FuelSOME

Multifuel SOFC system with Maritime Energy vectors

Efficient use of fuels in the maritime sector

PÉTER SZTRINKÓ

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AVL

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Today's Presenter

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Presentation Outline

01 Introduction

02 General discussion about fuels for SOFC

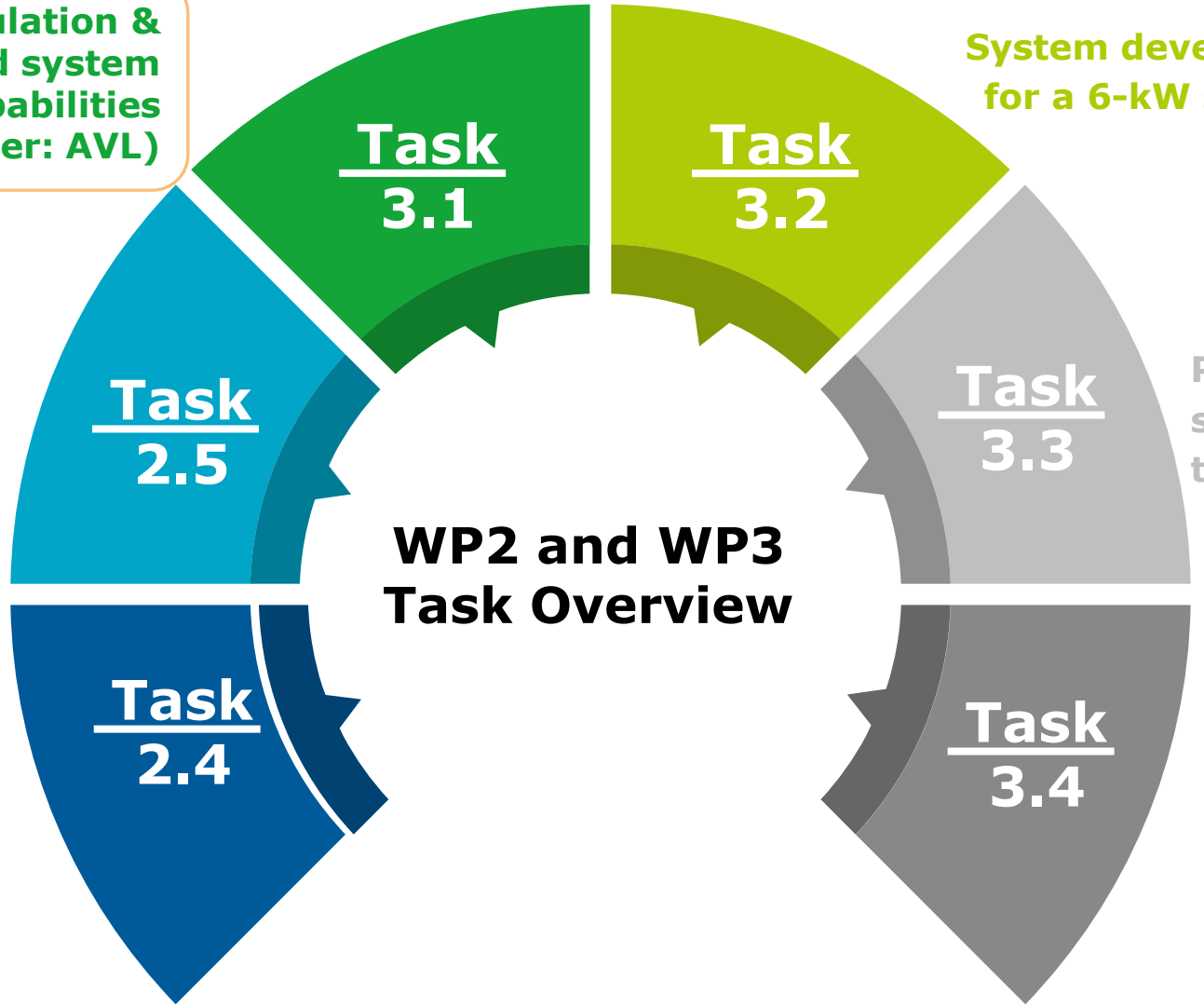
03 Theoretical system efficiency by fuels

04 Efficiency for the proposed system architecture

AVL Participation in the FuelSOME project

System Modelling, simulation & analysis of the integrated system with multi-fuel capabilities (Leader: AVL)

System development & integration for a 6-kW system (Leader: AVL)



Final report on stack performance with simulated multifuel feed

Performance testing of lab scale prototype along with test bed set up (Leader: AVL)

Initial report on stack performance with simulated multifuel feed

Scale-up, Integration potential with fuel production unit (Leader: VTT)

General description of the Fuels for SOFC application

Methanol

Preprocess is essential.
For SMR steam is required.

No single pass solution is possible reasonably.

Internal reforming possible.

Poisoning Carbon monoxide present in the system.

Ammonia

Corrosive aggressive agent.
On high temperature special metal components needed.

Internal cracking possible.

Stacks usually has limit on ammonia content at stack inlet.

Poisoning gas.

Hydrogen

No preprocessing needed.
Just the temperatures need to be controlled.

No internal cooling effect present.

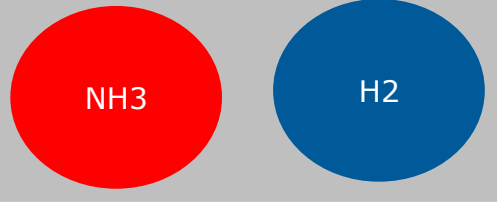
Most critical regarding explosive protection.

Basic Trade offs for a multifuel system

Water management in the recirculation

Water is advantages in the recirculation

Water is disadvantages in the recirculation



Fuel Processing

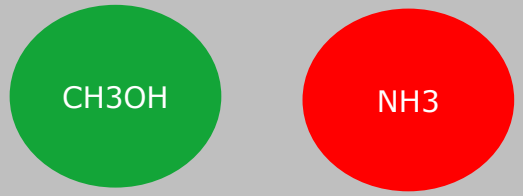
Steam Reforming

Cracking

Nothing

Stack thermal control

Internal cooling possible

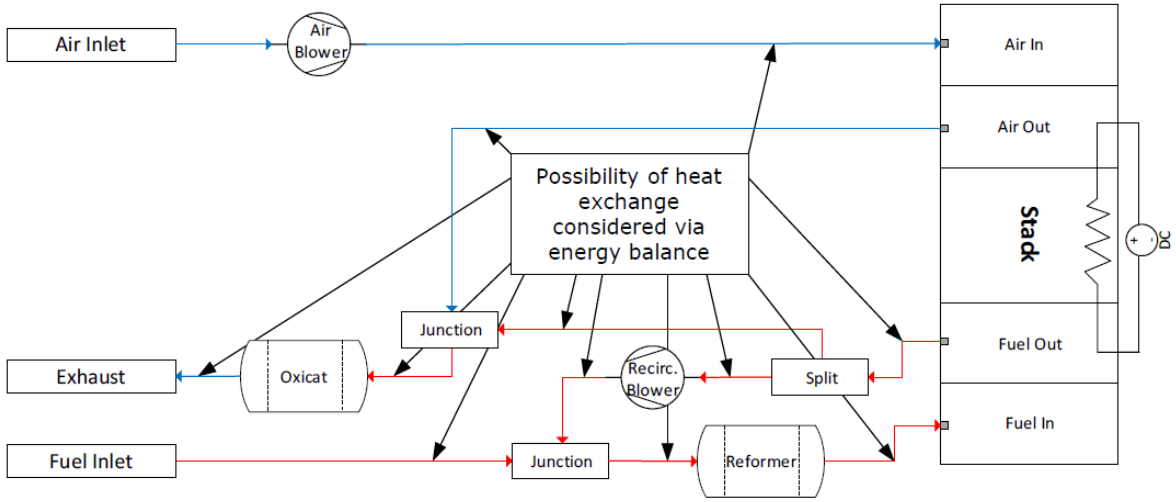


Only Air cooling

General v0 parameter study - Methodology

Model-based system development

- **Main aim:**
  To find an optimum operation point which is driven by the main component but not any specific heat exchanger network
- **Process and Tools:**
  Simulink model for basic model
  Cameo to run an active DoE on Simulink model and build an empirical model to use that for optimisation
- **Parameters to vary:**
  - Stack inlet temperature
  - Reformer outlet temperature
  - Recirculation rate
  - Current



General system flowsheet for parameter study

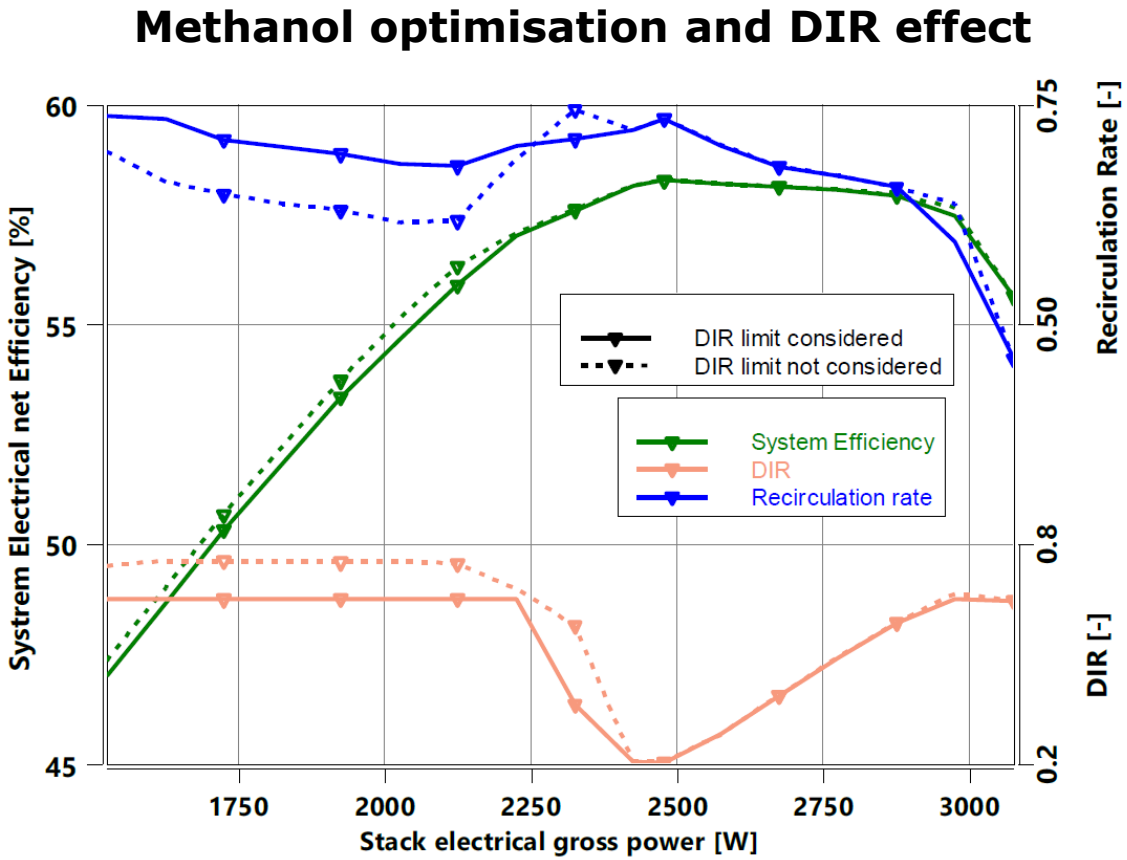
- Fuel flow rate into the system
- Air flow rate into the stack
- Internal heat recover efficiency
- Discharge of H2O, N2, CO2 in the recirculation path
- …

Methanol optimisation

Most interesting parameters:

- Direct internal reforming (DIR)
  Limit extension effect was examined
  (DIR <60% to <75%)

Other main parameters were open within the system and components (mainly stack and fuel processing unit) boundaries



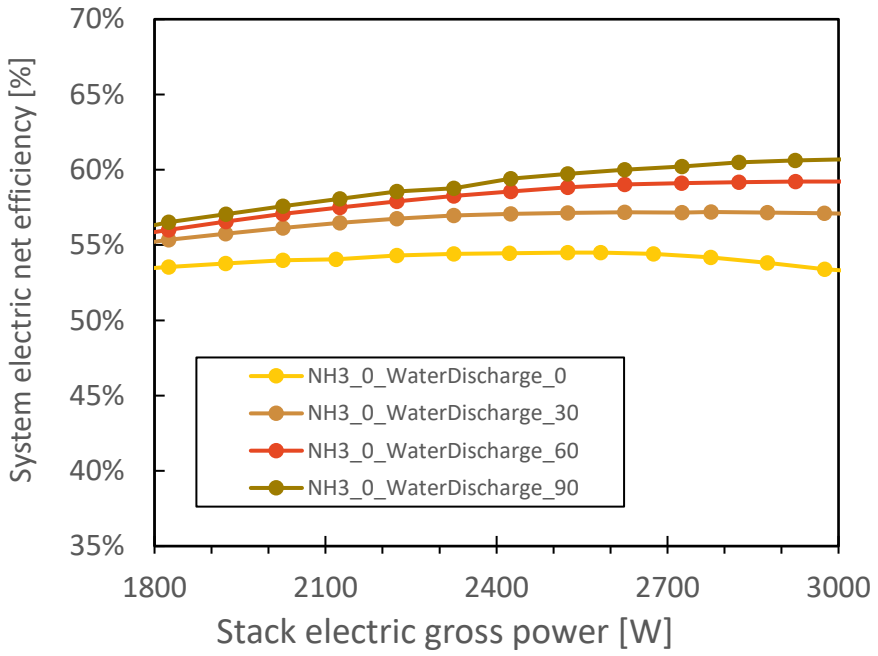
Ammonia optimisation

Most interesting parameters:

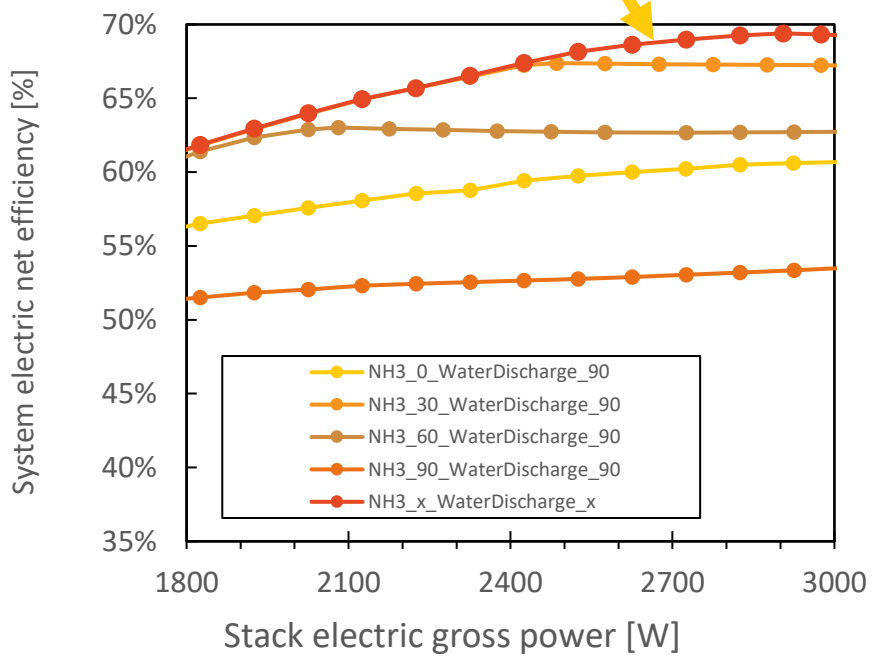
- Water discharge in the recirculation line
- Uncracked ammonia at stack fuel inlet

16% Ammonia content for **Maximum efficiency** and 90-100% water discharge

Water discharge effect on the system efficiency



Ammonia content effect on the system efficiency

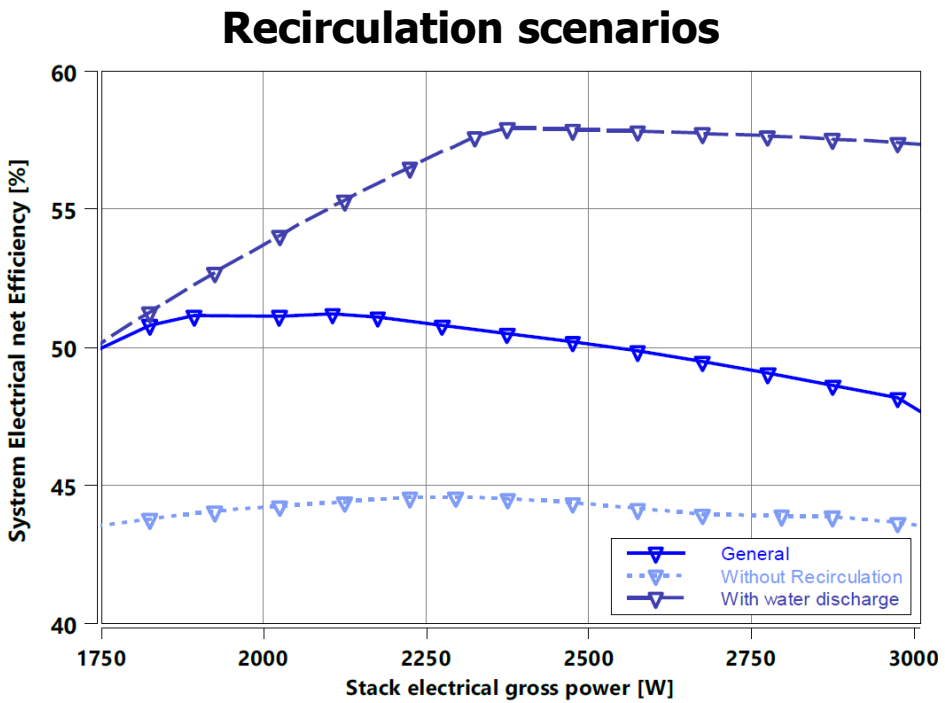


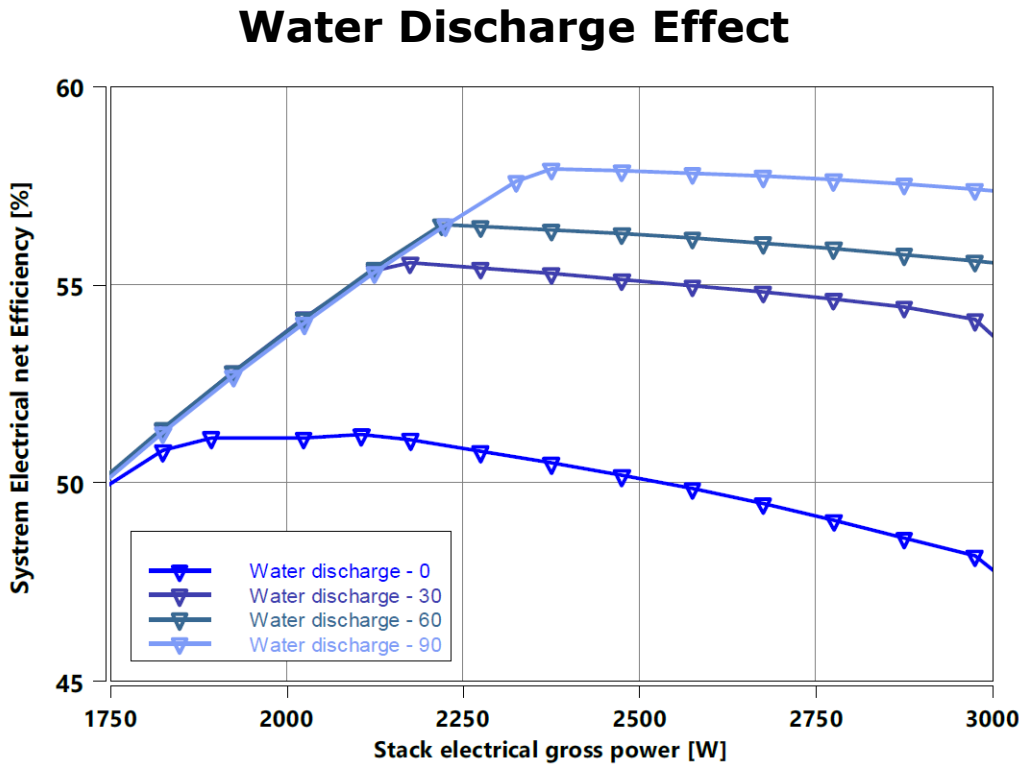
R. Neubauer, P. Sztrinko, M. Innerkofler, B.Reiter - Effect of Multifuel Approach on SOFC System Performance and Architecture Requirements – EFC23, Capri

Hydrogen optimisation

Most interesting parameters:

- Recirculation scenarios (Single pass or recirculation)
- Water discharge in the recirculation line

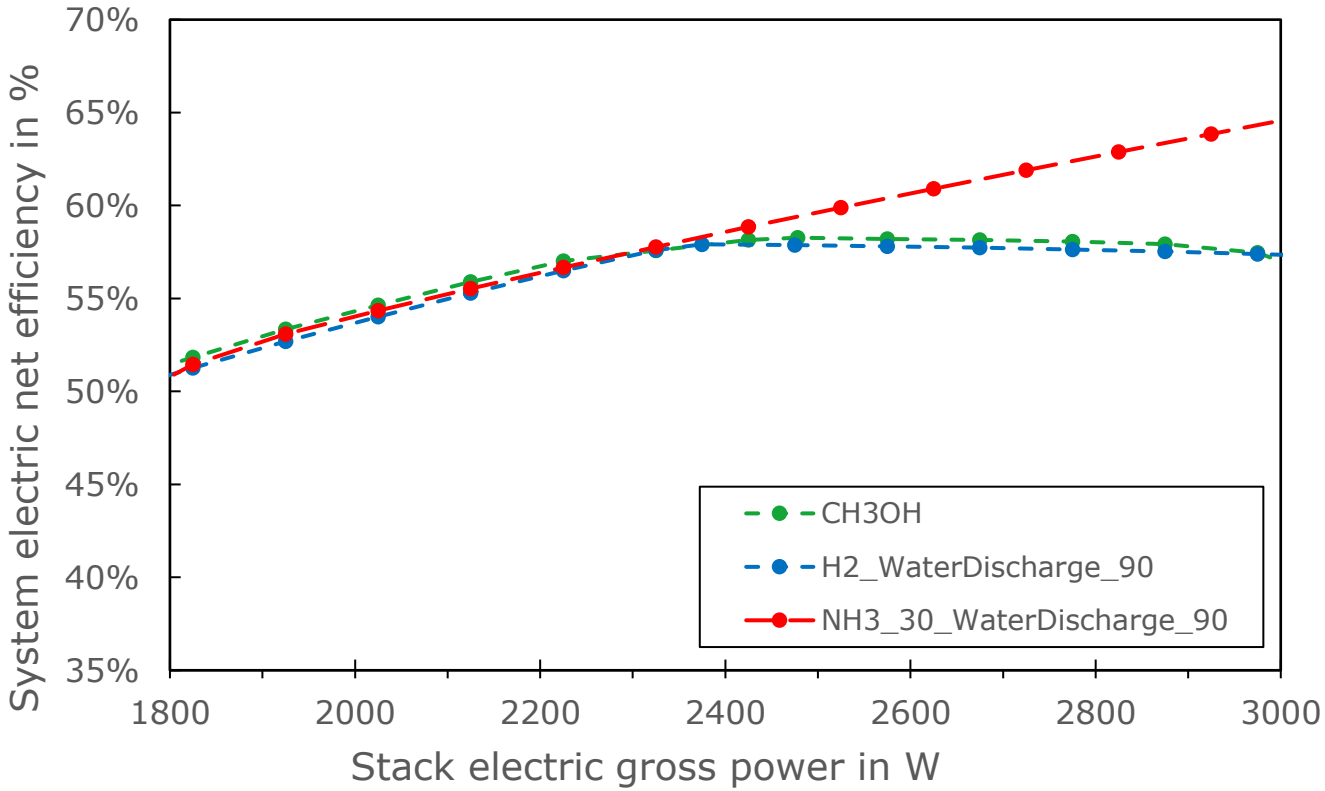




Comparisons of the different fuels

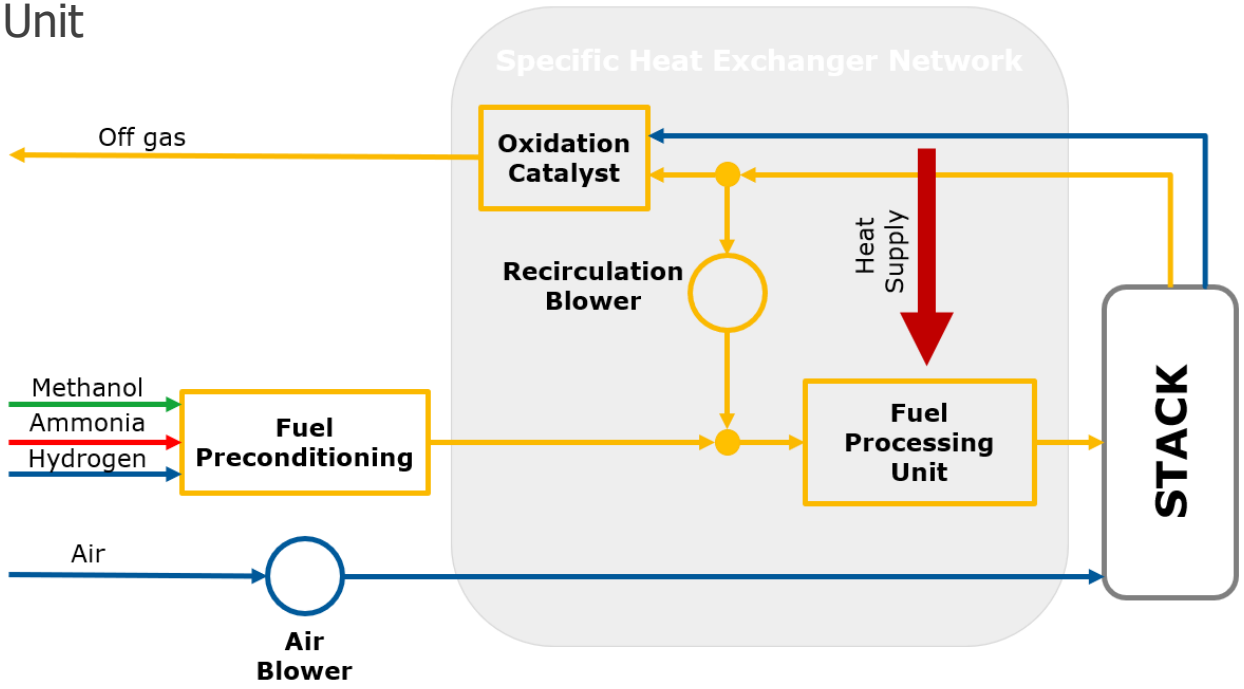
The optimal solution represented for the three different fuels

- Till ~ 80% load the 3 fuels performing similarly
- At full load ammonia general optimum (with water discharge and variable ammonia content) preforming best
- Hydrogen require the water removal to compete with the other fuels



System architecture for the multifuel System

- Fuel Processing Unit is heated with stack air off gas
- Controllable heat input to the Fuel Processing Unit
- Stack fuel off gas recirculation with blower
- No water Discharge
  - Reduce complexity
  - No available cooling power on vessels
- Central fuel Preconditioning System
- Start up heater for the system



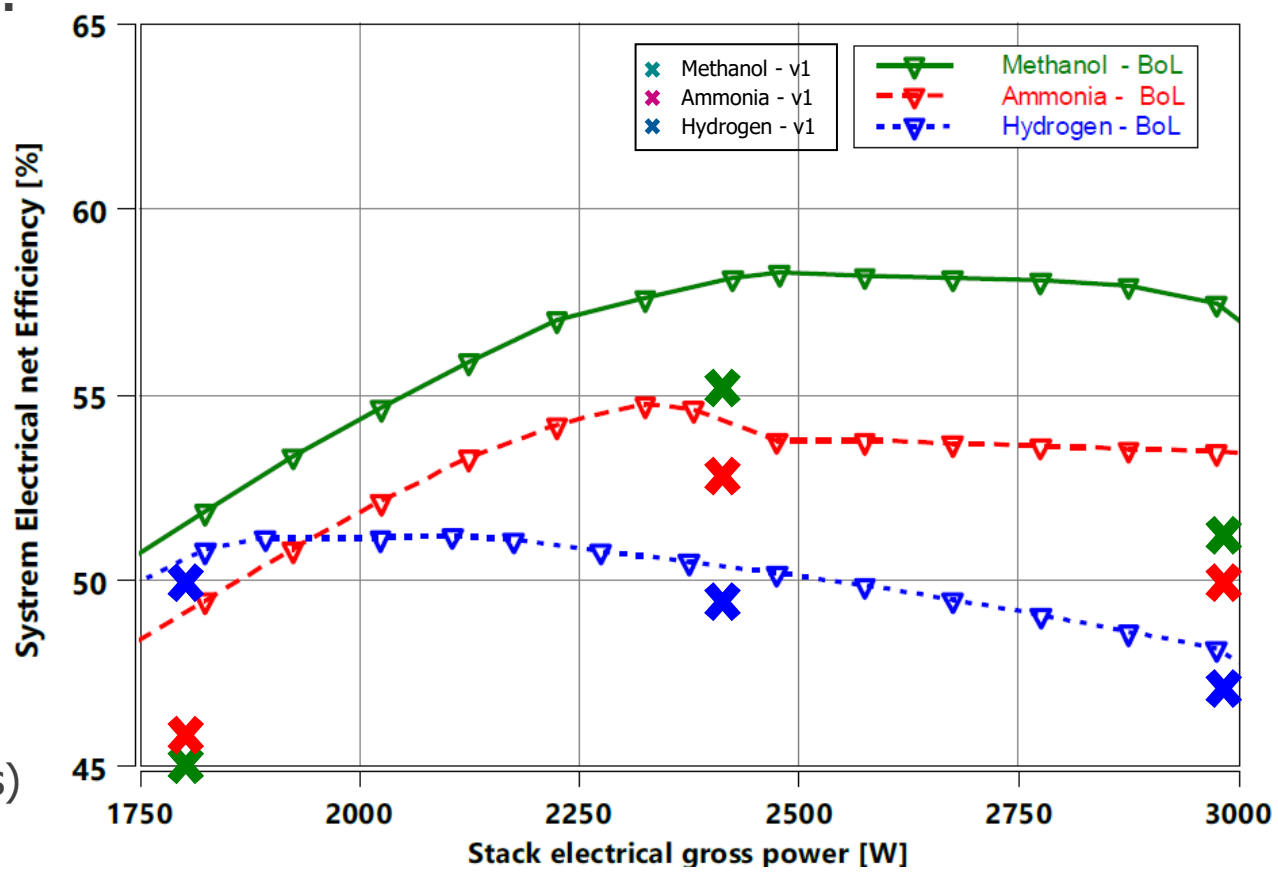
Efficiencies for the proposed multifuel system architecture

Peak System efficiencies for the multifuel system:

- Methanol: 55% (@80% load)
- Ammonia: 52% (@80% load)
- Hydrogen: 50% (@50% load)

Reasons for the differences:

- Conservative estimations for the real system
  - Heat Exchanger efficiency
  - Inverter efficiencies
- Limitations from the multifuel approach
  - No water discharge (disadvantage for ammonia and hydrogen)
  - Same components for different fuels (different operation requirement form different fuels)



Overview

- Multifuel system is possible and results reasonable efficient operation for all three examined fuels with some challenges, like:
  - **Water management**
    In order to utilize all fuel potential a really complicated water management system is required which increase the weight, cost and complexity of the system
  - Designing, applying and operating **Fuel Processing Unit** with three different fuels with significantly different requirements give a lot of limitations for the system
  - Maintaining pressure level on the stack is a challenge for multifuel system because fuel and air volume flows are varied for the different fuels.
- Specified system will have efficiency advantages over multifuel system
- Use case will define for the dedicated solution

Q&A

Open discussion in this topic

FuelSME

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Thank you!

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