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Fluidized particle-driven CSP integration model for MW-scale commercial applications

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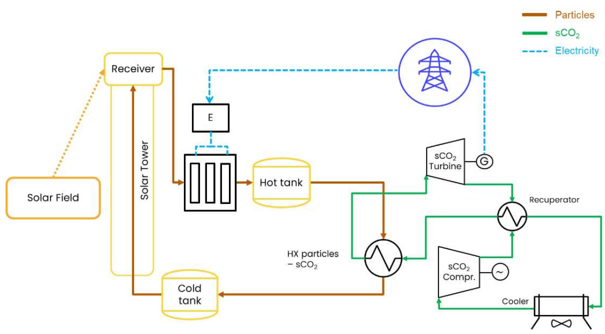
Main idea

- **Cross-sectorial system** performance analysis for **particles-driven solar receiver** and **sCO_2 power block** in the framework of the Powder2Power EU-funded project.
- sCO_2 power block **cycle configuration selection** based on both demand and solar receiver performance **optimization**.
- Implementation of a **temperature boosting electric heater** enables to:
  - Enhance overall system **performance**.
  - Greater operational **flexibility**.
  - **Hybridization** with renewable electricity generation and grid services.

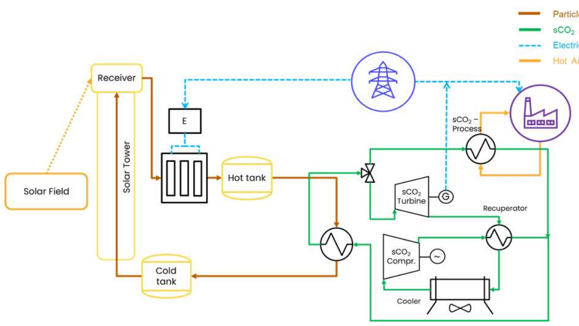
Case applications

- **In-Front-of-The-Meter (FTM) Applications considered:**
  - **Base load** operation.
  - **Peak load** operation.



FTM cases conceptual scheme.

- **Behind-The-Meter (BTM) Applications**
  - Higher Electricity demand ratio (direct steel production): **4 MWe and 0.6 MWth.**
  - Higher thermal demand ratio (hot air for drying purposes): **1 MWe and 4 MWth.**



BTM hot air process conceptual scheme.

Model implementation

- **Seville (Spain)** TMY measured data considered as reference location.
- **Industrial energy demand** characterization .
- **Solar receiver** temperature sensitivity analysis between **15 MWth and 120 MWth** peak absorbed power performance.
- Implementation of thermal losses due to air conveyance.
- **sCO_2** power block **cycle configuration**, considering different power levels:
  - Recuperation Cycle with Bypass.
  - Recompressed Cycle.
  - Partial Cooling Cycle.
- **Electric heater sizing** performed for nominal conditions.

Main results

Considering performance, the best suited cycle configuration and the optimal operating conditions are shown:

Optimized configurations and operating conditions summary

Case Description	SR Abs. Power (MW)	sCO_2 Eff. (%)	Photo-thermal Eff. (%)	sCO_2 Cycle Config.	EH Outlet Temp. (ºC)	SF Heat Ratio (%)	EH Heat Ratio (%)
BTM Hot Air Process	15	41.50%	66.54%	Recompressed Cycle	730	54.01%	45.99%
BTM - Hot Air Process	30	40.66%	63.40%	Recompressed Cycle	710	64.85%	35.15%
BTM - Steel Production	50	38.88%	62.66%	Recompressed Cycle	670	87.81%	12.19%
FTM - 50 MWth	50	47.43%	63.13%	Partial Cooling Cycle	750	59.93%	40.07%
FTM - 120 MWth	120	47.43%	53.05%	Partial Cooling Cycle	750	59.93%	40.07%

Conclusions and next steps

- **Recompressed cycle** is identified as the best-suited configuration for **BTM applications**.
- **Partial Cooling Cycles** is considered the best-suited configuration in terms of energy efficiency for **FTM applications**, presenting better efficiency at lower return particles temperature to the solar receiver.
- **Heating ratio** between the thermo-solar receiver and electric heater are **maintained** along the **optimum point**.

- **Project next steps** include:
  - Further optimization of the assets via a **techno-economical** assessment.
  - Model performance **validation** via pilot scale plant.

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