sCO2 power cycle

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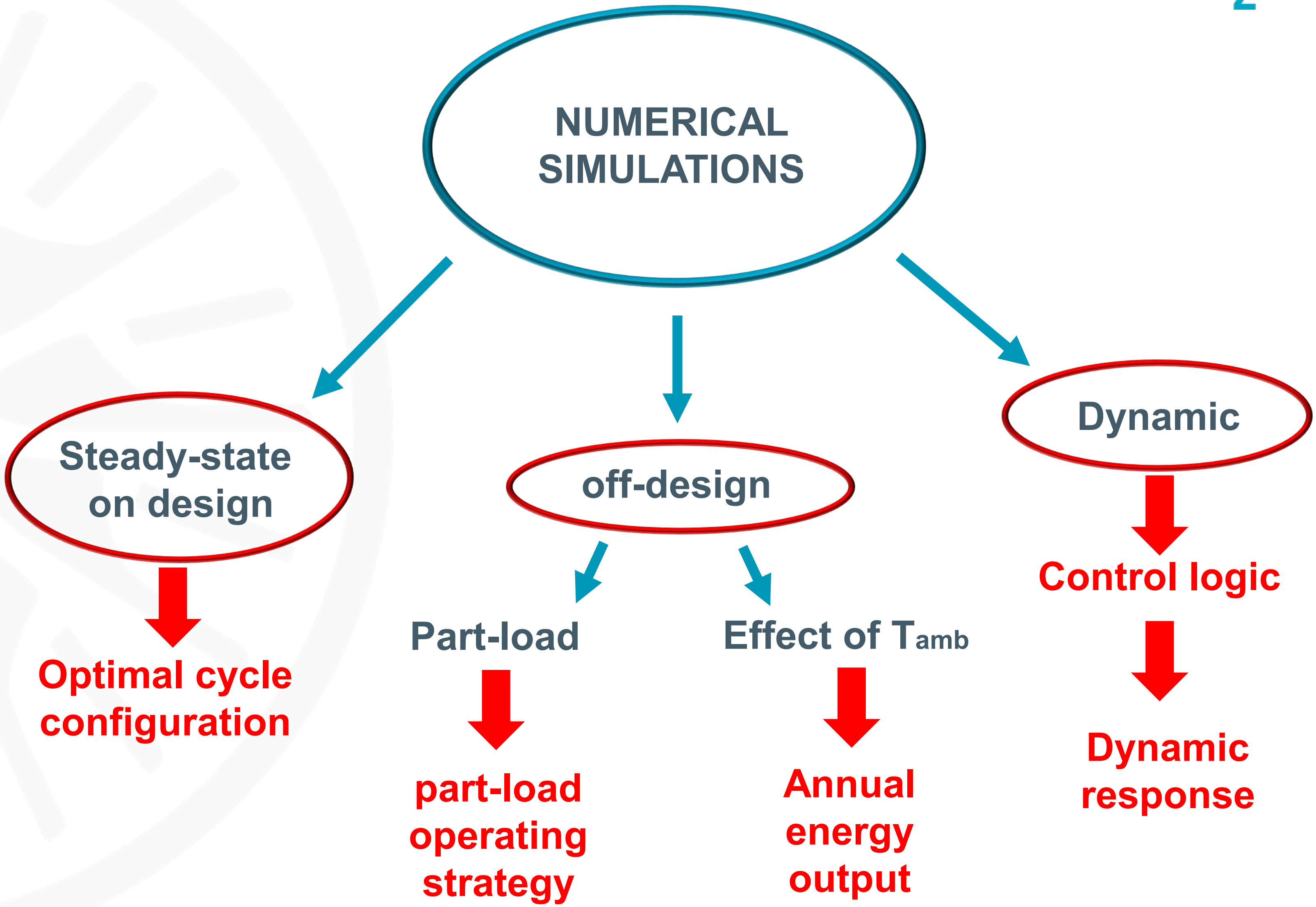
Can sCO_2 be the solution for fossil fuel power sector?

Safe and economic	chemical stability, low-cost, high availability, non-toxicity and non-flammability
High efficiency	Fluid compression starts close to the critical point, in a thermodynamic region with real gas effects
High heat transfer	Heat transfer coefficients of compressed CO_2 are largely higher than other gases and furthermore increased in proximity of critical point
Compact turbo-machines	Low pressure ratios and high molecular mass allow to design compact turbomachines
Reduced inertia	Possibly reduced thermal inertia of the heat exchangers and low rotational inertia for turbomachinery

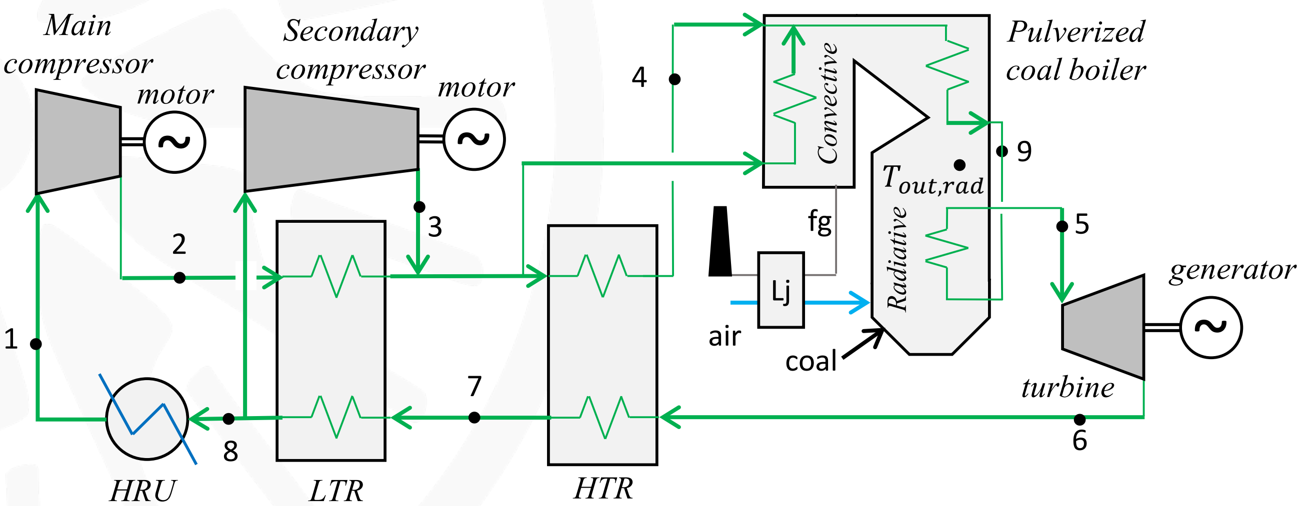
POLIMI activities in sCO2-Flex

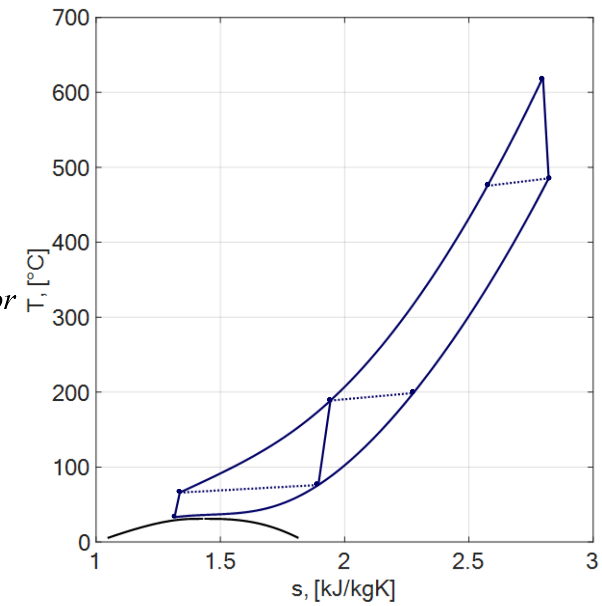


Develop a **scalar/modular design of a 25MW**:

- ✓ high efficiency (42.4%)
- ✓ 20% part-load operation
- ✓ fast transients

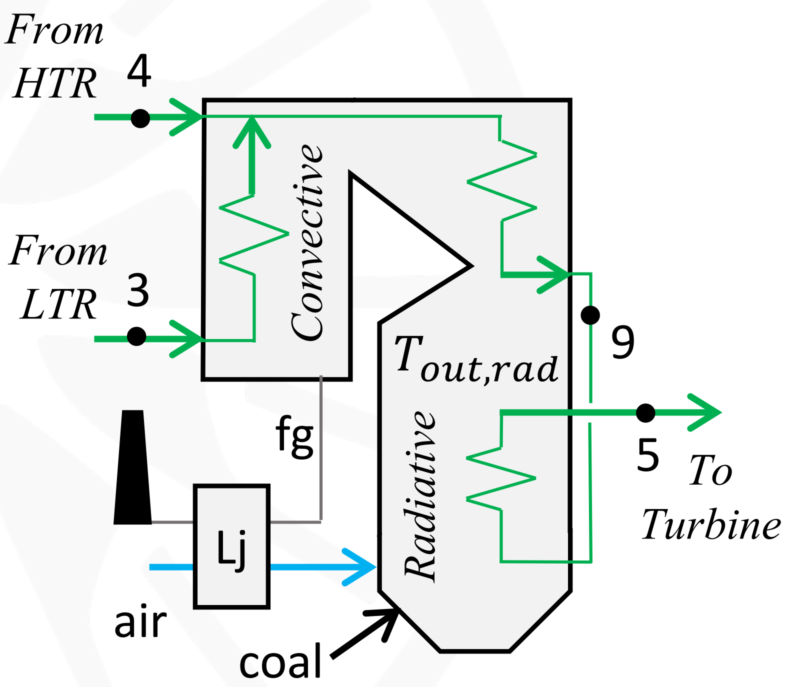
		HTR by-pass
Max T	°C	620
Min T	°C	33
Max P	bar	250
Min P	bar	79.8
CO_2 mass flow	kg/s	271.3

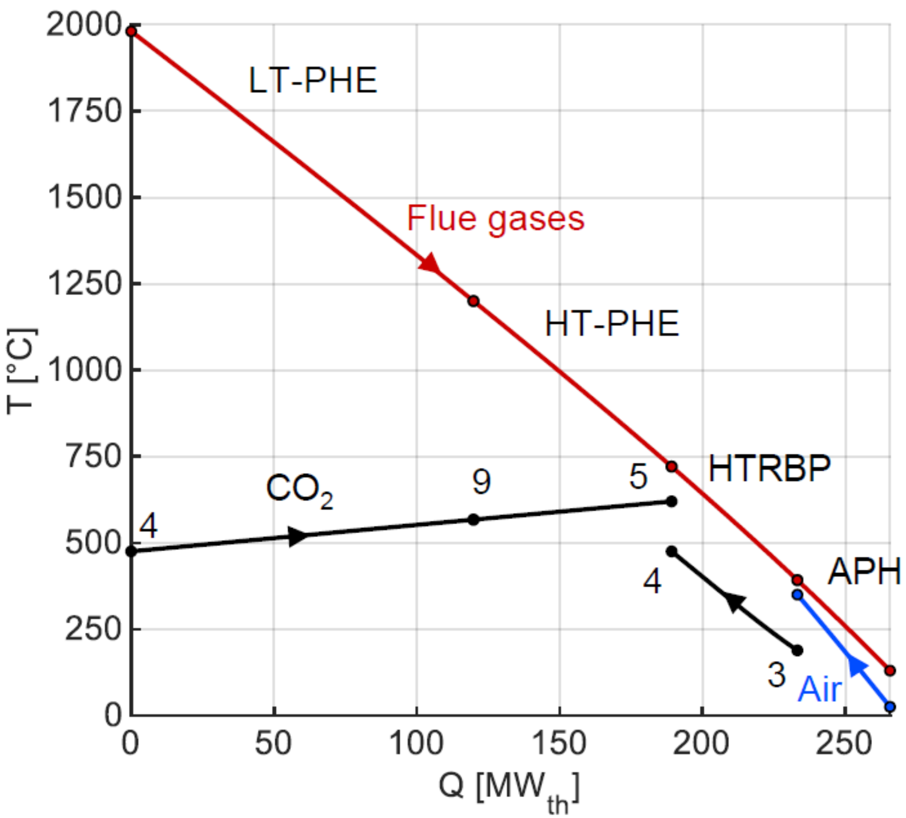




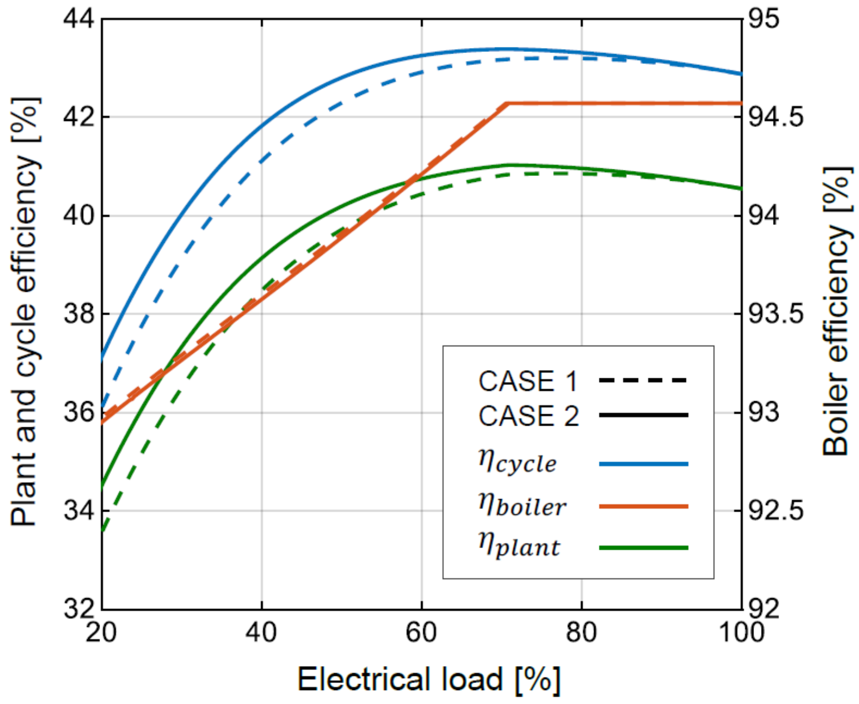
Recuperative recompressed with HTR bypass

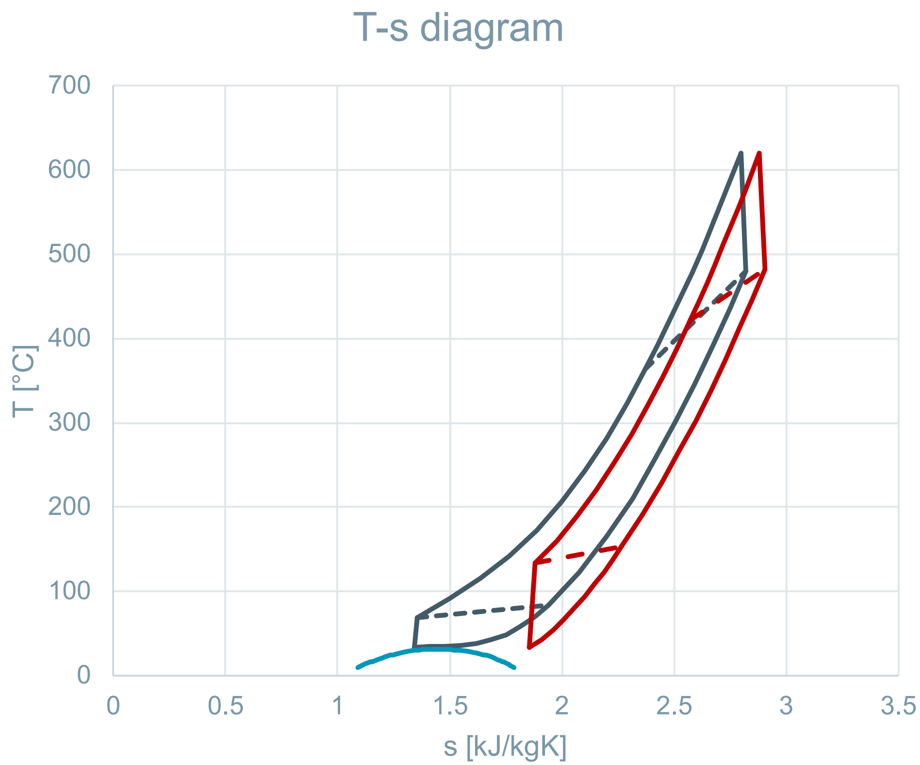
Pulverized coal boiler - design



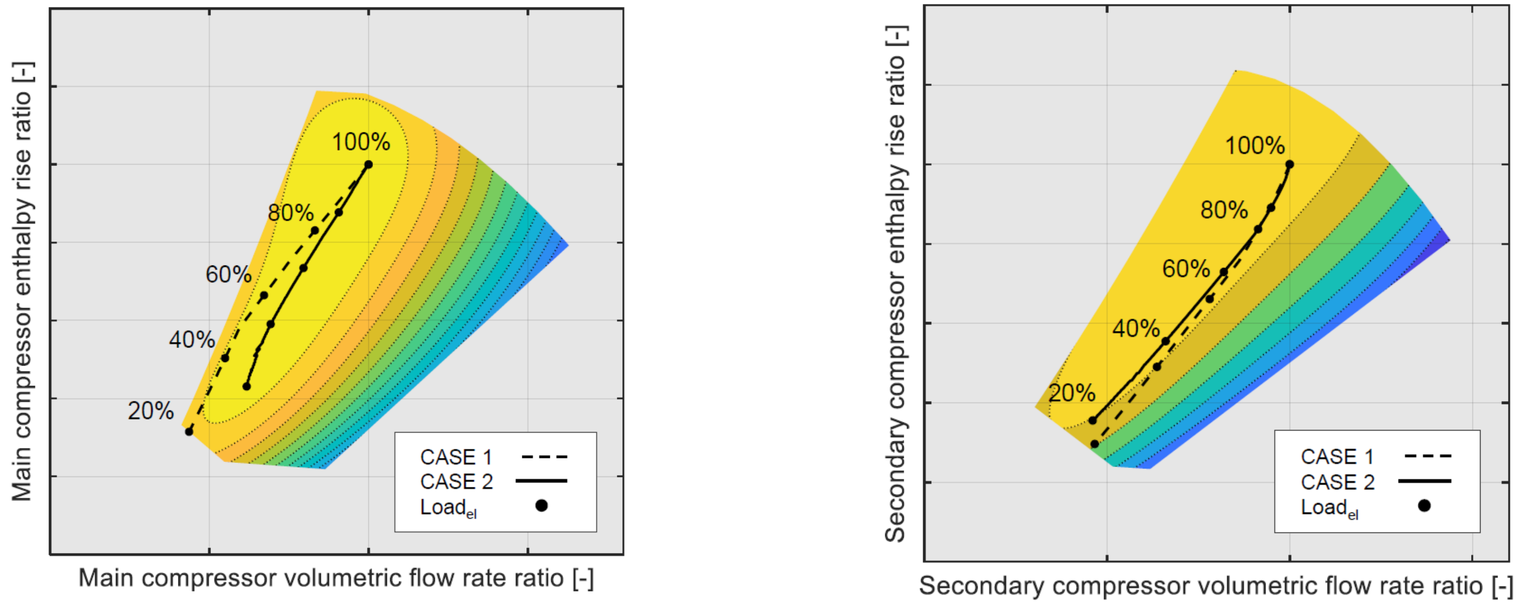


Part-load operation





Part-load operation - compressors



CASE 2 (variable Pmin) efficiency is higher than CASE1 (constant Pmin) because of the larger pressure ratio and the better performance of both the main and secondary compressor which operate far from surge line

Efficiency

Variable cost reduction
Limitation of CO_2 emission

High efficiency turbomachines

Low ΔP and ΔT (heat exchangers)

Flexibility

start-up time
power ramp up/down rates
time response to fuel input var.

Higher number of stages
Larger rotational inertia

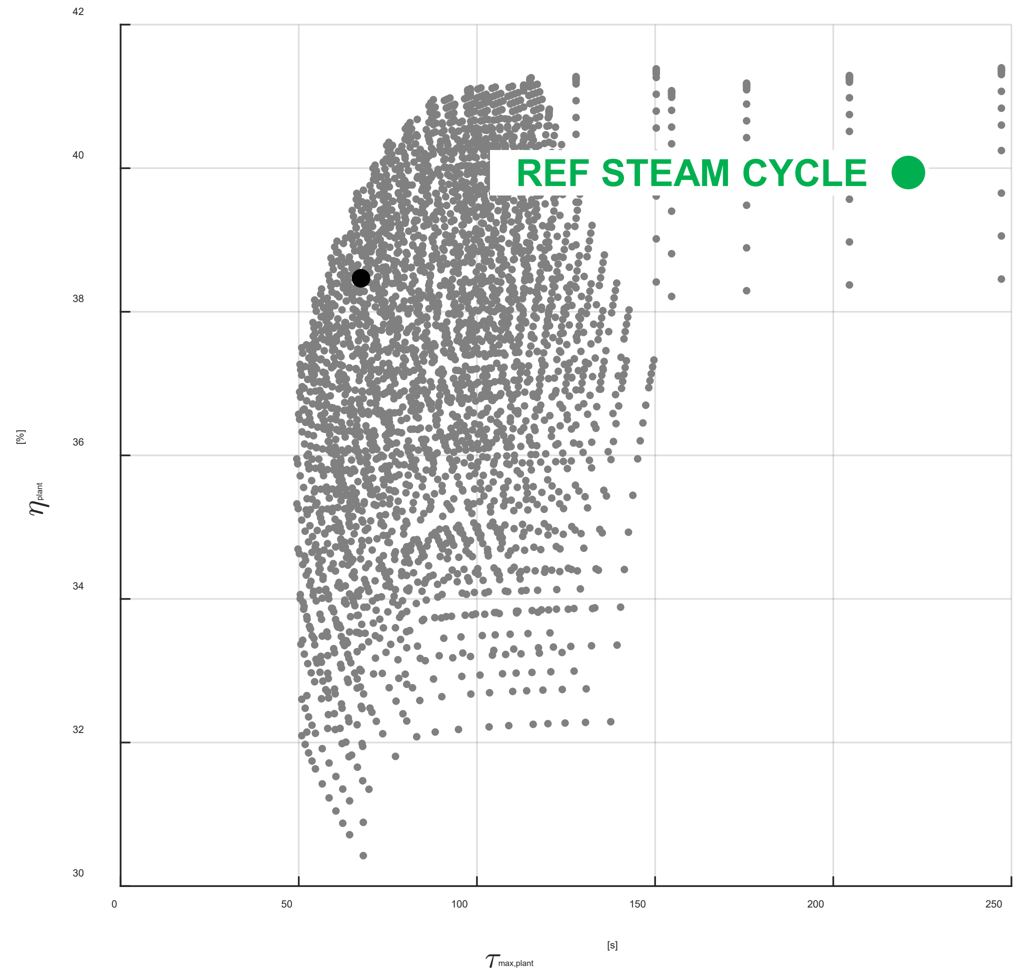
Bulky heat exchangers
Large thermal inertia

Residence time:

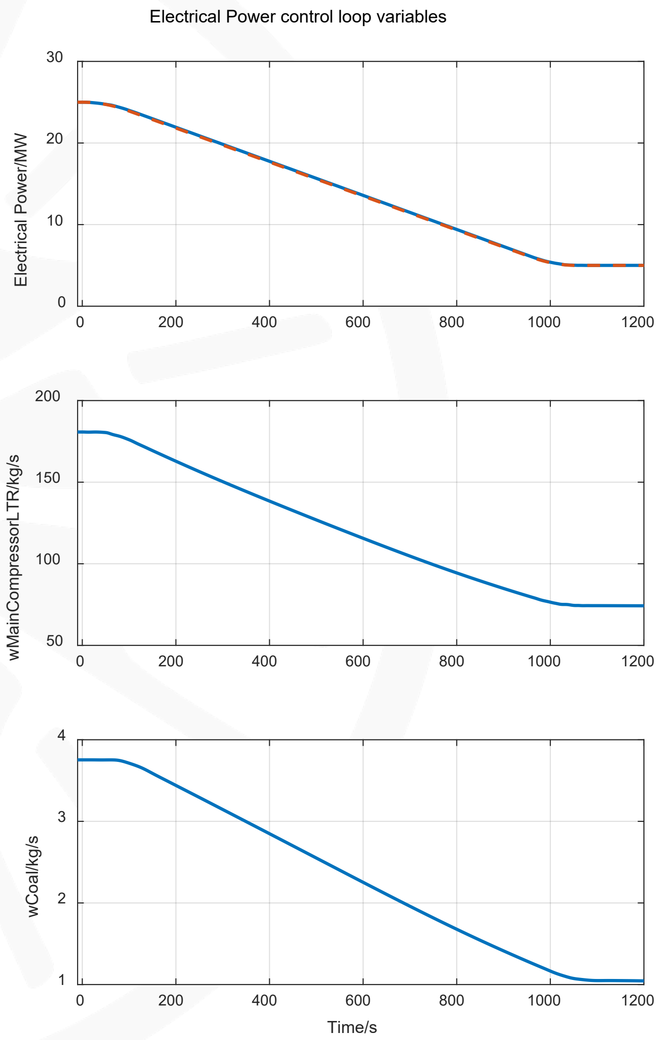
$$\tau_{r,i} = \frac{M_{fluid,i}}{\dot{m}_{fluid,i}}$$

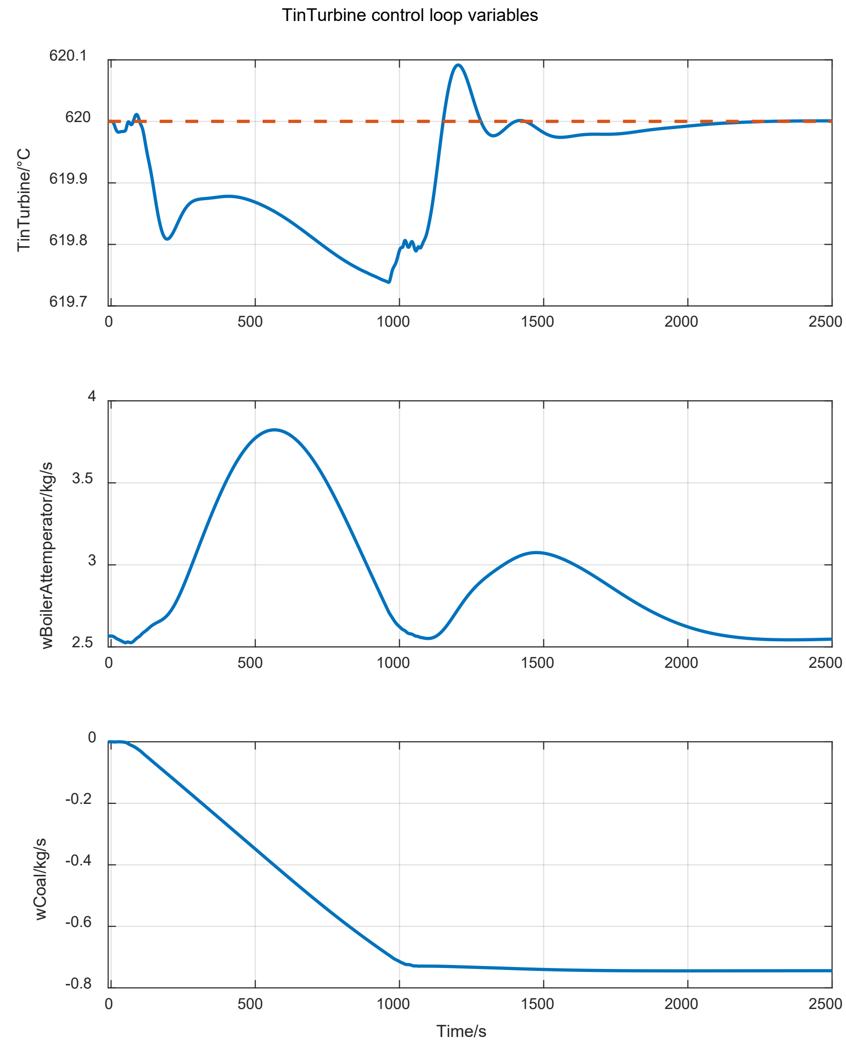
Metal-fluid time constant:

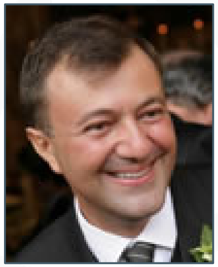
$$\tau_{mf,i} = \frac{M_{met}\, c_{met}}{\dot{m}_{fluid,i}\, c_{fluid,i}}$$



Ramp load 100% – 20% (5%/min)







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WP5 leader

Marco Binotti
WP6 leader

Thank you for your attention!

Francesco Casella
Responsible for the dynamic simulations

Dario Alfani
Responsible for the steady-state simulations