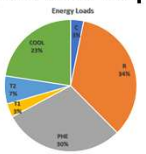
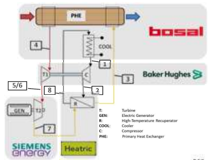
CO2OLHEAT
Industrial waste heat recuperation and its conversion into electricity via supercritical CO_2 cycles

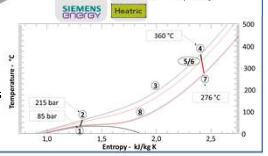
Authors: CO2OLHEAT Consortium

1 – scenario analysis and requirement definition

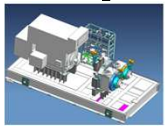


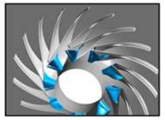


- Layout definition of the demo plant
- Analysis of the demo plant integration into the industrial site
- Thermodynamic and economic modelling and optimization of the selected demo cycle
- Off-design analysis of the selected demo cycle
- Definition of market scenarios for the WH2P plant in energy-intensive industries with a focus on cement considering the CEMEX demo site and definition of major boundary conditions
- Analysis of the interaction with the electric grid



2 – sCO_2 turboexpander unit

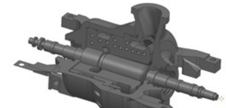




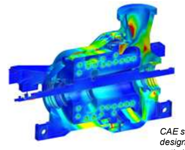
CFD model results showing the area with vapour formation on the first impeller of the compressor

- Design leveraging on the results got from sCO2flex project (funded by EU H2020) and STEP project (funded by DOE)
- Concept based on an integrated solution (two stages Compressor + Gearbox + two stages Expander)
- Equipment designed considering CAPEX optimization and footprint minimization.
- Challenges:
  - Define a specific compressor fluid dynamic numerical model to keep in consideration local phase changes of the fluid that could impact on the performance
  - Turbomachinery mechanical design and manufacturability process optimized to manage the small dimensions that could affect the performance.
  - Turboexpander operability & controllability in all the operating conditions (transients included)

3 – sCO_2 turbine



Barrel type sCO_2 turbine



CAE supported design analysis & optimisation

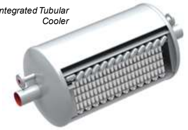
- Based on the results of the German R&D project Carbosola, a preliminary design concept of a demo turbine has been developed
- A barrel type turbine design with a circumferential split, allowing rotational-symmetrical design without local material build up even for high gas temperatures and pressures, thus minimizing unsymmetrical deformation and thermal loading
- Combining these results with UDE knowledge coming from previous sCO_2 EU-funded projects, this task will present a first sCO_2 turbine design considering the specific requirements at the demo-plant

4 – Cycle heat exchangers

Primary PCHE recuperator – Dimensions: 23.3 MW_{th}/m^3 - 2.24m x 1.4m x 1.52m - 5 tons

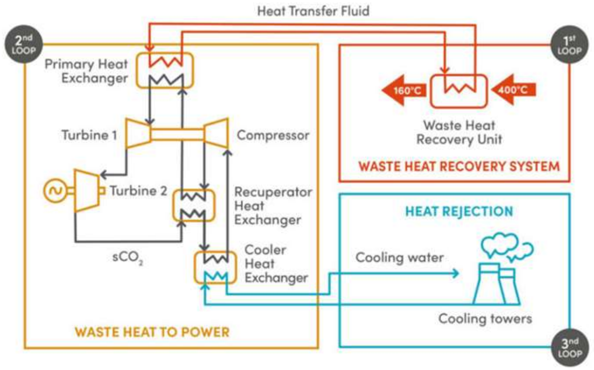
Next work package stages:
- Recuperator part loads cycle optimization
- Predictive operational behaviour testing / control methodology within power block
- Modular skid base integration including replication cases
- Operational data to consolidate recuperator modelling

Integrated Tubular Cooler

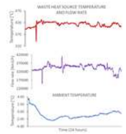


Modular design for the Cooler and the Primary Heat Exchanger:
- A cell consisting of 320 U-tubes and two collectors form a standardized building block.
- # of standard cells can be tuned for different applications (replicator sites)

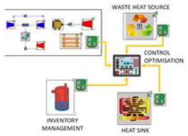
Next stages:
- Improve the fouling and abrasion resistance of the WHRU
- Guarantee the Cooler's operability & controllability for all seasons



5 – Dynamic simulation and control optimisation



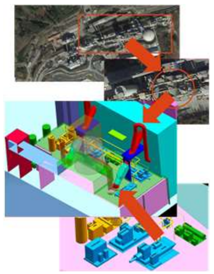
- Dynamic simulation of the integrated CO2OLHEAT system response (heat recovery, power block and heat rejection) to understand the challenges of control at start-up, shut down and fluctuations in waste heat source temperature and flowrate (shown above)



- Control architecture that integrates individual turbomachinery and heat exchanger controls to optimise performance and ensure safe operation
- Control strategy that maintains turbine and compressor inlet temperatures close to design values over a range of waste heat conditions and ambient temperatures.

Consortium

6 – Prachovice demo campaign



- Modular Design of the Power Cycle: single lift interconnected skid and modules composing the plant
- Maximization of pre-fabrication and pre-test @ workshops to minimize time length and extent of on-site activities
- Test at full scale in a real industrial environment the integration of the CO2OLHEAT concept – installation of the plant in CEMEX site in Prachovice (CZ)
- Take full advantage of installation flexibility, aiming to a plug and play approach applicable also to other potential replication sites

7 – Replication and impact analysis

- Current WHR systems experience significant gap in T range between 300 and 500˚C and CO2OLHEAT can close it
- Demo will confirm this and replication studies will further develop this hypothesis
- They will also pave the way towards future R&D activities, identified during this process
- If only 5% of the EU available waste heat could be recovered, a CO2OLHEAT plant could produce more than 200 GWh_{el}/year, save 575 GWh/year of primary energy, and avoid more than 100.000 tCO2/year

More information:

www.co2olheat-h2020.eu