Downloaded from orbit.dtu.dk on: Apr 27, 2024

DTU Library

TwoStage gasification of biomass for clean syngas: Technology and applications

Ahrenfeldt, Jesper

Publication date:
2013

Link back to DTU Orbit

Citation (APA):
Ahrenfeldt, J. (Author). (2013). TwoStage gasification of biomass for clean syngas: Technology and applications. Sound/Visual production (digital)
http://www.natlab.dtu.dk/Energikonferencer/DTU_International_Energy_Conference_2013

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

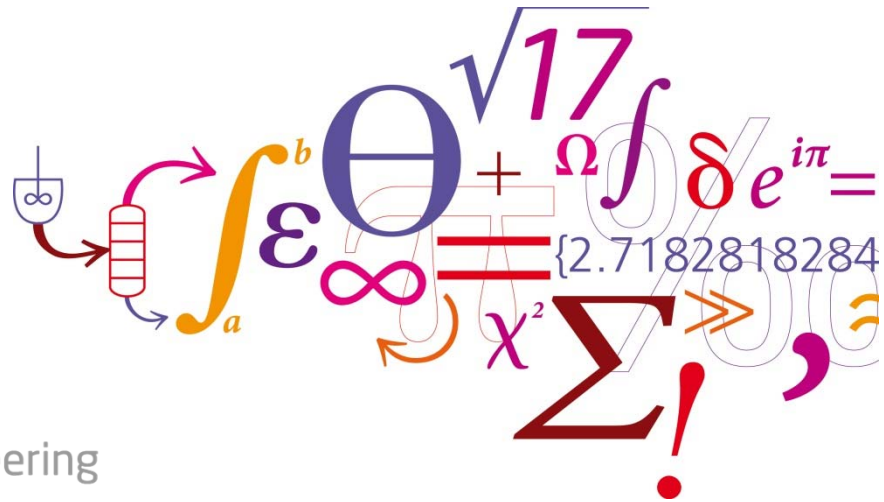
- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

DTU International Energy Conference 2013

TwoStage gasification of biomass for clean syngas: **Technology and applications**

Senior Scientist Jesper Ahrenfeldt
DTU Chemical Engineering



DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

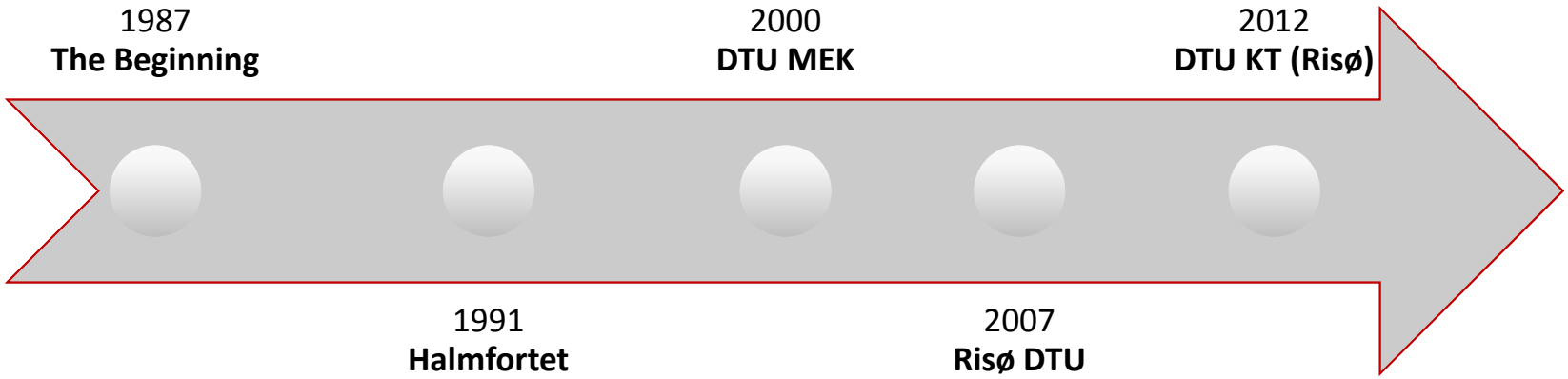
DTU IEC 2013 | Agenda

- Presenting **The Biomass Gasification Group**
- Describing **TwoStage downdraft gasification technology and gas characteristics**
- Examples **Application of clean synthesis gas**

BGG

HISTORY

Biomass Gasification Group | History



BGG History | History & Results

20 years of research, development and demonstration has resulted in **two pre-commercial gasification processes:**

1. **The TwoStage gasifier**, a high temperature process for gasification of wood (developed in cooperation with COWI)
2. **The PYRONEER gasifier** (Low Temperature Circulating Fluid Bed), a low temperature process for gasification of low grade biomass e.g. straw, manure and waste (developed in cooperation with Danish Fluid Bed Technology)

BGG

FACILITIES

BGG Facilities | DTU Chemical Engineering (KT)

Lyngby

Risø

BGG Facilities | BGG at DTU KT (Risø)

BGG Facilities | Building 313

PHYMLAB

Physical and mechanical testing

Grindability
Pelletization
Humidification
Drying
Sampling
Etc.

CHEMLABs

Chemical and analytical testing

GC
HPLC
Extraction
M-TGA
Heating value
Etc.

BGG Facilities | Building 321

THERMOLAB

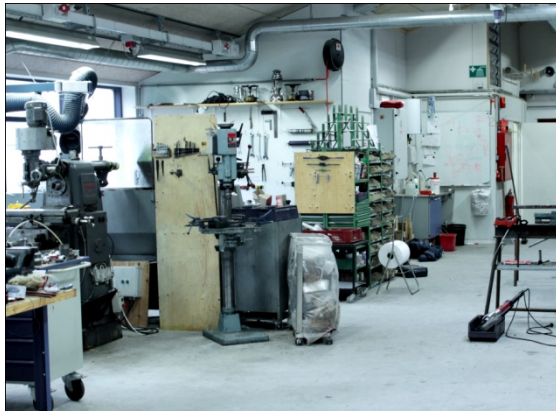
High temperature testing

Macro-TGA
Pyrolysis
Torrefaction
Drying
Annealing
Etc.

WORKSHOP

Preparation and large scale testing

Welding
Cutting
Construction
SOFC setup
LT-CFB setup
Etc.



Technology description

TWO-STAGE THERMAL GASIFICATION OF BIOMASS

Gasification | TwoStage Gasification

Gasification | TwoStage Gasification

The Viking TwoStage Gasifier

- Small scale fixed-bed two-stage CHP(70 kW fuel)
- Commissioned August 2002
- Fully automated and unattended operation
- 4004 (3600) hours of operation

Gasification | TwoStage Gasification

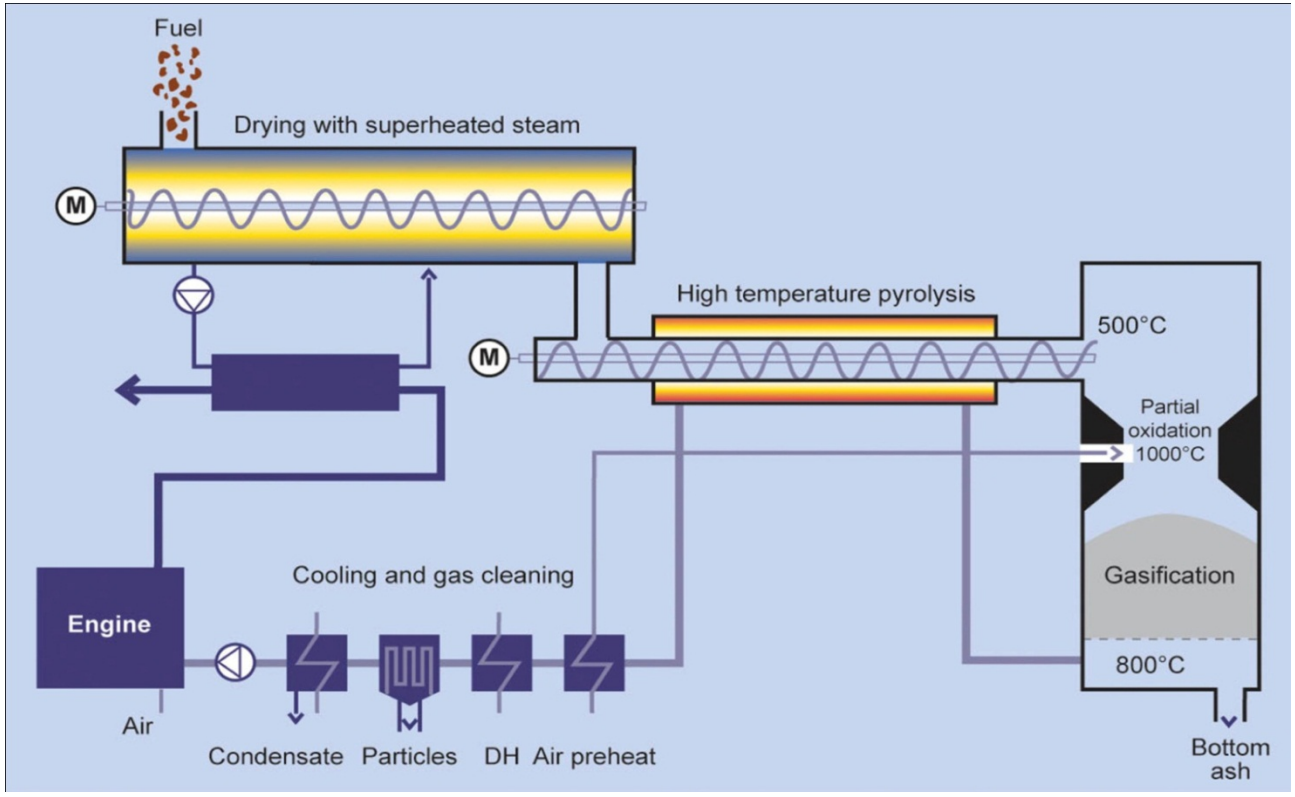
TwoStage downdraft pilot plant at Weiss A/S

VIKING **1:1**

Pilot plant at Weiss A/S **1:10**

Gasification | TwoStage Gasification

Up-scaling of TwoStage downdraft gasification for CHP production: Hadsund/Hillerød, Denmark



Courtesy Weiss A/S

Gasification | TwoStage Gasification

Weiss A/S, DTU KT and **COWI** have designed and build a **500 kW_{el} gasifier** in the city of Hillerød.

The plant will operate as a combined heat and power plant, producing heat for households and electricity for the grid.

1000 hours of operation during commissioning

TwoStage Gasification | Perspectives

- High gasification efficiency > 93%
- High electrical efficiency >40% with gas engines
- Potential electrical efficiency ~50% with SOFC
- Ideal for decentralised combined heat and power production (CHP)
- High total efficiency (CHP mode) >100%

TwoStage Gasification | Gas characteristics

- Permanent gas species composition:

Gas species	CO	CO_2	H_2	CH_4	N_2
Vol%, dry	19.6	15.4	30.5	1.2	33.3

Gas from the Viking gasifier operated on pine wood chips. Ahrenfeldt et al., 2006

- LHV_{gas}: 5-6 MJ/Nm^3 Ahrenfeldt et al., 2006
- Tar content: 0.02-0.1 mg/Nm^3 naphthalene only, Ahrenfeldt et al., 2006
- Suitable for SOFC operation, 150 hours single cell test completed

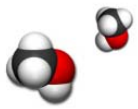
Technology description

APPLICATION OF SYNGAS FROM TWOSTAGE GASIFICATION

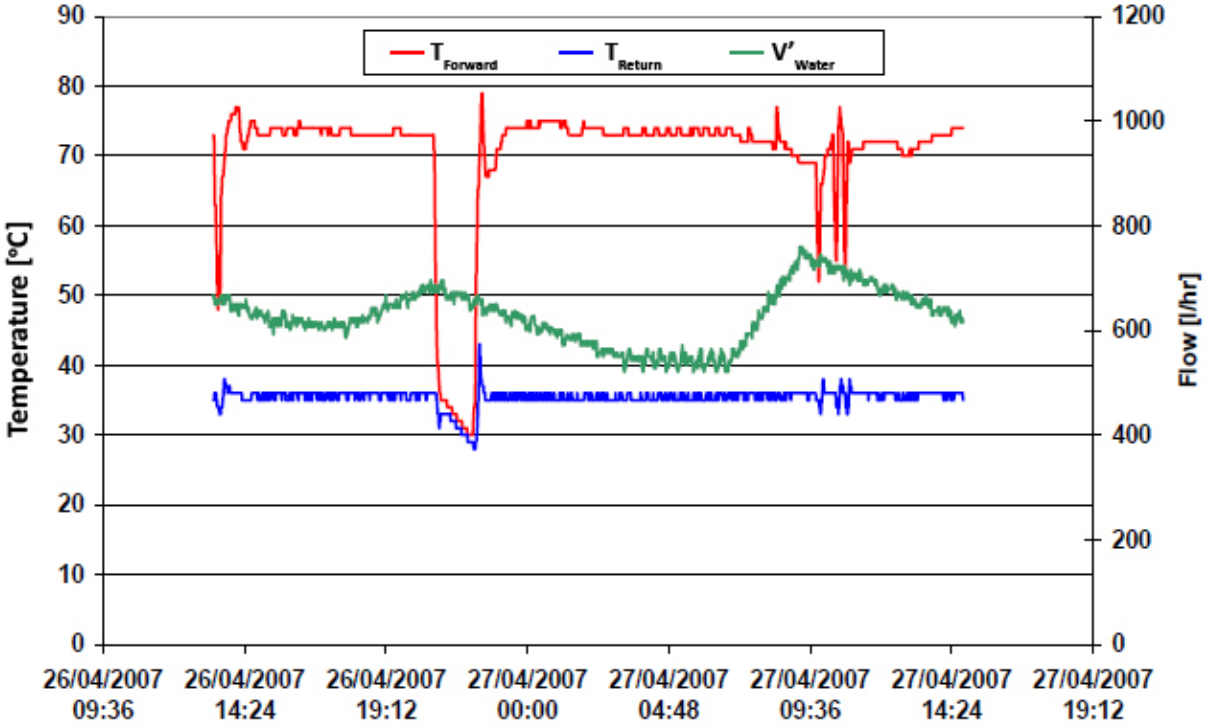
TwoStage Gasification | Gas application

1. Cogeneration of **heat and power**

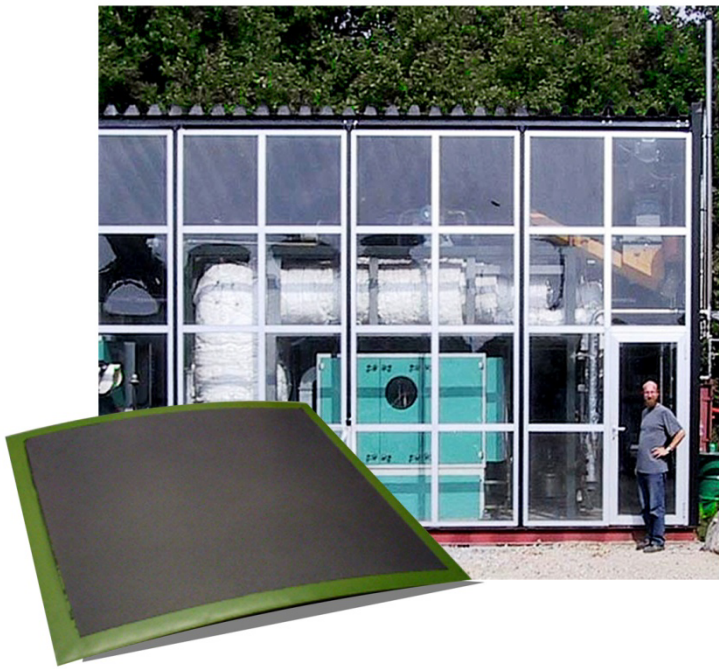
2. Polygeneration of **heat, (power) and biofuels**



Gas application | Flexible CHP



Gas application | CHP production via SOFC



Extremely clean producer gas

Single cell test successful in 2006
(150 h without catalyst degradation)

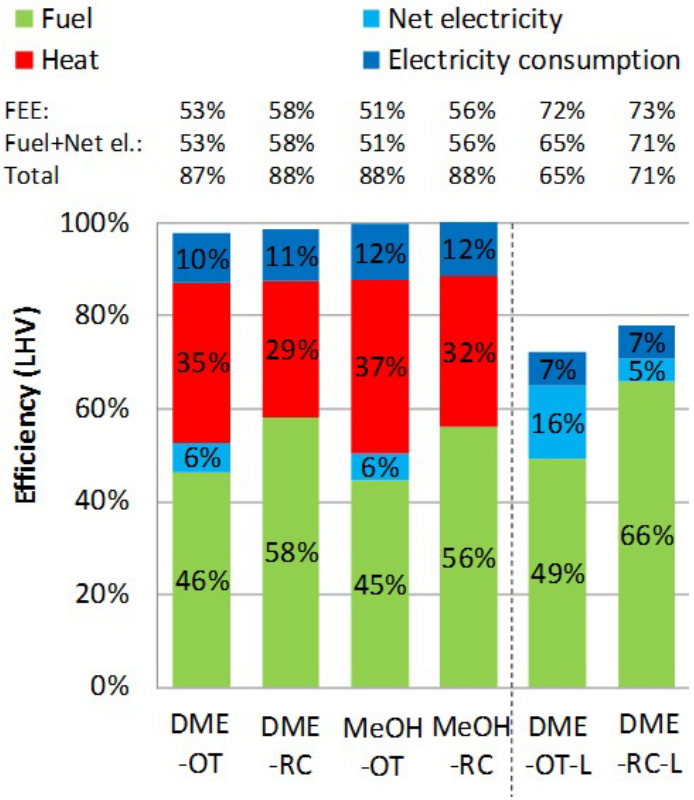
2 kW stack test starting up 2013

Model results on 500 kW gasifier:
Micro gas turbine (MGT): 28% el / 76% CHP
SOFC: 36% el / 80% CHP
SOFC + MGT: 50% el / 80% CHP

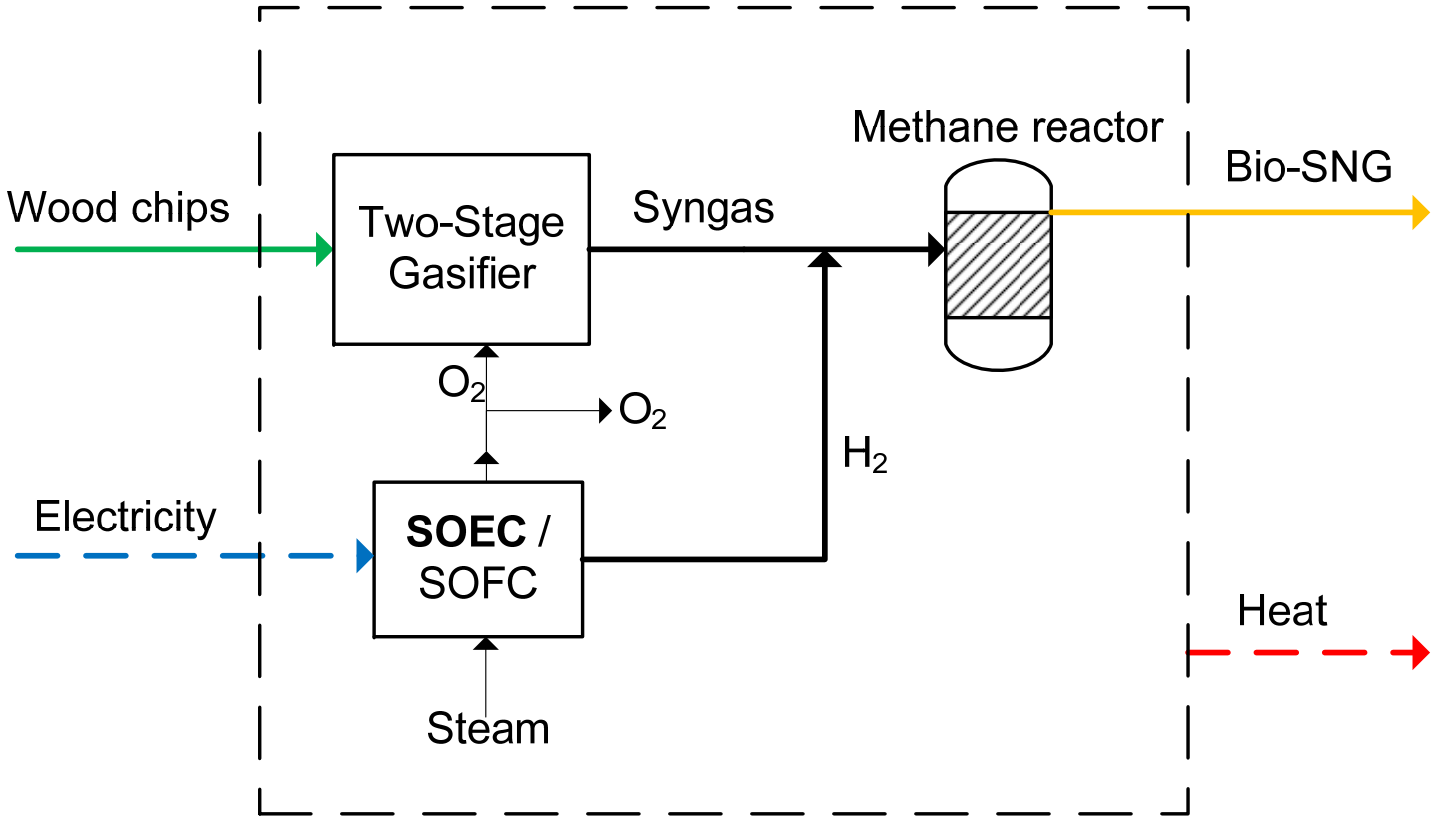
Gas application | Bio-methanol/DME

Thermodynamic model of process:

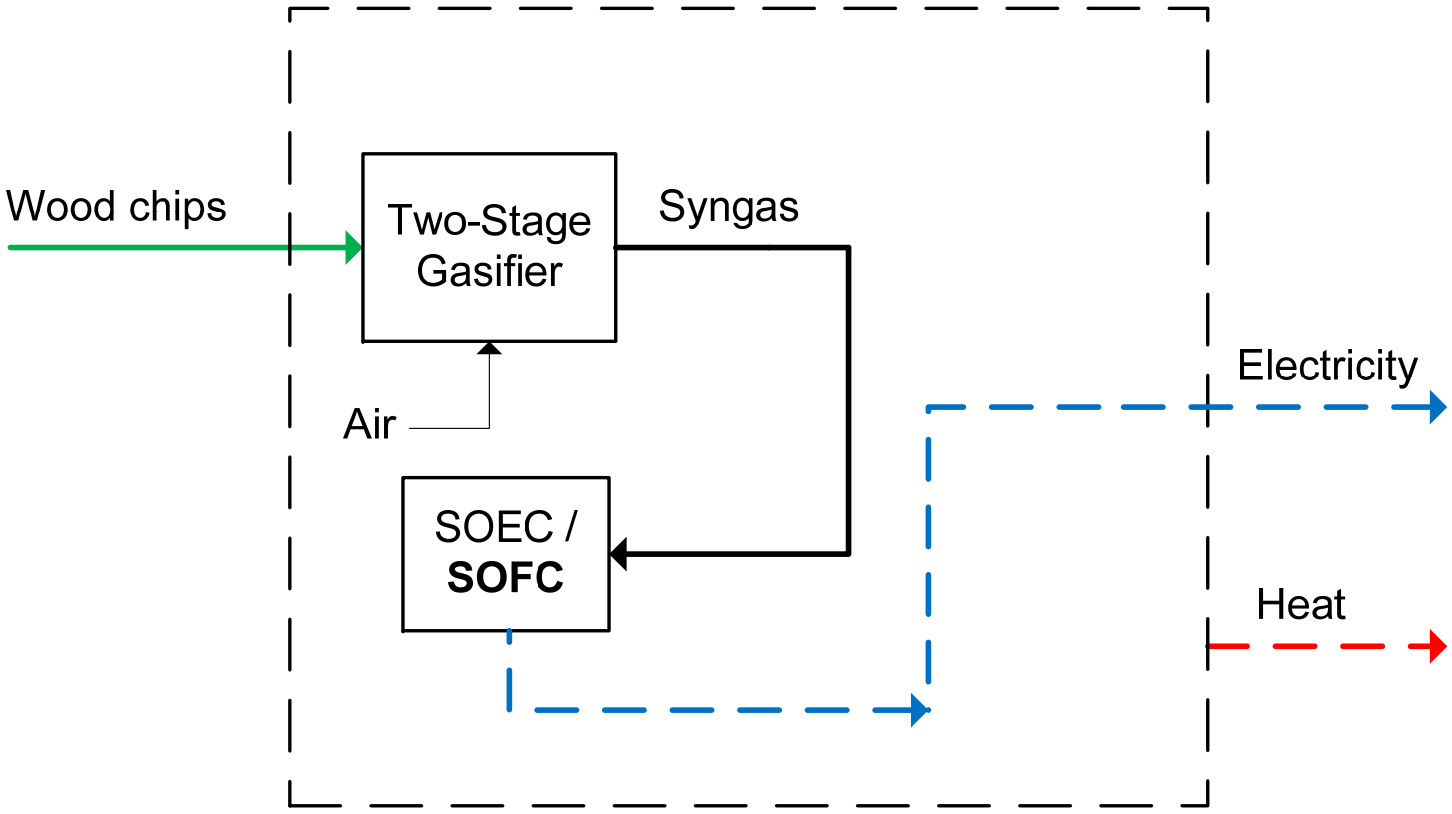
- 5 MW_{TH} input
- Feed stock: Wood chips
- Gas composition as Viking pilot plant
- Once-through >< Recycling plant
- Trigeneration of liquid fuel, power and district heating
- Compared to large, centralized plants



Gas application | BioSNG (Synthetic Natural Gas)



Gas application | BioSNG (Synthetic Natural Gas)



Gas application | BioSNG (Synthetic Natural Gas)

Plant efficiency estimations by DNA modeling (three designs):

- Biomass-to-SNG efficiency based on LHV: **65-78%**
- Overall plant energetic efficiency: **87-90%**

From Maria Mita (2013) Production of Synthetic Natural Gas based on the Two-Stage Gasifier. Master Thesis, DTU Mechanical Engineering

BGG | VISION

- Fact: **Biomass is a limited resource!**
- Thus there are three thing that matter:

BGG | VISION

- Fact: **Biomass is a limited resource!**
- Thus there are three thing that matter:
  - Efficiency

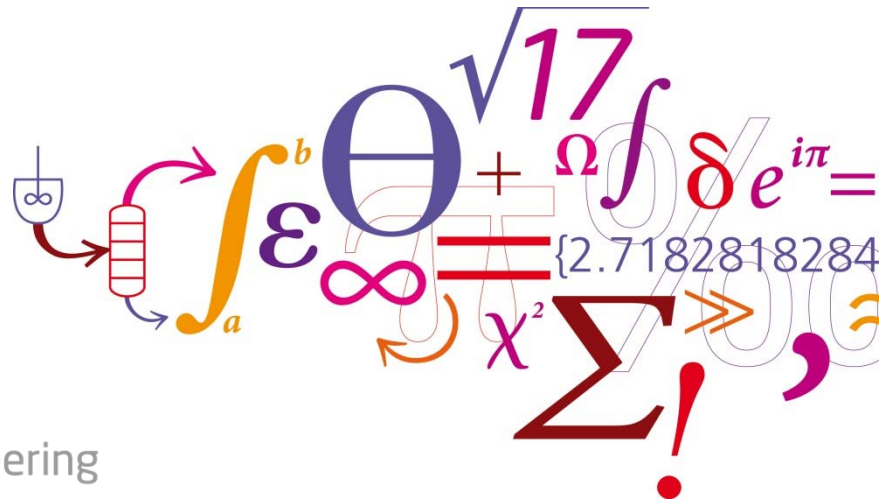
BGG | VISION

- Fact: **Biomass is a limited resource!**
- Thus there are three thing that matter:
  - Efficiency
  - Efficiency

BGG | VISION

- Fact: **Biomass is a limited resource!**
- Thus there are three thing that matter:
  - Efficiency
  - Efficiency
  - Efficiency

Thank you for your attention



DTU Chemical Engineering
Department of Chemical and Biochemical Engineering