Cheaper methanol production with alkali impregnation and novel syngas cleaning

Bio4Energy researchers' meeting
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Background

- Gasification of forest biomass…
  - …is a key technology to reach targets for fossil fuel independency
  - …is a resource efficient way to utilize e.g. lignocellulosic and residual biomass resources (forest fuels, agricultural residues, by-products, wastes etc.)
  - … has been successfully demonstrated at LTU Green Fuels and GoBiGas in Gothenburg
- Process economics at the current development status is a barrier to reach industrial break-through

R&D focused on improving the process economics is needed

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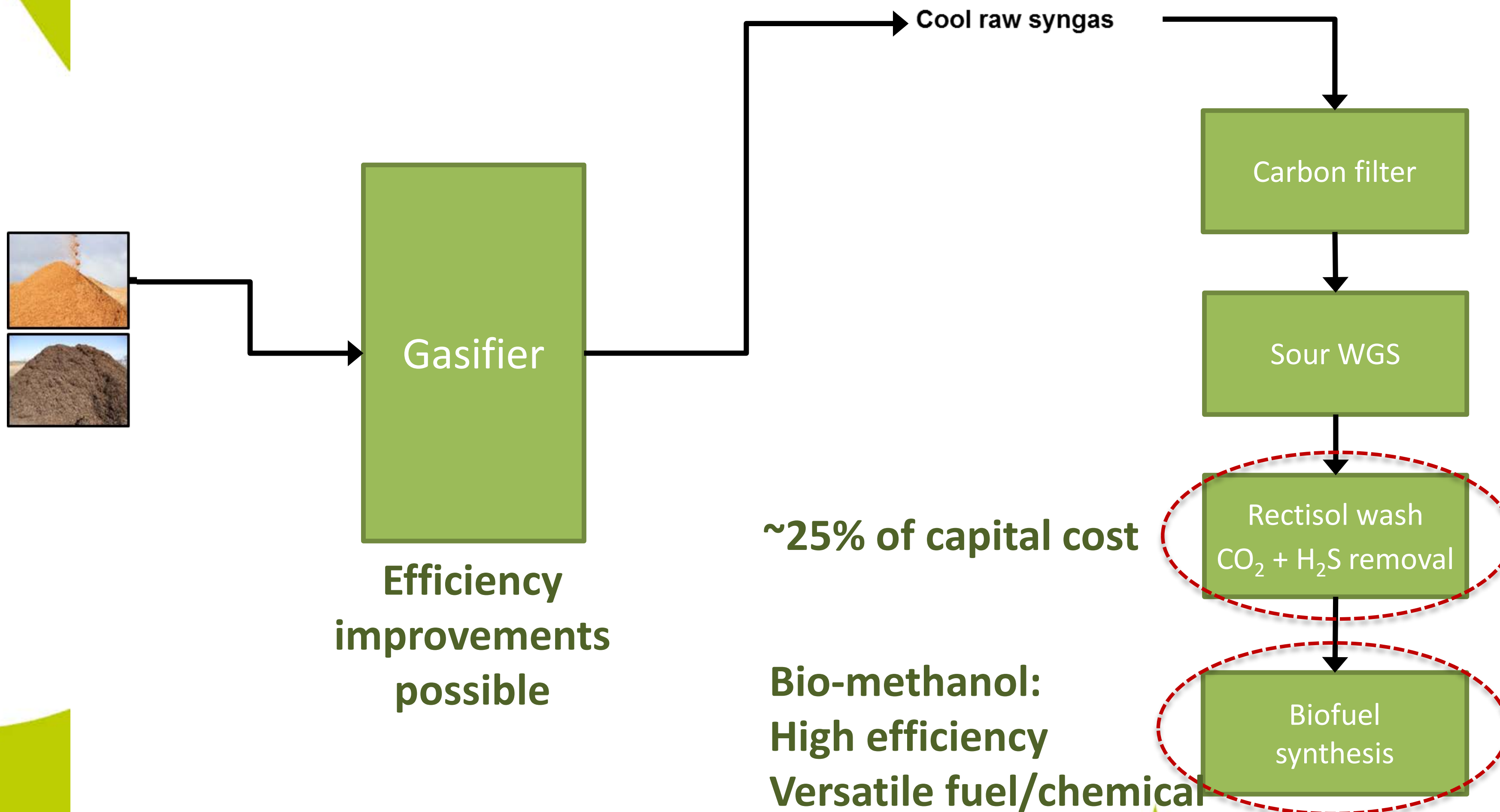
Conventional biomethanol production



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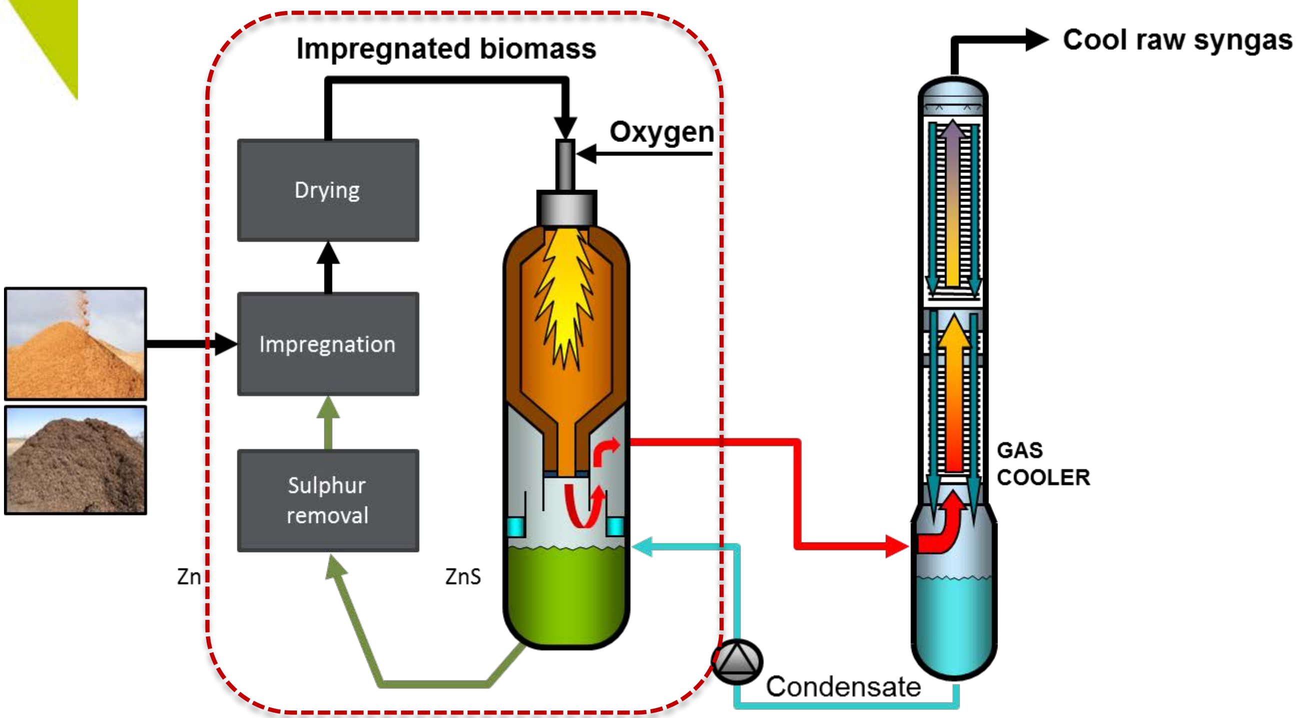
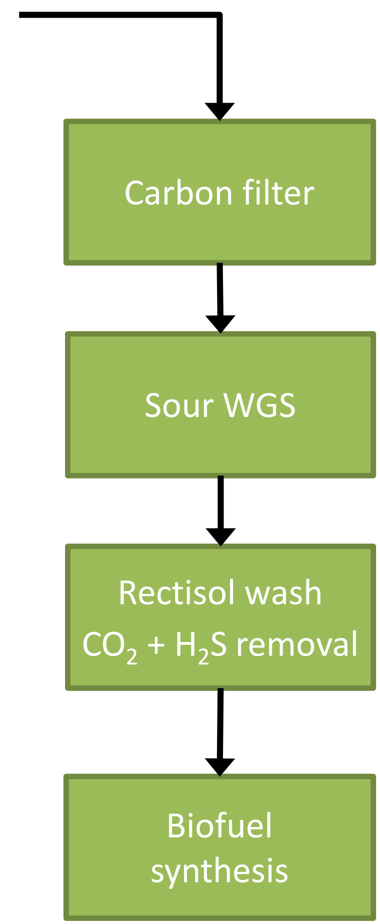
Alkali-enhanced biomethanol production





Alkali enhanced biomass gasification

- Improved char carbon conversion
- Soot & tar reduction
- Slag with low viscosity
- **90% in-situ sulfur capture**

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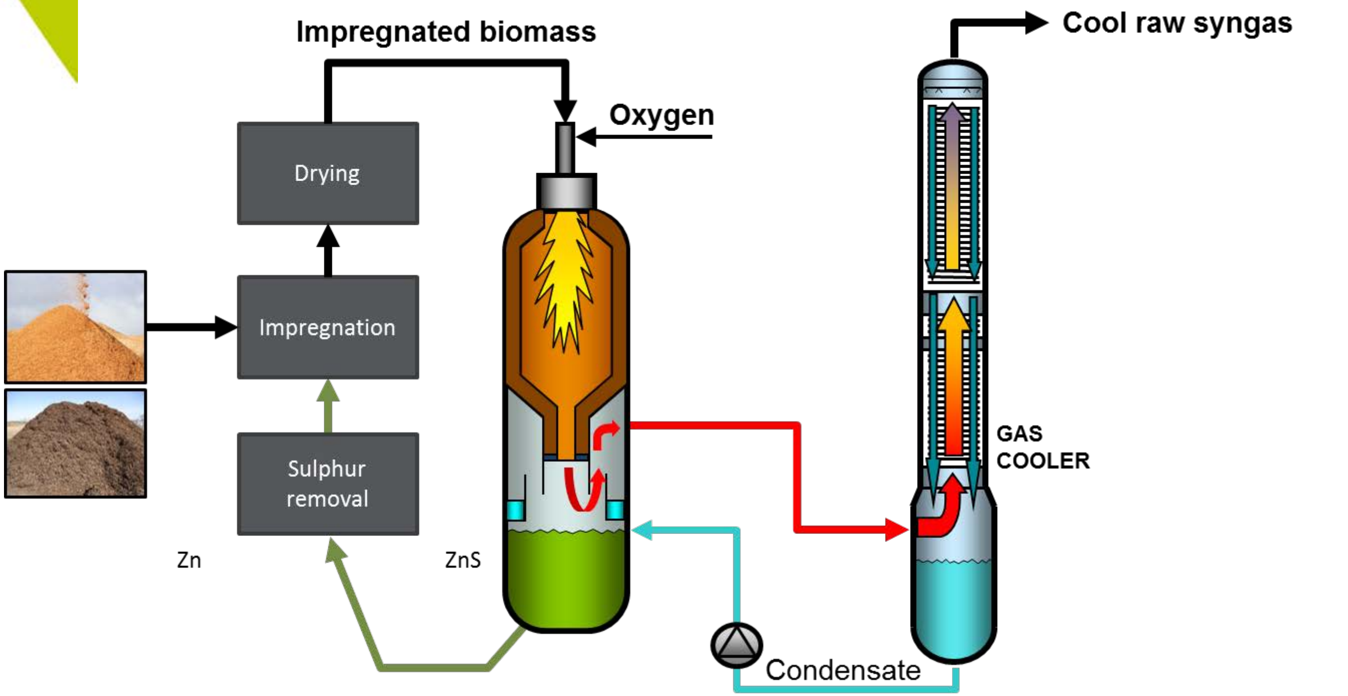
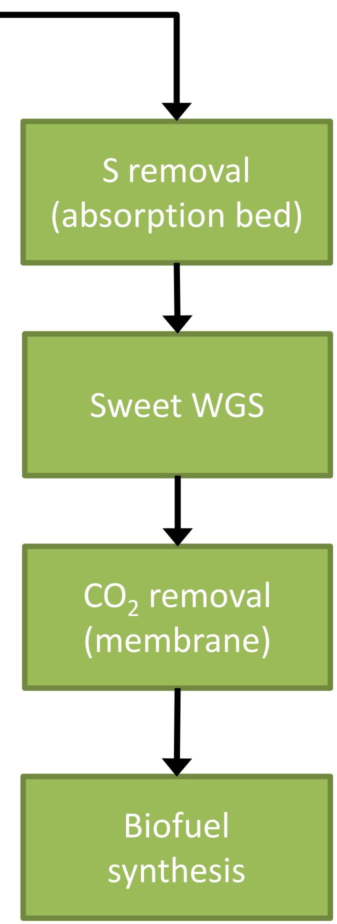
Alkali-enhanced biomethanol production with novel gas cleaning

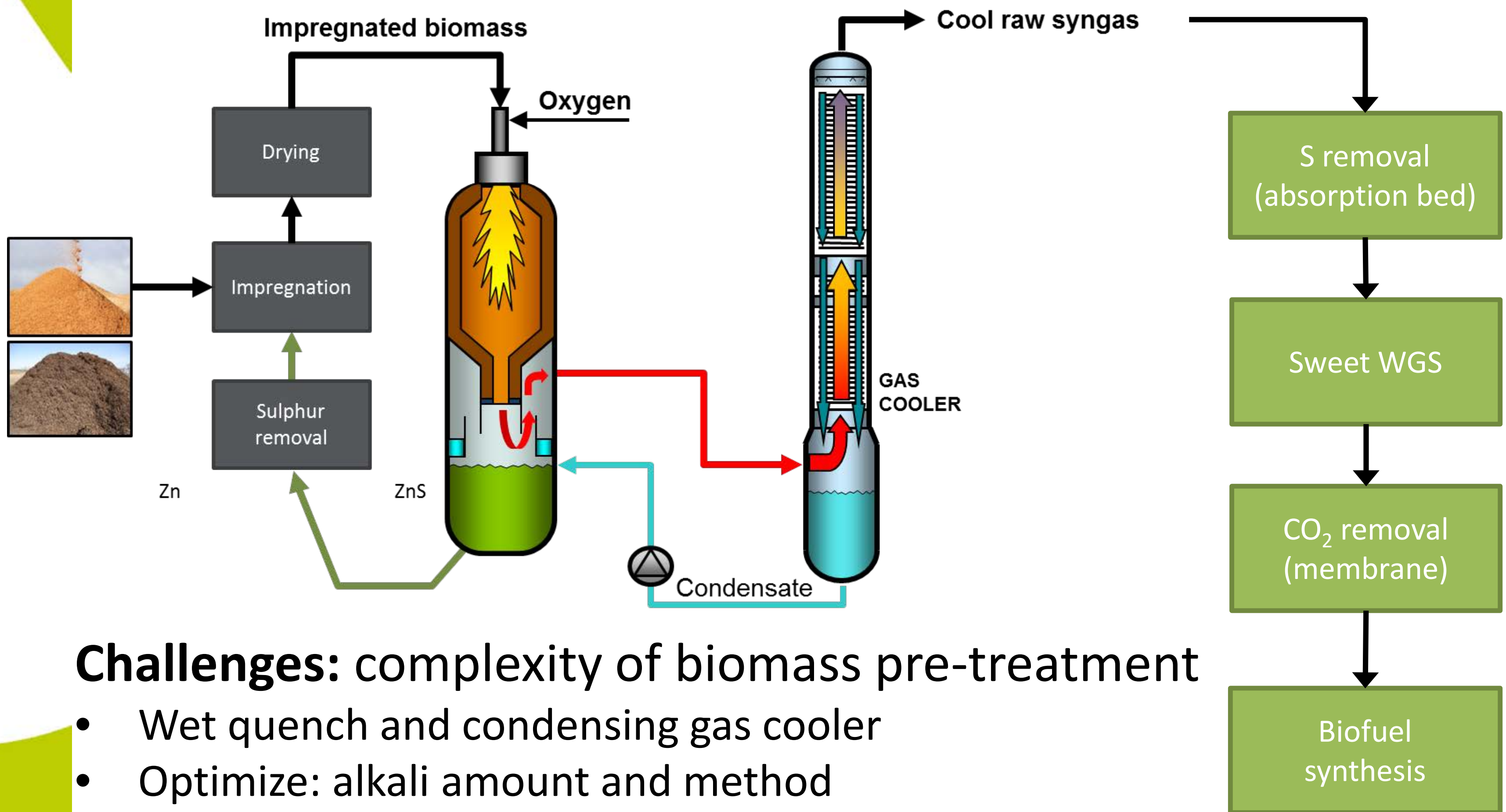




90% in-situ sulfur capture:

Raw syngas **with low S content (<5 ppm)** allows to replace **the Rectisol** with less capital intensive **zeolite membranes** and a ZnO guard bed

Alkali-enhanced biomethanol production with novel gas cleaning



Challenges: complexity of biomass pre-treatment

- Wet quench and condensing gas cooler
- Optimize: alkali amount and method
- Mechanism for tar/soot reduction?
- Proof of concept

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Objectives

- Overall objective of strategic Bio4Energy project:
  - Perform a techno-economic feasibility study of bio-methanol production, implementing alkali enhanced biomass gasification and a novel syngas cleaning concept
- Main objectives:
  1. Assess the fraction of sulfur that can be captured in situ for varying alkali impregnations and biomass types
  2. Design and optimize a zeolite membrane module and surrounding equipment for CO_2 separation from synthesis gas
  3. Assess the process economics and overall energy efficiency of the novel process as well as estimate the cost for CO_2 separation from synthesis gas by zeolite membranes in such a plant

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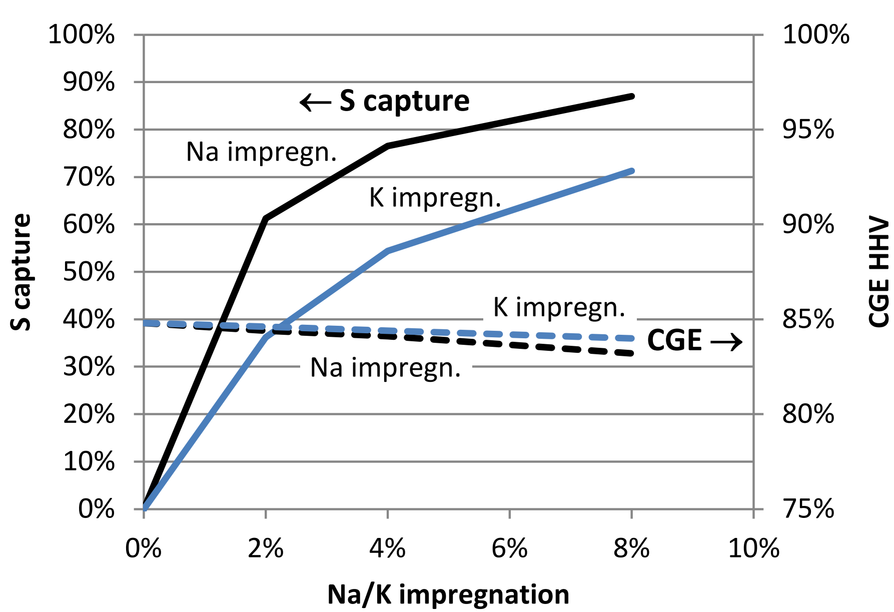
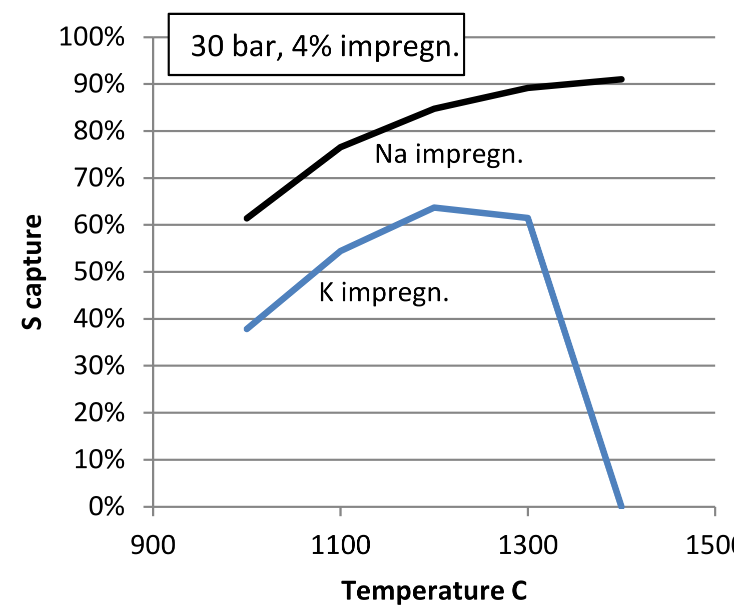
Results – Sulfur capture is dependent on conditions

Impregnation



Temperature effect



$K_2CO_3(l) + H_2S(g) \leftrightarrow K_2S(l) + CO_2(g) + H_2O(g)$

$Na_2CO_3(l) + H_2S(g) \leftrightarrow Na_2S(l) + CO_2(g) + H_2O(g)$

CGE: cold gas efficiency

Furusjö et al. (2018) Alkali enhanced biomass gasification with in situ S capture and a novel syngas cleaning. Part 1: Gasifier performance, Energy 157:96-105

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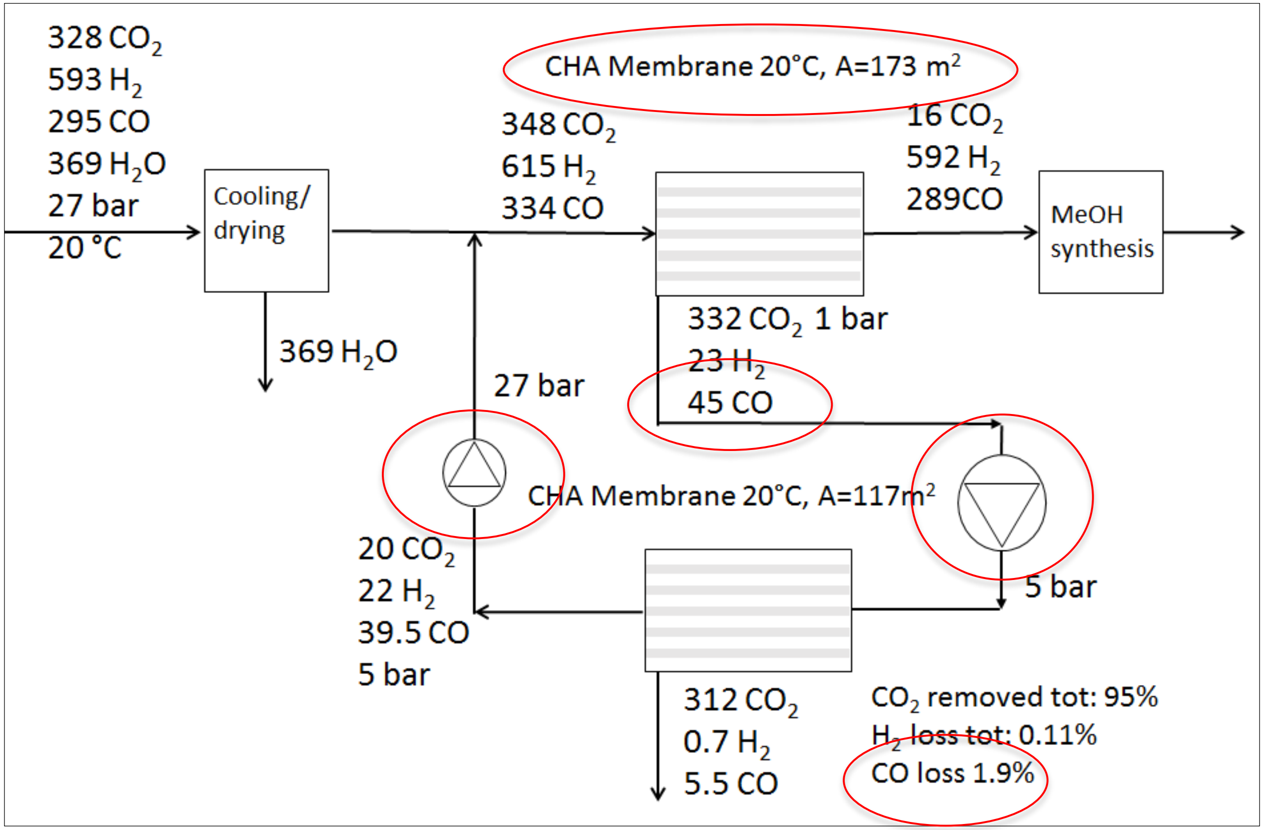
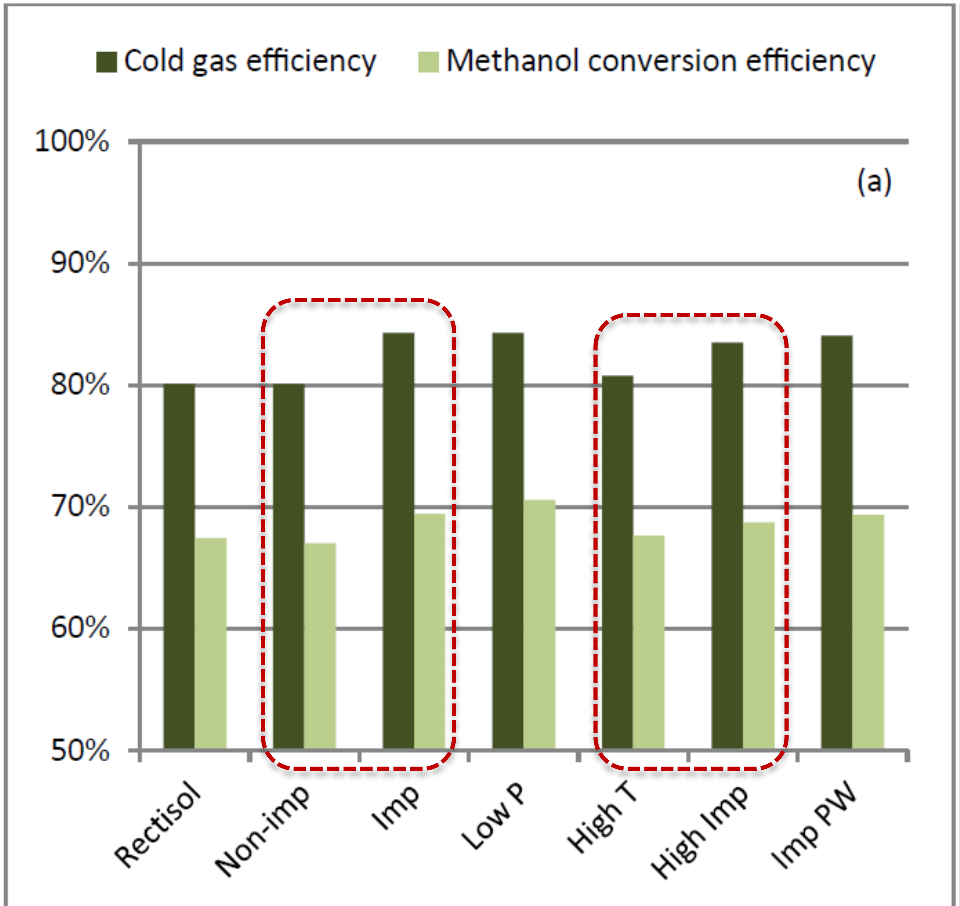
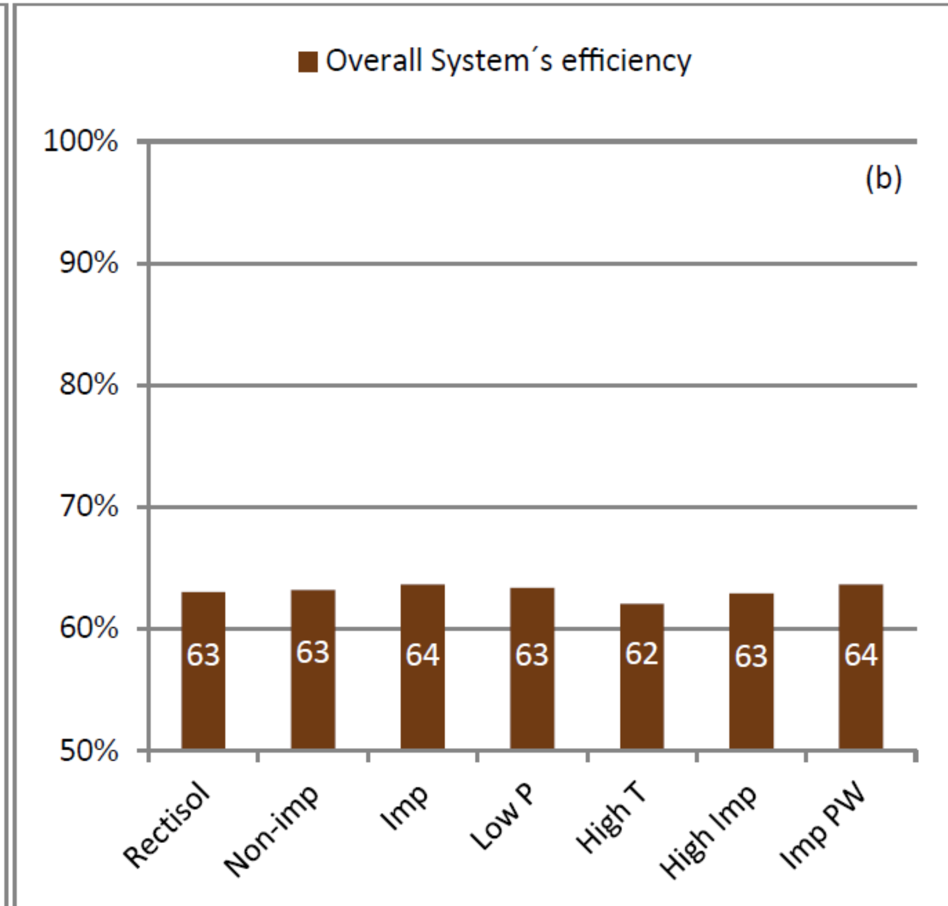
Results – Zeolite membranes for CO_2 removal



Results – Efficiencies





Carvalho et al. (2018) Alkali enhanced biomass gasification with in situ S capture and a novel syngas cleaning. Part 2: Techno-economic assessment, Energy 165:471-482

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Economic assessment

- Three years construction time and 20 years operation, 355 days per year
- Biomass price: 20 € per MWh
- Electricity price: 30 € per MWh

- Calculation of the required methanol selling price (RMSP) to reach IRR's of 10% and 20%

- Conventional bio-methanol production using Rectisol serves as a reference case

*IRR: internal rate of return

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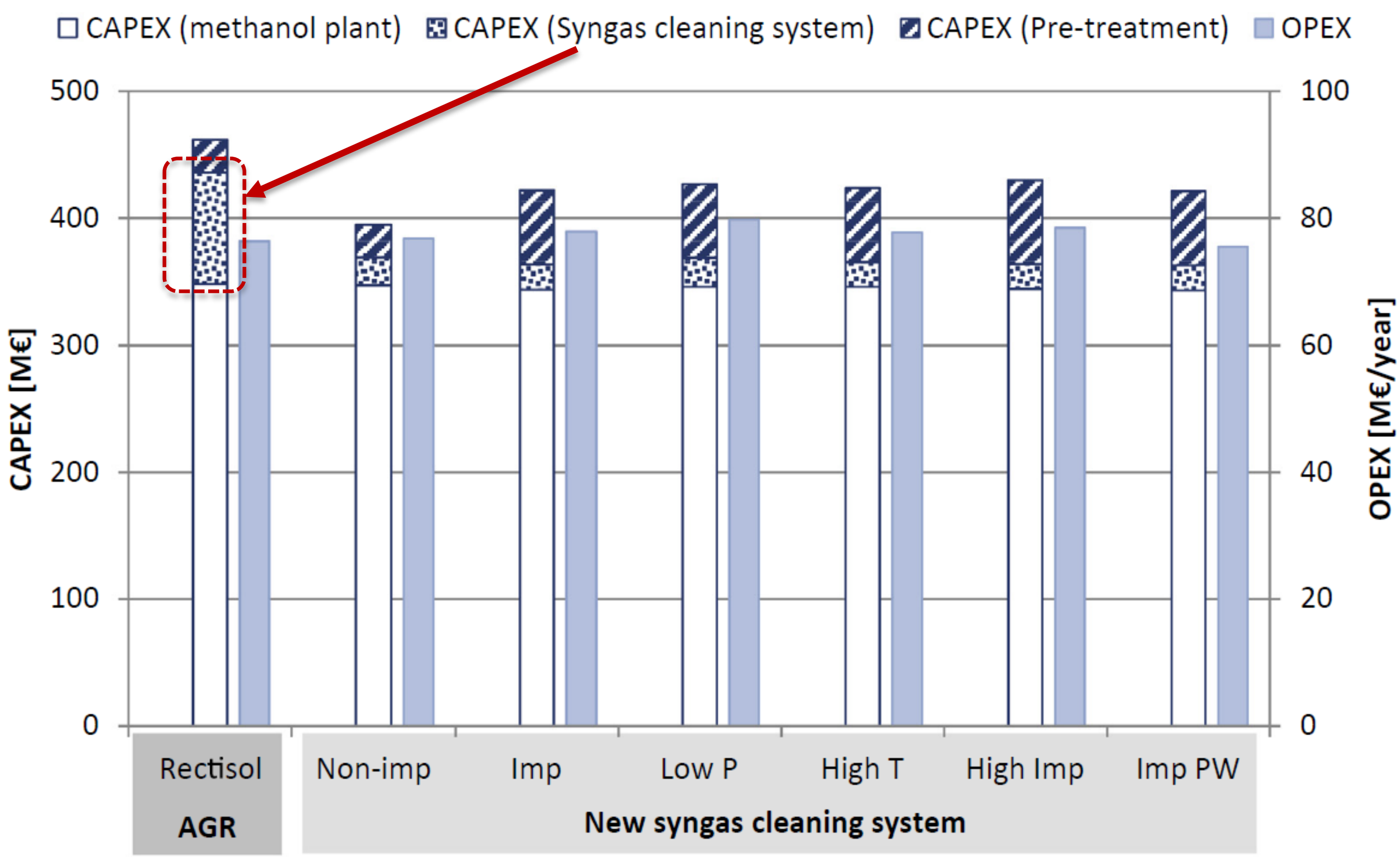
Results – Process economics



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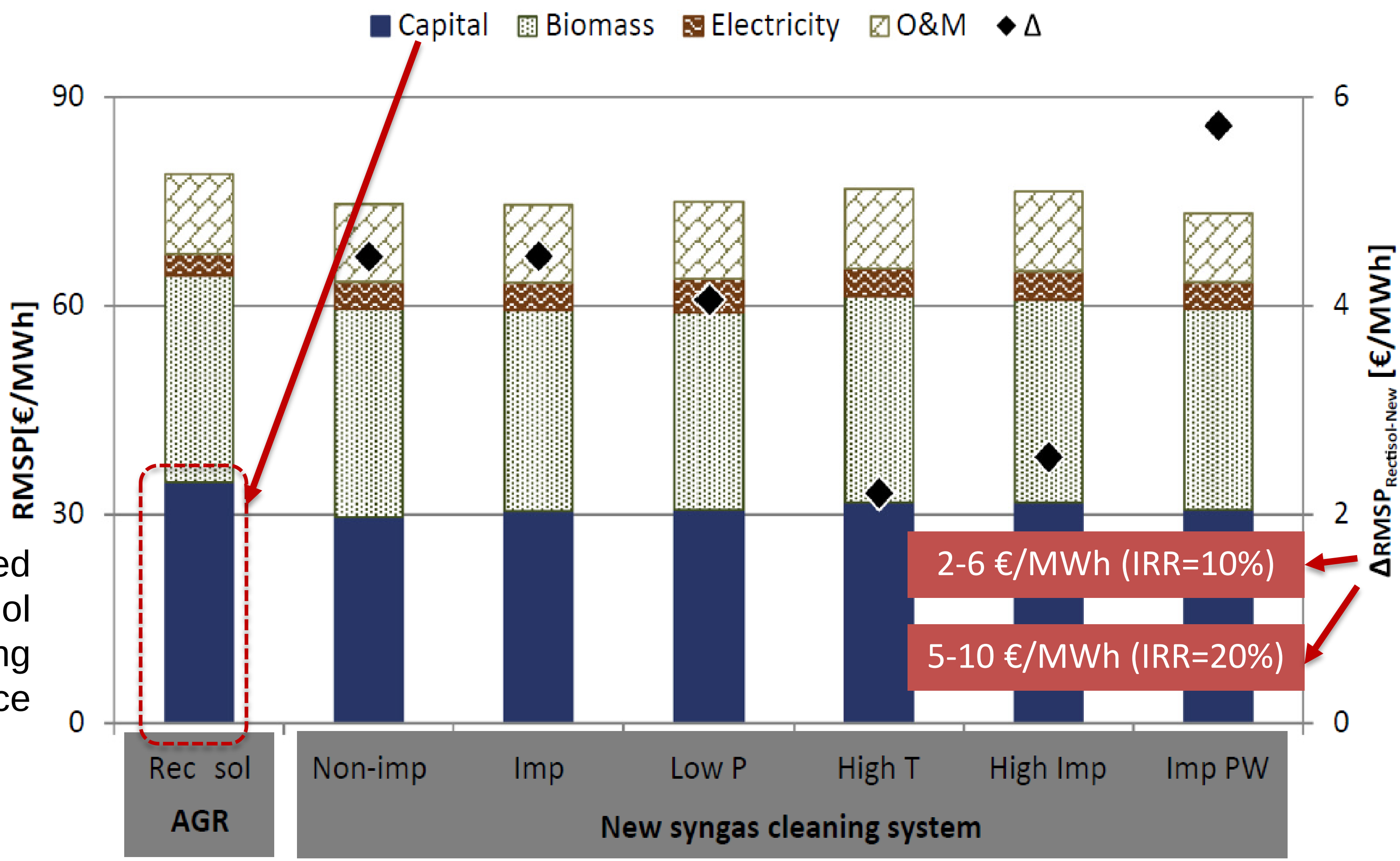
Results – Process economics



Required methanol selling price

RMSP: required methanol selling price

Carvalho et al. (2018) Alkali enhanced biomass gasification with in situ S capture and a novel syngas cleaning. Part 2: Techno-economic assessment, Energy 165:471-482

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Conclusions

- Alkali can give many advantages in entrained flow biomass gasification
  - Improves char and tar conversion, no soot — **Lower temp. – higher efficiency**
  - Slag flowability — **Improved operability**
  - In situ sulfur capture — **Lower CAPEX syngas upgrading**
- Enables biofuels plant with more inexpensive zeolite membrane CO_2 separation
  - Increases in cold gas efficiency and methanol efficiency
  - Small decrease in overall energy efficiency
  - Significantly lower CAPEX, but similar OPEX results in up to 10% lower required methanol selling price (RMSP)
  - Costs for zeolite membranes are uncertain, but has minor influence on the economics

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