

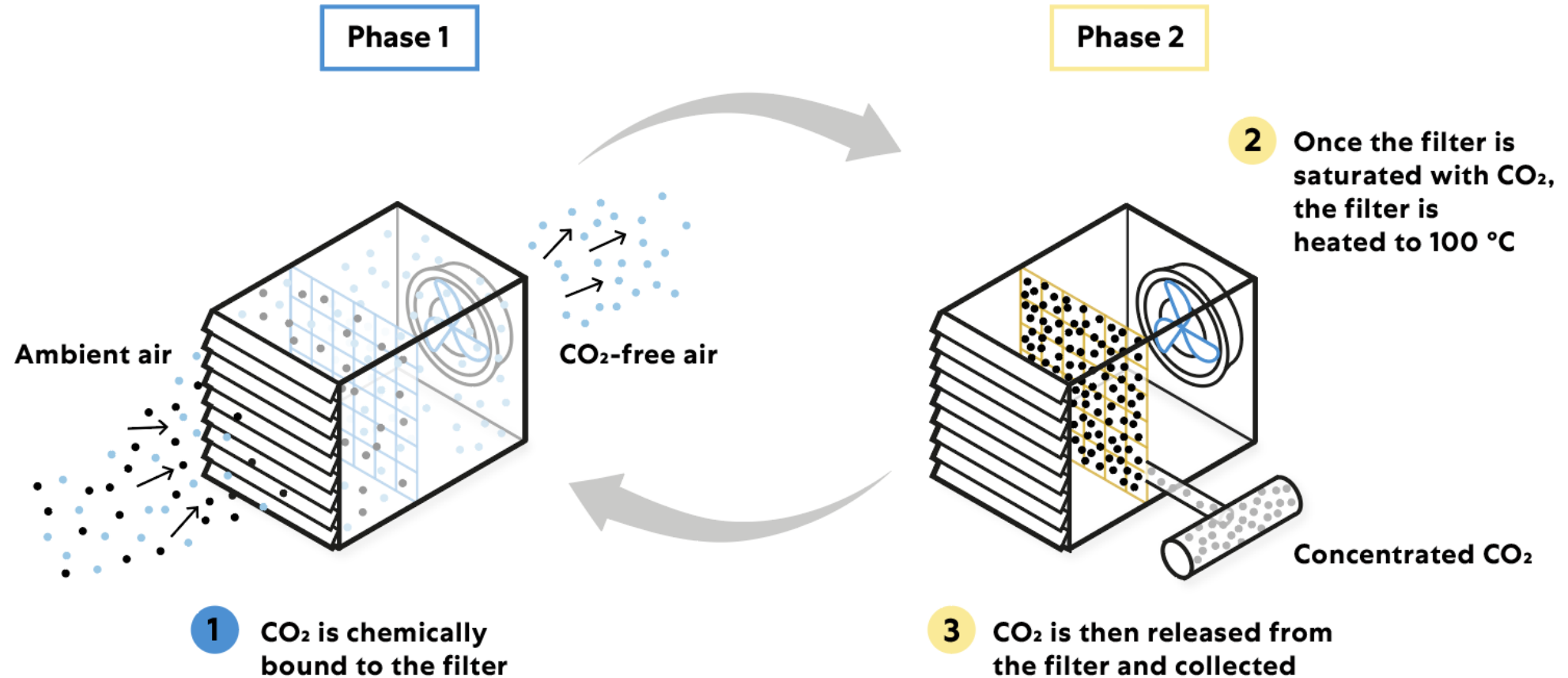


DACS: a scalable solution for negative emissions

April 2021



How our technology works

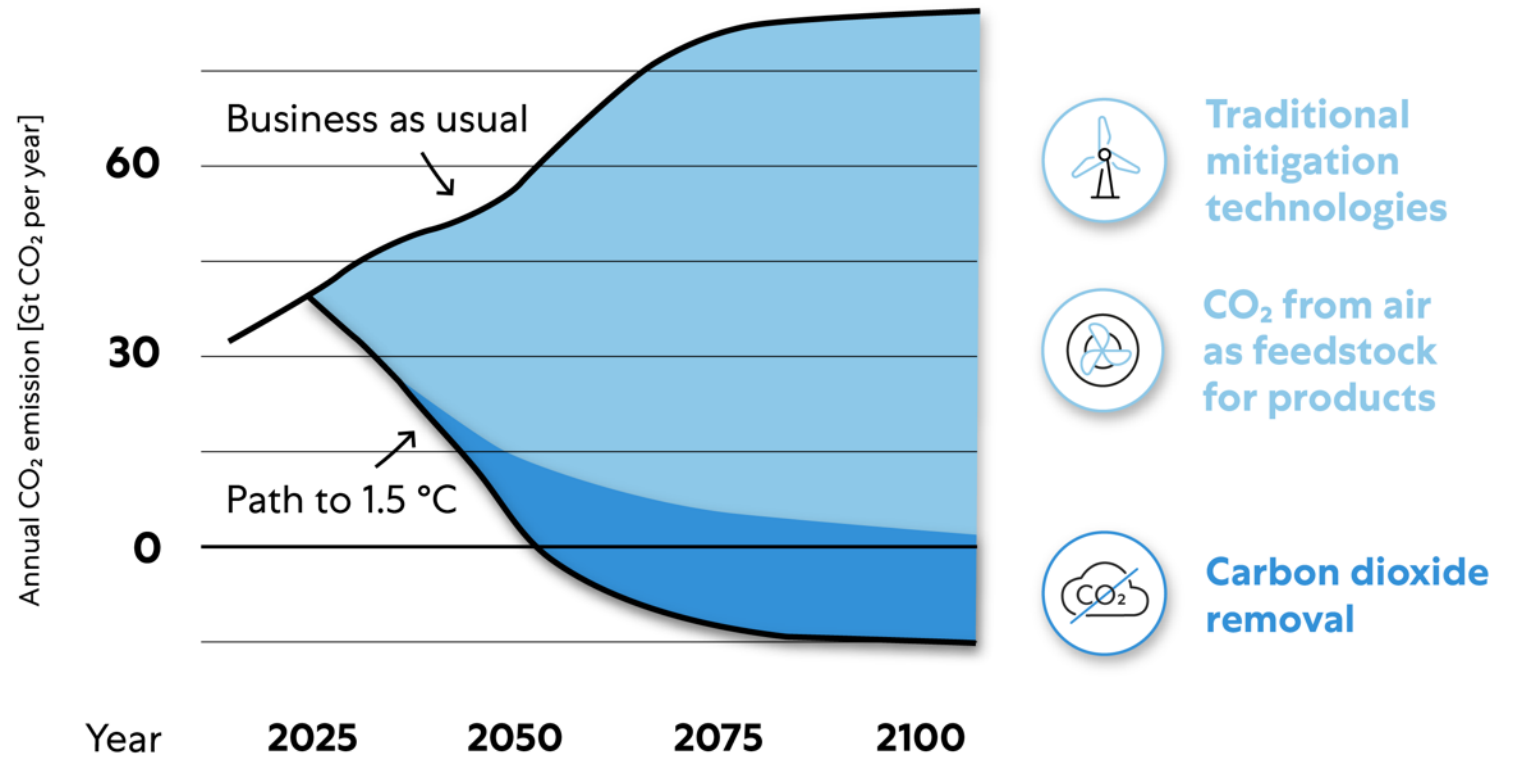


Why direct air capture?



How to keep global heating below 1.5°C















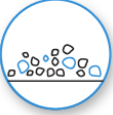









- Replace fossil carbon for fuels and materials
- Neutralize **unavoidable emissions** to reach net-zero
- Realize net **negative emissions** to achieve EU post 2050 climate targets
- **The challenge is to achieve volumes needed in time**



Data source: (with permission from) Mercator Research Institute

Comparison CDR of approaches



	Area required to remove 8 Gt CO ₂ per year	Water required to remove 8 Gt CO ₂ per year	Expected cost at large scale	Impact on environment*
 <p>Afforestation Large-scale tree plantations to increase carbon storage in biomass and soil.</p>	 <p>6'400'000 km² Europe = 10'500'000 km²</p>	 <p>740 km³ Yearly global freshwater withdrawal 2010 = 4'000 km³</p>	 <p>5–50 USD/t CO₂</p>	 Biodiversity  Albedo  Food Security
 <p>BECCS Bioenergy in combination with Carbon Capture and Storage.</p>	 <p>2'500'000 km²</p>	 <p>480 km³</p>	 <p>100–200 USD/t CO₂</p>	 Biodiversity  Albedo  Food security
 <p>Enhanced weathering Distribution of crushed silicate rocks on soil surfaces to absorb and bind CO₂ chemically.</p>	 <p>220'000 km²</p>	 <p>3 km³</p>	 <p>50–200 USD/t CO₂</p>	 River/ocean chemistry
 <p>Direct air capture Direct capture of CO₂ from ambient air through engineered chemical reactions.</p>	 <p>15'800km²**</p>	 <p>8 km³ Potentially zero</p>	 <p>< 200 USD/t CO₂</p>	 Minor

- BECCS and afforestation both put biodiversity and food security at risk when deployed on a large scale, because of significant land-use requirements. Albedo refers to the warming effect caused by the low reflectivity of forests and agricultural areas. Enhanced weathering affects water chemistry such as rising pH levels in rivers.

** Including energy provision via PV.

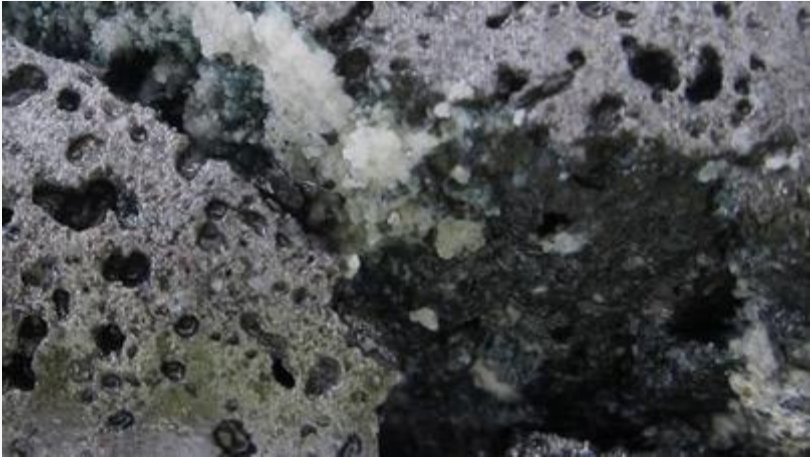


Climeworks plant locations

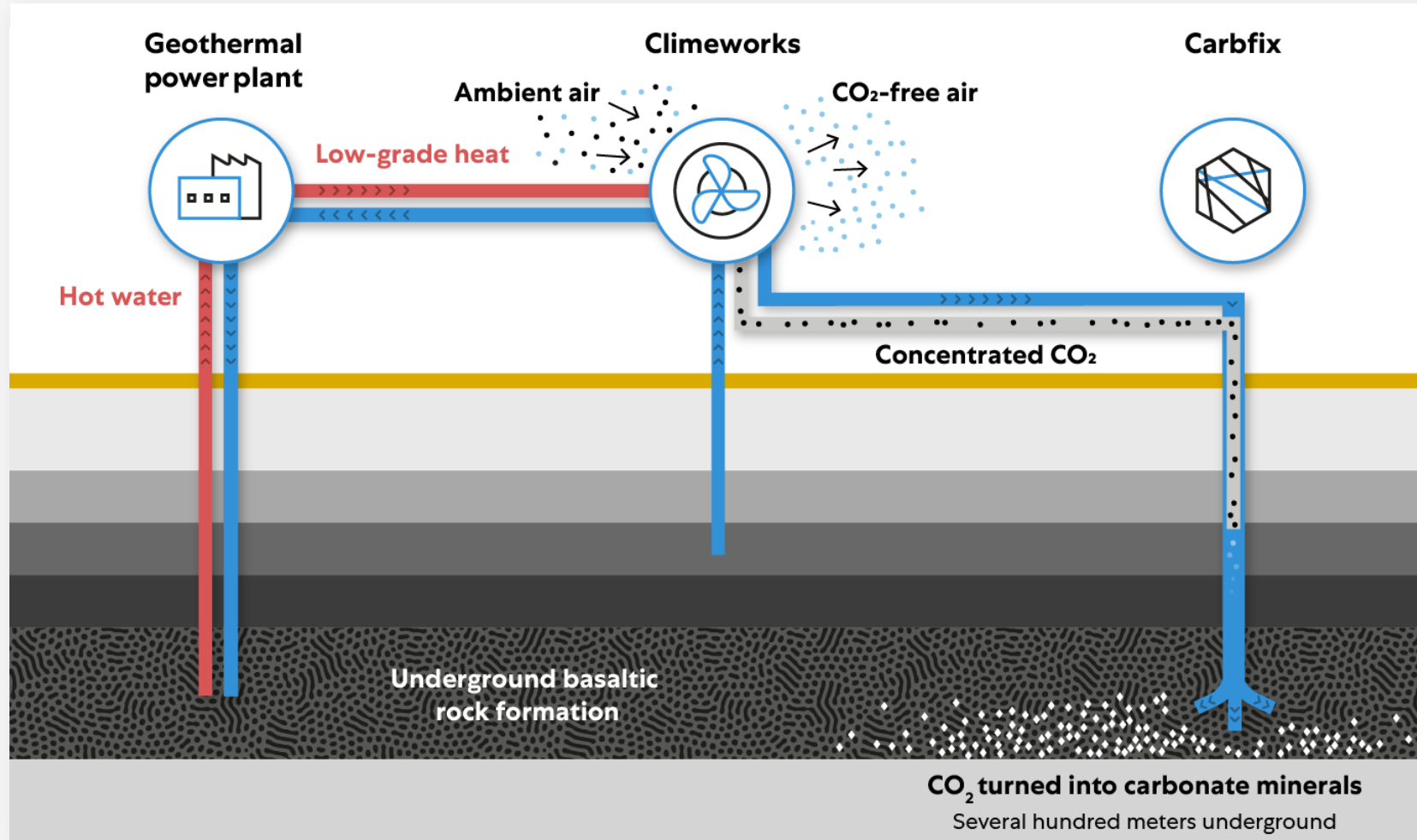
- **15 plants** currently in commissioning/operation across Europe
- **Many 10'000 hours** of operational experience
- Across a **wide range of climatic conditions** (Southern Italy to Iceland)



CO₂ removal at Hellisheiði Iceland



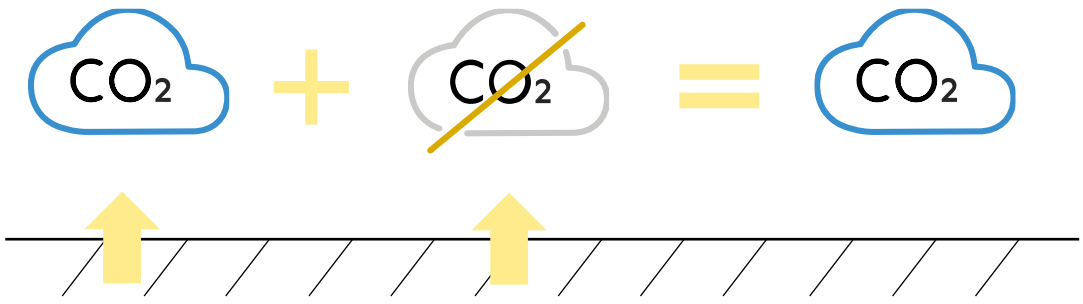
Direct air capture & mineralization = Safe and most permanent storage



Net zero vs. Carbon offsetting



A **CO₂ neutral strategy** with **offsetting** only maintains the current level of emissions

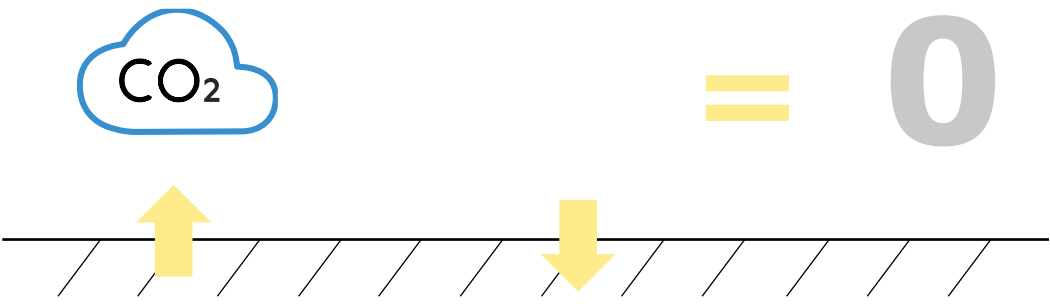


1 ton of CO₂ emitted

1 ton of CO₂ **avoided** elsewhere

1 ton of CO₂ emitted

A **net zero strategy** with **removal** reduces the current level of emissions



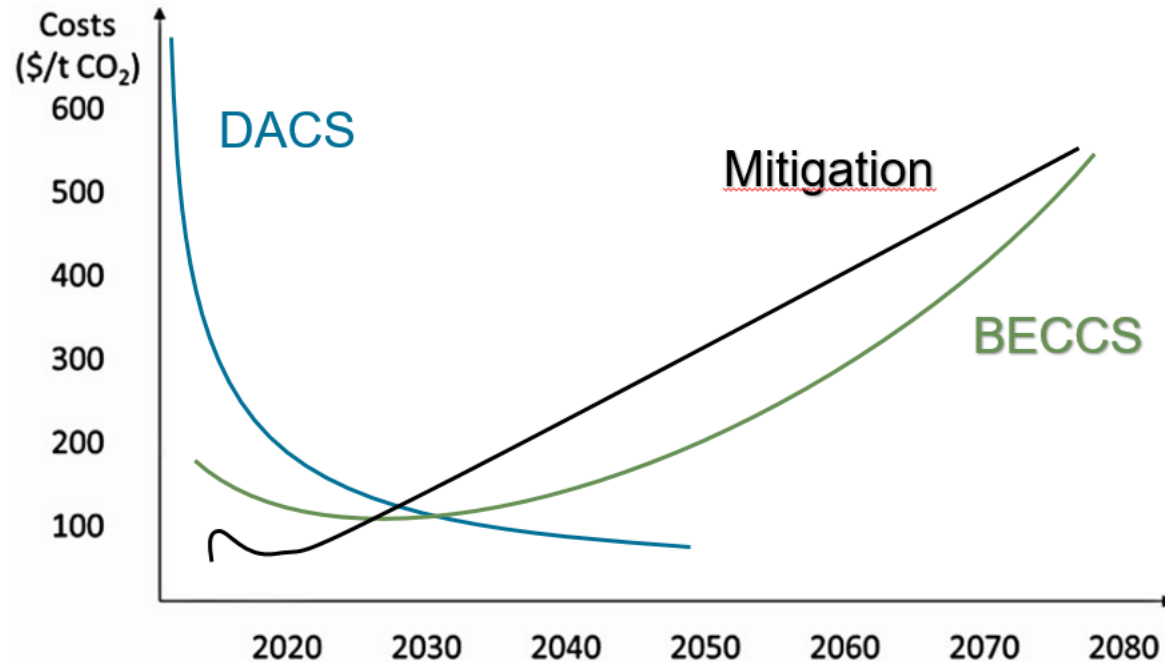
1 ton of CO₂ emitted

1 ton of CO₂ **removed**

No CO₂ emitted



Economics of Mitigation, BECCS & DACS



Source inspired by: Reiner & Honegger 2018: Development of costs of BECCS, DACS and classical mitigation over time assuming strong political will to cover mitigation costs.

Note: Curves are indicative.

- Cost of DACS is falling (blue curve)
- Whilst costs of mitigation and biomass based carbon removal (BECCS) will be rising in the long run due to resource constraints (land, water) and rising demand

Conclusion & Policy development



- Focus on emissions reductions. Negative emissions needed in addition to mitigation.
 - CDR for unavoidable emissions
 - Separate EU Net Zero target into emission reduction and CDR scale up target
 - No silver bullets: Promote a portfolio of Negative Emissions solutions
- As sustainable biomass is limited, technological CDR approaches need to be scaled up asap to meet negative emissions volumes needed for EU Net Zero 2050.
 - Promote scale-up of existing CDRTs in the 2020s to be able to reach gigatonne scale in the 2030s and 2040s
 - E.g. CFDs, government procurement, introduction of a dedicated CDR track in large scale EU IF
- Stringent certification standards for CDR, net zero frameworks and carbon removal markets needed.
 - Removals have to be permanent, stringent MRV standards needed.
 - Avoided emissions certificates should not be part of any net zero framework or strategy.
 - Policies to strengthen and scale carbon removal markets (not trading avoided emissions) needed.



Negative Emissions is a massive opportunity for Europe

CDR will need to become a trillion Euro Industry if we want to comply with the Paris accord



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