Geothermal and CCUS in Iceland

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Mannvit is now COWI

Mannvit, which has a long legacy in geothermal energy consulting, joined COWI in 2023.

Our services in geothermal energy consulting range from technical due diligence and project development to power plant design and operational consulting.

>60 years experience

>30 countries

>2000 MW in geothermal energy projects

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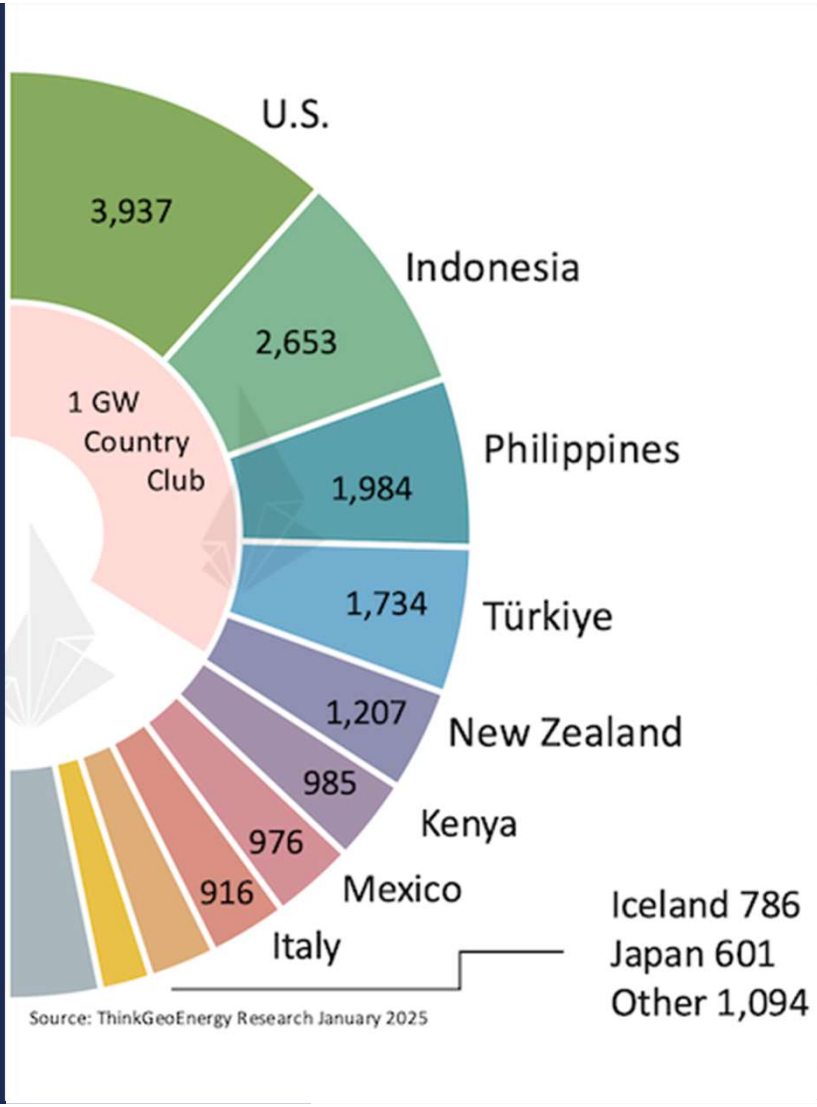
Geothermal Energy

A green baseload energy source



TOP 10 Geothermal Countries 2024

Installed Capacity January 2025

Total 16,873 MW

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Geothermal Power Plant Emissions

Low emissions

Geothermal typically has lower emission than fossil fueled power plants, and no CO_2 created

Site specific emissions

Non-condensable gases (NCGs) are mainly **CO_2**, **H_2S**, H_2, N_2, CH_4, NH_3, and Ar

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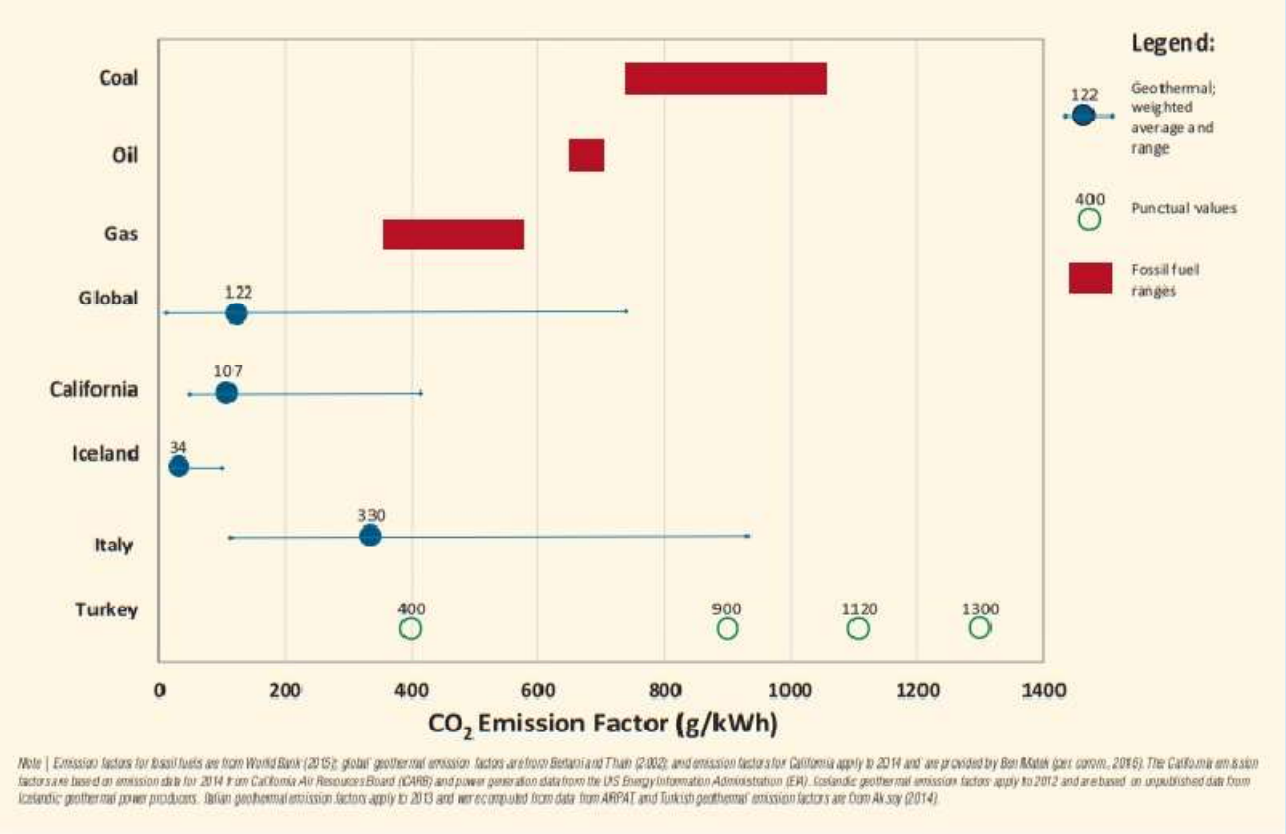
Technical report 009/16; Greenhouse gases from geothermal power production. ESMAP, World Bank. 2016

Emission factors



Note | Emission factors for fossil fuels are from World Bank (2015); global geothermal emission factors are from Bertani and Thain (2002) and emission factors for California apply to 2014 and are provided by Ben Matek (pers. comm., 2016). The California emission factors are based on emission data for 2014 from California Air Resources Board (CARB) and power generation data from the US Energy Information Administration (EIA). Icelandic geothermal emission factors apply to 2012 and are based on unpublished data from Icelandic geothermal power producers. Italian geothermal emission factors apply to 2013 and were computed from data from ARPAT and Turkish geothermal emission factors are from Aksoy (2014).

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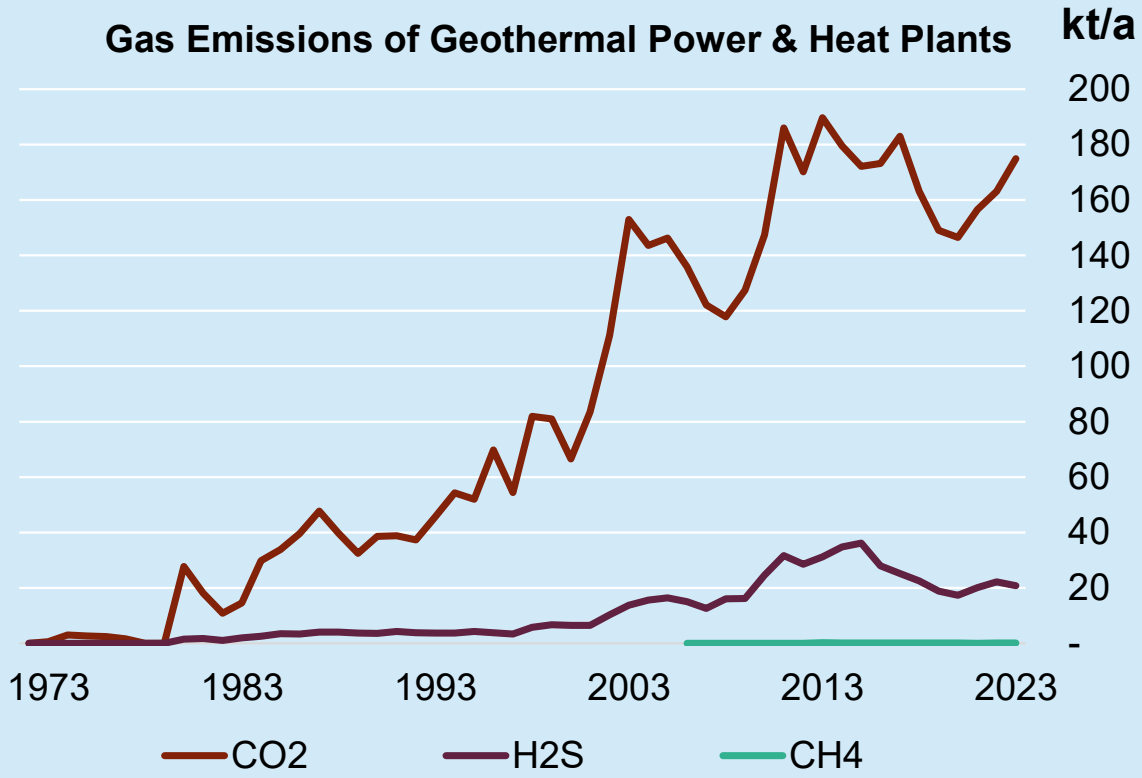
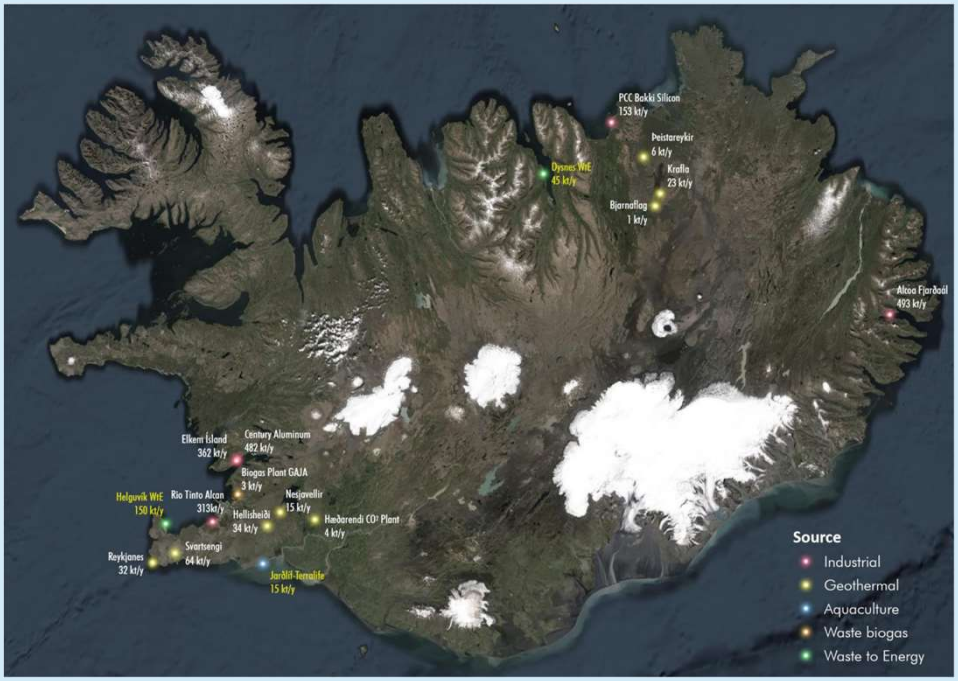
CO_2 emission in Iceland





Orkustofnun Data Repository OS-2024-12

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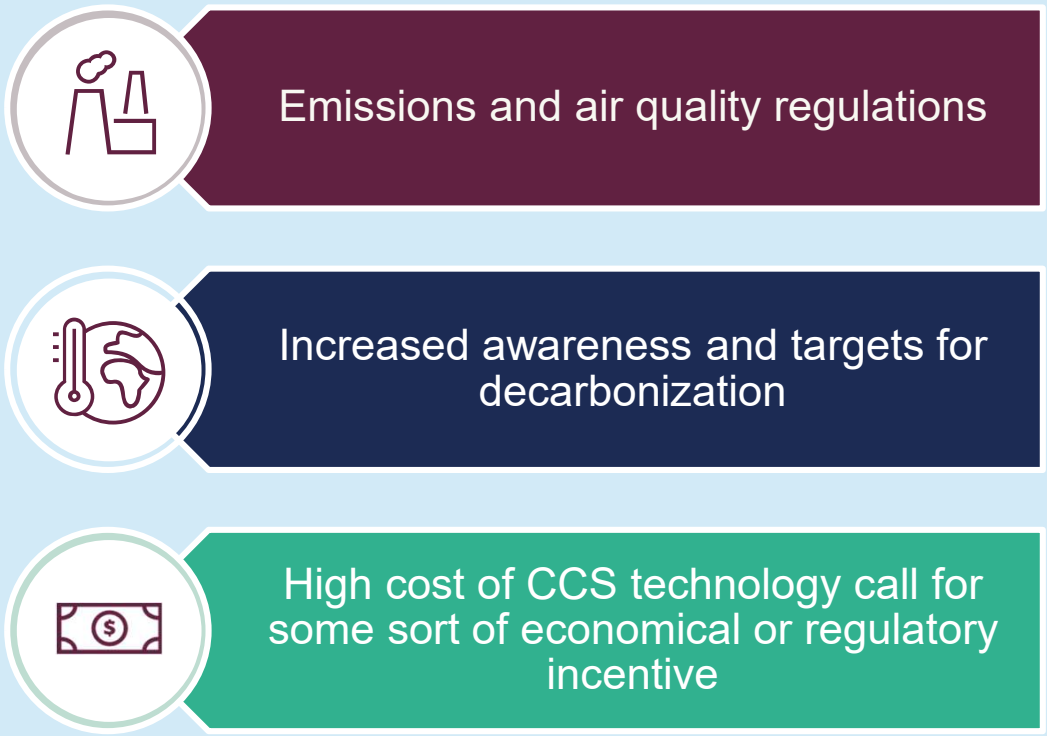
Why implement abatement systems for geothermal emission?



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Geothermal & CCS in Iceland

- CCS in Iceland started with the abatement system development in Hellisheiði GPP
- COWI has been involved from the beginning and designed several CCS processes in co-operation with Carbfix in Iceland
- **Water absorption**
  - Suitable when water is readily available
  - Low selectivity
  - Simple system

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Timeline

Abatement system at Hellisheiði GPP

2022 -	Project Silverstone
2017	Capture of 34% of the plants CO_2 and 68% of H_2S emissions
2016	Result show that up to 95% of the gas was mineralized within 2 years
2014	Upscale to industrial scale
2012	Pilot injection carried out with pure CO2 and a H2S/CO2 gas mixture. Findings indicated mineralization within a few months
2010	The construction of a pilot gas capture plant was finalized
2007	Initiation of the Carbfix Project
2006 - 2011	Hellisheiði GPP commissioned in 5 stages with installed capacity of 303 MWe and 200 MWth

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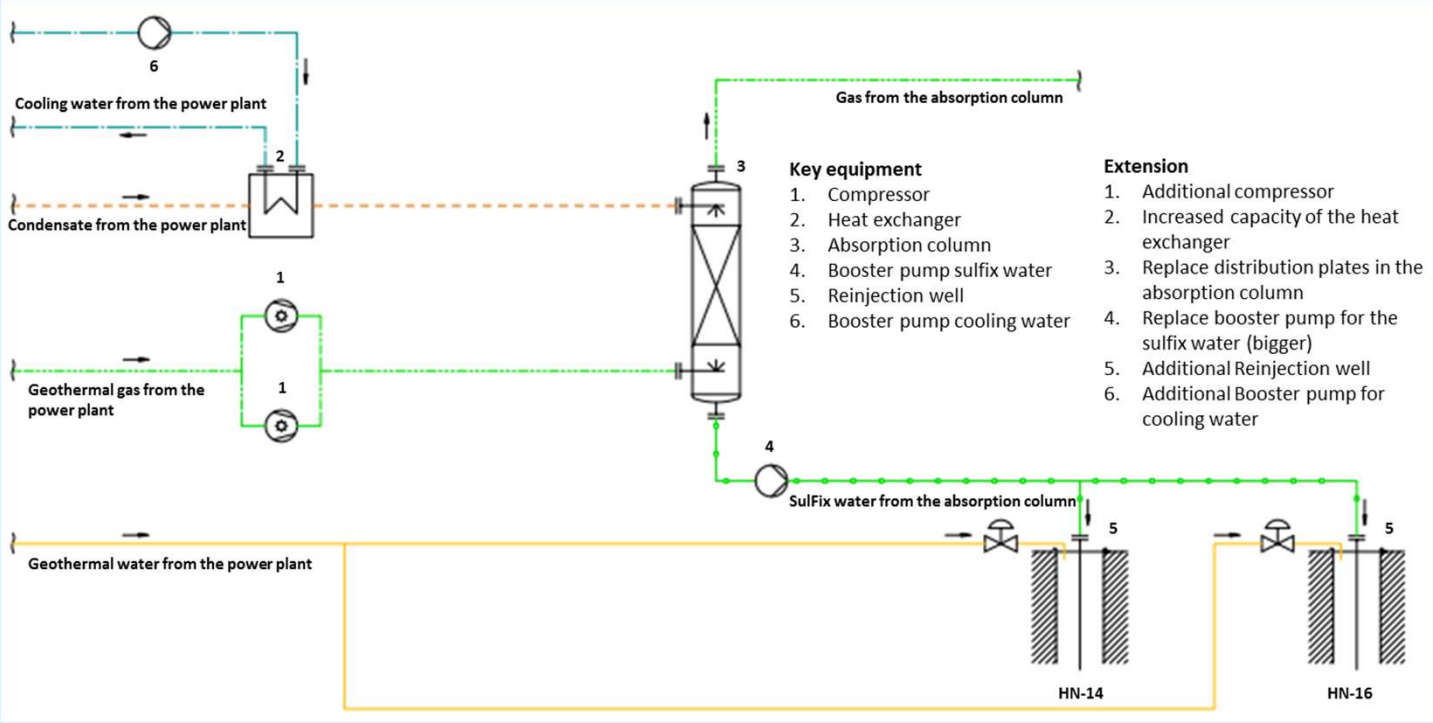
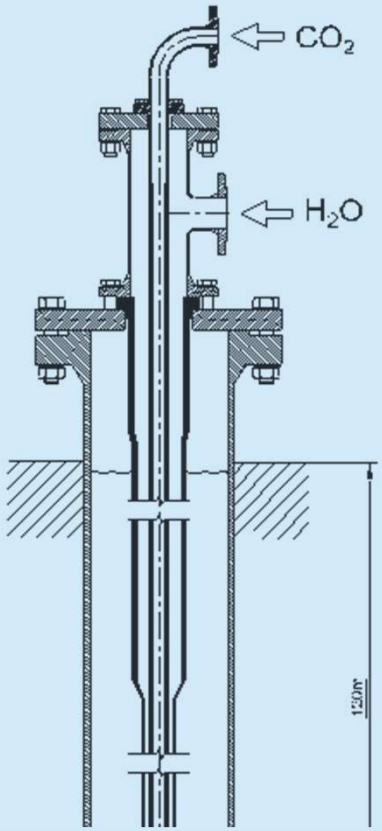
Carbfix technology

Design of system with water scrubber and gas charged water injection





Design of system with separate injection and sparger to mix in well

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Silverstone, Hellisheiði GPP

EU-funded project to deploy full-scale CO_2 capture, injection, and mineral storage with the Carbfix technology

Detailed design of a new CO_2 capture plant in Hellisheiði GPP with CO_2 capture efficiency of 95% from the plant's current emissions.

Approximately 34,000 tons of CO_2 will be captured and stored annually.

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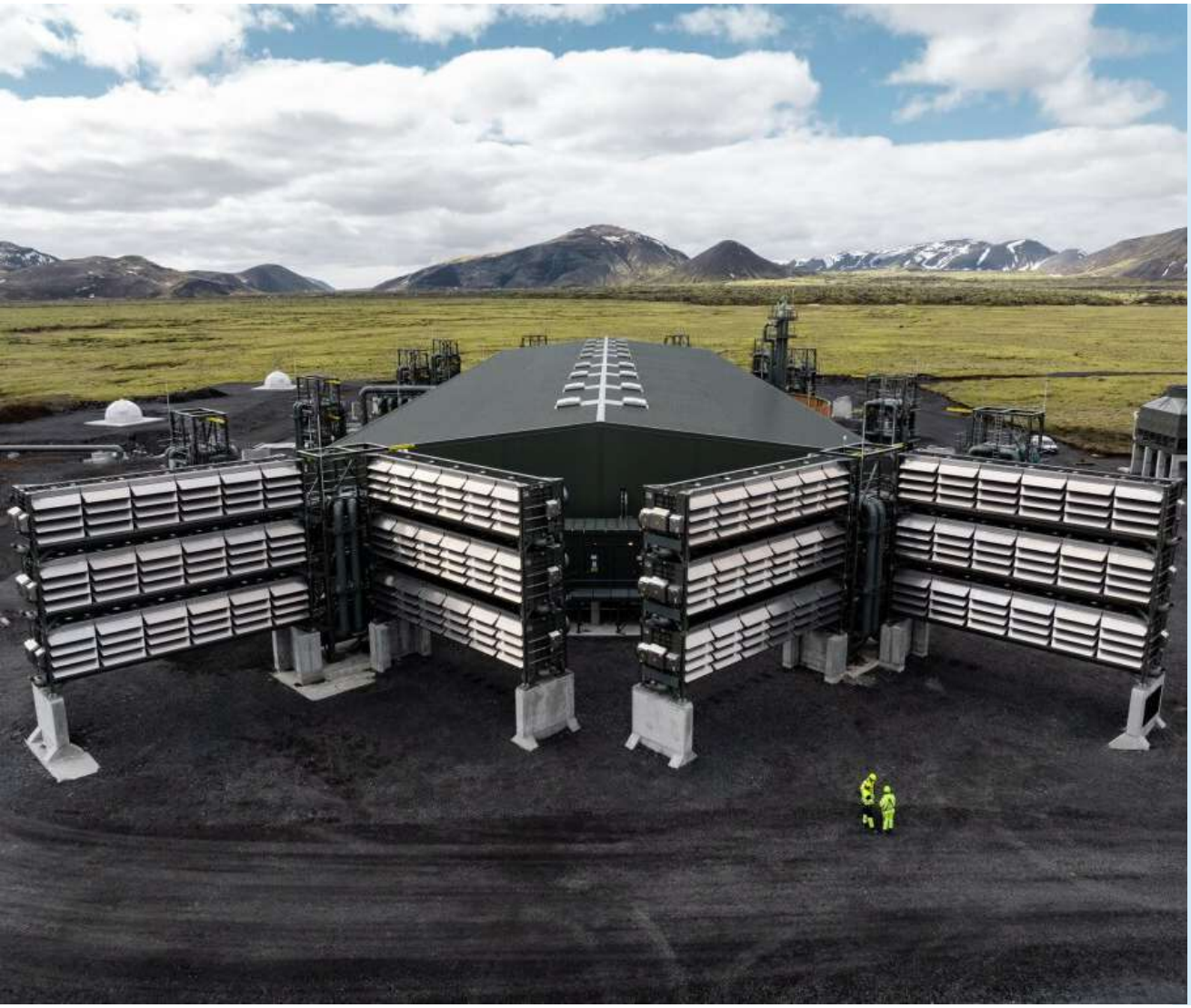
Pilot plant in Nesjavellir GPP

Capture CO_2 and H_2S from the geothermal gases and inject into bedrock, turning it into stone with the Carbfix technology.

Design of a pilot plant, absorption tower, well equipment and connections to the existing system in a power station.

The performance of the system is up to 500 kg/h of non-condensable gas (NCG).



Direct Air Capture (DAC) Climeworks

CO_2 removal using Climeworks' direct air capture technology.

- Phase 1 (Orca) captures 4.000 tons of CO_2 per year.
- Phase 2 (Mammoth) captures 36.000 tons of CO_2 per year.

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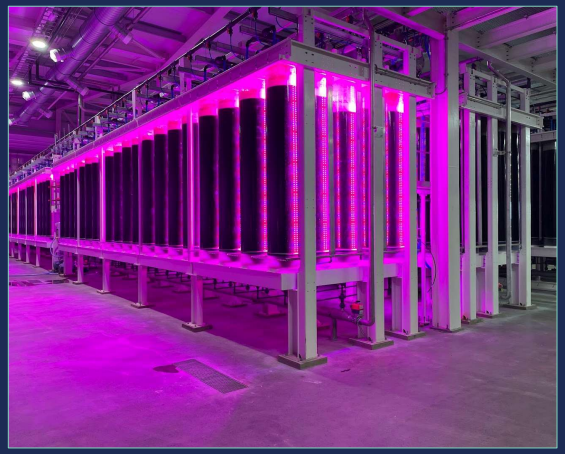
Geothermal & CCU in Iceland



Turning waste to value

- **Carbon Recycling International** developed an Emissions-to-Liquid technology for converting CO_2 from Svartsengi GPP exhaust gas to e-methanol
  - The demonstration plant was operated from 2011-2015
- Algae nutrition and enhance growth
  - **Blue Lagoon**
  - **Vaxa Impact Nutrition**
- Other Power-to-X projects are in planning

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Co-benefits of using geothermal sources for PtX

- The **stable power** generated by geothermal energy is advantageous as it ensures a high capacity factor
- **Direct use** of geothermal heat sources e.g. heat supply for SOEC
- The non-condensable geothermal exhaust gas might already contain **H_2 and CO_2**
- **Oxygen as a by-product** from electrolysers is saturated with water vapour and difficult to liquify. It can however be used for various processes related to geothermal e.g. fish farming

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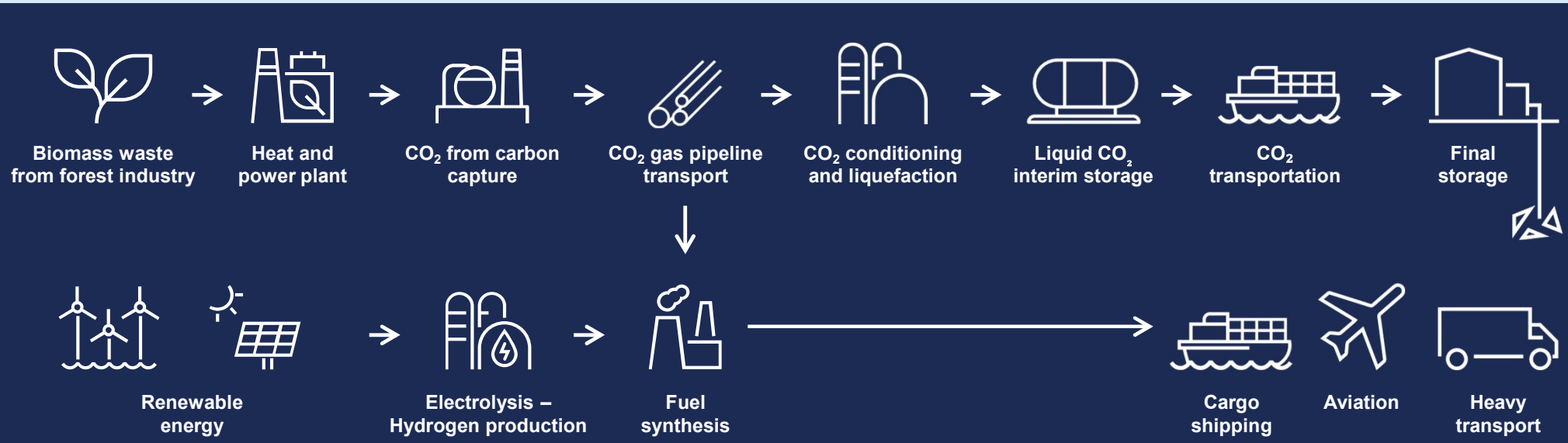
CCUS value chain



We feel the need from our clients who are seeking to **decarbonize and move towards carbon neutrality**, particularly those with urgent demands for large volumes of certified green fuel.

Examples of industries that could benefit from green methanol or other green fuels:

- Aviation
- Shipping

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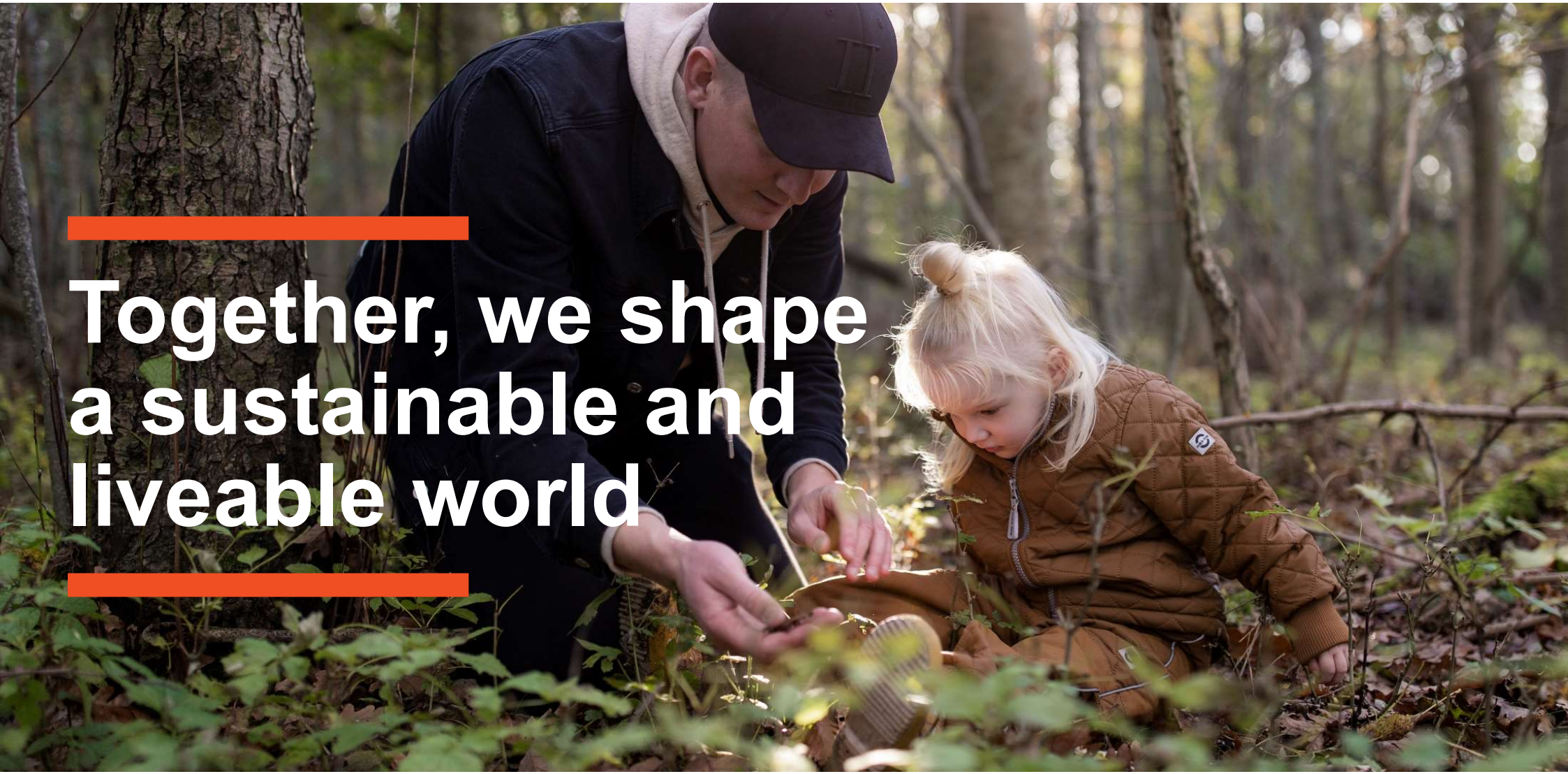
Together, we shape
a sustainable and
liveable world

Thank you

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