Horizon 2020
European Union Funding
for Research & Innovation

Operational Experiences and Design of the sCO2-HeRo Loop

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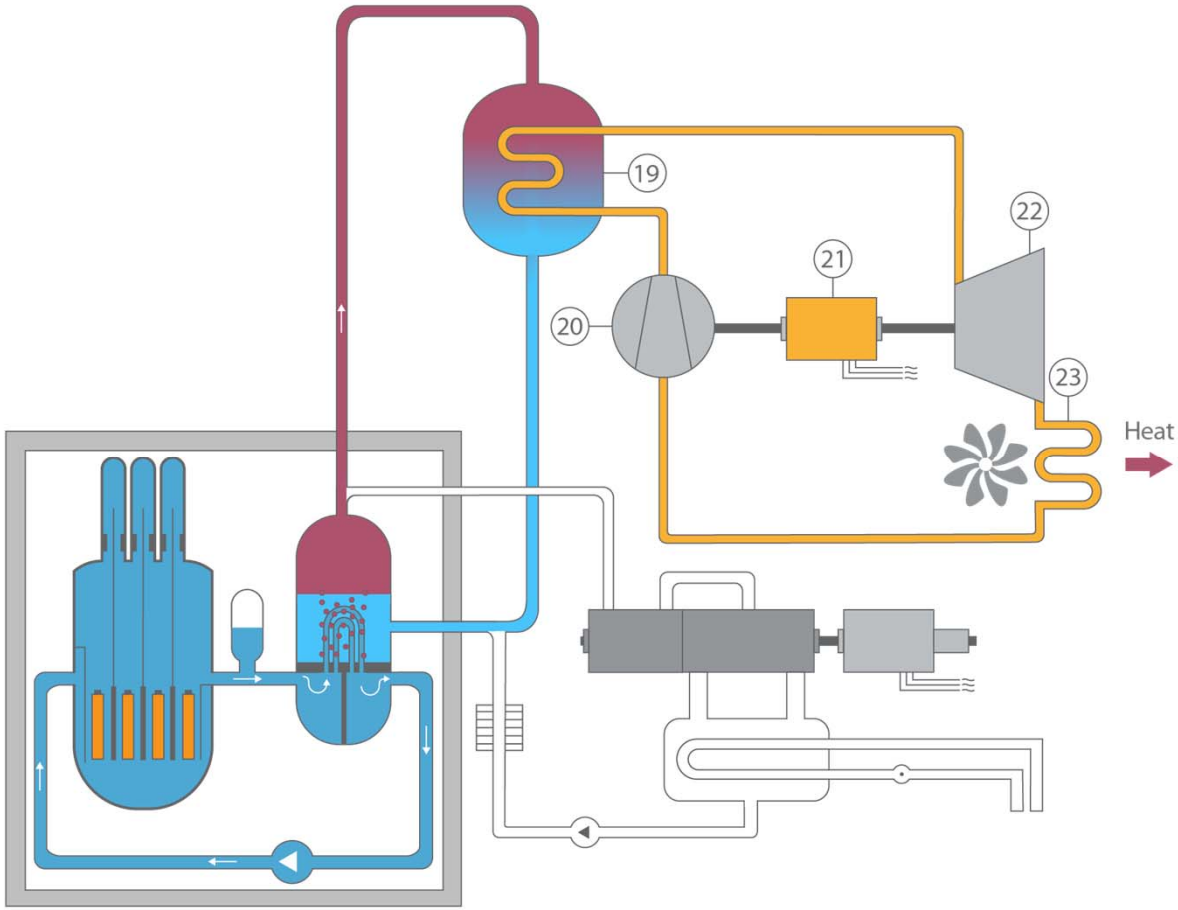
sCO2-HeRo concept

Overall target: Prevent overheating of nuclear core



Scenario:

Loss of electricity, heat sink & infrastructure

sCO2-HeRo solution:

- **Core cooling**
  - **Natural convection in primary cycle**
- **Self-sustainability**
  - **Simple Joule cycle running on decay heat**
- **Self-starting**
- **Compactness**
  - **Supercritical CO_2**

sCO2-HeRo-Loop design targets

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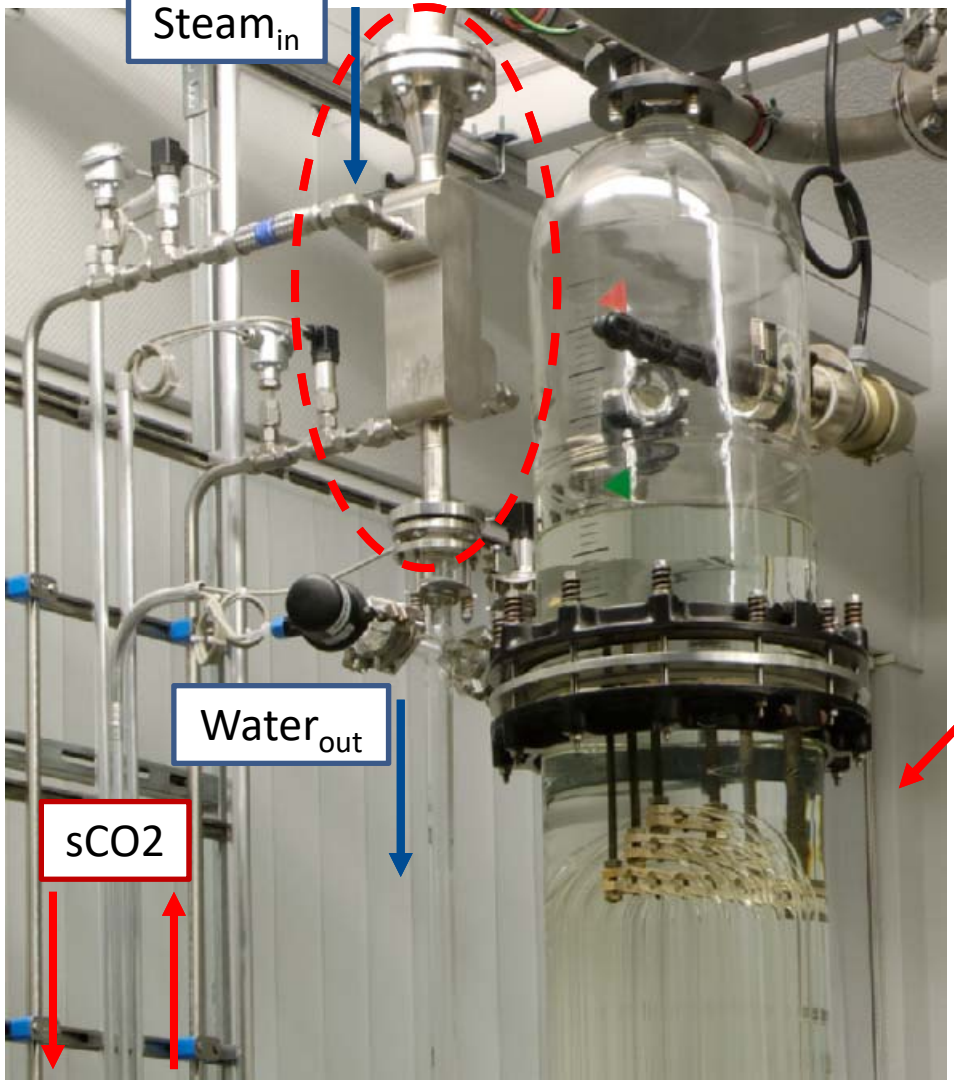
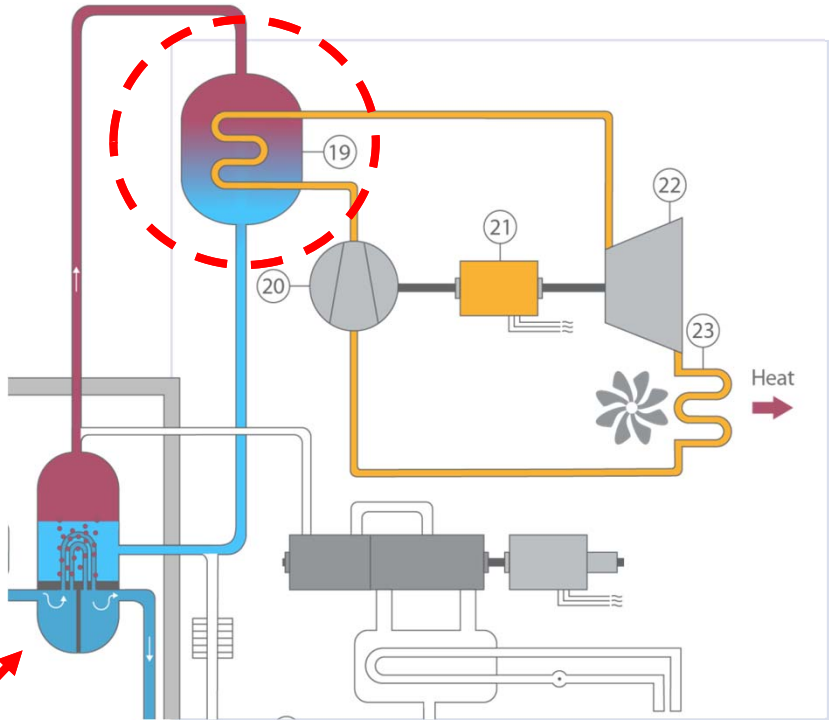
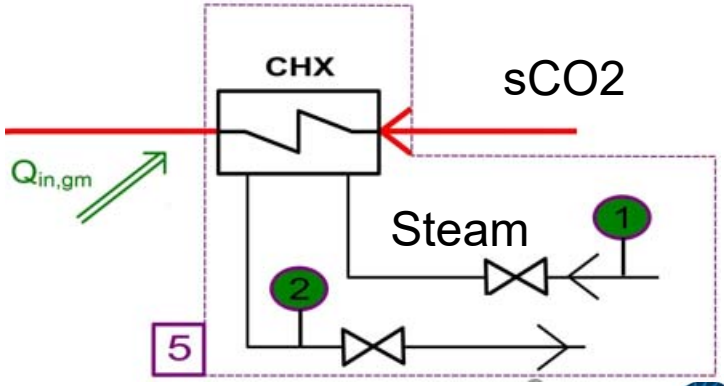
Overall: Validate sCO2-HeRo concept to TRL 3

- General operation ability
- Show heat transfer in CHX
  - Demonstrate cooling of the core in the primary cycle
- Evaluate limitations of self-sustaining cycle operation
  - Off-design performance
- 2 start-up concepts
  - Motor
  - Pressure surge on turbine

Compact heat exchanger – CHX





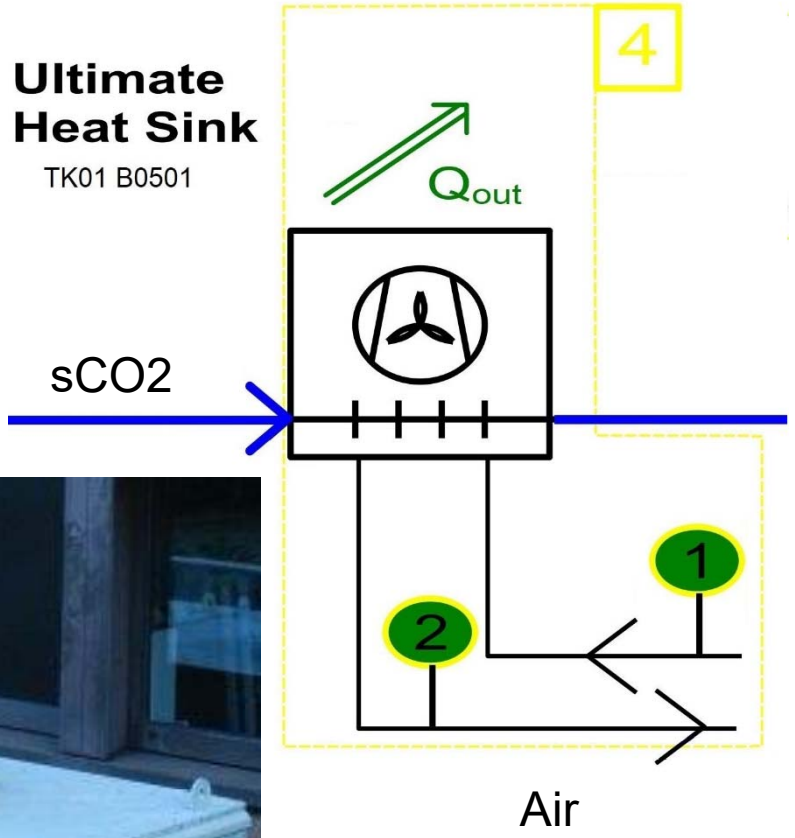


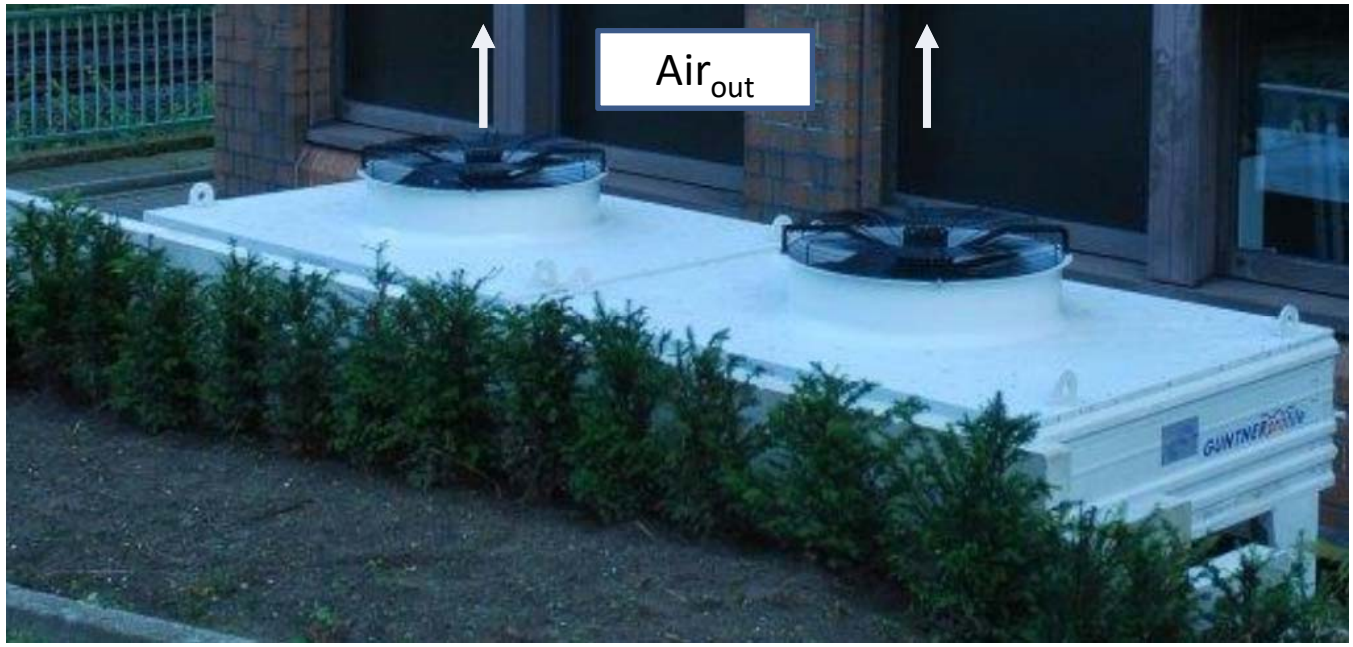
Task: Transfer heat from the steam to the sCO2 cycle

Ultimate heat sink – UHS

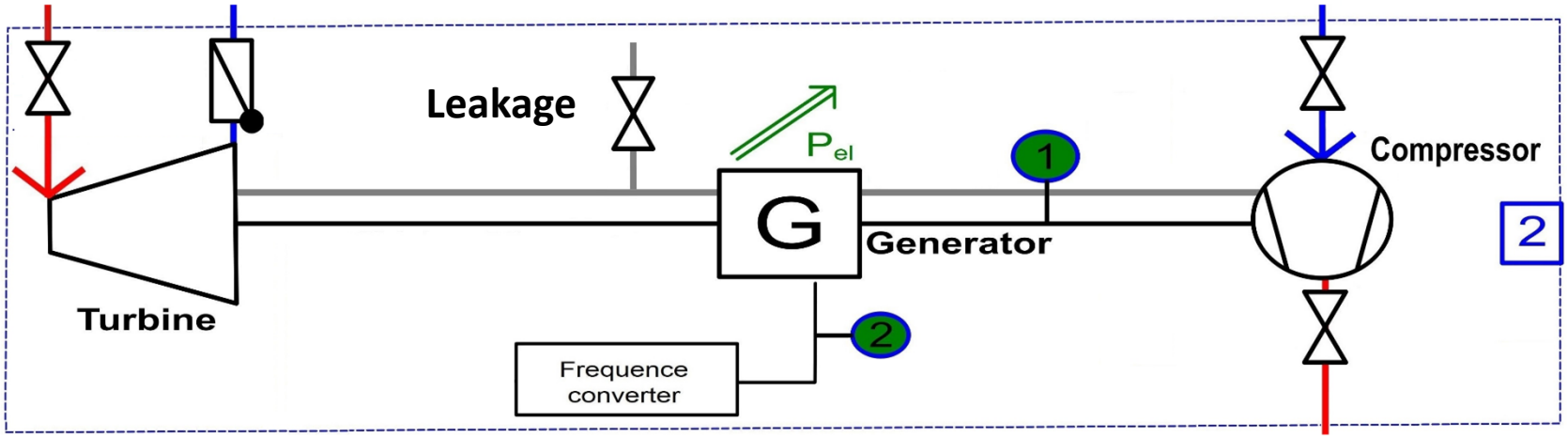
Task **Reject the heat to the environment**

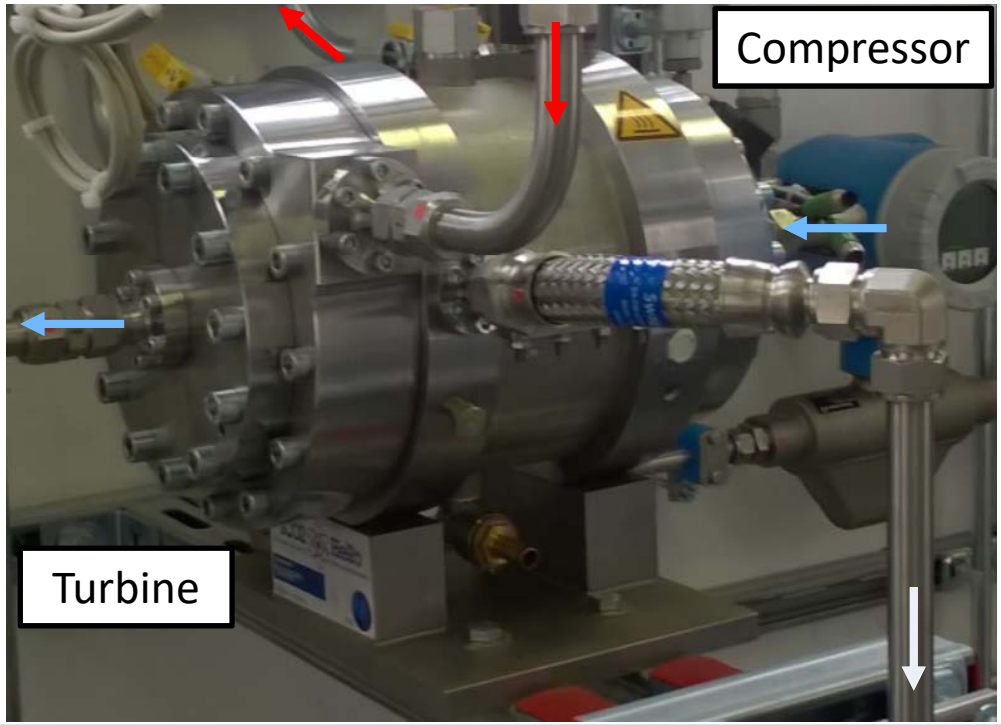
Setup **Two units in parallel**





Turbomachine – TAC

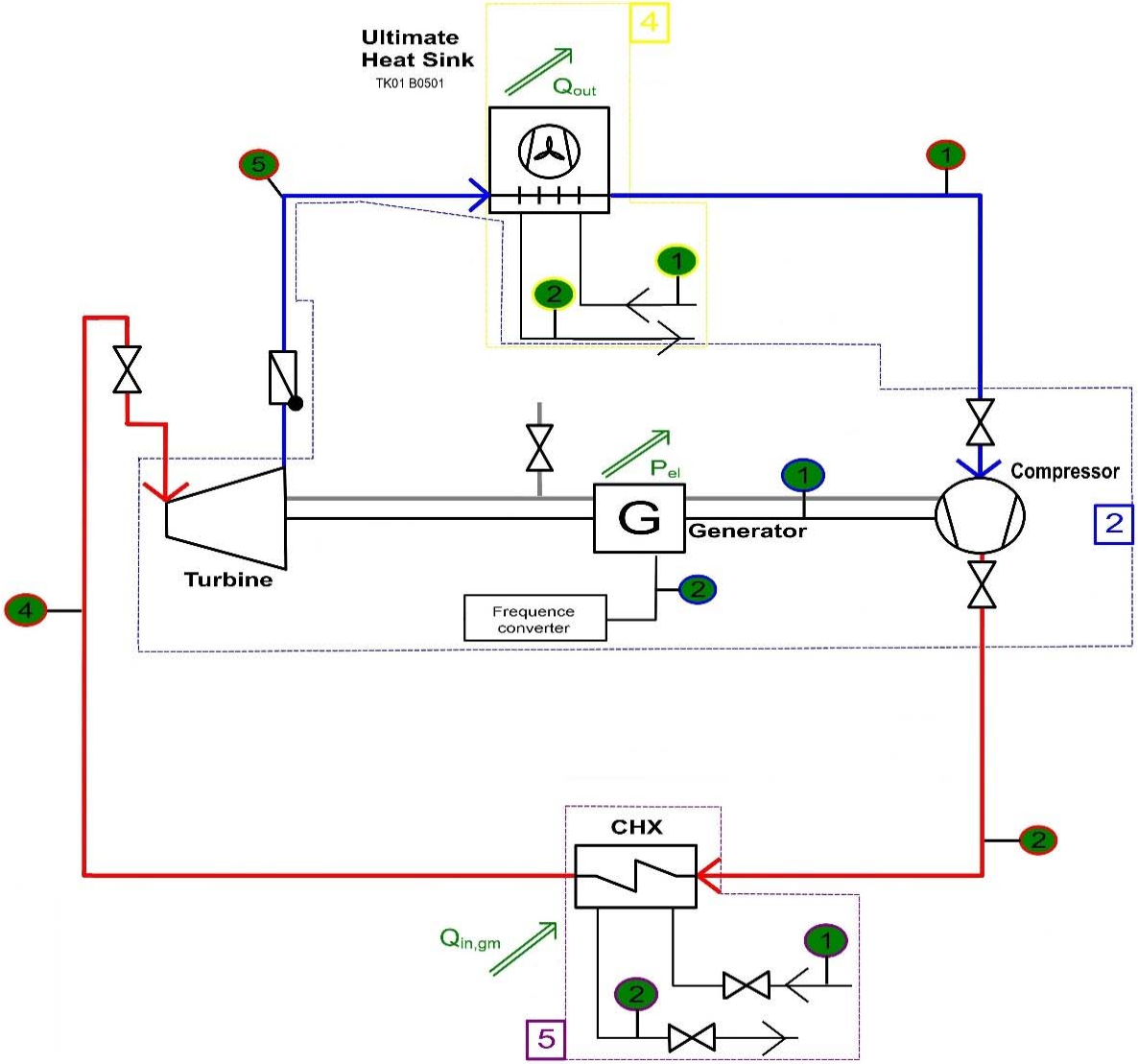




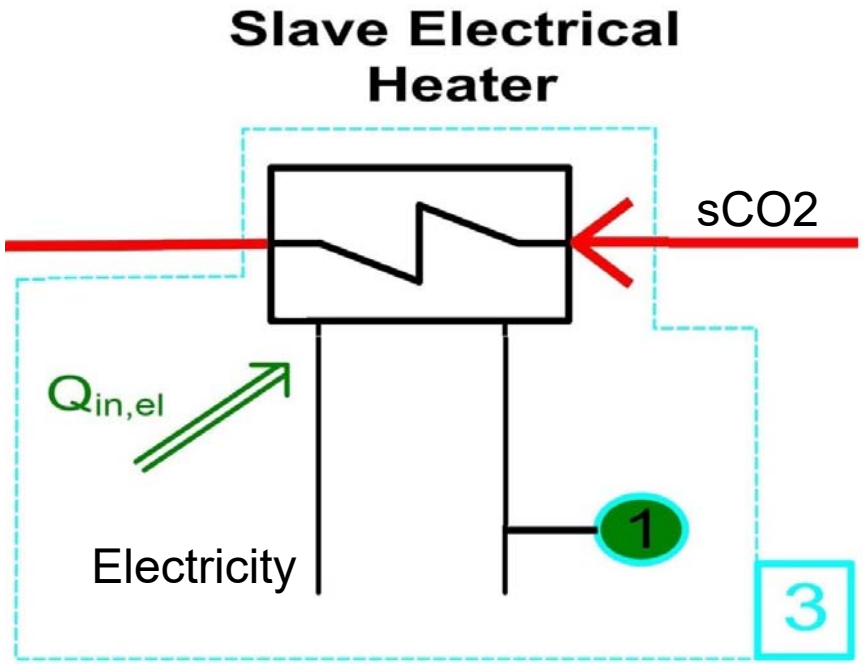
Task: Drive the cycle & Generate electricity

Setup Turbine, Alternator and Compressor on one shaft in one casing

PID – sCO2-HeRo

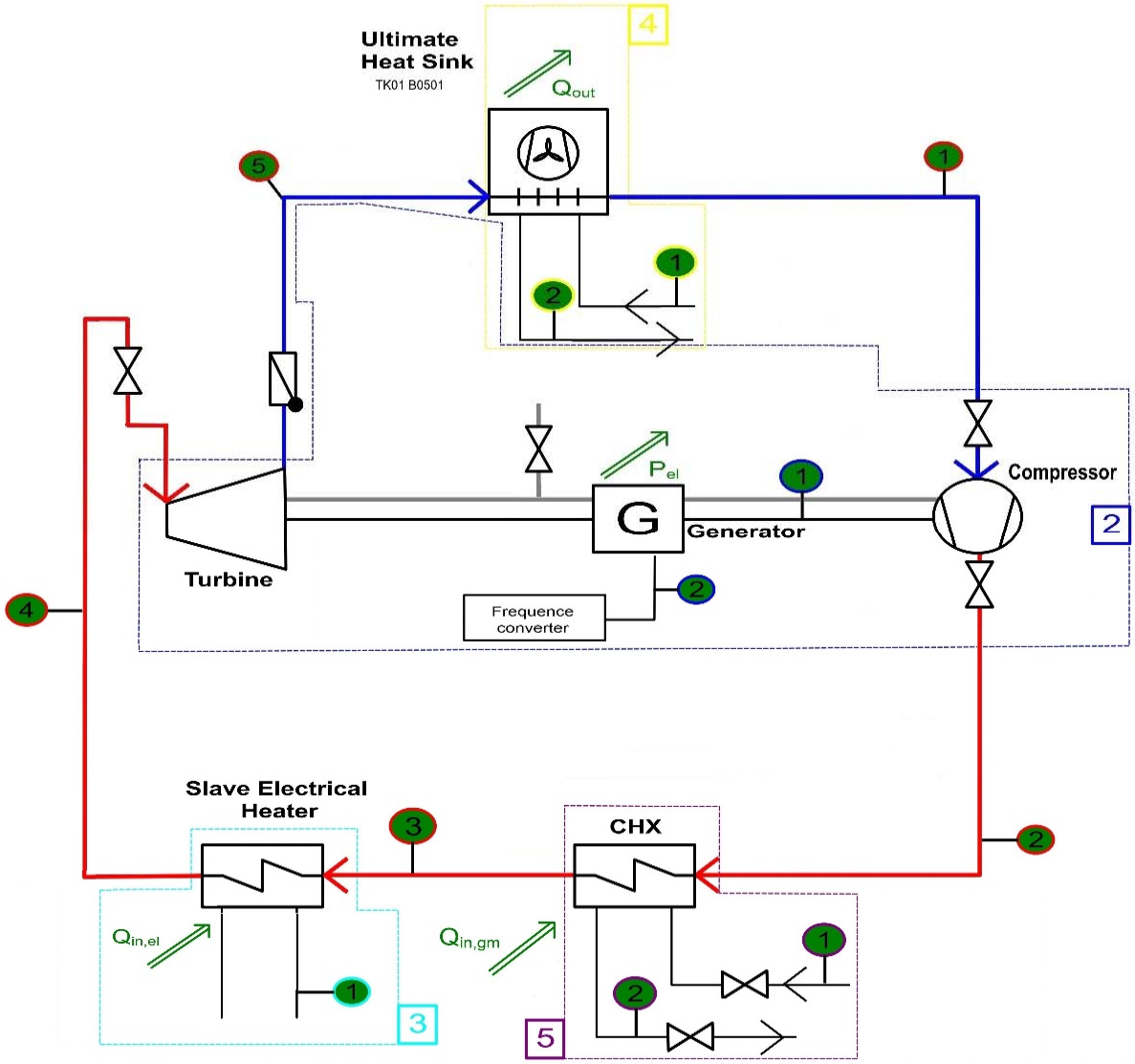


Slave electric heater – SEH



Task: Provide additional heat

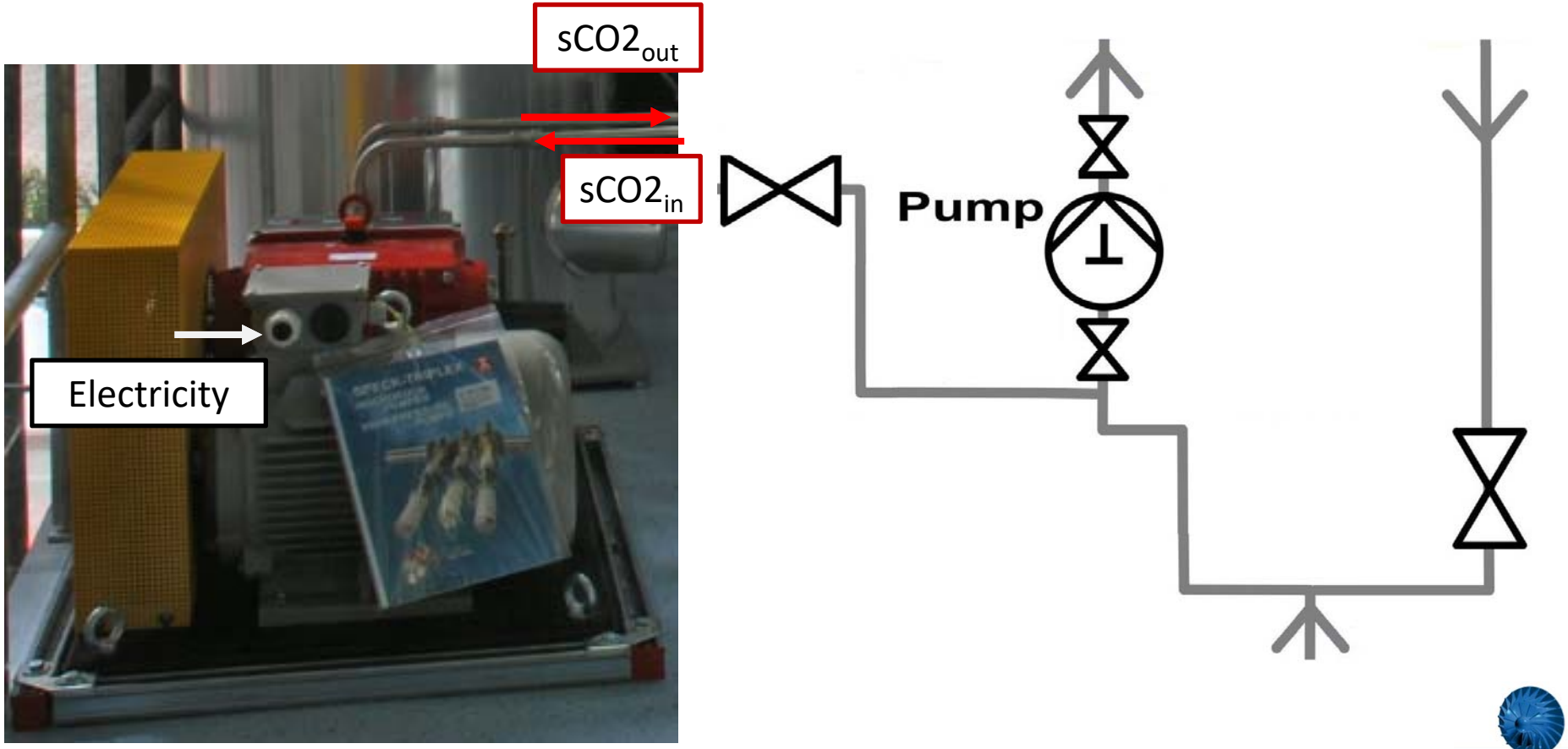
PID – sCO2-HeRo



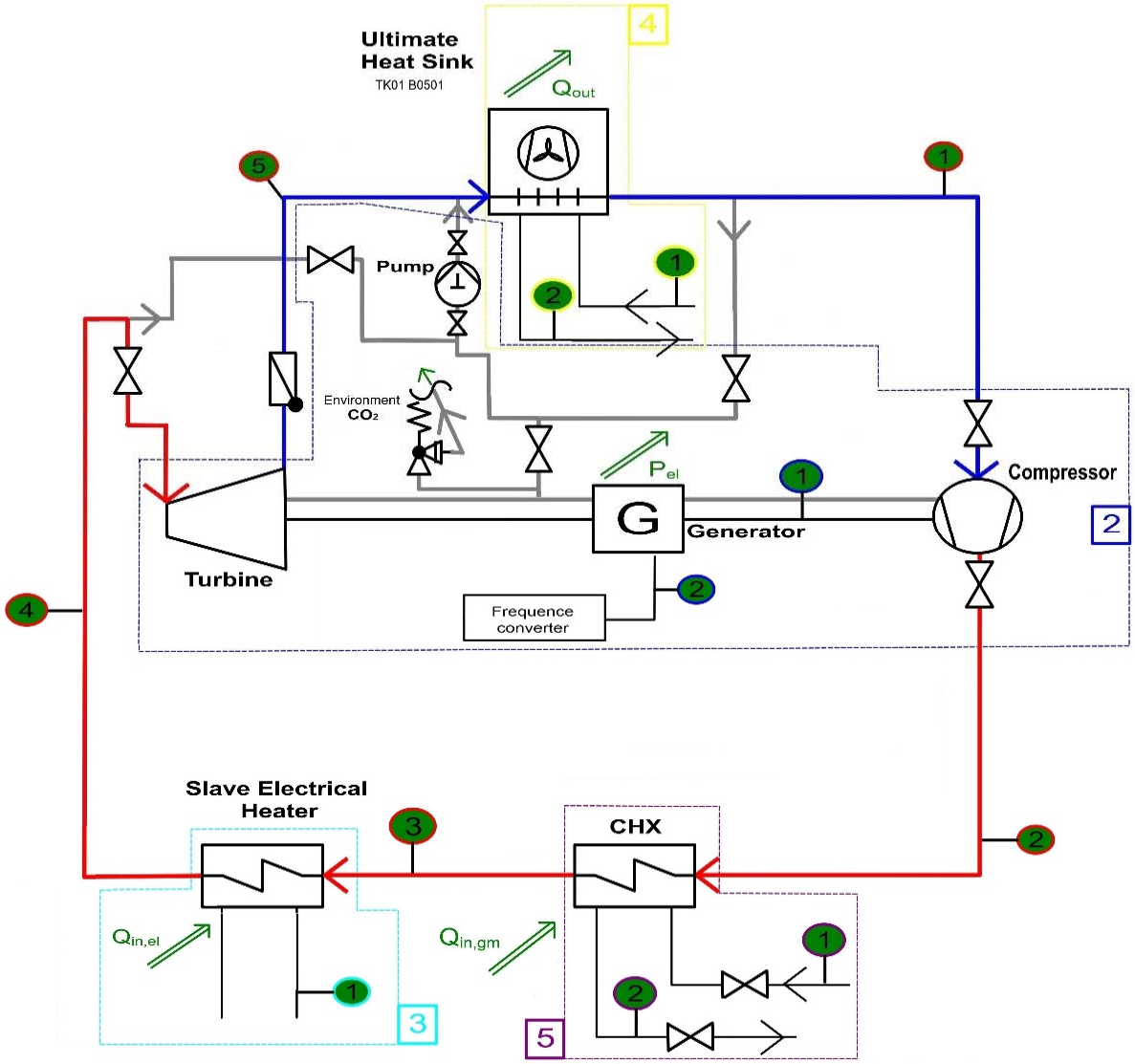
Slave electric heater – SEH

Tasks: Extract leakage from turbomachine to reduce the pressure in the central housing

Allow circulation of CO_2 without the turbomachine



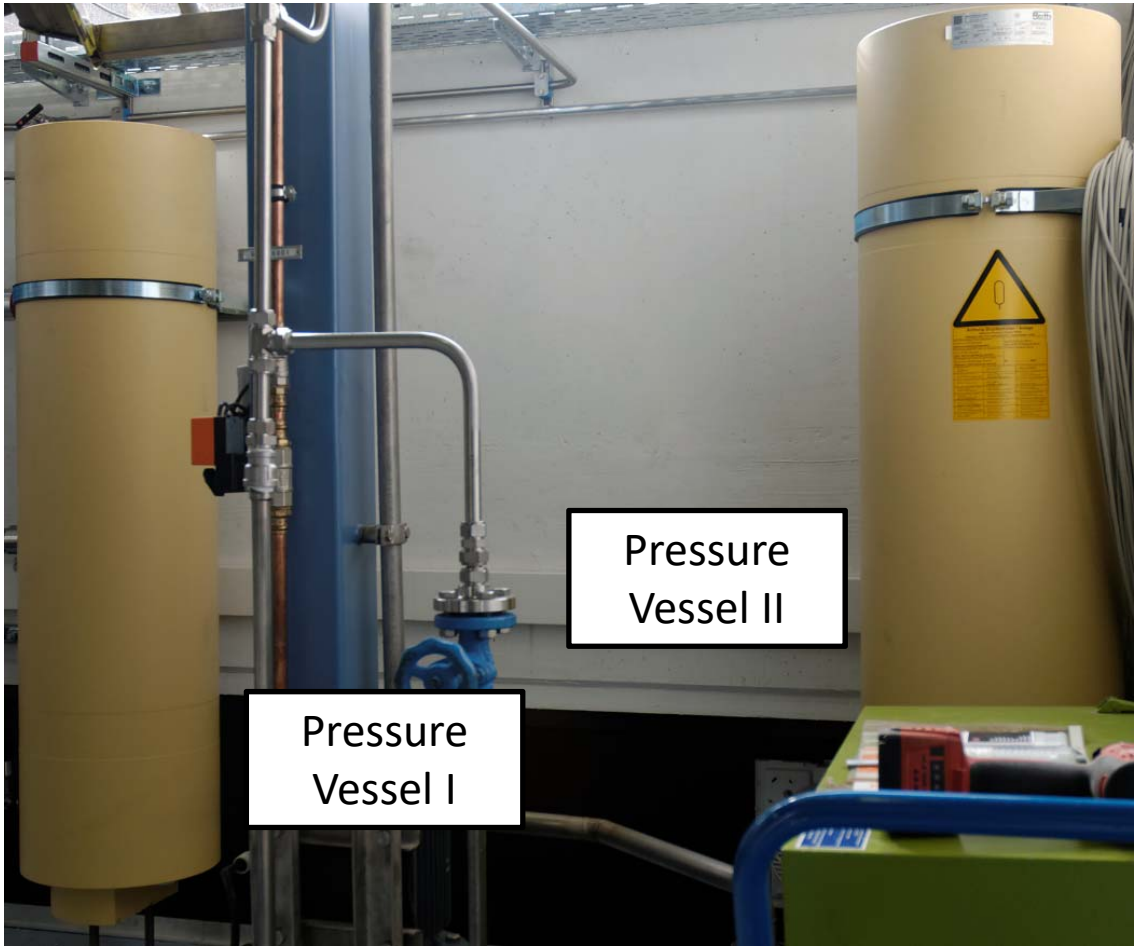
PID – sCO2-HeRo

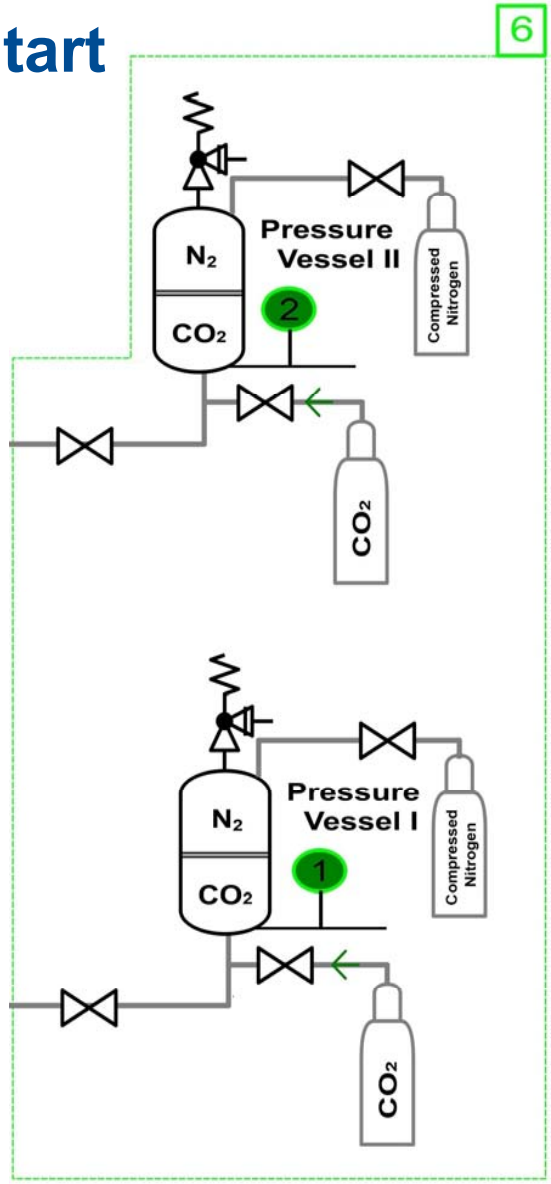


Pressure vessels – PV

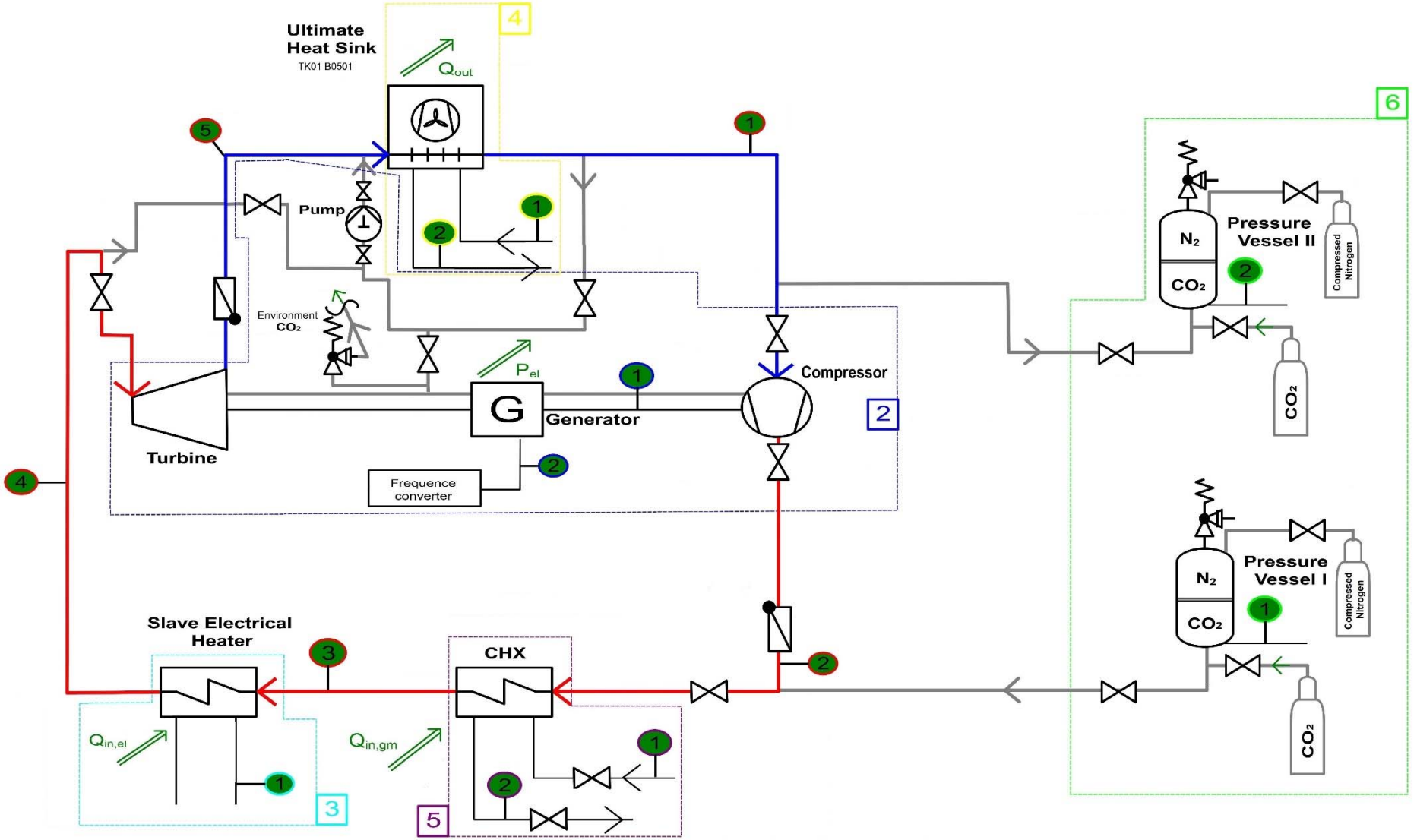
Task **Provide CO2 for pressure surge start**
Balance pressure fluctuations

Setup **Piston accumulators**

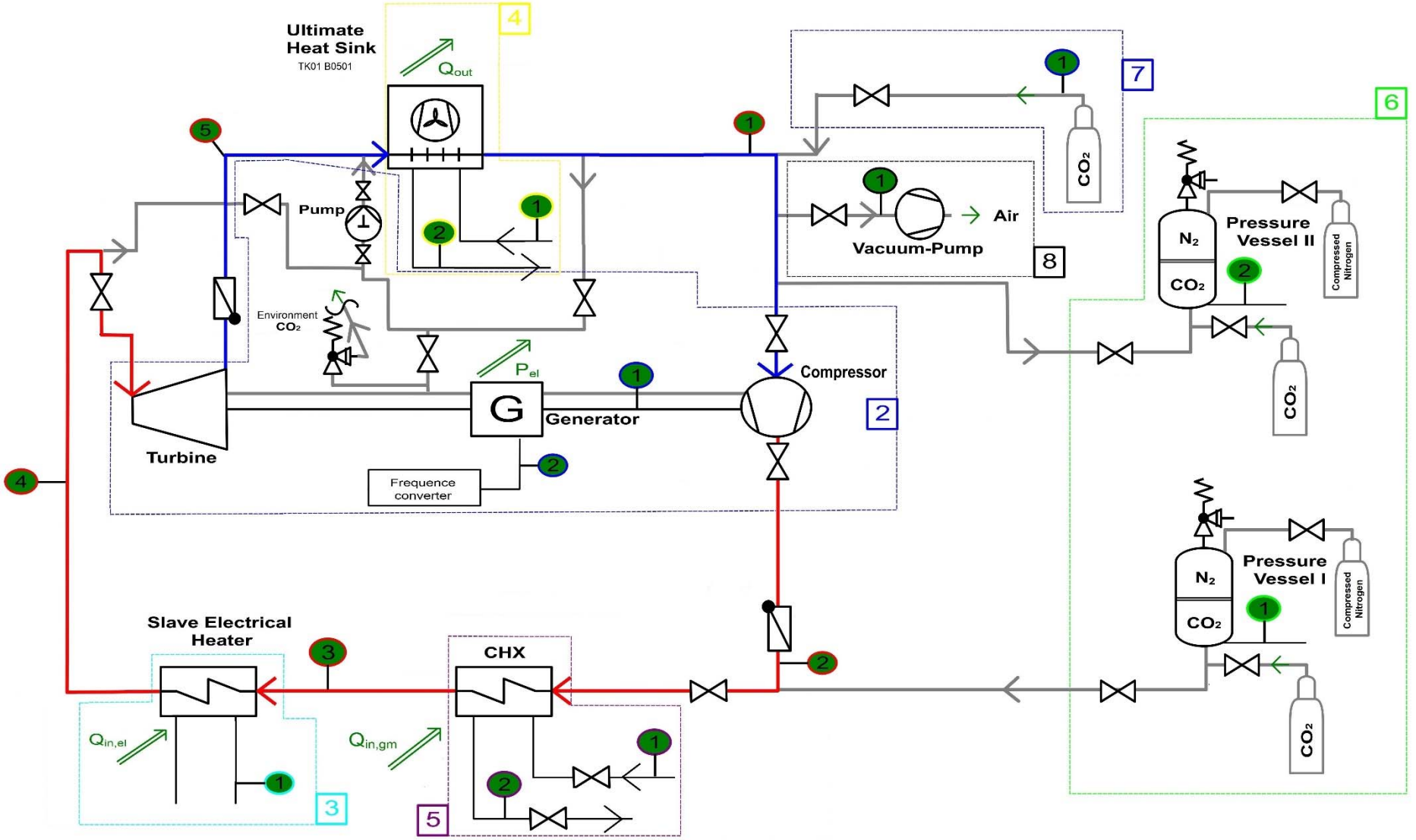




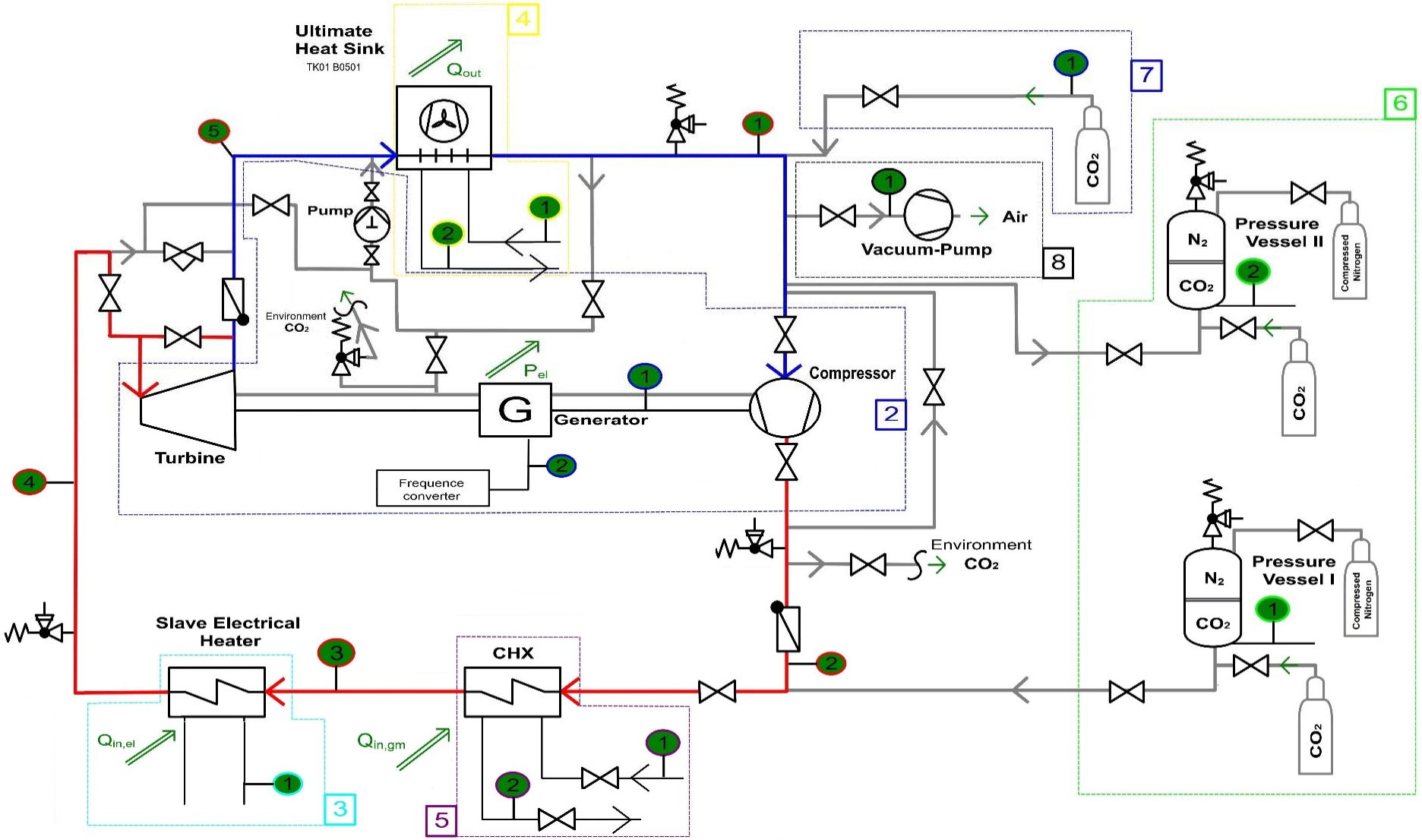
PID – sCO2-HeRo



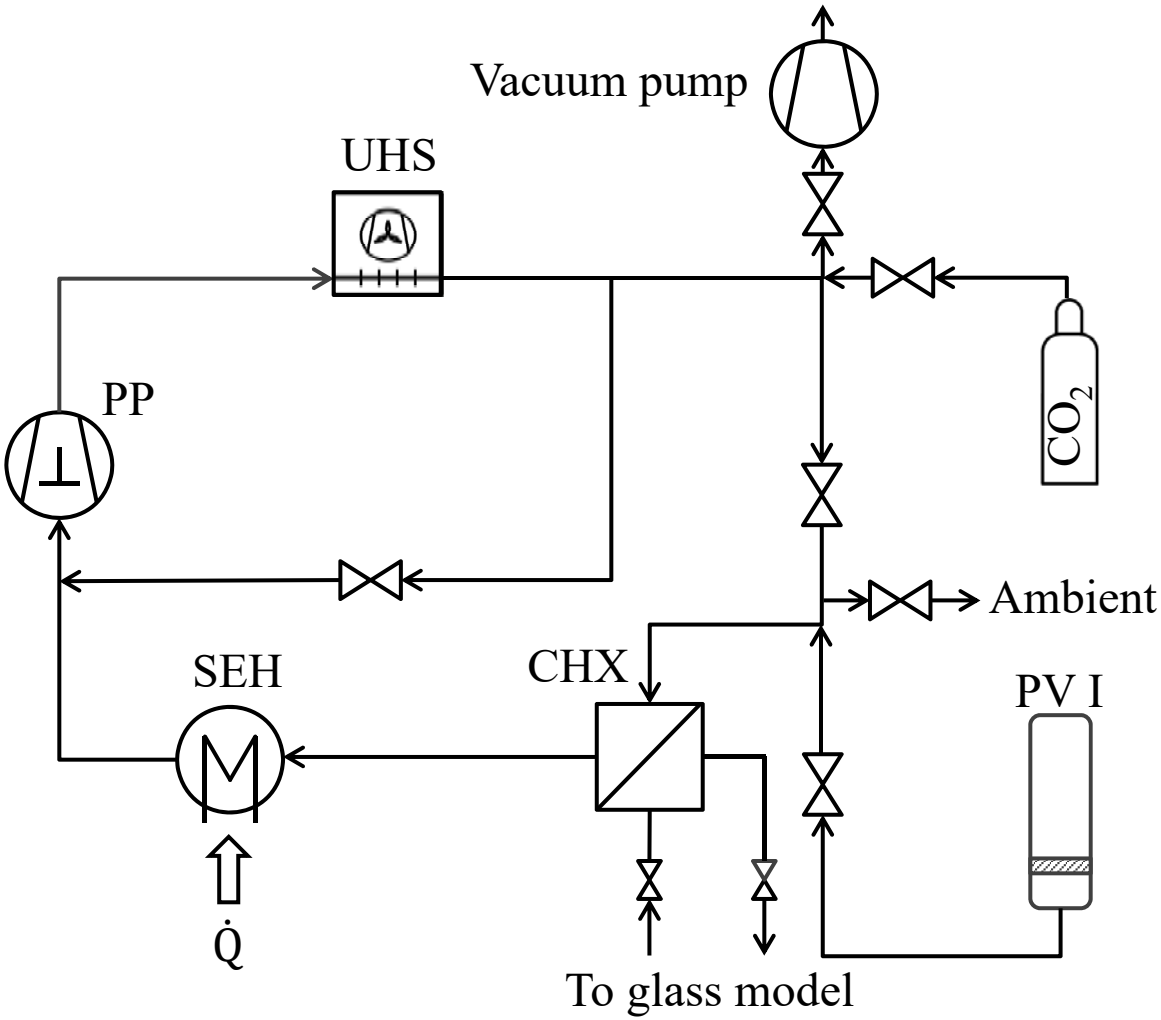
PID – sCO2-HeRo



PID – sCO2-HeRo



sCO2-HeRo – Circulation loop



Circulation loop tasks

- Conditioning of the cycle prior to TAC start
- Validation of heat exchanger behavior
- Validation of pressure losses
- Comparison to SUSEN and SCARLETT loop

Other loops in the sCO2-HeRo project

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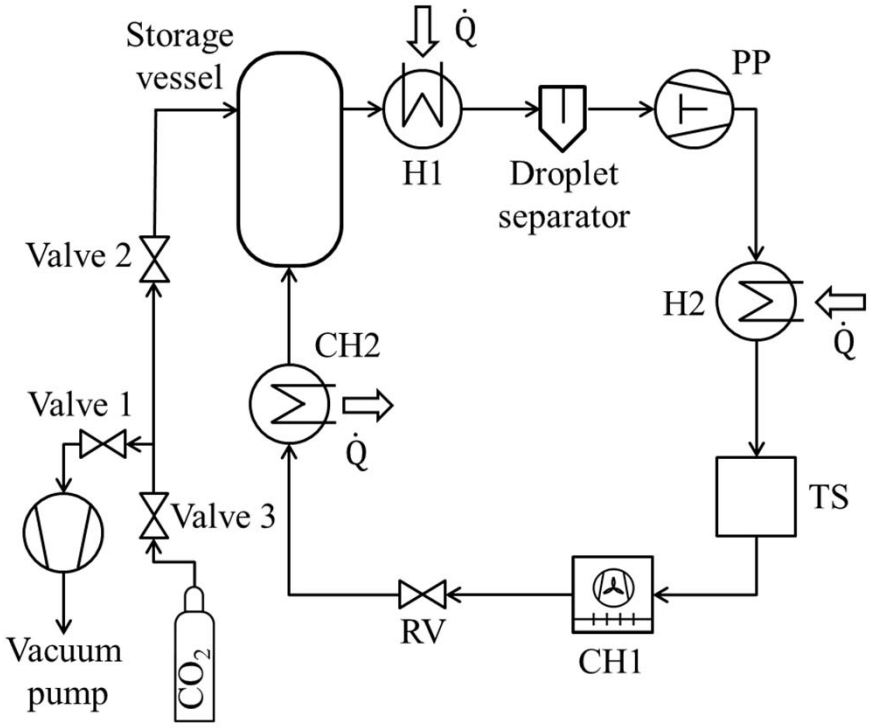
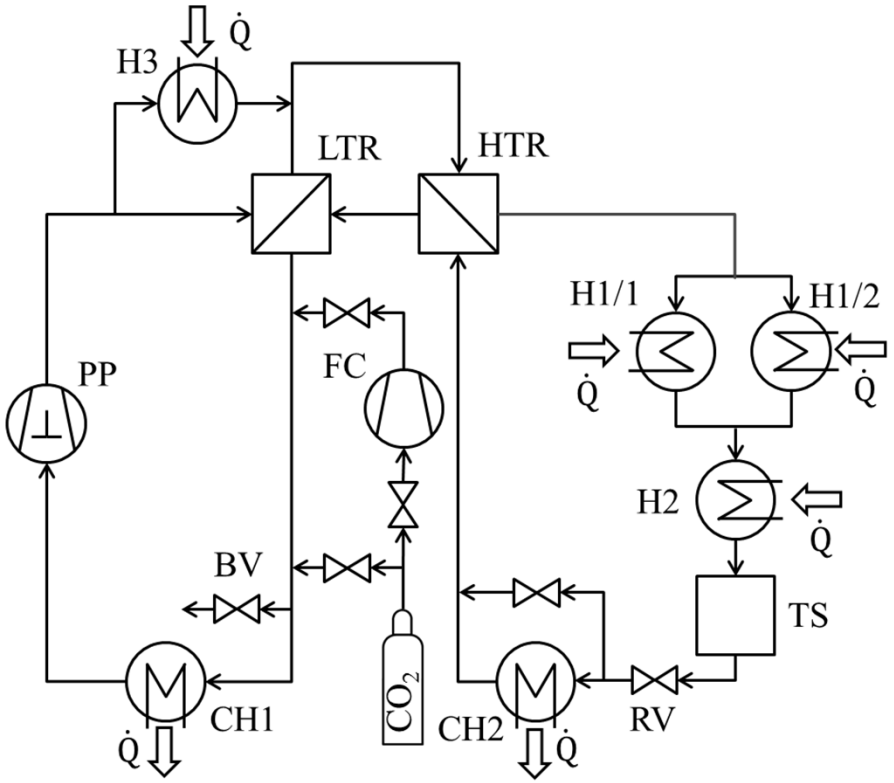
SCARLETT
(University of Stuttgart)



Heat transfer tests close to the critical point

SUSEN
(Research Centre Rez)



Heat transfer and material tests at high temperature

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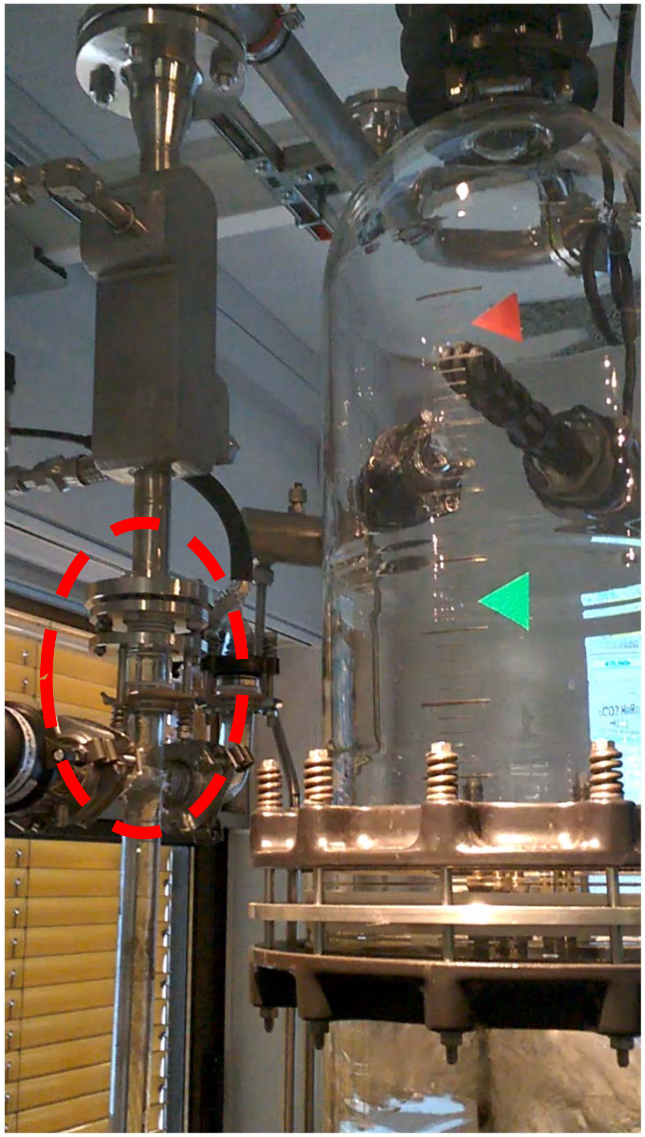
Evaluation

	sCO2-HeRo	SCARLETT	SUSEN
Gas bottle type	Dip-tube	Dip-tube	Gas
Filling pump	-	-	Piston type booster pump
Filling/Storage vessel	2 piston accumulators	Tank with 2-phase CO_2	-
Filling speed	Fast filling	Fast filling	
Reachable conditions	Determined by initial CO_2 mass	Freely adjustable in TS	Freely adjustable in TS
Changing conditions	Fast	Fast	

Demonstration of condensation in CHX



Operation mode:

- Circulation with PP

Demonstration:

- Condensation of steam in the CHX can be observed in the glass tube

Summary and future tests

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Summary

- **Testing of the sCO2-HeRo cycle has begun**
- **Cycle purpose and components have strong influence**
  - **Filling speed**
  - **Reachable cycle conditions and flexibility**

Future tests

- **Start-up and re-start options**
- **Design and off-design cycle performance**
- **Transient load and heat transfer cases**

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Prof. Dr.-Ing. Dieter Brillert

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Thank you for your attention!

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