CLIMEWORKS

Capturing CO_2 from air

Direct Air Capture for Zero Emission Jet Fuel

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Public

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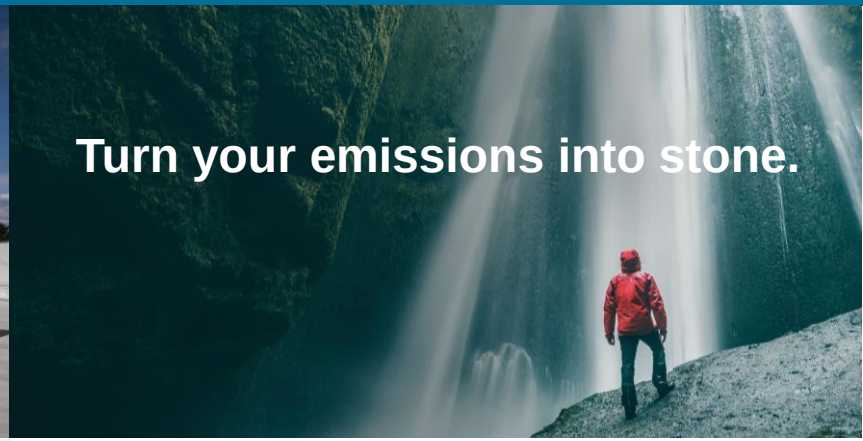
CLIMEWORKS – Capturing CO_2 from air

- **16 DAC plants across Europe, TRL 4-8**
- **75** FTEs in Headquarters in **Zurich**, Switzerland with a subsidiary in **Cologne**, Germany
- **World's first** company supplying atmospheric CO_2 to customers
- **Modular** CO_2 capture plants for quick **scale-up** via mass production
- **Low-temperature heat** (renewable or waste) as main energy source (4/5th)
- **Minimal carbon footprint:** Currently 90% net efficiency cradle-to-grave, mid-term target 95%
- **Cost:** Currently ~600CHF/ton, mid-term goal 100CHF/ton

Products and potential markets for air-captured CO_2



NICHE MARKETS

- Onsite CO_2 supply for niche markets (greenhouses, bottlers)
- Operational since May 2017
- **30 million tCO_2 / year**
  (source: Global CCS Institute)
- Location: Hinwil, Switzerland

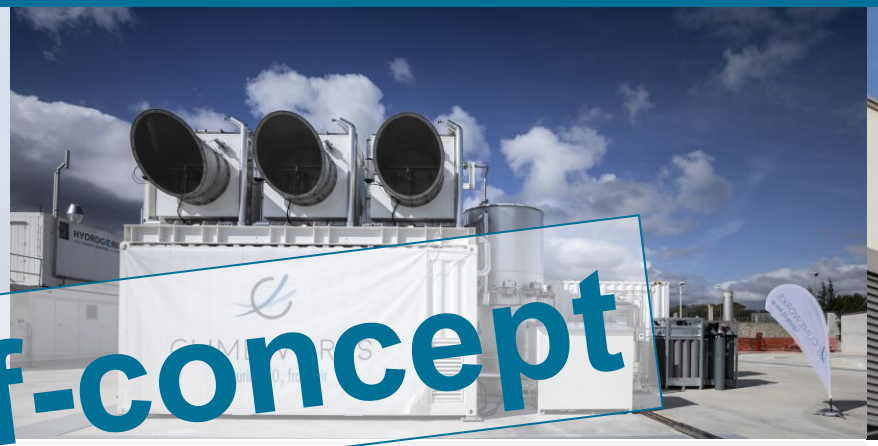
RENEWABLE FUELS

- Onsite CO_2 supply for methanation
- Operational since October 2018
- **2 billion tCO_2 / year**
  (source: CO_2 Sources & The Global CO_2 Initiative)
- Location: Troia, Italy

CARBON DIOXIDE REMOVAL

- CO_2 removal & permanent mineralization
- Operational since October 2017
- **Up 20 billion tCO_2/y by 2050**
  (source: IPCC)
- Location: Reykjavik, Iceland

Renewable Fuels Projects



Proof-of-concept

FLAGSHIP

KOPERNIKUS POWER-TO-X

- Power-to-Liquids
- 46 Partners, EUR 30 million budget
- Successful demonstration of renewable Jet Fuel

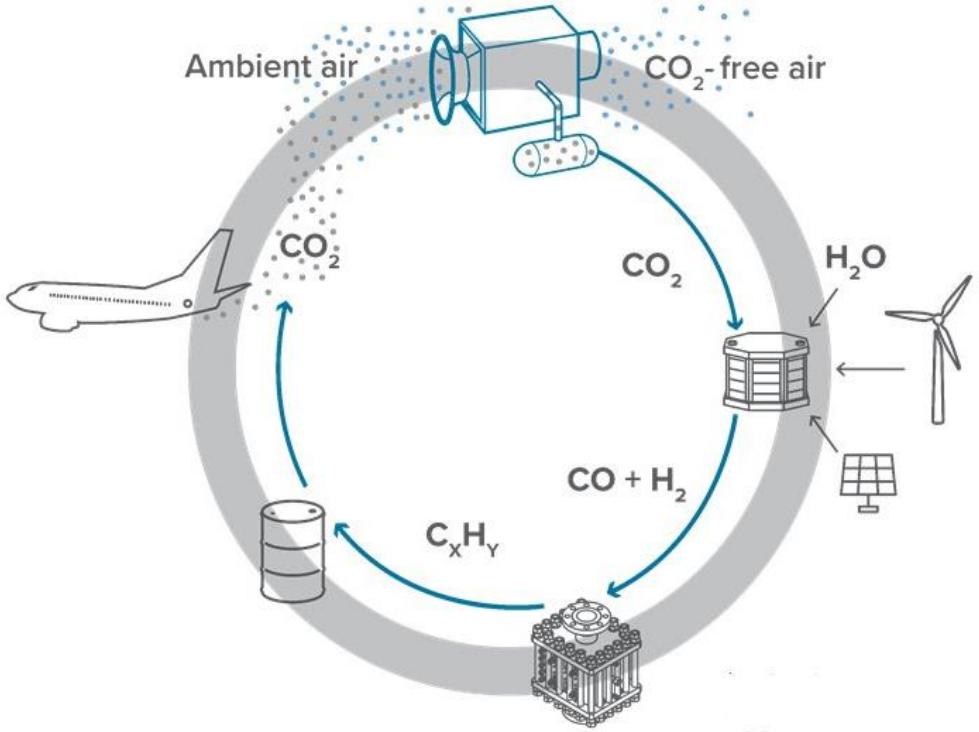
STORE&GO

- Power-to-Methane
- 27 Partners, EUR 27 million budget
- H2020 funding

THE HAGUE AIRPORT

- Renewable Jetfuel
- **1st MW-scale PtL project**
- Pre-study commissioned
- **INNOVATION FUND** for CAPEX

Synfuels from air: closing the carbon cycle



Closed carbon cycle

ICAO (2013). Annual report

Location-independent production

Stationary CO_2 supply insufficient in a zero-2050 world

Biofuels availability insufficient

Project Details

- Financing gap? Dependence on other projects, development of infrastructure or adoption/amendment of certain EU or national regulation?
  - Willingness to pay for synfuels is growing in aviation industry. Cost of synfuels are decreasing.
  - No major additional regulation needed apart from funding to arrive at scale/cost reduction. Taxation of fossil kerosene (ETS) would further boost development of renewable jetfuel.
- Capital expenditure, operational costs and benefits over 10-year period?
  - Operational costs shall be covered by fuel sales to airlines
  - CAPEX expected to be between 25 and 35 M€ for first of its kind pilot
- Level of certainty over envisaged costs and benefits? Key variables influencing them?
  - Based on proof-of-concept projects. Extent of cost reduction with scale-up to be demonstrated.
- Steps to be taken/conditions met before Final Investment Decision? Timeline?
  - Successful pre-study
  - FEED
  - 1-2 years for Detail Engineering and Construction

Climeworks technology meets EU Innovation Fund

1. Large-scale demonstration of DAC (> 1000 t/year) in operational environment
   - Efficient production: developing towards mass production
   - Cost reductions at scale
   - Maturing: Plant availability > 85%
2. Upstream and downstream integration of Climeworks DAC plant
   - Heat and material integration with CO_2 utilization processes
     - Synthetic hydrocarbon production (fuels and materials)
     - Electrolysis
   - Low-carbon energy providers
     - Solar heat
     - RE-powered heat pumps

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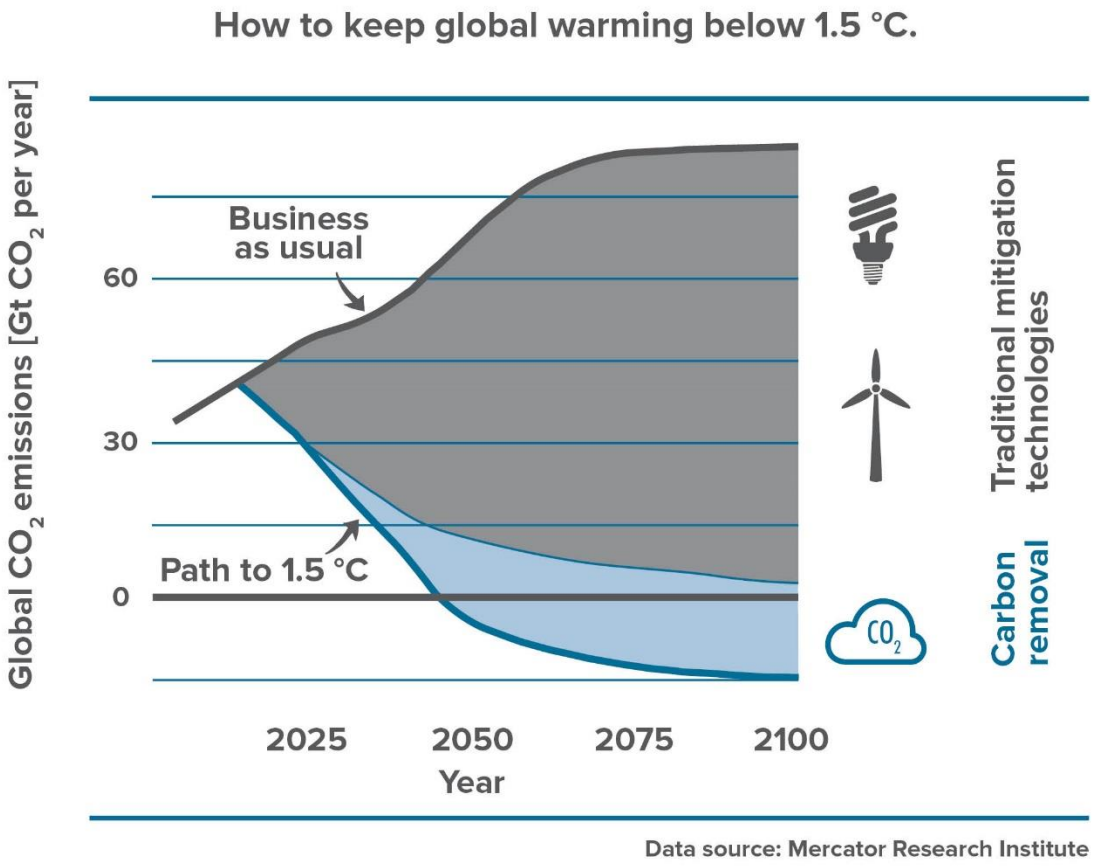
BACKUP

WHY DIRECT AIR CAPTURE OF CO_2

Reduce, reuse, remove!

All IPCC mitigation scenarios compatible with the 1.5°C target - and 87% of 2°C – rely on the assumption of **large-scale atmospheric CO_2 removal**



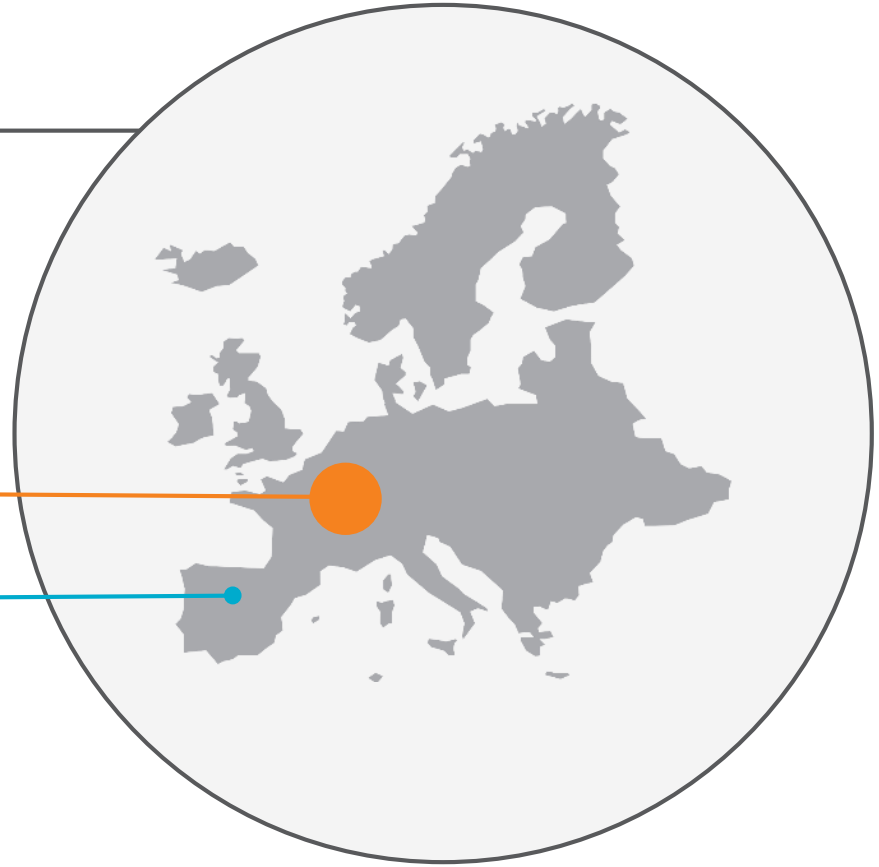
SCALEABILITY AND LAND REQUIREMENT

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

Corn Biofuel
28’000’000 km^2
of arable land
(yield assumption 18 g/ac/y)

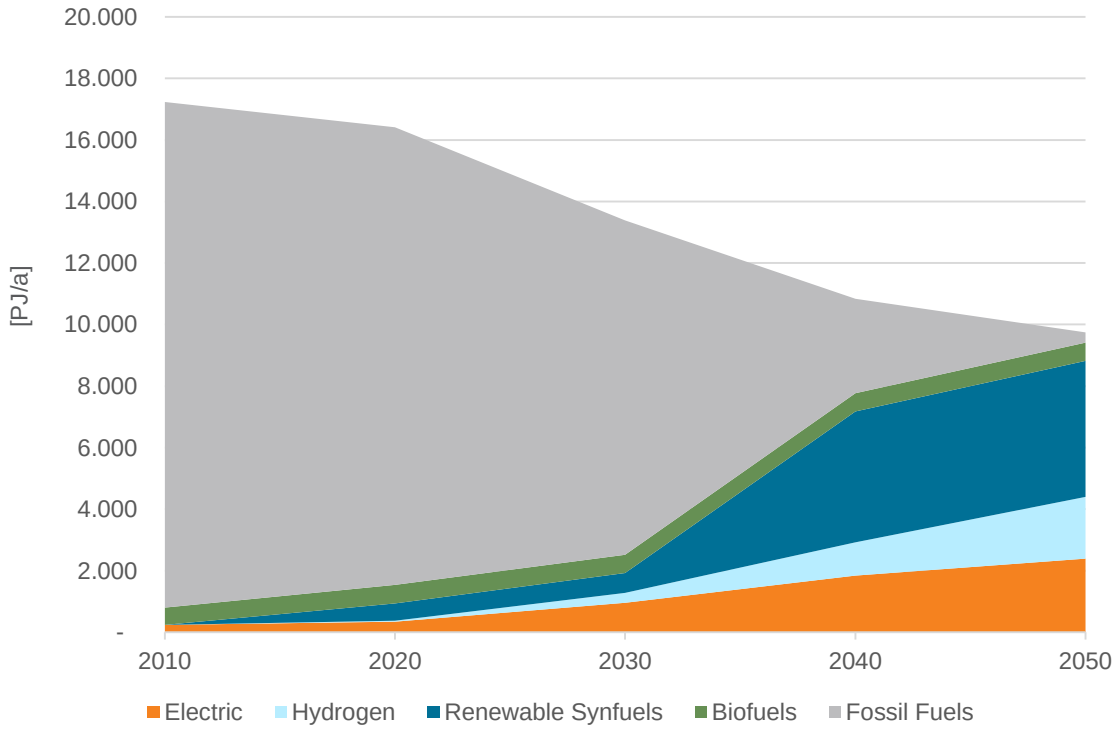
Algae Biofuel
200’000 km^2
of barren land
(yield assumption 2’500 g/ac/y)

Renewable Synfuels
14’200 km^2
of barren land
(assumption: 1’900kWh/m^2,
$\eta_{PV} = 25\%, \eta_{PtX} = 70\%$)



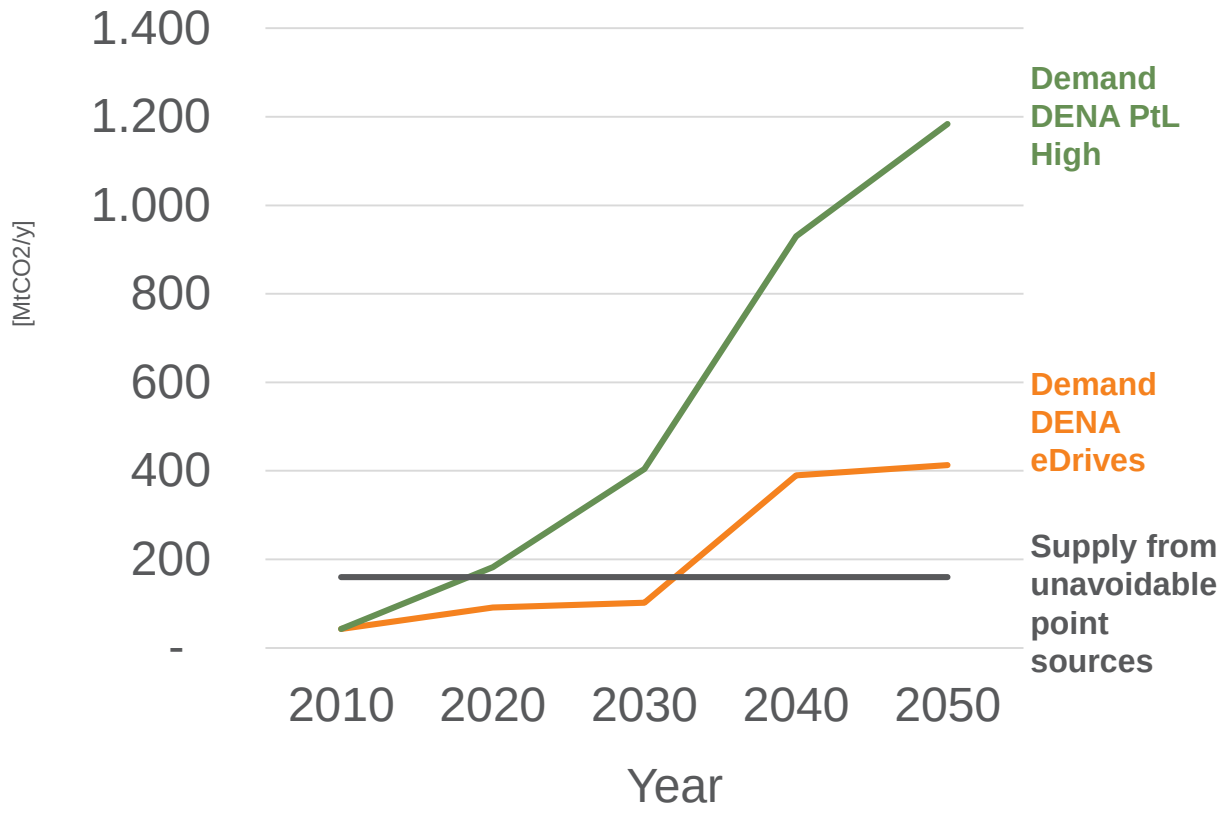
CO_2 WILL BE A SCARCE RESOURCE

EU Transportation sector final energy demand by fuel type
(eDrive scenario)



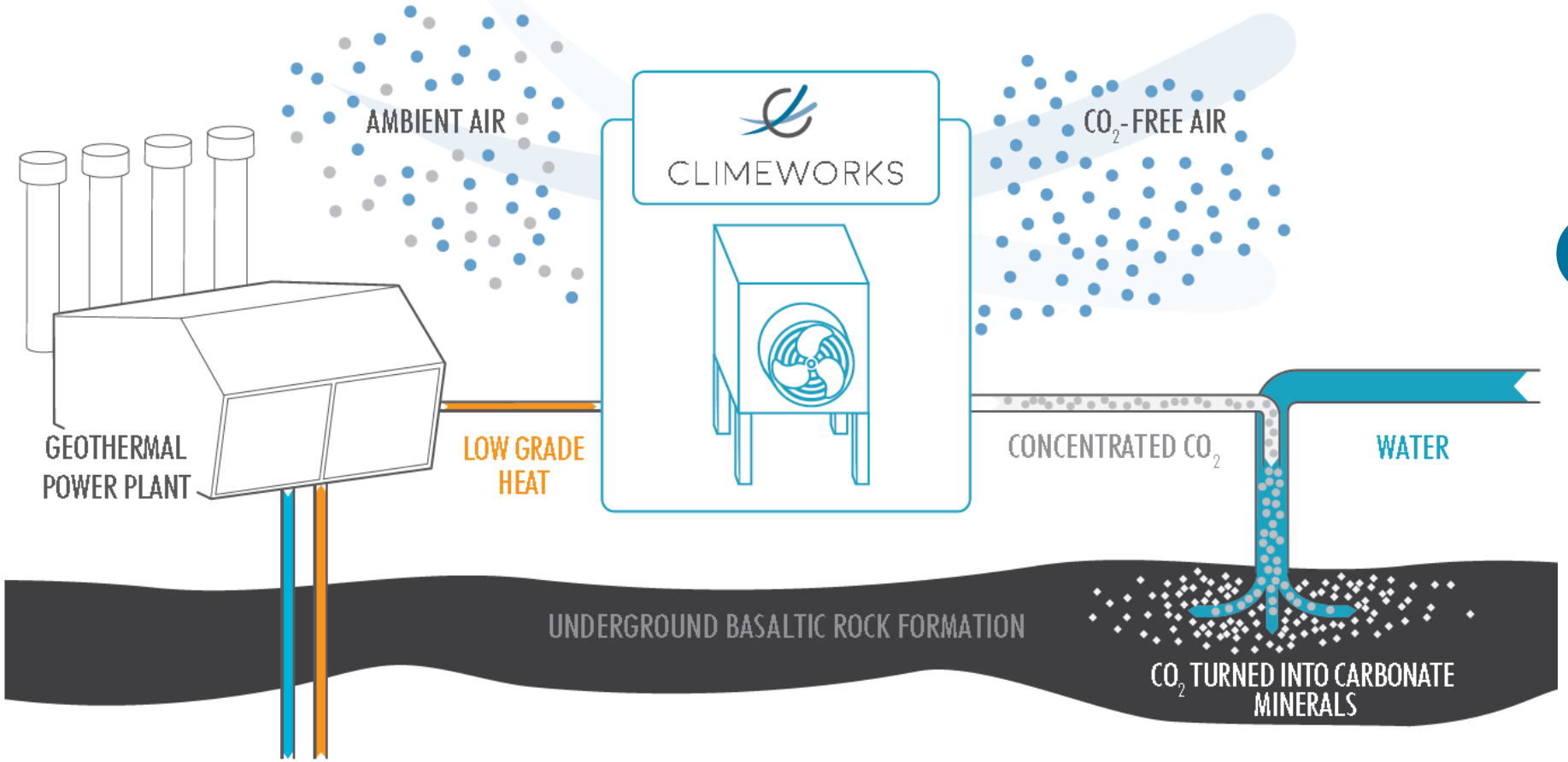
Source: DENA (2017) The Potential of electricity-based fuels for low emissions transport in the EU

EU CO_2 demand for synfuels vs. fossil fuels



DAC Also Enables Negative Emissions

1 CO_2 is captured directly from ambient air using renewable, e.g. geothermal energy.



2 CO_2 is pumped underground at favorable CO_2 storage sites, e.g. Iceland.

3 CO_2 reacts with underground rock formations and is mineralized. CO_2 is thereby bound permanently and safely, reducing the CO_2 content of the atmosphere.

CARBON DIOXIDE REMOVAL FLAGSHIP