



CLIMEWORKS

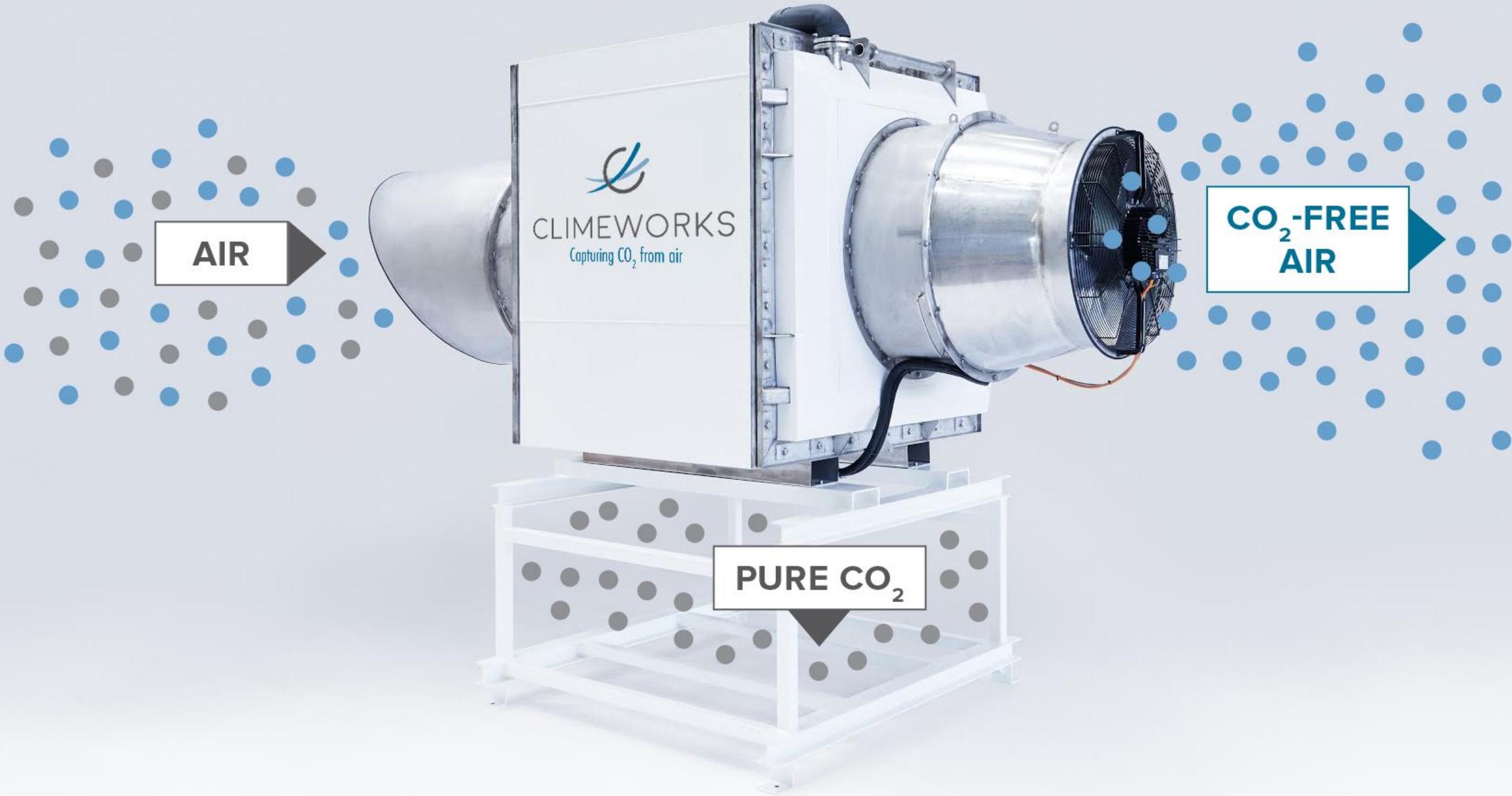
Capturing CO₂ from air

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Herbstworkshop Energiespeichersysteme, TU Dresden

29 November 2017

Jan Wurzbacher, Director & Founder, jw@climeworks.com



AIR

CLIMEWORKS
Capturing CO₂ from air

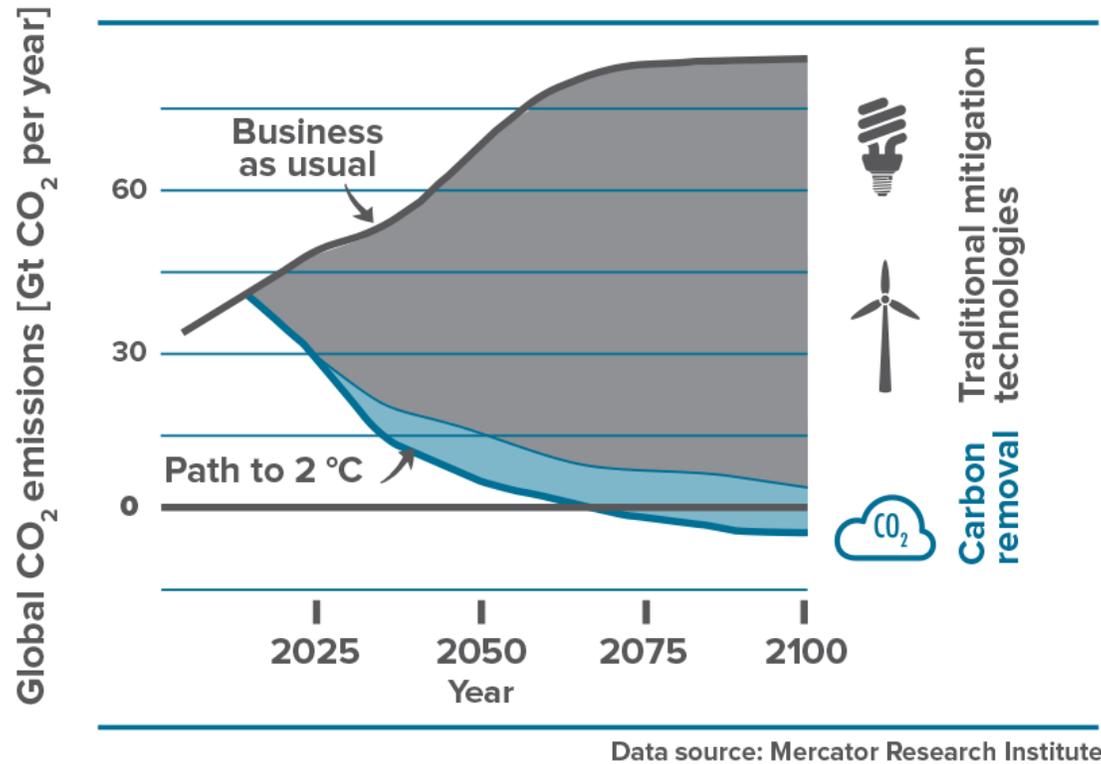
CO₂-FREE
AIR

PURE CO₂

WHY DIRECT AIR CAPTURE OF CO₂



How to keep global warming below 2 °C.



Achievement of climate targets can be summarized in 3 points:

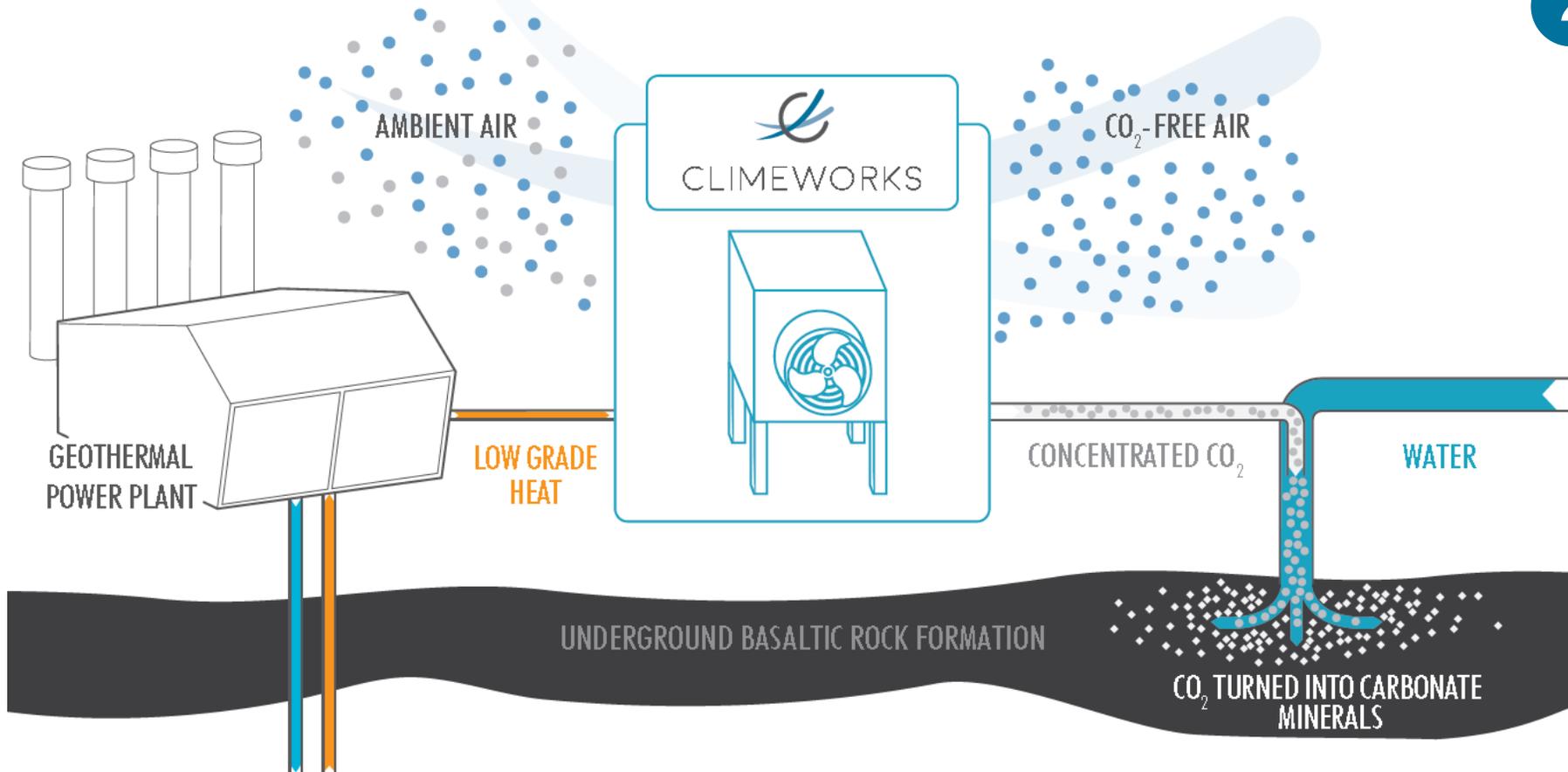
1. Until 2050 global CO₂ emissions have to reach 0 Gt/y
2. In order to achieve 0 Gt/y all mitigation technologies have to be combined with carbon removal
3. Starting 2050 global CO₂ emissions have to become negative in order to revert climate change

87% of IPCC modeling scenarios consistent with **2 °C of global warming** involve large scale deployments of CO₂ removal from air.

CO₂ REMOVAL VIA DIRECT AIR CAPTURE



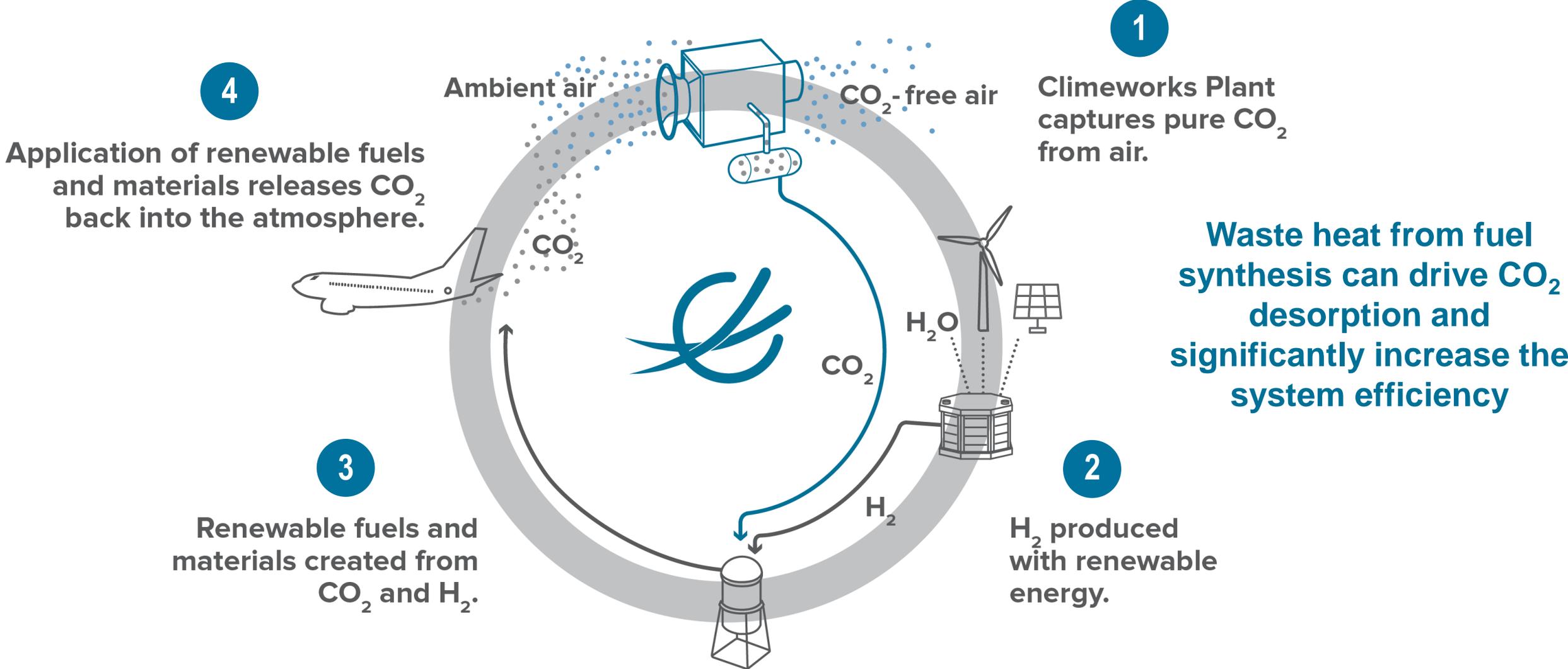
- 1 CO₂ is captured directly from the air using renewable, e.g., geothermal energy



- 2 CO₂ is pumped underground at favorable CO₂ storage sites, e.g. Iceland.

- 3 CO₂ reacts with underground rock formations and is mineralized. Thereby CO₂ is bound permanently and safely, reducing the CO₂-content of the atmosphere.

CO₂-NEUTRAL FUELS VIA DIRECT AIR CAPTURE



THE CLIMEWORKS SOLUTION



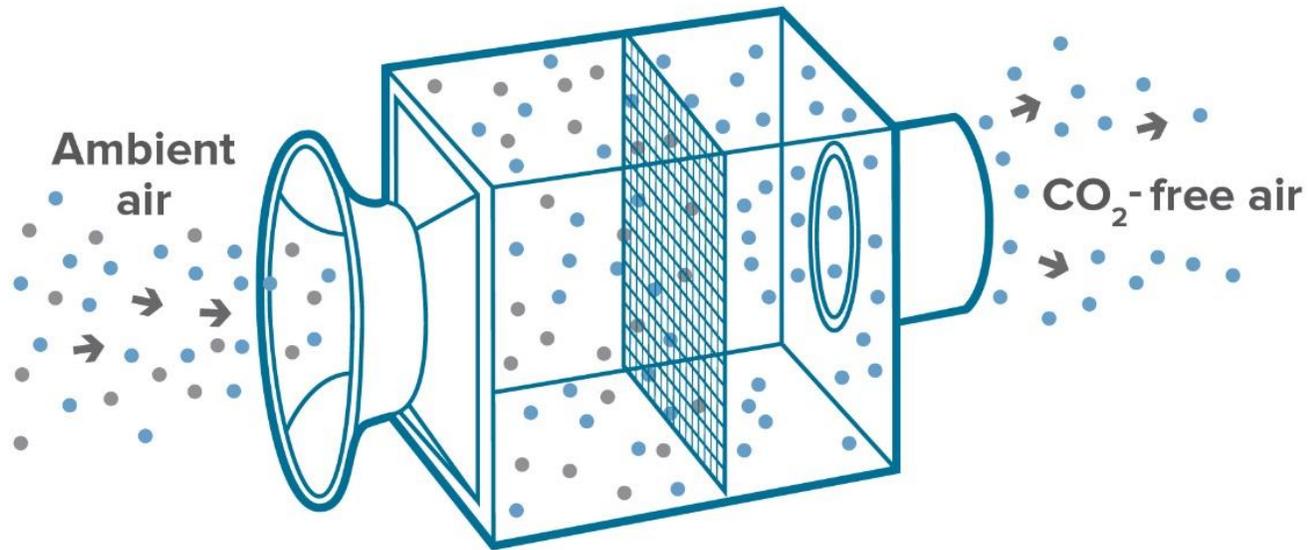
- **Worldwide first** company supplying atmospheric CO₂ to customer
- **Industrial** CO₂ capture plants
- **Scale-up** through mass production of CO₂ Collector modules
- **Low-temperature heat** (solar/waste) as main energy input
- **Minimal carbon footprint**
< 10% side emissions (CO₂-eq)



HOW OUR TECHNOLOGY WORKS



PHASE 1



Ambient air

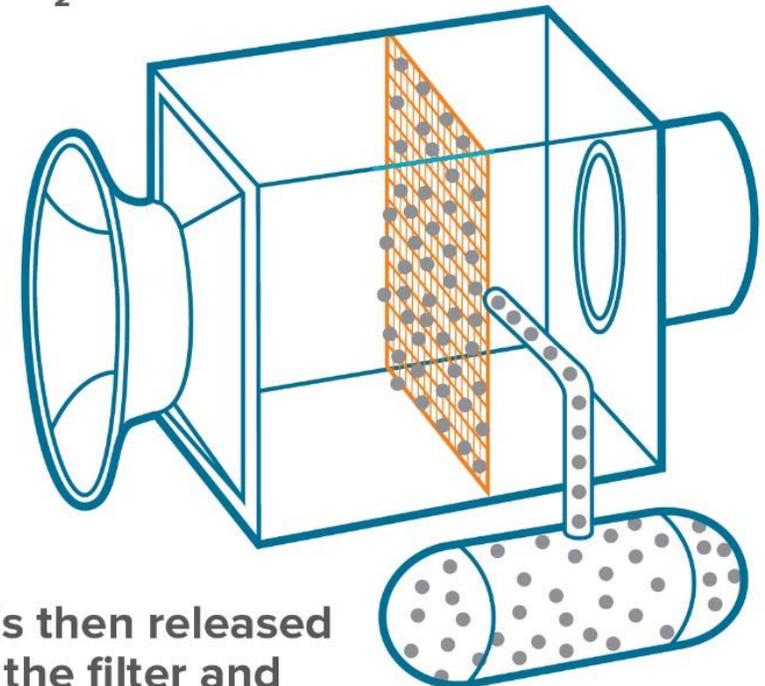
CO₂-free air

CO₂ is chemically bound to the filter.



PHASE 2

Once the filter is saturated with CO₂ the filter is heated to 100 °C.

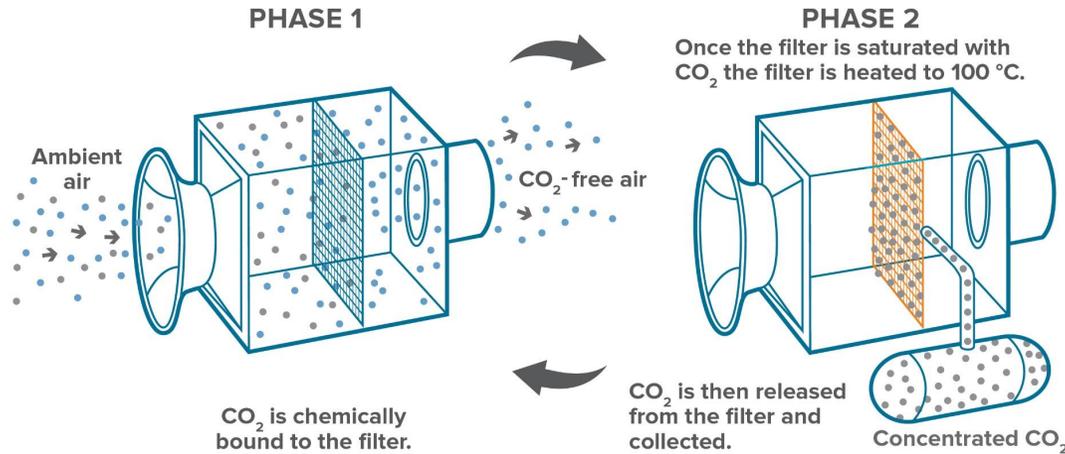


CO₂ is then released from the filter and collected.

Concentrated CO₂



HOW OUR TECHNOLOGY WORKS



Climeworks plants capture atmospheric CO₂ with a filter. Air is drawn into the plant and the CO₂ within the air is chemically bound to the filter.

Once the filter is saturated with CO₂ it is heated (using mainly low-grade heat as an energy source) to around 100 °C. The CO₂ is then released from the filter and collected as concentrated CO₂ gas.

CO₂-free air is released back into the atmosphere. This continuous cycle is then ready to start again. The filter is reused and lasts for several thousand cycles.

- Developed in collaboration with ETH Zurich and the Swiss Federal Laboratories for Material Testing (Empa)
- The development has been supported by total public funding of CHF 7M
 - 6 European Union projects
 - 2 projects funded by the Swiss Federal Office of Energy
 - 1 project funded by the German Ministry of Education and Research
- Climeworks owns 10 patent families, covering the filter, the process, the apparatus and certain applications
- More than 10'000 hours of operational experience; technology has been tested in full scale during 1 year

ETH zürich

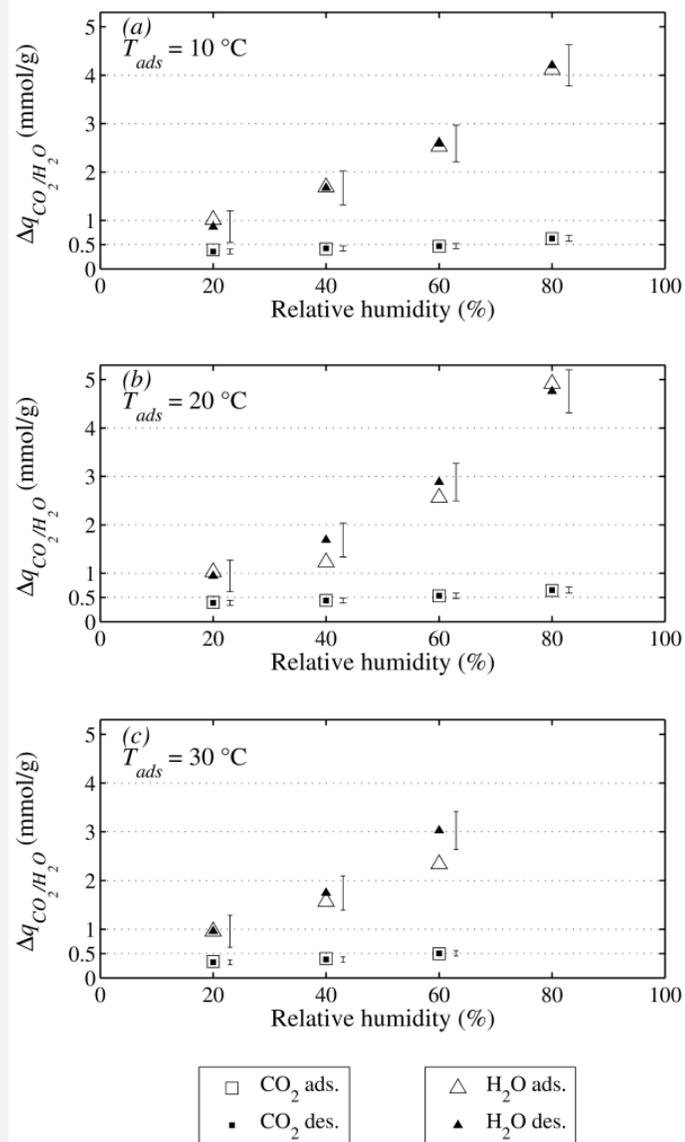
EMPA
Materials Science & Technology



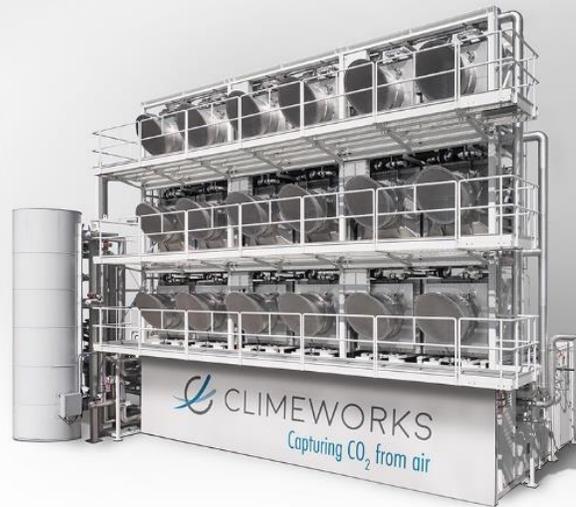
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE

FONA
Forschung für Nachhaltige
Entwicklung
BMBF

EXAMPLE: CO₂ AND H₂O CAPACITIES



- Effect of increasing RH 20 → 80%
 - $q_{CO_2} \times \approx 1.7$
 - $q_{H_2O} \times \approx 5$
- Minor effect of adsorption temperature
- H₂O desorption can account for 50%+ of heat consumption



CLIMEWORKS CO₂ CAPTURE PLANT

- 50+ t CO₂ / y
- Integrable with customer utilities
- Online since 2014
- 6 units sold



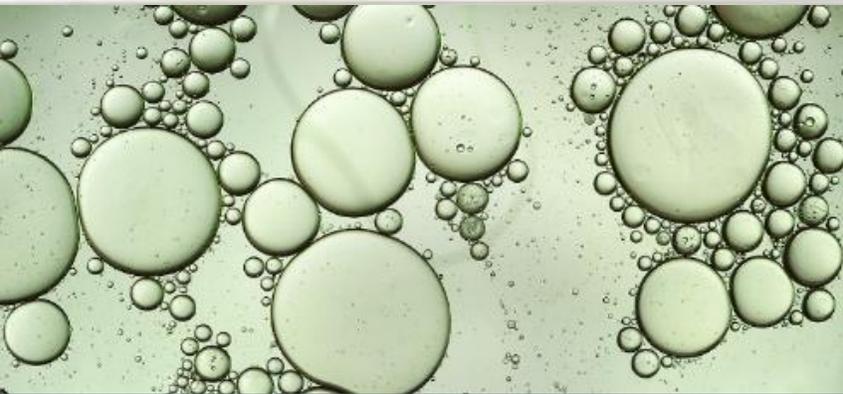
CLIMEWORKS CO₂ DEMONSTRATOR

- 2 t CO₂ / y
- Stand-alone and mobile device
- Online since 2012
- 4 units sold



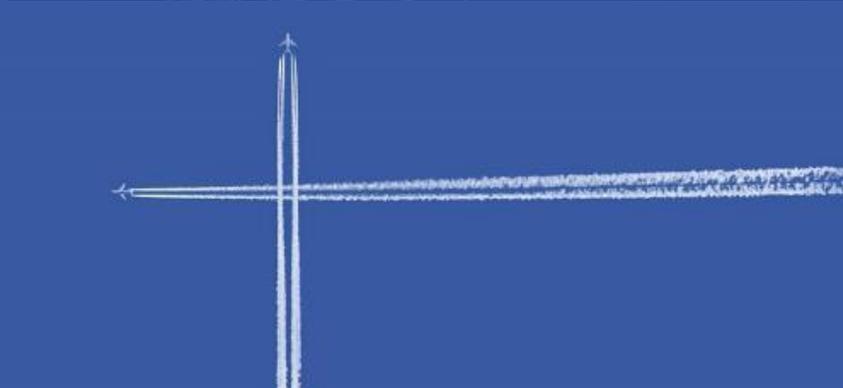
MERCHANT MARKET

- Onsite CO₂-supply for bottlers, greenhouses, etc.
- **10-15Mt CO₂ / y**



RENEWABLE FUELS AND MATERIALS

- Onsite CO₂-supply for renewable fuel synthesis
- **120Mt fuel / y**



CARBON DIOXIDE REMOVAL

- Large-scale CO₂ removal from air
- **10Gt CO₂ / y**

GREENHOUSE FLAGSHIP PROJECT



Plant type:	DAC-18
CO₂ capacity:	2'460 kg/day
Customer:	Greenhouse
Heat source:	Waste heat
Location:	Hinwil, CH
Commissioning:	31 st May 2017

Worldwide first commercial DAC plant

RECOGNITION AS INDUSTRY LEADER



Tech Reports

This power plant captures CO2 from the atmosphere

 tech

A Look at How a Swiss Company is Trying to Slow Climate Change

 **NBC NEWS**

Health & Science

A small effort to extract CO2 from the atmosphere aims to create big change

The Washington Post

WEATHER EYE

Using carbon dioxide to help grow veg

THE  TIMES

Kohlendioxid-Rückgewinnung

Zürcher Startup-Unternehmen mit Weltpremiere: CO₂ wird aus der Luft gefiltert

Neue Zürcher Zeitung

"Catturiamo CO2 e la trasformiamo in fertilizzante", in Svizzera il primo impianto commerciale al mondo

la Repubblica 

CO₂ REMOVAL FLAGSHIP PROJECT



Plant type:	DAC-1
CO₂ capacity:	100 kg/day
CO₂ application:	Mineralization of CO ₂ → negative emissions
Heat source:	Geothermal
Location:	Hellisheidi, Iceland
Commissioning:	11 th Oct. 2017

Worldwide first CO₂ removal via DAC

CUSTOMERS & REFERENCES

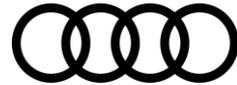


Food, beverages & agriculture



- Selling CO₂ from DAC-18 plant to greenhouse
- Closed CO₂ purchase agreement with globally leading beverage company to supply atmospheric CO₂ from DAC-18 plant

Renewable fuels & materials



- Sold Demonstrator and DAC-1 plant to AUDI

- Sold DAC-1 plant to UK utility

- Sold DAC-3 plant for Power-to-Gas demonstration project



- Sold two Demonstrators for renewable materials demonstration project



- Sold Demonstrator for Power-to-Liquid research project



Carbon dioxide removal



- Selling negative emissions from DAC-1 plant

1 plant (+1 in pipeline)

7 plants

1 plant

Climeworks has to date sold 9 plants/CO₂ purchase agreements in all key market segments

COMPANY HISTORY



Founded as ETH
spin-off by Jan
Wurzbacher and
Christoph Gebald

2009



2010



Won **Venture Kick**,
Switzerland's leading
startup incubation
initiative

2011



Finalist of **Virgin Earth
Challenge**, a USD 25 mio.
prize by Richard Branson

2013



Established strategic
partnership with carmaker
AUDI

2014



Developed modular
CO₂ collector

2017



Commissioned the
world's first commercial
scale direct air capture
plant and the **world's first
negative emissions** plant
via DAC

45 FTE's, largest team of experts in the field

Raised over **CHF 22 M** through equity and grants



- Current production capacity: Up to **100 CO₂ Collectors** annually, which is the equivalent of 5 DAC-18 CO₂ capture plants as operated for the greenhouse in Hinwil, Switzerland
- In-house manufacturing of CO₂ Collectors (core components)
- Large supplier network for other plant components
- Assembly of turnkey plants with minimal installation effort onsite

The background of the image shows a complex industrial machine, possibly a CO2 capture system, with various pipes, valves, and large cylindrical components. The entire image is overlaid with a semi-transparent blue filter. A white rectangular box is centered on the image, containing text.

VISION 1/25

CAPTURE 1% OF GLOBAL CO₂ EMISSIONS BY 2025

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