Gas Workshop DTU 2017

Biomass Gasification

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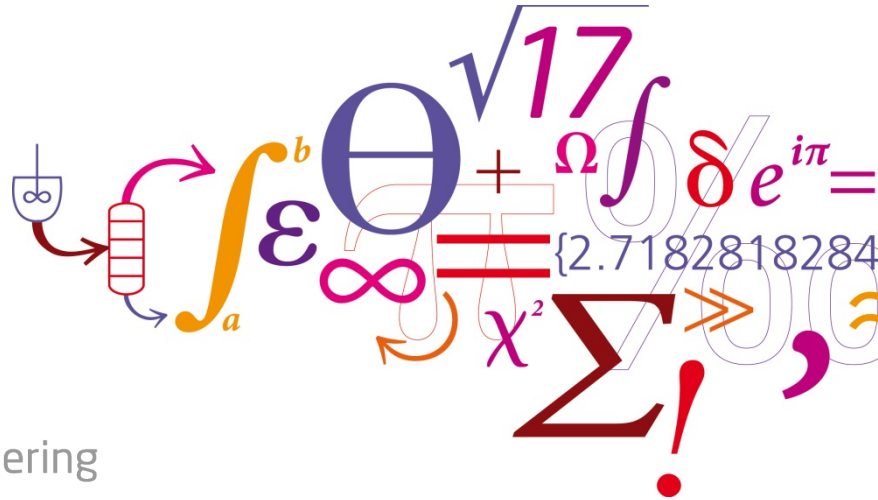
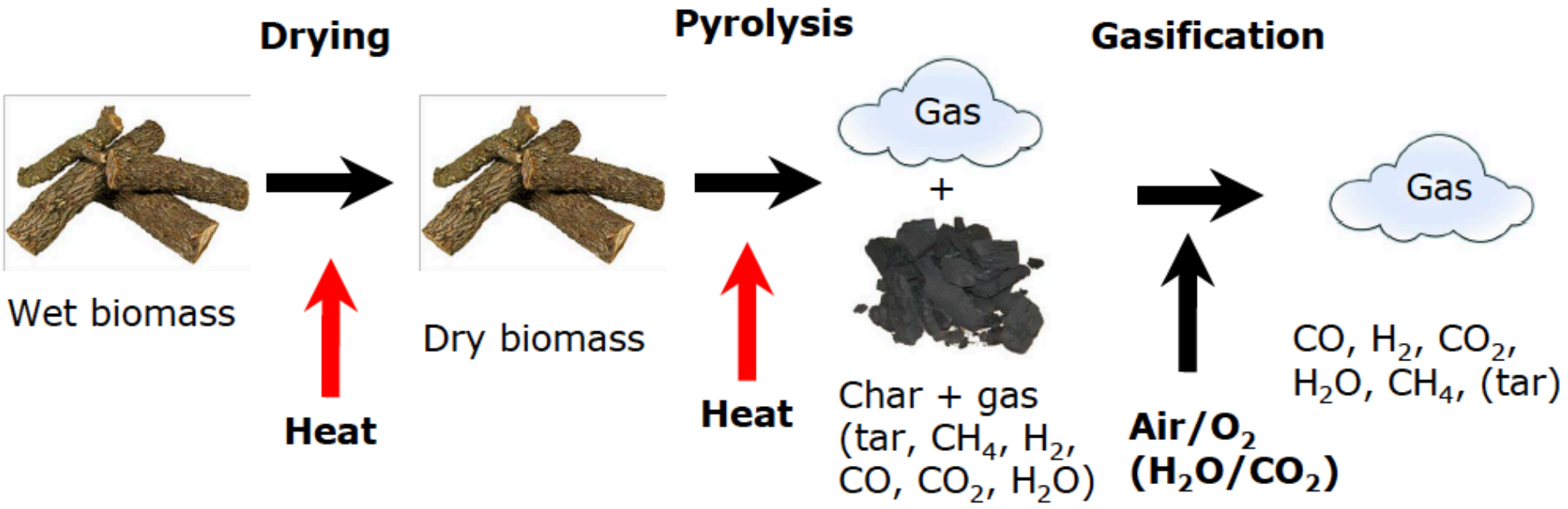


DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

Workshop| Agenda

- **Biomass Gasification 101**
- **SNG Synthesis**
- **Exampel of industrial scale**
- **Chalanges**
- **Biomass Gasification + Electrolysis**

Gasification of biomass



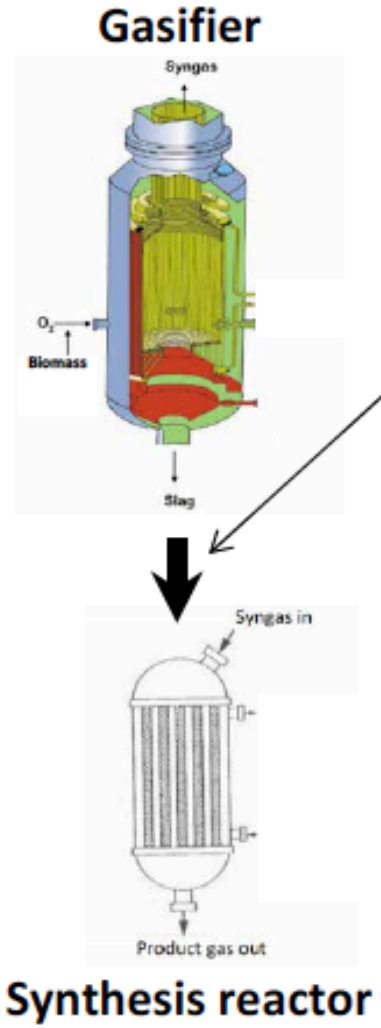
High conversion:

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



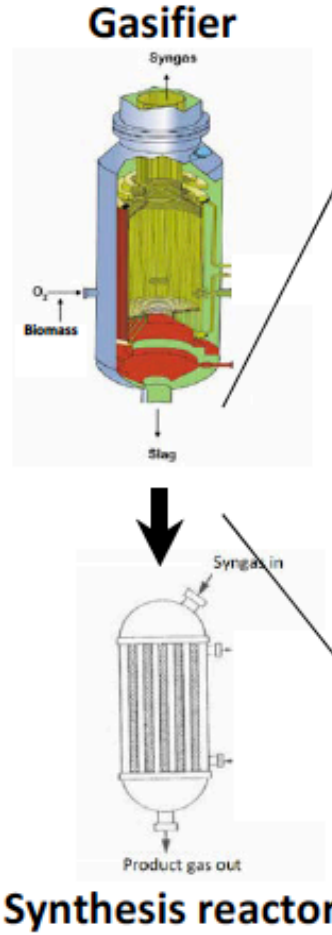
Syngas (synthesis gas)

- 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

Fuel Synthesis



After the gasifier the gas needs to be cleaned and conditioned:

- Removing CO_2 to increase the conversion to biofuel and lower the size of downstream equipment
- Removing sulfur components (H_2S, COS) because they are poisonous to the catalytic material in the synthesis reactor
- The H_2/CO-ratio is adjusted to the requirements of the synthesis reaction

Fuel Synthesis | BioSNG (Synthetic Natural Gas)

Methane synthesis reactions:

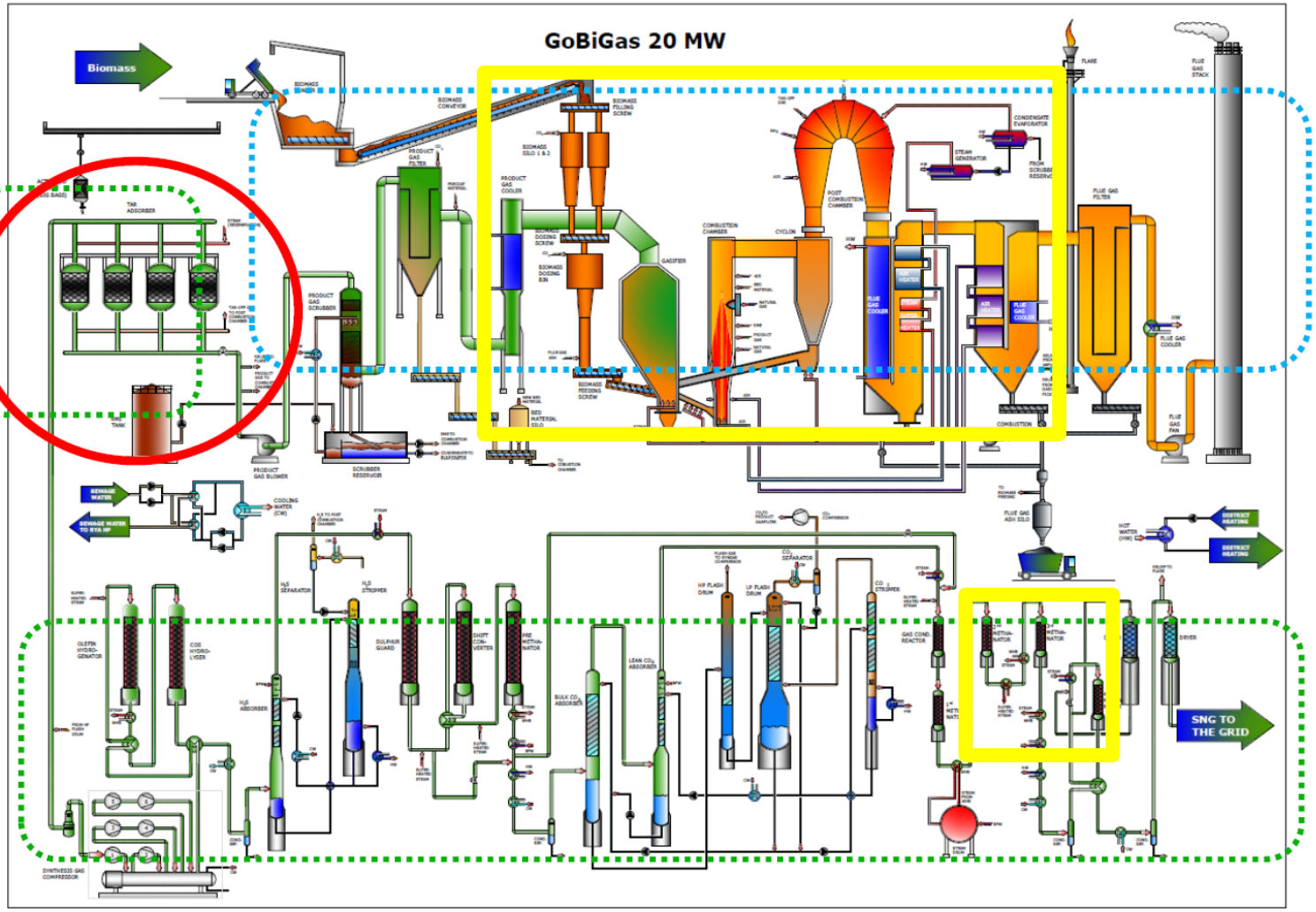
$$CO + 3H_2 \leftrightarrow CH_4 + H_2O \quad -206\ kJ \qquad (1)$$

$$CO_2 + 4H_2 \leftrightarrow CH_4 + 2H_2O \quad -165\ kJ \qquad (2)$$

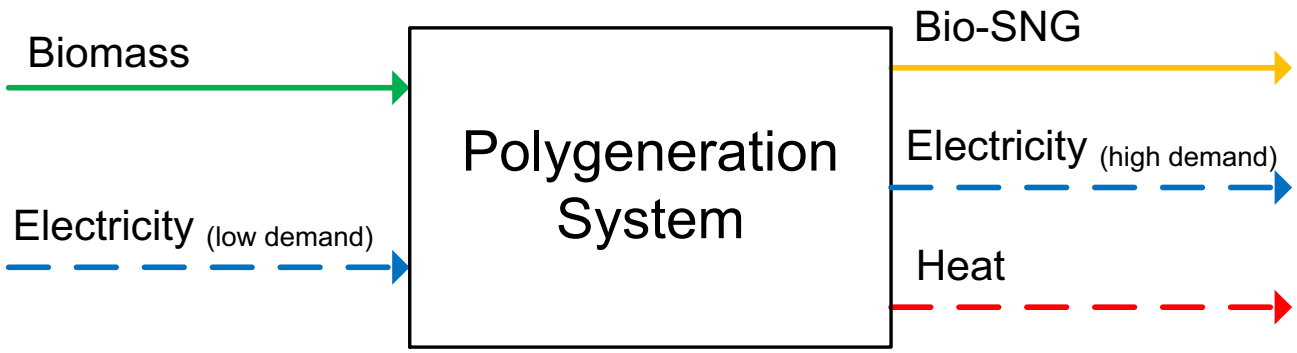
Optimal yield

- High CH4 content in the syngas
- High H2 content in the syngas

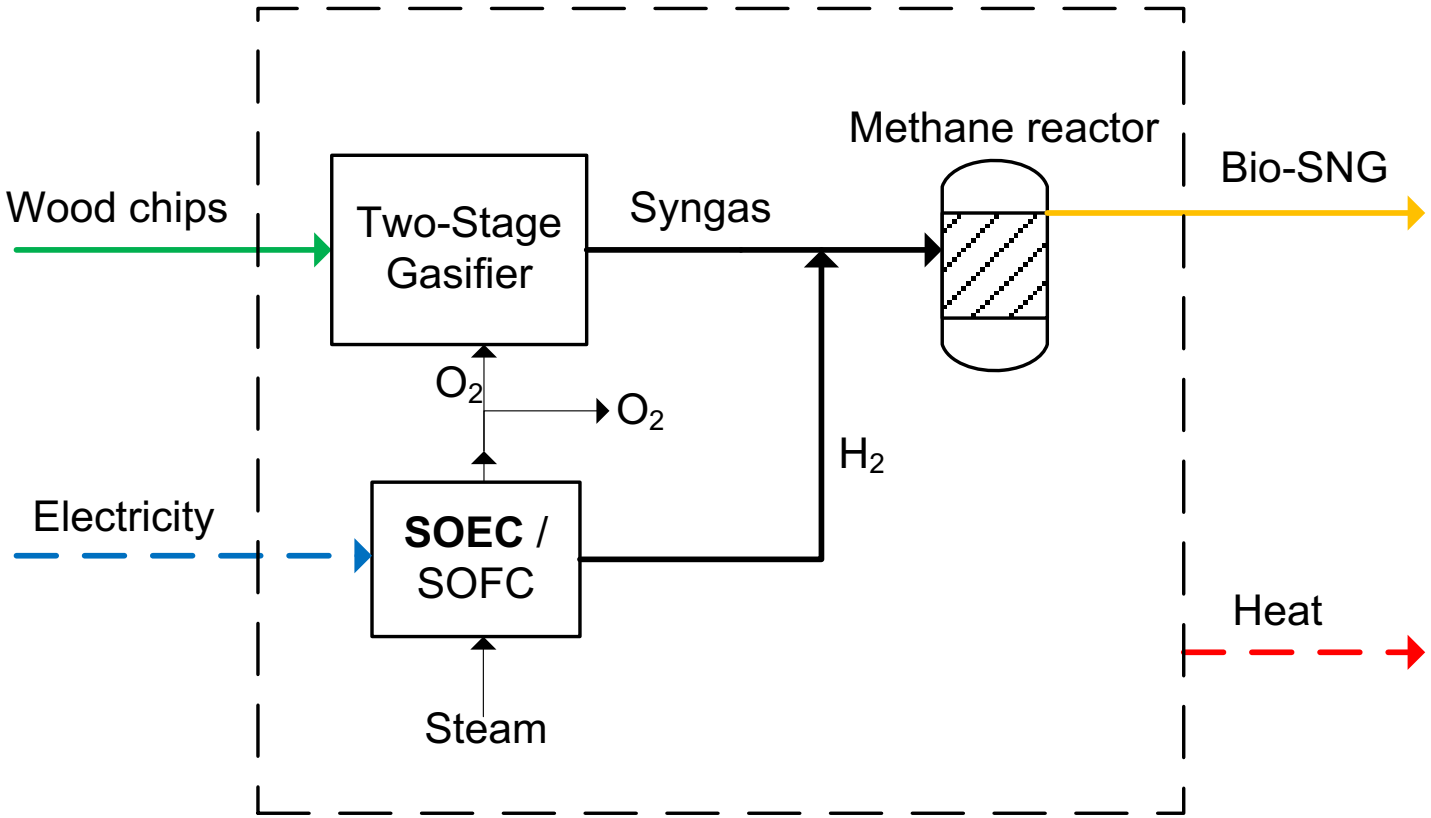
GoBiGas | Industrial scale gasification with challenges



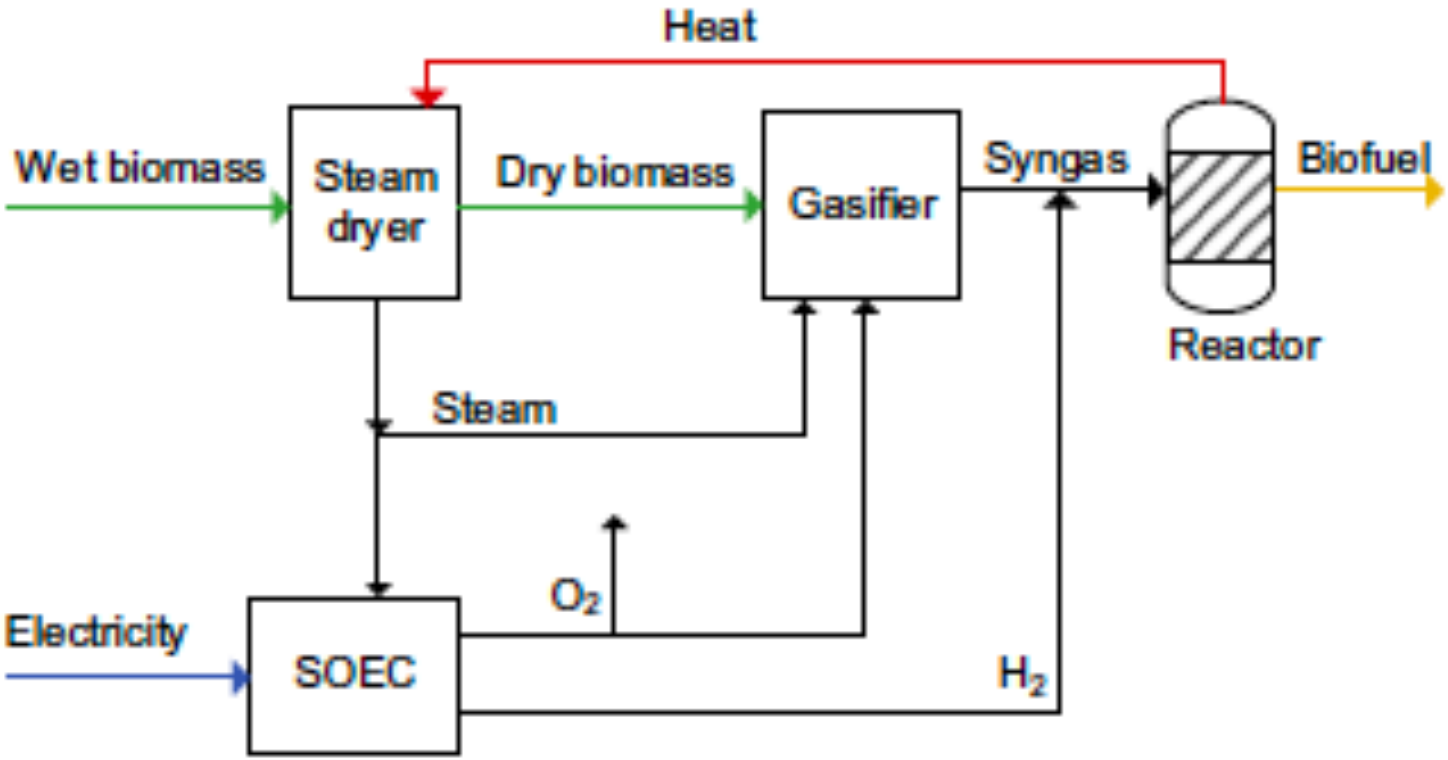
Gas application | Polygeneration



Gas application | BioSNG (Synthetic Natural Gas)



Gas application | BioSNG (Synthetic Natural Gas)



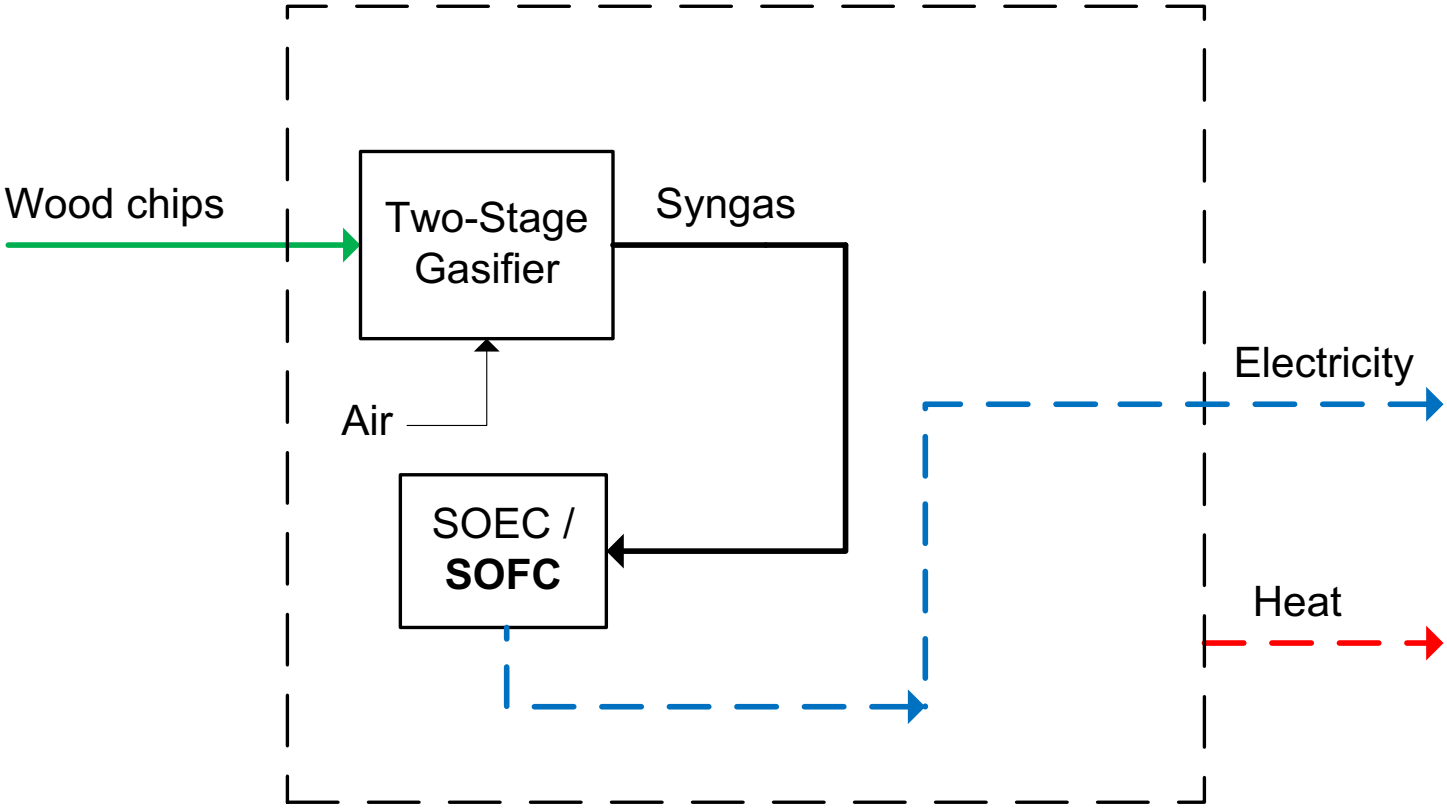
Gas application | BioSNG (Synthetic Natural Gas)

Plant efficiency estimations by DNA modeling (three designs):

- Biomass-to-SNG efficiency based on LHV: **65-78%**
- Overall plant energetic efficiency: **87-90%**
- **More than doubling of the SNG yield**

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

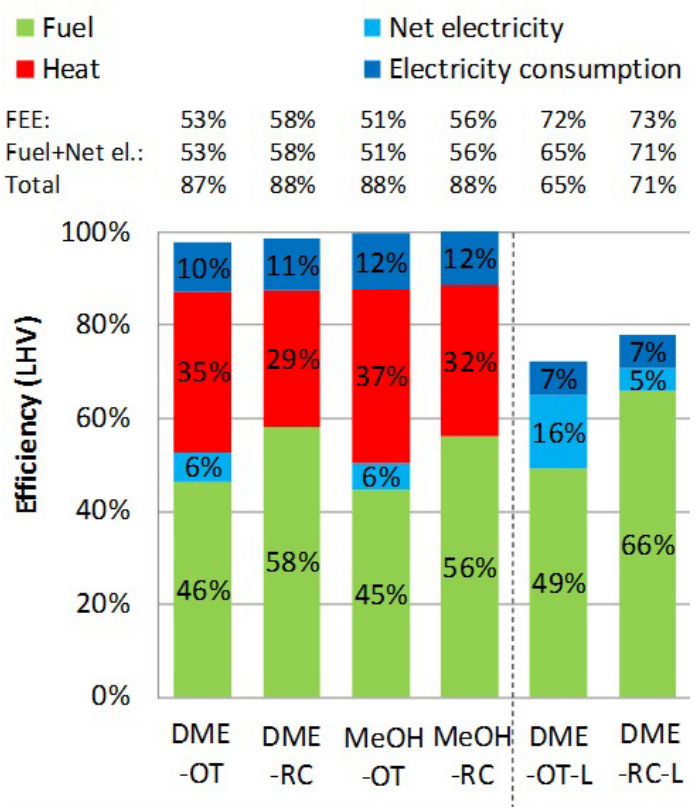
Gas application | SOFC CHP



Gas application | Bio-methanol/DME

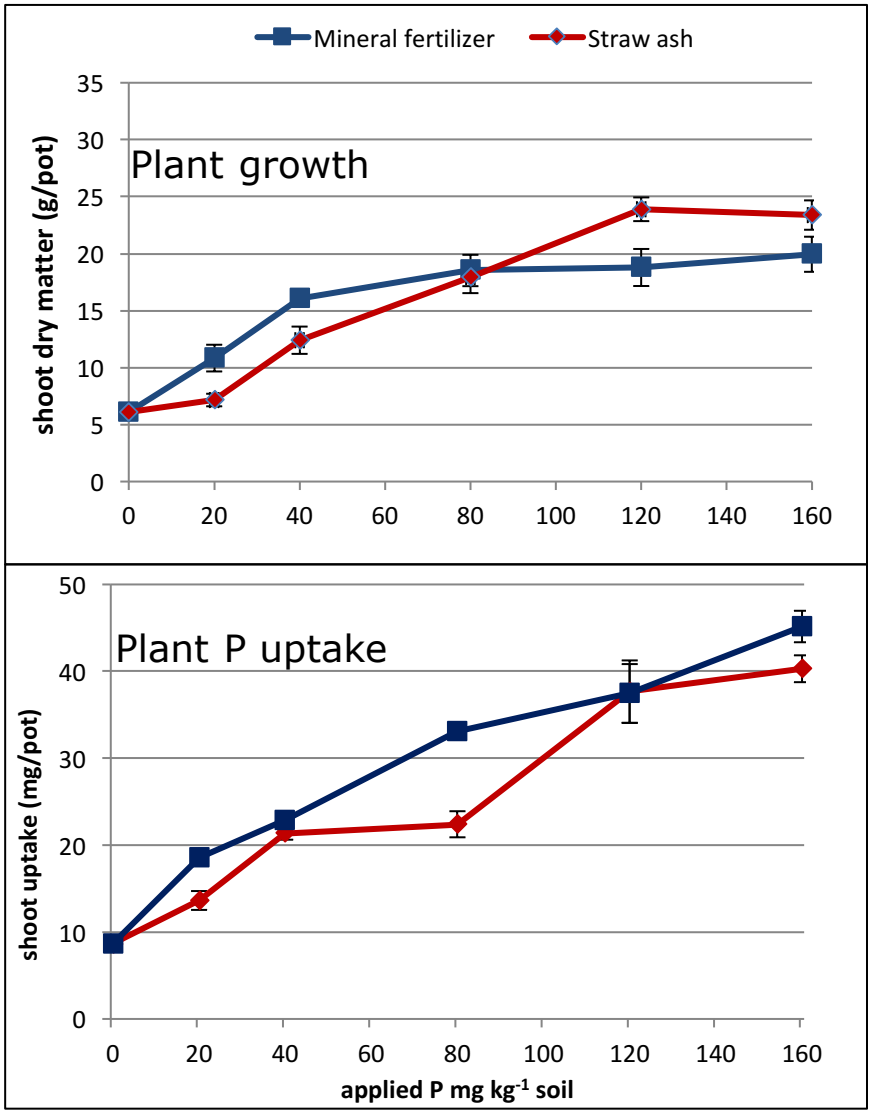
Thermodynamic model of process:

- 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



Lasse R. Clausen (2011) "Thermodynamic analysis of small-scale DME and methanol plants based on the efficienct two-stage gasifier"

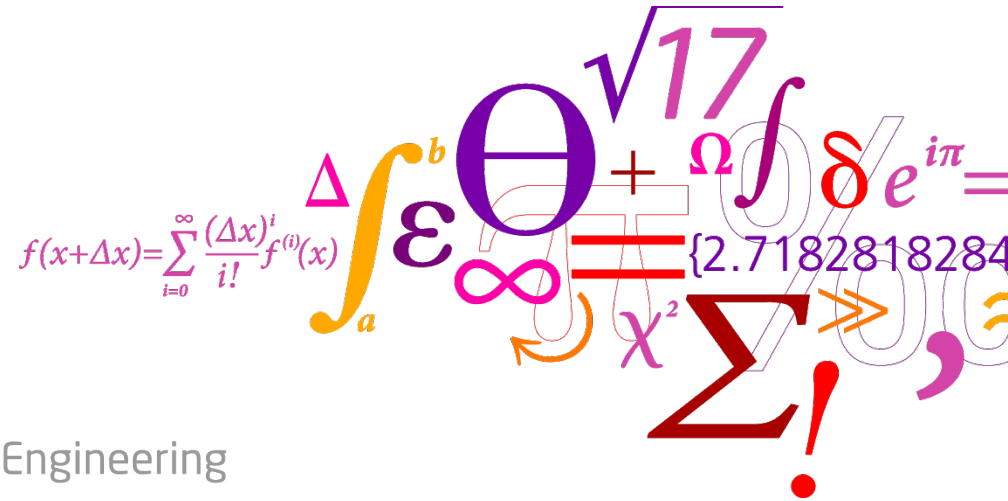
Phosphorus fertilization effect of straw gasification ash



Barley growth at 80 mg P kg^{-1} soil as straw ash (right) or KH_2PO_4 (left)

Thank you for your attention

Biomass Gasification Group



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