R&D Activities on sCO_2 in Europe

Webinar series – 1st episode

22 September 2022

Block I. – "Solar"

- CARBOSOLA
- COMPASsCO2
- SCARABEUS
- DESOLINATION
- SOLARsCO2OL

CARBOSOLA

A. Jäger, U. Gampe, S. Rath, T. Gotelip,
S. Unger, U. Hampel, S. Glos, L. Heller

Gefördert durch:

Bundesministerium
für Wirtschaft
und Energie

aufgrund eines Beschlusses
des Deutschen Bundestages

Presentation structure

- Project summary
- Objectives & expected impact
- Scope
- Main results/outcomes
- Options for exploitation/collaboration/follow-up activities

CARBOSOLA

Project summary

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Funding source	Federal Ministry for Economic Affairs and Climate Action
Budget	2.2 million €
Duration	42 months (October 2019 – March 2023)
Start TRL	3
End TRL	4

Partners

TU Dresden, Institute of Power Engineering, Chair of Thermal Power Machinery and Plants

Helmholtz-Center Dresden-Rossendorf, Institute of Fluid Dynamics

SIEMENS AG, Power & Gas Division Erlangen/Mülheim

German Aerospace Center, Institute of Solar Research

CARBOSOLA

Objectives & expected impact

Potential Study

Use Case WHR
Thermo-economic optimization

Use Case CSP
Thermo-economic optimization

- Process architectures & parameters
- Integral optimization
- Requirements on component design
- Product technology

Technology Development

- Design Methodology & Technology
- Component & System Design
- Modular Test Facility

Validation of sCO_2 technology

SIEMENS energy

DLR

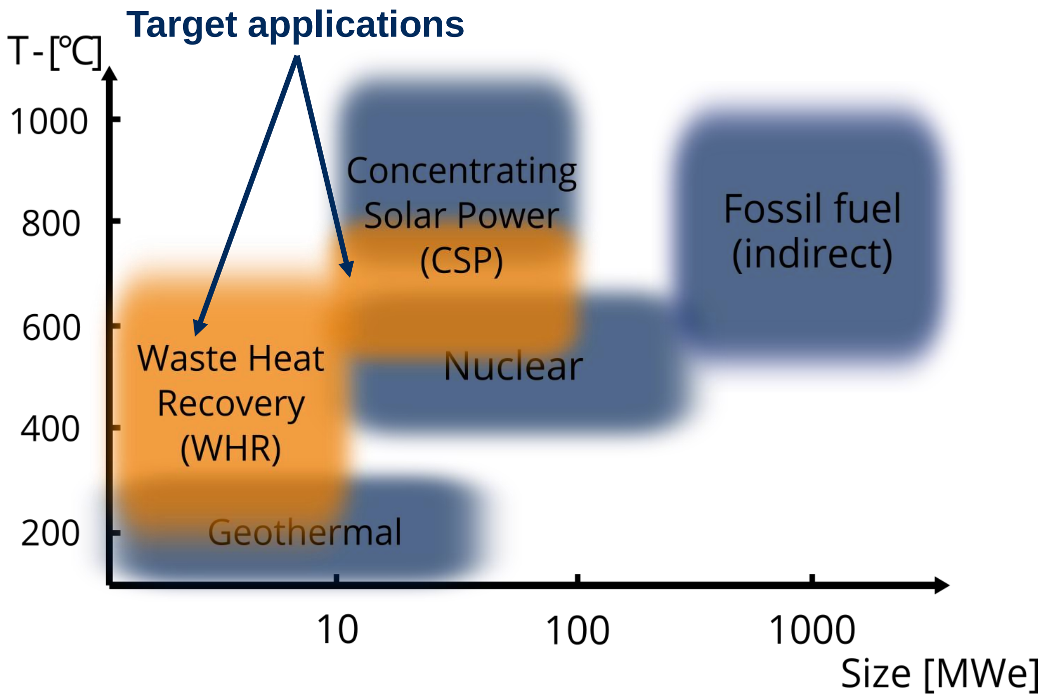
TECHNISCHE UNIVERSITÄT DRESDEN

HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

ETN Global

CARBOSOLA

Objectives & expected impact



CARBOSOLA

Scope

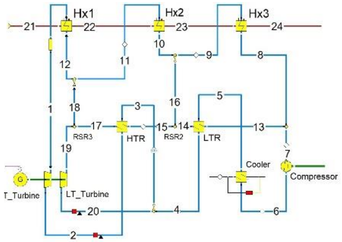
- Setting up a MW_{th} class sCO_2 facility, which targets development of WHR and CSP applications
- Technology development:
  - Component development and testing
  - Static and transient system analysis
  - Process reliability and safety
- Generic investigations:
  - Fluid composition / impact on cycle performance
  - Validation of CFD models
  - Heat transfer modeling
  - Near critical point stability criteria
  - Failure models and effect analysis (FMEA)
- Target parameters: $T = 600\ °\mathrm{C}$, $p = 300\ \mathrm{bar}$, $\dot{Q}_{\mathrm{th}} = 2.5\ \mathrm{MW}$

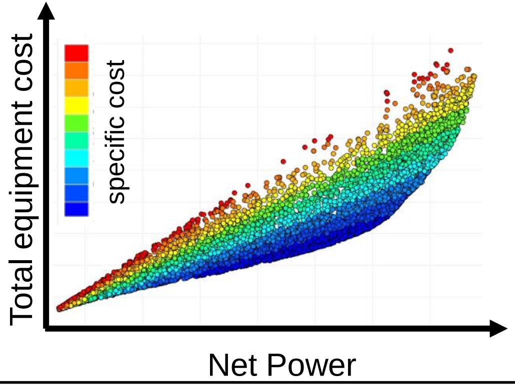
CARBOSOLA

Main results/outcomes

Use Case WHR

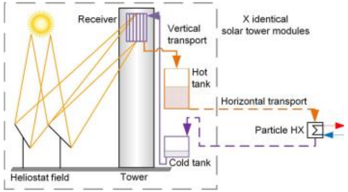
- Investigation of different configurations
- Cost models for components
- Cycle modeling with EBSILON ®



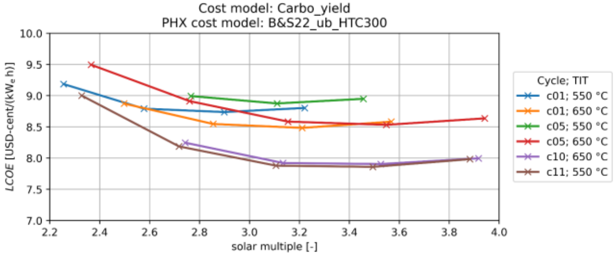


Use Case CSP

- Design of the CO_2 system
- Design of the CSP system
- Define the LCOE



- Bauxite particles for heat transfer
- Cost optimization for various cycle designs



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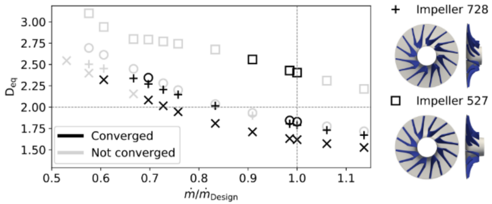
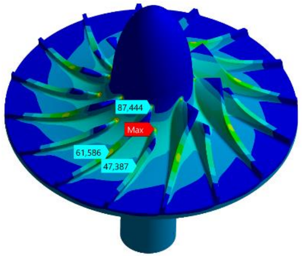
Main results/outcomes

Design Methodology & Technology

- Optimization of impeller design
- CFD and FEM-Modell development
- Iterative adaption of wall thickness
- Evaluation of 1067 designs

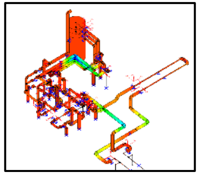


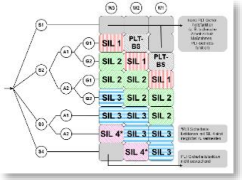


- Determination of eigenfrequency
- Design and manufacturing of fluid blower

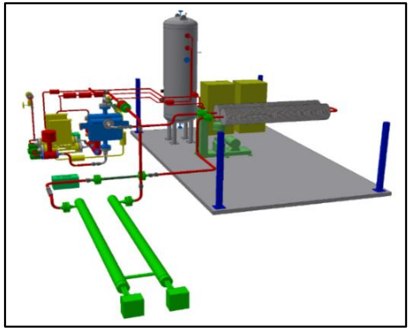
Modular Test Facility

- Development of experimental facility
- Temperature of 600 °C, pressure of 300 bar
- Safety regulation
- Pressure vessel design





- Assembly of the components
- Commissioning and operation in 2023



CARBOSOLA

Options for exploitation/ collaboration/ follow-up activities

Granted and planned follow-up projects:

- EU-Project SHARP-sCO_2
  - Positive evaluation, anticipated start: end of this year

- CARBOSOLA II (Federal Ministry for Economic Affairs and Climate Action)
  - Proposal to be handed in

CARBOSOLA

Contacts

- For questions and inquiries, please contact: andreas.jaeger@tu-dresden.de

CARBOSOLA

Components' and Materials' Performance for Advanced Solar Supercritical CO_2 Powerplants

COMPASsCO2

Daniel Benitez
German Aerospace Center (DLR)
daniel.benitez@dlr.de

This project has received funding from the European Union's Horizon 2020 Research and Innovation Action (RIA) under grant agreement No. 958418.

Presentation structure

- Project Summary
- Objectives & expected impact
- Scope
- Main results/outcomes
- Options for exploitation/collaboration/follow-up activities

COMPASsCO2

Project summary

Funding source	Horizon2020 Topic: Novel high performance materials and components (RIA)
Budget	Approx. 6 Mio. EUR
Duration	48 months (November 2020 – October 2024)
Start TRL	2
End TRL	5

Partners

COMPASsCO2

Objectives

1. Develop highly durable and efficient particles for CSP plants
2. Develop optimized structural materials for heat exchanger tubes in contact with particles and sCO_2
3. Demonstrate material lifetime by measuring and modeling the degradation of the materials
4. Design, construct and operate a particle/sCO_2 heat exchanger section in order to validate the degradation and heat transfer models
5. Evaluate the economic benefits of a CSP-sCO_2 plant using the materials and components developed and compare it with state-of-the-art CSP plants

COMPASsCO2

Expected impact

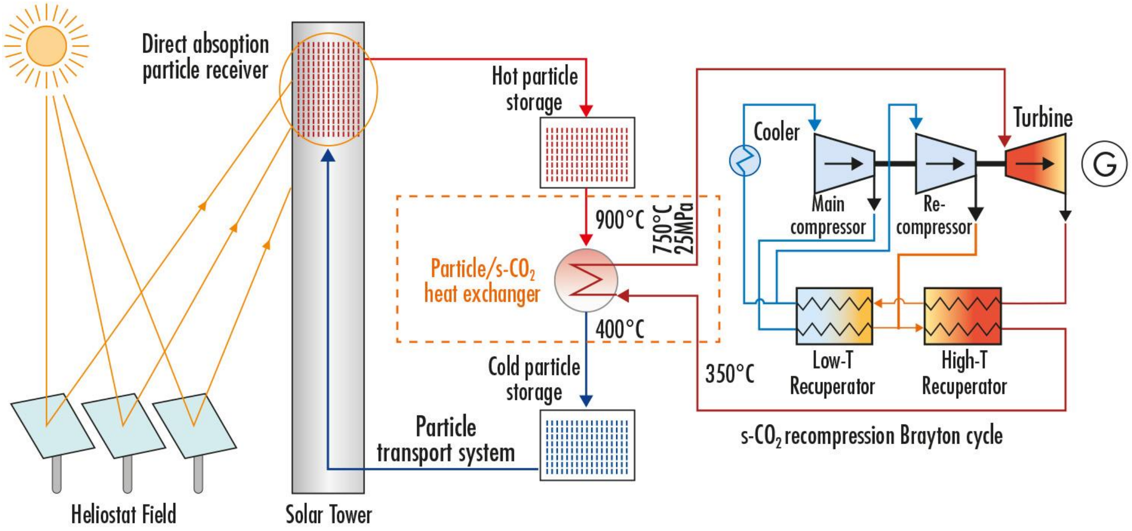
- **Sun-to-electricity efficiency of the overall system improved by 30%** compared to the current state-of-the-art CSP plants
- **100% CO2-reduction for electricity production** by replacing a fossil power plant with the new sCO2-solar-tower-system
- **20% longer service life of the particles** compared to absorber coatings of molten salt receivers.

COMPASsCO2

Scope

The project focus is to develop **new materials for extreme conditions** in order to integrate two innovative systems:

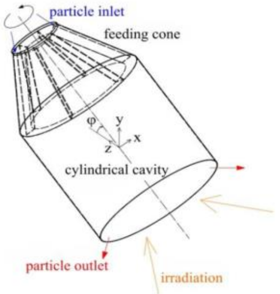
CSP plants with particles and sCO2 Brayton power cycles

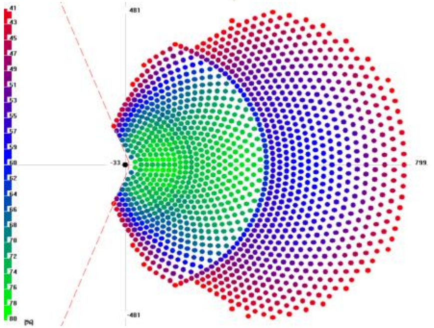


COMPASsCO2

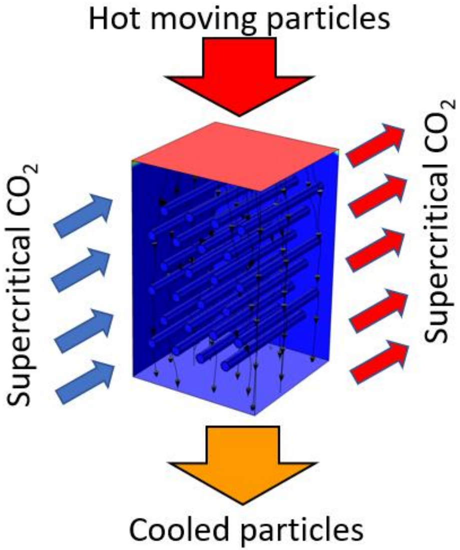
Main results/outcomes

Solar receiver & field optimization

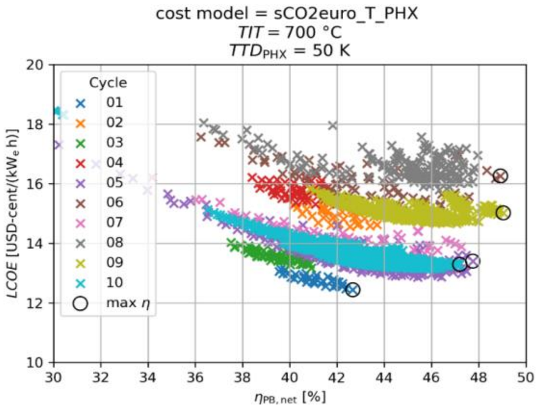




Heat Exchanger conceptual design



sCO2 Brayton power block investgation

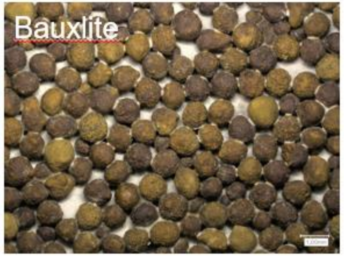


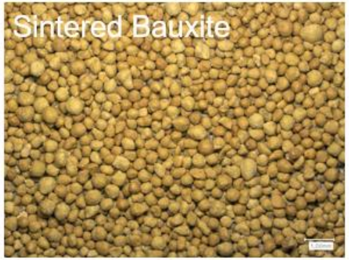
See public Deliverable 1.1 and 1.2

COMPASsCO2

Main results/outcomes

ETN Global





Light weight proppants

Intermediate strength

High strength

State of the art proppants

Al_2O_3 rich

Price: ~1 – 1.2 €/kg

SaintGobain stopped proppant production → alternatives are needed!

3 generations developed

Raw material : recycled iron oxide from steel industry (~1 €/kg possible)

Very good thermal stability

2 generations developed

Raw materials : >70wt. % of recycled products (today)

Very high absorptance

Electrofusion process is expensive (~3 €/kg)

New particles

Tailored for CSP/CST application

See publication about development and testing of new particles

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Main results/outcomes

Metals for HX tubes

- State-of-the-art steels and Ni-based alloys selection
  - P92, IN740, Haynes 282, Sanicro 25, IN617
- Characterization (hardness, microstruture, precipitates, grain size, etc.)
- **Development and production of novel Cr-NiAl alloys**
  - Paper in preparation, ageing behavior > 1000 °C, corrosion test, simulations, mechanistic studies
- **Development of Cr-based with silicides intermetallics alloys and coatings for conventional Fe-, Ni-base materials**
  - Slurry coating, diffusion coatings with increase hardness.
- Modelling (precipitates, diffusion bonding, microstructure, etc.)

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Main results/outcomes

ETN Global

Particles + Metal + sCO2 interation

- Creep tests in air
- Creep tests in CO_2
- Corrosion tests in air and CO_2 at 700 and 900 °C
- Cyclic oxidation testing in air and CO_2
- Isothermal oxidation tests in CO_2 at 700 °C
- Preparation of corrosion tests under supercritical CO_2
- High temperature erosion in air
- Simulation of corrosion and erosion

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Main results/outcomes

Heat Exchanger pilot testing plant

- Pneumatic particle transportation system tests
- Electric particle heater design
- Cold test to assess particle flow field
- Hot long-term abrasion test design
- Heat exchanger and final demonstrator design

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Options for exploitation/ collaboration/ follow-up activities

- Optimization of sCO2 Brayton cycles for CSP applications
- Development of particles as heat carriers for high temperature processes (>1000°C)
- Development of structural materials for harsh conditions regarding temperature, pressure, erosion, oxidation, corrosion, thermal cycling, etc.
- Testing and modelling of material degradation
- Scientific publications, joint dissemination events, etc.

COMPASsCO2

Contacts

@Co2Compa

@compassco2-horizon2020

https://www.compassco2.eu/

COMPASsCO2

contact@compassco2.eu

Communication and Dissemination:

abdelghani.elgharras@ome.org

Coordinator:

daniel.benitez@dlr.de

COMPASsCO2

Supercritical Carbon Dioxide/Alternative Fluids Blends for Efficiency Upgrade of Solar Power Plants

SCARABEUS

The SCARABEUS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 814985

Presentation structure

- Project Summary
- Objectives & expected impact
- Scope
- Main results/outcomes
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Project summary

Funding source	Horizon 2020 Programme
Budget	€ 4,950,266.25
Duration	48 months (April 2019 – March 2023)
Start TRL	TRL4
End TRL	TRL6

Partners

UNIVERSIDAD DE SEVILLA

TU WIEN IET

UNIVERSITAS STUDIORUM BRIXIAE

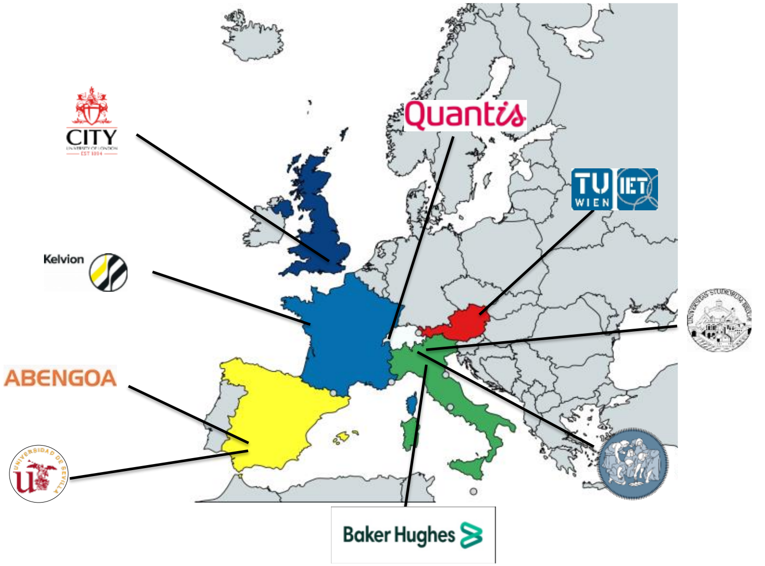
CITY UNIVERSITY OF LONDON EST 1894

Baker Hughes

Kelvion

ABENGOA

Quantis



SCARABEUS

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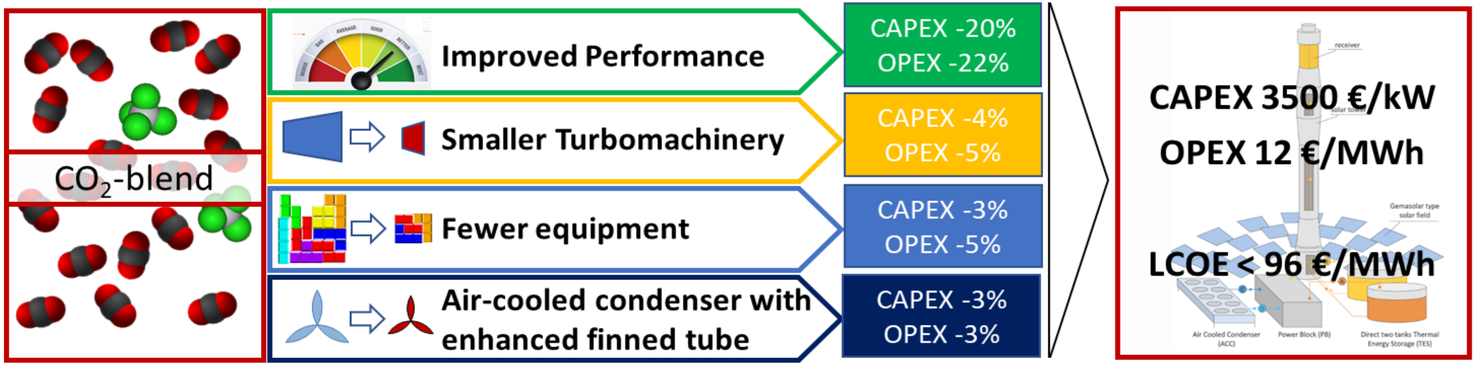
Objectives & expected impact

- **Demonstrate** that **sCO_2 blends in CSP plants** can **reduce CAPEX by 30% and OPEX by 35%** with respect to SoA steam cycles, thus exceeding the reduction achievable with standard sCO_2 technology.
- This translates into **30% lower LCoE than currently possible.**
- **Demonstrate the innovative fluid** and newly developed heat-exchangers **at a relevant scale (300 kW_{th}) for 300 h** in a CSP-like operating environment.



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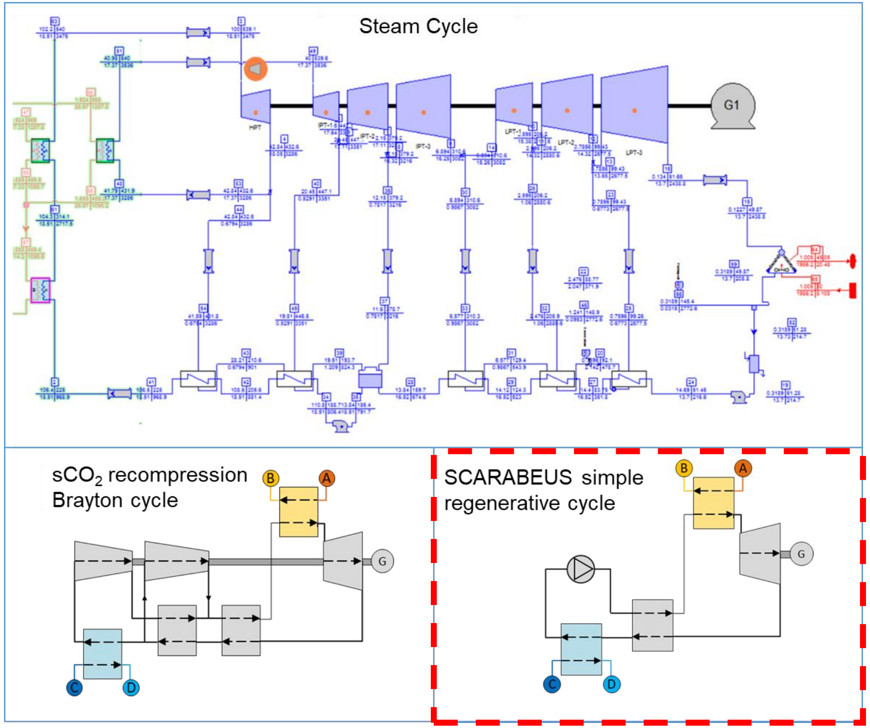
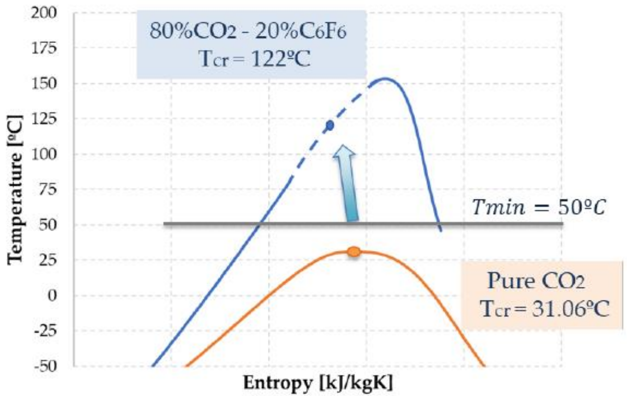
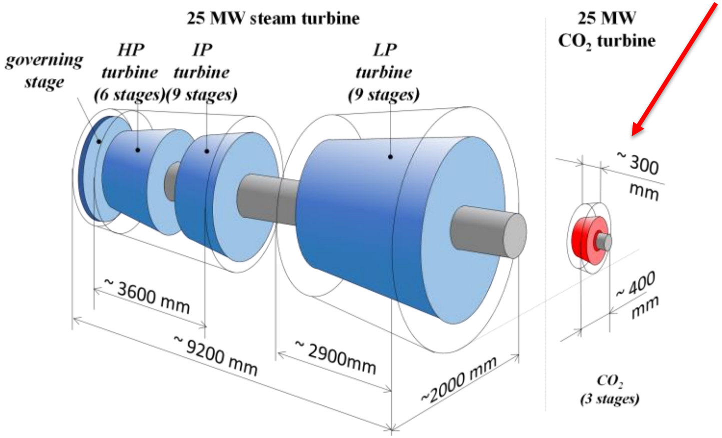
Scope



Simpler cycle (lower component count)



Condensation @ high T_{amb}



Smaller footprint

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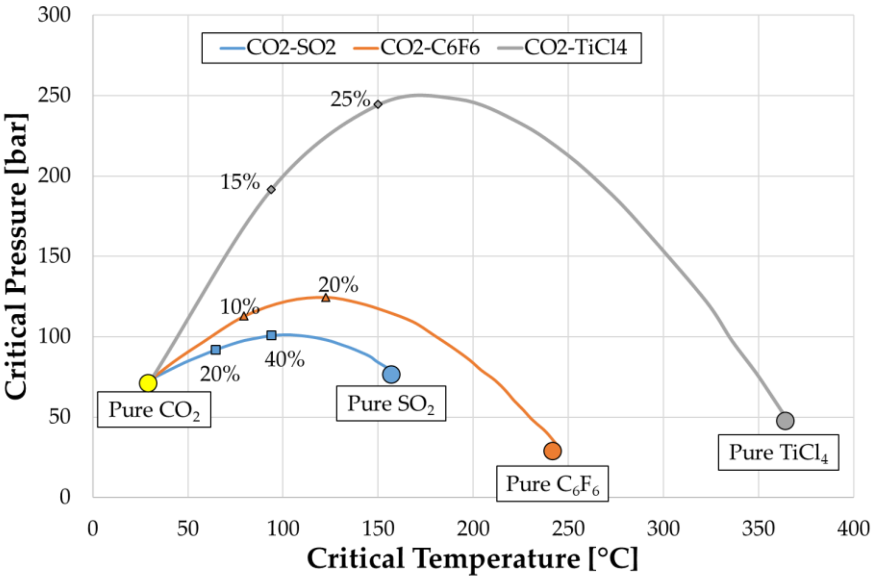
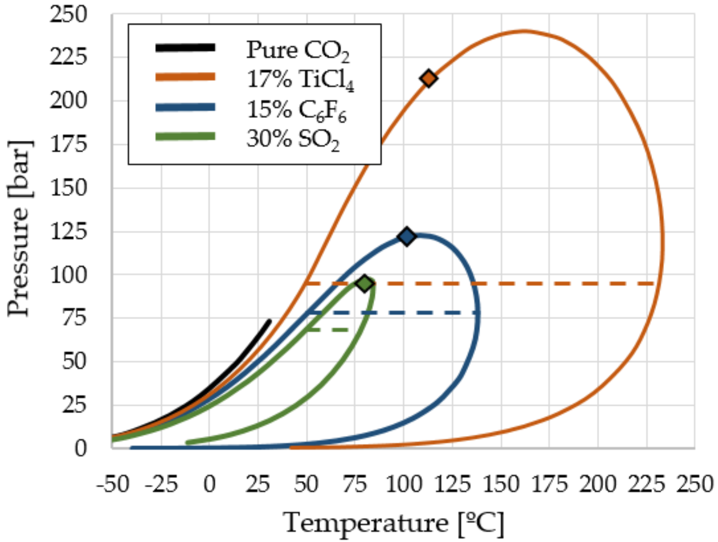
Main results/outcomes





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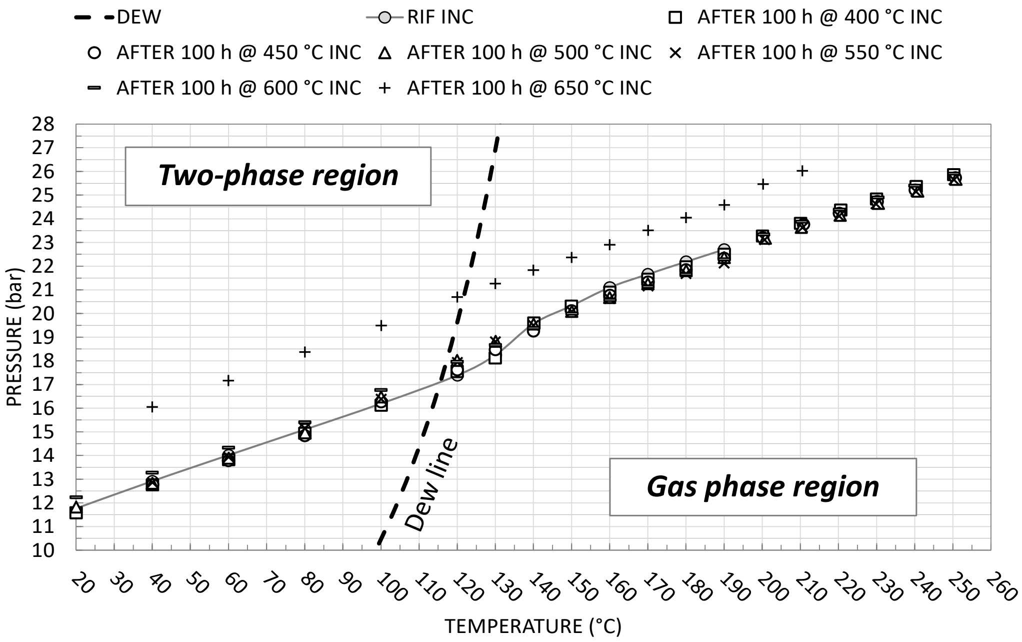
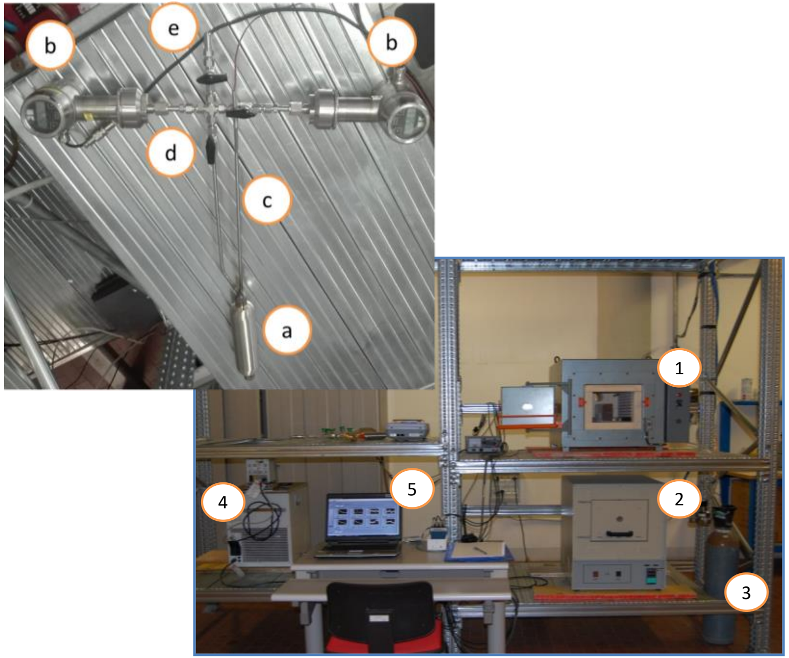
Main results/outcomes





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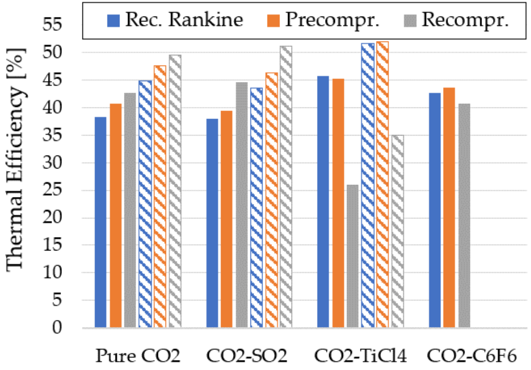

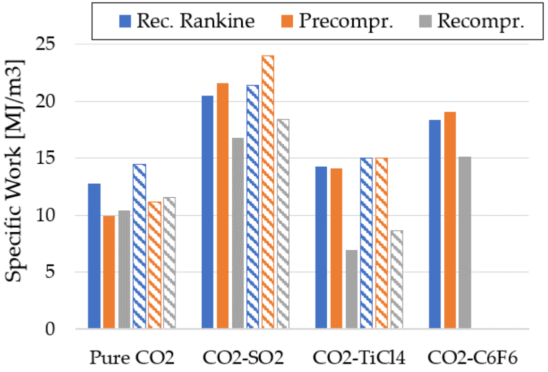

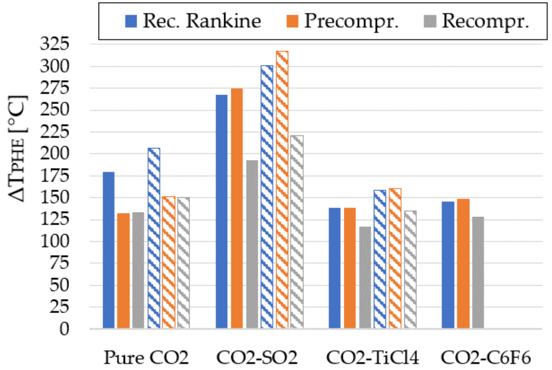

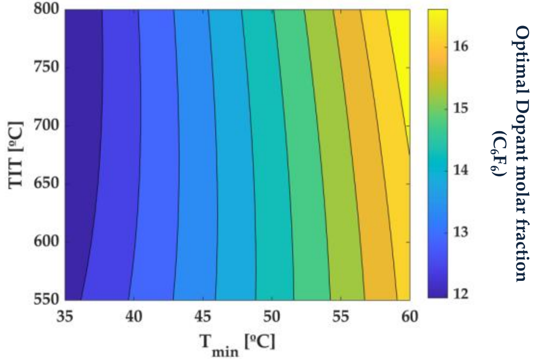

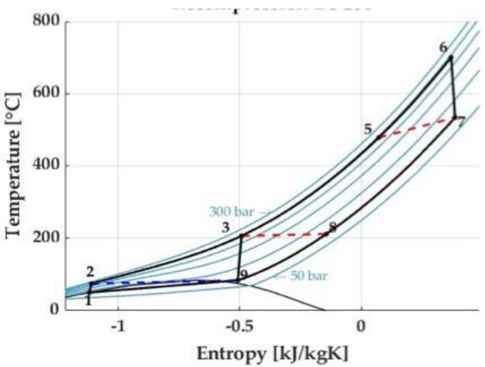

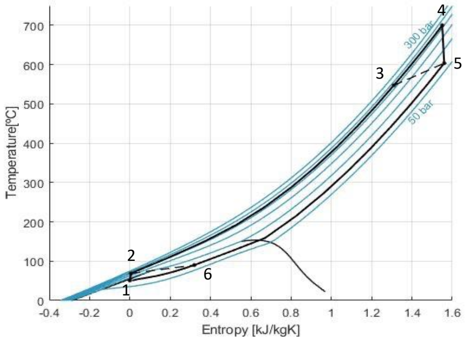

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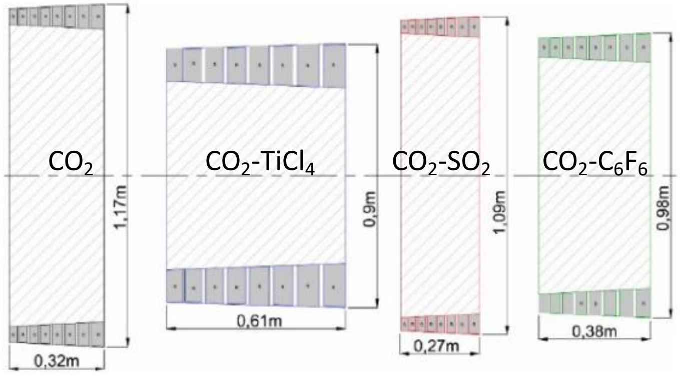

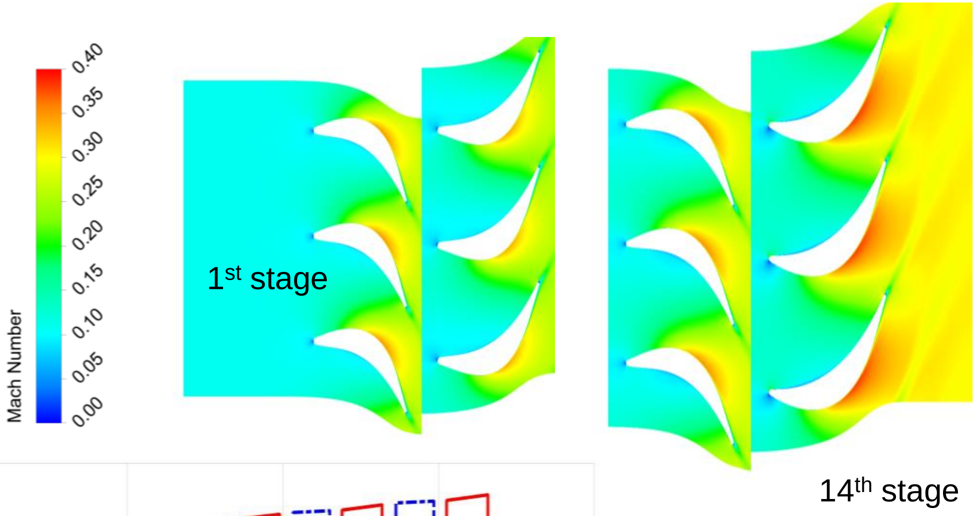

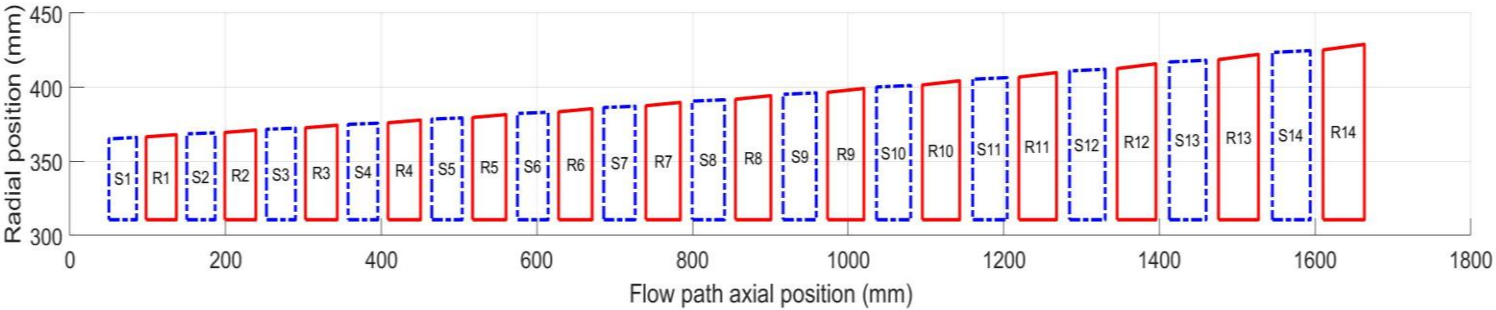

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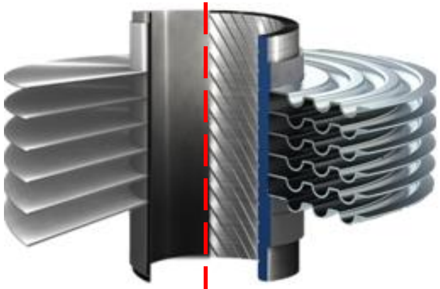
Main results/outcomes

Kelvion



Conventional tube
- Aluminum fins at airside
- Smooth surface on the inside

DIESTA CO2 SC1
- Groovy fins at airside
- Microfins at inside (HAT enhancement: x1.5-3.2)
- Specifically designed and tested for condensation of sCO_2-mixtures

SCARABEUS

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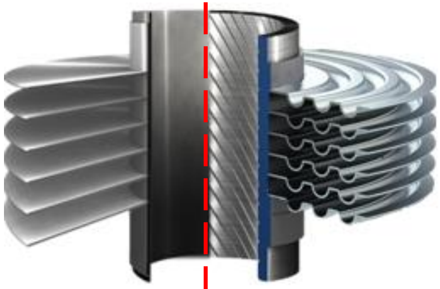
Main results/outcomes

Kelvion



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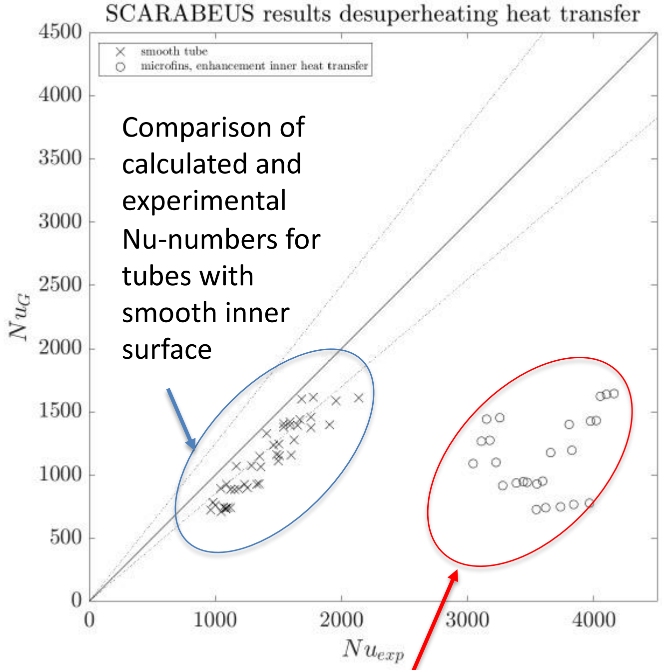


....and for inner finned tubes – HTC ↑

The SCARABEUS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 814985

Main results/outcomes

Validation of the SCARABEUS concept at TUW.

The SCARABEUS project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N° 814985

Options for exploitation/ collaboration/ follow-up activities

- Exploitation:
  - Mixture composition
  - Optimised plant design
  - Heat exchanger design
  - Turbomachinery design/solutions
- Currently enrolled in the "Exploitation Booster" programme of the EC

- Collaboration:
  - Primary Heat Exchanger
  - New dopants (identification and testing)
  - Application to WHR
  - High temperature receiver development
  - High temperatura Thermal Energy Storage
  - Hybridisation and CSP+D
  - Operation and flexibility

The SCARABEUS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 814985

Contacts

- Project Coordinator: Prof. G. Manzolini, Politecnico di Milano
  giampaolo.manzolini@polimi.it

- Dissemination Coordinator: Prof. D. Sánchez, University of Seville
  ds@us.es

- Website: www.scarabeusproject.eu

- Linkedin: SCARABEUSPROJECT (Link)

The SCARABEUS project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N° 814985

DESOLINATION

Giampaolo Manzolini – Politecnico di Milano

POLITECNICO MILANO 1863

LC-SC3-RES-20-2020, grant agreement No. 101022686

Presentation structure

- Project Summary
- Objectives & expected impact
- Scope
- Main results/outcomes
- Options for exploitation/collaboration/follow-up activities

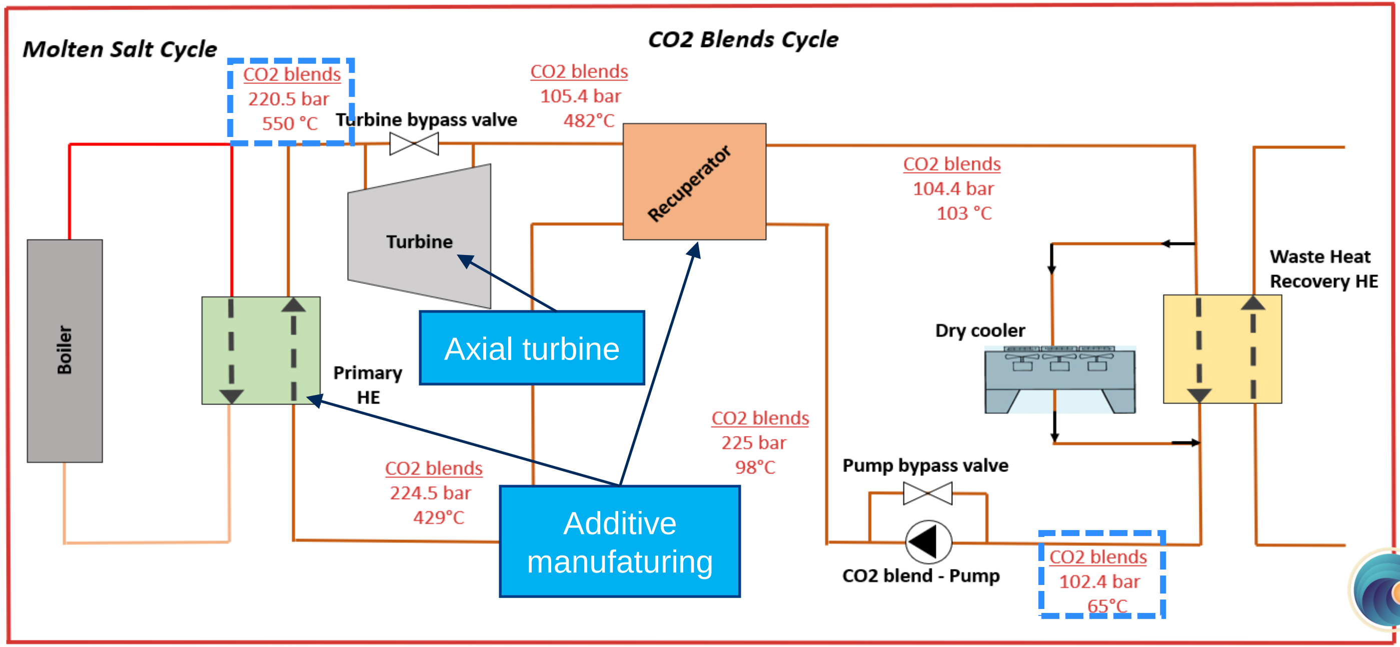
Project summary

Funding source	H2020 project in collaboration with Gulf Cooperation Council
Budget	14.5 M€ project cost, 10 M€ provided by the EU commission
Duration	48 months (June 2021 – May 2025)
Start TRL	5
End TRL	7

Objectives & expected impact

- DESOLINATION **will develop and demonstrate a 2 MW power cycle based on CO_2 blends and coupled with desalination process**
  - Demonstrate the CO_2 blends concept in Saudi Arabia and at relevant size;
  - Increase the thermal-to-electric conversion efficiency with respect to both conventional steam cycle and pure sCO2 cycle;
  - Reduce the power block specific costs with respect to both conventional steam cycle and pure sCO2 cycle;

Scope – the demo concept



Demonstration for >2000 hrs
Design efficiency >30%

DESOLINATION

Main results/outcomes

- Identify the CO_2 blend which optimizes the cycle within the operating temperature range;
- Select the most suitable material for the considered working fluid and the operating conditions;
- Determine the optimal heat exchanger design with the innovative manufacturing procedure;
- Design a 100 MW cycle for CSP applications;

Options for exploitation/ collaboration/ follow-up activities

- Modelling: Benchmark cycle design and performance;
- Material compatibility testing: identify the most suitable material for the innovative blend;
- Heat transfer measurement: determine the heat transfer properties of the innovative blend;
- Demo plant: synergies for the demonstration might be considered and explored

Contacts

- Website: www.desolination.eu
- LinkedIn: H2020 DESOLINATION
- Twitter: @desolination
- Email: contact@desolination.eu

DESOLINATION Team

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101022686.

Solar based sCO2 Operating Low-cost plants

Rafael Guédez

KTH Royal Institute of Technology

rafael.guedez@energy.kth.se

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.952953

Presentation structure

- Project Summary
- Objectives & expected impact
- Main preliminary results/outcomes
- Options for exploitation/collaboration activities

Project summary

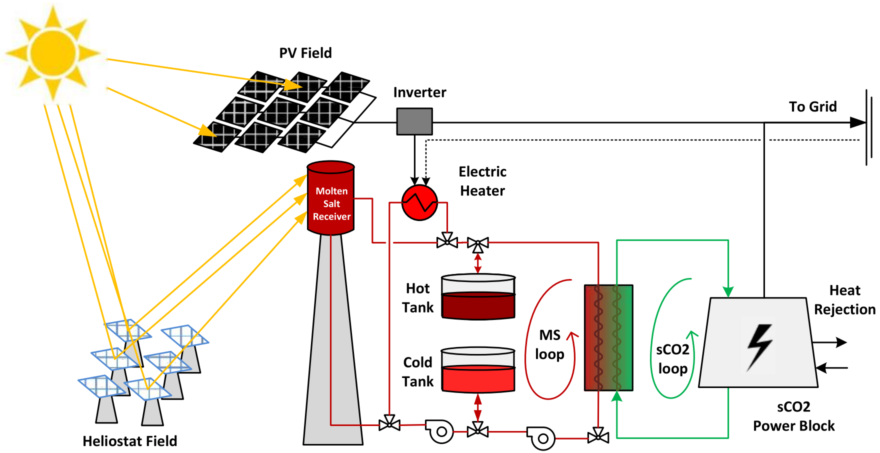
Funding source	H2020_LC-SC3-RES-35-2020
Budget	Approx. 15 M EUR total (10 M EUR Grant Agreement No. 952953)
Duration	48 months (start: October 2020) – Currently under amendment
Start-End TRL	5-7

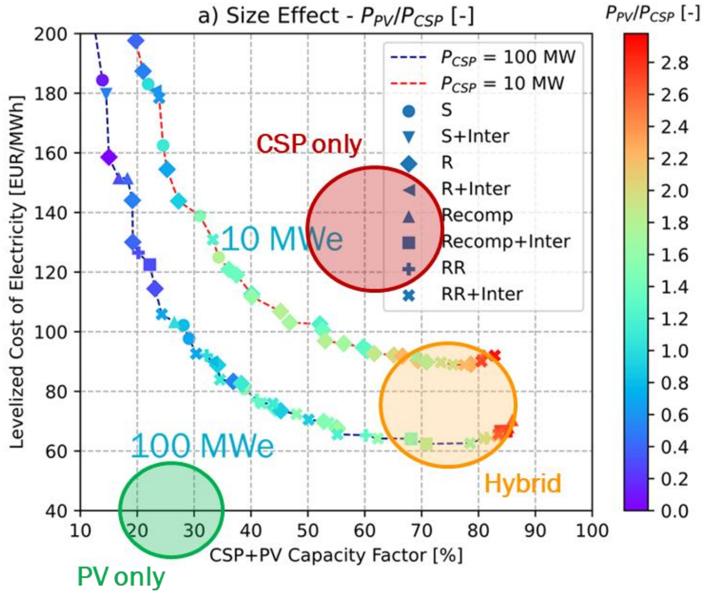
Objectives

1. Demonstration of MW scale sCO2 cycle (operating from molten salts)
   - 2 MW-scale simple-recuperated cycle, including new turbomachinery and HEx
2. Demonstration of MW scale molten salt electric heaters
3. Techno-economic investigations of high temperature Hybrid PV-CSP-sCO2 power plant layouts (incl. Gen 3 and new HTFs)

Expected impact (vision)

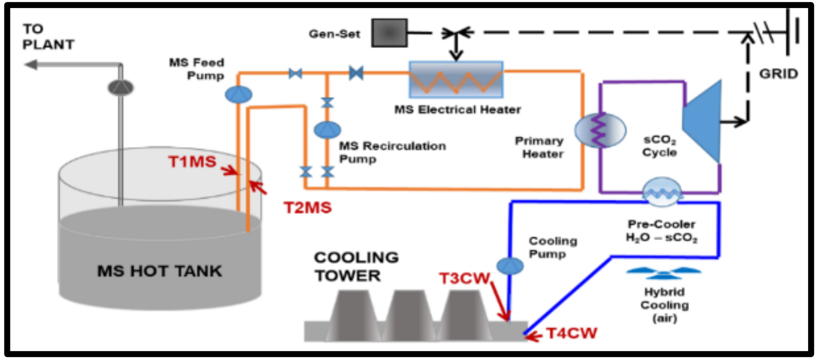
- Cost-competitive hybrid PV-CSP-sCO2 using conventional “solar salts”





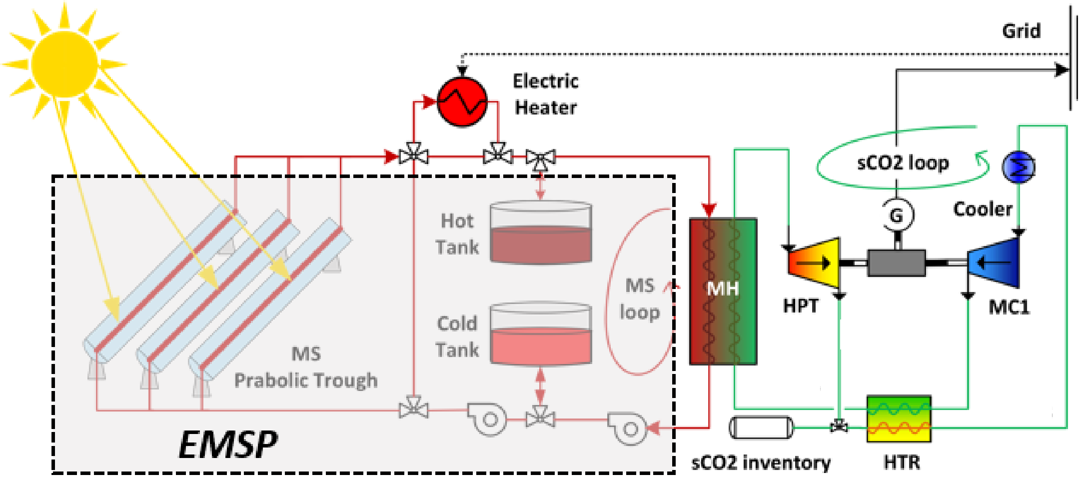
Demo site

- Initial goal: direct integration in operating CSP plant in southern Spain
  - Taking advantage of existing molten-salt system, cooling and infrastructure (utilities)
- Frustrated due to new ownership – new site under investigation



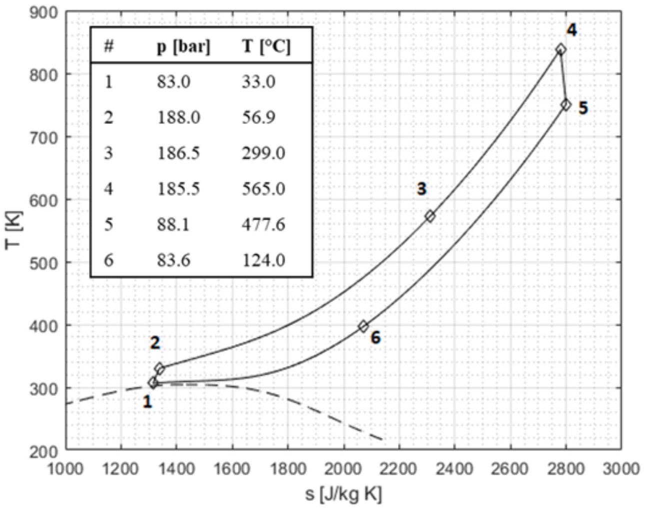
Demo site (new)

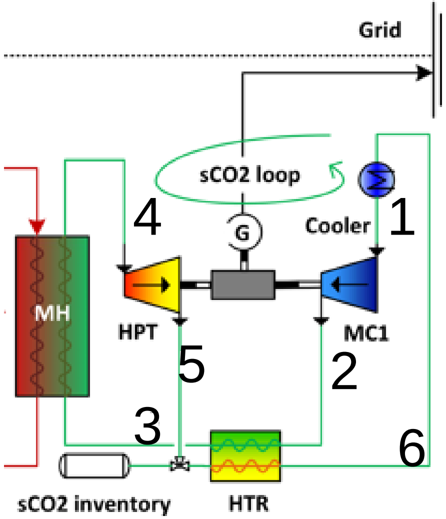
- Discussions on-going for new demo-site and integration plan
  - Awaiting approval from EC.
- Simple-recuperated cycle (same as initially proposed)



Preliminary Results

- Cycle specification and optimization based on costs and scalability



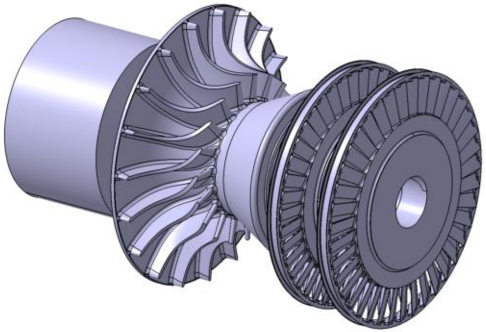


Parameter	DEMO SC-R 2 MW	Upscaled SC-R 10 MW	Upscaled RR 100 MW
Total efficiency [%]	21.3	31.4	49.5
Compressor eff. [%]	67.2	75.0	84.0
Re-compressor eff. [%]	-	-	88.0
Re-compressor slit [%]	-	-	31.0
Turbine(s) efficiency [%]	86.5	88.5	92.0
Mechanical eff. [%]	96	98	99
Electrical efficiency [%]	96	98	99
Turbine Inlet P [bar]	185.5	185.5	250.0
Intermediate P [bar]	-	-	165.0
Δp Heater [bar]	1	1	1
Δp Hot side Recup. [bar]	4.5	2	2
Δp Cold side Recup [bar]	1.5	1.5	1.5
Δp Cooler [bar]	0.6	0.6	0.6
Recuperator(s) Eff. [%]	80	95	95

Preliminary Results

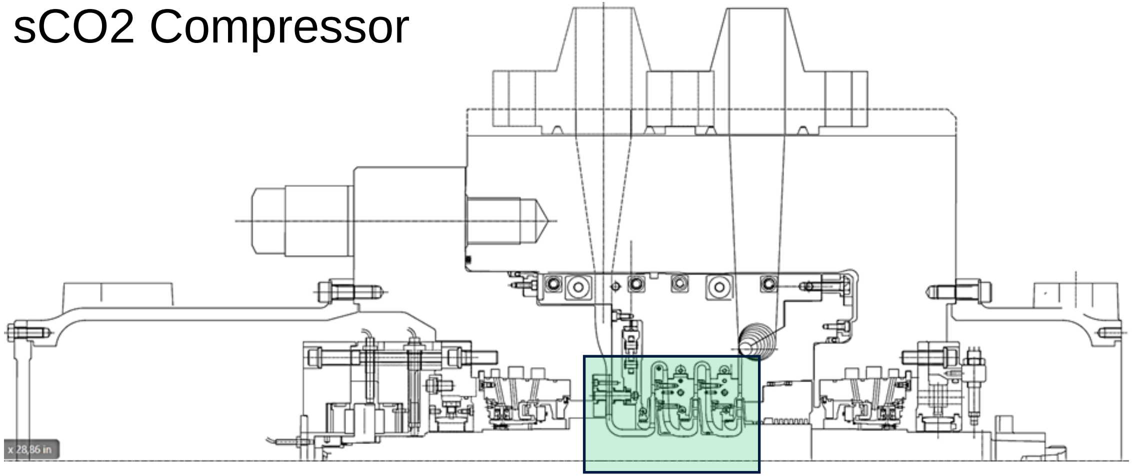
- Turbomachinery conceptual design

sCO2 Turbine



FRANCO TOSI MECCANICA

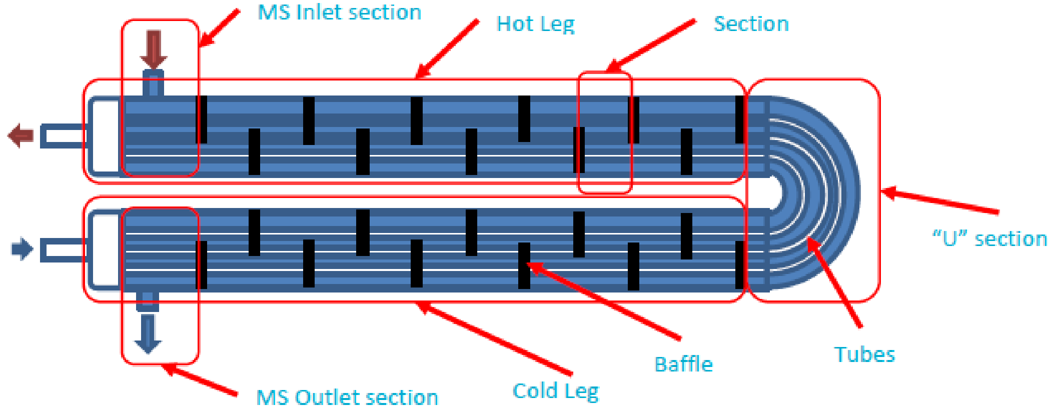
sCO2 Compressor

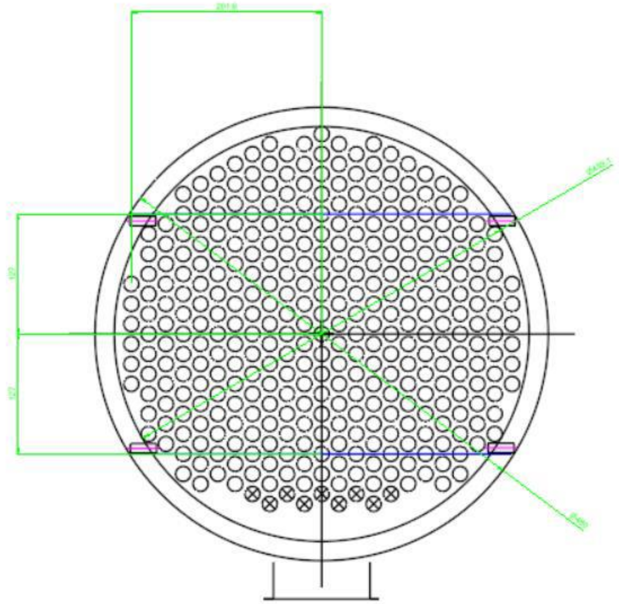


Baker Hughes

Preliminary Results

- Primary molten salt to sCO_2 HEx
  - **CO2: in: 186.5 bar; 299 °C; out: 185.5 bar, 565°C**
  - **MS: in: 3 bar; 580°C; out: 2.65 bar, 380°C**





Summary

- SOLARSCO2Ol is a 4-year project, 15 partners (+2?), approx. 15 M€ (10 M€ EU grant).
- Project goal: demonstrate a 2 MW sCO2 cycle and MW-scale electric heater to enable near-term cost-competitive sCO2 CSP – PV plants (FOAK in EU)
- Achievements: system conceptualization, demo pre-engineering and component design.
- Challenges presented related to site – final site yet to be determined.
- Conservative approach: turbine 565°C, 185.5 bar; compressor T = 33 C; P: 83:188 bar
- Turbomachinery scalable up to 10 MW, possibly more:
  3-stage turbine (1 rad + 2 ax), 30'000 rpm; 3-stage centrifugal compressor, 12865 rpm
- Primary HEx scalable undergoing CFD based optimization. Recuperator under design.

Options for collaboration

Following activities are carried within the consortium, but collaboration with third parties could be possible:

- Evaluation and optimization of hybrid CSP-PV plants
- High-fidelity CFD and FEM for component design optimization
- Testing and modelling of material degradation

Scientific publications, joint dissemination events, etc.

Contacts

https://www.solarsco2ol.eu

contact@solarsco2ol.eu

Communication and Dissemination:

Konstantinos.Genikomsakis@estelasolar.org

Coordinator:

rafael.guedez@energy.kth.se

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.952953

Block II. – "Carbon-free non-renewable"

- CO2OLHEAT
- sCO2-Efekt
- sCO2-4-NPP

Supercritical CO_2 power cycles demonstration in Operational environment Locally valorising industrial waste HEAT

Rene Vijgen, ETN Global

Project coordinator

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N° 101022831

Project summary

Funding source	H2020_LC-SC3-CC-9-2020
Budget	€18.8 mil (€14 mil financed by the EU)
Duration	48 months (June 2021 – May 2025)
Start TRL	TRL5/6
End TRL	TRL7 with roadmaps to TRL9

Partners

Project Objectives/Impact

Technical

Development and demonstration of a **2MW highly flexible** sCO_2 WH2P power block with a heat source T>400ºC and efficiency η_{NOM}>23%

Development of sCO2 power cycle components: **turbomachinery, heat exchangers**

Development of **control systems enabling flexibility enhancements** (related to part load, lower WH temperatures) and **power grid interoperability**

Replication

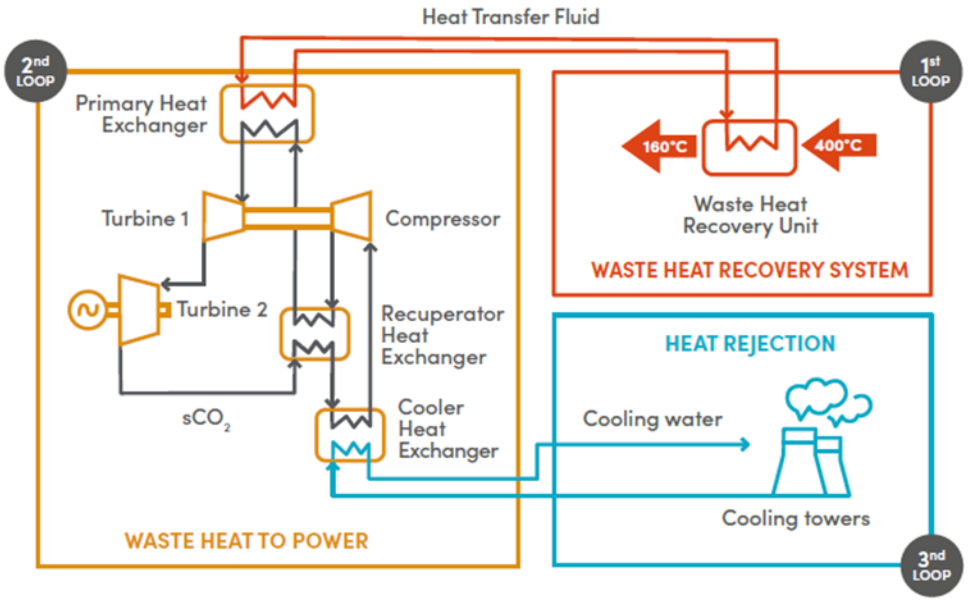
Replication of CO2OLHEAT concept in **6 applications**: aluminium, steel, glass, CSP, waste incinerator, CCGT

Wide **dissemination** and creation of a **pan-European** $\mathbf{sCO_2}$ **WG**

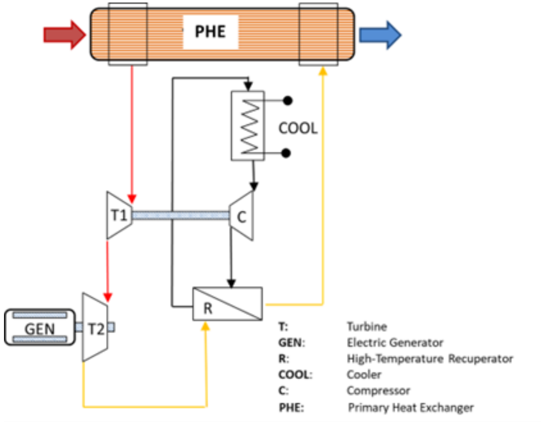
Econ/ env/ soc

Demonstrate **economic** and **replication** feasibility, **environmental** impact and **social** acceptance

The cycle

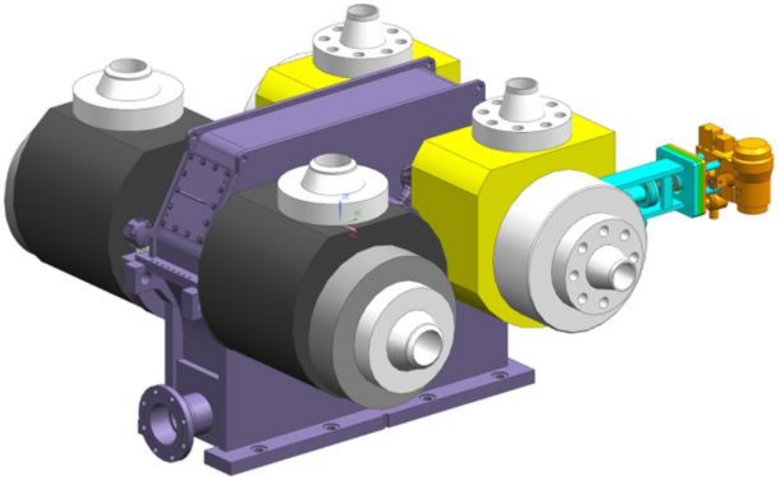

Heat Transfer Fluid
2nd LOOP
1st LOOP
3rd LOOP
Primary Heat Exchanger
Turbine 1
Compressor
Turbine 2
Recuperator Heat Exchanger
sCO2
Cooler Heat Exchanger
WASTE HEAT TO POWER
160°C
400°C
Waste Heat Recovery Unit
WASTE HEAT RECOVERY SYSTEM
HEAT REJECTION
Cooling water
Cooling towers

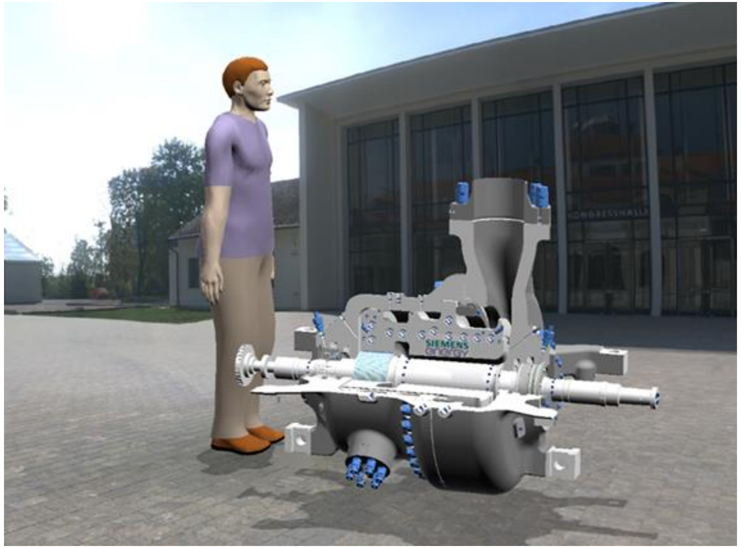
Nominal point



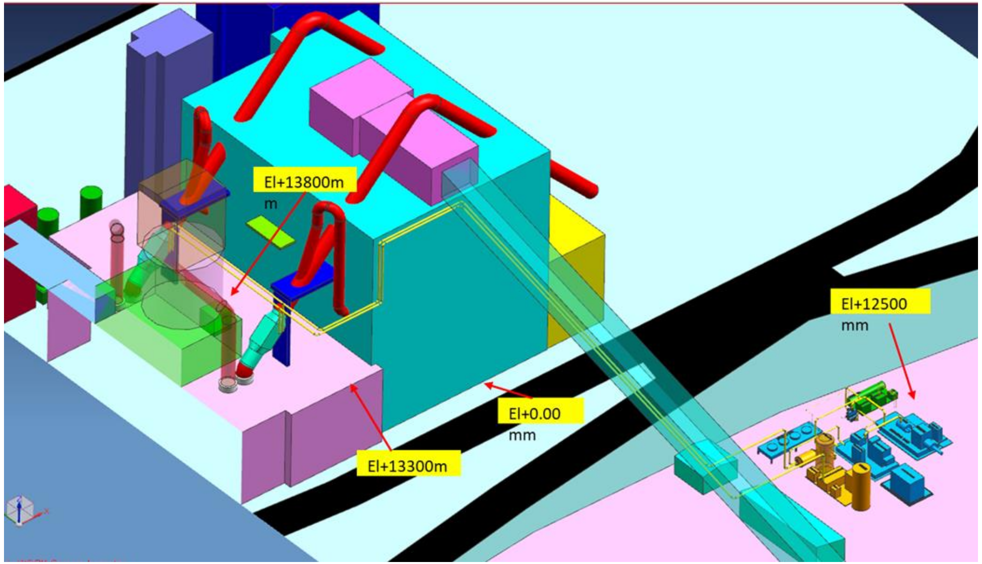
	Temperature [°C]	Pressure [bar]	Density [kg/m3]	Enthalpy [kJ/kg]	Entropy [kJ/kgK]
1	33	85,0	670,35	294,5	1,3037
2	59	215,0	752,06	318,4	1,3218
3	189	214,0	291,26	577,1	1,9914
4	360	210,5	177,16	800,0	2,4064
5	333	162,2	144,64	774,8	2,4143
6	333	162,2	144,64	774,8	2,4143
7	276	89,0	88,835	723,2	2,4351
8	69	88,0	202,84	464,5	1,8364

Initial design concepts





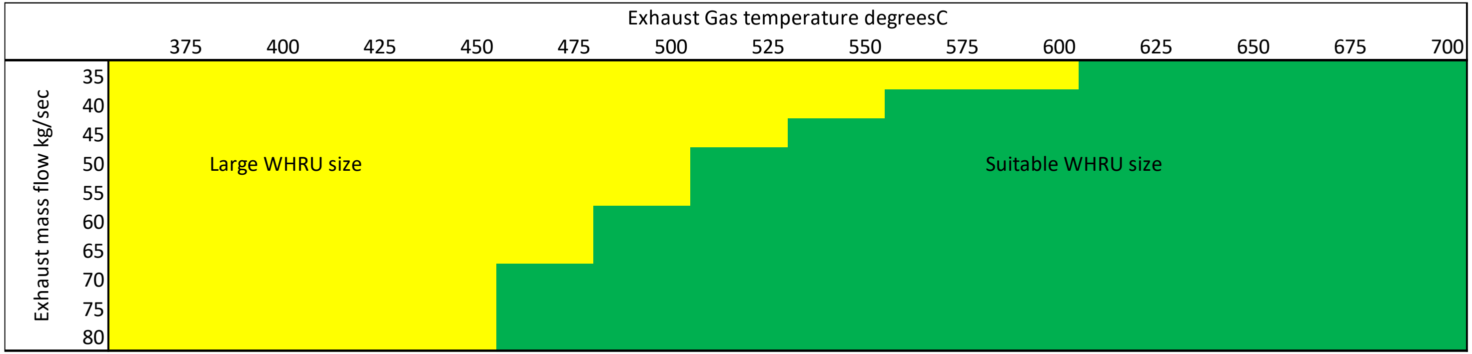
Site Integration (Pre-FEED)



Pre-FEED study revealed that high integration and material costs exceed the project budget. Need for other demo sites in the energy intensive industry for easy integration and additional funding

What do we need

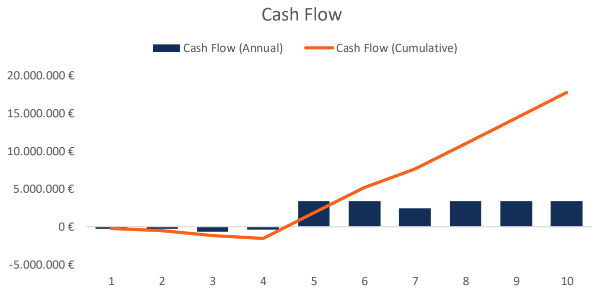
- Easily accessible site
- Enough footprint
- Full auxiliaries: electricity, cooling, compressed air
- Enclosure
- Additional funding
- “Clean” and sufficient exhaust gas to reduce the size and costs of the WHRU



WHRU size as a function of mass flow and exhaust gas temperature

What do we offer

- Strong consortium
- Robust thermodynamic cycle
- Best in class turbo machinery manufacturers
- 2 MW WH2P cycle
- Integration within existing infrastructure
- Full technical and operational experience of a sCO2 cycle
- Exploitation of a 2 MW power plant after the DEMO has ended



2 MW power cycle, able to produce more than 17000 MWh electrical power per year and a revenue/saving exceeding 3 MEURO (pay back<5 years)

Contacts

- co2olheat-h2020.eu
- info@co2olheat-h2020.eu
- Project Coordinator – Rene Vijgen (rv@etn.global)
- Communication and Dissemination – Jitka Špolcová (js@etn.global)

Research Centre Řež

sCO_2 - Efekt

Development of innovative systems for efficient energy storage

TAČR Theta 2, TK02030059

Presentation structure

- Project Summary
- Objectives & expected impact
- Scope
- Main results/outcomes
- Options for exploitation/collaboration/follow-up activities

Project summary

Funding source	TAČR – Technological Agency of Czech Republic MPO – Ministery of Industry and Trade – Institutional support Own resources
Budget	~ 4 Mil. €
Duration	66 months (5/2019 – 10/2024)
Start TRL	4
End TRL	6

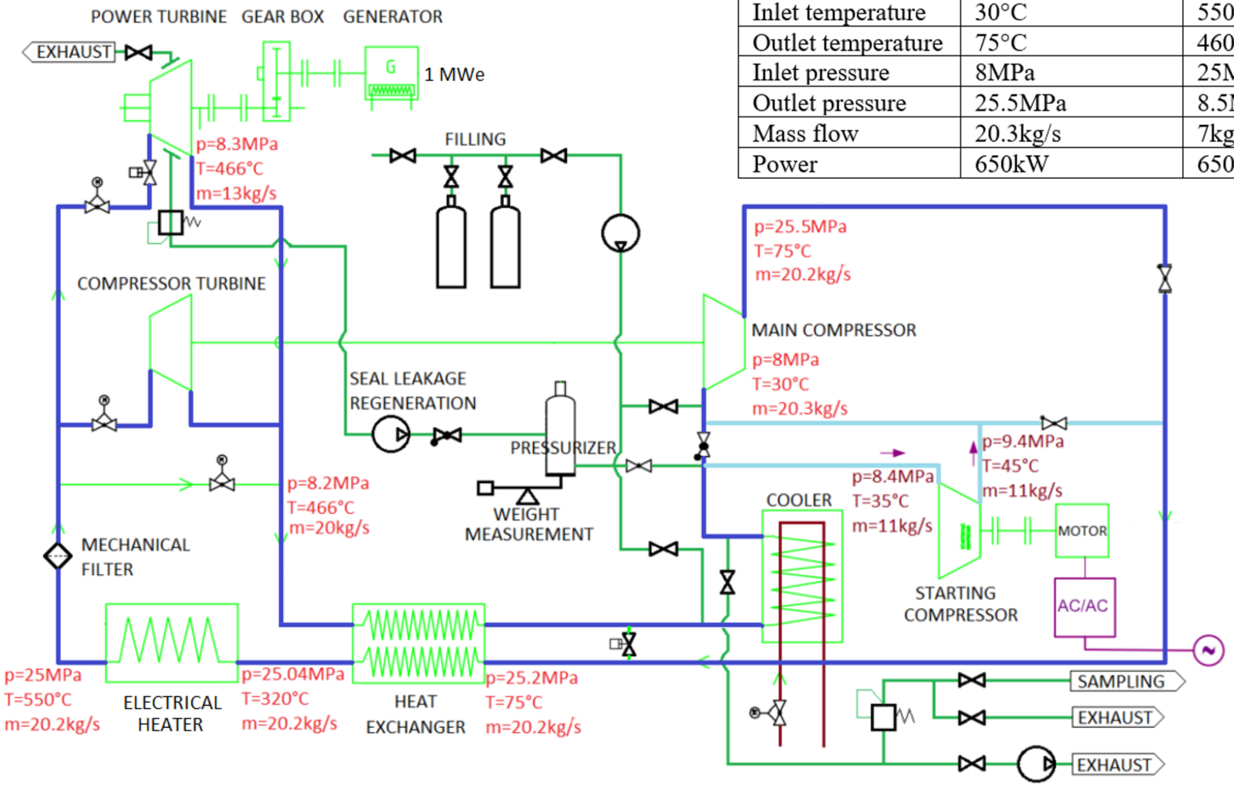
Partners: CVR, Doosan Škoda Power, Inpraise Systems, ÚJV

Objectives & expected impact

- Design of a "zero emission heating plant" - flexible and effective system for thermal energy storage (TES) and its reverse use for a combined power and heat supply.
- Design, fabrication and experimental verification of the key components of the designed energy storage system in relevant environment.
- Application of the system to be developed will support the power grid stability and enable to increase the share of renewable resources.

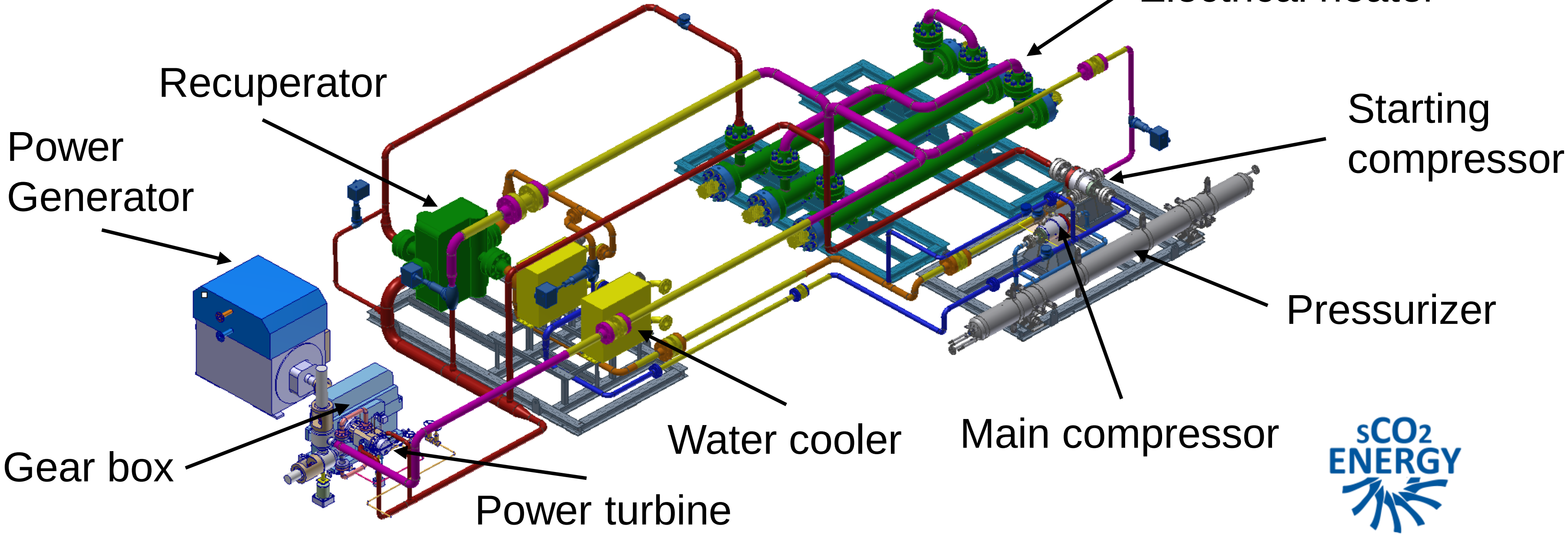
Scope

	Compressor	Comp. Turbine	Power Turbine
Inlet temperature	30°C	550°C	550°C
Outlet temperature	75°C	460°C	462°C
Inlet pressure	8MPa	25MPa	25MPa
Outlet pressure	25.5MPa	8.5MPa	8.5MPa
Mass flow	20.3kg/s	7kg/s	13kg/s
Power	650kW	650kW	1050 kW

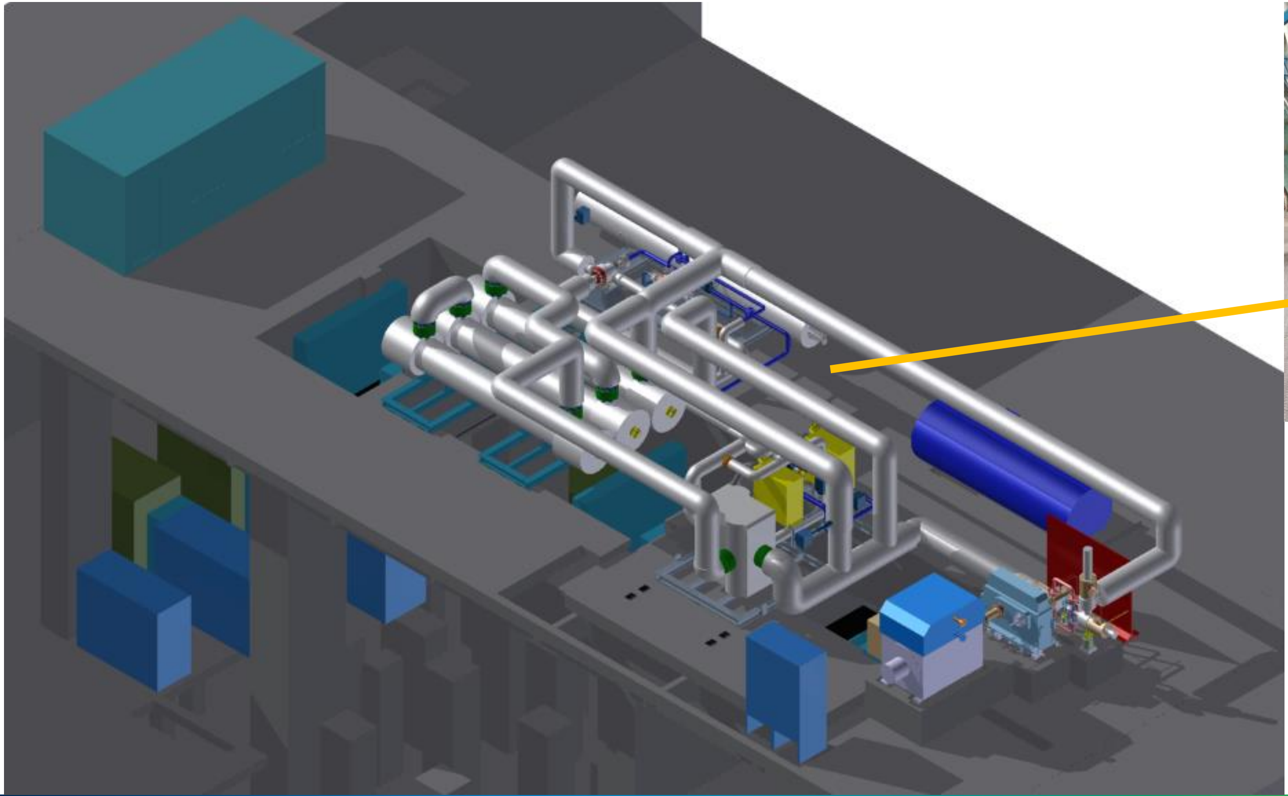


Scope

- The SOFIA facility will be realized at the site of Mělník heating plant
- The first operation expected in 2024
- Further modification to the recompression cycle is being discussed

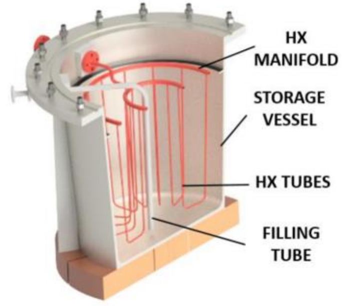


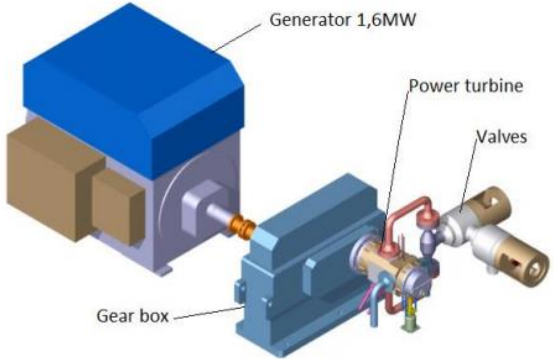
Scope

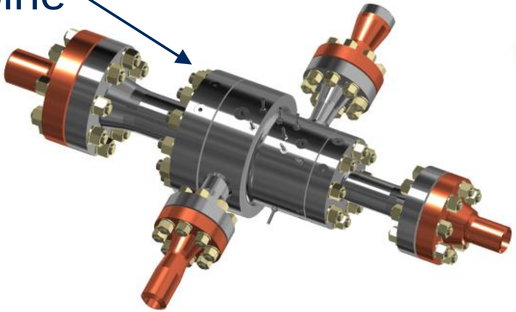


Main results/outcomes

- Thermal storage tank mock/up
- Experimental loop for testing of
    - compressors
    - turbines up to 1,6MWe
- Power turbine - 1 MWe
- Starting compressor
- Main compressor with a drive turbine







Options for exploitation/ collaboration/ follow-up activities

- Testing of compressors, turbines and other components
- Testing of cycle flexibility, hot start-up procedures, stand-by regimes
- CVR is widely involved in EC supported project and is open to any kind of cooperation
- Coupling with heat storage system
- Upgrade to recompression cycle

Contacts

- Website: sco2energy.com (Under preparation)
- Email: otakar.frybort@cvrez.cz, tomas.melichar@cvrez.cz

Project sCO_2 Efekt (TK02030059) has received funding from Czech Technological Agency TAČR, programme Theta 2

sCO2-4-NPP

ETN Global

Innovative sCO2-Based Heat Removal Technology for an Increased Level of Safety of Nuclear Power Plants

Albannie Cagnac, EDF

Project Coordinator

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 847606.

Presentation structure

- Project Summary
- Objectives & expected impact
- Scope
- Main results/outcomes
- Options for exploitation/collaboration/follow-up activities

Project summary

Funding source	EU-funded EURATOM project
Budget	2,786,971€
Duration	36 months (Sept. 2019 – Aug. 2022)
Start TRL	TRL3
End TRL	TRL5

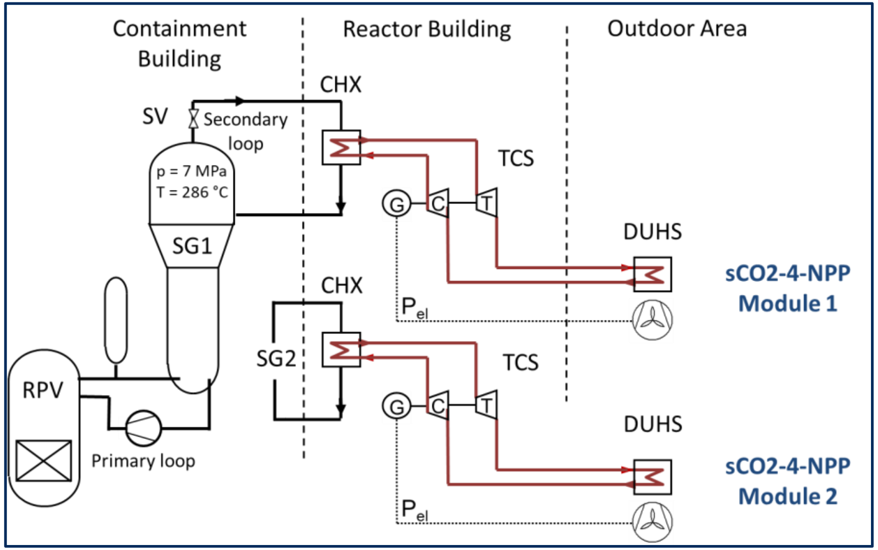
Partners

Objectives & expected impact

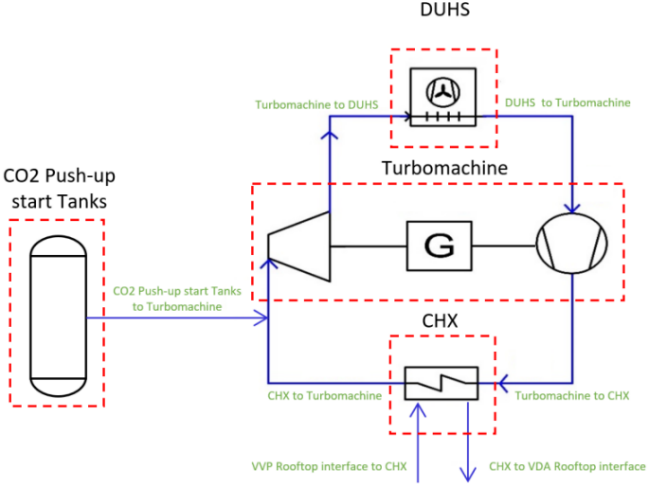
Development of an Innovative sCO2-Based Heat Removal Technology for an Increased Level of Safety of Nuclear Power Plants

The vision: sCO2-System

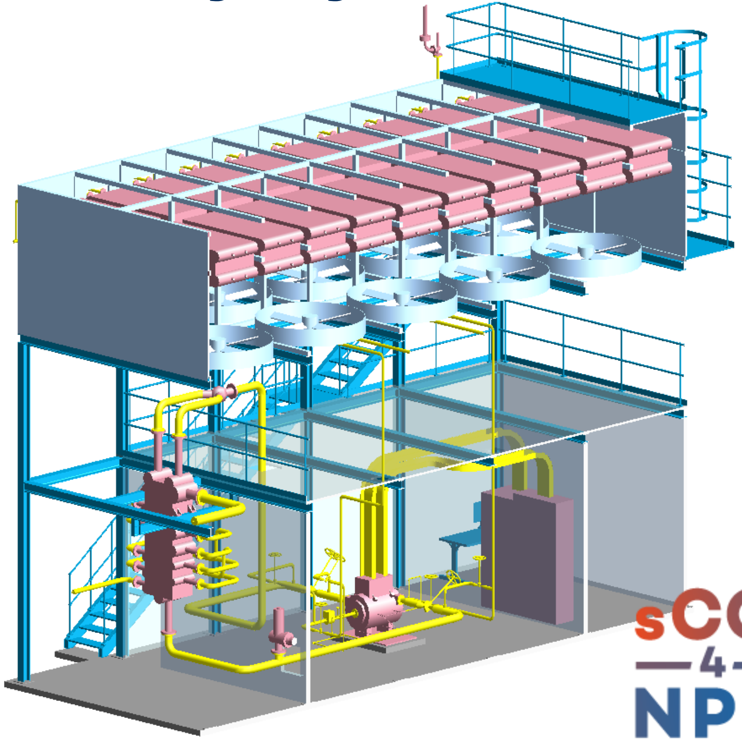
- Electricity made out of decay heat
- Modular
- Self-starting
- Self-sustaining
- Retrofittable for existing PWR, BWR, etc.
- Innovative power conversion system for SMR, GEN IV, etc.



Scope : sCO2 Heat recovery system



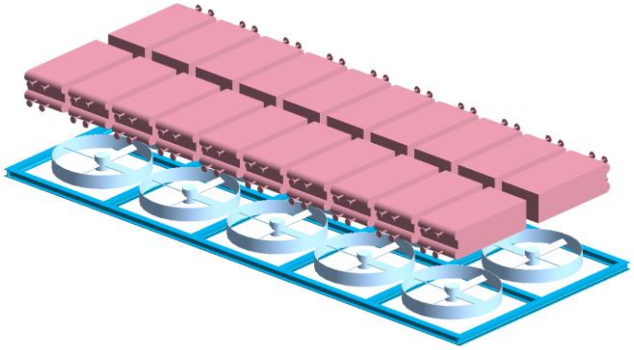
	P [bar]	T [°C]
Compressor inlet	126.3	55.0
Compressor outlet	214.7	80.8
CHX inlet	213.4	80.86
CHX outlet	213.4	280.51
Turbine inlet	211.7	286.6
Turbine outlet	127.5	243.2
UHS inlet	122.2	149.92
UHS outlet	122.2	55.01



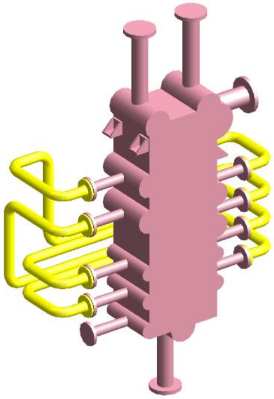
Scope : sCO2 Heat recovery system

Small-scale equipment developed and tested

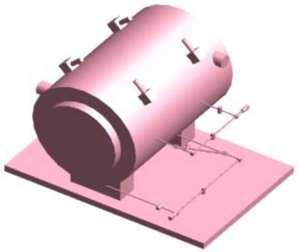
DUHS Exchangers with fin-fan coolers



CHX Exchanger



Turbomachine



- Several sCO2 loops for tests (2 in Germany, 1 in Czech Republic)
- Integration in a NPP simulator

Main results/outcomes 1/2

1: Validation of sCO_2 models in thermal-hydraulic system codes on lab scale

- ✓ Simulations of sCO2 test loop in ATHLET, CATHARE and ATHLET/MODELICA

2: Specification of an upscaled system, boundary conditions & simulations for sCO2-4-NPP loop implementation in a full-scale NPP (PWR)

- ✓ Specification of accident simulation
- ✓ Simulations of upscaled sCO2 system

3: Preparation of a licensing roadmap of the sCO2-4-NPP system to ensure compliance with applicable regulation

- ✓ Licensing and construction requirements
- ✓ Roadmap

4: Design of components for the sCO2-4-NPP loop in the context of licensing requirements

- ✓ Design of upscaled Heat Exchangers
- ✓ Design of upscaled Turbocompressor

Main results/outcomes 2/2

5: Final design of the system architecture of sCO2-4-NPP integrated in a full-scale NPP

- ✓ Drawings of scale design of sCO2-4-NPP modules integrated in PWR and safe heat removal of the designed system validated by ATHLET and CATHARE simulations.

6: Validation of sCO2-4-NPP loop in a virtual “relevant nuclear environment” PWR

- ✓ Operation of sCO2-4-NPP integrated into the KONVOI NPP simulator without negatively interfering with the existing safety and operational systems

7: Prepare technical, regulatory, financial and organisational roadmaps to bring sCO2-4-NPP to market

- ✓ Detailed technical, regulatory, financial and organisational roadmaps for bringing sCO2-4-NPP to market.

Options for exploitation/ collaboration/ follow-up activities

- Instruction of a follow-up project
  - Integration of new start-up and operating procedures (via thermal-hydraulic modelling and simulator)
  - Performance improvements of main equipment
    - Prototypes on a larger scale
    - Quantification and reduction of modelling uncertainties
  - Continued work on regulation
- Open the system to other applications
  - Industrial heat recovery, ...
  - Flexibility and performance improvements in addition to reliability

Contacts

- Coordinator: albannie.cagnac-1@edf.fr
- Project website: www.sco2-4-npp.eu (public deliverables on website)

Thank you for your participation

Further questions?

js@etn.global