Batería Carnot, una alternativa posible

Repurposing of existing coal-fired power plants into Thermal Storage Plants for renewable power in Chile

Dr. Ing. Michael Geyer, Dr.rer.nat. Franz Trieb, Stefano Giuliano (DLR)
Rainer Schröer (GIZ)

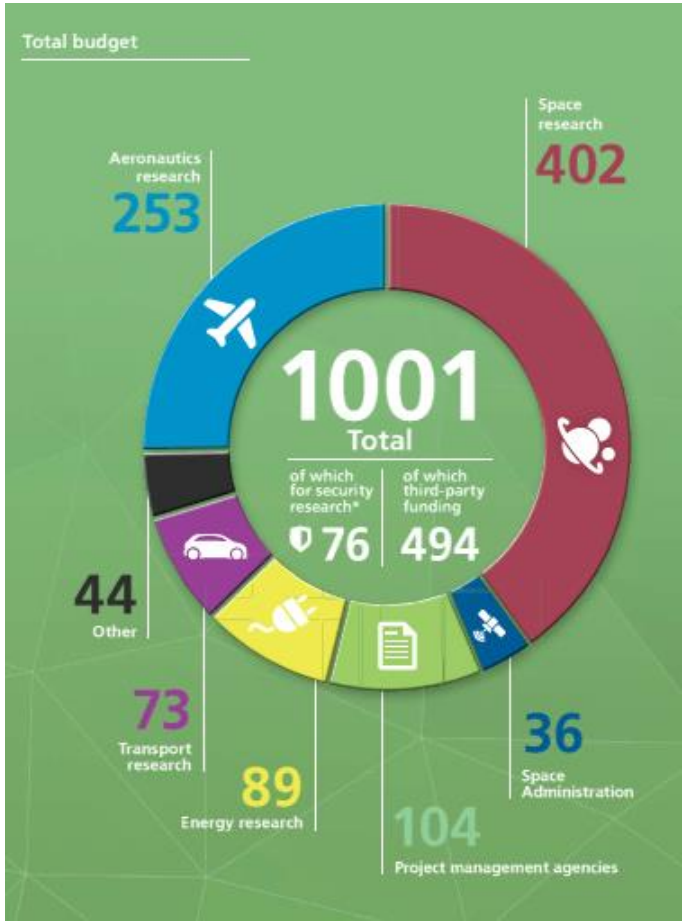
Results from GIZ Contract PN: 69.3020.0-001.00
“Decarbonization of the Chilean Energy Sector”

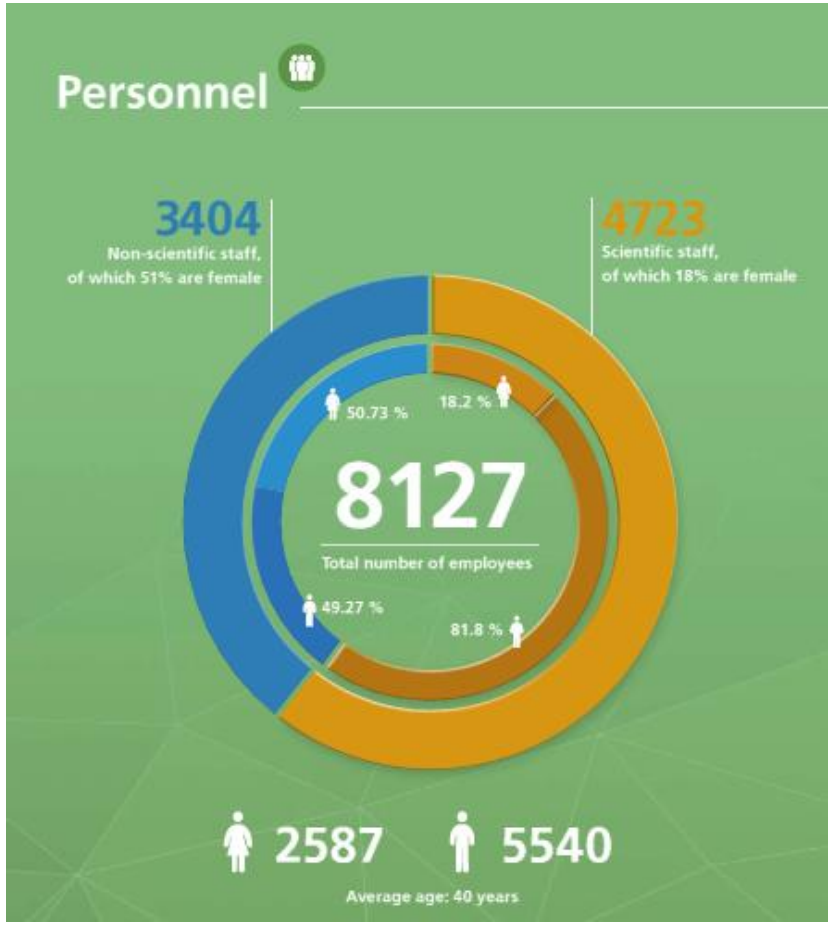
DLR

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

DLR in facts and figures

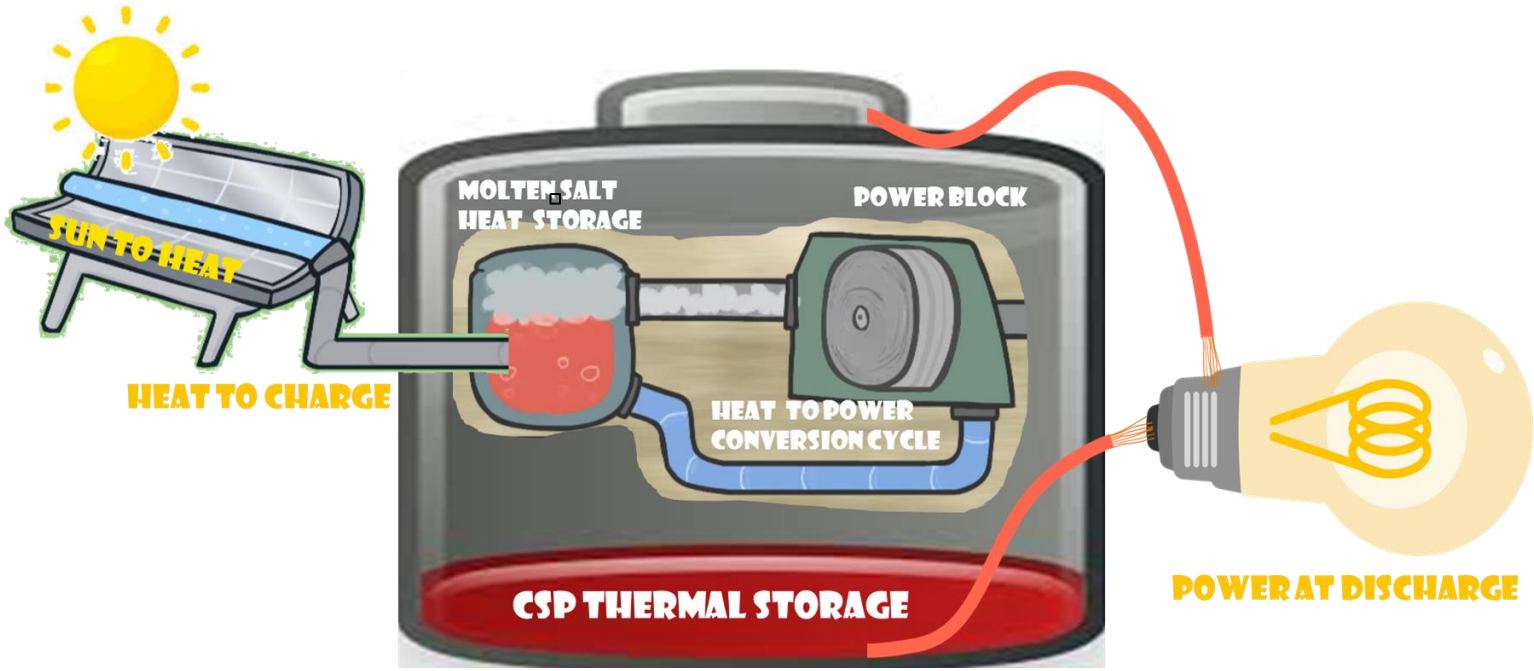
20 sites, 40 institutes and facilities, the Space Administration and Project Management Agencies





DLR TESIS Thermal energy storage test facility for molten salts

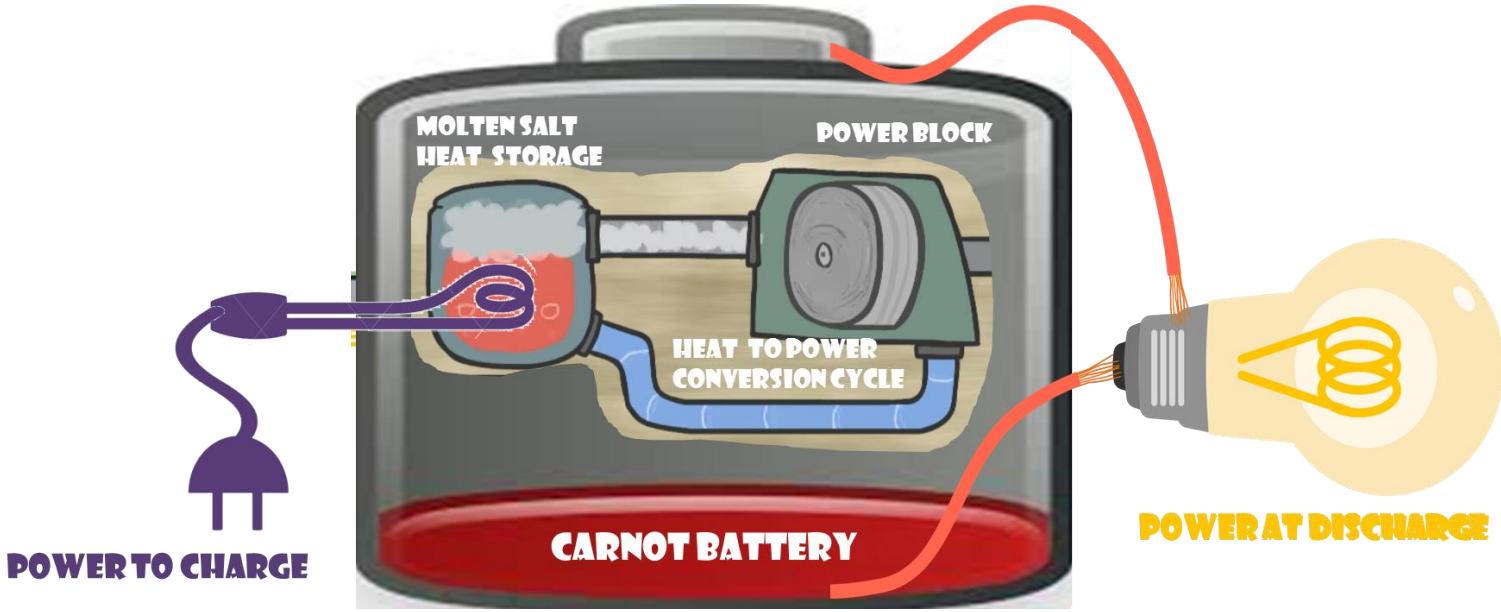
What is a Carnot Battery?



Process is

1. Sun to Heat
2. Heat to Storage
3. Heat from Storage
4. Heat to Power

By converting Concentrated Solar Power Storage into a Carnot Battery



Process is

1. Power to Heat
2. Heat to Storage
3. Heat from Storage
4. Heat to Power

Photographer: Krisztian Bocsi

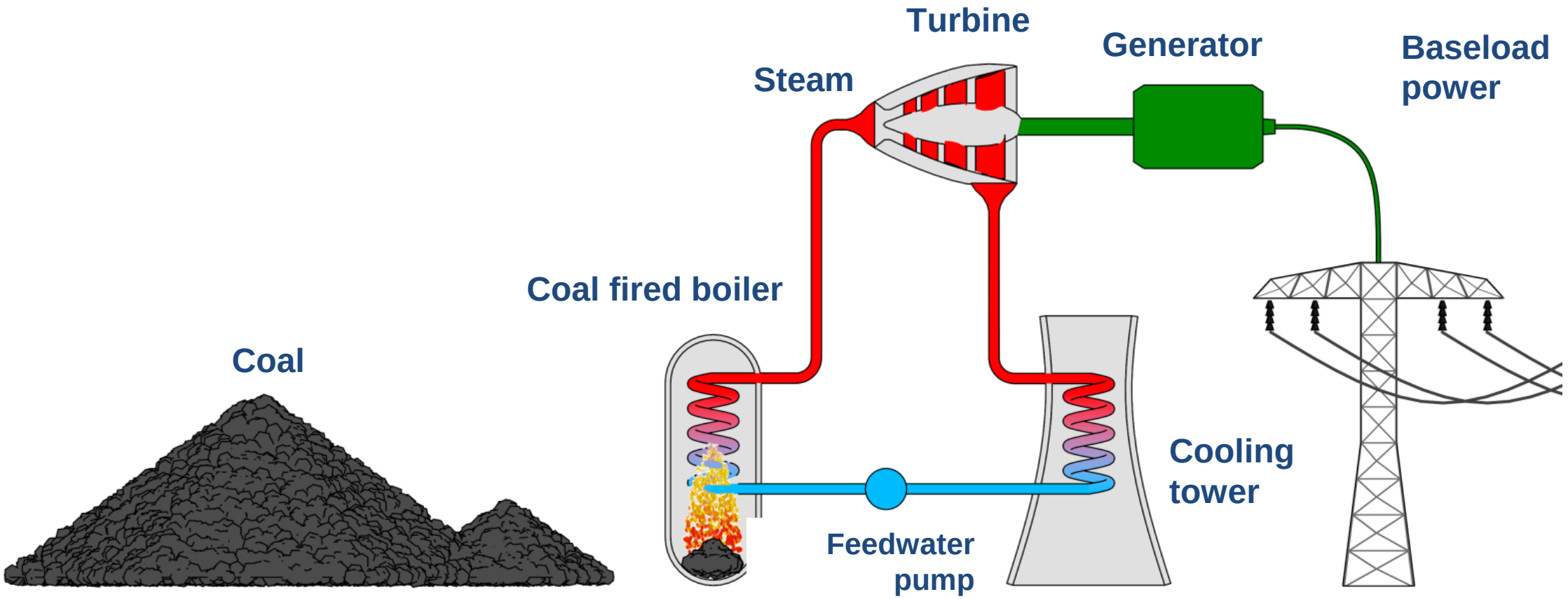
Climate Changed

Germany's Coal Plants May Be Converted to Giant Batteries

By Brian Parkin and William Wilkes
10 de abril de 2019 9:01 GMT-4

The storage units "could be converted from the mid-2020s to innovative, long-term power plants storing surplus wind and solar power," the Economy and Energy Ministry said in its 32-page report on coal phaseout planning. No particular storage technology has been selected for the switch yet, according to the April 4 report.

From fossil lignite coal to dispatchable clean renewable power generation



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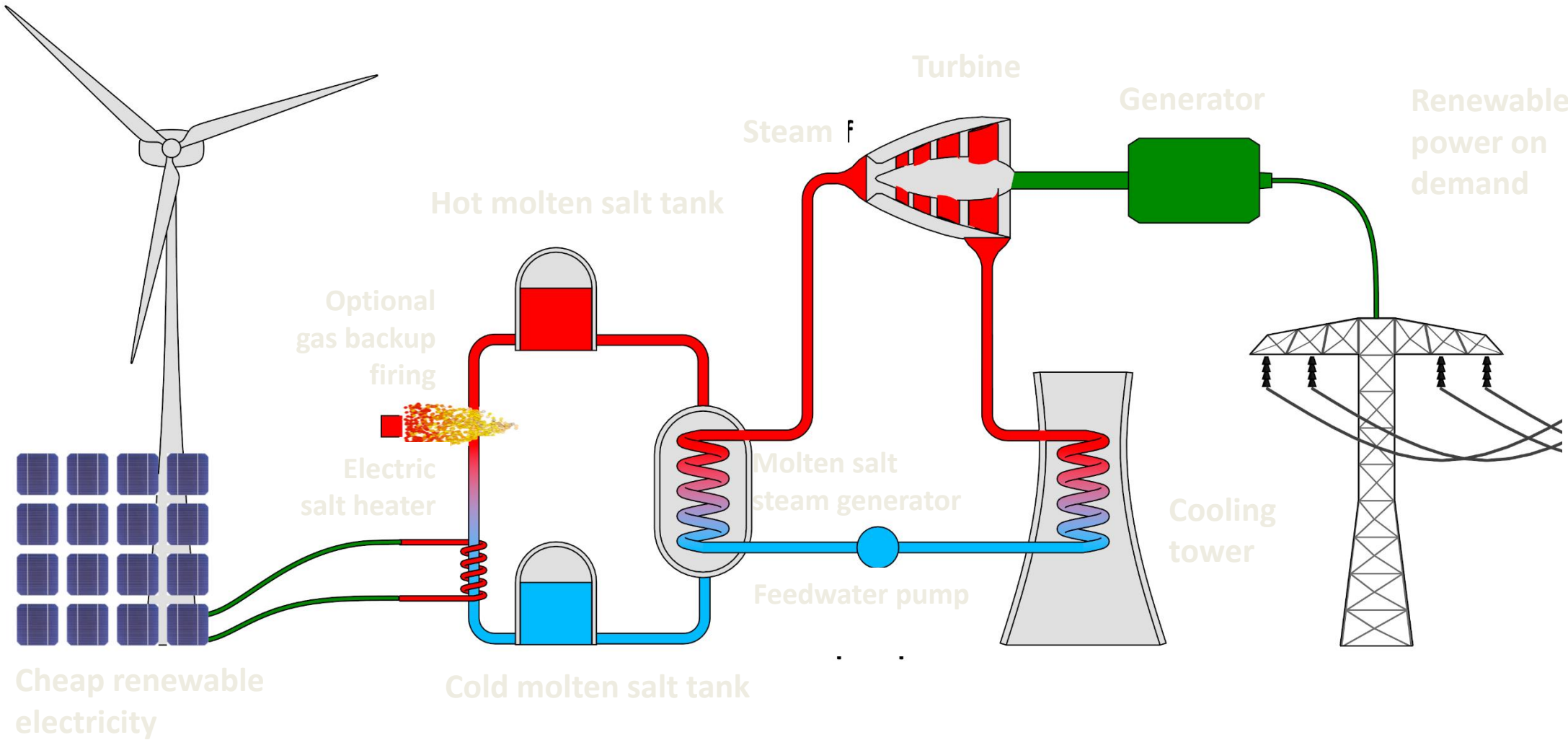
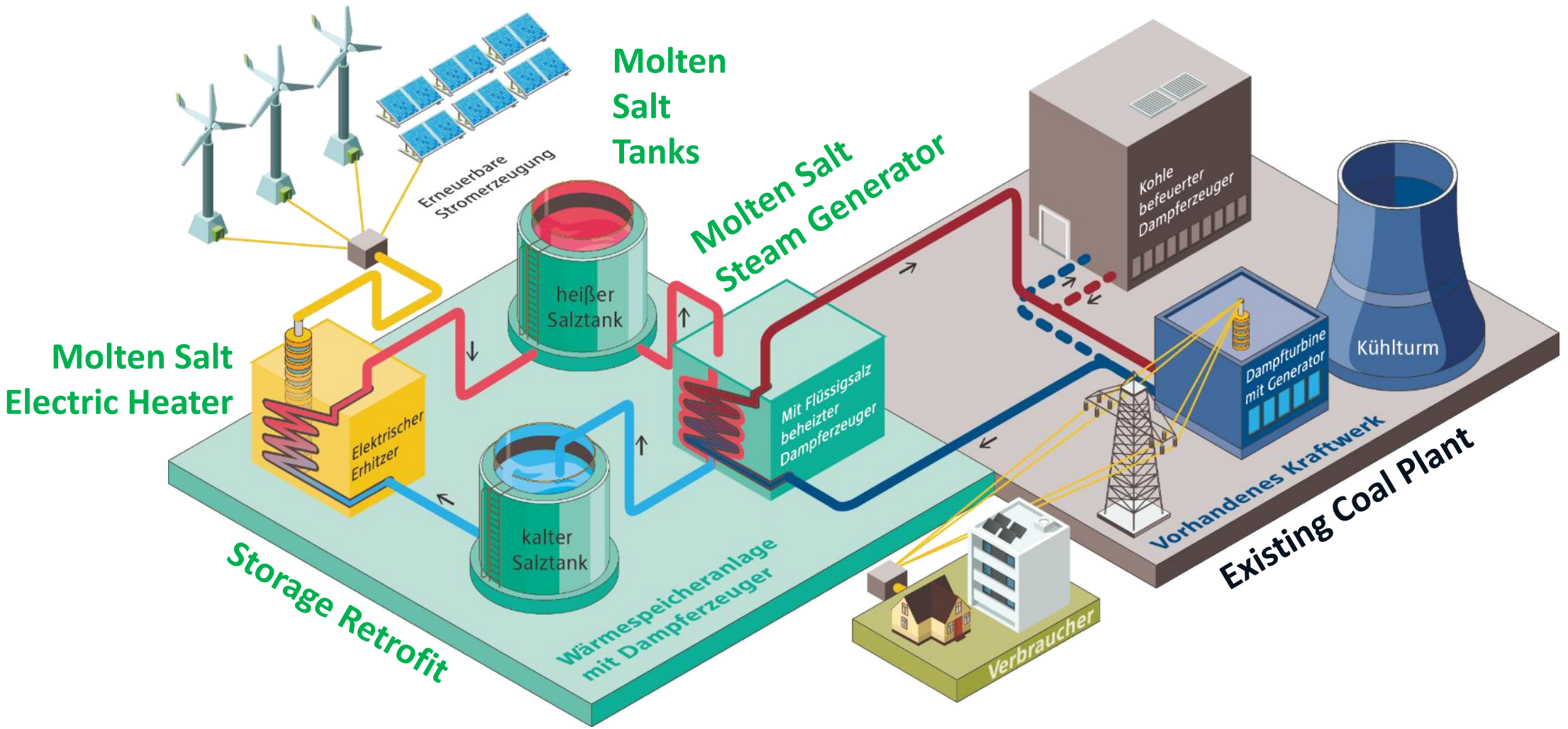


Give Greek Coal Plants a Second Decarbonized Life



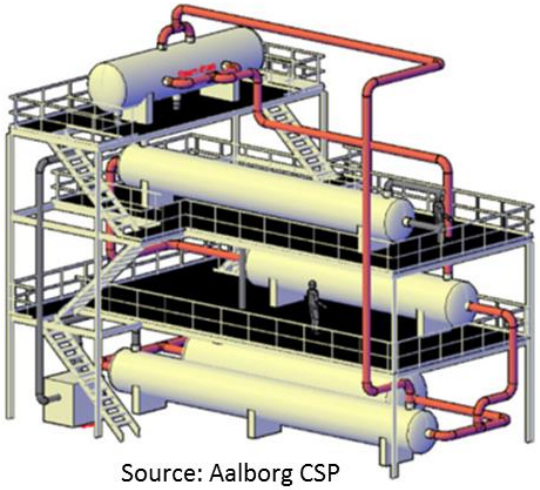
Equipment to be retrofit to coal plant

Source: Volcanic S.A.

Electric heaters for charging molten salts - fired by PV/wind power

Molten salt tanks – hot and cold

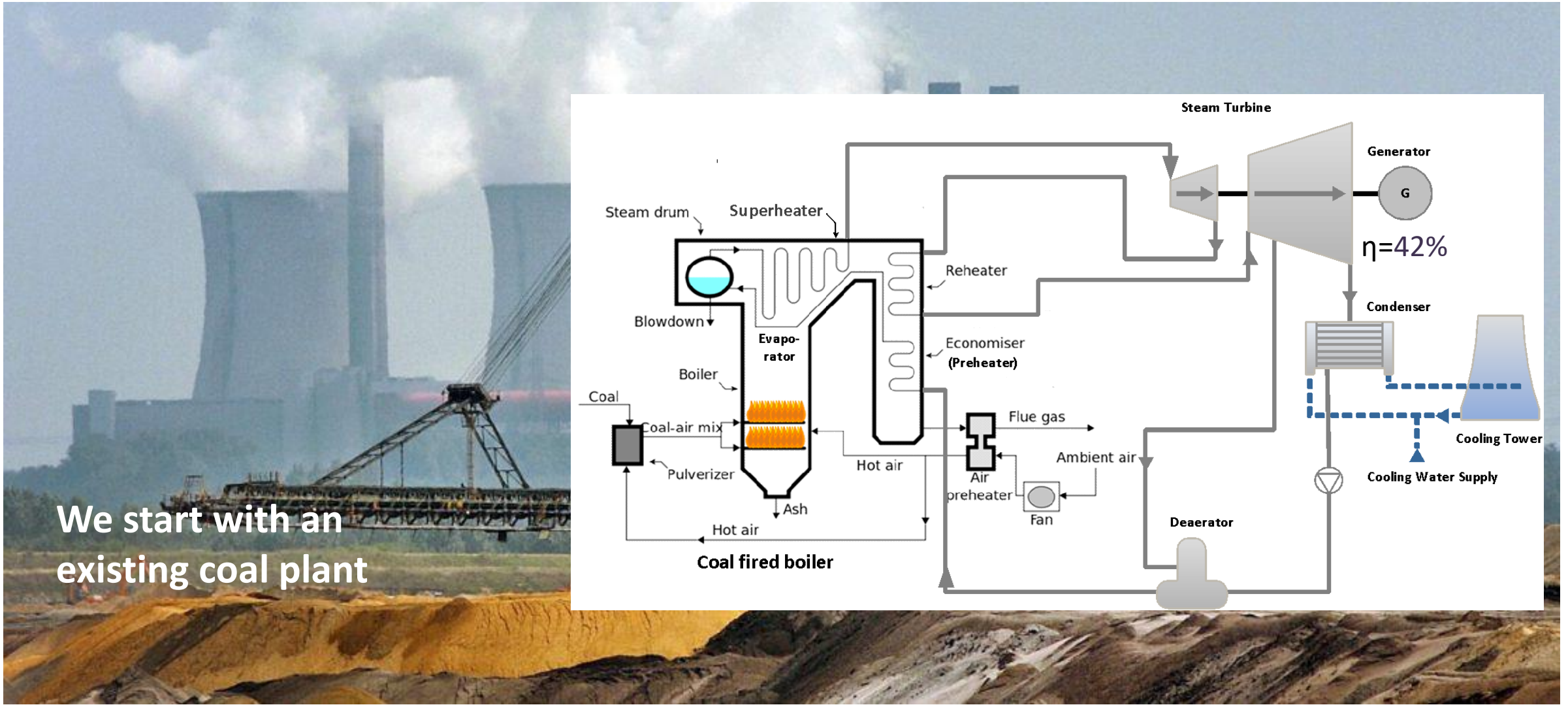
Molten salt steam generators for discharging



Source: Aalborg CSP

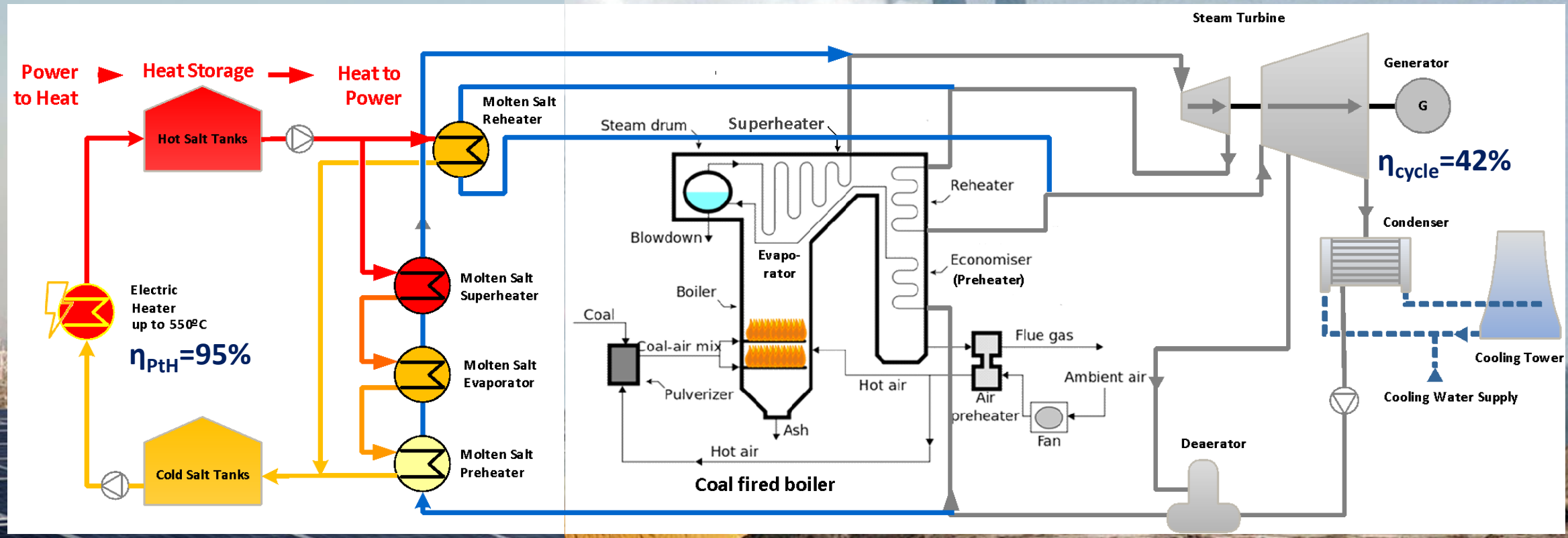
Chile coal plants have space to add molten salt storage systems

Conversion of existing coal plant in a Carnot Battery thermal storage plant

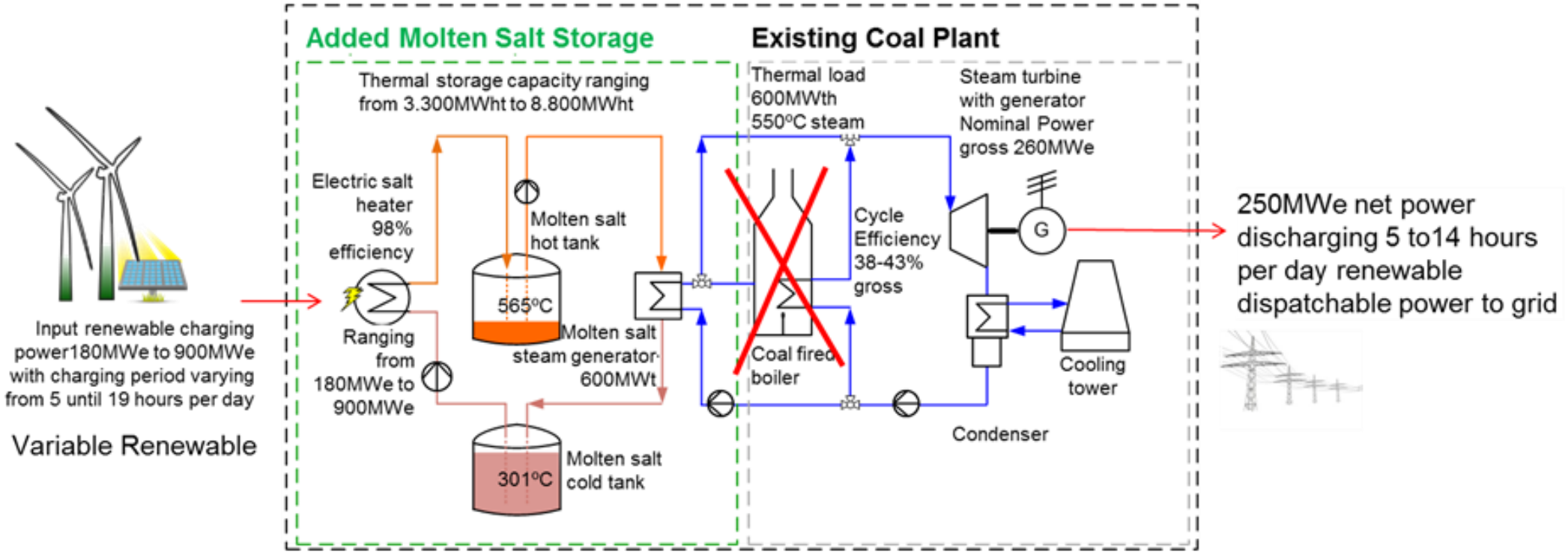


Addition of the molten salt storage island to the existing Rankine Cycle

Phase 1: Pilot integration of molten salt storage in existing coal plant – proof of concept $\eta_{roundtrip}$ = 40%

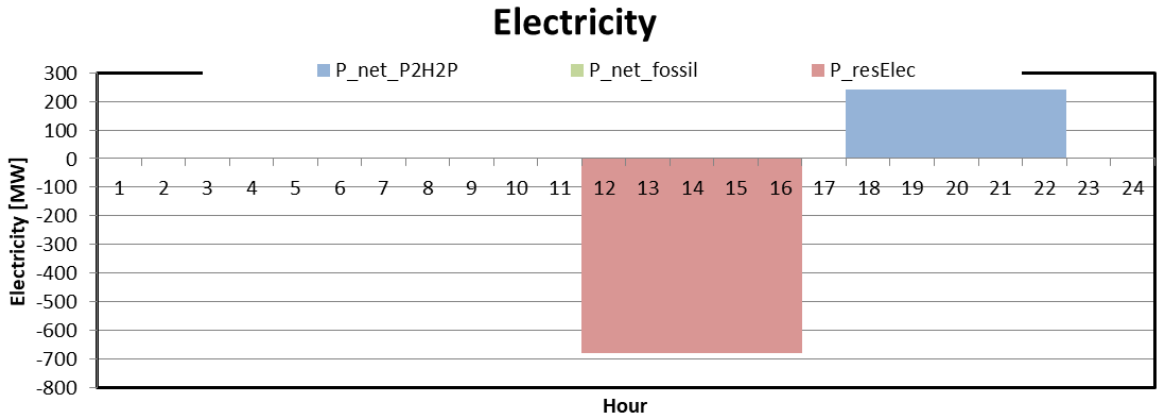


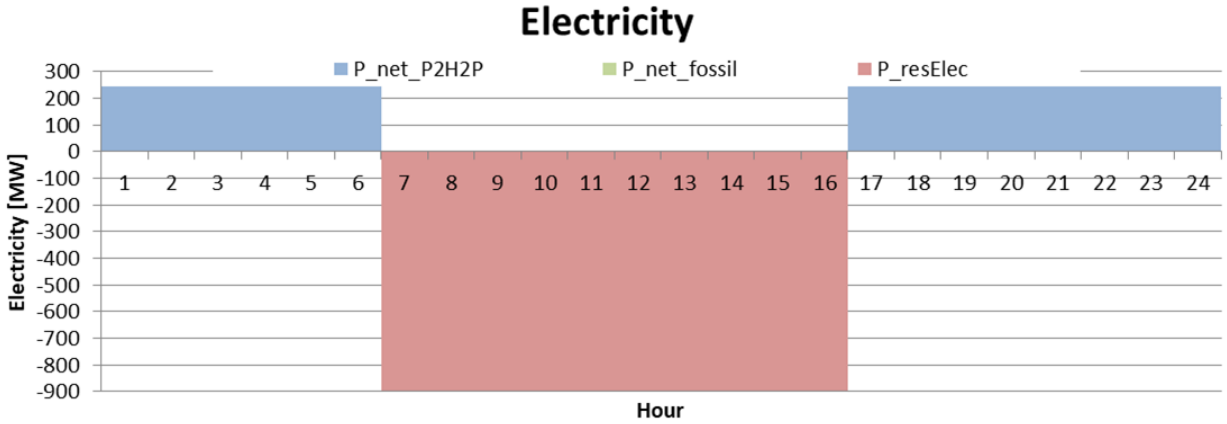
Analysis of a 250MWe Chilean Coal Plant



Sensitivity Variant	Unit	V1-O1	V1-O2	V1-03	V1-O10	V1-O11	V1-O12
Discharging Duration	[hours]	5,00	5,00	5,00	8,00	12,00	14,00
Thermal storage capacity	[GWht]	3,33	3,33	3,33	5,15	7,57	8,79
Charging Duration	[hours]	5,00	10,00	19,00	11,00	11,00	10,00
Charging el. salt heater capacity	[MWe]	680	340	179	478	703	897

Sensitivity of duration of charging and discharging





V1-01: 5h charging / 5h discharging (current regulation on capacity payments)

V1-12: 10h charging / 14h discharging (allows 24/7 combined with PV)

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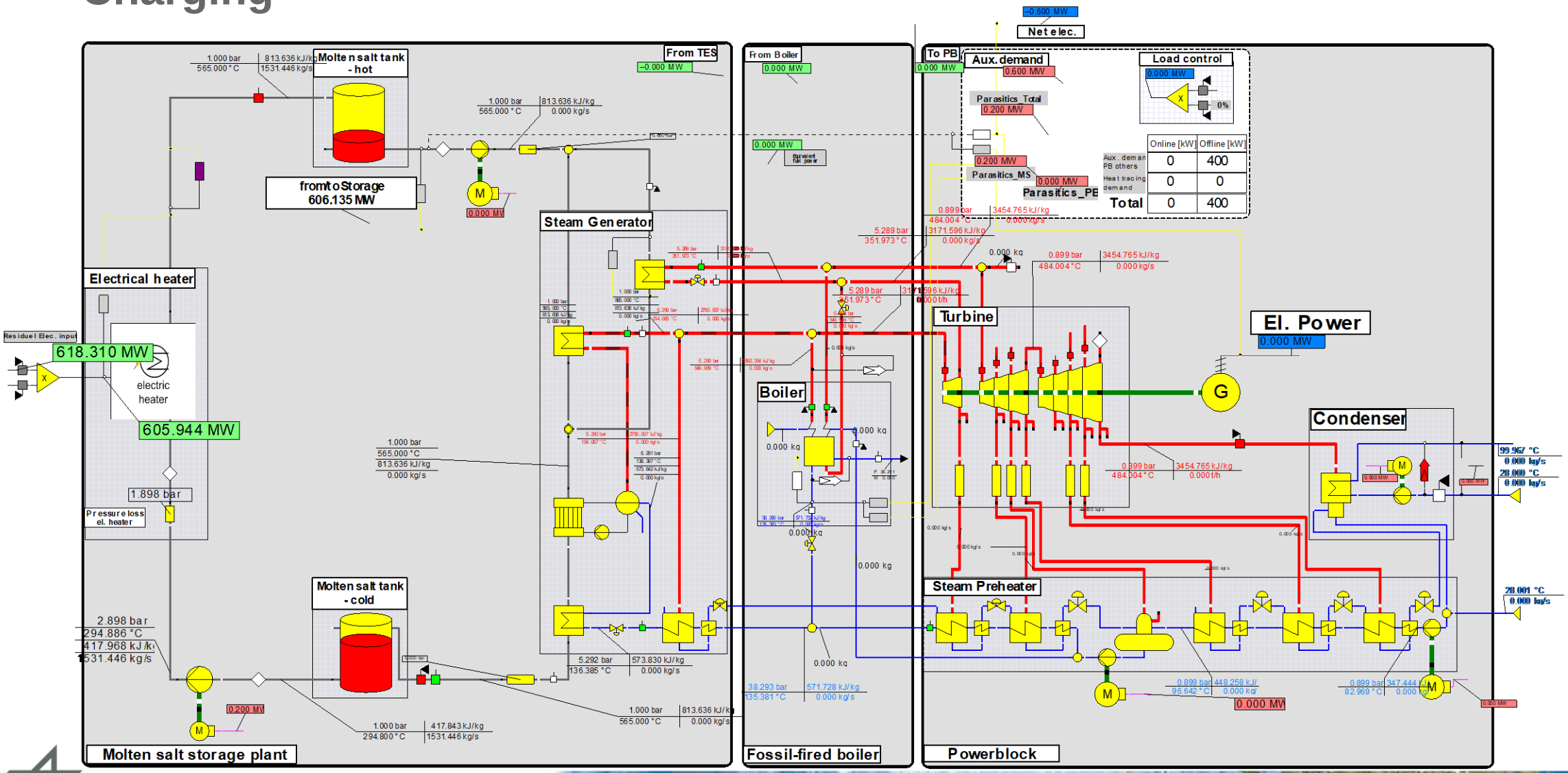
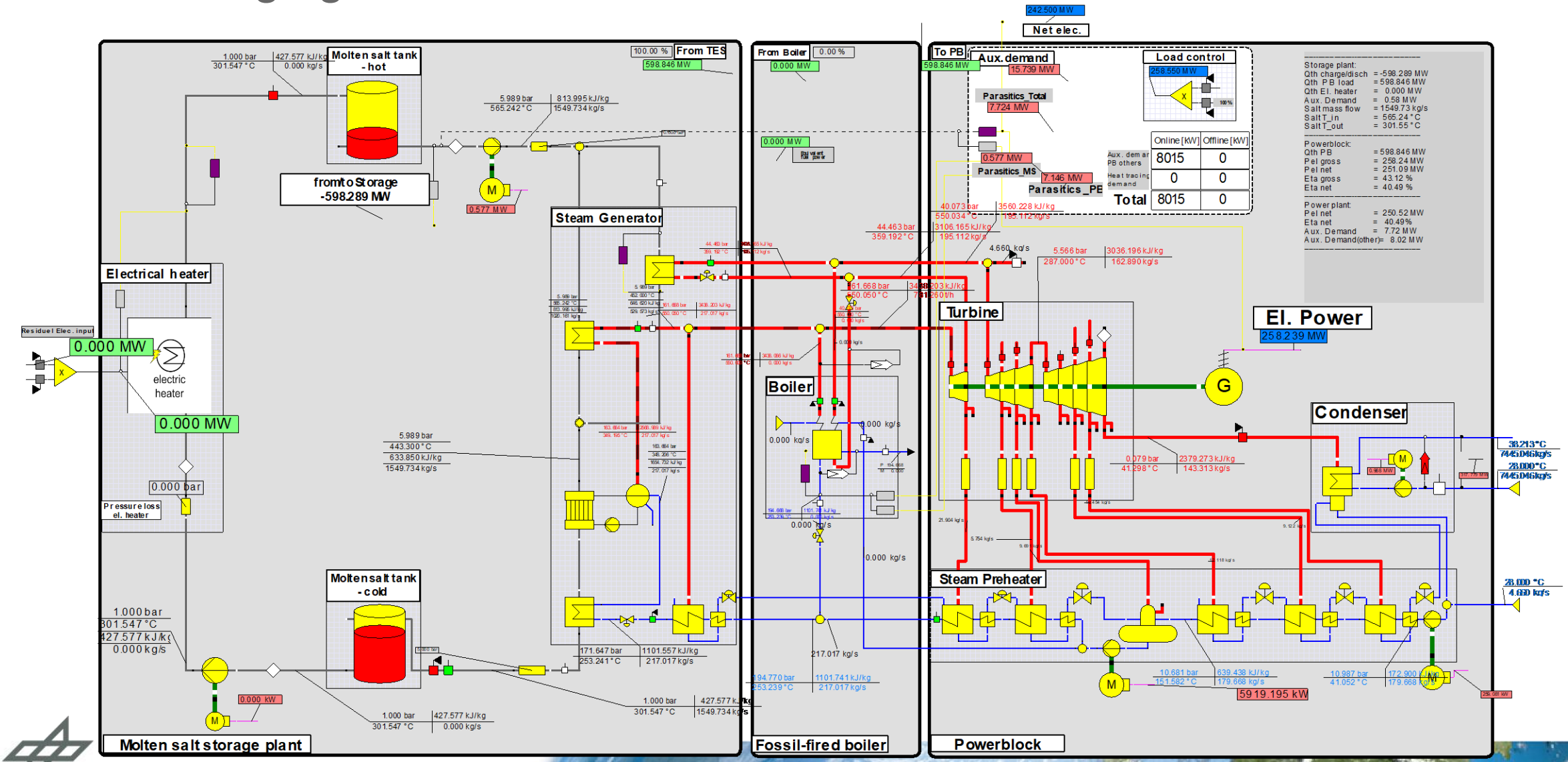
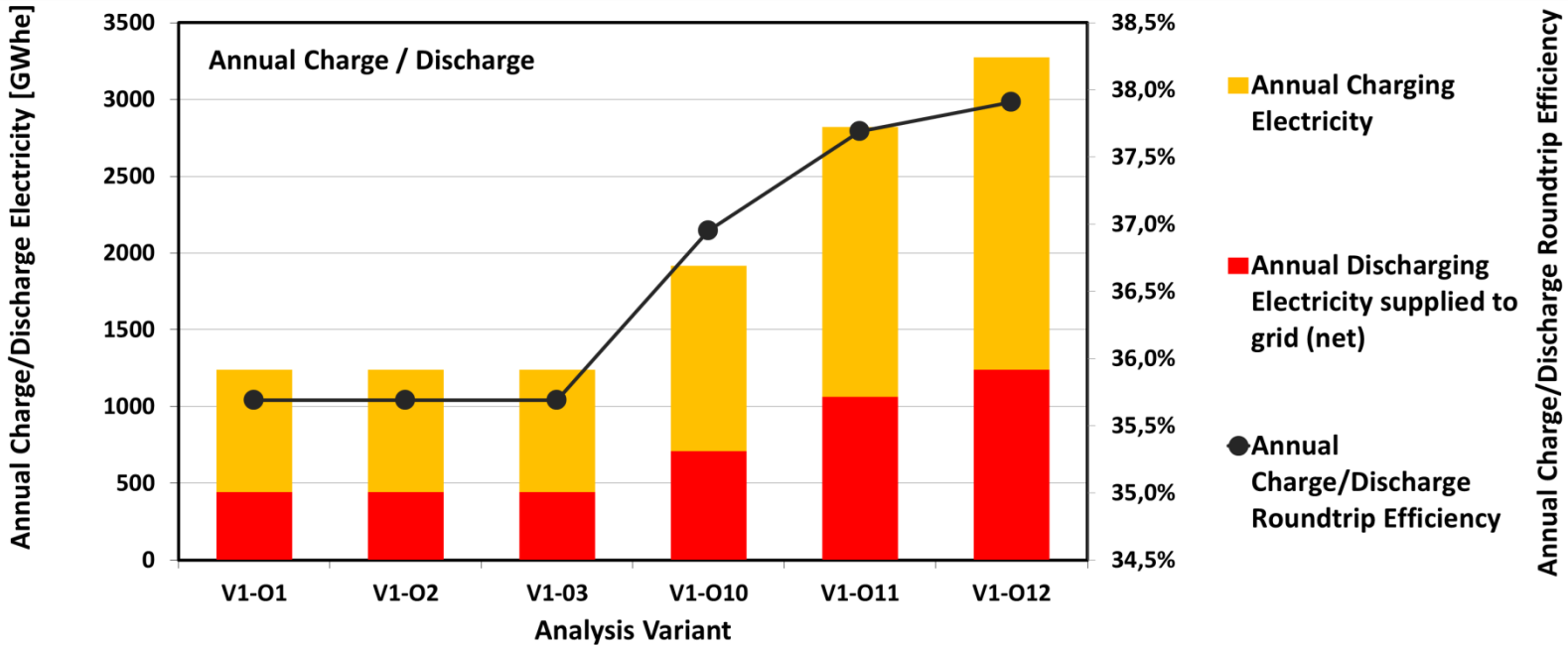
Case study Chile of a 250MWe coal plant retrofit with molten salt storage Charging



Case study Chile of a 250MWe coal plant retrofit with molten salt storage Discharging



Annual charging/discharging electricity and annual roundtrip charging/discharging efficiency



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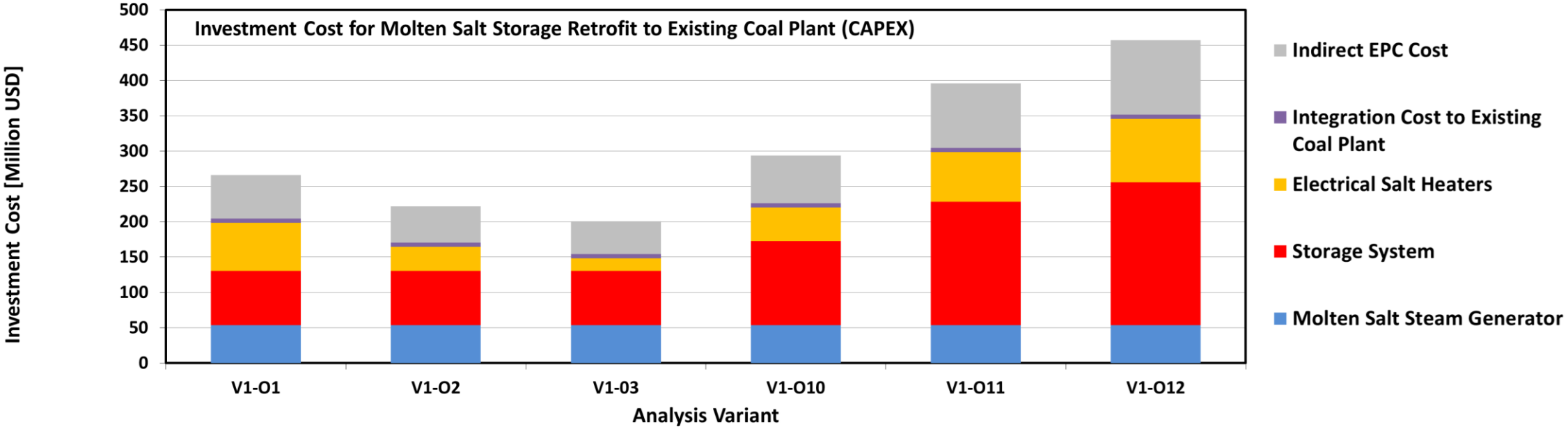
Investment cost (CAPEX) estimate for the retrofit of a molten salt storage



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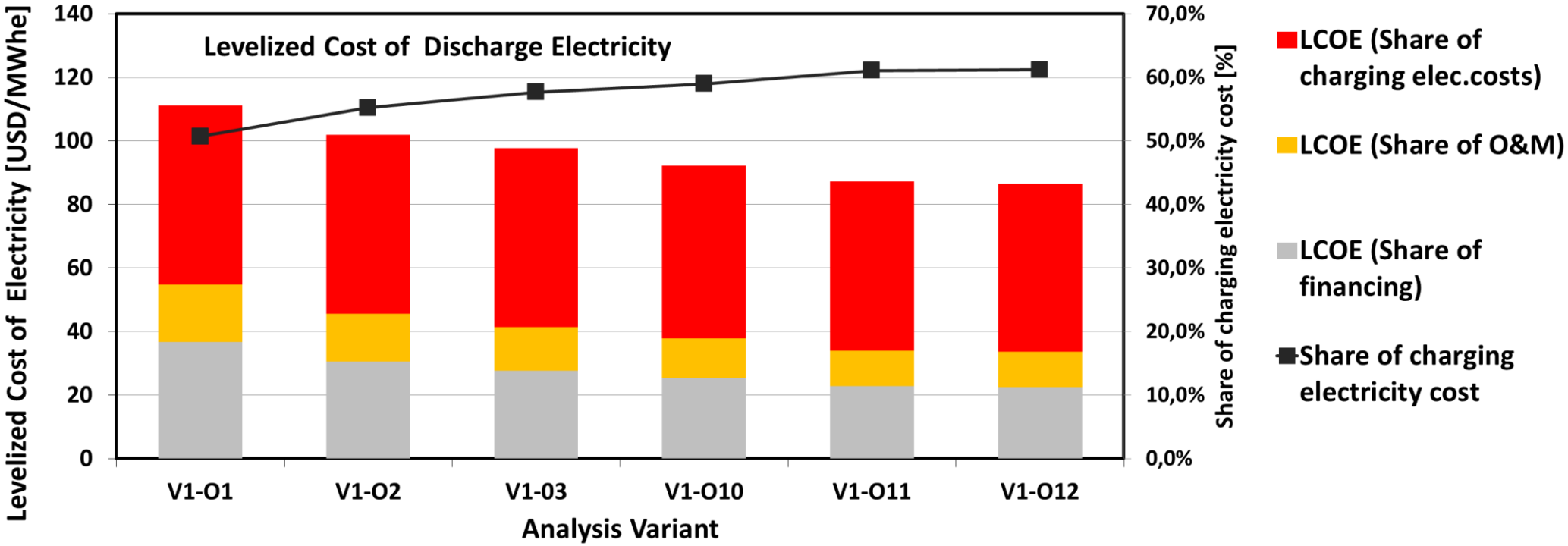
Levelized cost of discharge electricity for the retrofit of a molten salt storage



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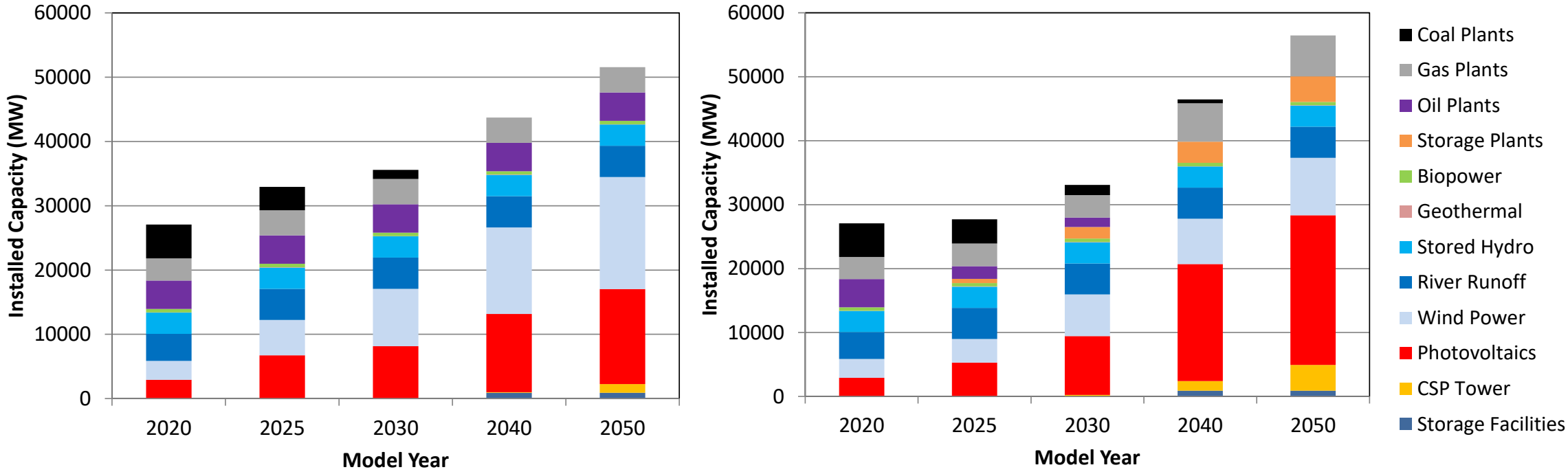
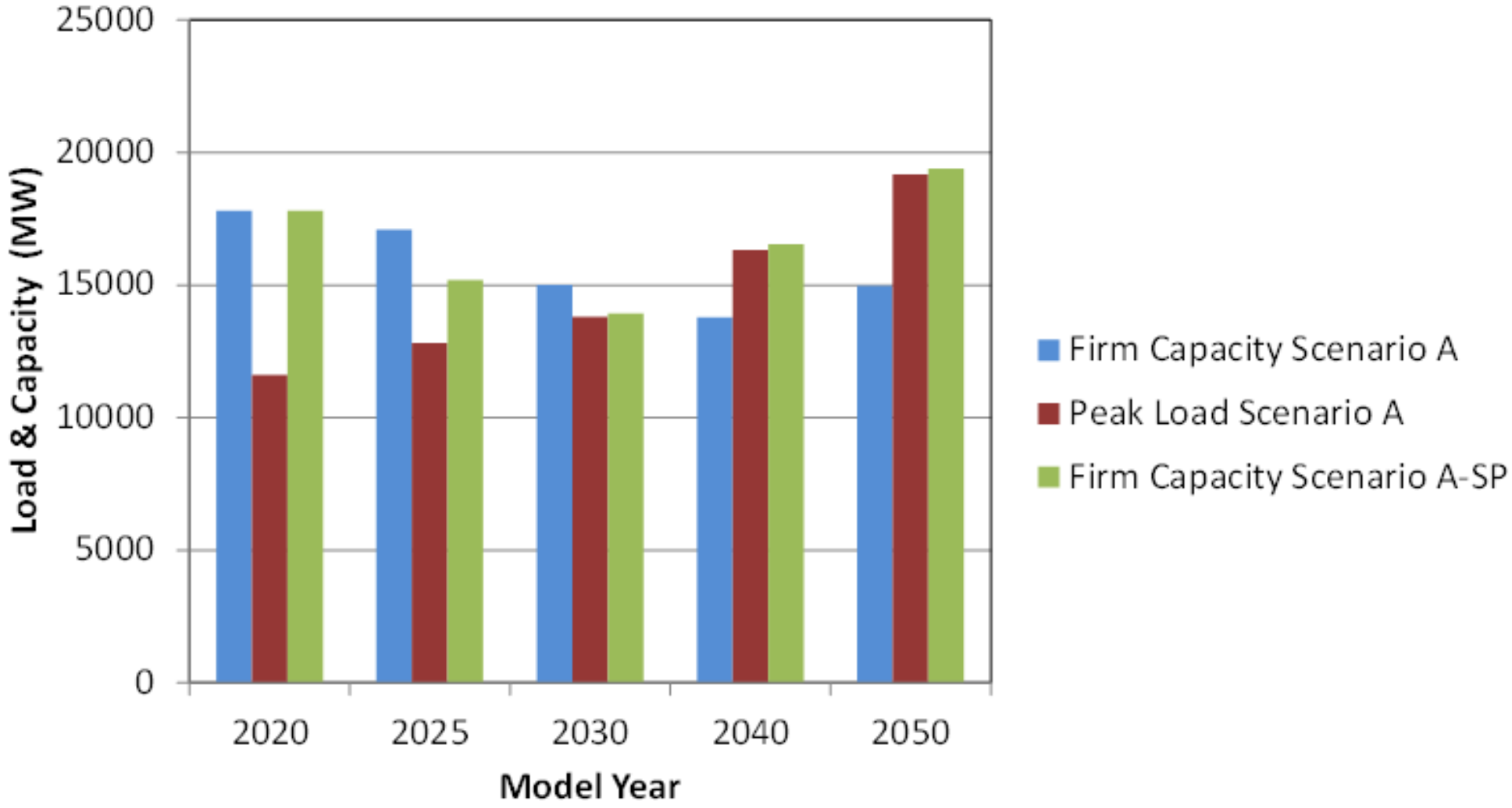
Adding storage plants to Planificación Energética de Largo Plazo (PELP)



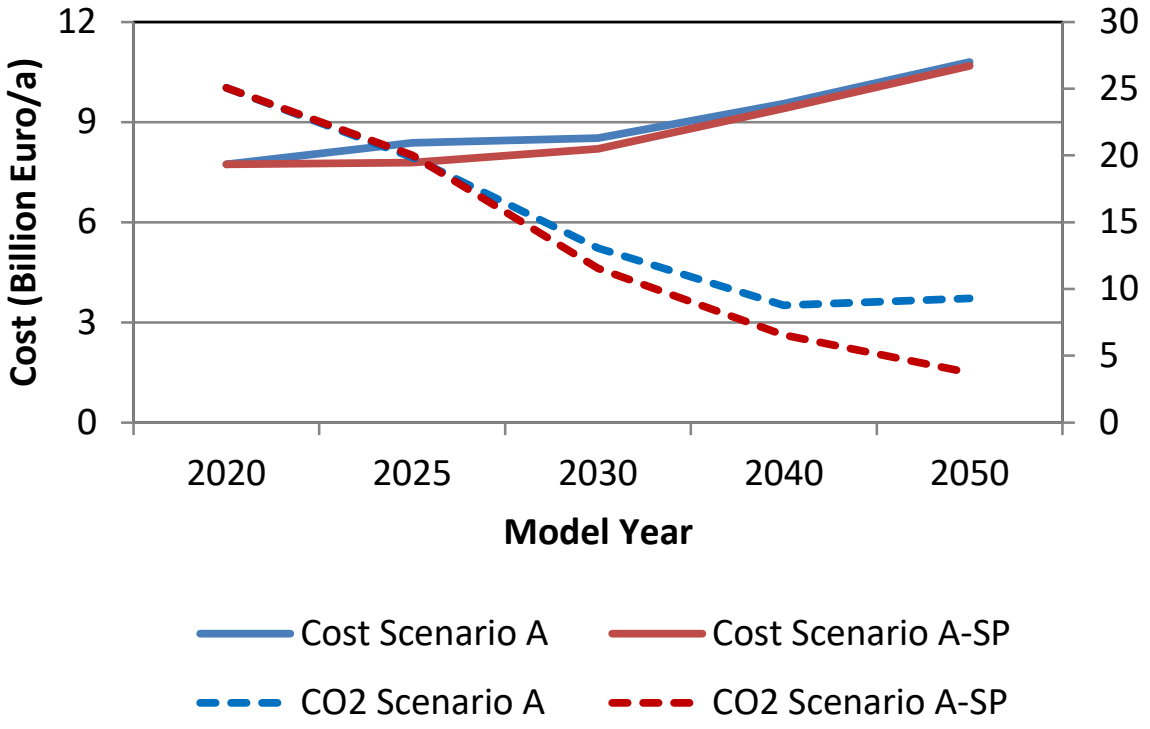
(a) Scenario A

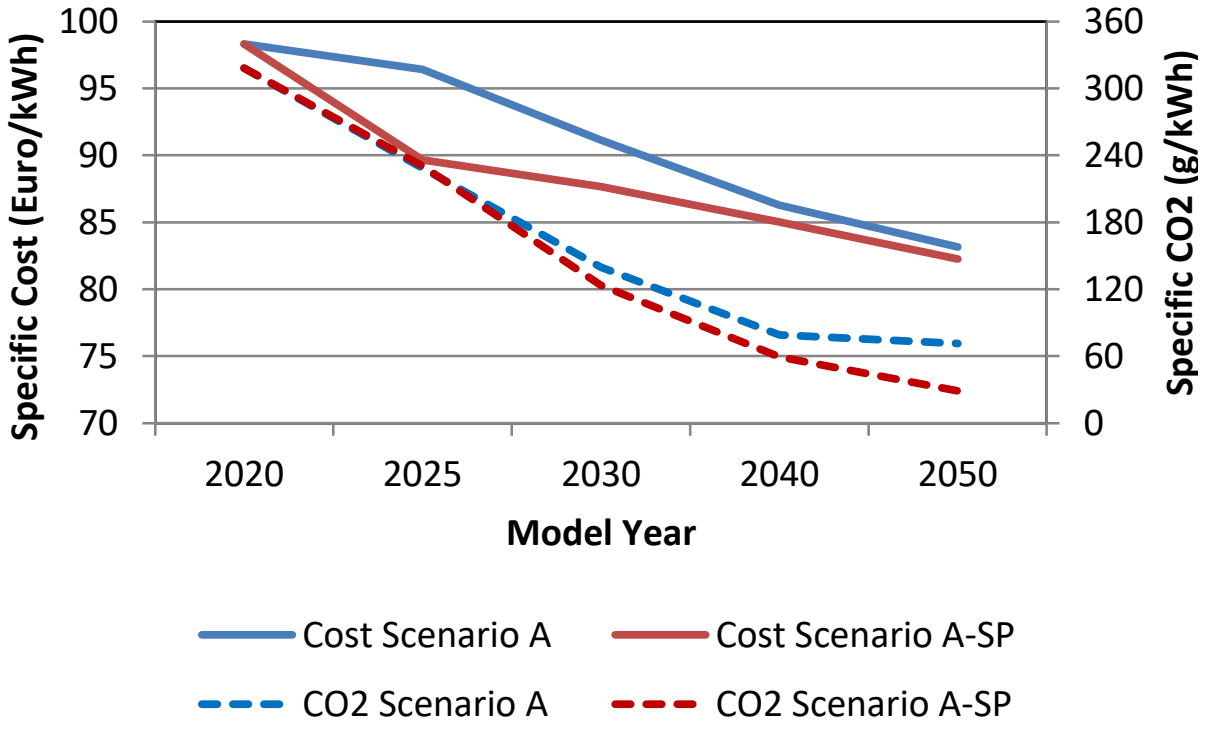
(b) Scenario A-SP

Adding storage plants improves secured firm capacity



Adding Storage Plants to Planificación Energética de Largo Plazo (PELP) reduces specific generation cost and CO2 emissions





a. Total annual Chilean power generation cost versus total annual carbon emissions

b. Specific Chilean cost of electricity versus its specific carbon emissions per kWhe

Chile has world wide best conditions for repurposing coal plants

- **World best solar resource => lowest cost of solar electricity.**
- **Import of coal => relatively high cost of coal electricity.**
- **Storage retrofit of plants decarbonizes the Chilean power park while granting 100% secure dispatchability of the power demand for the mining industry. Fossil backup firing option can be maintained.**
- **Storage thermal plants in the Northern grid system avoiding/reducing curtailment of PV electricity in Northern Chile.**
- **Chilean thermal power plants are relatively new and have a lot of space around their construction area, facilitating repurposing.**
- **Storage thermal plants make perfect use of existing power plant infrastructure and grid connection in strategic points of the electric transmission system.**
- **Operation experience and salts are locally available (SQM, CSP, Atacama Desert).**
- **Maintaining operations in existing sides, is maintaining jobs, avoiding social implications of energy transition.**

Chile has also world best mineral resources for electricity storage systems

Lithium Mining in the Atacama

Solar Salt Mining ($NaNO_3$ and KNO_3) in the Atacama