Supercritical CO2 Waste Heat Recovery System

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sCO2 systems for industrial WHR:

sCO2 systems could be an interesting alternative to more conventional and well-established technologies

- Steam plants → cannot be down-scaled to be applied in many WHR cases
- ORC plants → can be applied only at low-medium temperature

sCO2 technology could be successfully applied also to WHR small/medium plants with relatively high efficiency, aiming at a market share currently underserved.

CO2 is inert and non-flammable.

Other advantages over steam and ORC plants consist in the plant flexibility, reduced water use and plant compactness.

The primary disadvantage of the sCO2 technology is related to the novelty of the technology and the lack of experience.

The Business Case:

Facility for cast iron cookware production.
The opportunity to recover heat lies in the enamel coating process: the dedicated ovens work at a temperature of 800°C, therefore the temperature of the off-gases leaving the process is between 400 and 600°C.

The industrial facility:

- 4000 hours of activity per year
- $4 \cdot 10^6$ kWh of electricity consumption (for the furnace)
- 10^7 kWh_{eq} of gas consumption (for the enamel kilns)

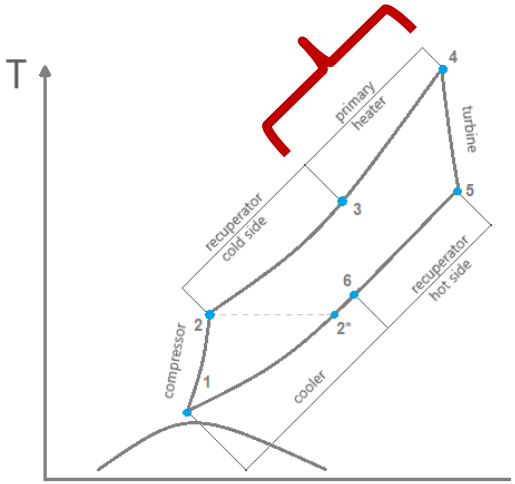
The measurements:

- 550°C of average temperature
- 80° of st. deviation
- 2.2 kg/s of mass flow rate

Waste Heat Potential

1.25 MW_{th}

Thermodynamic analysis:



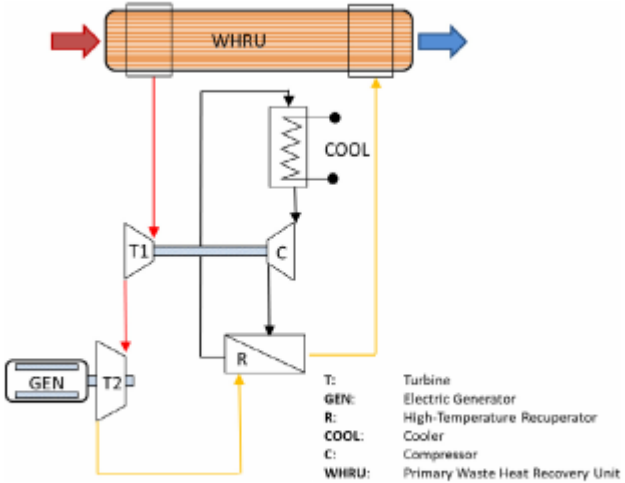


Fig. 1. Simplified schematic of the sCO_2 RBC.

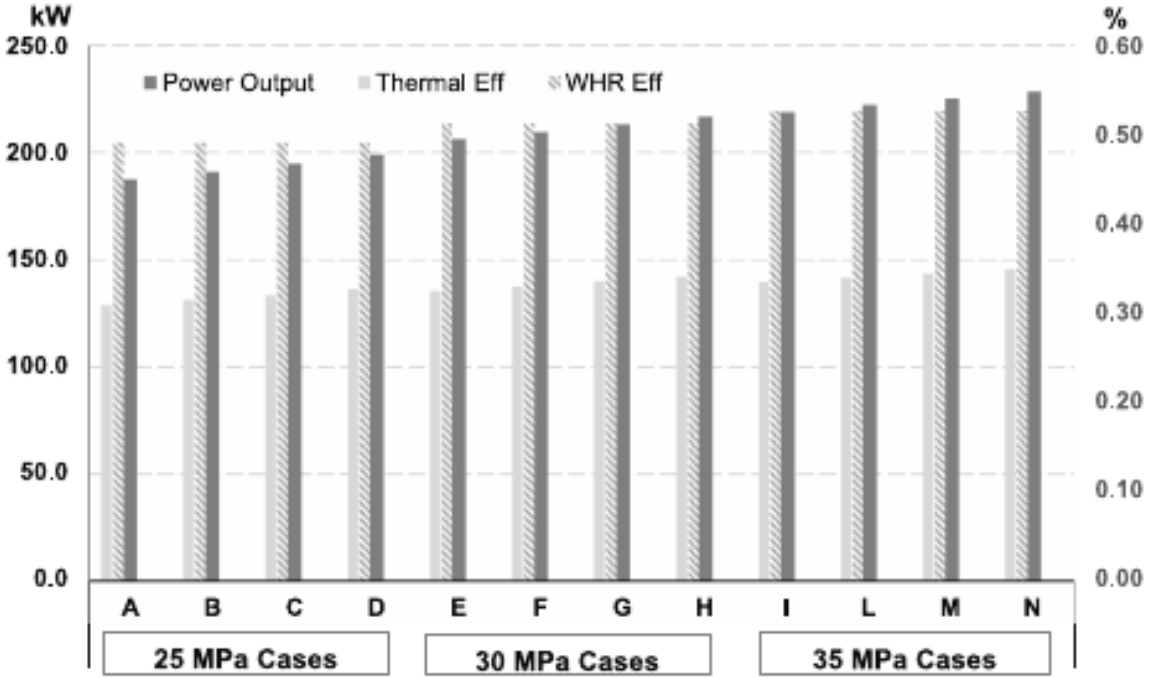
Table 1. Key technical input data for the parametric analysis.

Input parameter	Value
Minimum cycle pressure	8.5 MPa
Turbine isentropic efficiency	90%
Compressor isentropic efficiency	85%
Heat Exchangers pressure drop	2%
Minimum Cycle Temperature	37 °C
ΔTu[a]	20 °C
WHR inlet temperature (sCO_2)	270 °C

[a]Difference between the temperature of flue gases and sCO_2 temperature at WHR inlet section.

Simple Recuperated Brayton Cycle

Thermodynamic analysis:



Economic analysis:

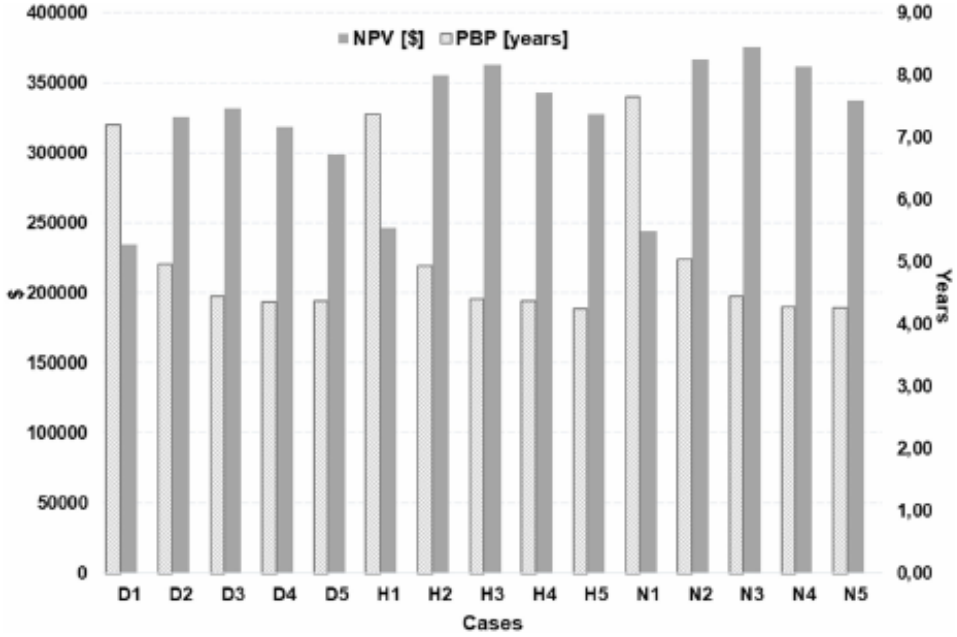


Table 3. Key economic assumptions.

Input parameter	Value
Inflation rate	5%
Operating costs (c_{OM})	30 $/kWe
Increase of capital costs (Cia)	30%
Escalation rate	3%
Degradation rate	1%
Cost of electricity (ce)	8 c$/kWh
Plant life	20 years
Operating hours	4000 hours/year
Ratio between salvage revenue and total capital costs	5%
Capital costs uncertainties	+50%/−30%
Operating costs uncertainties	+10%/−10/

Thank you for your attention!