Industrial Thermal Energy Recovery Conversion and Management

Industrial Thermal Energy Recovery, Conversion and Management 'I-ThERM'

Project Number: 680599

Pilot Implementation Challenge and Lessons Learned

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Brunel University London

Institute of Energy Futures

- Medium size university (15000 students) - outskirts of London
- 2500 staff (700 academic)
- Turnover ~270 million EUR of which around 30 million EUR in research income annually.
- **Current H2020 projects by the Brunel Research Team**
  - I-ThERM – Industrial Thermal Energy Recovery and Management,
  - 2015 -2021 – Coordinators – GA 680599
  - ASTEP - Application of Solar Thermal Energy to Processes (2020-2024) - GA 884411.
  - CO_2OLHEAT Supercritical CO2 power cycles demonstration in Operational environment Locally valorising industrial Waste Heat (2021 – 2025).

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Aim of the I-ThERM Project

Investigate, design, build and demonstrate innovative plug and play waste heat recovery solutions to facilitate optimum utilisation of energy in selected industrial applications with high replicability and energy recovery potential in the temperature range 70°C-1000°C.

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Major Objectives:

- Develop heat recovery and heat to power conversion technologies in packaged or easily customisable plug and play forms that can readily be applied in industry.
- Develop an intelligent system for monitoring and on-line integration and control of the operation of these technologies to maximise heat recovery and conversion.
- Implement, monitor and evaluate the performance of the technologies, evaluate their impact on overall energy consumption and CO_2 emissions.
- Disseminate the outputs widely to industry, other key stakeholders and policy makers.

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Consortium

13 partners: 3 large industry, 7 SMEs, 3 RTDs

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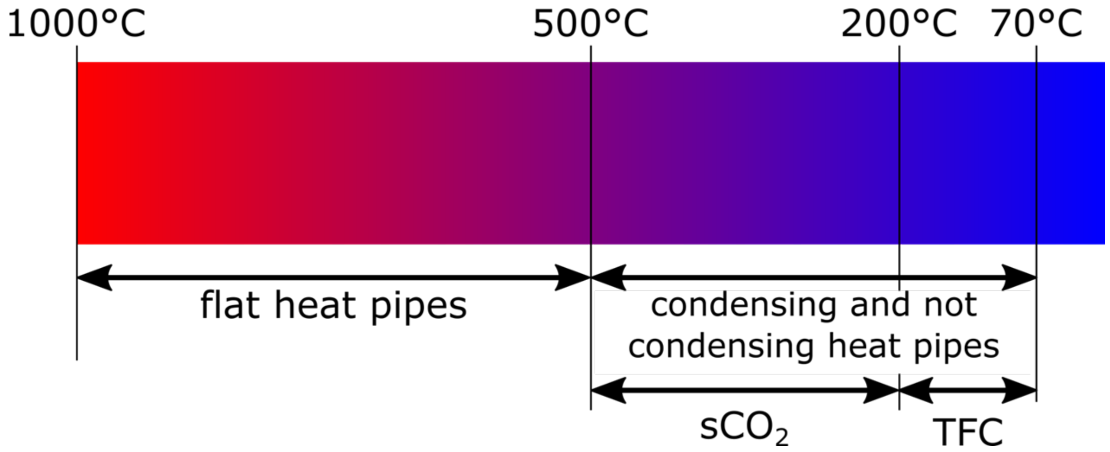
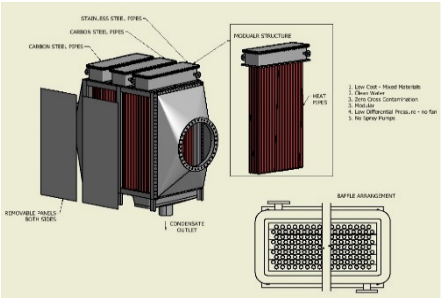
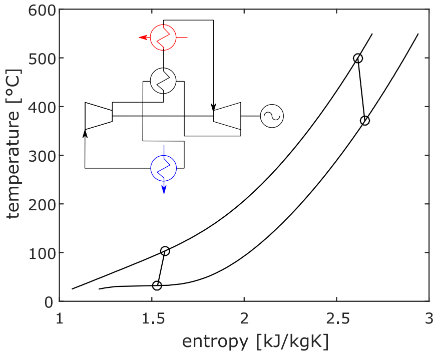
4 PLUG AND PLAY TECHNOLOGIES

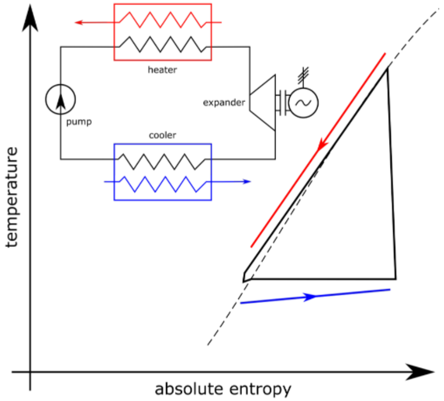


Heat Pipe Condensing Economiser





Supercritical CO_2 (sCO_2) cycle



Trilateral Flash Cycle (TFC)

Flat Heat Pipe System

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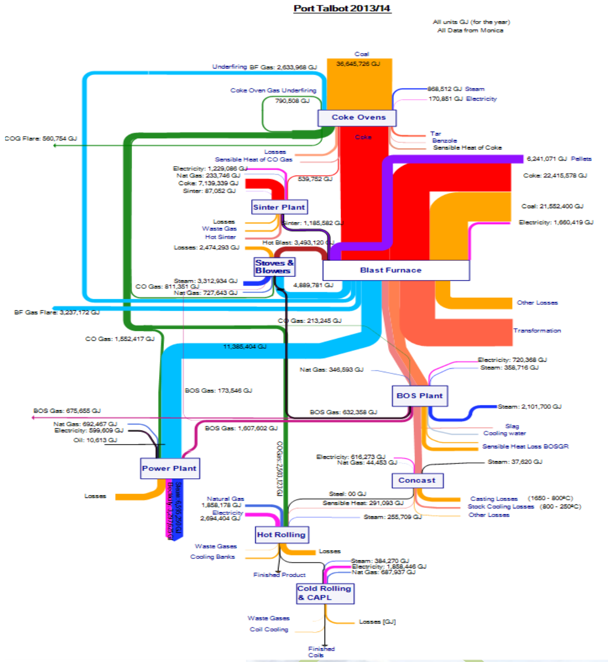
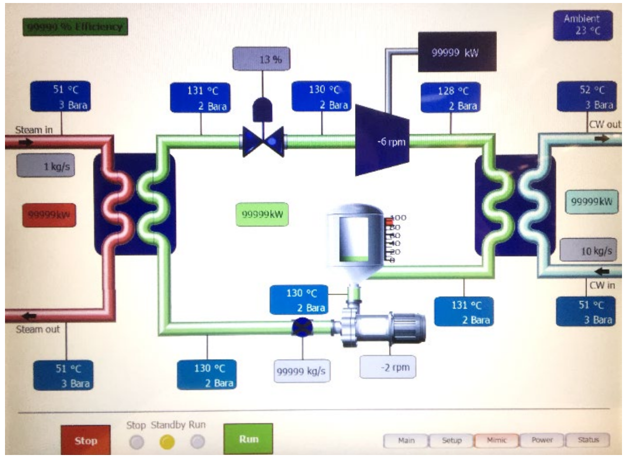
Trilateral Flash Cycle System (TFC)

Objective:

Develop build and demonstrate a TFC system suitable for waste heat to power conversion at less than 100^{o}C.





Supercritical CO_2 (sCO_2) Heat to Power System Demonstrator

Objective:

Develop build and demonstrate a 50 kWe sCO_2 system suitable for waste heat to power conversion at temperatures up to 800 ^oC.

Demonstration site:

Brunel University London.

Heat rejection from gas fired heat source.

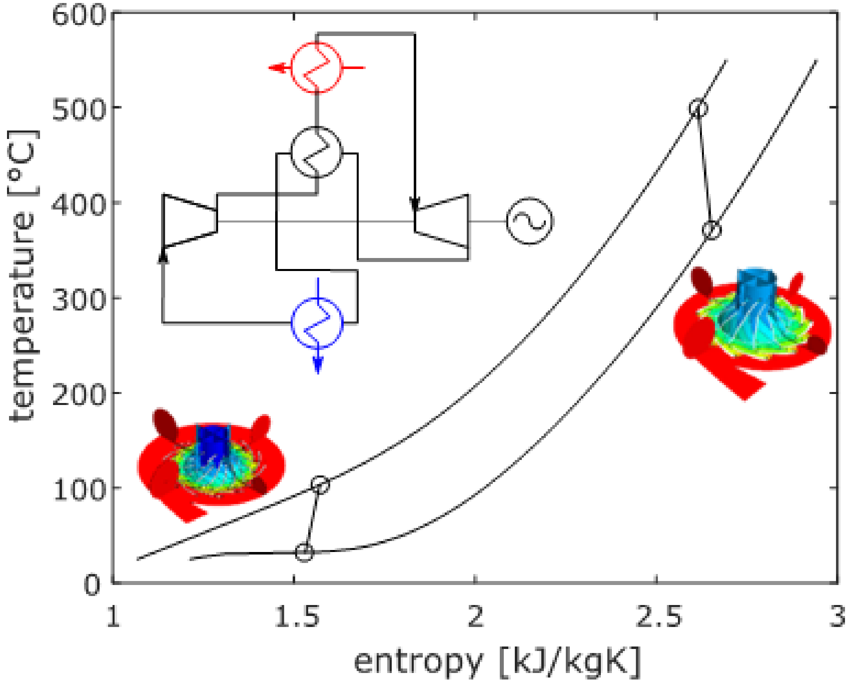
Research and Development work:

i) Simulate, design and build a 50 kWe unit;

ii) Design and procure a 1.0 MW heat source;

iii) Design and build test facilities;

iv) Commission, test and demonstrate the unit.



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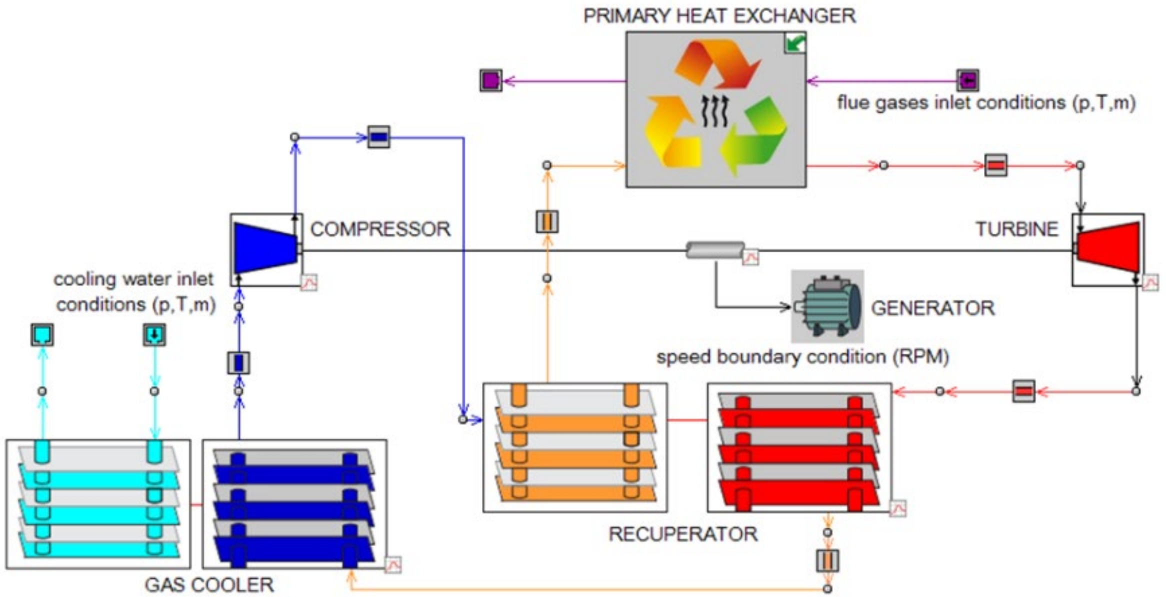
sCO_2 Heat to Power System Demonstrator

- 50 kWe design power output at ~20% efficiency
- Simple regenerative layout
- Developed through multi-scale (0D-1D-3D) modelling and control



min/max pressure [bar]	min/max Temperature [°C]	CO_2 mass flow rate [kg/s]
75/127.5	35/400	2.25

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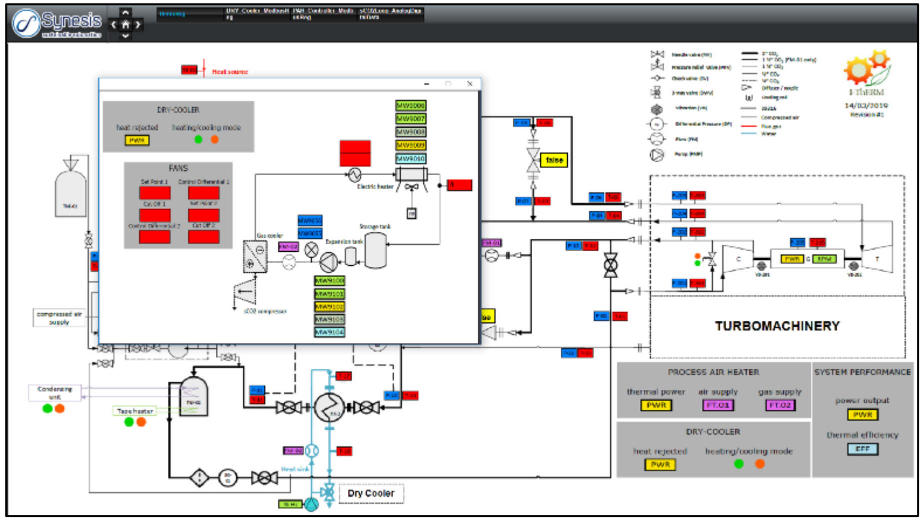
sCO_2 Heat to Power System Demonstrator

- 800 kW_{th} heat source (Process Air Heater)
- Simple regenerative layout
- Developed through multi-scale (0D-1D-3D) modelling and control



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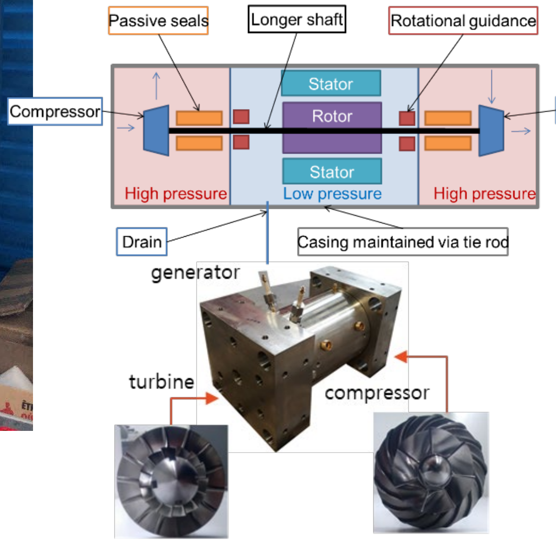
Supercritical CO_2 (sCO_2) heat to power Cycle

Gas cooler
Plate heat exchanger

Heatric 600kW recuperator
Printed circuit heat exchanger



Power generation unit

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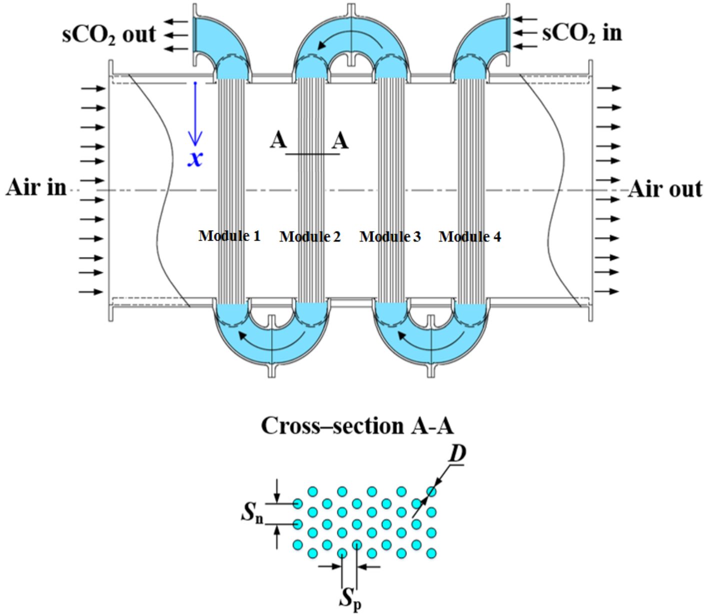
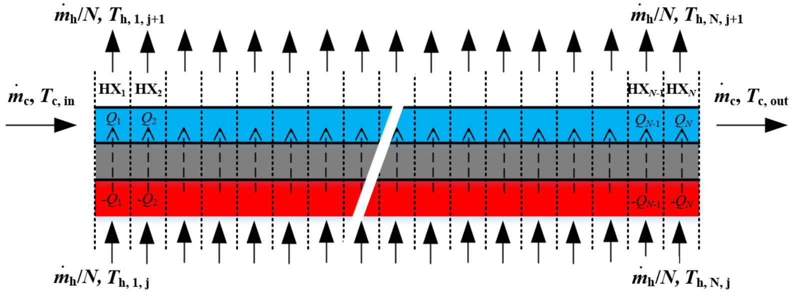
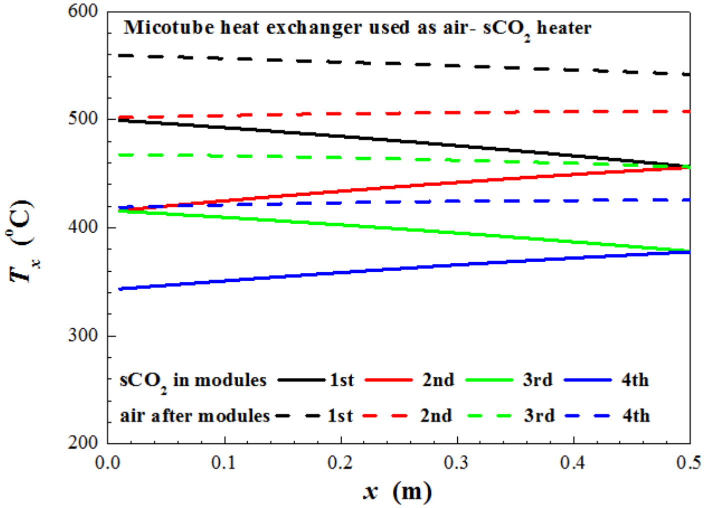
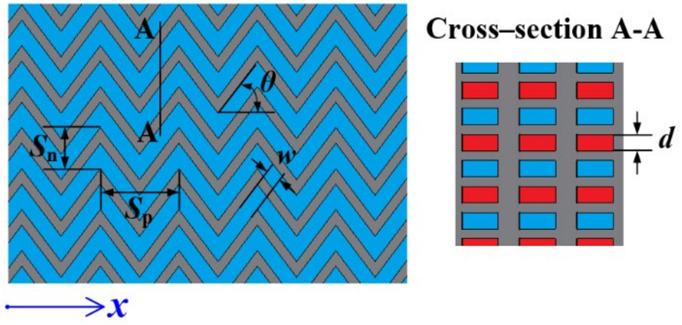
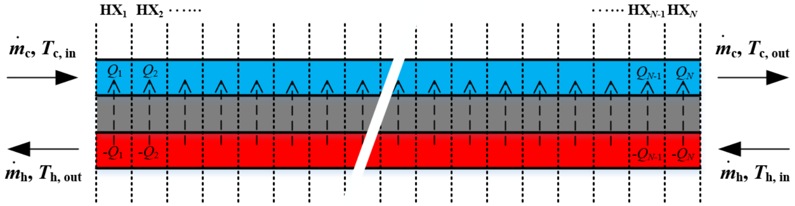
Heat exchanger design

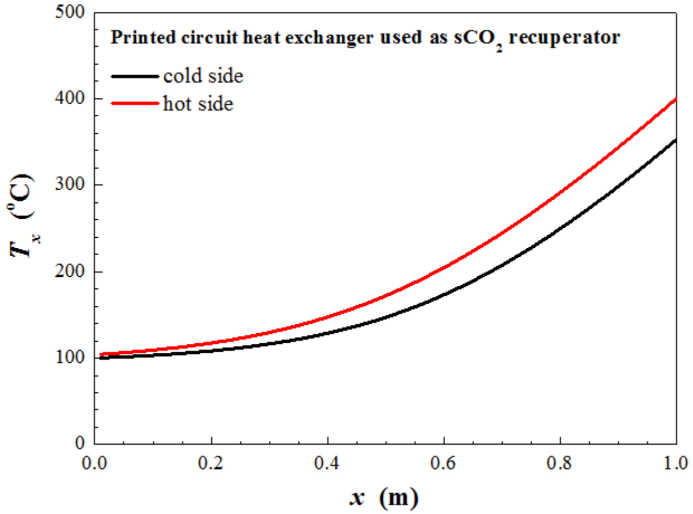












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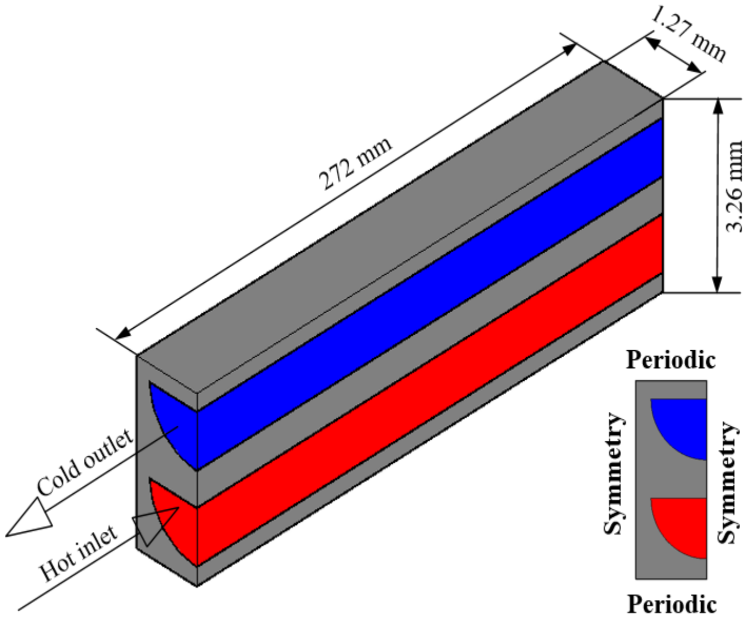
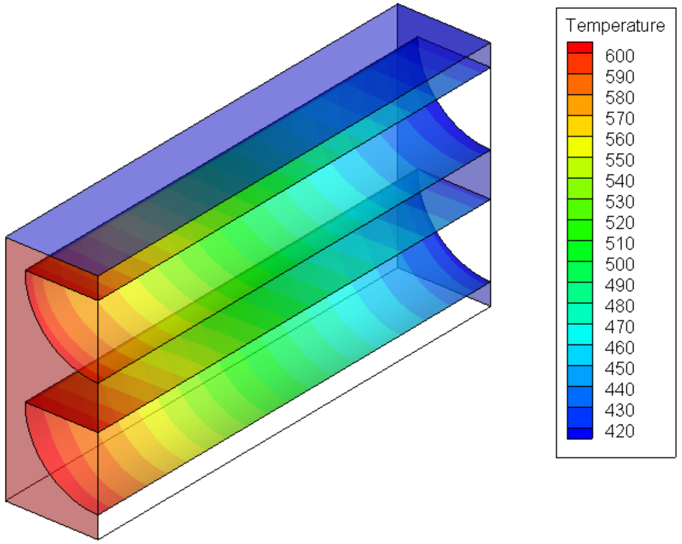
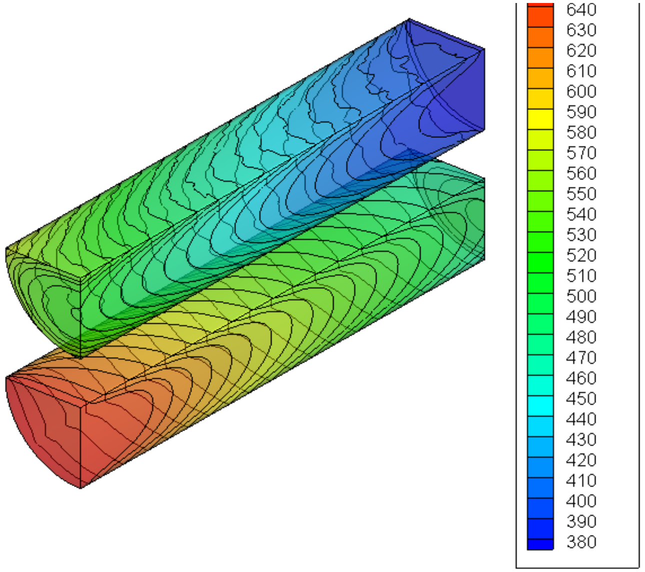
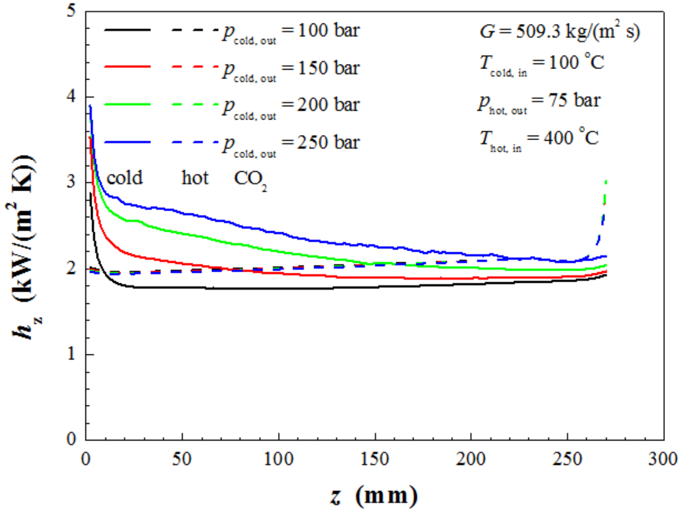
3D CFD Modelling

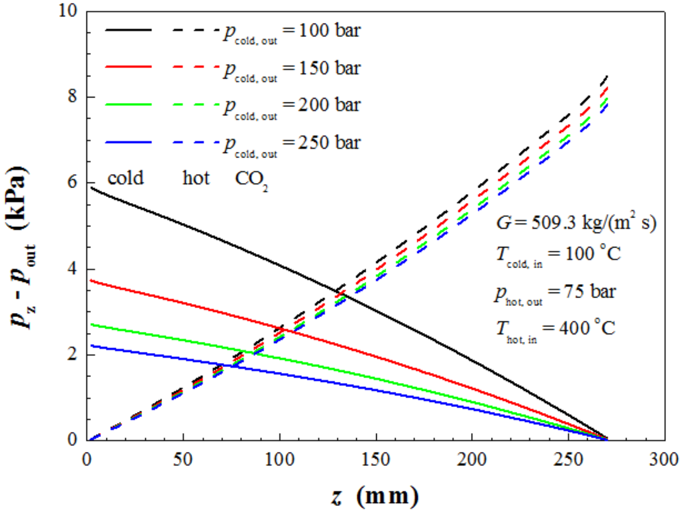
PCHE











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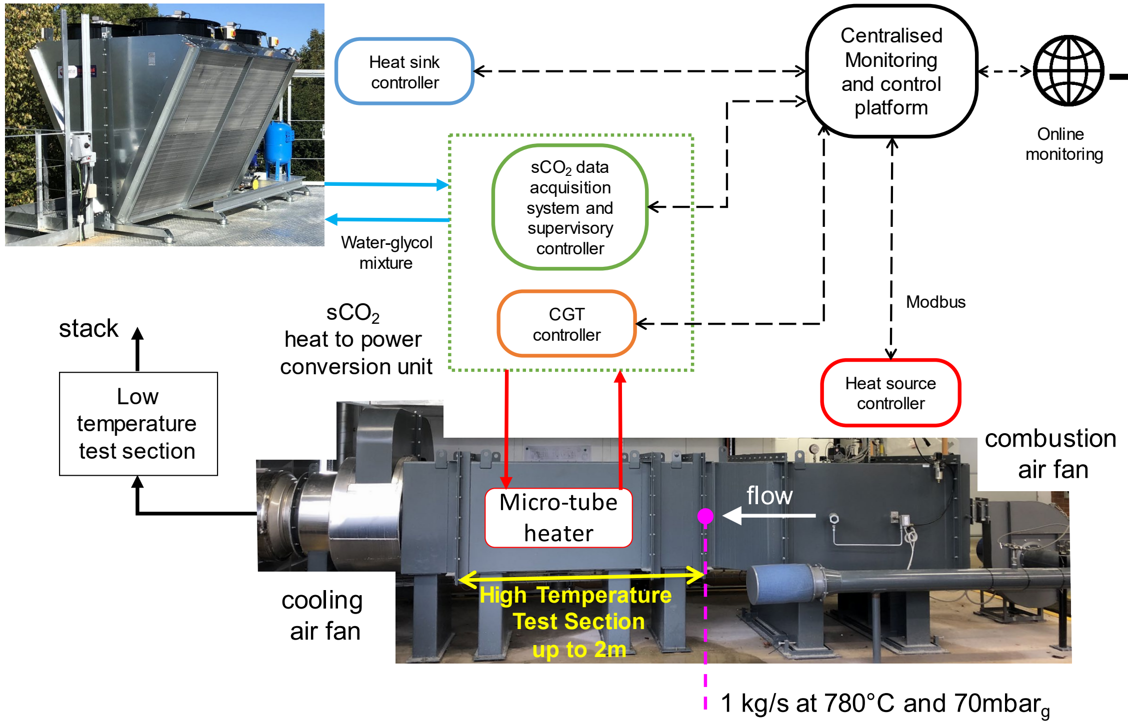
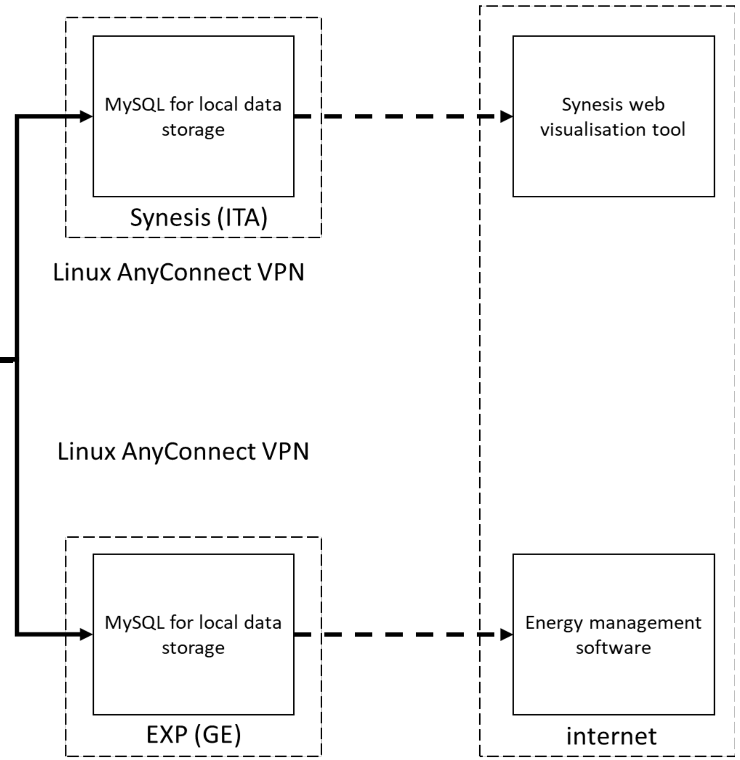
Monitoring, Control and Communications System

Demonstrator control architecture (IEC 61499 standard)





Online platform

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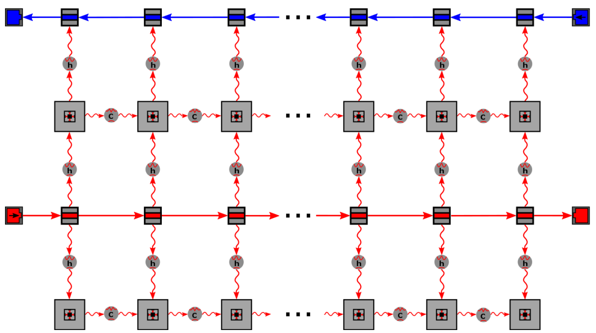
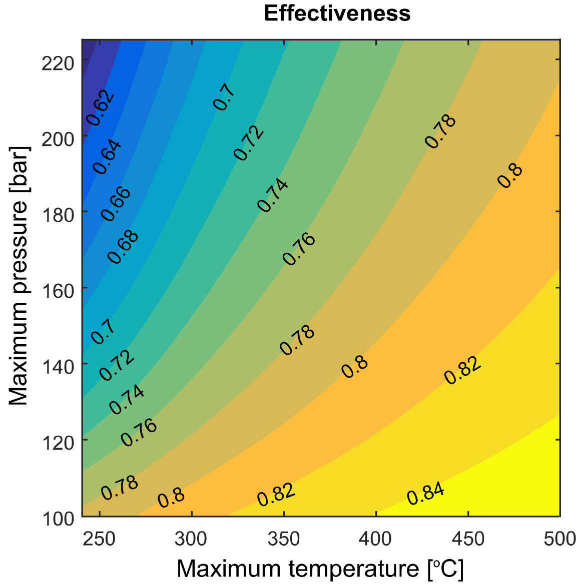
Dynamic Simulation

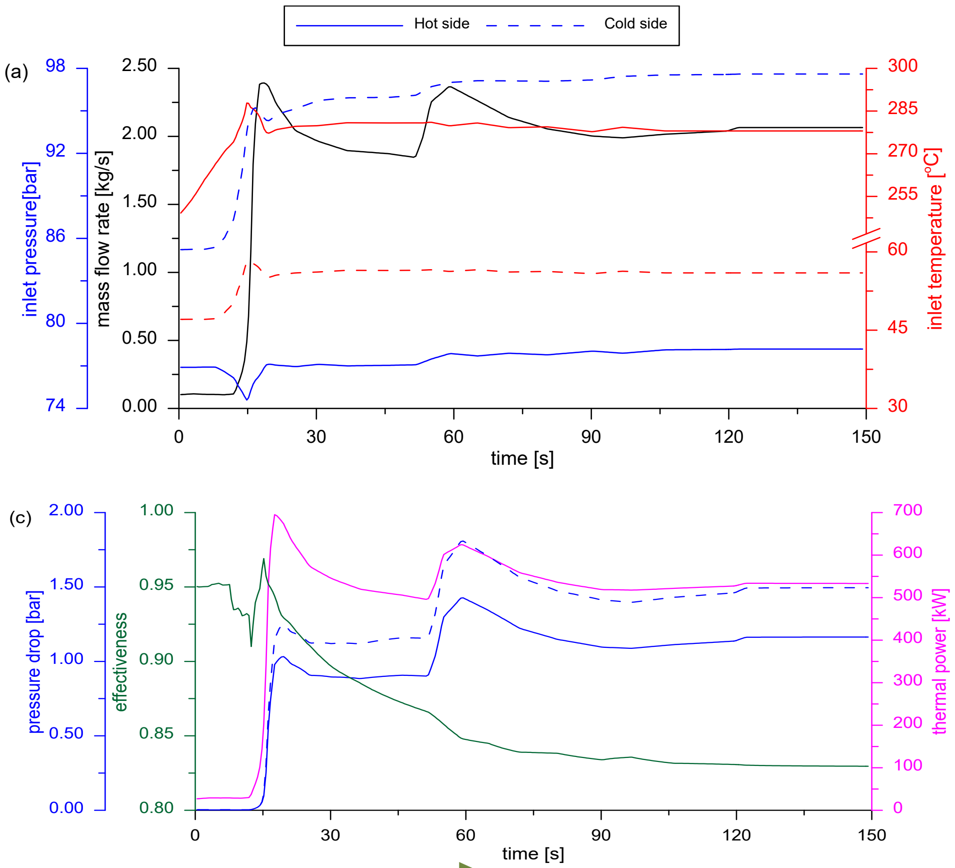
1D modelling approach



Performance maps



Transient simulations



Pros:
- Low computational cost
- Transient analysis & control
- Component & systems simulations

Research methodology

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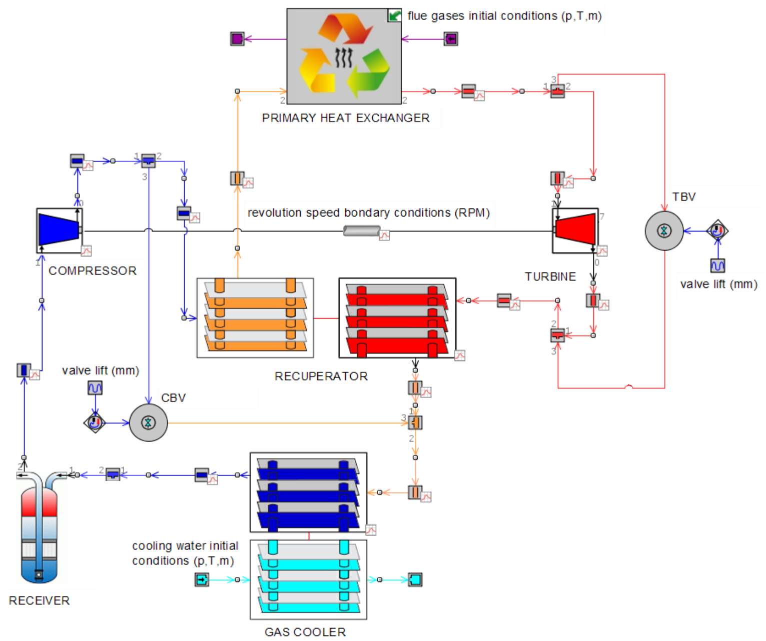
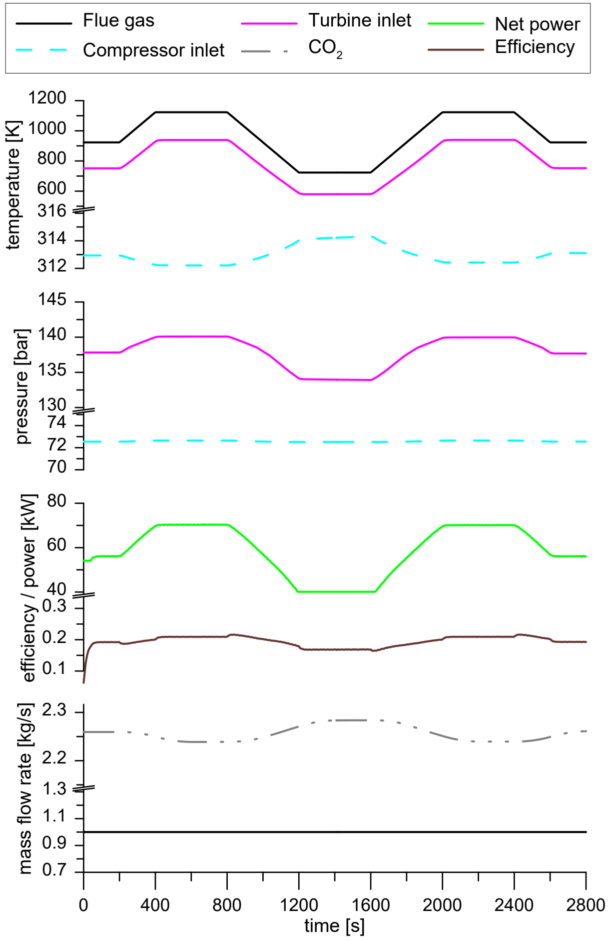
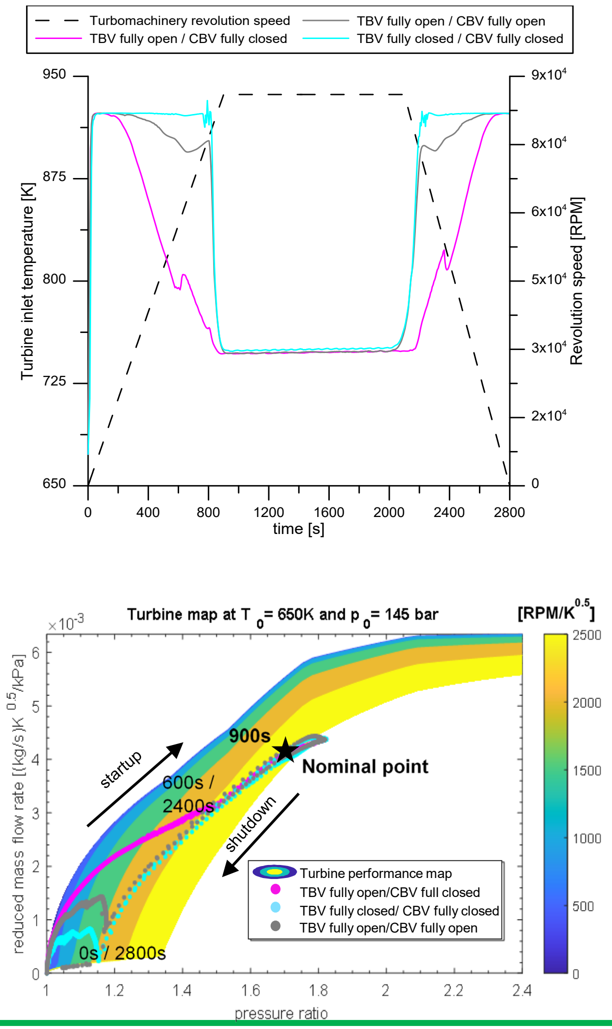
Dynamic Simulation

1D CFD system model





Start-up and shut-down



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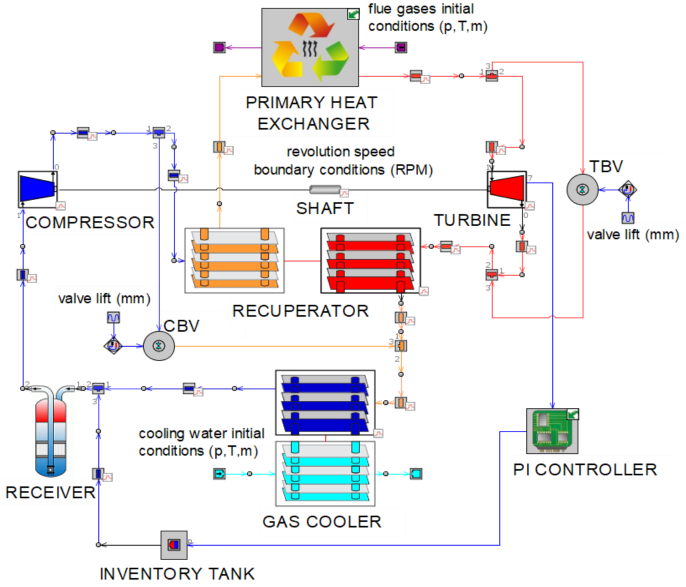
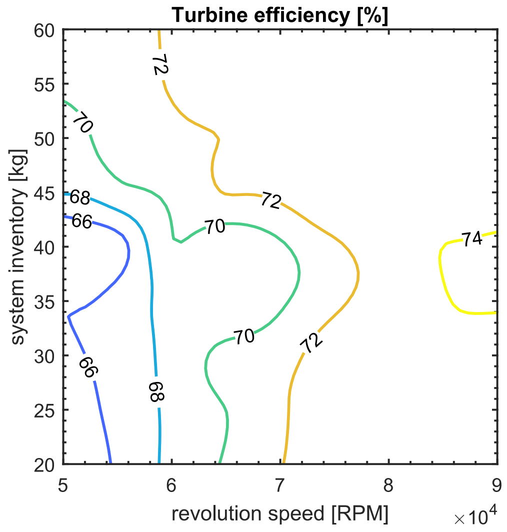
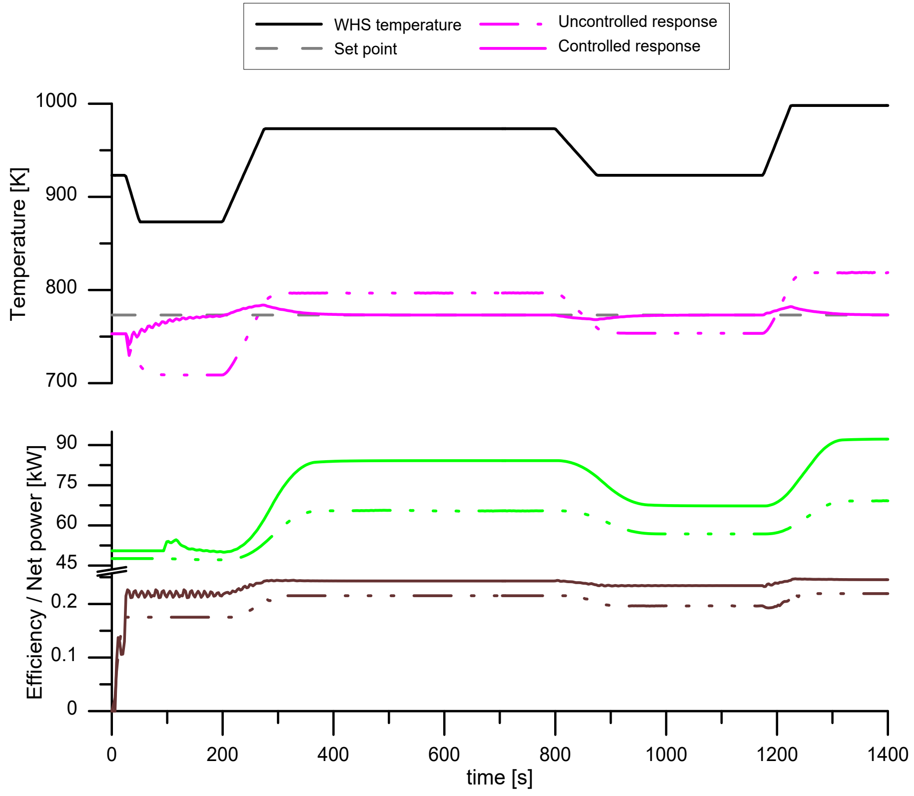
Comparison of control variables

(Inventory vs Turbomachine speed)





Control strategy simulations



- Inventory control
- Heat load following control strategy
- Turbine inlet temperature as control objective

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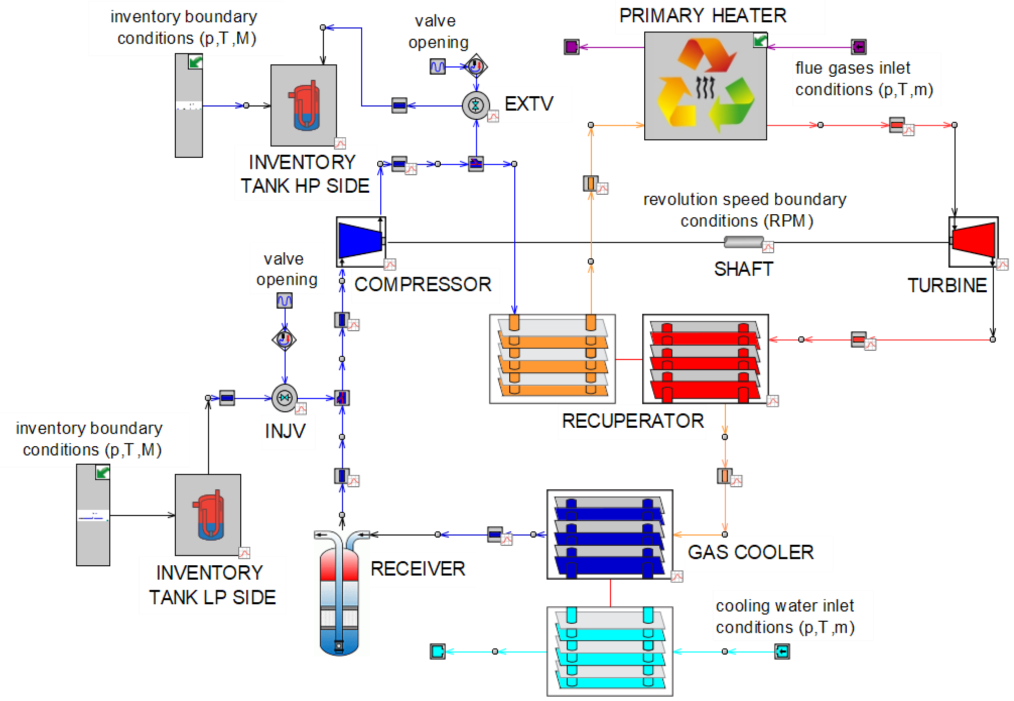
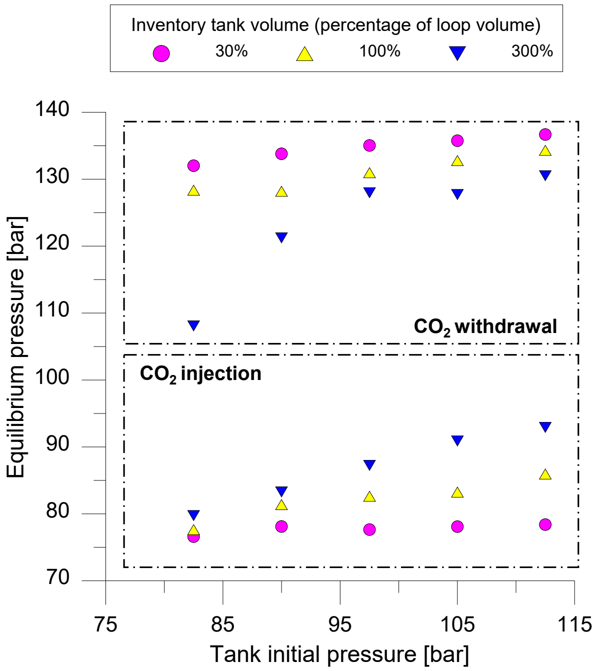
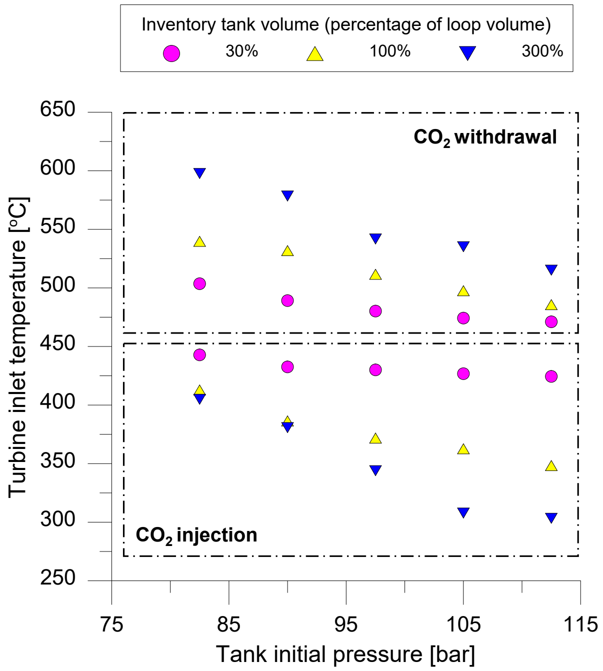
Inventory Control

Inventory tanks finite capacity



Inventory tank sizing and dynamics





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Future Developments

- Commission turbomachinery and complete unit
- Validate steady state and dynamic simulation models
- Utilise test facility for:
  - Advanced heat exchanger development and testing
  - Investigation of control strategies
  - Different cycle and turbomachinery arrangements

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Thank You

Questions?

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