# TECHNO-ECONOMIC AND ENVIRONMENTAL ASSESSMENT OF **SOLAR DIRECT AIR CAPTURE**


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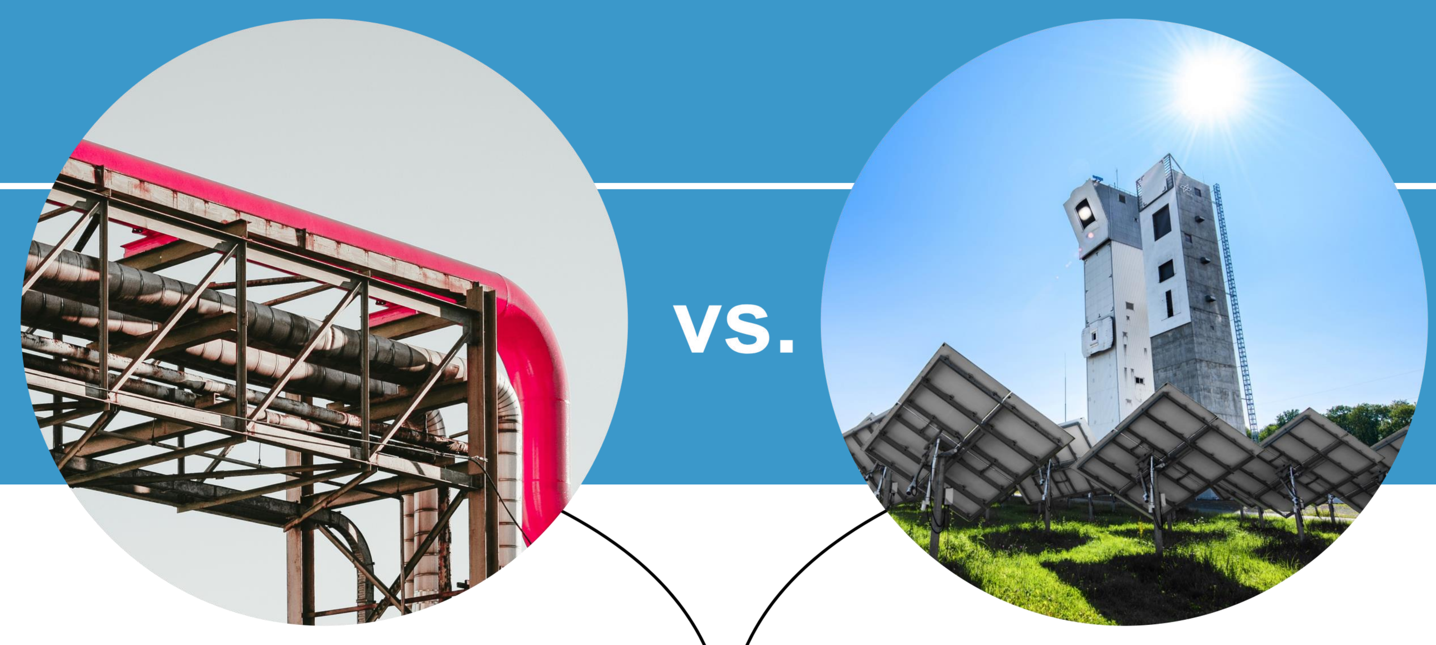
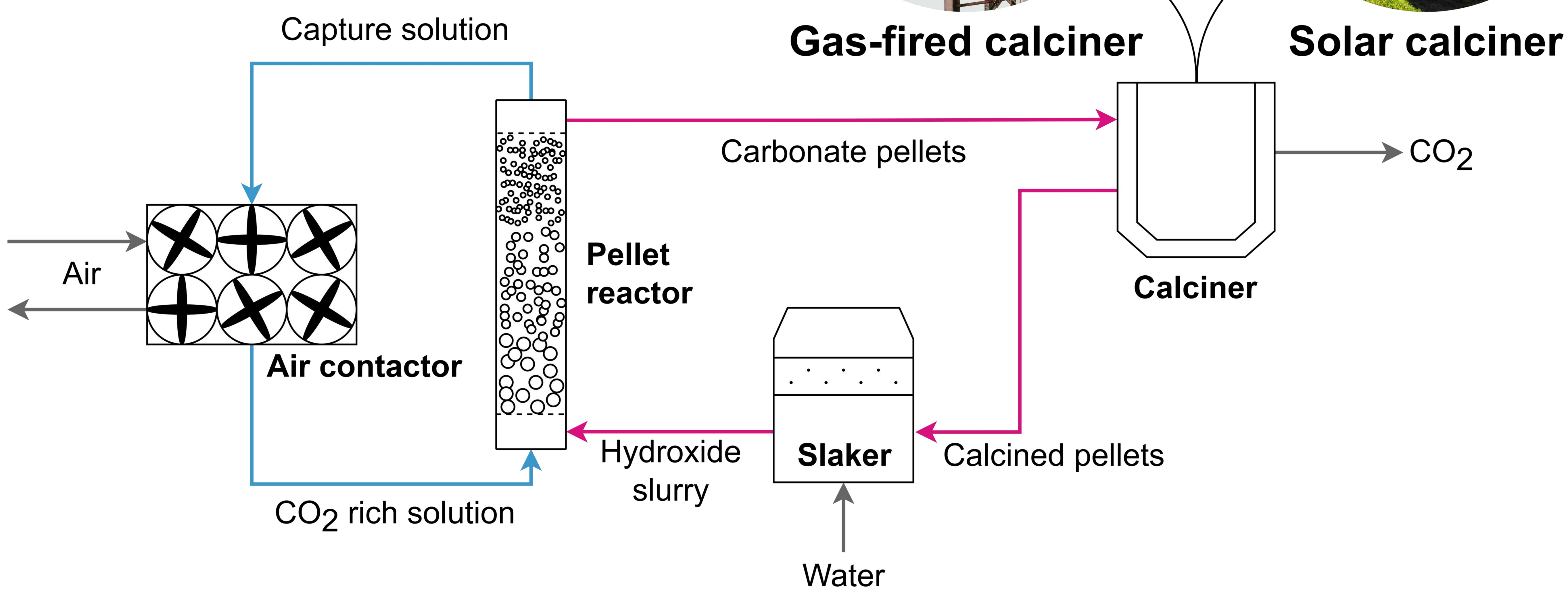



Direct air capture (DAC) is a technology that captures $CO_2$ from the atmosphere. Liquid solvent DAC (L-DAC) is one of the most advanced DAC technologies. It uses a liquid alkali solution like potassium hydroxide to react with atmospheric $CO_2$, forming carbonates. These carbonates are then heated to around 900 °C to release pure $CO_2$, typically using natural gas, resulting in mixed fossil and captured $CO_2$. Solar-powered L-DAC improves this process by using solar thermal energy instead of natural gas for the high-temperature calcination.

## Methodology

**Simulation:** Process units were simulated with Aspen Plus, HFLCAL and Greenius. The model was fed with real meteorological data with hourly resolution from Meteonorm.

**Screening of locations:** A geospatial analysis was conducted to understand the impact of climate. It focused on coastal areas with access to desalinated water and latitudes below 45°. Criteria for land availability included slope, land cover, and protected areas.

**Techno-economic assessment:** An optimization algorithm sized the solar equipment to minimise CAPEX while maintaining the plant energetic self-sufficiency. Fixed OPEX was based on CAPEX and variable OPEX included make-up chemicals and labour.

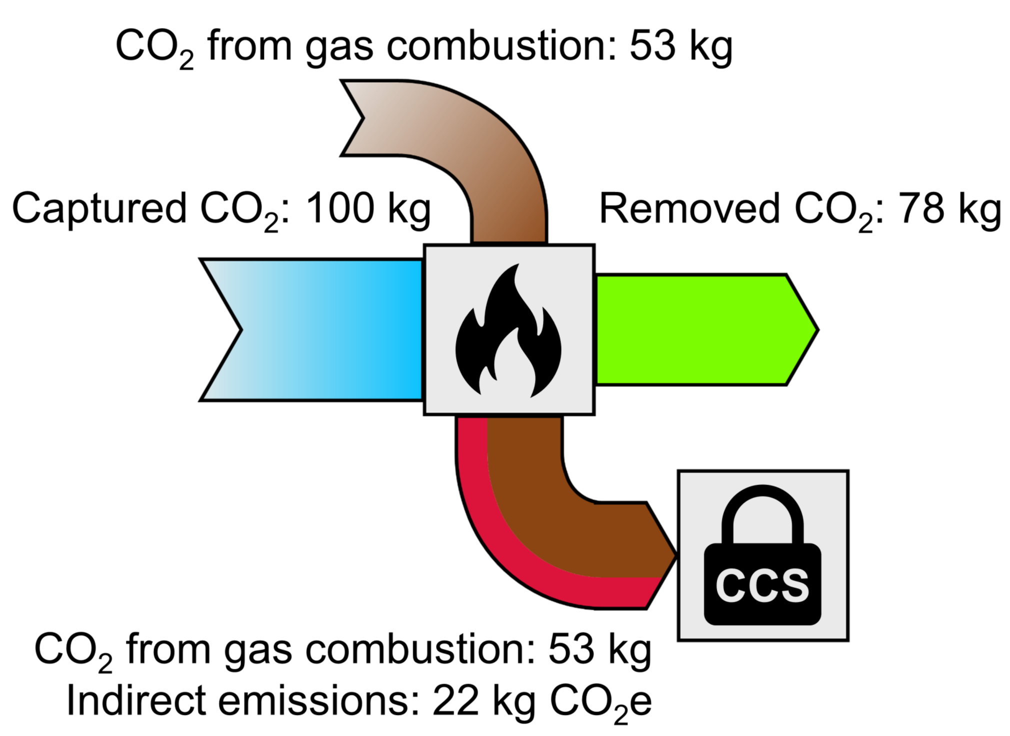
**Life cycle assessment:** Based on literature inventories and conducted with openLCA 2.0.0 using the ecoinvent 3.7.1 database and the *ReCiPe Midpoint (H) w/o LT* method.

## Model overview:

| | |
|---|---|
| meteonorm | Meteorological data |
| | Process simulation |
| DLR | Solar field & PV models |
| ecoinvent | LCA database |
| openLCA | LCA software |
| | Cost estimation |

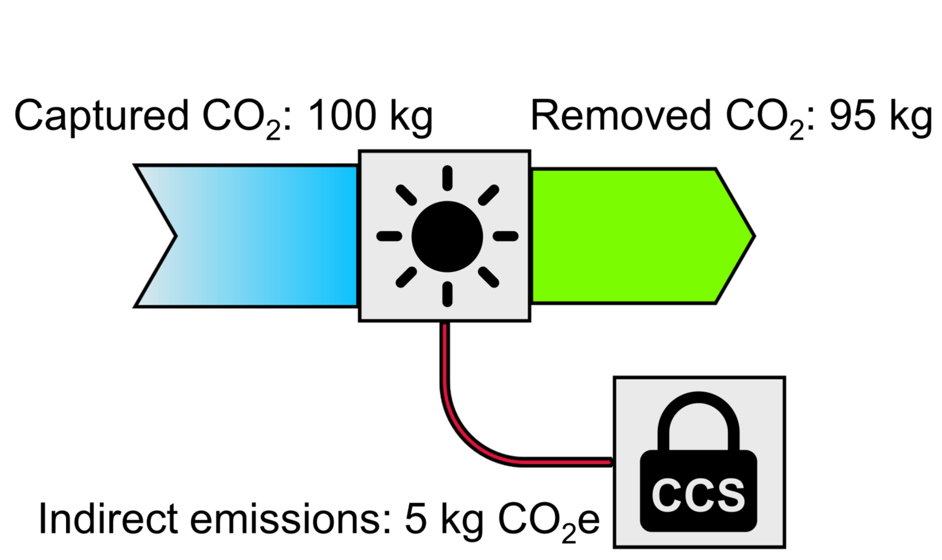
### Gas-powered DAC

320 – 440 USD/t $CO_2$ removed




### Solar-powered DAC

260 – 320 USD/t $CO_2$ removed




## Results

**DAC's importance**: DAC can be an enabler of the energy transition.

**Synergies with solar energy:** Solar-powered L-DAC is competitive in many locations.

**Promising alternative**: Solar thermal energy can decouple L-DAC and other industrial processes from fossil fuels.

DLR