

S^{OLAR} CRATCES

Umberto Tesio, Elisa Guelpa, Vittorio Verda

Comparison of Different Integrations of Cal-CSP through Multi-objective Approach



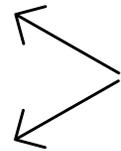
Premises and Objectives

Wide variety of alternatives for CSP-CaL integration

- Direct integration → Open/closed CO₂ Brayton cycles
- Indirect integration → ORC, Rankine, Brayton, Stirling cycles

Technical constraints

Performances



Choice influenced by

Costs

Layout complexity

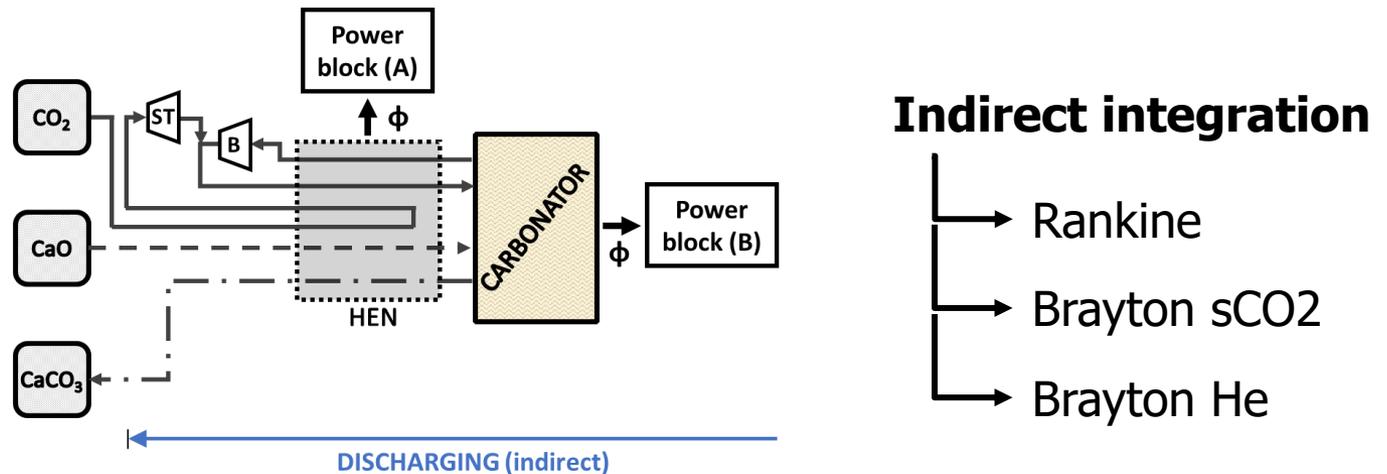
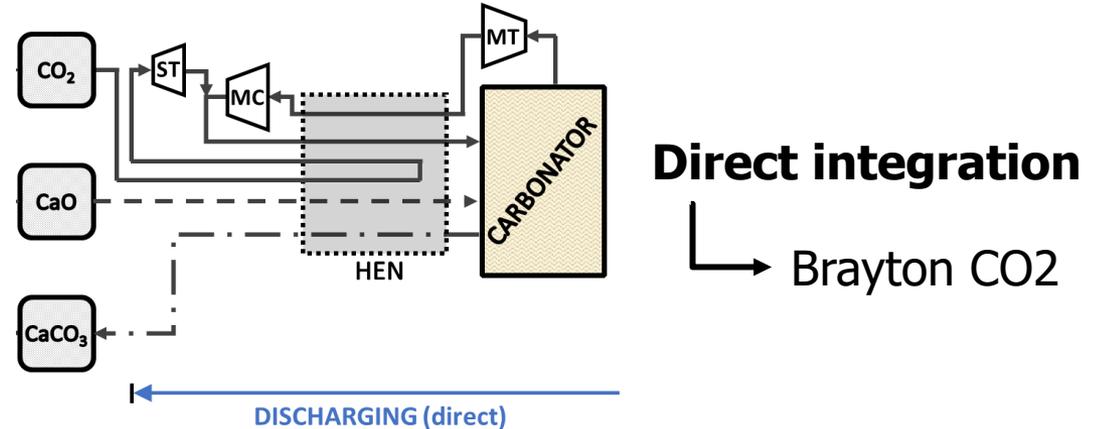


Objectives: optimize and compare the most promising CSP-CaL integrations

Case study

Assumptions

- Size = 2 Mw_e
- Discharging time = 24h
- CaO deactivation = 0.5
- Try to avoid heat transfer between solids and solid stream split



Methodology

Required characteristics:

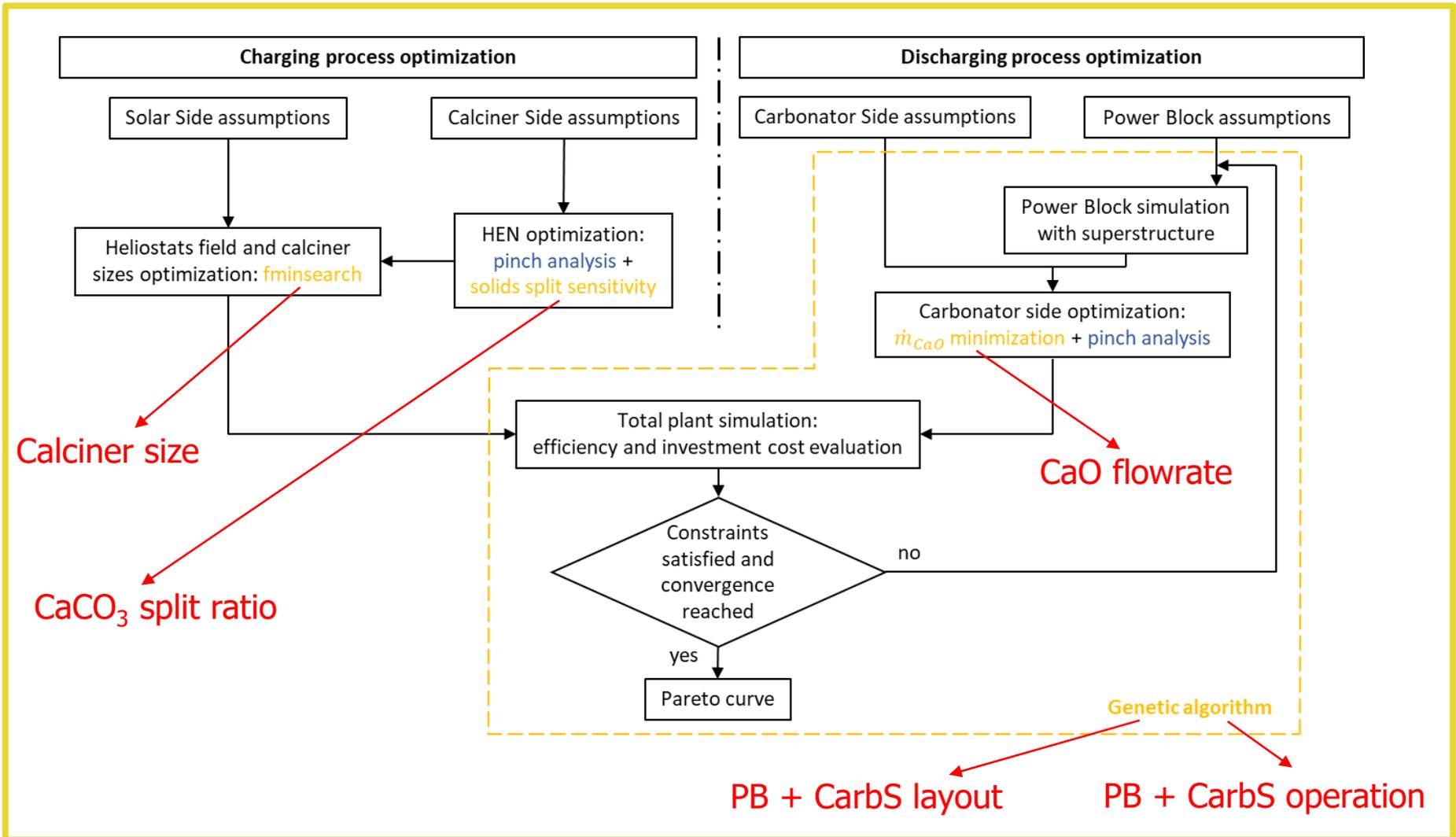
- Optimized heat transfer processes
- Investigation on layout synthesis
- Optimized operating conditions
- No external resources consumption



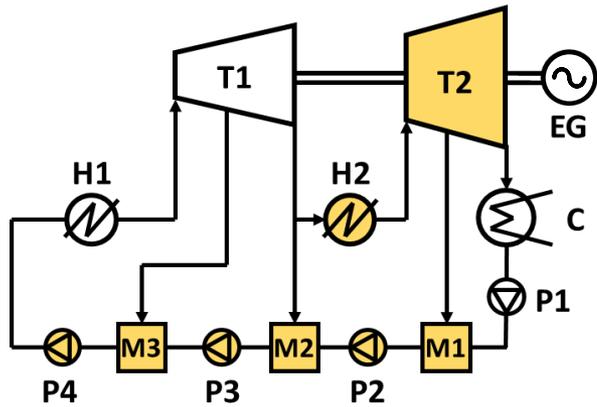
HEATSEP method

HEATSEP allows the comprehensive optimization of synthesis, design and operation for nearly any kind of process integration and has a high level of personalization

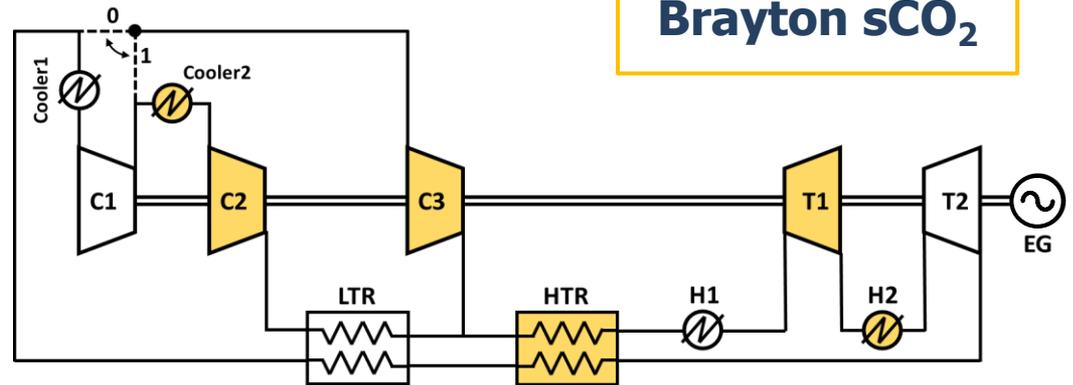
Methodology



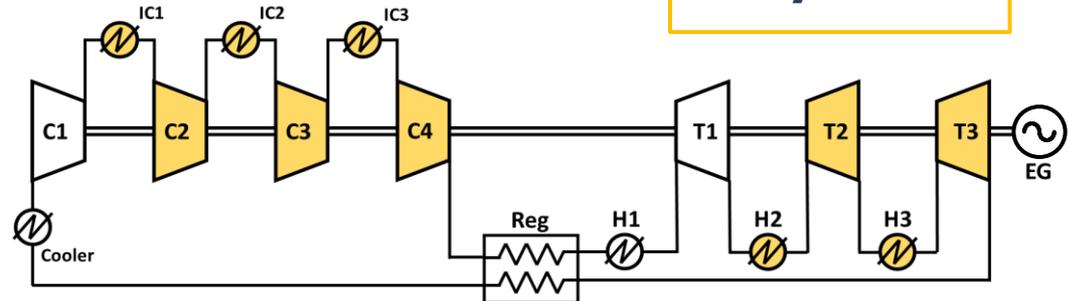
Methodology: Power block layout



Rankine



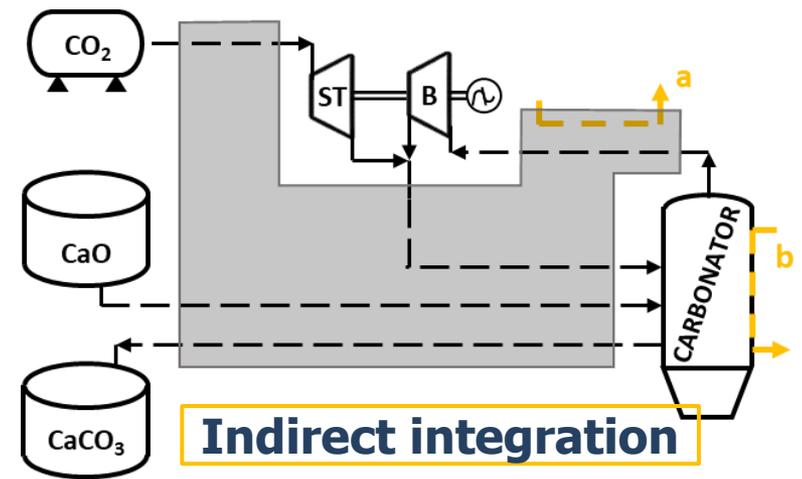
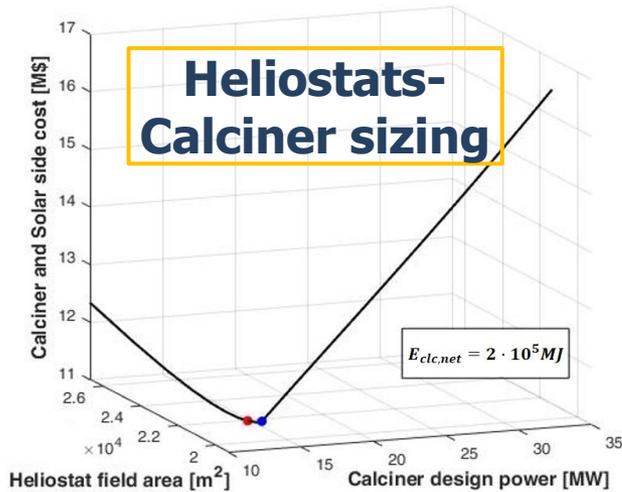
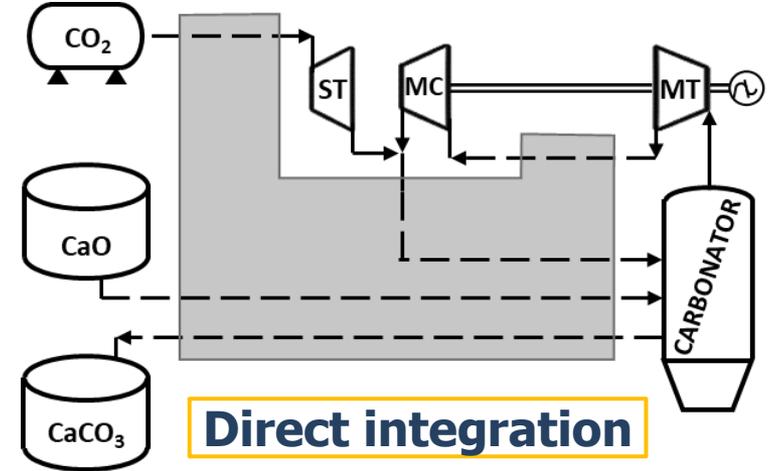
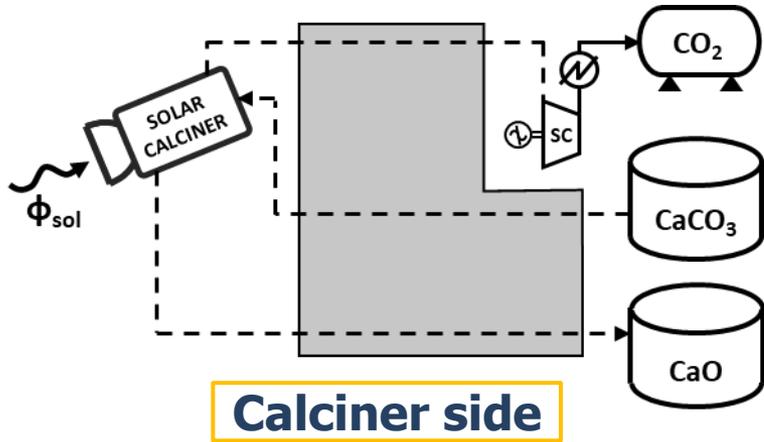
Brayton sCO₂



Brayton He

-  Fixed component
-  Removable component

Methodology: Calcium-Looping



Methodology: Objective functions

Energy analysis

$$\eta = \frac{E_{el}}{E_{sun}} = \frac{P_{el} \cdot 24h}{\int_{24h} \varphi_{sun}(t) \cdot A_{helio} \cdot dt}$$

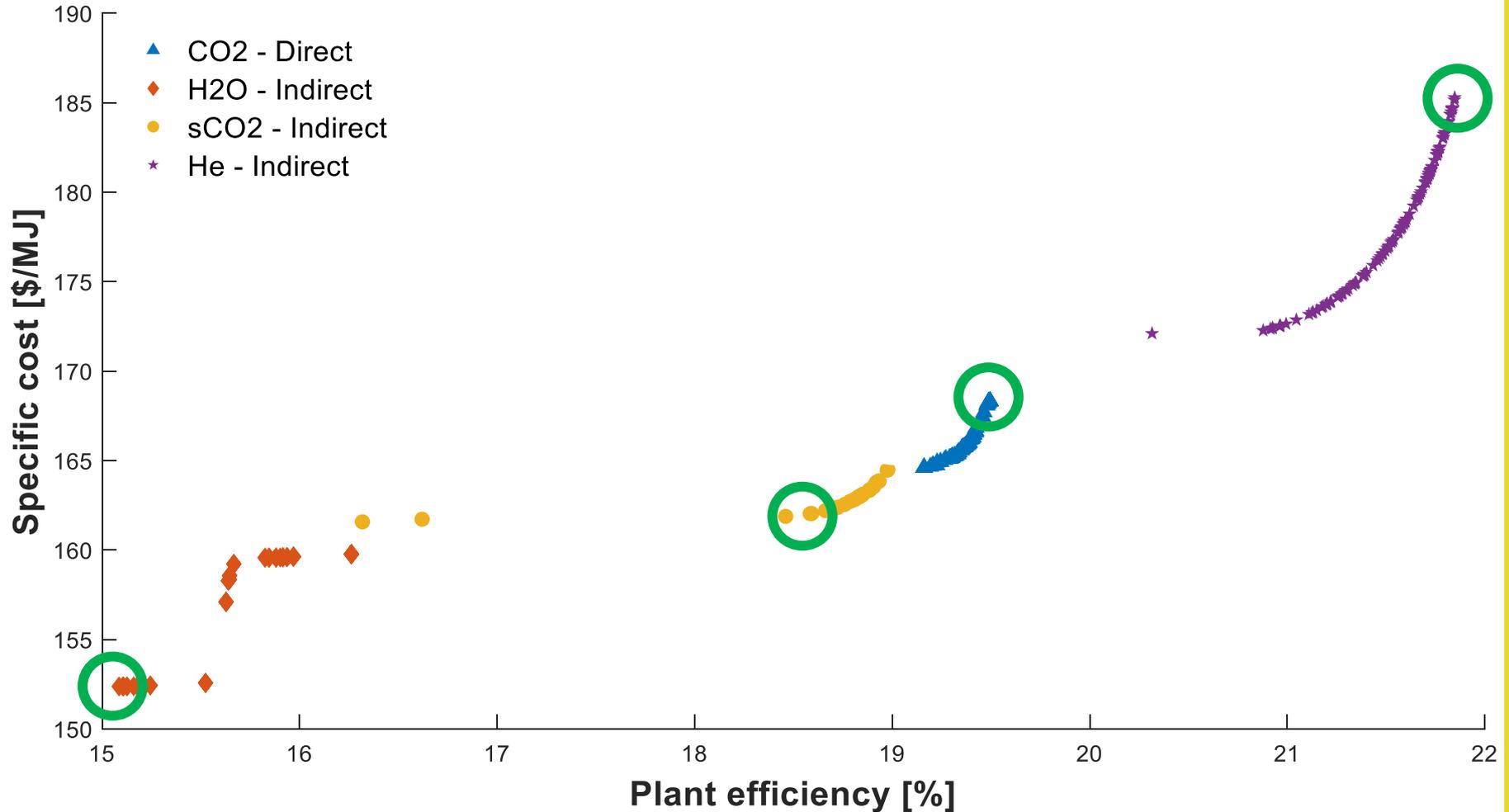
Economic analysis

$$ic = \frac{\sum[IC]}{E_{el}}$$

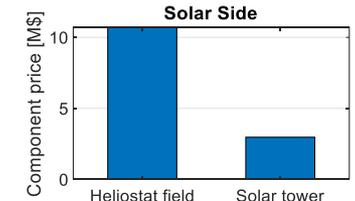
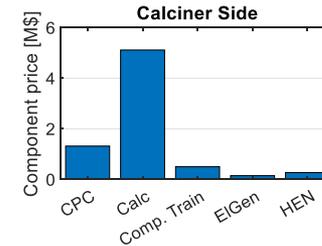
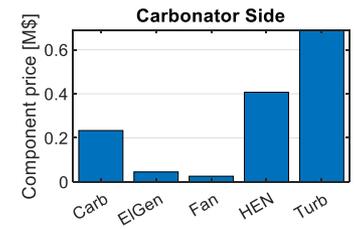
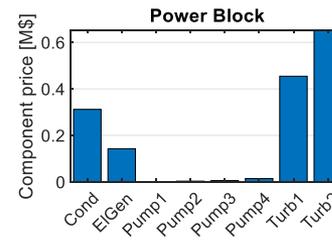
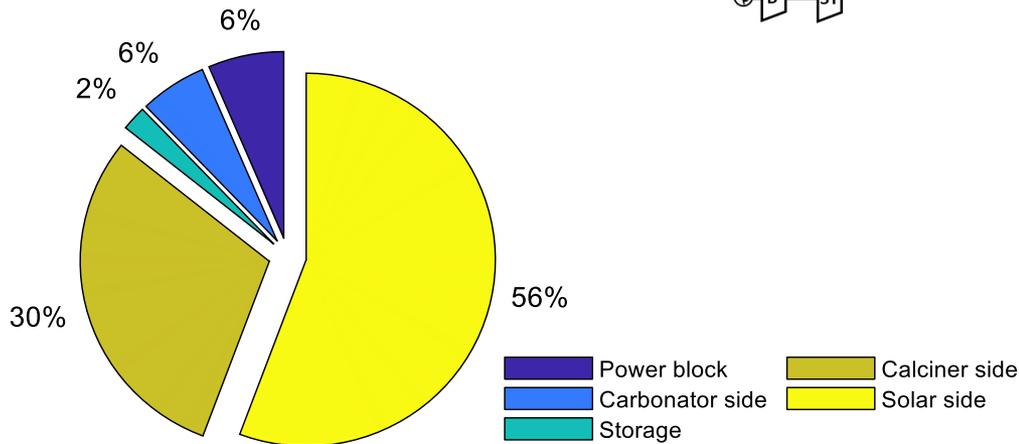
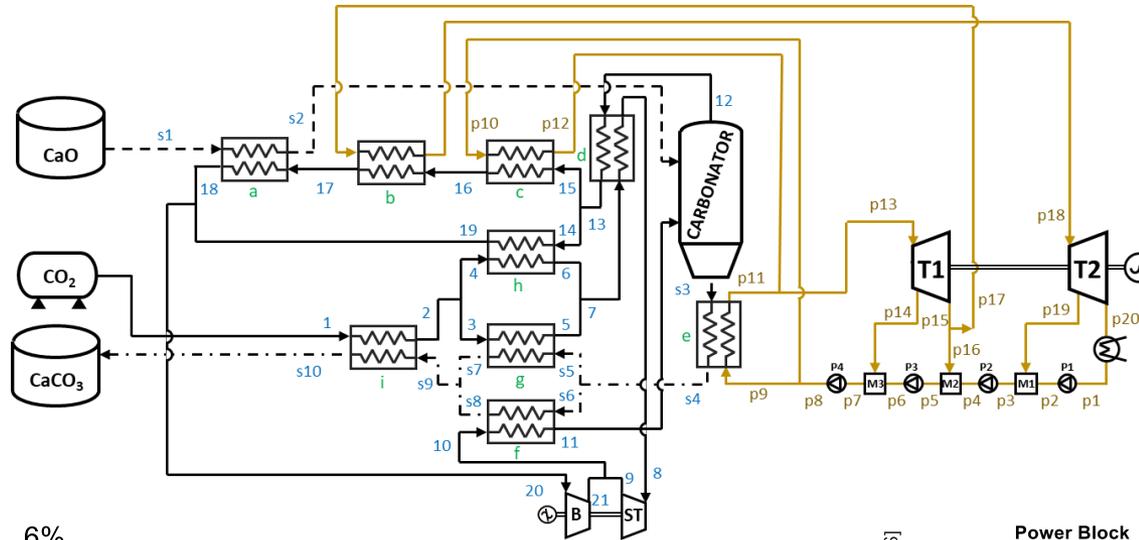
Components' cost included for:

- Turbomachinery
- HENs
- Chemical reactors
- CO2 storage
- Solar tower
- Heliostat field

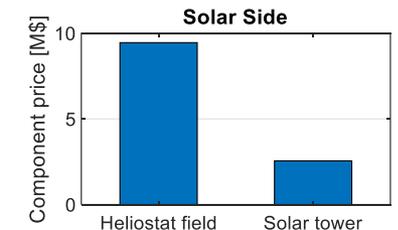
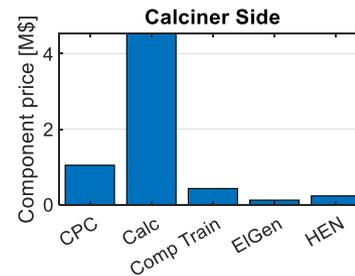
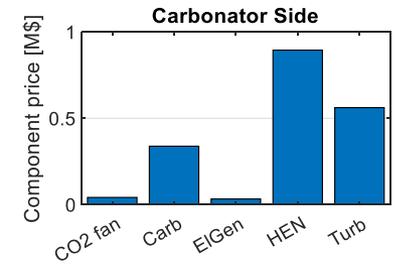
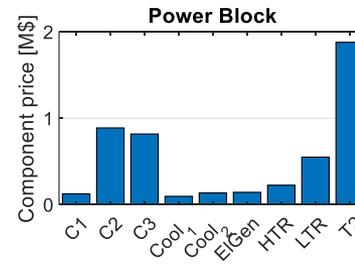
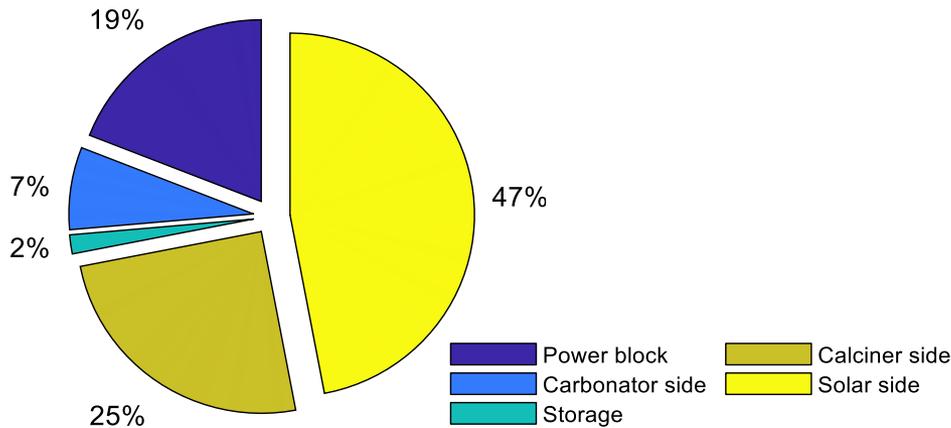
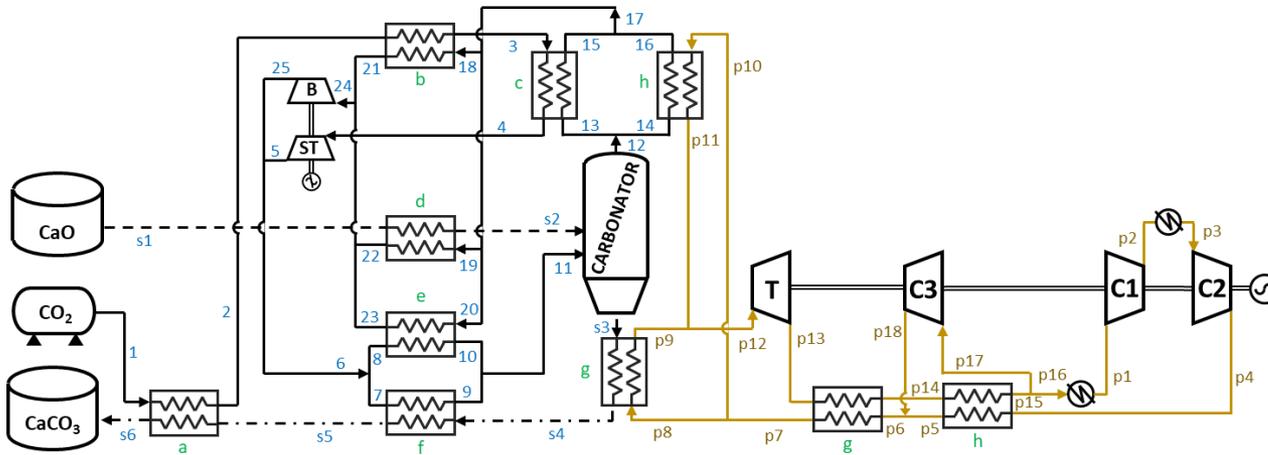
Results: Multi-objective optimizations



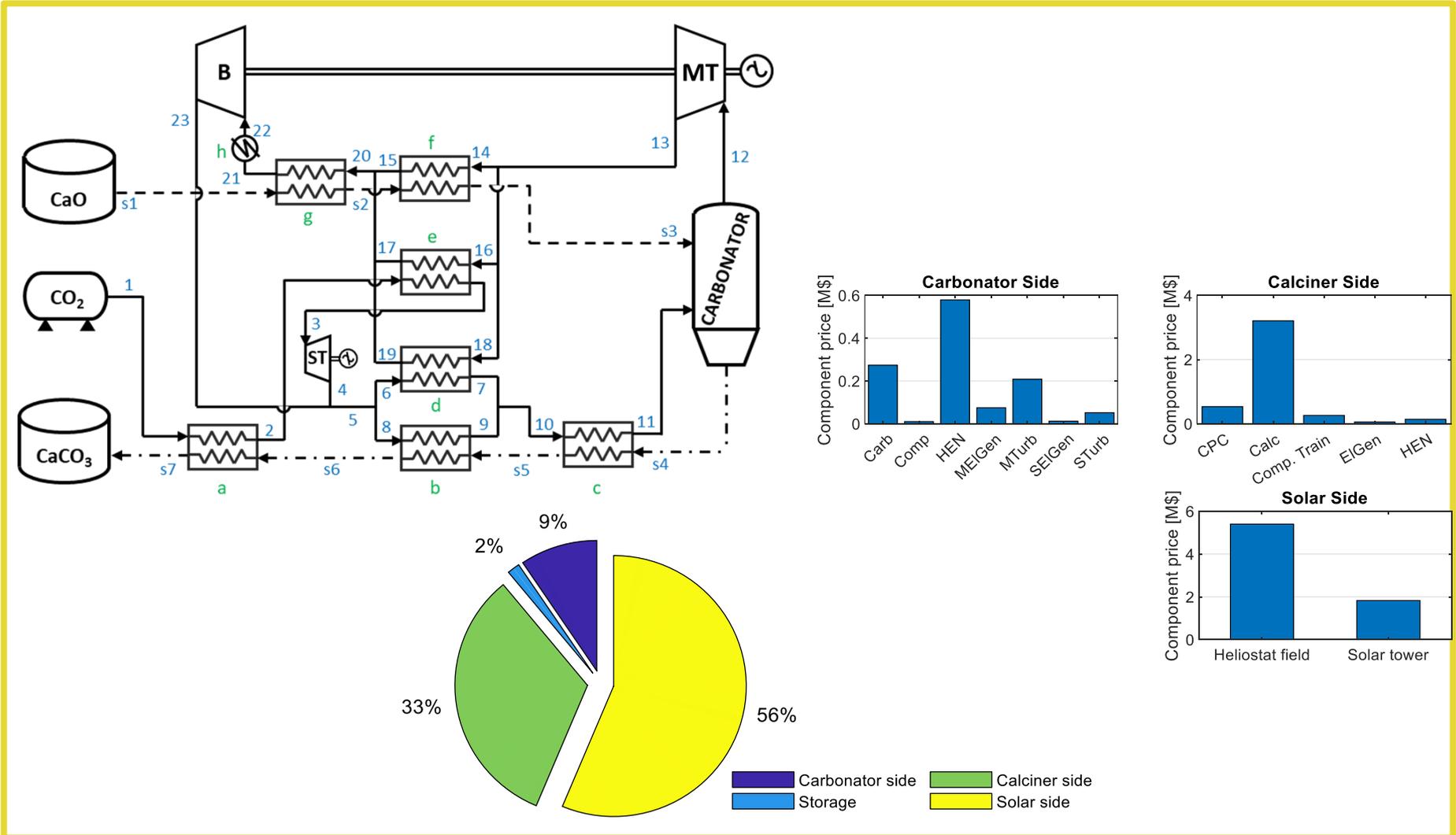
Results: H2O - Indirect



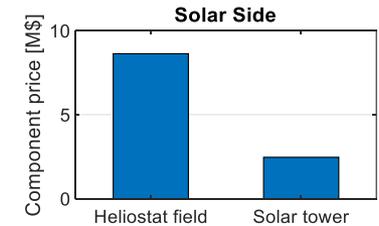
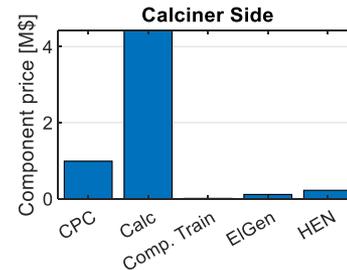
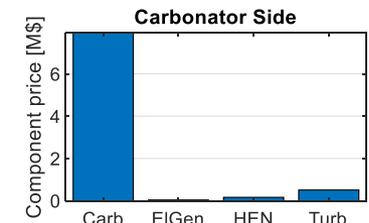
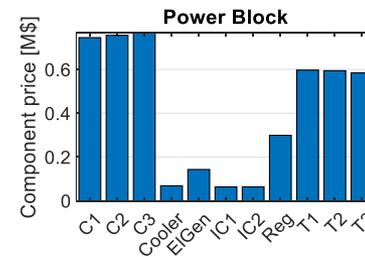
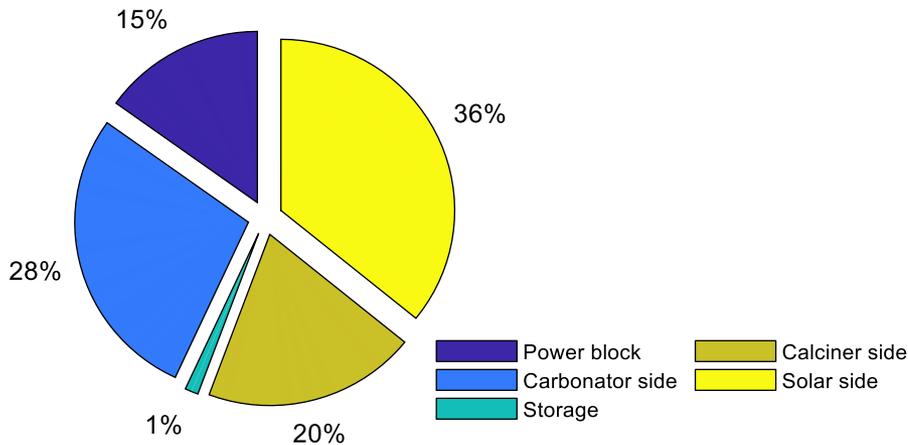
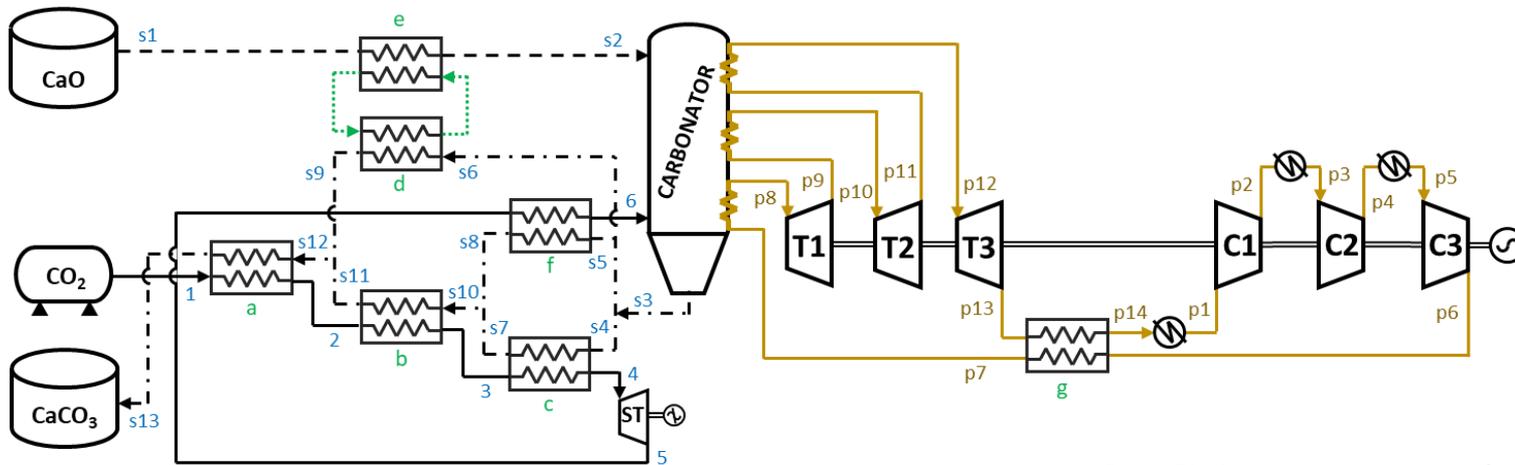
Results: sCO₂ - Indirect



Results: CO₂ - Direct



Results: He - Indirect



Conclusions

Higher power
block efficiency



Lower charging
side costs



Much higher power
block costs

Power block fed on
carbonator wall

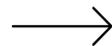


Higher discharging
performances



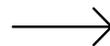
Much higher
reactor costs

Adiabatic carbonator



Direct integration (Brayton CO₂)

Non-adiabatic carbonator



Indirect integration (Brayton He)

SO^{CRAT}CES

Thanks for your attention



This Project has received funding from European Commission by means of Horizon 2020, the EU Framework Programme for Research & Innovation, under Grant Agreement no.727348.

