Biomass gasification as a Pathway for Sustainable Aviation Fuel

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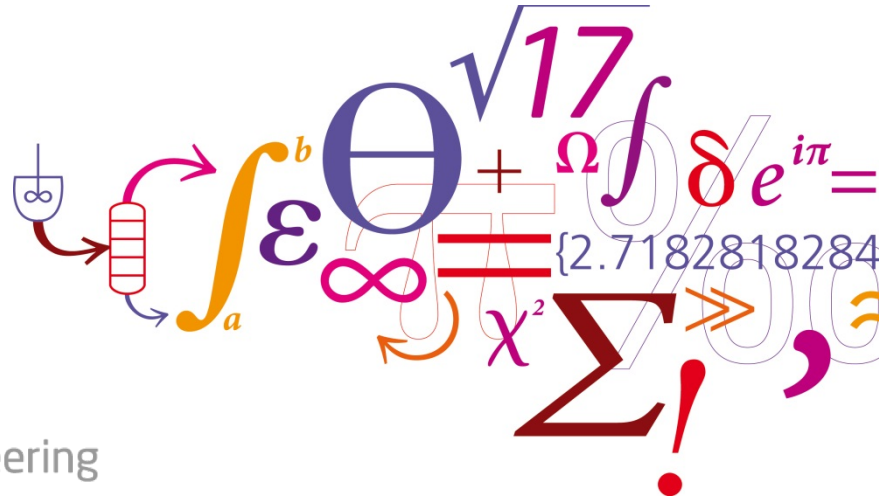

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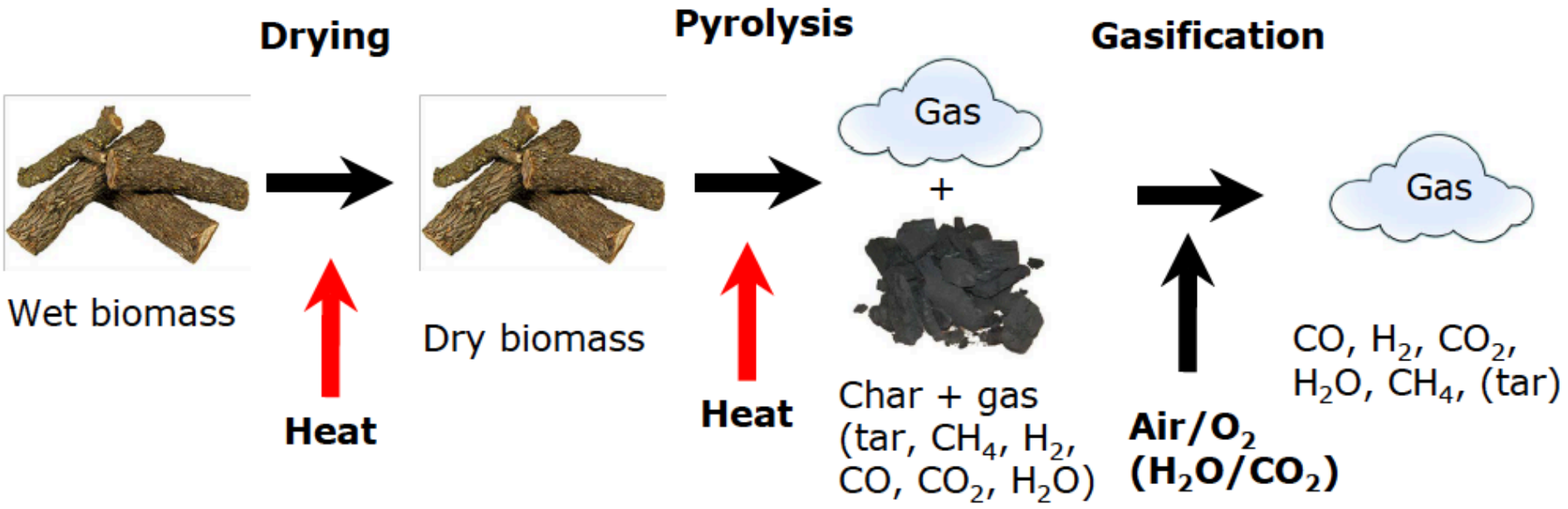
BGE| Agenda

- **Introduction to Thermal Gasification of Biomass and Synthesis of Biofuels**
- **Thermal Gasification and Electrolysis – a Perfect Match**
- **Status and Challenges**

Gasification of biomass



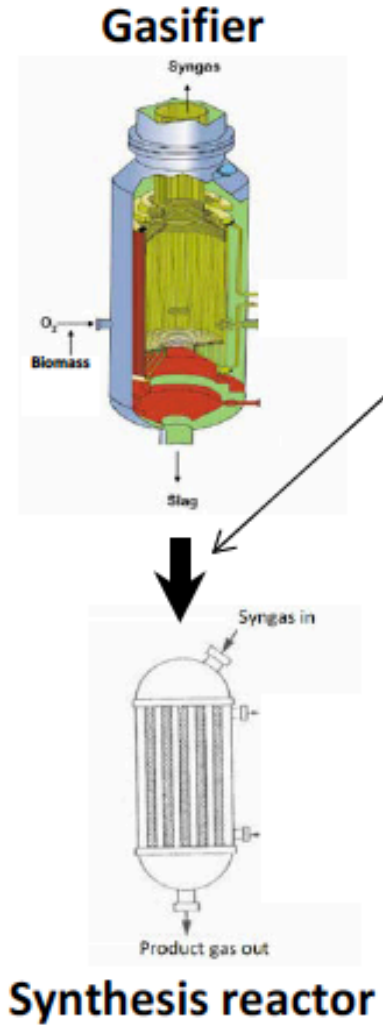
High conversion:

Almost all the organic matter in the biomass ends up in the gas (some carbon in the ash)

High efficiency:

Up to 75-93% of the heating value in the biomass can end up as heating value in the produced gas

Fuel Synthesis



Syngas (synthesis gas)

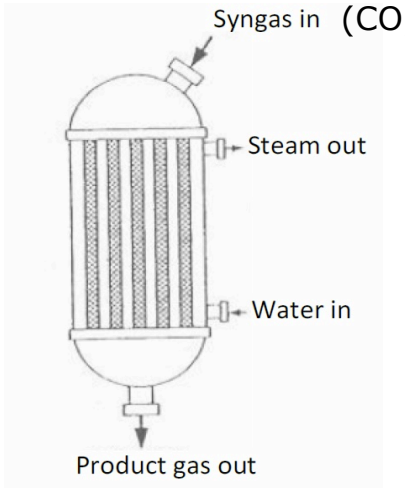
- Consist of CO and H_2 (the building blocks for chemical synthesis)

Requirements for gasifier:

- High content of CO and H_2
- Low content of other combustible gasses - mainly CH_4 and tar

Chemical synthesis

Reactor:
7-150 bar
200-300 °C



Fuel product
Dimethyl ether (DME)
Methanol
Synthetic natural gas (methane)
Fischer–Tropsch fuels
Synthetic gasoline

Catalyst in reactor:

Synthesis of Bio-fuel

Fischer-Tropsch

- Synthesis takes place at 200-350 ^{o}C and 25-60 bar.

The main reactions for FT-synthesis are:

Alkanes: $nCO + (2n+1)H_2 \rightarrow CnH_{2n+2} + nH_2O$

Alkenes: $nCO + 2n\ H_2 \rightarrow C_2H_{2n} + nH_2O$

Water-gas-shift: $CO + H_2O \leftrightarrow CO_2 + H_2$

The optimal H_2/CO ratio is 2

Synthesis of Bio-fuel

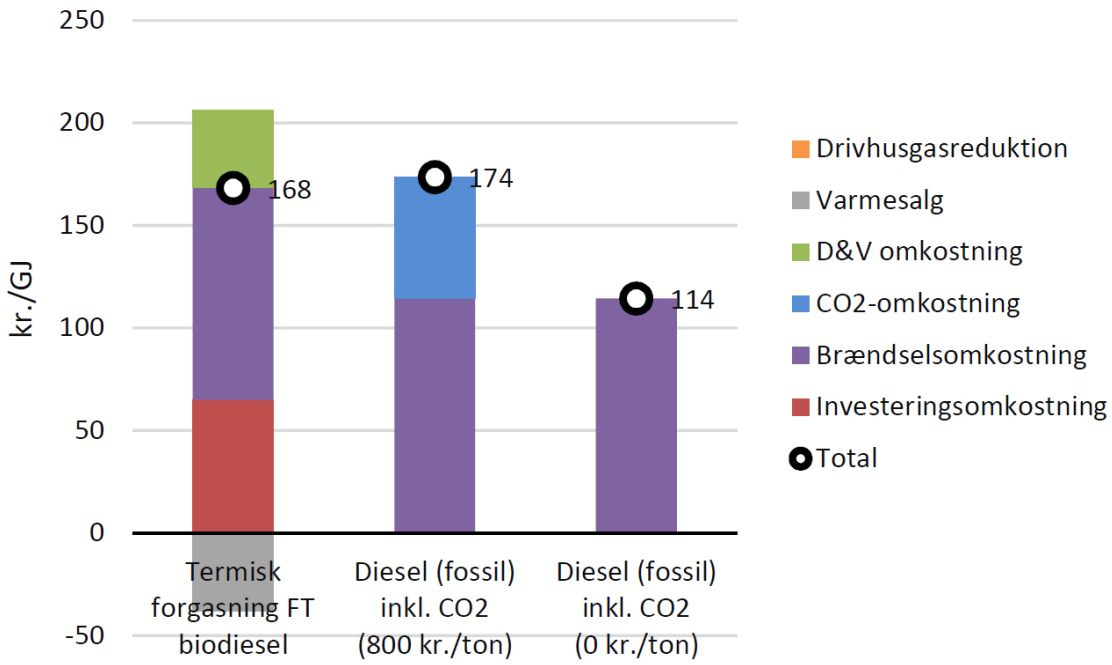
Fischer-Tropsch (FT)

- FT synthesis produces a range of products, primarily a-olefins and waxes. The distribution depends on the used catalytic materials and process conditions.
- In a subsequent refining process synthetic fuels can be produced.
- The highest conversion from syn-gas to diesel is 60%
- The synthesis is exothermic, about 20-30% of den chemical bound energy is released as Heat.

- Sasol, PetroSA, Shell…

Liquid Biofuel production costs

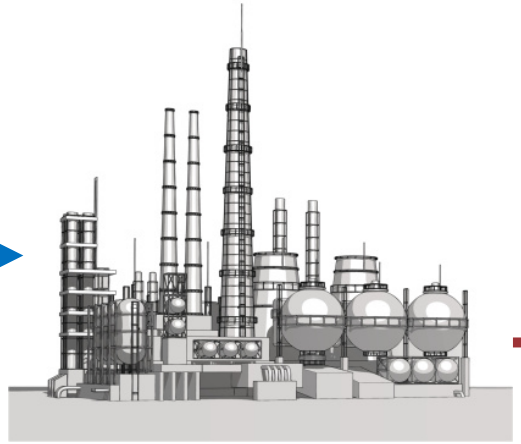
Socioeconomic perspective



Figur 13. Sammenligning af produktionsomkostning for flydende brændstof af diesel typen (LCOE) for 2050 opdelt på omkostningskategorier. For diesel er letolieprisen baseret på IEA's 450 ppm CO_2-eq. scenarie fra World Energy Outlook 2015.

The International Agency for Renewable Energy (IRENA) estimates that the demand for liquid biofuels will be quadrupled from 2015 to 2030, where it will be approximately 500 billion liters, to reach a total of 1,120 billion liters by 2050.

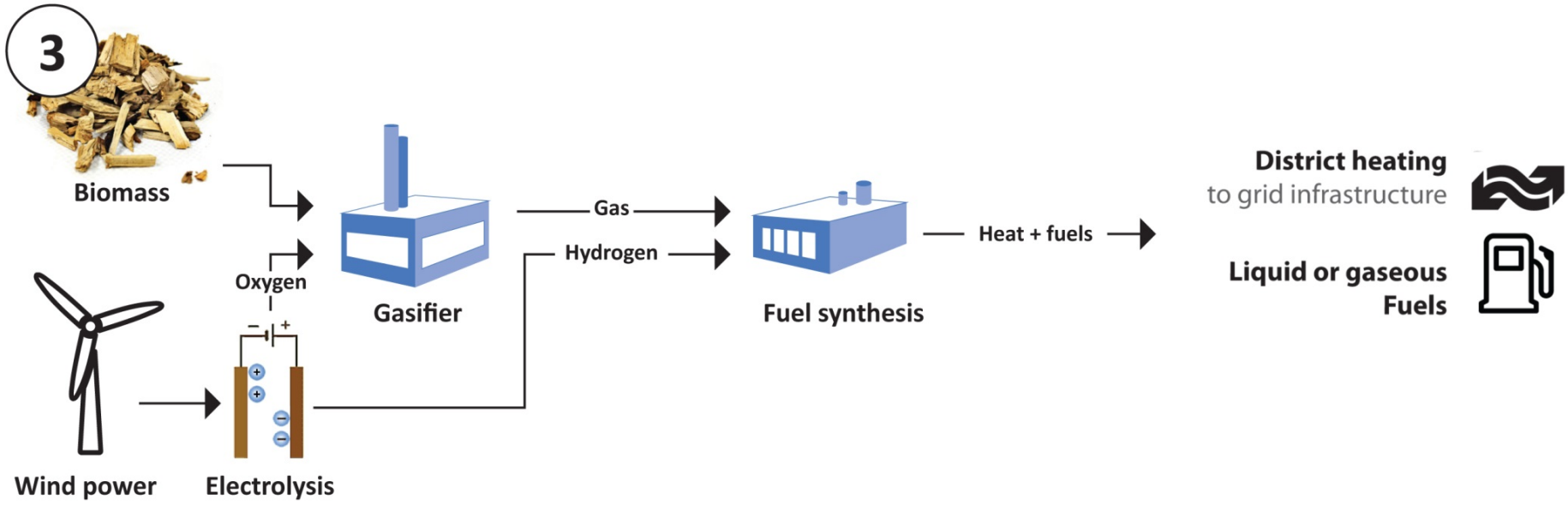
Production of electrofuels



- Methane
- Methanol
- DME
- Gasoline
- Diesel
- Jet fuel

- Indirect electrification of transport sectors (e.g. aviation, shipping)
- Full utilization of biomass carbon (twice as much fuel per biomass input)

Example of Electro Biofuel production



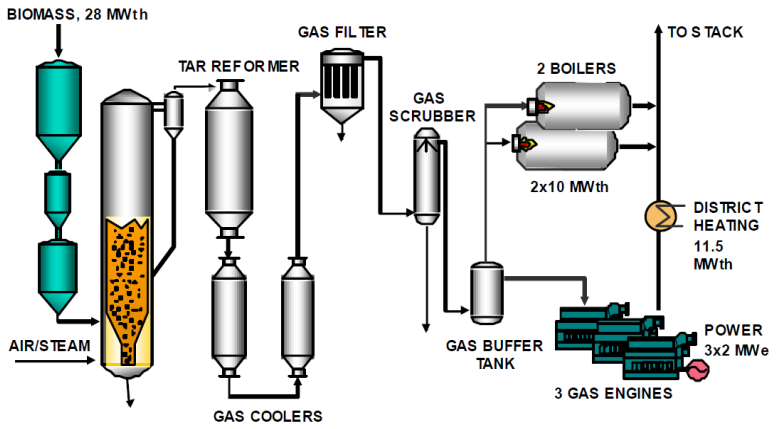
Perspectives

- Production of fuels by *biomass gasification + electrolysis + fuel synthesis* plays **a vital role** in green energy system scenarios
- Biomass **Carbon Efficiency is doubled** in thermal biofuel systems with H2 and O2 from electrolysis
- *Biomass gasification + electrolysis + fuel synthesis* is a highly versatile technological platform with **high product flexibility**

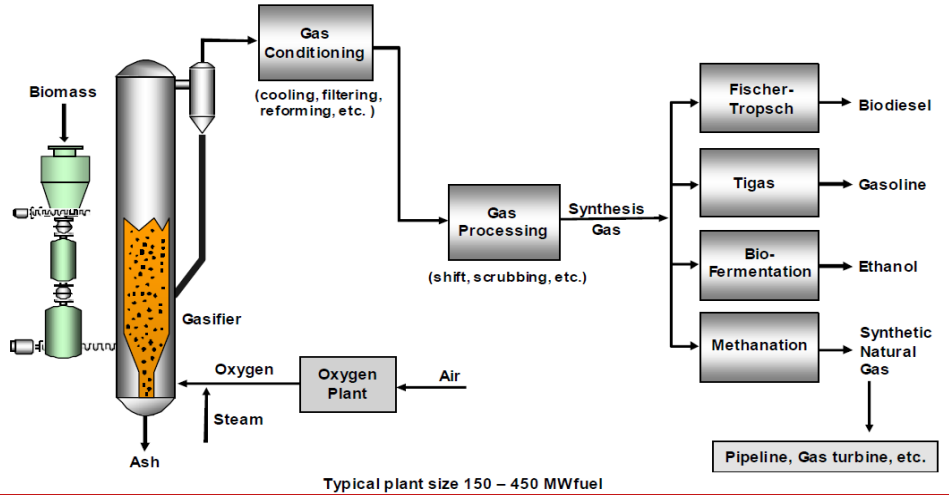
Examples of Gasification Technologies

Skive

- Bobbling fluid bed
- 28MW_{th} max capacity
- 20MW_{th} nominal capacity
- Cold gas efficiency 77%

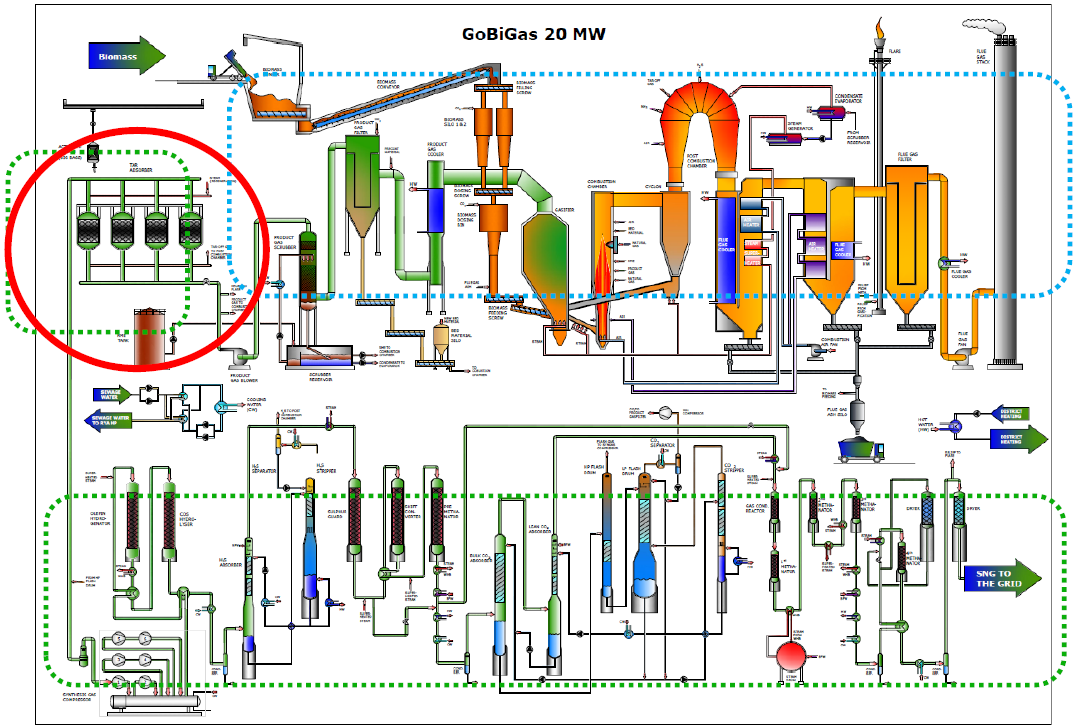


- Slip stream production of gasoline/diesel



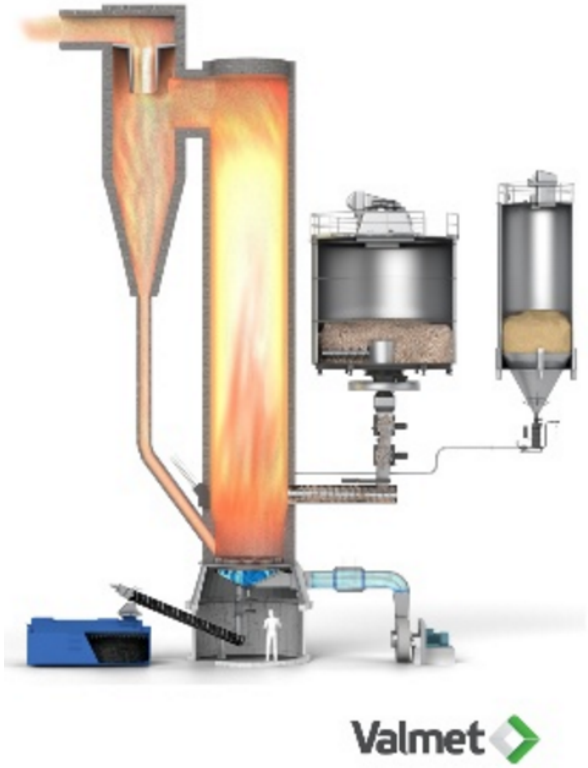
GoBiGas

- Circulating fluid bed
- 20MW$_{th}$ capacity
- Cold gas efficiency 77%
- Biomass-to-SNG efficiency ca. 60-65%



Valmet

- Circulating fluid bed
- Commercial gasification plant 140MW$_{th}$ for wood and 160MW$_{th}$ for waste



Ongoing projects

- SynFuel (Innovationsfonden); DTU Energy, DTU KT, AAU, HTAS :
  - Gas cleaning of Pyroneer gas
  - Oxygen blown gasification
  - Initial integration of SOEC
- BGP (ForskEL/EUDP); DTU KT, DTU MEK, DGC, Dall Energy:
  - Polygeneration
  - Oxygen blown gasification
  - Large Scale Concepts of the TwoStage process
  - System analysis
- EP2Gas (ForskEL/EUDP); DTU Energy, DTU KT, DTU MEK, HTAS :
  - Development of Large Scale TwoStage Concept
  - SOEC development
  - System analysis

Challenges and Opportunities

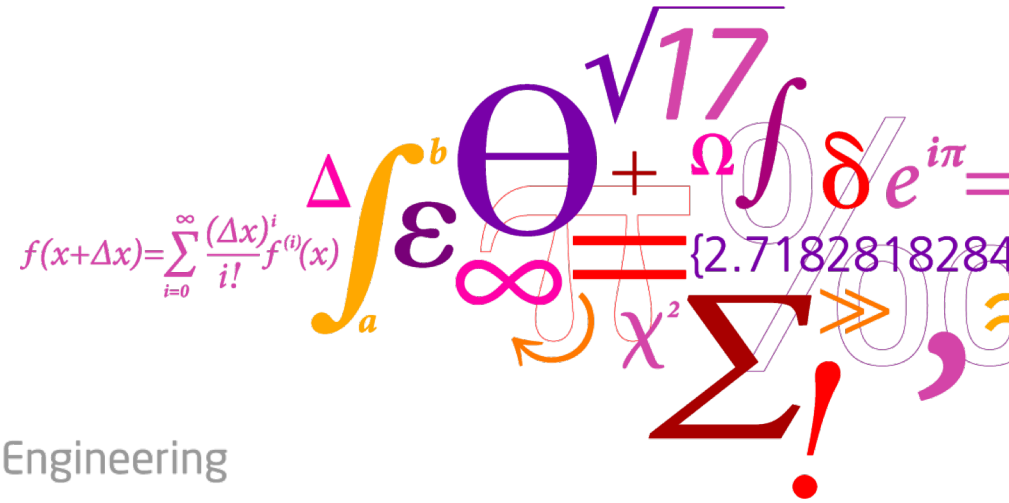
- Framework conditions

- Thermal integration of SOEC/electrolysis
- Gas conditioning/cleaning
- Pilot scale demonstration of integrated BGE plant
- Maturing of Biomass Gasification Technology
- Up-Scaling of SOEC technology

- Danish competencies
- Biomass infrastructure present
- District Heating Network present

Thank you for your attention

Biomass Gasification Group



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