SYNERGIES BETWEEN **DIRECT AIR CAPTURE** AND **SOLAR HYDROGEN** AND **FUEL** PRODUCTION

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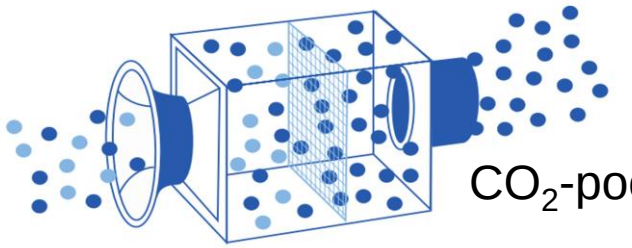
DLR

What is direct air capture of CO_2?

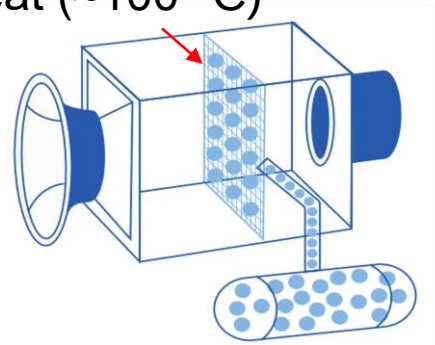
How does direct air capture work?

Solid Direct Air Capture (S-DAC)



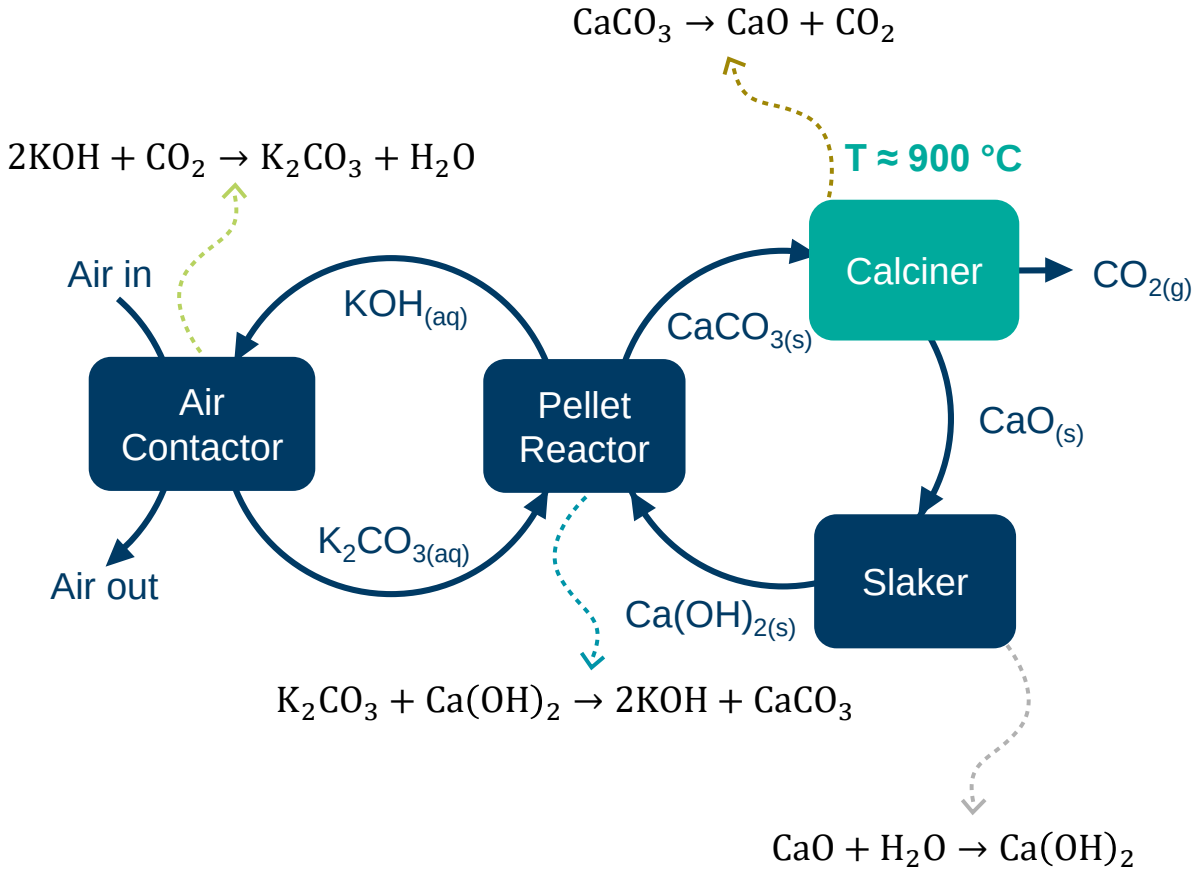
CO_2-poor Air

Heat (≈100 °C)



Concentrated CO_2 (+H_2O)

Liquid Direct Air Capture (L-DAC)



Source: Deutz and Bardow 2021

How does direct air capture work?

Solid Direct Air Capture (S-DAC)

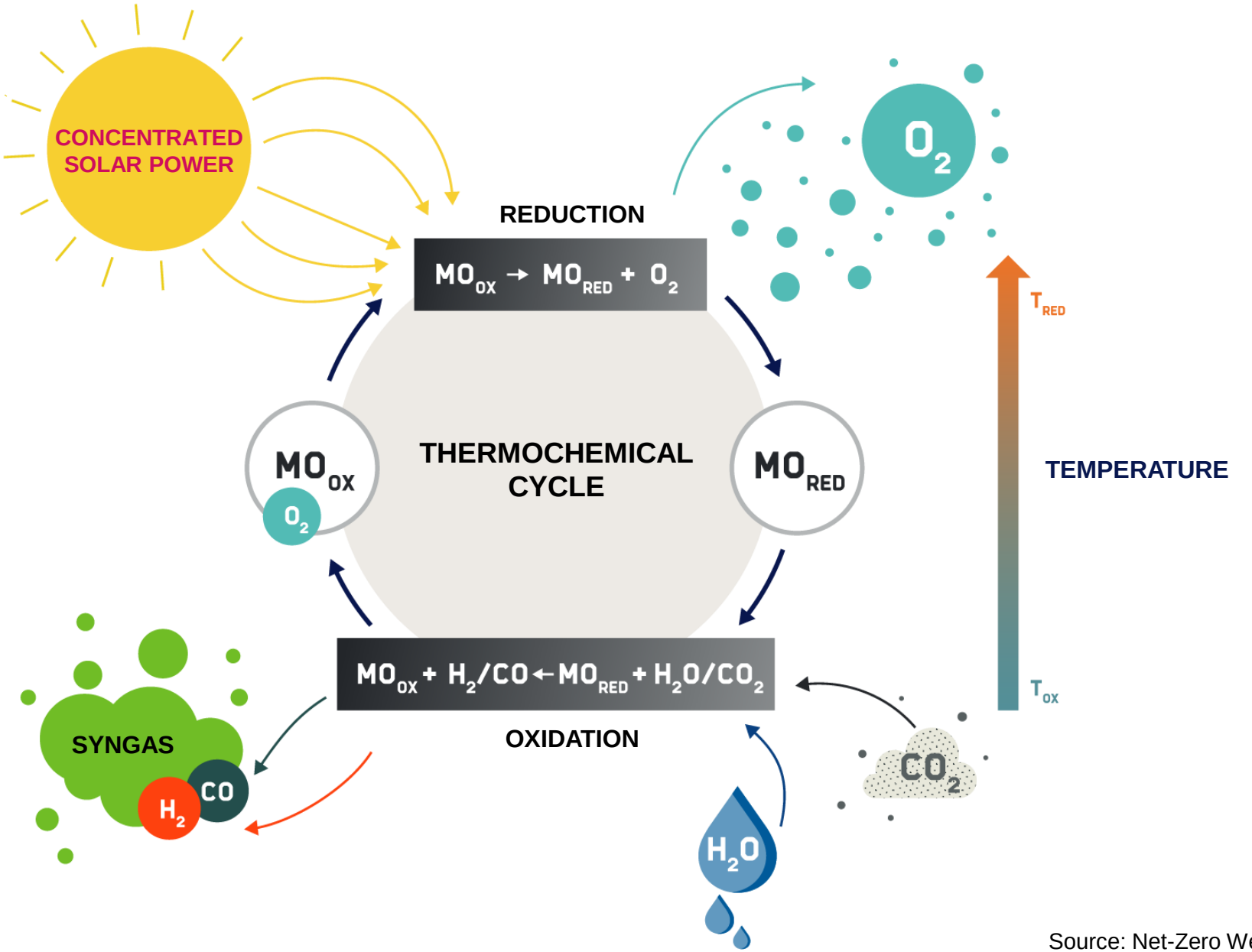
Climeworks (2021, 4 kt CO_2/y, Iceland)

Liquid Direct Air Capture (L-DAC)

Carbon Engineering (2025, 0.5 Mt CO_2/y, US)

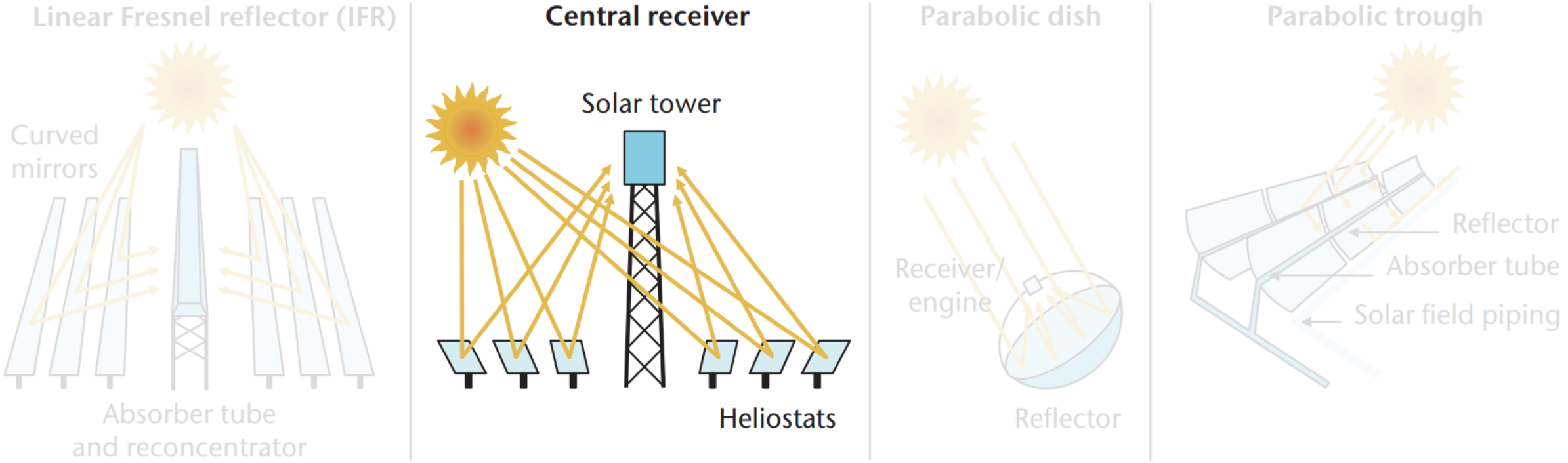
Sources: climeworks.com; iea.org

Production of solar fuels with thermochemical cycles



Source: Net-Zero Web-Atlas (atlas.netto-null.org)

How are thermochemical cycles powered?



Source: IEA, 2014

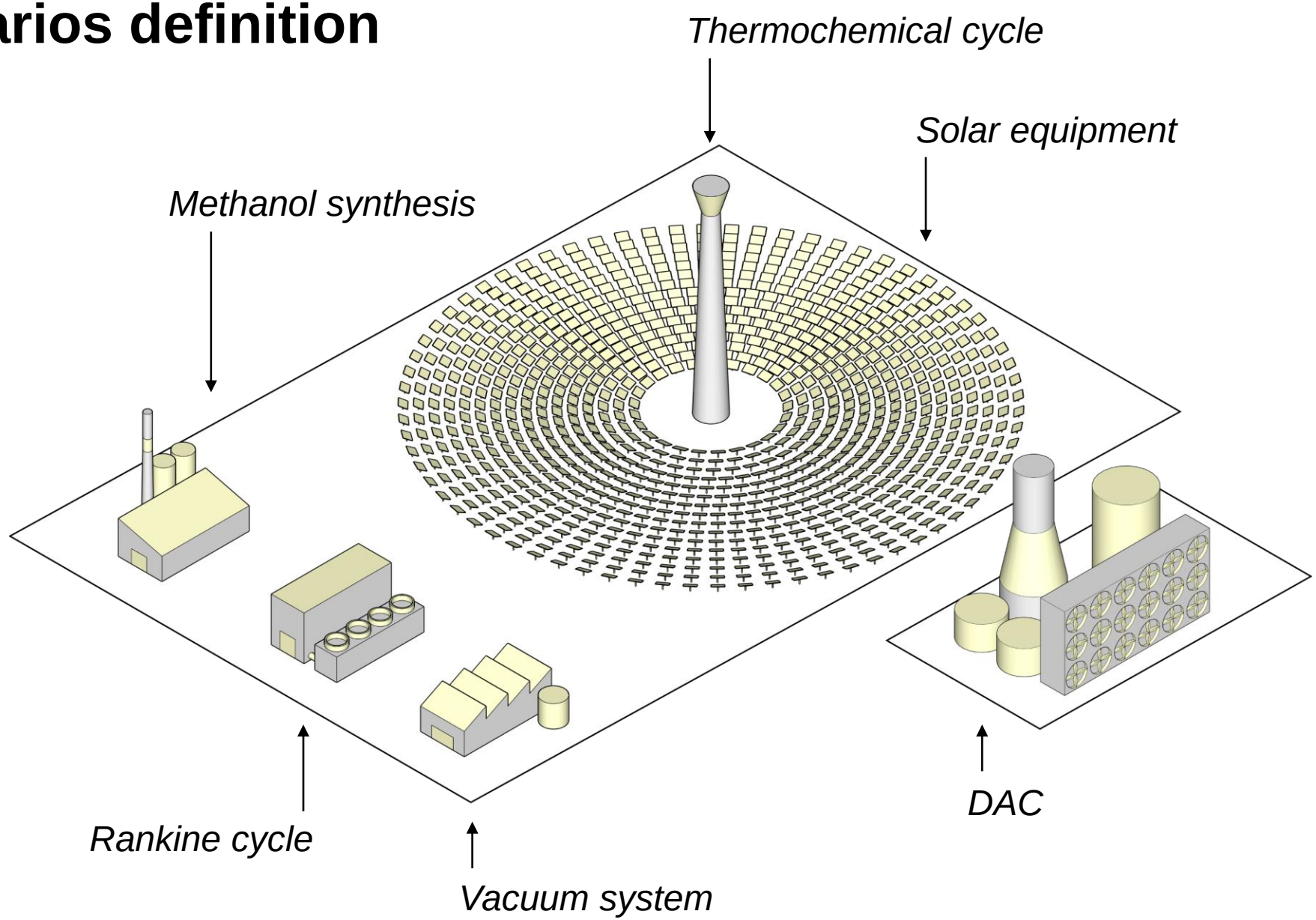
How are thermochemical cycles powered?

Noor III (150 MW), Morocco

Jülich Solar Tower (1.5 MW), Germany

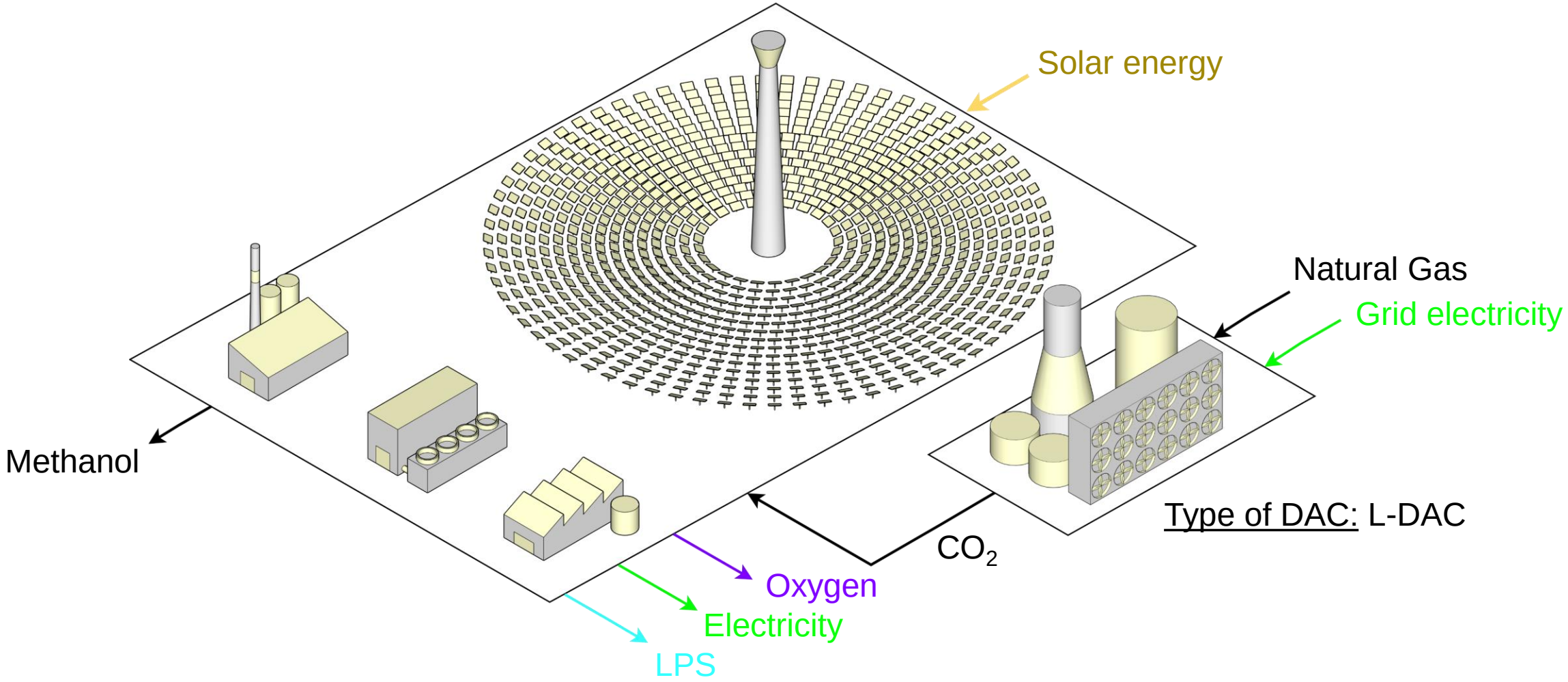
Source: SolarPACES, DLR Images

Scenarios definition



Scenarios definition: Baseline

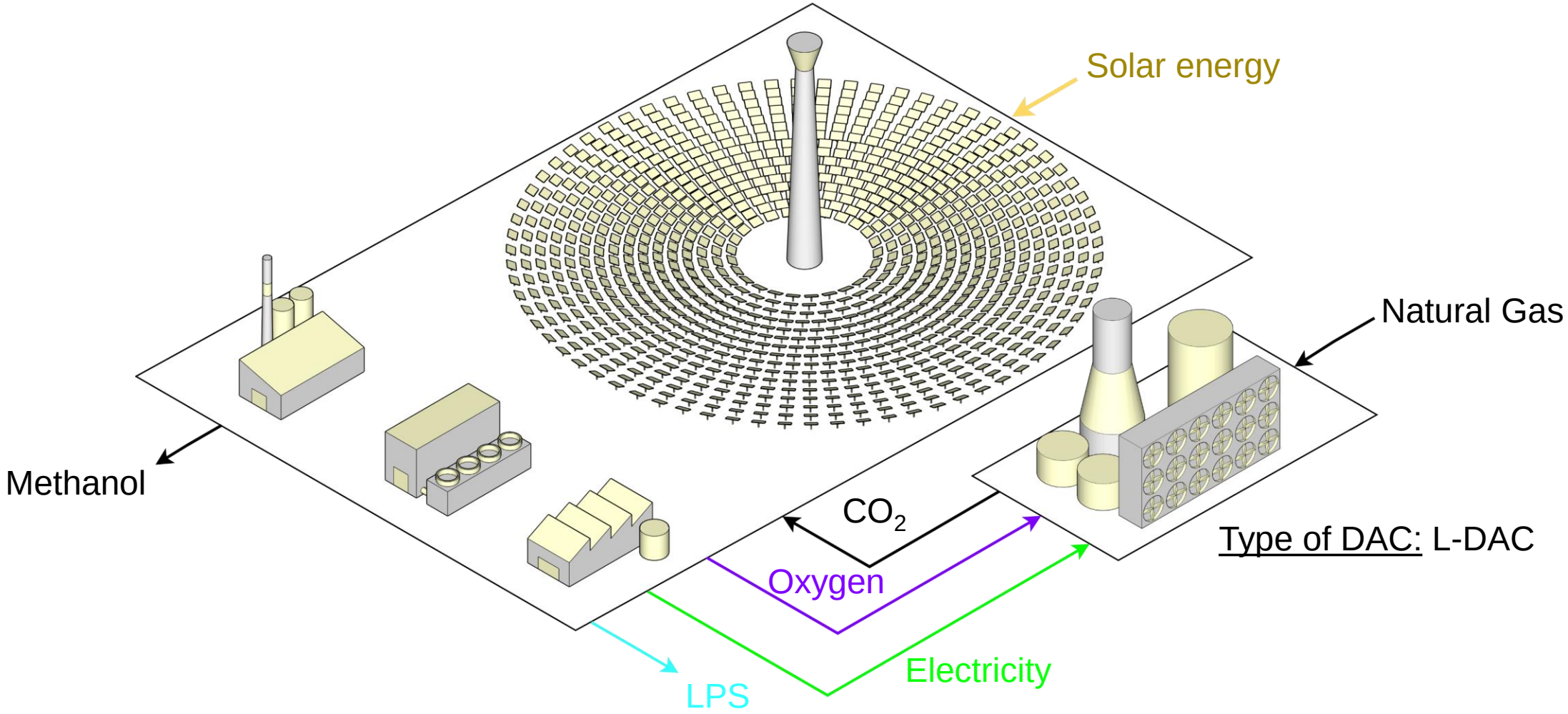
System view



L-DAC: liquid DAC; LPS: low pressure steam

Scenarios definition: L-DAC + O_2

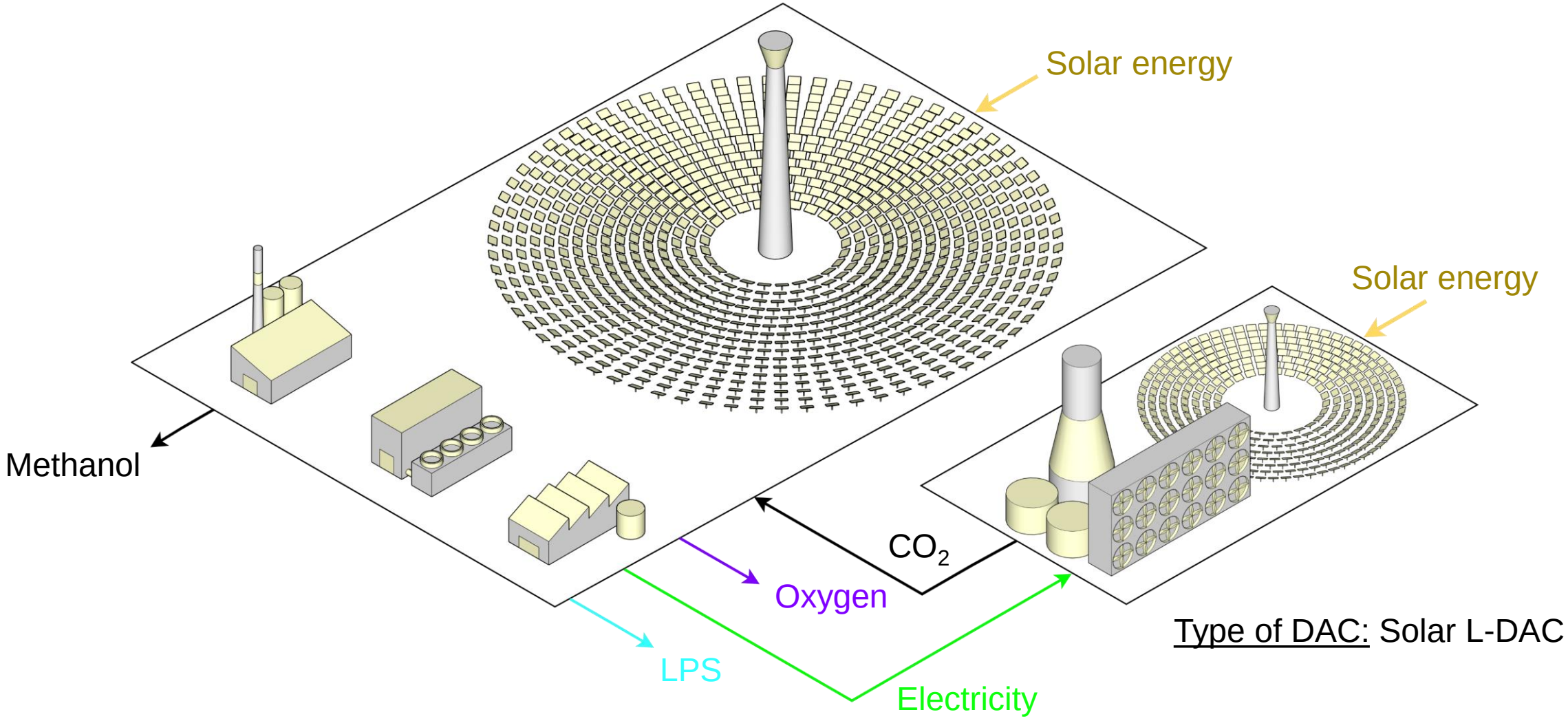
System view



L-DAC: liquid DAC; LPS: low pressure steam

Scenarios definition: L-DAC + Solar

System view

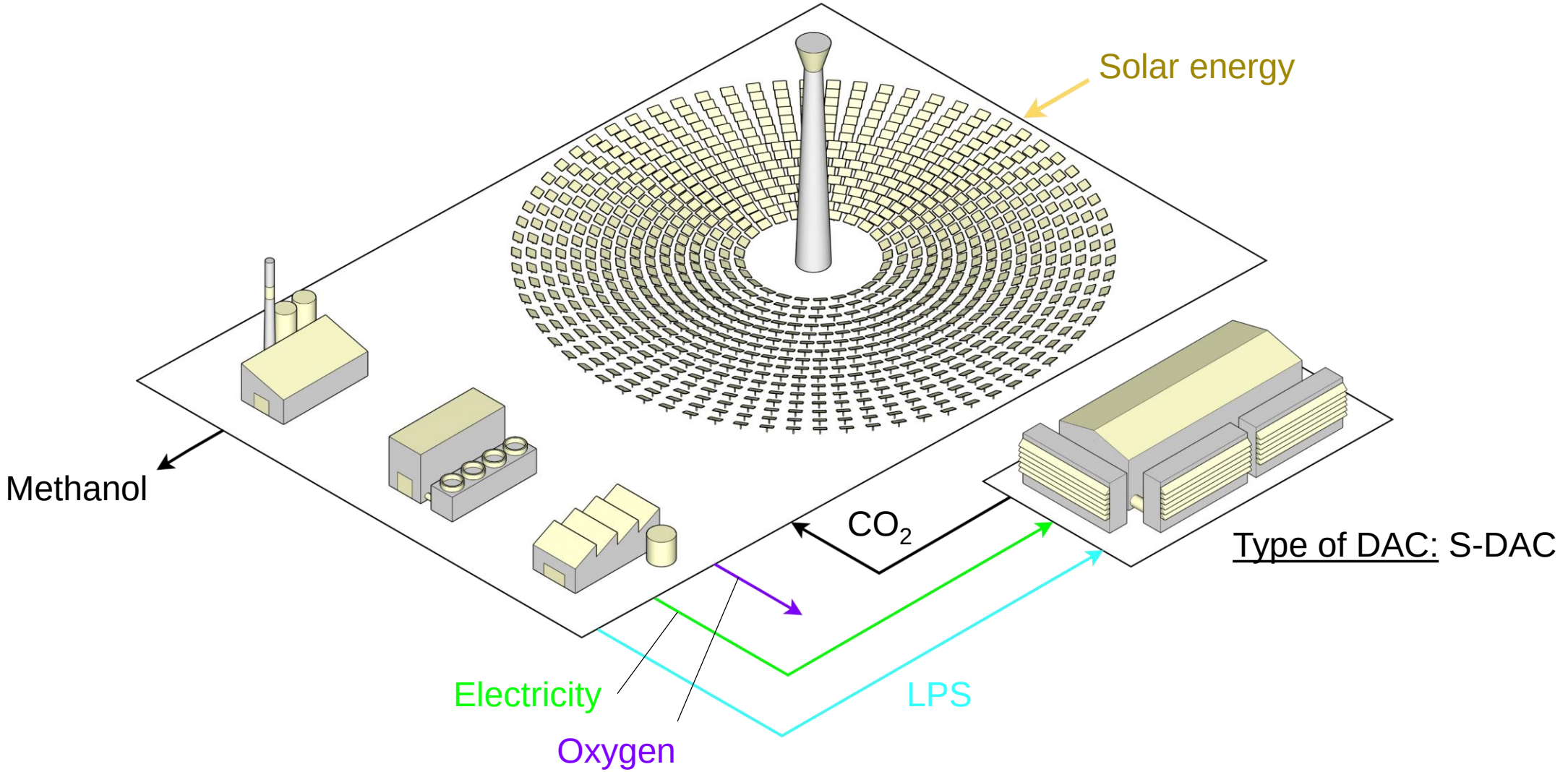


Type of DAC: Solar L-DAC

L-DAC: liquid DAC; LPS: low pressure steam

Scenarios definition: S-DAC + LPS

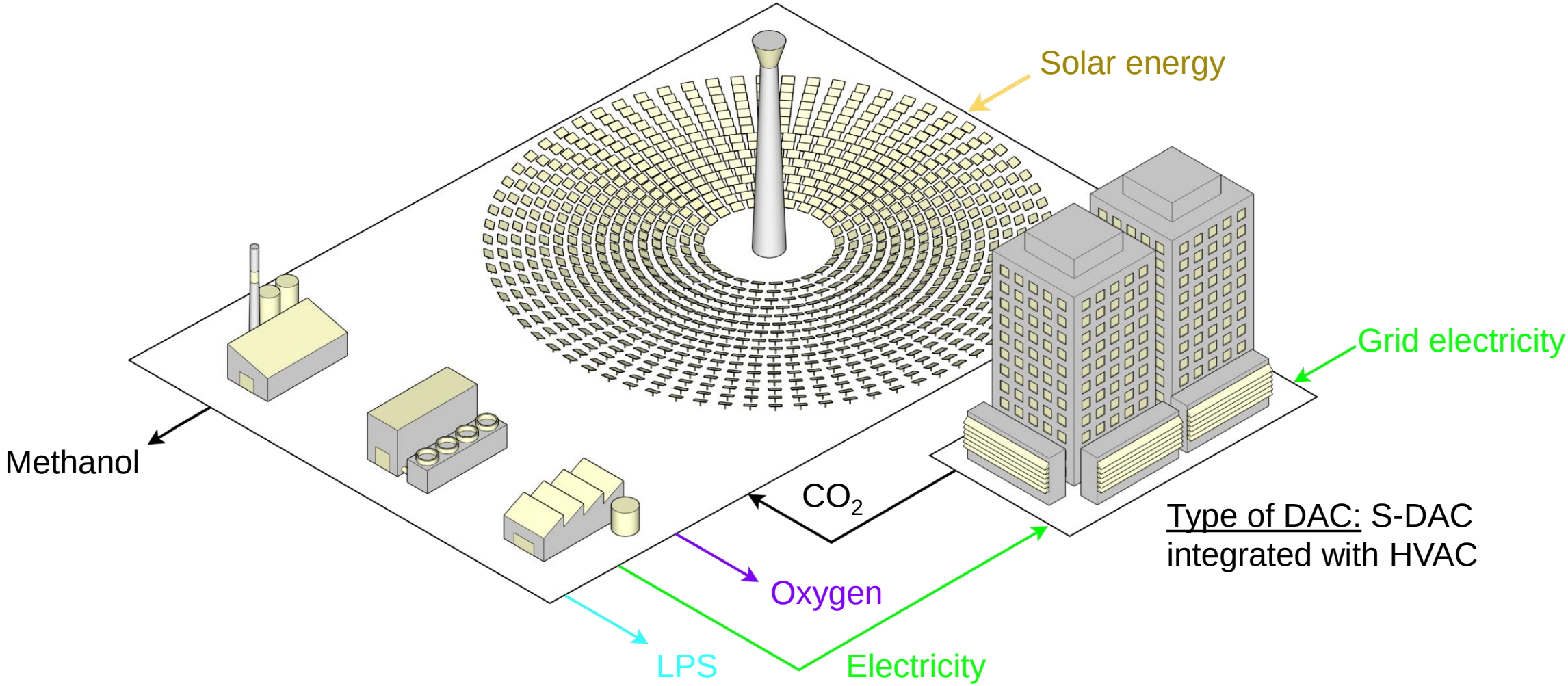
System view



S-DAC: solid DAC; LPS: low pressure steam

Scenarios definition: S-DAC + HVAC

System view



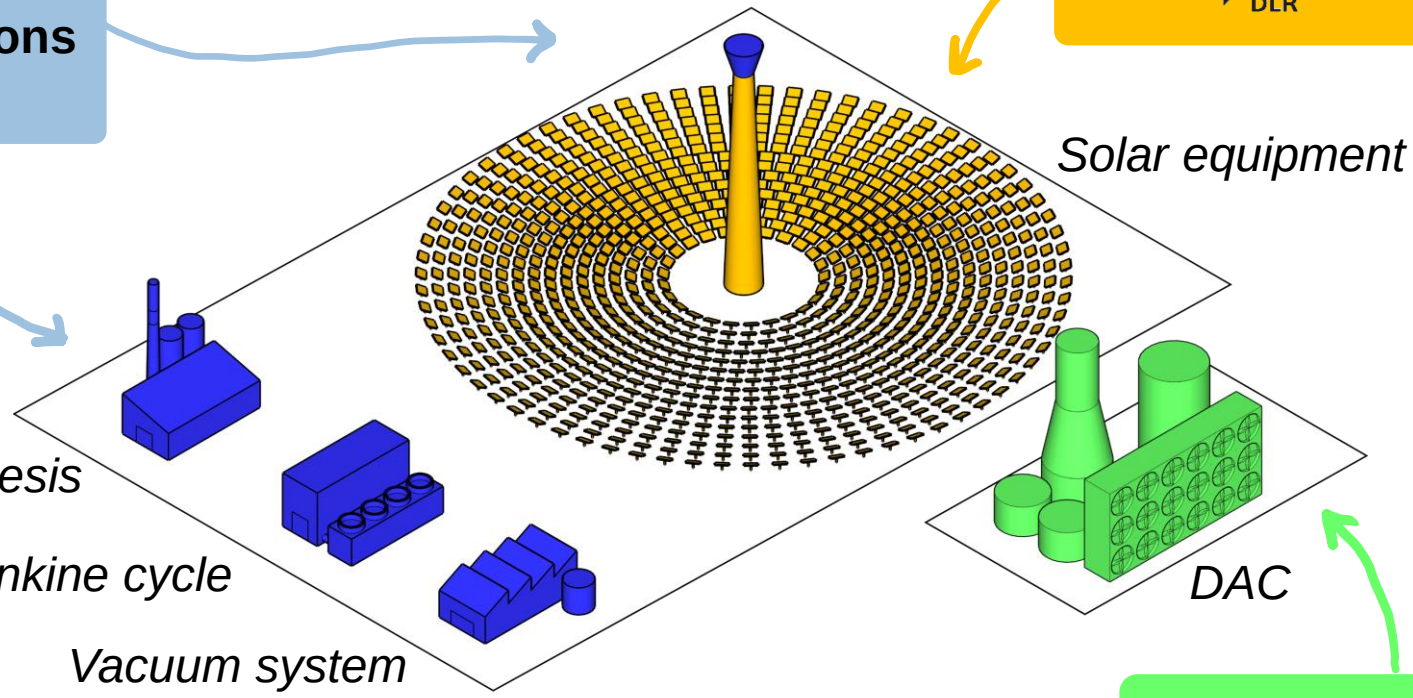
S-DAC: solid DAC; HVAC: heating ventilation and air conditioning; LPS: low pressure steam

Methodology

Simulations

Meteonorm

HFLCAL Model



Saudi Arabia

10 kt/y Methanol

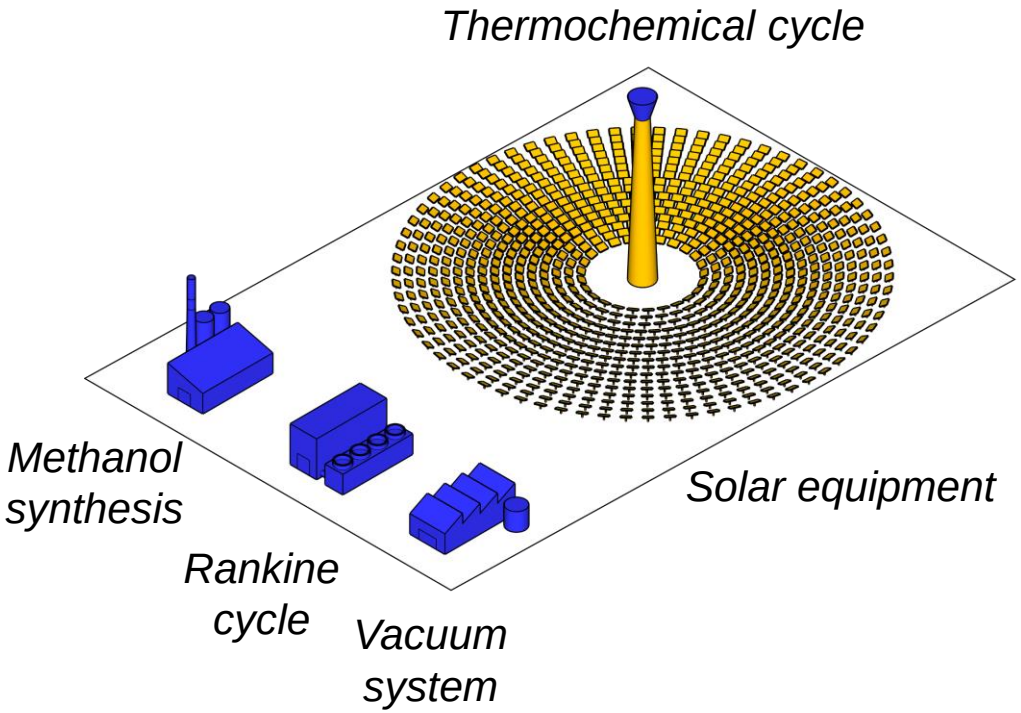
+ Literature & Databases for Cost Estimation

Literature (L-DAC, S-DAC)

or

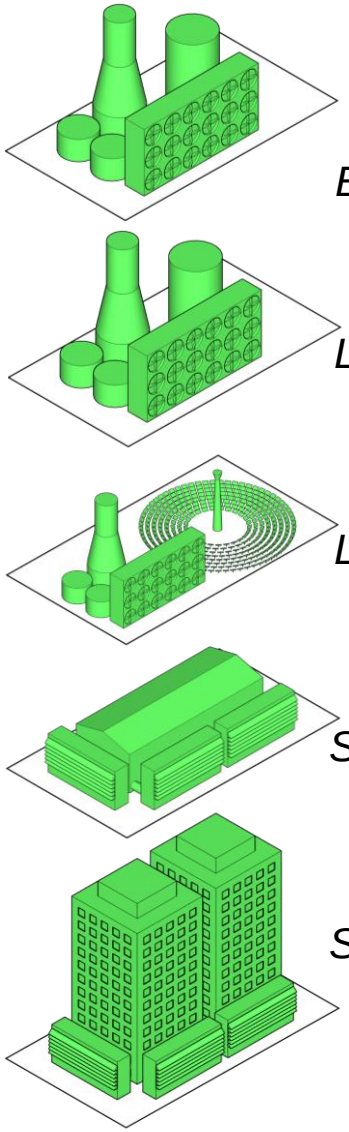
Simulation (Solar L-DAC)

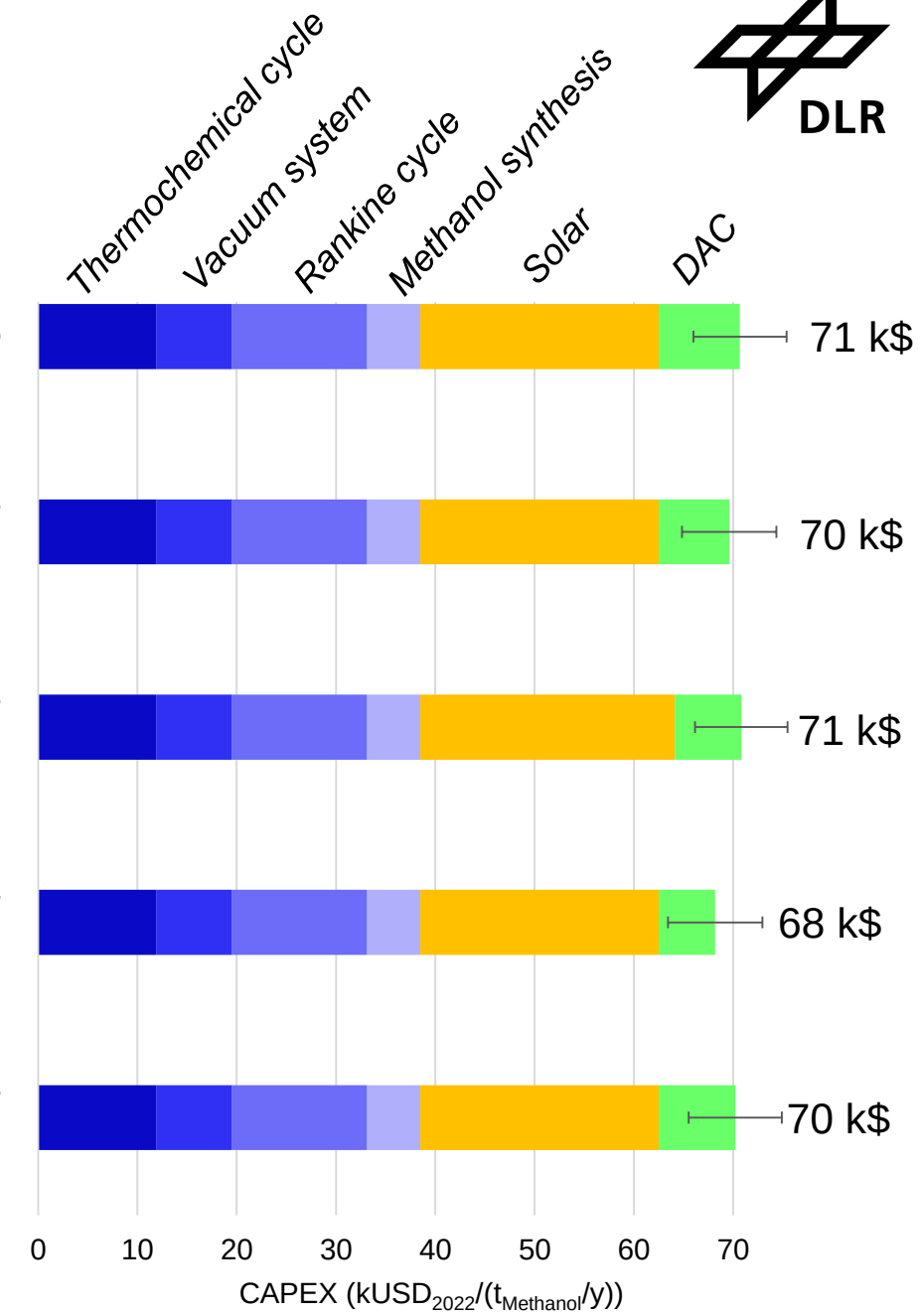
Techno-economic assessment: CAPEX



Saudi Arabia

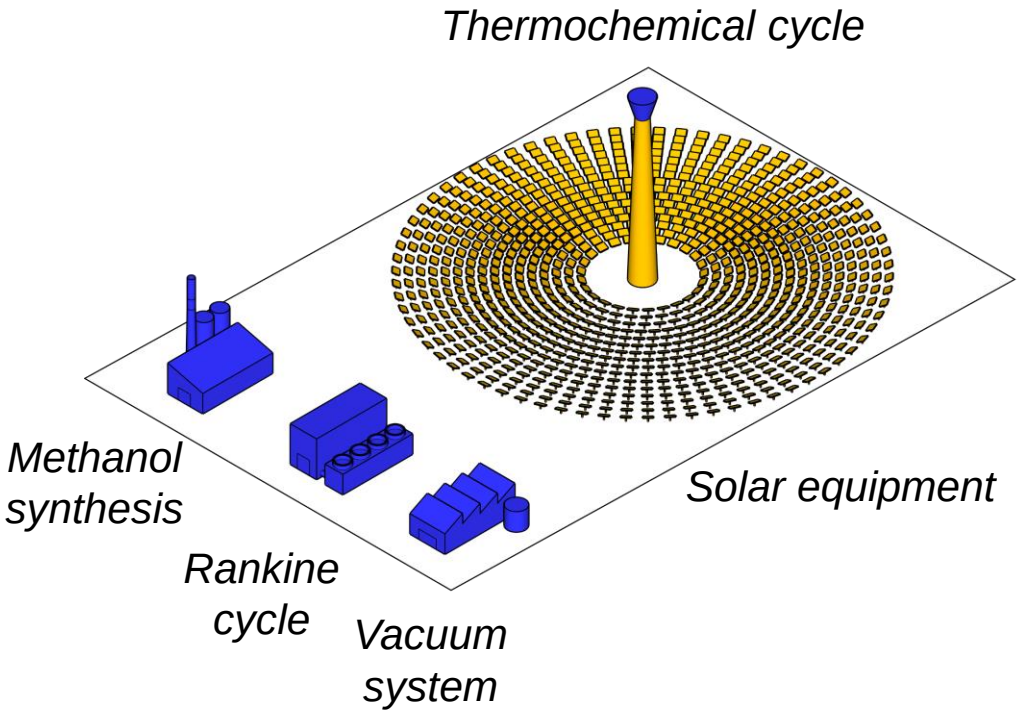
10 kt/y Methanol

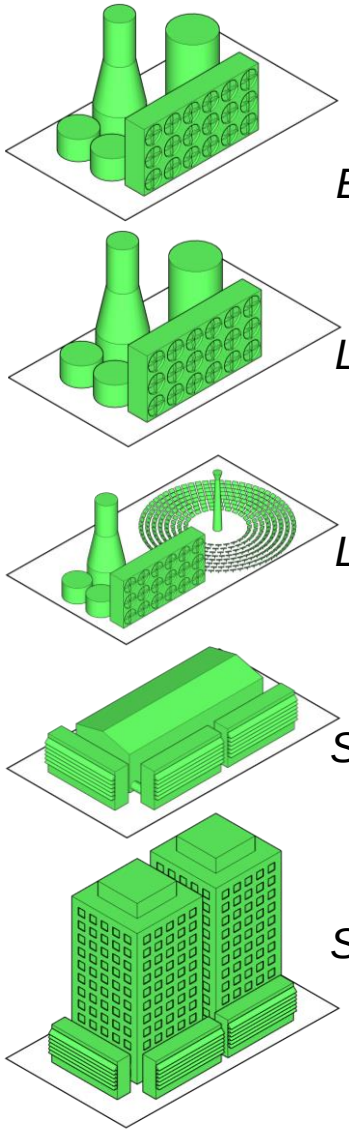


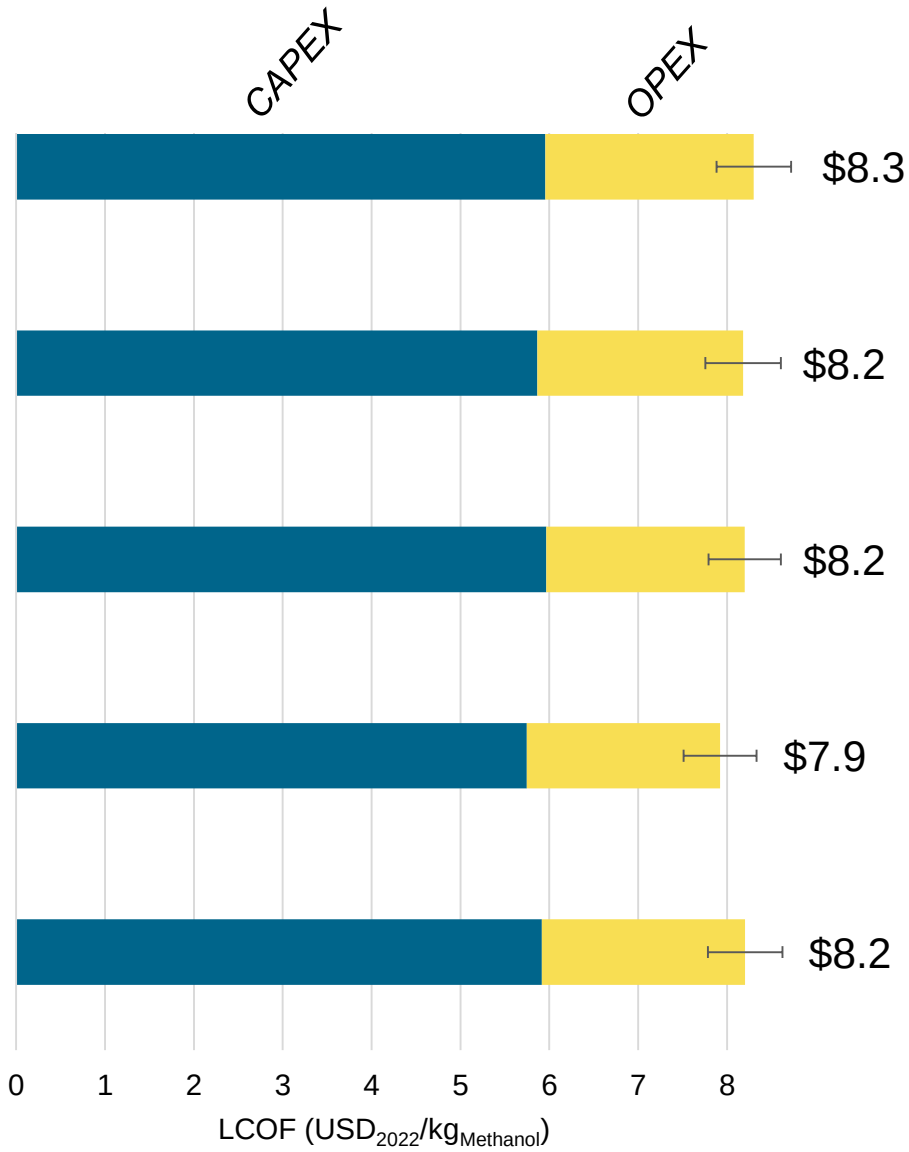


CAPEX: capital expenditure

Techno-economic assessment: LCOF







Saudi Arabia

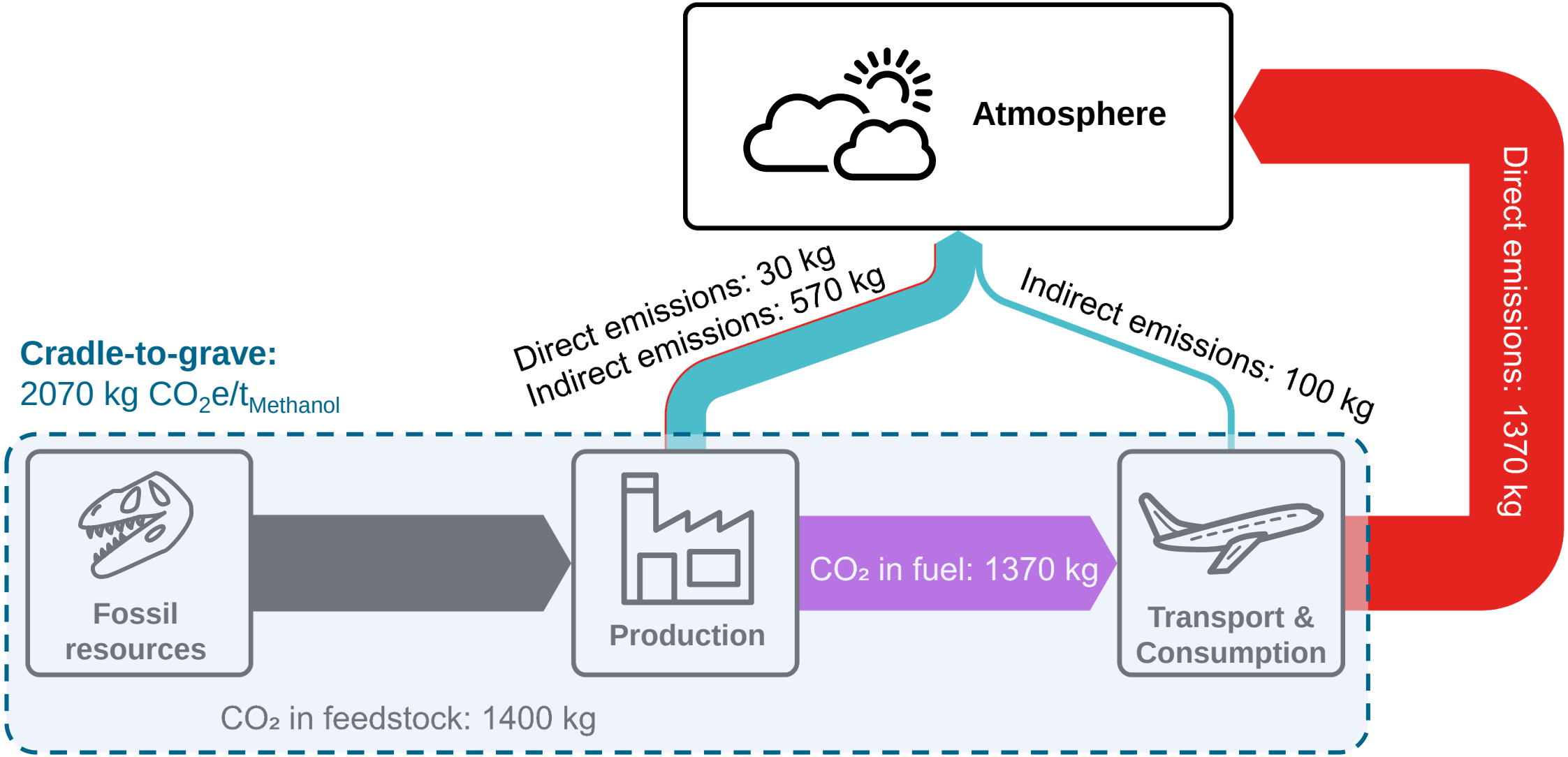
6.8% WACC

10 kt/y Methanol

25 y Lifetime

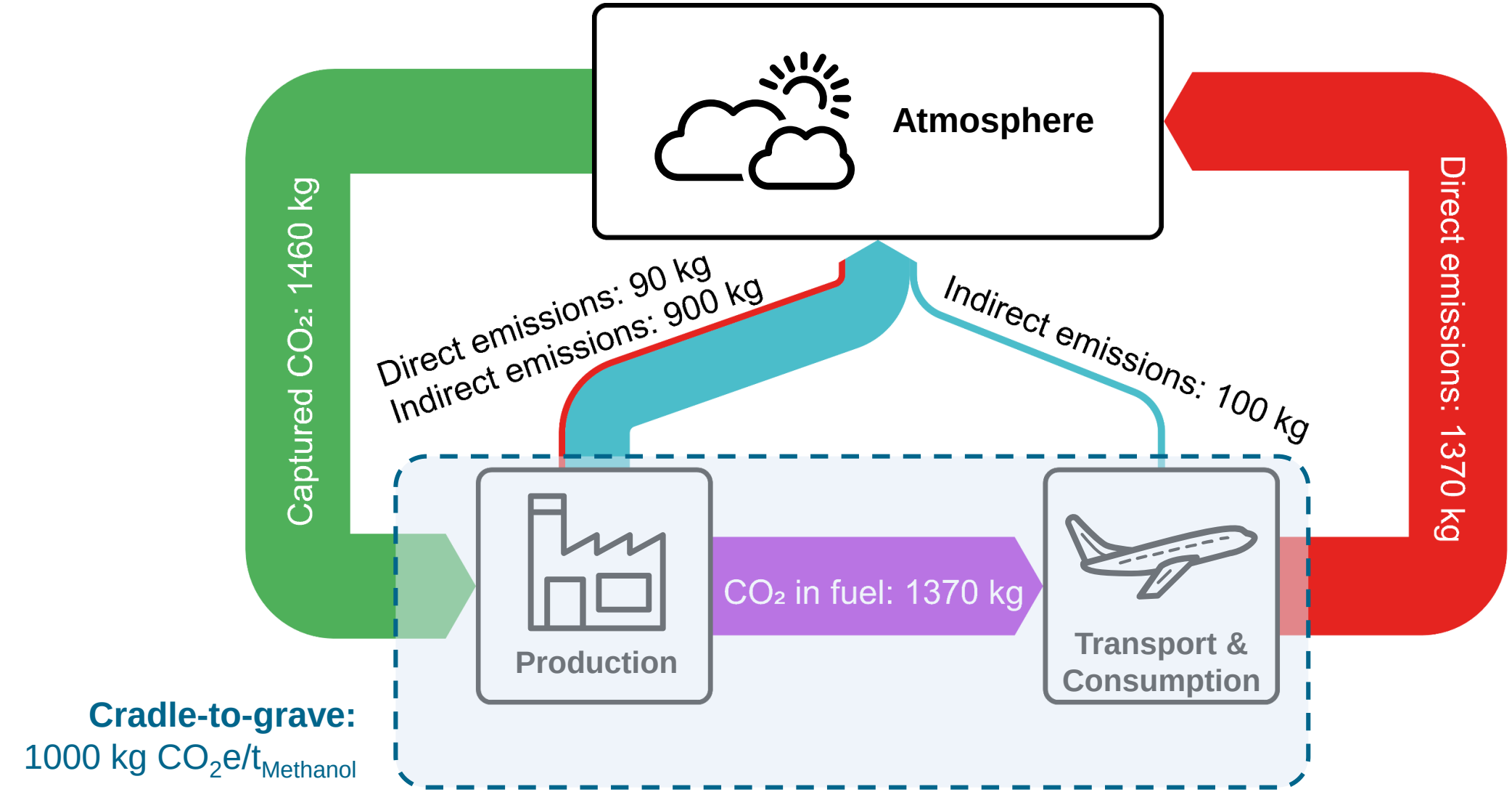
CAPEX: capital expenditure; OPEX: operational expenditure; LCOF: levelized cost of fuel; WACC: weighted average cost of capital

Environmental assessment: Fossil Methanol



*All flows expressed in kg CO_2e/ per ton of methanol

Environmental assessment: Solar Methanol



Cradle-to-grave:
1000 kg $CO_2e/t_{Methanol}$

Take-home messages

DAC & H_2: Enabling the energy transition

Synergies of DAC and (solar) fuels production

Most cost-effective integration: S-DAC + LPS

Reduced cradle-to-grave emissions compared to fossil

Thanks for your attention!

Enric Prats-Salvado
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The authors of this work gratefully acknowledge the funding of the **HI-CAM** project by the **German Helmholtz Gemeinschaft**, as well as the financial support from **DLR's basic funding** for the **SOLHYKO** project.