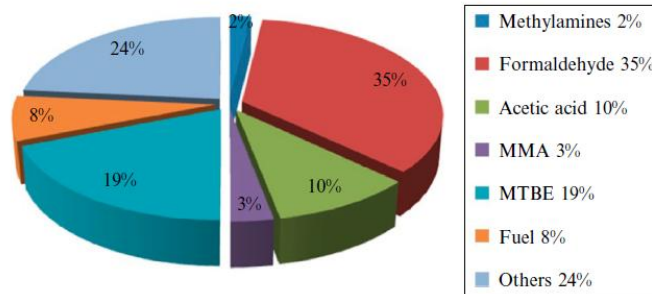
- Basic chemical
- Simple alcohol
- Liquid at ambient temperature and pressure



- Advantage:
- Polar liquid, rapidly degradable anaerobically and aerobically Low toxicity compared to petroleum

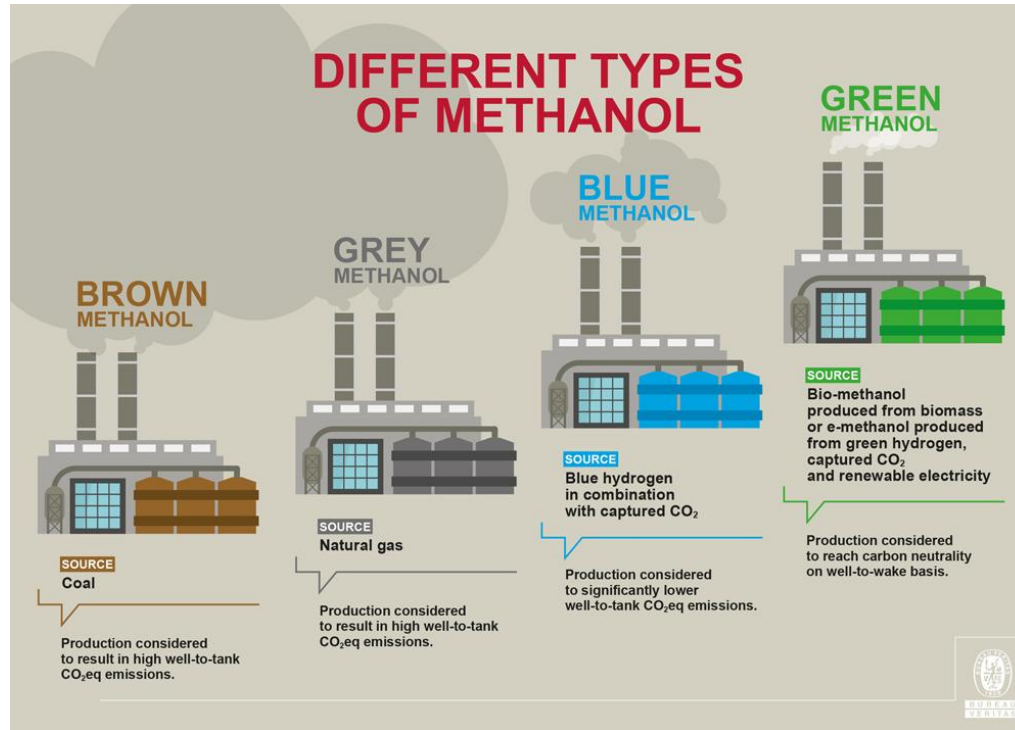
Beispielprozess Power to Methanol

- Kraftstoff für Hochleistungsmotoren mit Funkenzündung
- chemischer Rohstoff
 - z. B. Kunststoffindustrie, Methanol-zu-Olefin-Prozesse



- Chemischer Speicher: Power-to-Liquid
 - Dt. 2050: prognostizierter Überschussstrom 24 TWh/a
potentielle Methanolmenge von 1,9 mio t/a)

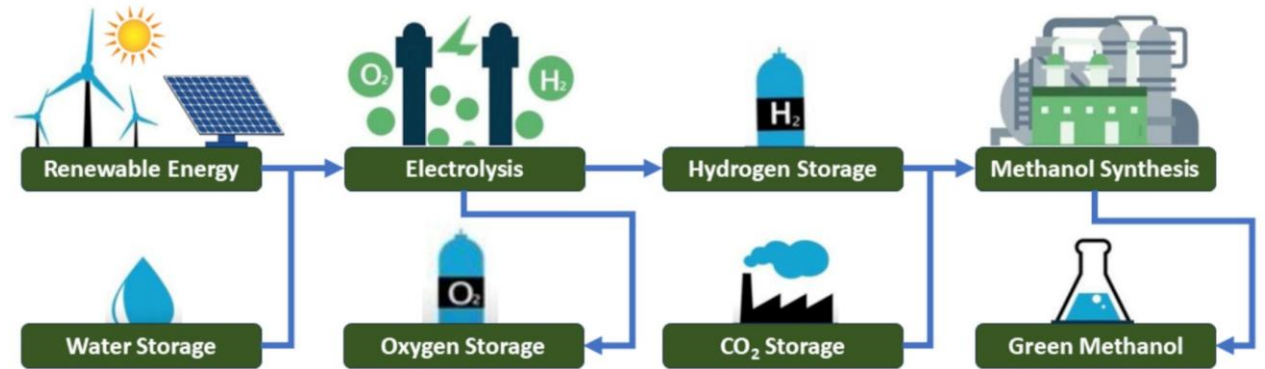
Beispielprozess Power to Methanol



Beispielprozess Power to Methanol

Power-To-Methanol

- Determination of the operating parameters of all sub-processes:
 - H₂ Production
 - CO₂ Production
 - Methanolsynthese

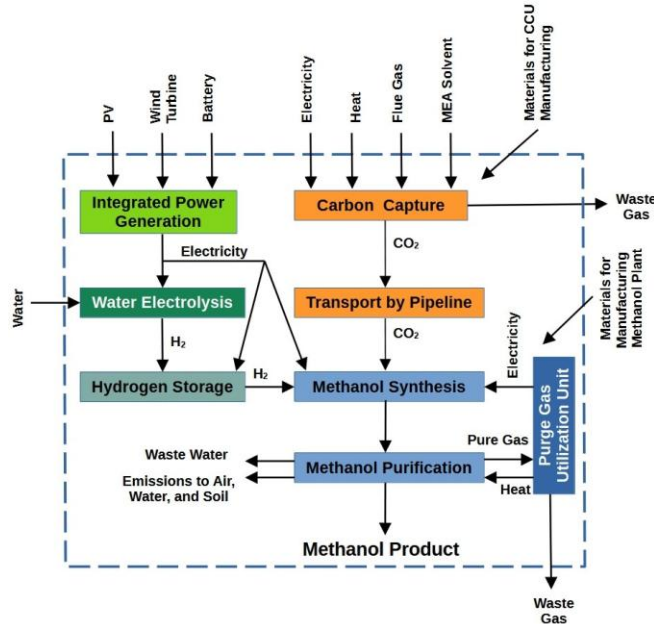


Beispielprozess Power to Methanol

Power-To-Methanol

- Framework conditions:
 - Production volume von 250.000 t pro Jahr
 - 8.500 h/a
- Literature research and subsequent implementation in Aspen Plus

Beispielprozess Power to Methanol



Beispielprozess Power to Methanol

Presentation Literature Research (20.05.2026)

- Each group presents their results of the literature research
- Some questions that can help you to structure the presentation:
 - How should the annual production volume from the task be classified?
 - What is the critical component in the chain?
 - Which CO₂ source is selected?
 - Which separation method for CO₂ capture?
 - Critical evaluation of the results

- Announcement of the case study and group assignments : 14. April, 14 - 16 Uhr in CIP Pool
- Apsen Plus Introduction and Research for boundary conditions for simulation
- Different aspects of the group
- During the semester: wednesday 14-18 Uhr im CIP Pool

- Stage 1: Background literature
- What are the main process routes for green methanol production from renewable electricity, water, and carbon dioxide?
- Which process units are typically included in a green methanol plant, and which are optional depending on the process concept?
- What are the key performance indicators used in the literature for green methanol systems?
- What are the main technical bottlenecks reported for green methanol production?
- How do system boundaries influence the interpretation of process performance and sustainability results?

- Stage 2: Literature linked to Aspen Plus simulation
- Which process configuration is best suited for a teaching-scale Aspen Plus model, and why?
- Which property method is most appropriate for the gas–liquid system in green methanol synthesis?
- Which reactor model is most suitable: equilibrium, stoichiometric, or kinetic?
- How should recycle, purge, and separation sections be represented in a simplified simulation?
- Which assumptions have the strongest effect on methanol yield, energy demand, and convergence behavior?
- How can literature values be used to check whether the simulation results are plausible?:

- Stage 2: Literature linked to Aspen Plus simulation
- Which process configuration is best suited for a teaching-scale Aspen Plus model, and why?
- Which property method is most appropriate for the gas–liquid system in green methanol synthesis?
- Which reactor model is most suitable: equilibrium, stoichiometric, or kinetic?
- How should recycle, purge, and separation sections be represented in a simplified simulation?
- Which assumptions have the strongest effect on methanol yield, energy demand, and convergence behavior?
- How can literature values be used to check whether the simulation results are plausible?:

- Stage 3: Detailed research by focus
- **Focus: Electrolysis**
- Which electrolyser technologies are relevant for green methanol production: alkaline, PEM, or solid oxide?
- What membranes are used in these electrolysers, and why are they chosen?
- How do membrane properties affect conductivity, selectivity, degradation, and water management?
- What are the main operating conditions of the electrolyser, such as current density, temperature, pressure, and efficiency?
- How do these operating conditions influence hydrogen cost and overall methanol process economics?
- What techno-economic analyses have been published for hydrogen production by electrolysis in the context of methanol synthesis?
- Which cost drivers are most important in those techno-economic analyses?
- How sensitive is the electrolyser economics to electricity price, membrane lifetime, stack efficiency, and capacity factor?

- Stage 3: Detailed research by focus
- **Focus: Energy integration**
- Which unit operations have the largest heating and cooling duties in the methanol process?
- Where can heat integration reduce external utility demand?
- Which streams are suitable for heat recovery or preheating?
- How does energy integration affect total process efficiency and operating cost?
- Which assumptions are needed to estimate energy integration potential in a simplified model?

- Stage 3: Detailed research by focus
- **Focus: CO2 supply and process boundaries**
- Which carbon dioxide sources are most realistic for green methanol production?
- How do CO2 purity, compression demand, and impurity removal affect the process?
- Which upstream emissions should be included when evaluating the process?
- How do different process boundaries change the interpretation of carbon efficiency and sustainability?

- Stage 3: Detailed research by focus
- **Focus: Reactor and synthesis section**
- What are the main reactions in methanol synthesis from CO₂ and H₂?
- Which operating temperature and pressure ranges are commonly reported for methanol synthesis?
- How do feed ratio, recycle ratio, and purge rate affect conversion and selectivity?
- Which catalyst-related assumptions are typically made in literature-based process studies?
- How do reactor design choices influence process performance and economics?

- Stage 3: Detailed research by focus
- **Focus: Techno-economic analysis**
- What are the main components of a techno-economic analysis for green methanol production?
- Which cost categories dominate the electrolyser and the full methanol plant?
- How are CAPEX and OPEX typically estimated in published studies?
- Which economic indicators are most useful: methanol production cost, levelized cost, or minimum selling price?
- How do electricity price, electrolyser efficiency, and plant scale affect the final methanol cost?
- How does membrane lifetime influence total cost of ownership in electrolyser-based systems?
- Which assumptions make techno-economic results difficult to compare across studies?