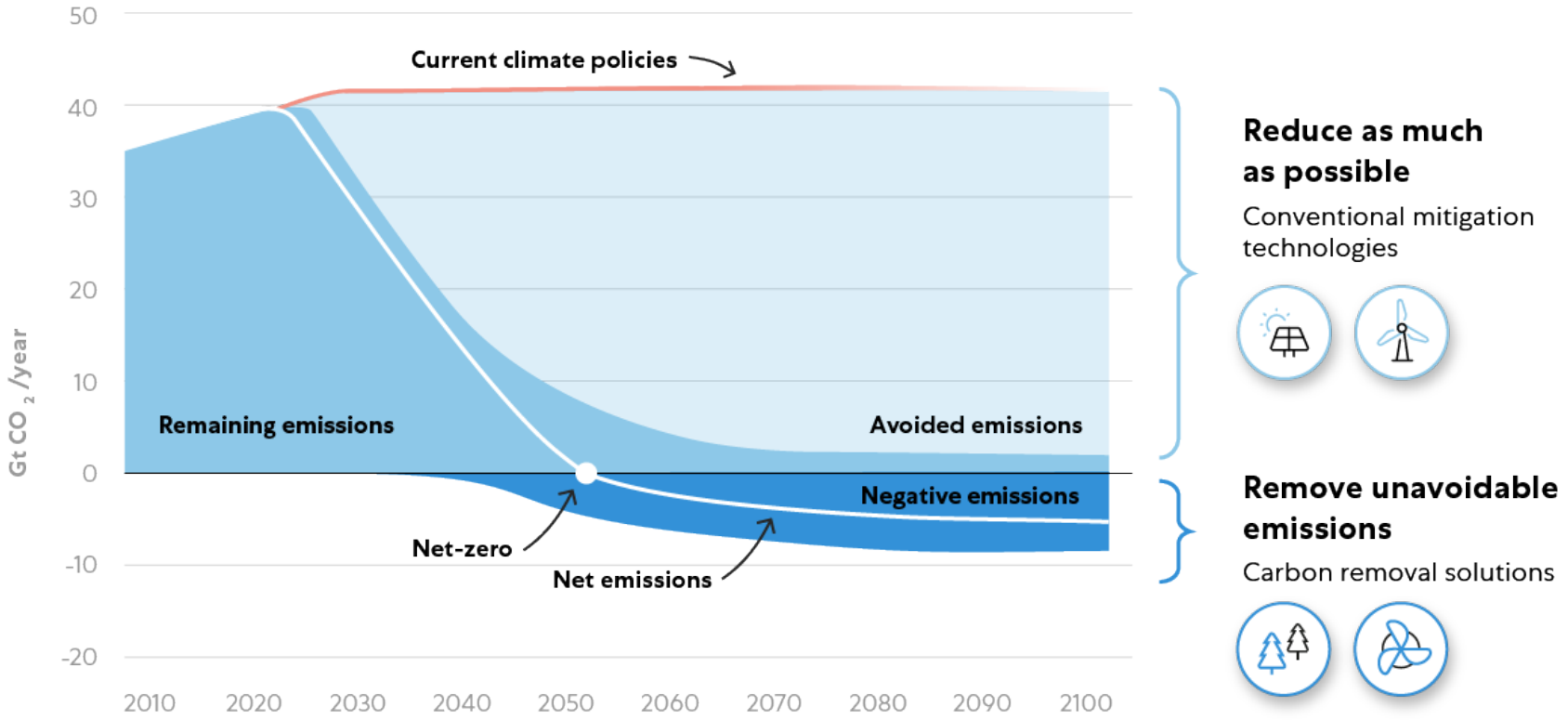
climeworks

Climeworks and Life Cycle Assessment

Sustainability Circle, 2024

September 24

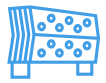
Net zero requires carbon dioxide removal (CDR)



- Based on all IPCC scenarios, **CO_2 must be removed from the air** to keep global warming within 1.5°C.
- Companies need to accelerate emissions reduction while starting to invest in **removals for your residual emissions.**

Source: Adapted from IPCC (2022) & United Nations Environment Programme (2021)

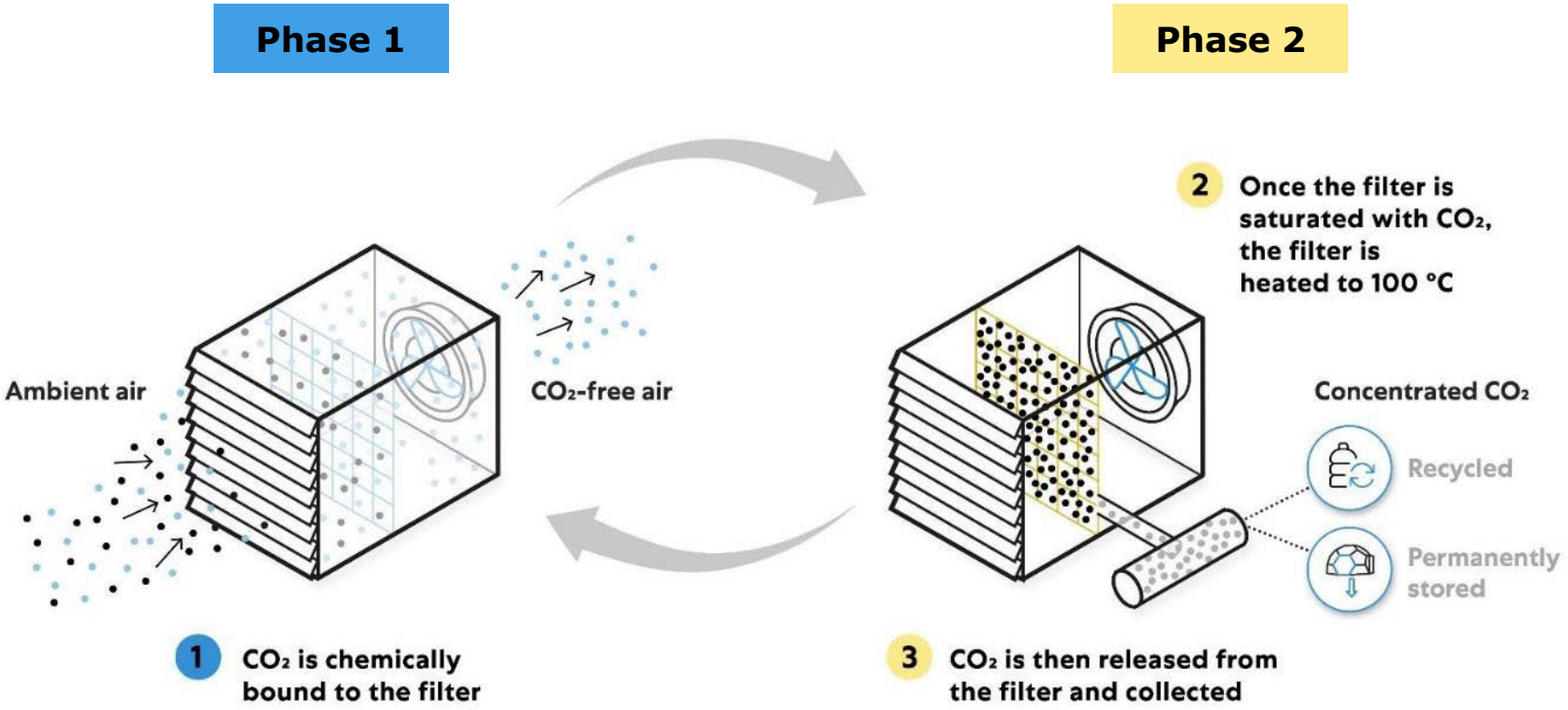
Varying mechanisms of CDR technology

 Afforestation/ reforestation	Drives **biomass** carbon uptake through **non-forest to forest land conversion**. AF vs RF differ in how long the non-forest condition has prevailed
 Biochar	Utilizes **pyrolysis** to heat biomass at high temperatures and store carbon in a more stable form **in addition to soils**
 Enhanced weathering	Accelerates natural **chemical mineralization** of CO_2 to capture CO_2 from the atmosphere through **treatment/distribution of minerals**
 BECCS	Involves **processing biomass** for **bioenergy** while capturing and storing the CO_2, with variations depending on the storage methodology
 DAC+S	Uses a **chemical process** to **absorb** CO_2 from **ambient air**, and **stores** the captured CO_2 **underground** in geological reservoirs

Note: BECCS = bioenergy with carbon capture and storage; DAC+S = direct air capture and storage
Source: IPCC

This is how our technology solution works

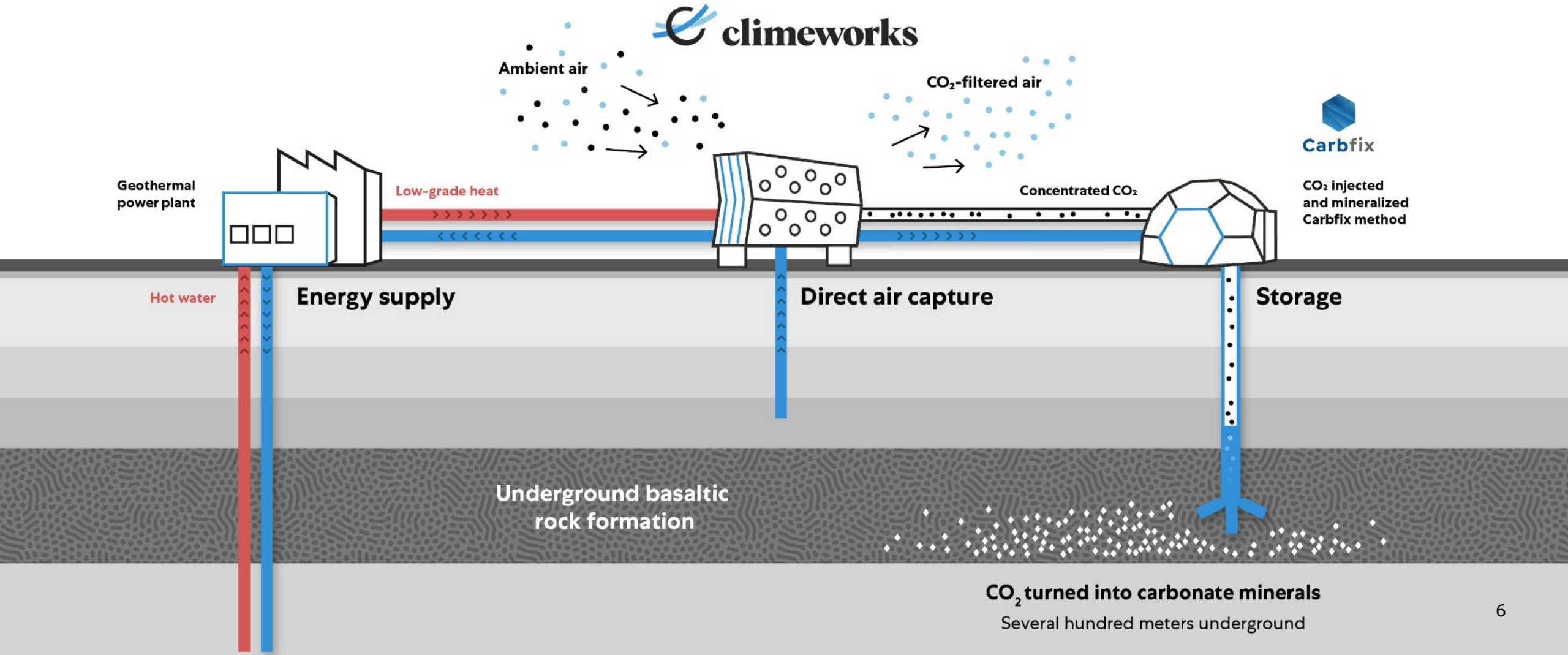
How our technology works



- The air is drawn with a fan into the collector where the CO_2 is captured on a **filter material**.
- The collector is then closed the temperature is increased up to 100 °C to **release the CO_2**, to be collected for storage.

Direct air capture and mineralization

Energy supply, direct air capture and storage with Climeworks' Orca

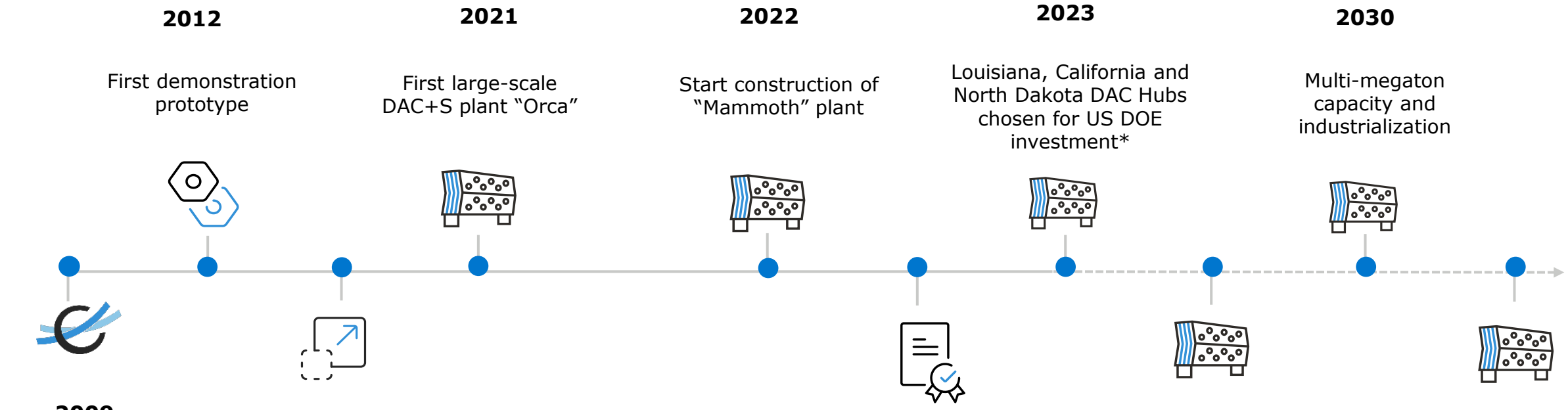


Hellisheidi geothermal power plant, Iceland.

Orca Direct Air Capture facility, Iceland.

Injection well or igloo where CO_2 is permanently sequestered.

Our journey to impact at scale



*Climeworks and project partners have been invited to proceed to the next round of negotiations with the DOE
**Anticipated launch date, subject to updates

Climeworks plans continuous DAC capacity increase

Iceland
Hellisheiði

4,000 tons
per year

Iceland,
operational

Orca

2021
Enable scale-up

Iceland
Hellisheiði

+36,000 tons
per year

Iceland,
operational

Mammoth

2023 - 2024
Commercially proven

USA
Louisiana,

Multi-megaton range

Historic US DAC Hub
announcement

Cypress

2026 - 2030
Industrialization

Global

Gigaton range

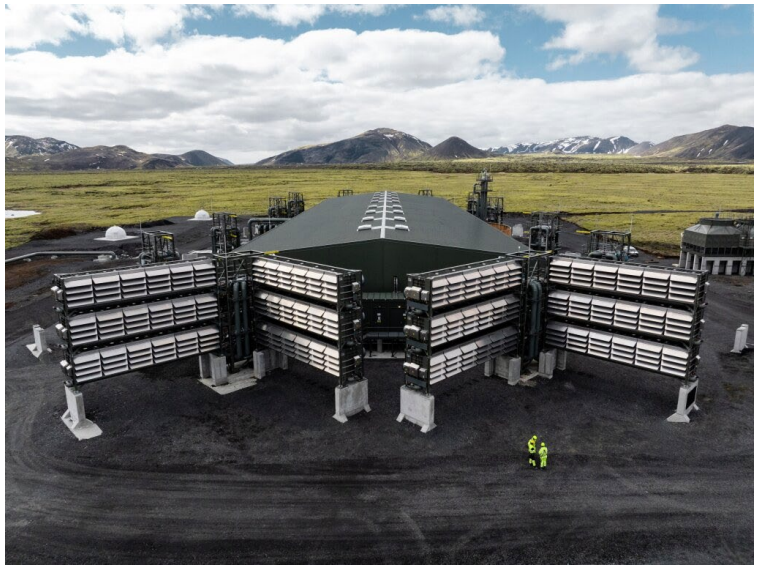
TBC

2050
Large-scale industrialization

- Most advanced DAC player with real **field experience**
- World's **largest DAC+S facility** in commercial operations
- Over 120,000 hours of **operational experience** in diverse climatic conditions
- A clear strategy to **scale removal capacity** to megaton scale by 2030 and gigaton scale by 2050

*from 2027 onwards and is subject to changes.

Climeworks and Life Cycle Analysis



Mammoth, Iceland
Nameplate capture capacity: 36,000 tons per year.

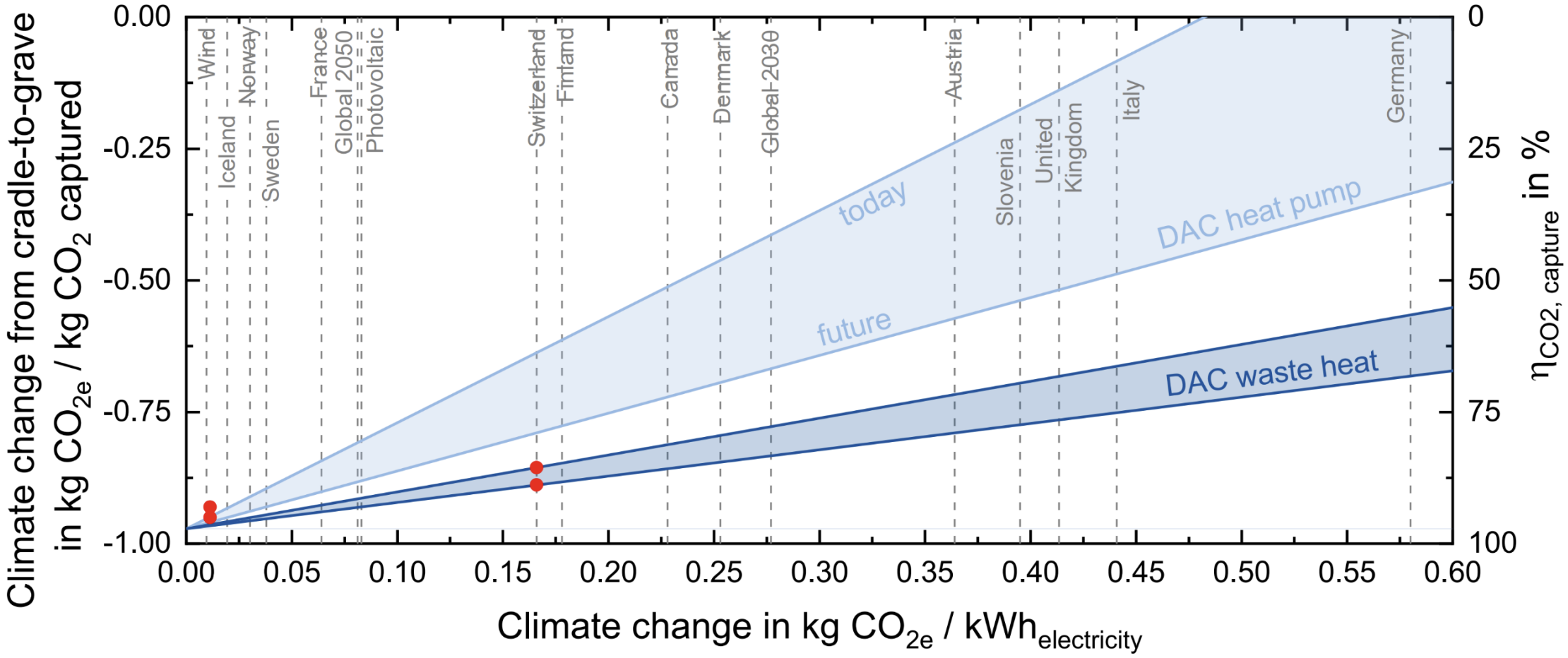
Nameplate capacity of 36,000 represents the **gross** capture capacity.

For **net CDR** produced, grey emissions created during the construction and operation of the plant need to be deducted.

The grey emissions fall into the following buckets:

- Project emissions – steel, concrete and collector containers.
- Energy – even low emissions energy such as geothermal or PV has an emission factor per kWh.
- Sorbent filter material
- Emissions associated with sequestering the CO_2 underground.

Importance of energy emission factor

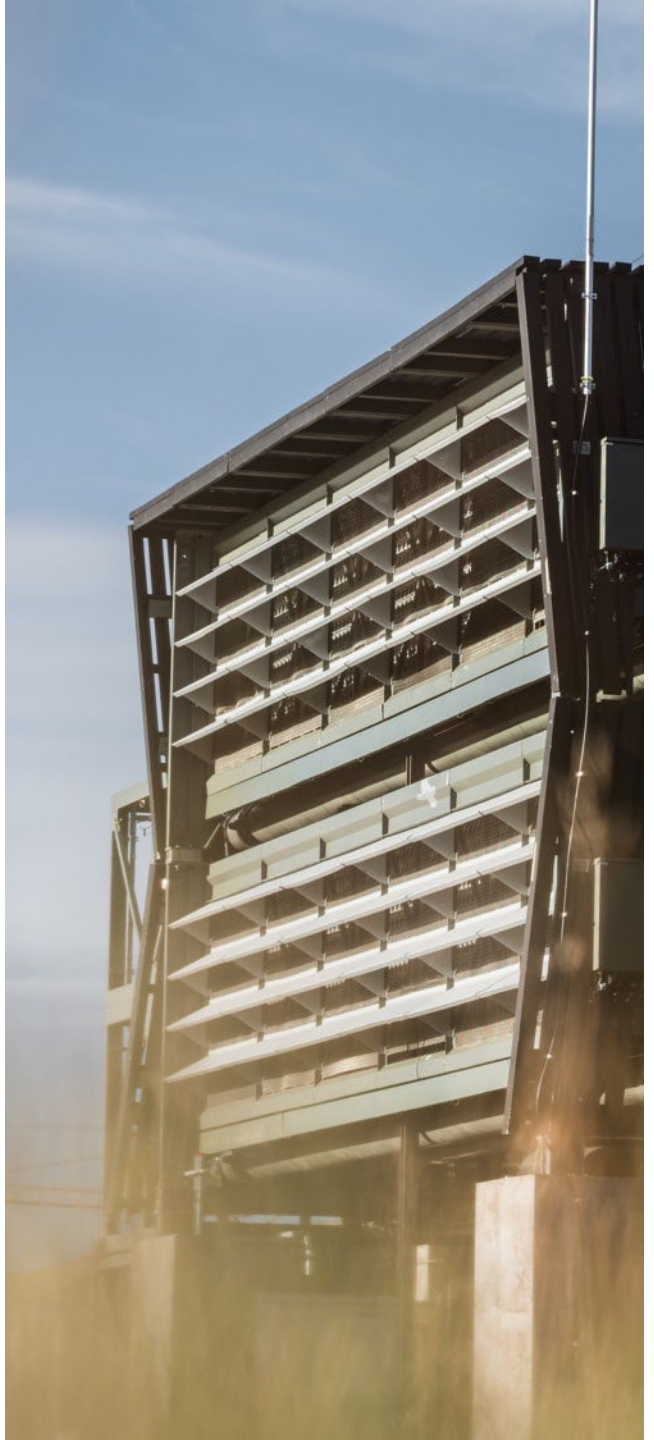


Source: Deutz and Bardow, 2021

Climeworks and loss to grey emissions

Deutz and Bardow's LCA shows that direct air capture has

- a low carbon footprint when run on low-carbon energy, such as waste heat or renewable energy.
- Specifically, it found that Climeworks' plants can reach a net carbon dioxide removal efficiency of more than 90%. In other words, over its whole lifespan (including construction, operations and recycling), a typical Climeworks plant re-emits less than **10% of the carbon dioxide it captures**.

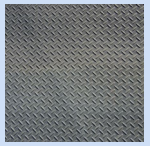


Reality - 2023 loss to grey emissions: 20-25%

Why?

1. The filter material (sorbent) that was used for the first fill of Orca was an early version in the sorbent portfolio.

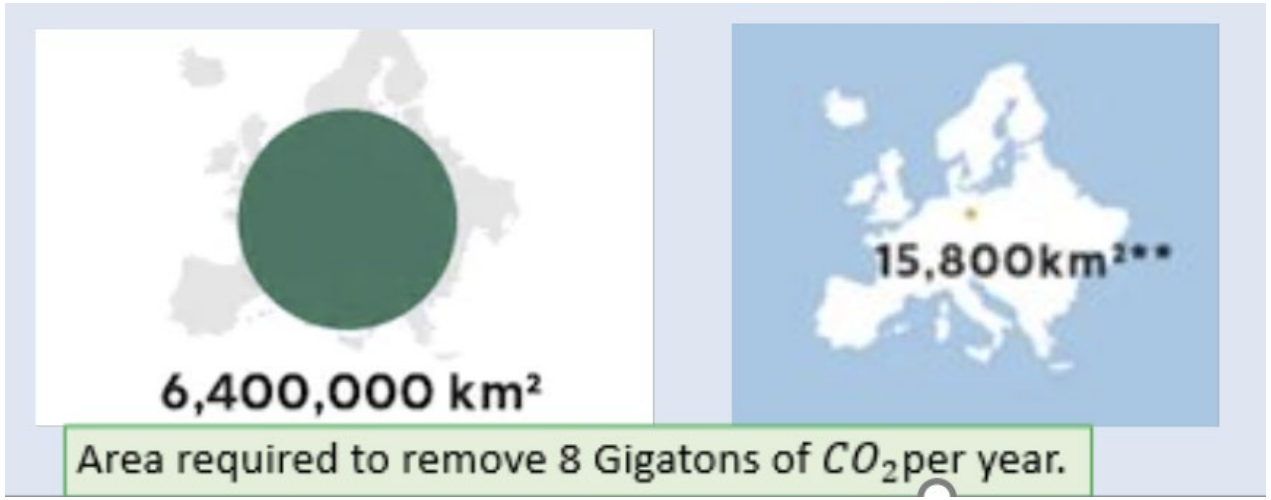
2. First of a kind (FOAK) plant, there were more interruptions than anticipated.



3. Choices were made to proceed with components that had a lower service life, for example, carbon steel instead of stainless steel

Orca Plant during harsh Icelandic winter.

Land use



- The land footprint of Climeworks' Orca and Mammoth plants are 1.7 and 7.5 hectares respectively.
- The indirect land use includes land required to produce renewable energy for Climeworks' operations.
- US research shows that even ambitious growth of photovoltaic panels will have a negligible effect on agricultural land or food supply.
- Climeworks estimates that to remove 8 gigatons of CO_2 a year using DAC+S would require 15,800 km^2 of land. Removing the same quantity by planting trees would require 400 times more land. This chimes with the IPCC report which suggests that land use is no a restraining factor for DAC+S to become climatically significant.

Orca – our living proof

The world's **first** and to-date **largest** commercial direct air capture & storage facility

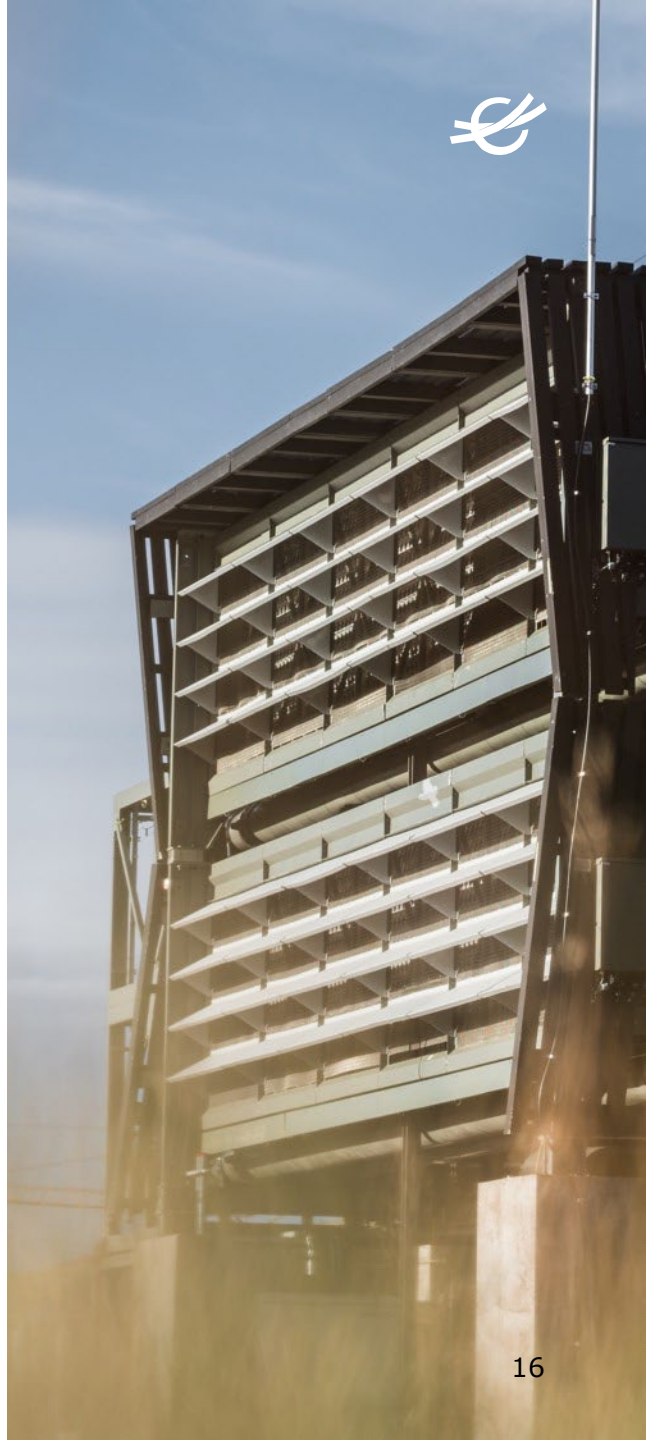
Started operation in September **2021**

Nominal capacity of up to **4,000 tons of CO_2** per year

Located in **Iceland**

Powered 100% by **geothermal energy**

CO_2 permanently stored underground through **mineralization** (via Carbfix)



Climeworks customers:

Microsoft · Swiss Re · BCG · shopify

LGT · SWAROVSKI · Square · verdane

stripe · ocado · amag · Audi

- **For companies**
- High-quality CO_2 removal as part of corporate emissions reduction roadmaps to achieve net zero and beyond.

- **For individuals**
- CO_2 removal as a service for individuals to remove emissions and enable DAC's scale-up: www.climeworks.com/subscriptions

Our co-CEOs and co-founders named to the inaugural TIME100 Climate list 2023

TIME100 CLIMATE | Powered by TIMECO2

Climeworks has been named to Fast Company's Worlds' 50 Most Innovative Companies of 2024

Making it to #1 in the Sustainability category

- Our vision

To inspire 1 billion people to remove carbon dioxide from the air

climeworks

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