

# SOLAR DIRECT AIR CAPTURE

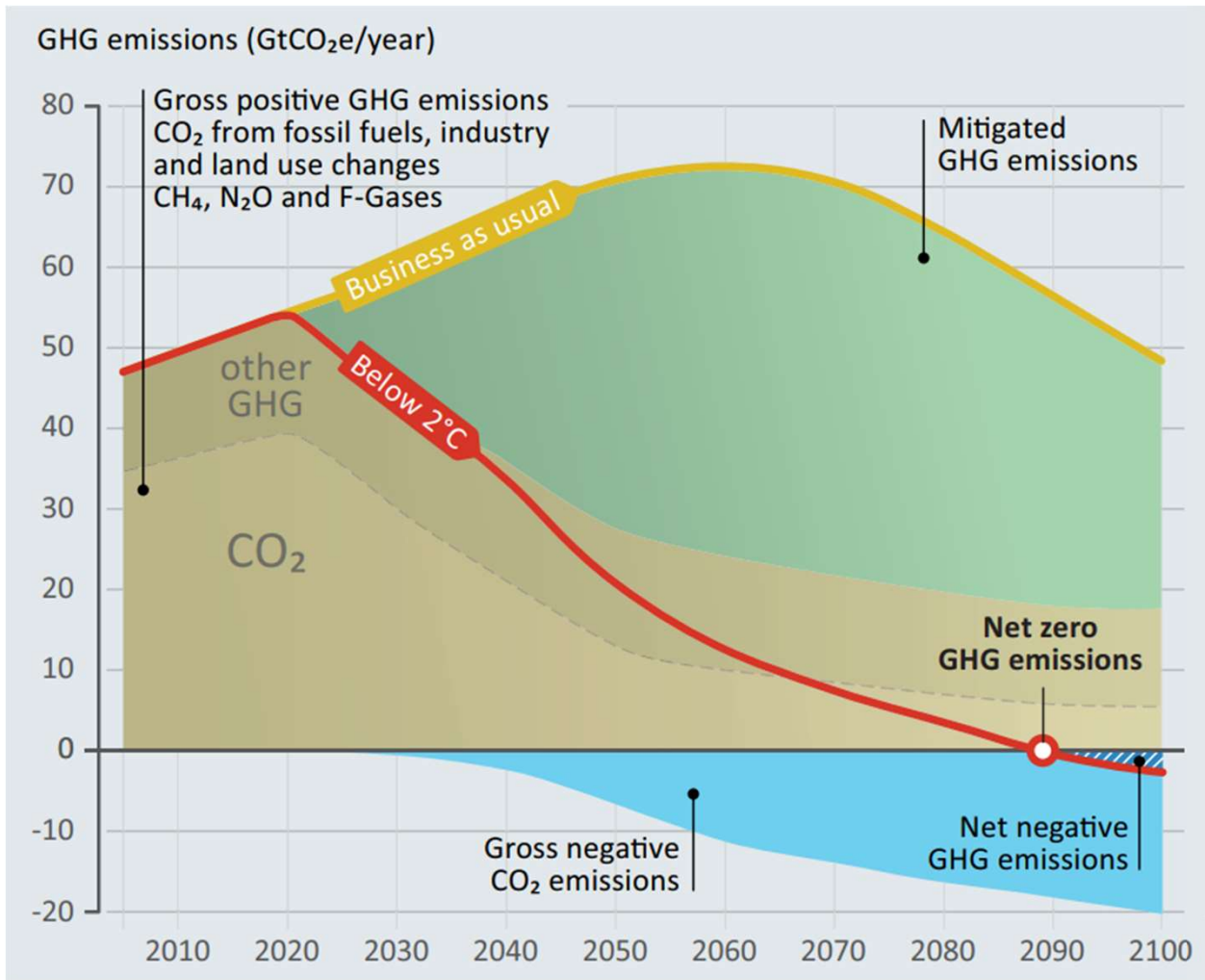
Enric Prats-Salvado – DLR Doctoral Symposium 2023



# What is direct air capture of CO<sub>2</sub>?



# Why do we need direct air capture?



## Carbon Capture & Storage (CCS):



Reverse emissions



## Carbon Capture & Utilization (CCU):



Main solution for hard-to-abate sectors



Accelerate transition in other sectors

Source: UNEP Emissions Gap Report 2017

# How does direct air capture work?



## Solid Direct Air Capture (S-DAC)



Climeworks (2021, 4 kt CO<sub>2</sub>/y, Iceland)

## Liquid Direct Air Capture (L-DAC)

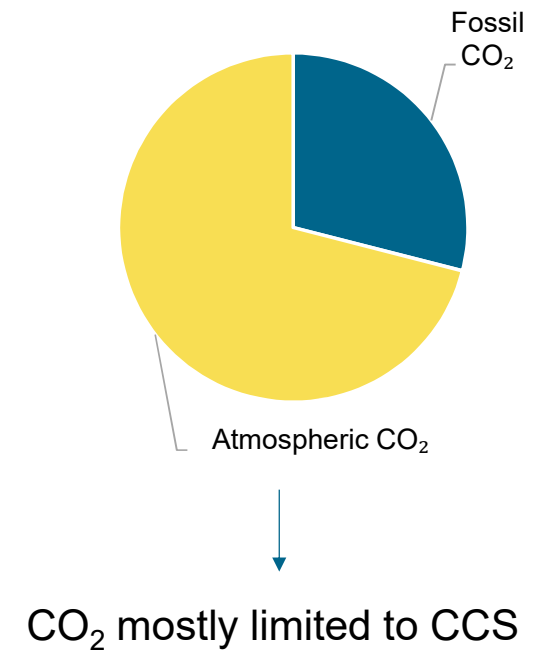
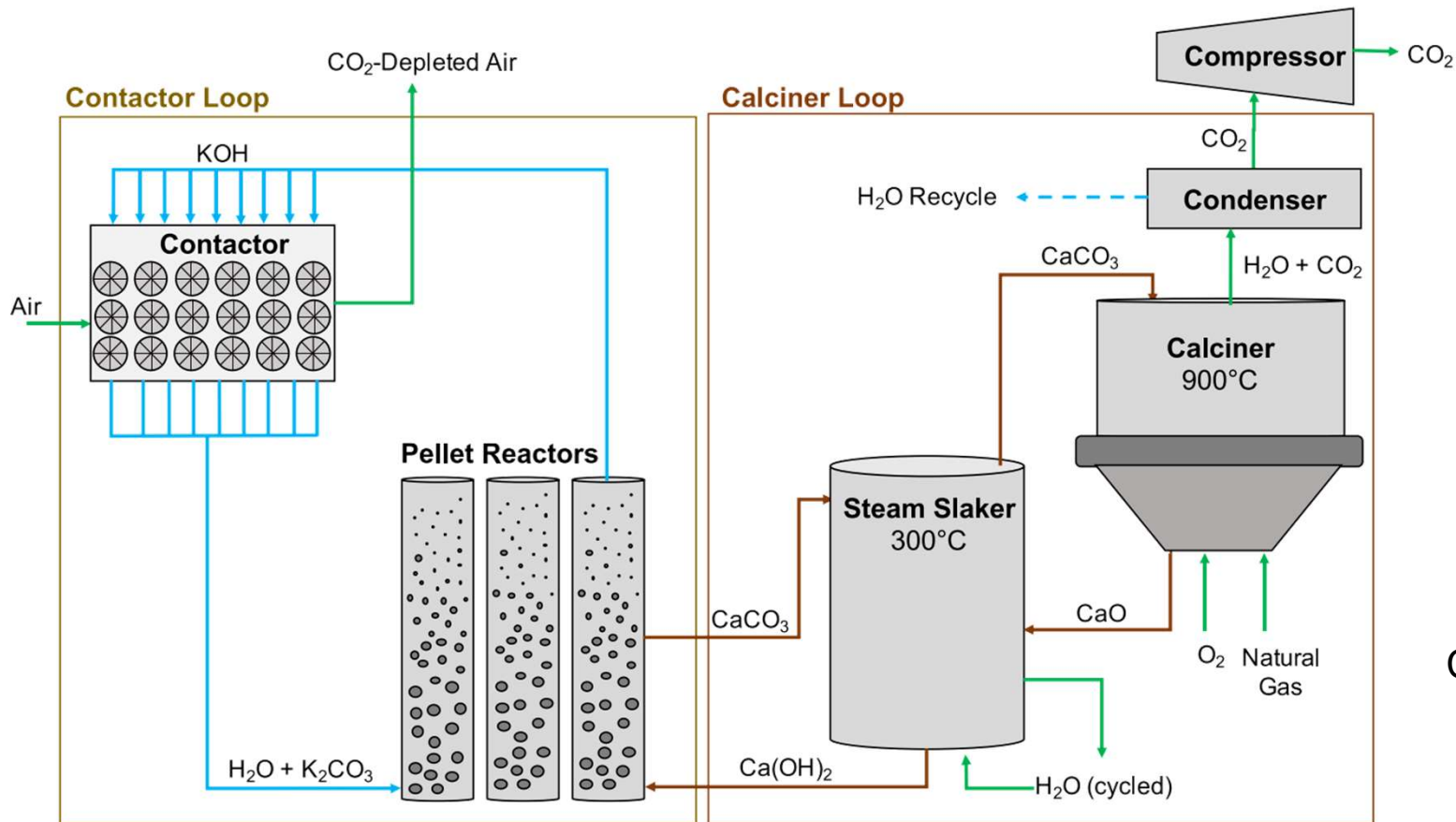


Carbon Engineering (2024, 0.5 Mt CO<sub>2</sub>/y, US)

Sources: climeworks.com; iea.org




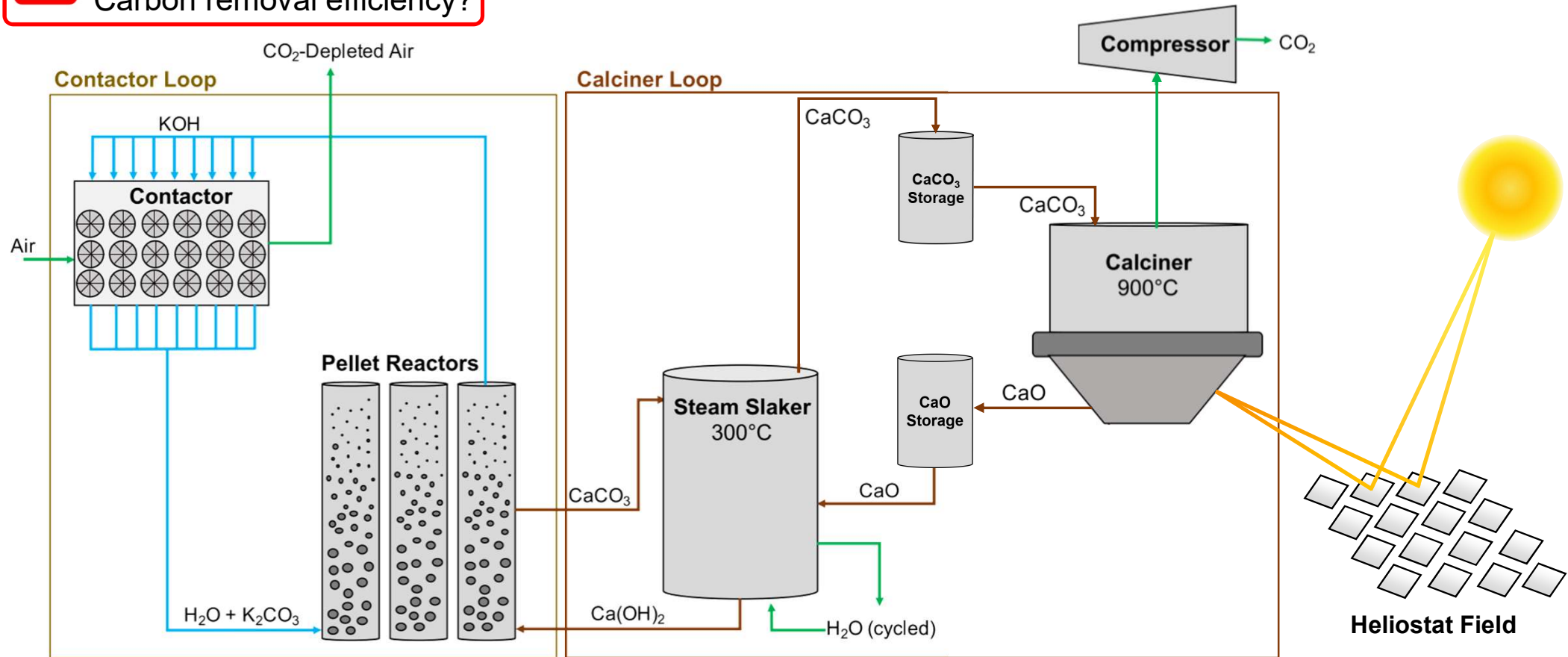
# How can we use solar energy in L-DAC?



Sources: Fasihi 2019, McQueen et al. 2021

# How can we use solar energy in L-DAC?

 Water losses?  
Carbon removal efficiency?



# Is there a suitable location for solar L-DAC?

## Requirements:

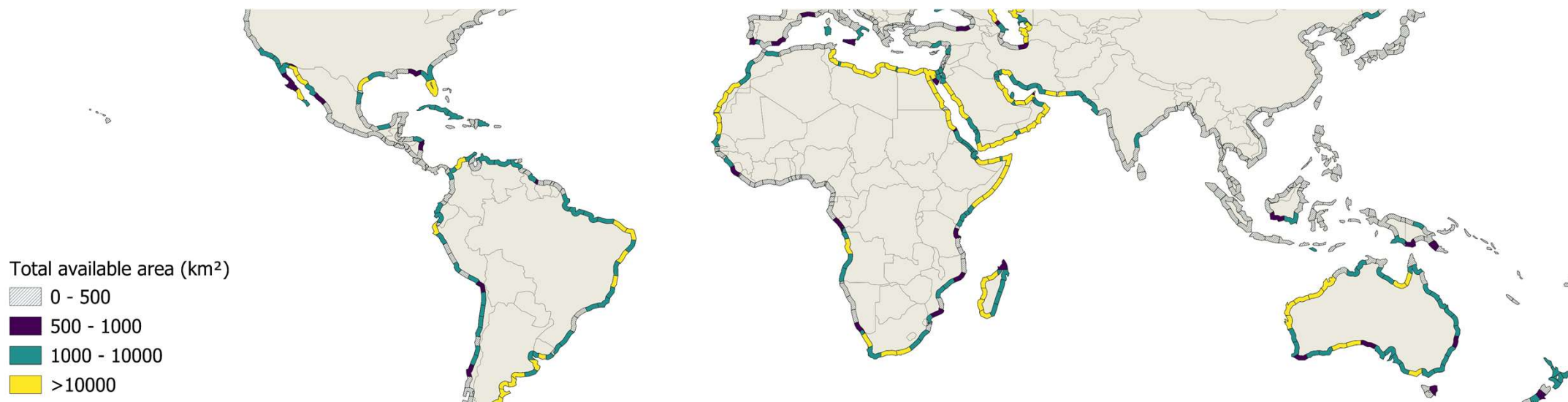
- 1) L-DAC is water-intensive and must be scalable → Desalination water →  $\approx 100$  km from sea
- 2) Solar equipment is a significant part of the CAPEX → Between  $\pm 45^\circ$  Latitude



# Is there a suitable location for solar L-DAC?

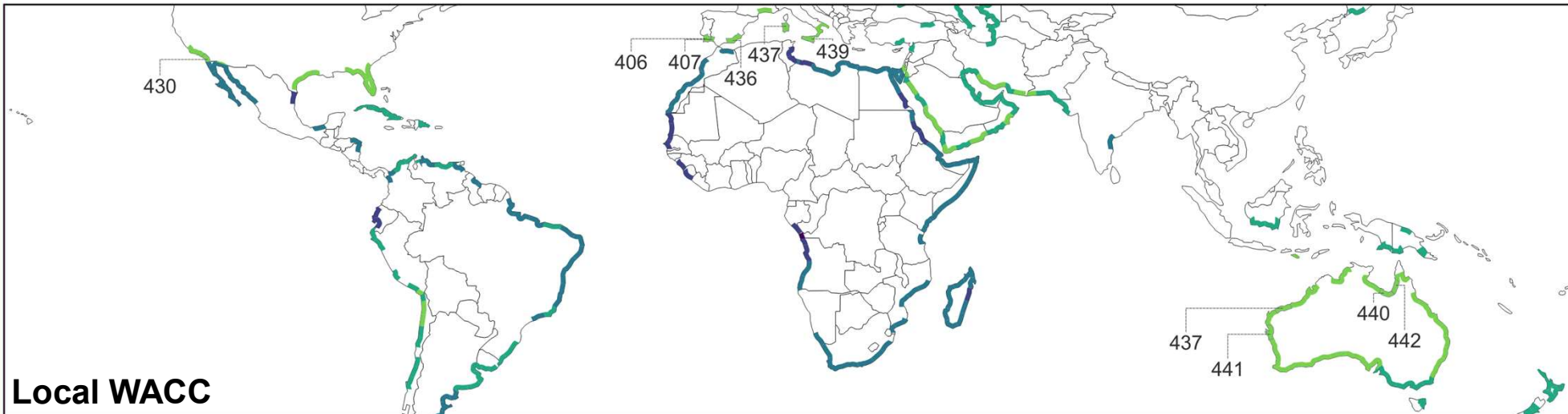
Criteria for considering land as available:

- 1) Maximum slope < 2.1%
- 2) Land use: shrubs, herbaceous vegetation, bare / sparse vegetation
- 3) No protection of the land





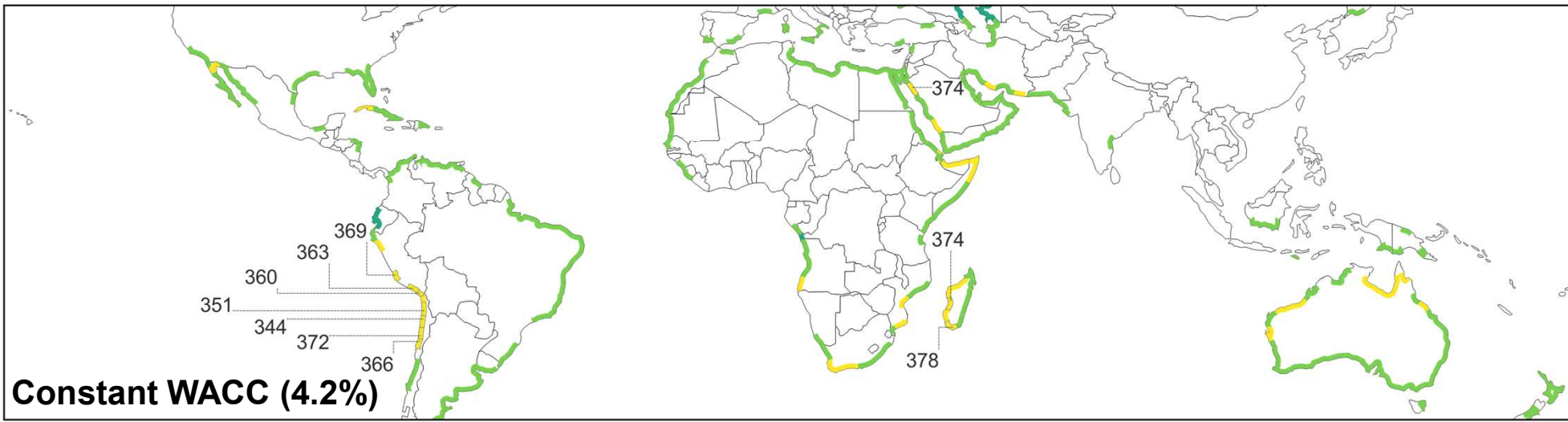
# Levelized Cost of Produced CO<sub>2</sub> (LCOP)



LCOP  
(USD<sub>2022</sub>/t CO<sub>2</sub>)

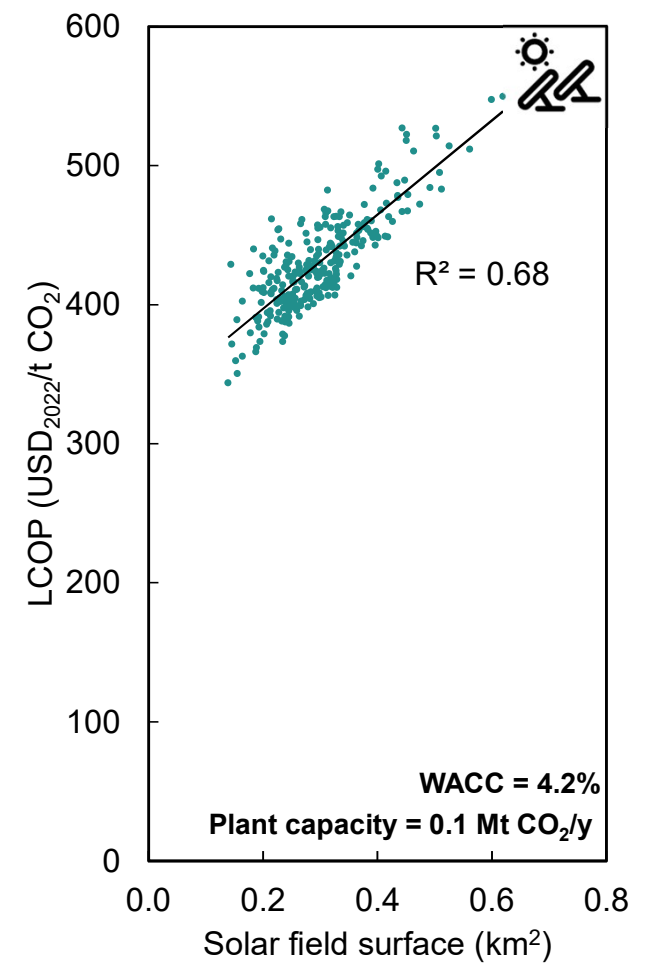
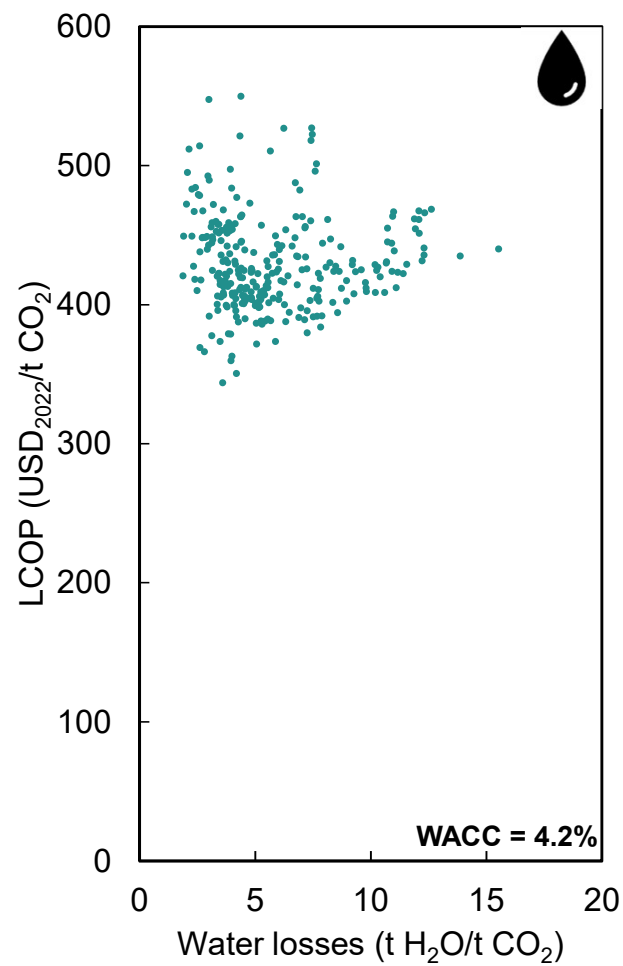
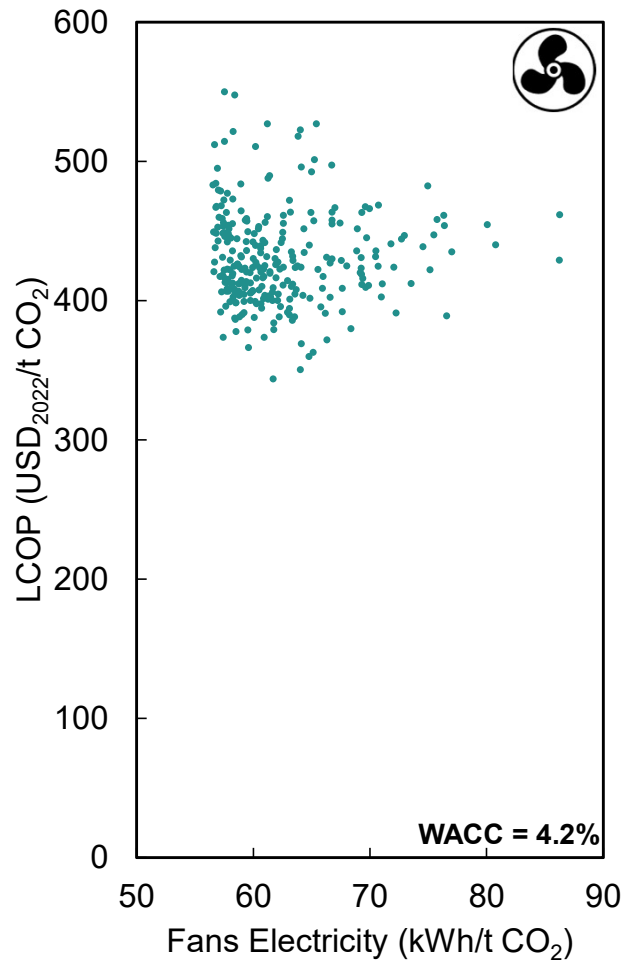
- 300 - 400
- 400 - 500
- 500 - 600
- 600 - 700
- 700 - 800
- >800

Plant Size:  
0.1 Mt CO<sub>2</sub>/y



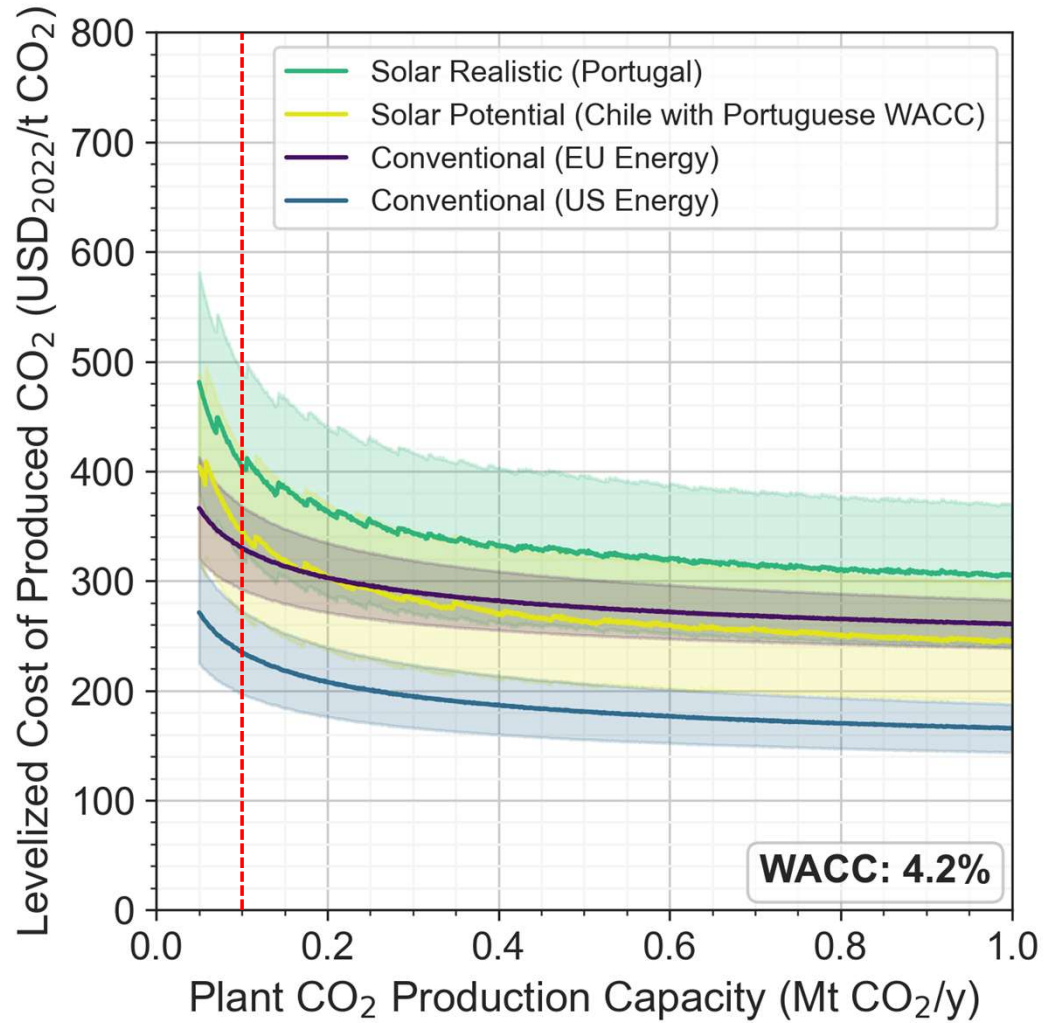
WACC: Weighted Average Cost of Capital

# Impact of environmental conditions: Correlations

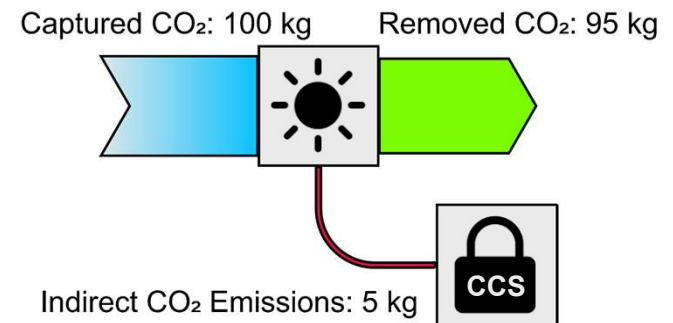
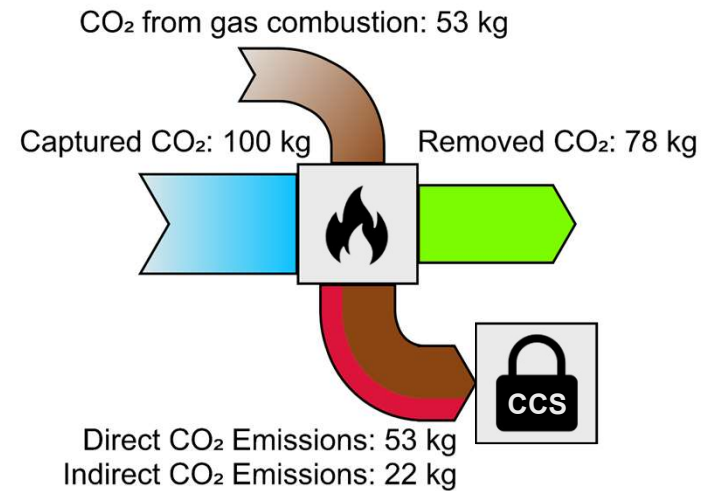
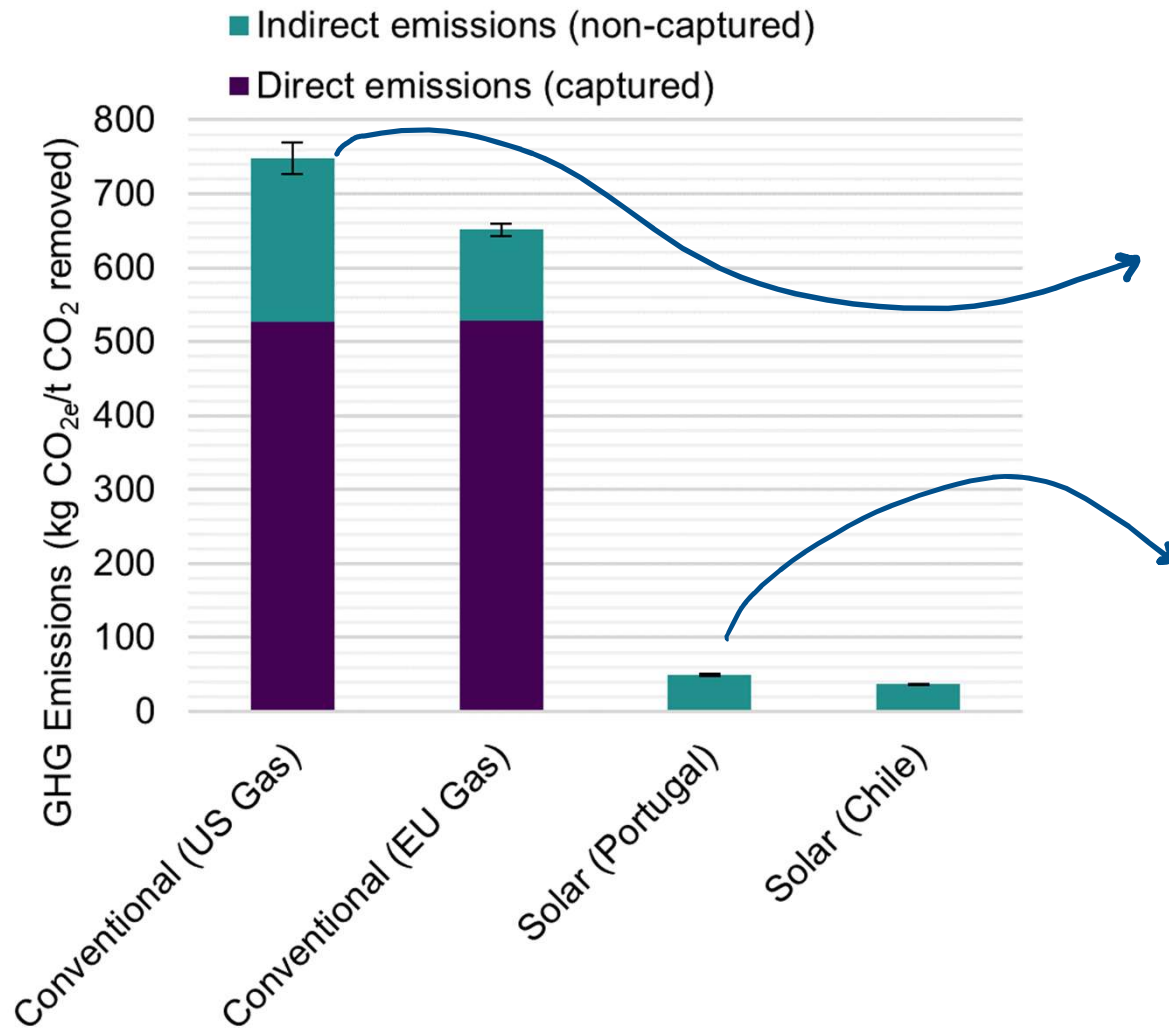


WACC: Weighted Average Cost of Capital

# Impact of scale

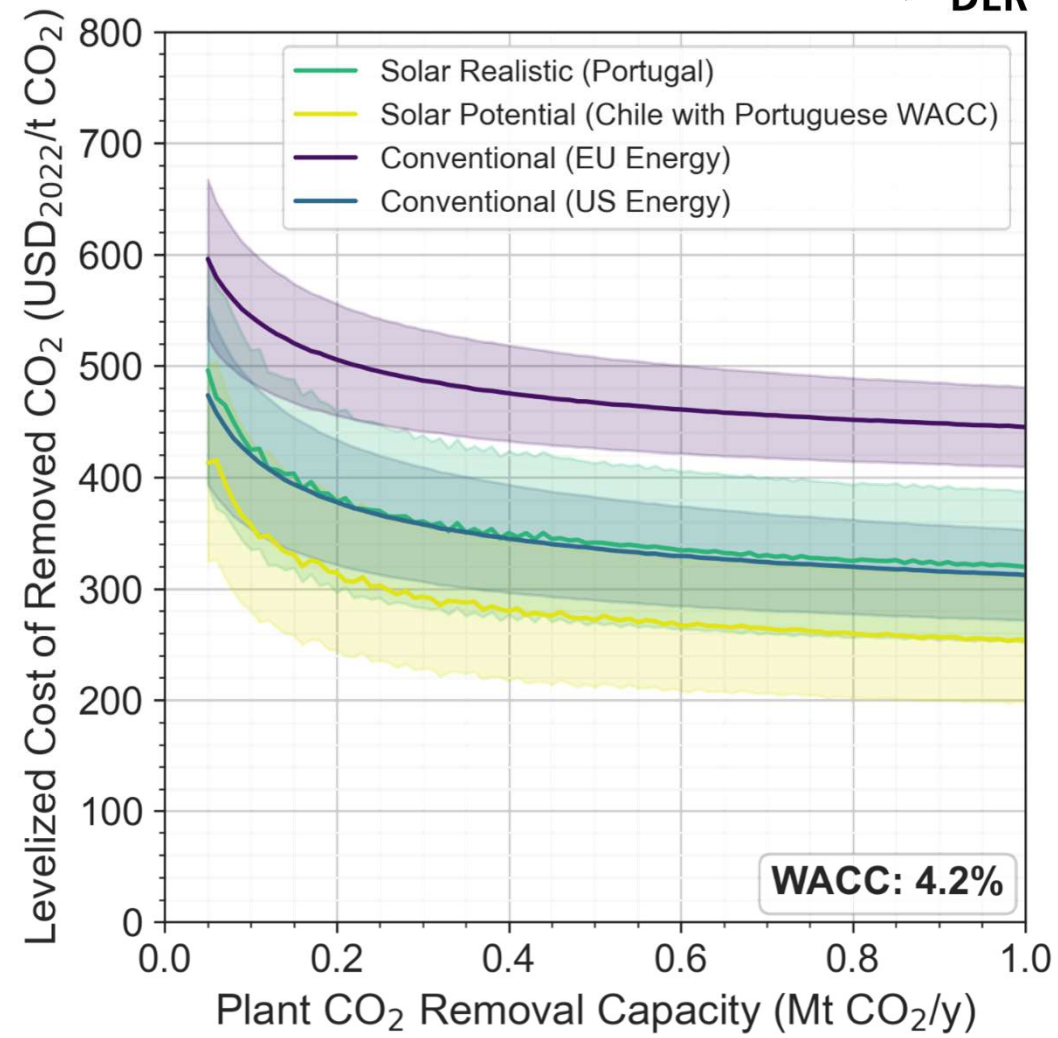
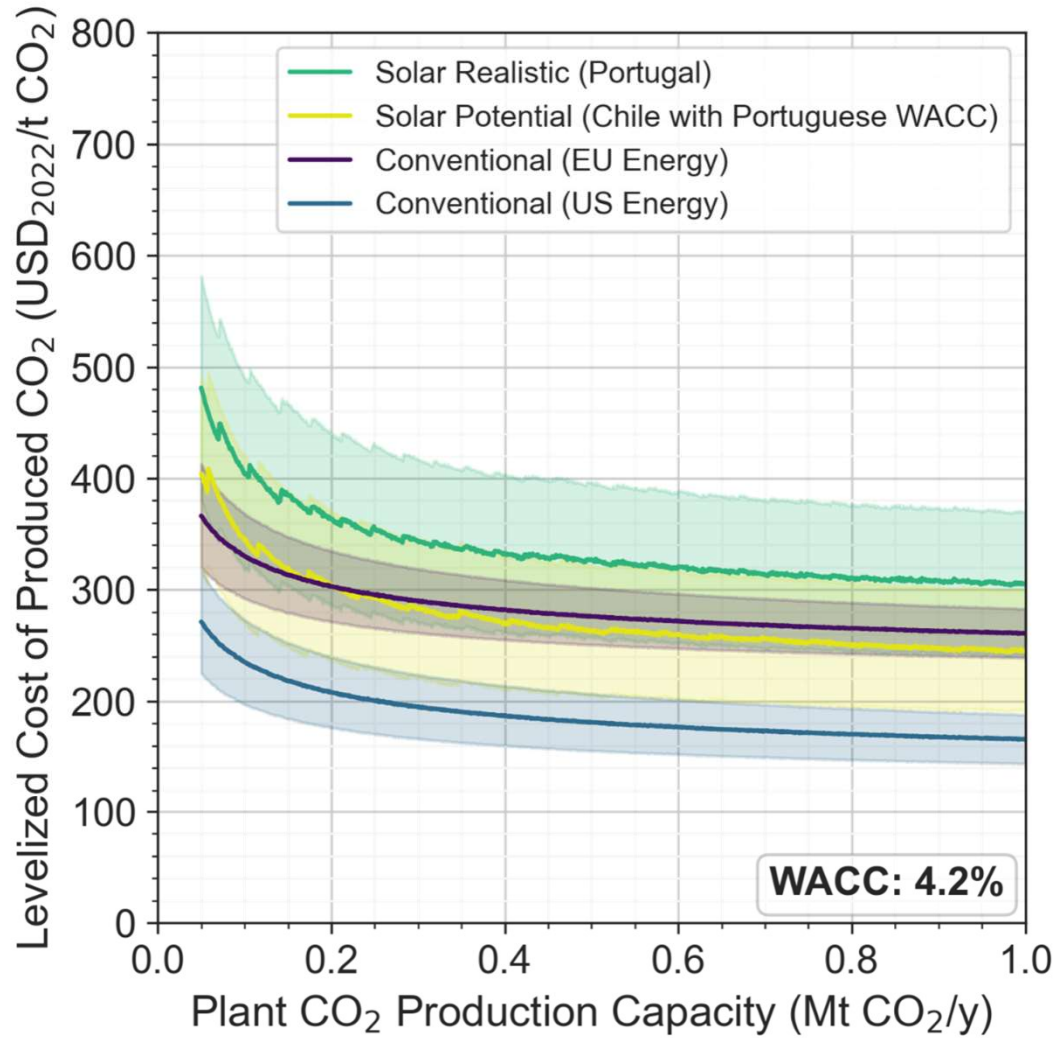


# Impact of associated emissions (LCA)





# Impact of associated emissions



# Take home messages



DAC: Enabling the energy transition



Solar energy & DAC: Synergies in specific locations



Solar thermal energy: Cost-effective solution for decarbonization

Thanks for your attention!

