



CLIMEWORKS

Capturing CO<sub>2</sub> from air

# DAS POTENTIAL VON DIRECT AIR CAPTURE (DAC)

Innovationstagung CO<sub>2</sub>

MAY 2019

Dominique Kronenberg

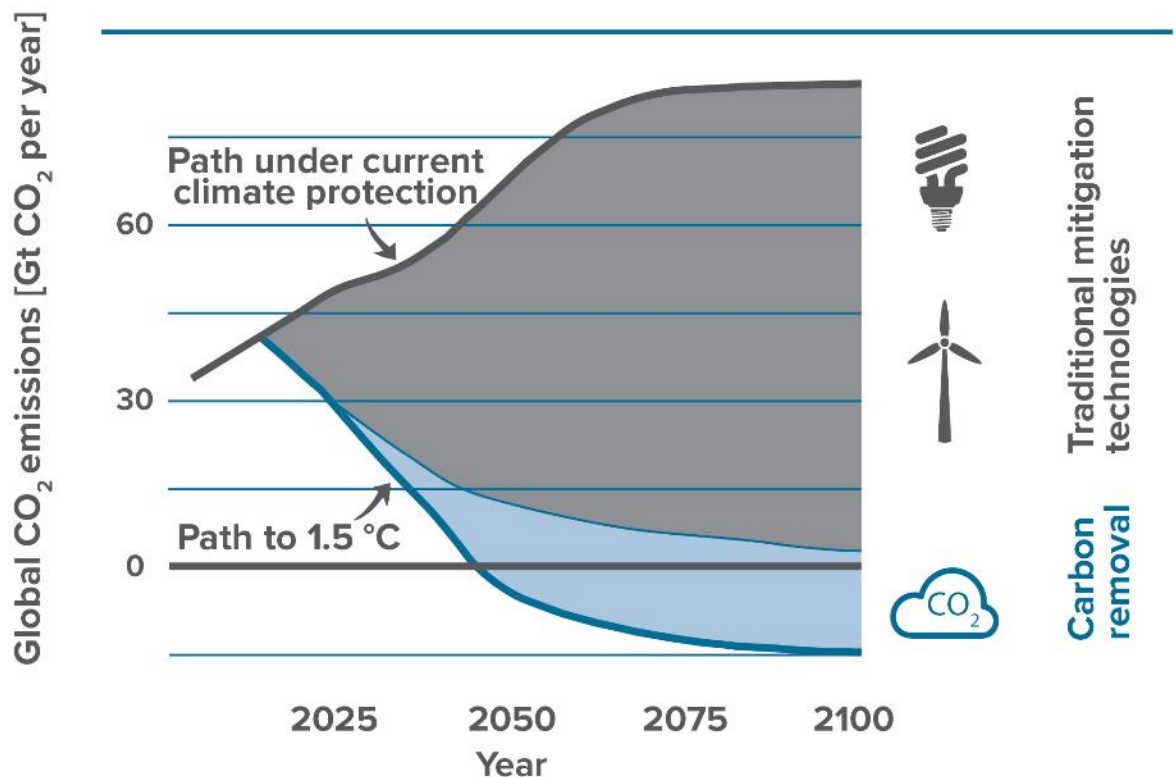
[dk@climeworks.com](mailto:dk@climeworks.com)



# WHY DIRECT AIR CAPTURE



How to keep global warming below 1.5 °C.



Data source: Mercator Research Institute

All IPCC mitigation scenarios compatible with the 1.5°C target rely on the assumption of **large-scale CO<sub>2</sub> removal**

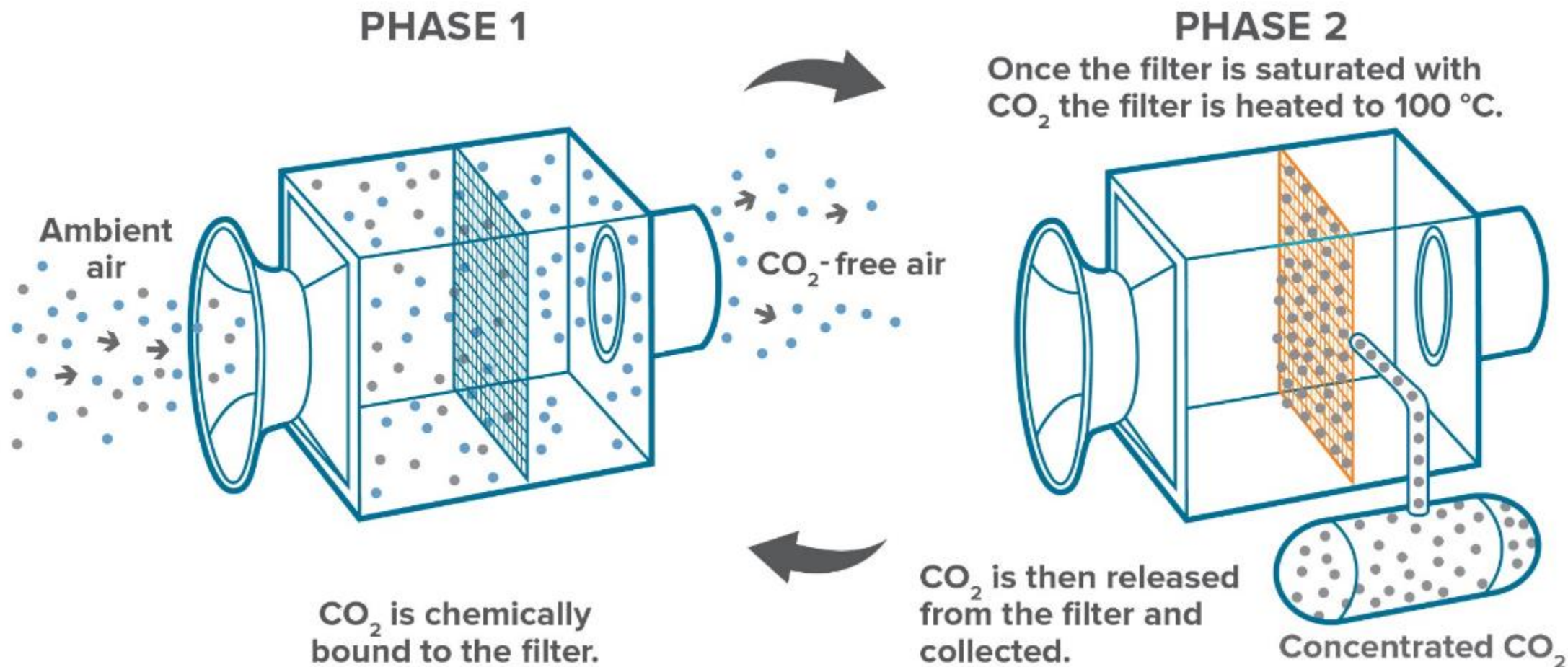
# THE CLIMEWORKS SOLUTION



- **World's first** company supplying atmospheric CO<sub>2</sub> to customers
- **Modular** CO<sub>2</sub> capture plants
- **Scale-up** via mass production of CO<sub>2</sub> collectors
- **Low-temperature heat** (renewable or waste) as main energy source
- **Minimal carbon footprint:** 90% net efficiency (mid-term target 95%)



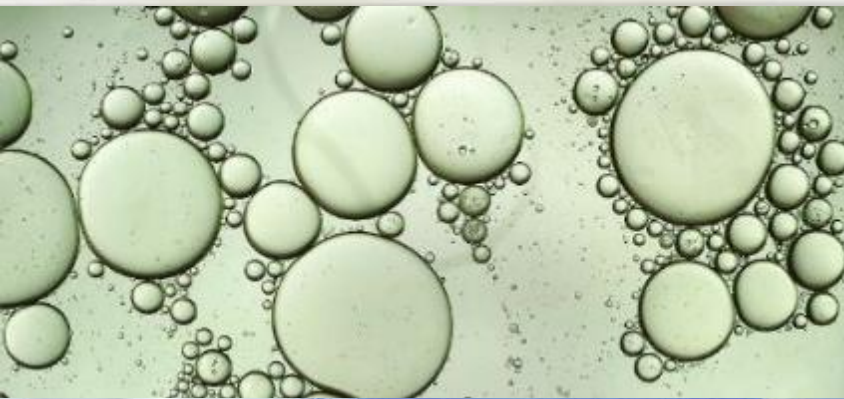
# HOW OUR TECHNOLOGY WORKS





## MERCHANT MARKET

- Onsite CO<sub>2</sub> supply for bottlers, greenhouses, etc.
- **30 million tCO<sub>2</sub> / year** (source: Global CCS Institute)



## RENEWABLE FUELS & MATERIAL

- Onsite CO<sub>2</sub> supply for renewable fuel synthesis
- **2 billion tCO<sub>2</sub> / year** (source: CO<sub>2</sub> Sources & The Global CO<sub>2</sub> Initiative)



## CARBON DIOXIDE REMOVAL (CDR)

- Large-scale CO<sub>2</sub> removal from air
- **12 billion tCO<sub>2</sub> / year** (source: IPCC)

# CLIMEWORKS' FLAGSHIP PLANTS



## MERCHANT MARKET

- Onsite CO<sub>2</sub> supply for greenhouse fertilization
- Operational since May 2017
- Location: Hinwil, Switzerland



## RENEWABLE FUELS

- Onsite CO<sub>2</sub> supply for methanation
- Operational since October 2018
- Location: Troia, Italy



## CARBON DIOXIDE REMOVAL

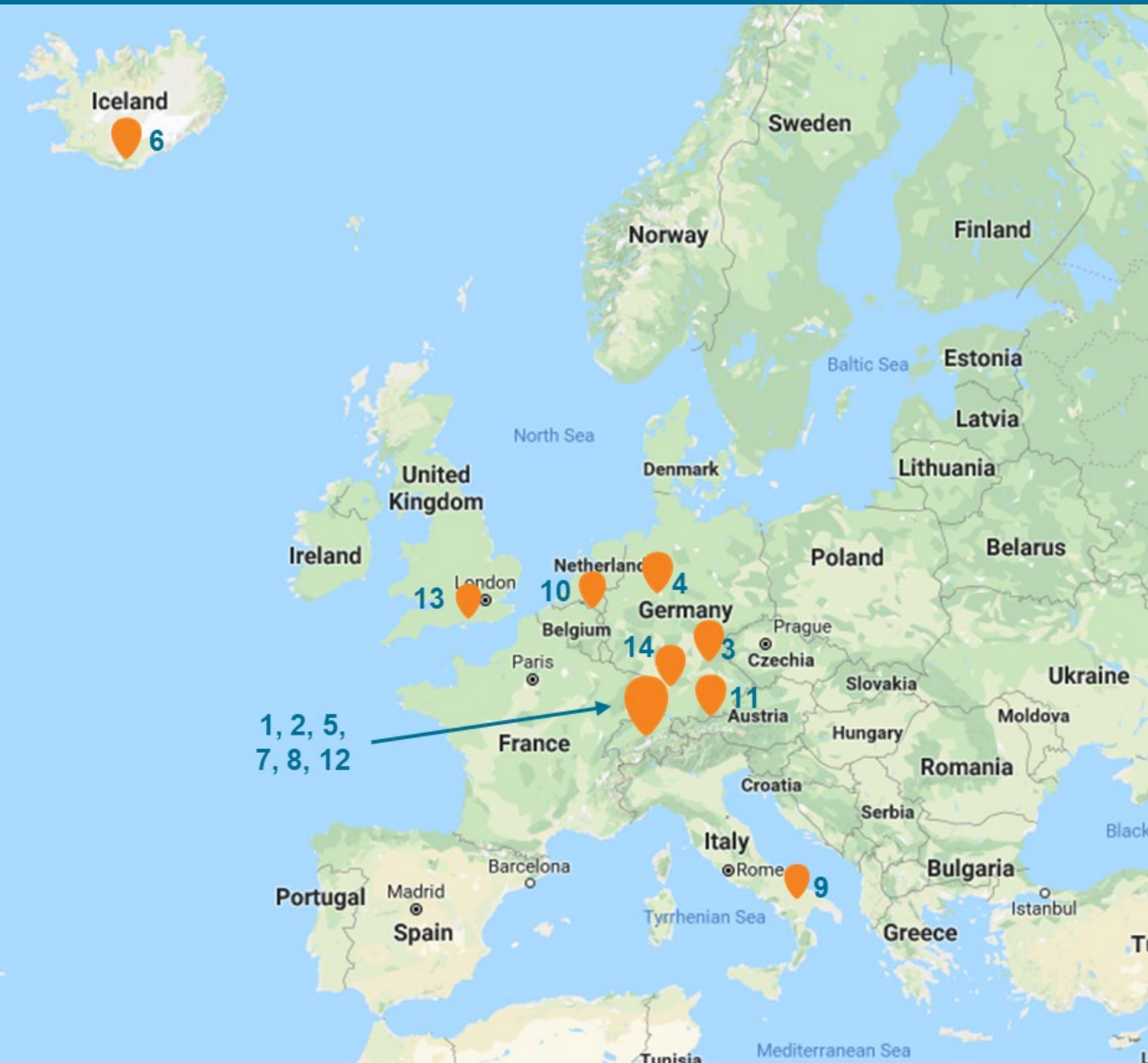
- CO<sub>2</sub> removal & mineralization
- Operational since October 2017
- Location: Reykjavik, Iceland

# CLIMEWORKS' FIRST-MOVER PARTNERS





# PLANT LOCATIONS



- **14 plants** currently in operation
- More than **10'000 hours** of operational experience across a wide range of climatic conditions

# MERCHANT MARKET FLAGSHIP



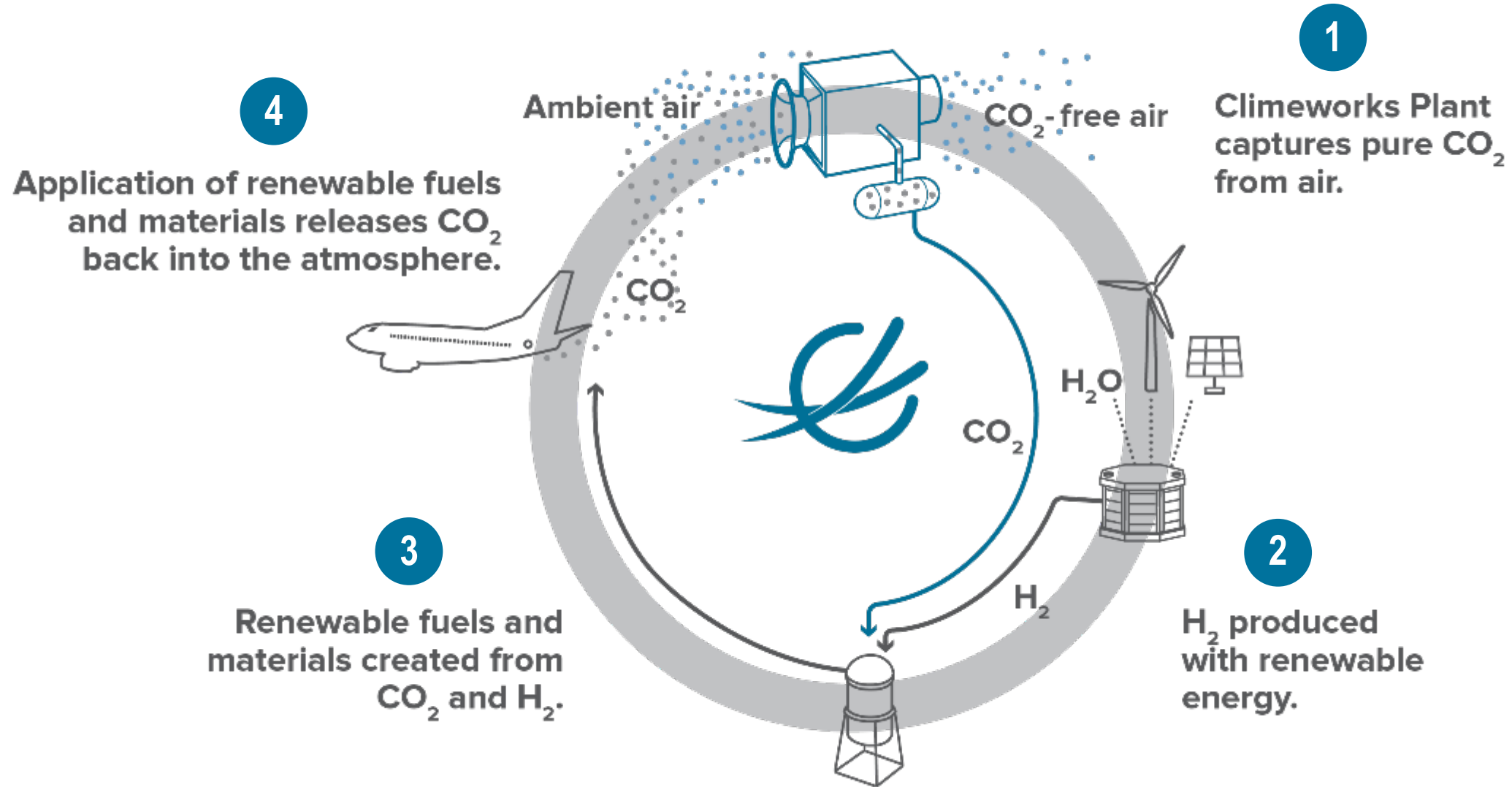
## World's first commercial DAC plant

|                                    |                           |
|------------------------------------|---------------------------|
| <b>Plant type:</b>                 | DAC-18                    |
| <b>CO<sub>2</sub> capacity:</b>    | 2'460 kg/day              |
| <b>CO<sub>2</sub> application:</b> | Greenhouse                |
| <b>Heat source:</b>                | Waste heat                |
| <b>Location:</b>                   | Hinwil,<br>Switzerland    |
| <b>Commissioned:</b>               | 31 <sup>st</sup> May 2017 |

An aerial photograph of a vast mountain range with numerous peaks covered in snow. The image is overlaid with a semi-transparent blue gradient that is darker at the bottom and lighter at the top. The text 'RENEWABLE FUELS & MATERIALS' is centered in white, bold, uppercase letters.

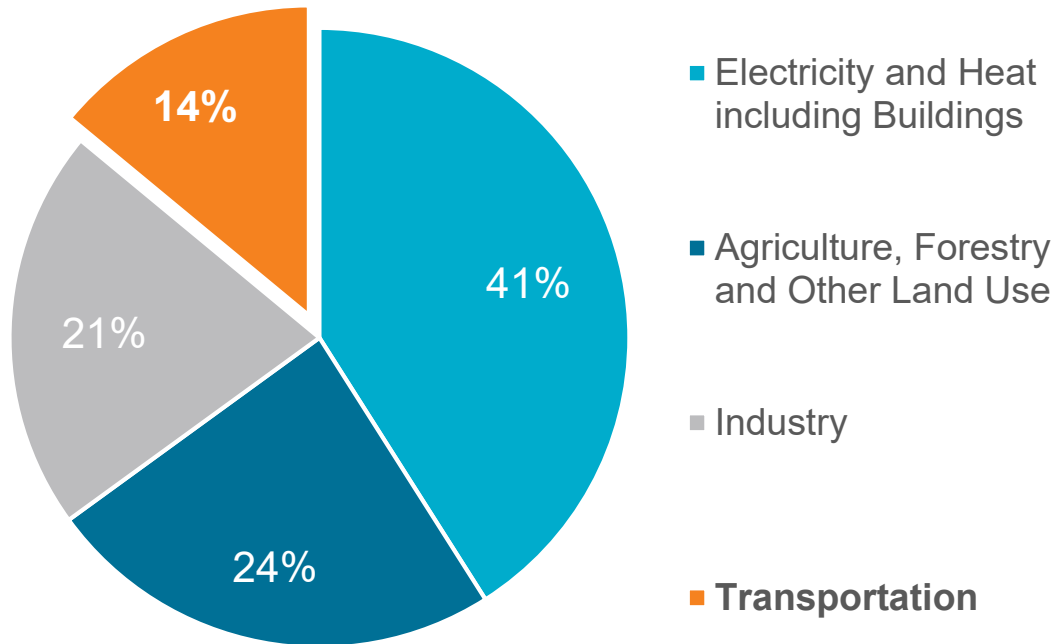
# RENEWABLE FUELS & MATERIALS

# CO<sub>2</sub>-NEUTRAL FUELS VIA DIRECT AIR CAPTURE





## Global CO<sub>2</sub> Emissions by Sector

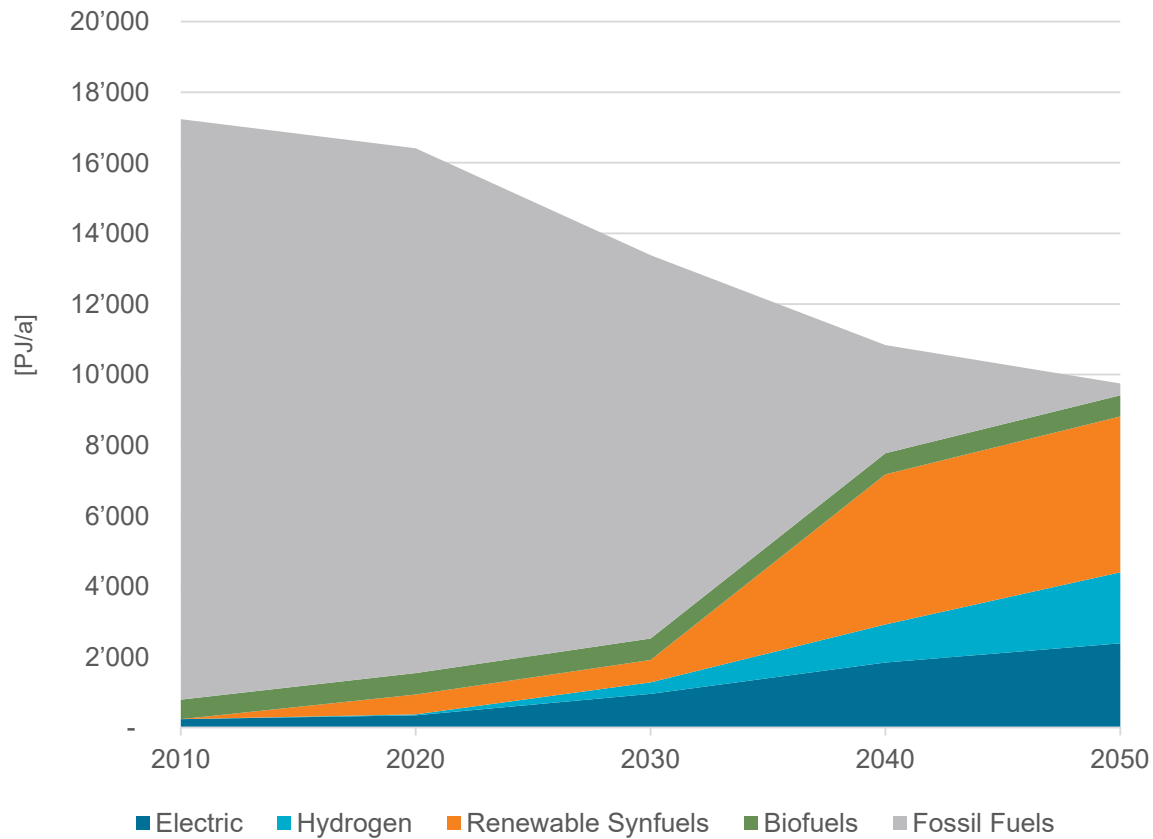


Source: IPCC (2014) 5th Assessment Report

- Fossil-sourced electricity & heat needs replacing by **Renewables**
- Agricultural emissions need addressing through **Land Management**
- Industrial emissions reduction requires **Carbon Capture & Storage**
- Transportation sector, especially for maritime shipping and aviation, requires **Direct Air Capture**



EU Transportation sector's total energy demand by fuel type  
(eDrive scenario)



Source: DENA (2017) The Potential of electricity-based fuels for low emissions transport in the EU

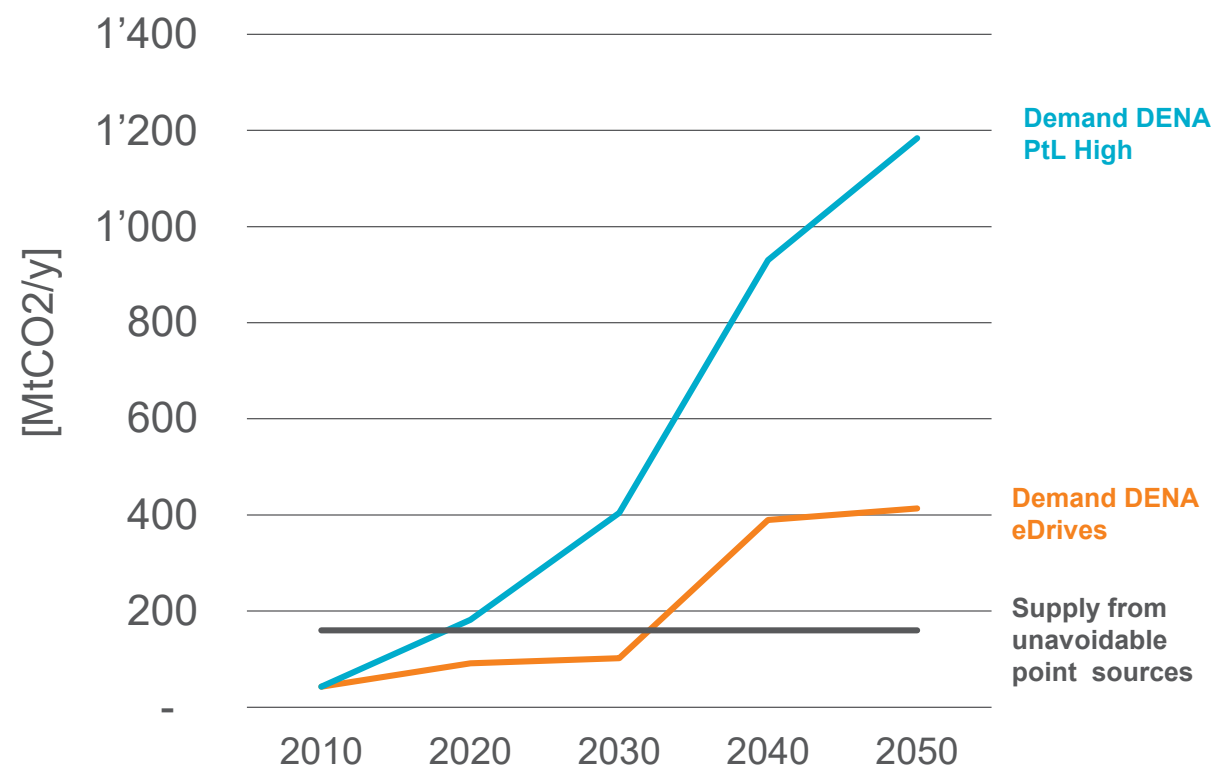
- Study conducted by **German Energy Agency** (DENA)
- Potential of biofuels limited to 600 pJ/year due to **land use and food safety** concerns
- Renewable synfuels are key to decarbonizing **aviation and maritime transportation**

# CO<sub>2</sub> AS A SCARCE RESOURCE



- About **2.5 kg CO<sub>2</sub>** is required to produce **1 litre** of renewable synfuel
- Under 200 Mt CO<sub>2</sub> from **point sources** available as fossil power production is phased out
- CO<sub>2</sub> demand for renewable synfuels to **exceed point sources** before 2030
- Majority of CO<sub>2</sub> will have to be provided through **Direct Air Capture**

## EU CO<sub>2</sub> Demand for Synfuels vs. Fossil Fuels



Source: DENA (2017) The Potential of electricity-based fuels for low emissions transport in the EU



**Demonstration of large-volume energy storage with Power-to-X**

|                                    |                              |
|------------------------------------|------------------------------|
| <b>Plant type:</b>                 | DAC-3                        |
| <b>CO<sub>2</sub> capacity:</b>    | 410 kg/day                   |
| <b>CO<sub>2</sub> application:</b> | Methane synthesis            |
| <b>Heat source:</b>                | Heat recovery from synthesis |
| <b>Location:</b>                   | Troia, Italy                 |
| <b>Commissioning:</b>              | 1 <sup>st</sup> Oct 2018     |





# CARBON DIOXIDE REMOVAL

**One Collector captures  
the same amount of CO<sub>2</sub>  
per year as 1'000 trees.**



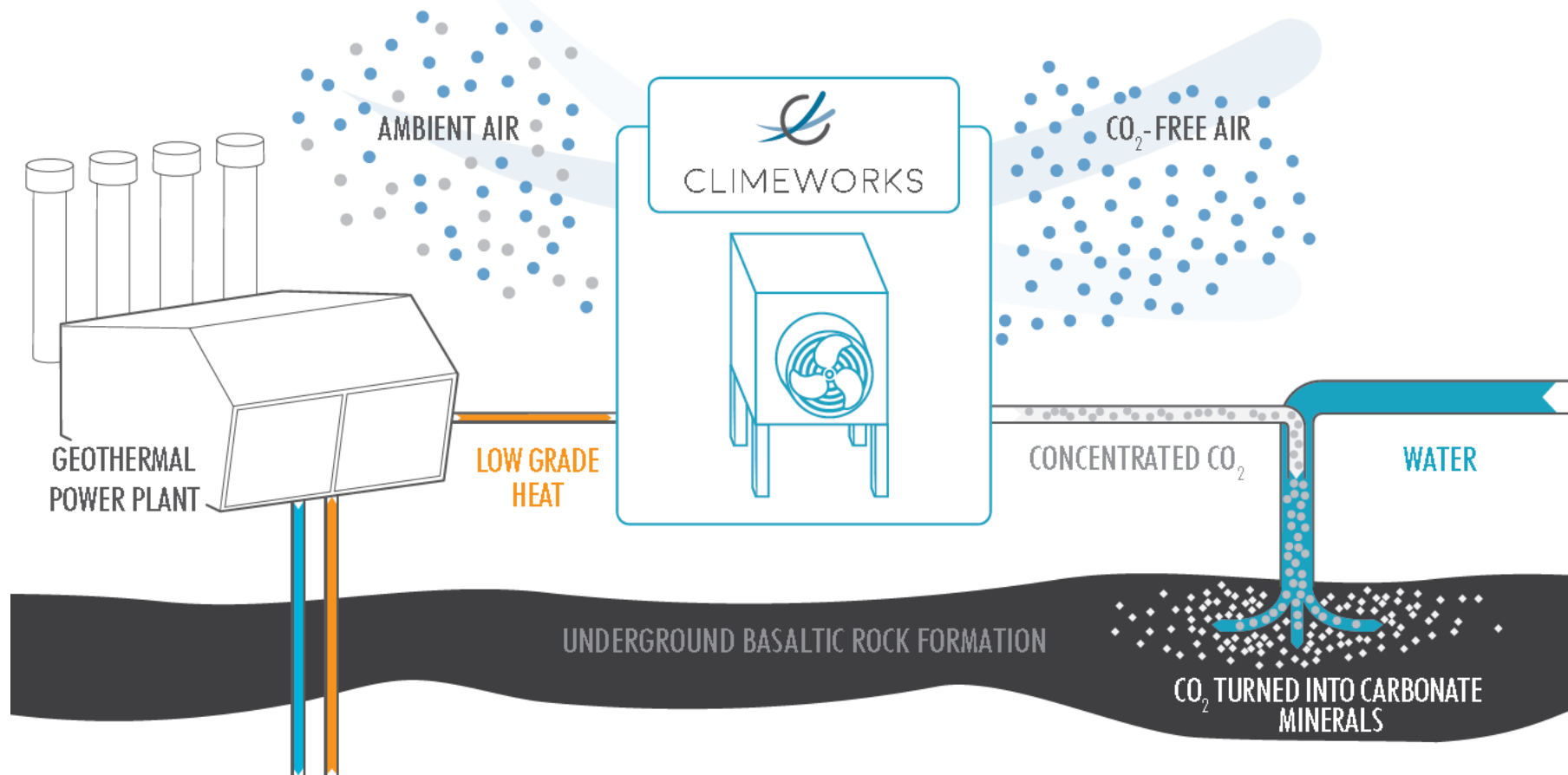
# CARBON DIOXIDE REMOVAL FLAGSHIP



- 1 **CO<sub>2</sub> is captured directly from ambient air using renewable, e.g. geothermal energy.**

- 2 **CO<sub>2</sub> is pumped underground at favorable CO<sub>2</sub> storage sites, e.g. Iceland.**

- 3 **CO<sub>2</sub> reacts with underground rock formations and is mineralized. CO<sub>2</sub> is thereby bound permanently and safely, reducing the CO<sub>2</sub> content of the atmosphere.**



# CARBON DIOXIDE REMOVAL FLAGSHIP





**World's first carbon dioxide removal plant enabled by DAC**

|                                    |                           |
|------------------------------------|---------------------------|
| <b>Plant type:</b>                 | DAC-1                     |
| <b>CO<sub>2</sub> capacity:</b>    | 135 kg/day                |
| <b>CO<sub>2</sub> application:</b> | Mineralization            |
| <b>Heat source:</b>                | Geothermal                |
| <b>Location:</b>                   | Hellisheidi,<br>Iceland   |
| <b>Commissioned:</b>               | 11 <sup>th</sup> Oct 2017 |

# OUR TEAM



- **65** FTEs
- Headquarters in **Zurich**, Switzerland
- Subsidiary in **Cologne**, Germany
- Founded by mechanical engineers **Christoph Gebald** & **Jan Wurzbacher**
- Team includes R&D, Order Processing, Production, Logistics, Marketing & Sales



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 the text.

VISION 1/25

CAPTURE 1% OF GLOBAL CO<sub>2</sub> EMISSIONS BY 2025



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COO

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Presskit: <http://bit.ly/climeworkspresskit>

Climeworks video: <http://bit.ly/clivideo>



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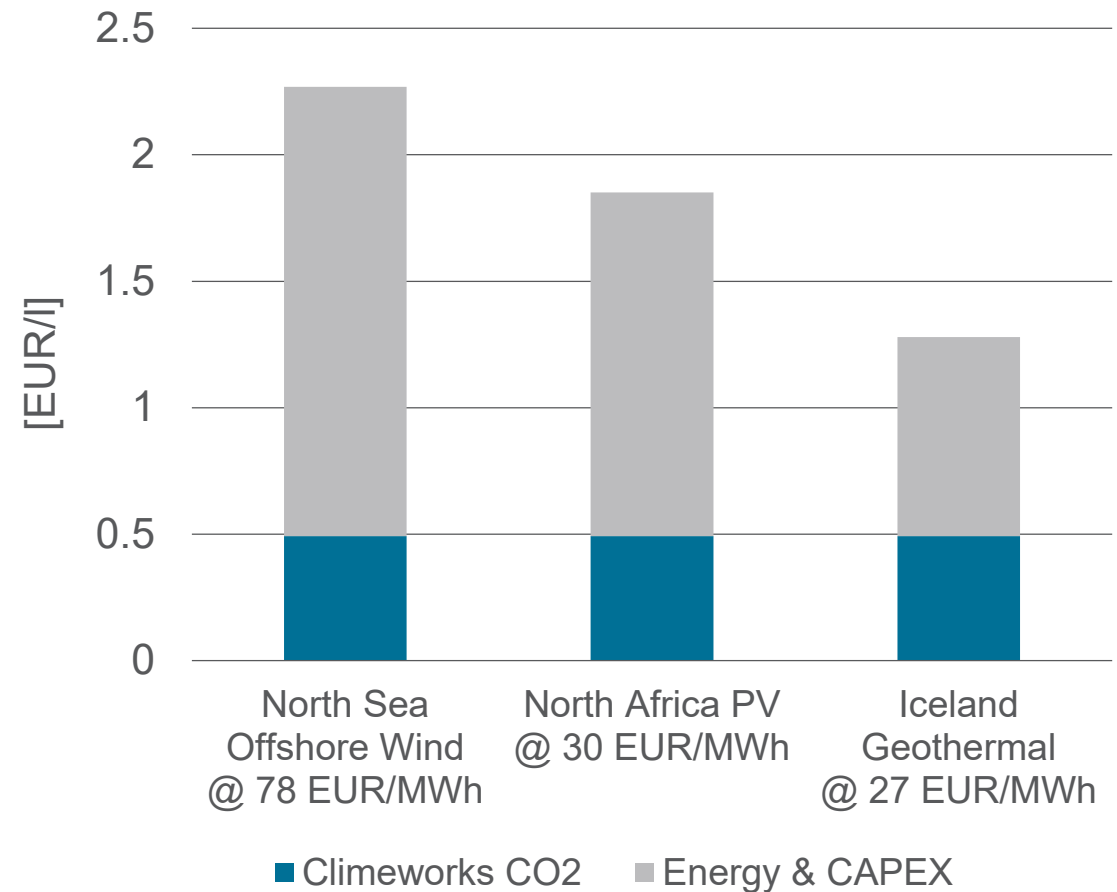
CLIMEWORKS

Capturing CO<sub>2</sub> from air



Make advantage of the location with the **lowest energy costs** by using CO<sub>2</sub> from the air.

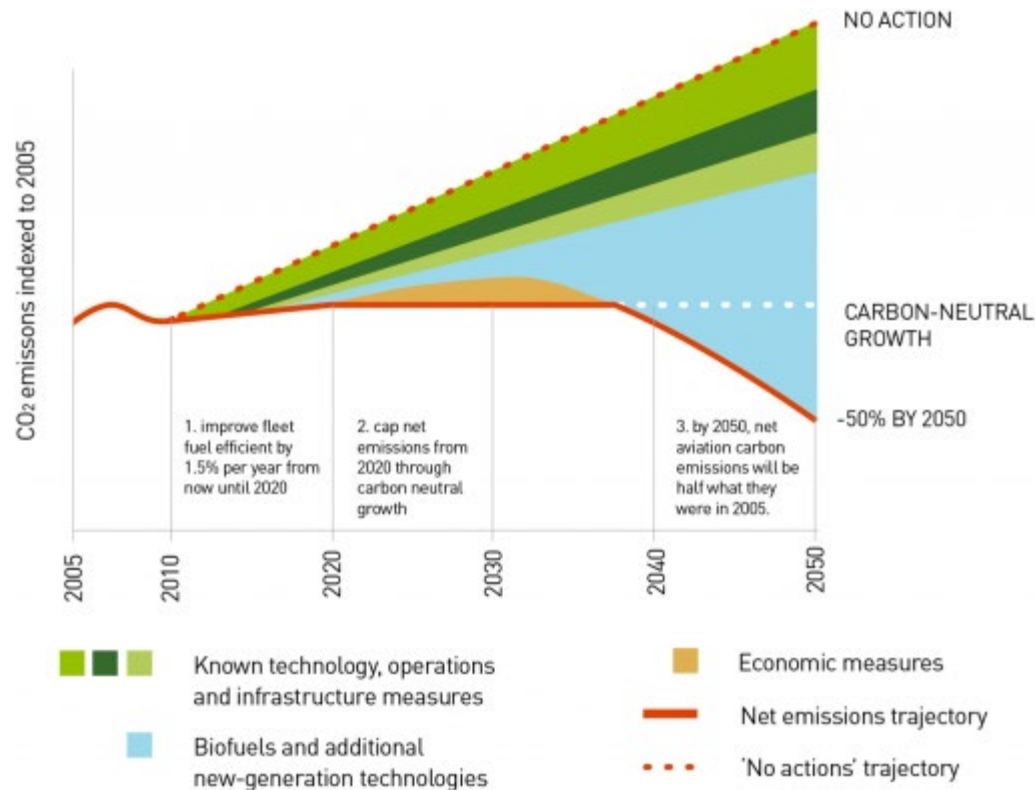
### Renewable Synfuel Production Cost by 2025



Source: Agora (2018) The Future Cost of Electricity-Based Synthetic Fuels / Climeworks



## CO<sub>2</sub> Reduction Options for Aviation



About  
**500 thousand tons**  
sustainable aviation  
**fuels per day**  
required by 2050.

Source: SkyNRG/ATAG



Surface area needed to meet the 2010 EU transportation energy demand (17,000 pJ/year)

## Corn Biofuel

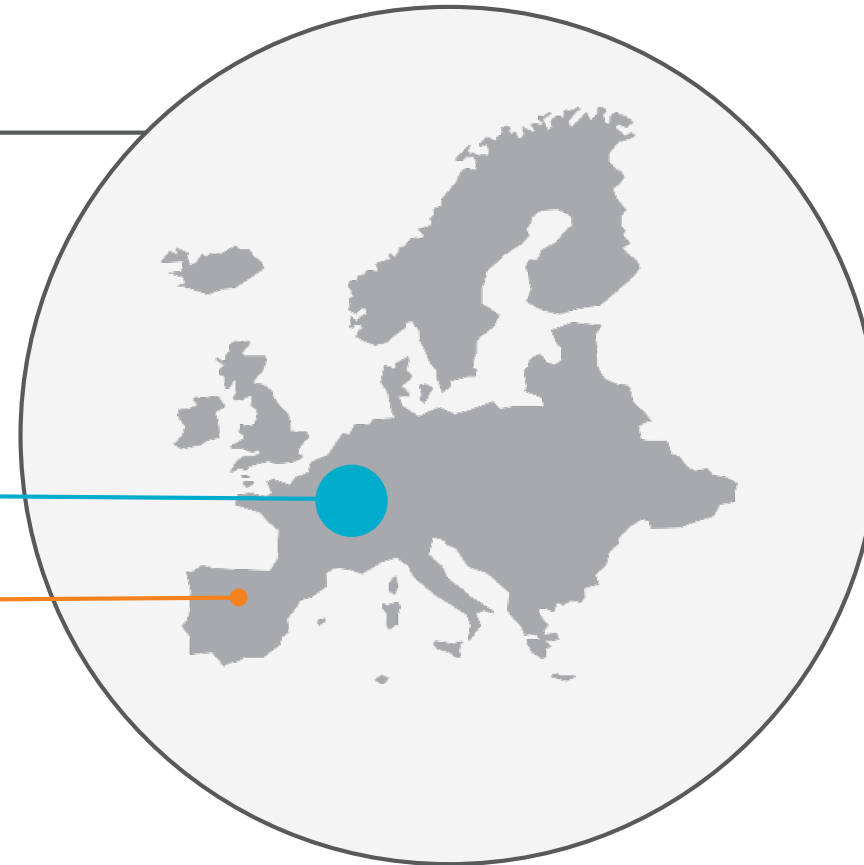
28'000'000 km<sup>2</sup>  
of arable land  
(yield assumption 18 g/ac/y)

## Algae Biofuel

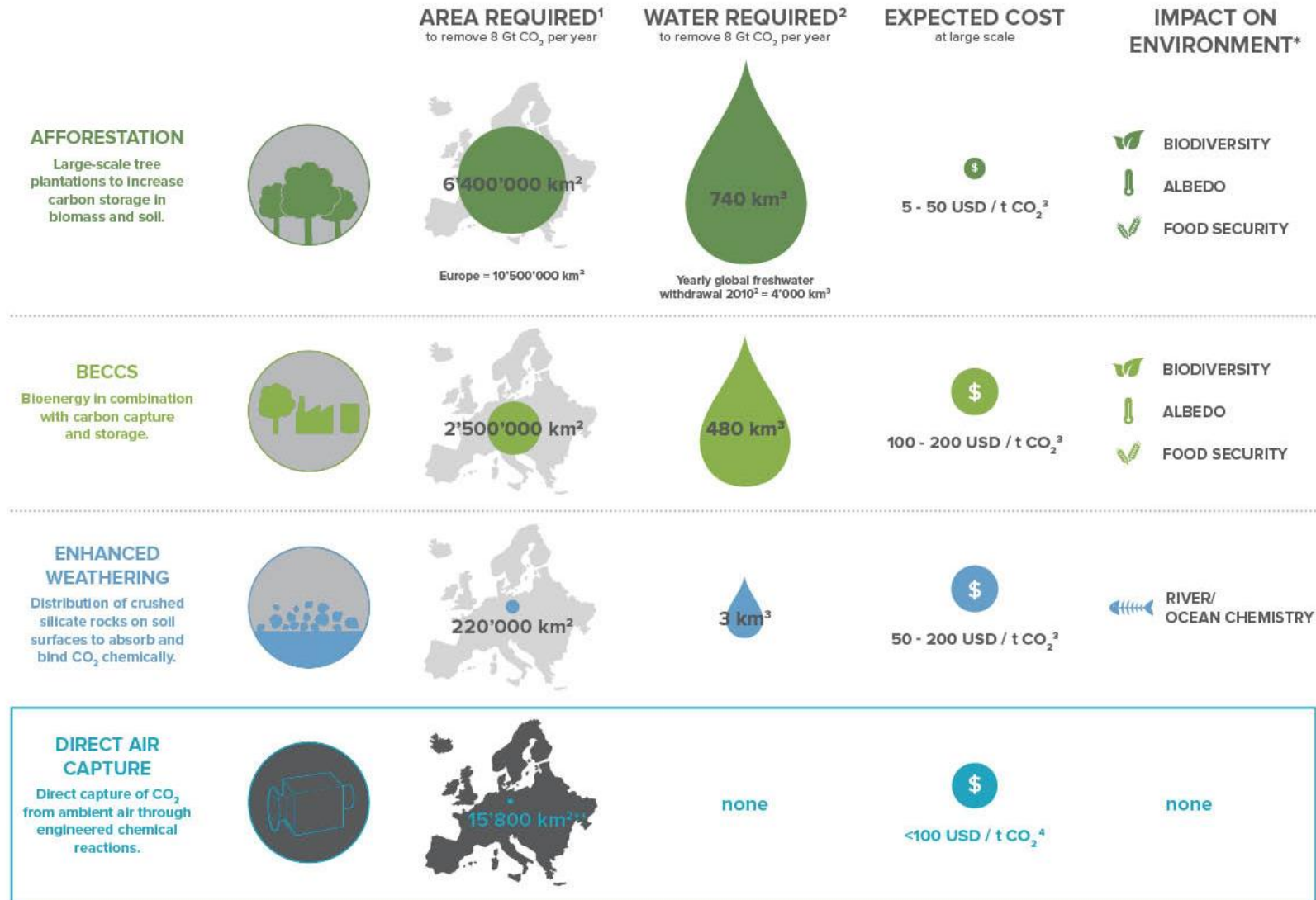
200'000 km<sup>2</sup>  
of barren land  
(yield assumption 2'500 g/ac/y)

## Renewable Synfuels

14'200 km<sup>2</sup>  
of barren land  
(assumption: 1'900kWh/m<sup>2</sup>,  
 $\eta_{PV} = 25\%$ ,  $\eta_{PtX} = 70\%$ )



# CO<sub>2</sub> REMOVAL – A COMPARISON





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“Reversing our emissions through Climeworks allows us to compensate those emissions that cannot be avoided and thus reach our goal of becoming CO2-neutral. We are proud to support a disruptive Swiss technology with huge potential to combat climate change.”

Zürcher Kantonalbank

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“Direct air capture technologies are one of the leading solutions for addressing our climate crisis. Companies like Climeworks are facilitating businesses and governments to achieve carbon neutrality goals.”

Robert Swan

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# WORLDWIDE RECOGNITION



Neue Zürcher Zeitung

Kohlendioxid-Rückgewinnung

**Zürcher Startup-Unternehmen mit Weltpremiere:  
CO<sub>2</sub> wird aus der Luft gefiltert**

indiatimes

**Switzerland Has A Giant Machine That Sucks Carbon Dioxide From Air,  
Performs Better Than Plants**

手机搜狐  
SOHU.COM

**Climeworks发布二氧化碳捕捉设备，或将改善全球  
变暖问题**

Obnovitelně.cz  
chytrá řešení pro život

**Obří zařízení vysává oxid  
uhličitý ze vzduchu**

la Repubblica.it

**"Catturiamo CO<sub>2</sub> e la  
trasformiamo in fertilizzante",  
in Svizzera il primo impianto  
commerciale al mondo**

YAHOO!  
奇摩

**吸碳不如減排 歐專家：捕碳技術無法解決暖化**

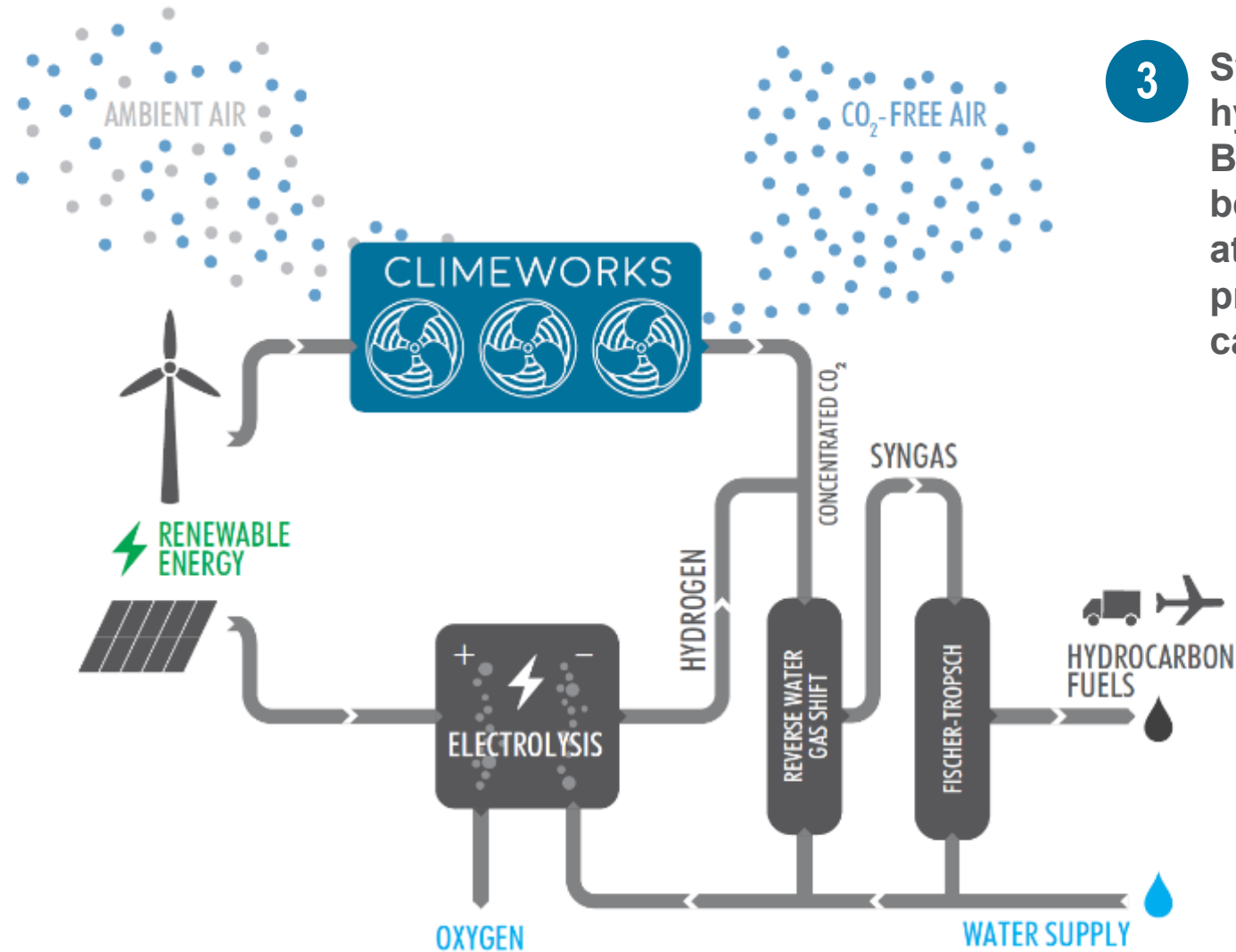
# RENEWABLE FUELS TECHNOLOGY CHAIN



1 CO<sub>2</sub> is captured directly from ambient air using renewable energy.

2 Together with the hydrogen from the electrolysis, CO<sub>2</sub> is turned into syngas.

3 Syngas is turned into hydrocarbon fuels. Because the CO<sub>2</sub> has been captured from the atmosphere, the produced fuels are carbon neutral.







## KOPERNIKUS POWER-TO-X

- Power-to-Liquids
- Supplied Climeworks Demonstrator
- 46 Partners, EUR 30 million budget



## STORE&GO

- Power-to-Methane
- Supplied Climeworks Plant DAC-3
- 27 Partners, EUR 27 million budget



## CELBICON

- Power-to-Chemicals
- Supplied Climeworks Demonstrator
- 13 Partners, EUR 6 million budget