

Climate Change and Direct Air Captures (DAC) Technologies

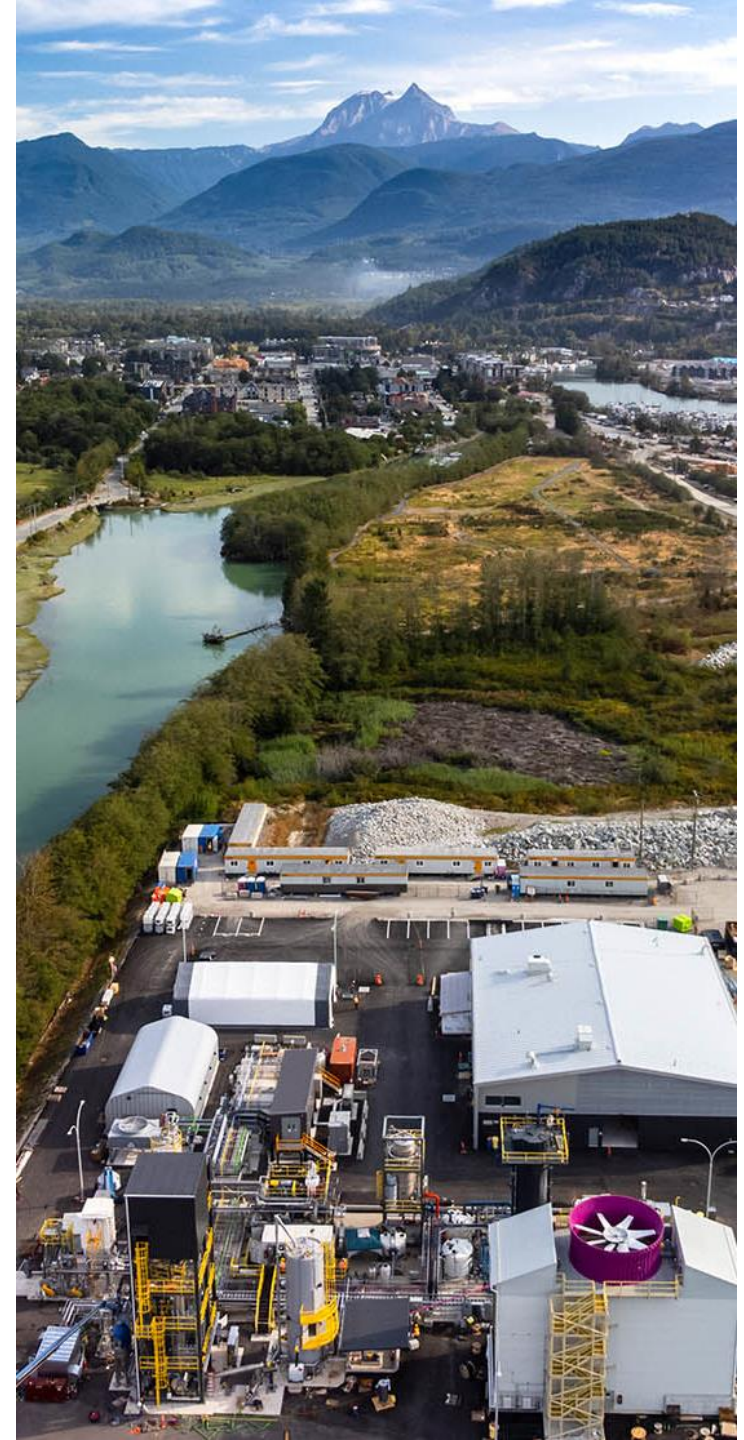
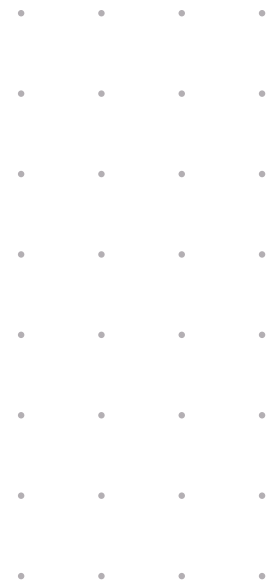
PRESENTED BY:
Mohsen Mandegari, Ph.D.

COMPANY:
Carbon Engineering Ltd.

DATE
Nov 2nd, 2023

AGENDA

- ▶ Climate change and carbon dioxide (CO₂)
- ▶ Direct Air Capture (DAC)
- ▶ Carbon Engineering Technology
- ▶ DAC Commercialization

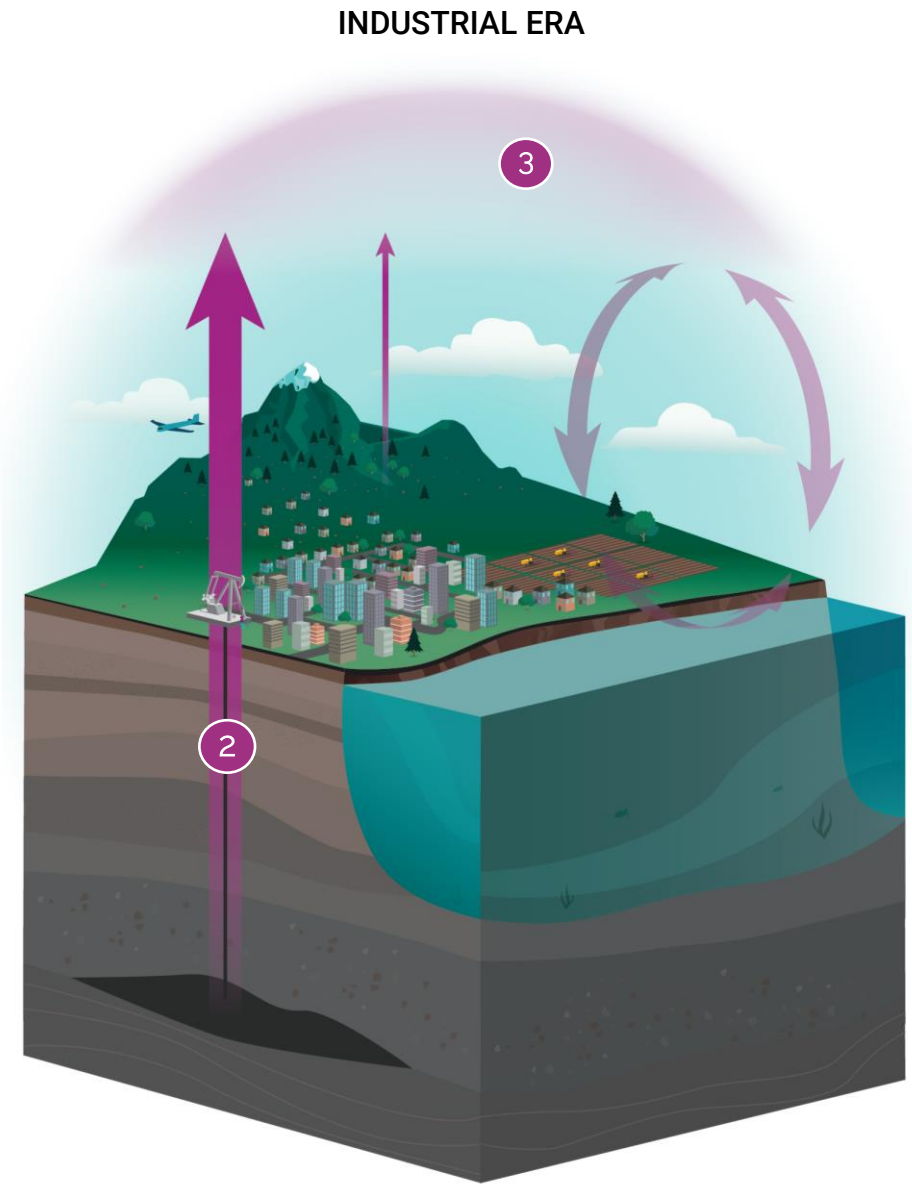
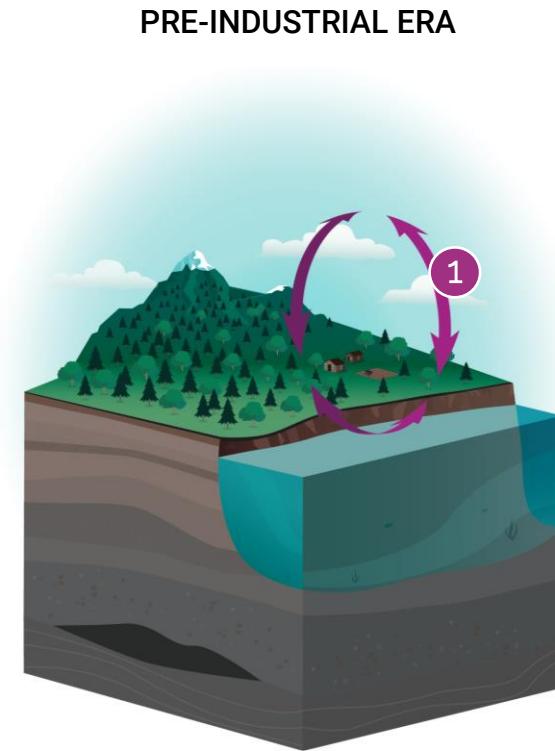


AN ENVIRONMENTAL NECESSITY, FINANCIALLY COMPELLING

The Carbon Cycle is Out of Balance

- 1 PRE-INDUSTRIAL ERA:** Carbon flows naturally between the air, plants, land, and oceans in a balanced “carbon cycle” that helps keep the Earth’s climate relatively stable.
- 2 INDUSTRIAL ERA:** For ~200 years, humans have extracted large quantities of fossil fuels out of the geosphere, resulting in a one-way flow of CO₂ into the atmosphere. Deforestation and agricultural practices also release CO₂ into the air.
- 3** CO₂ is building up in the atmosphere, throwing the carbon cycle out of balance, resulting in rapid and dangerous climate change.

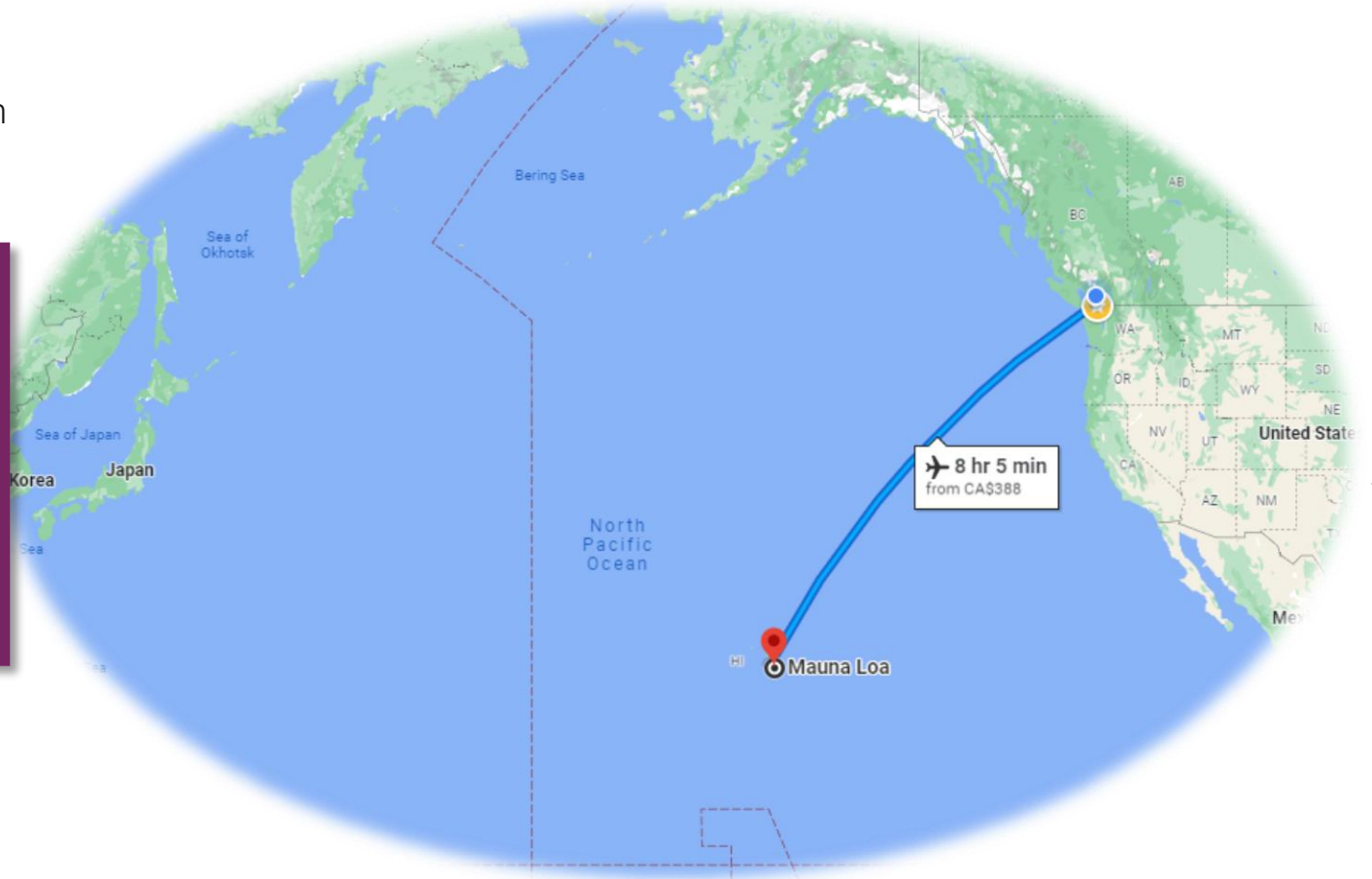
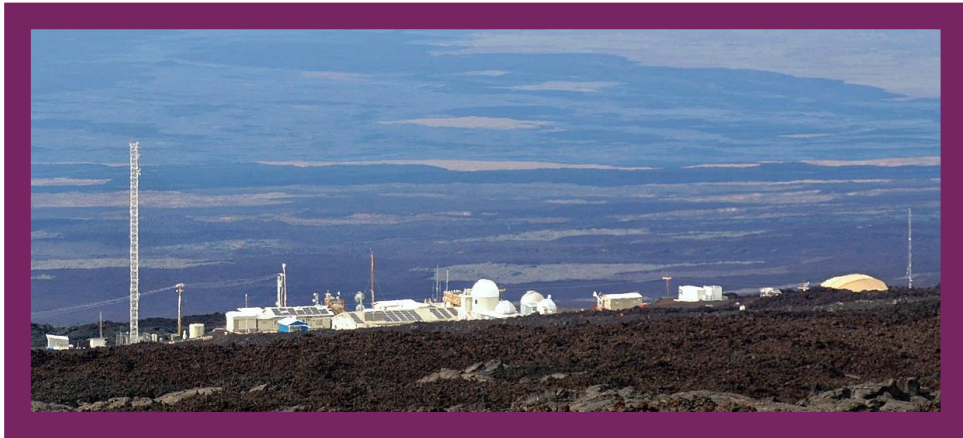
*The concentration of CO₂ in the atmosphere has **increased from ~280 ppm in pre-industrial times to ~419 ppm today.**¹*



¹ Data Source: [The Kneeling Curve](#)

Is the atmospheric carbon dioxide concentration really on the rise?

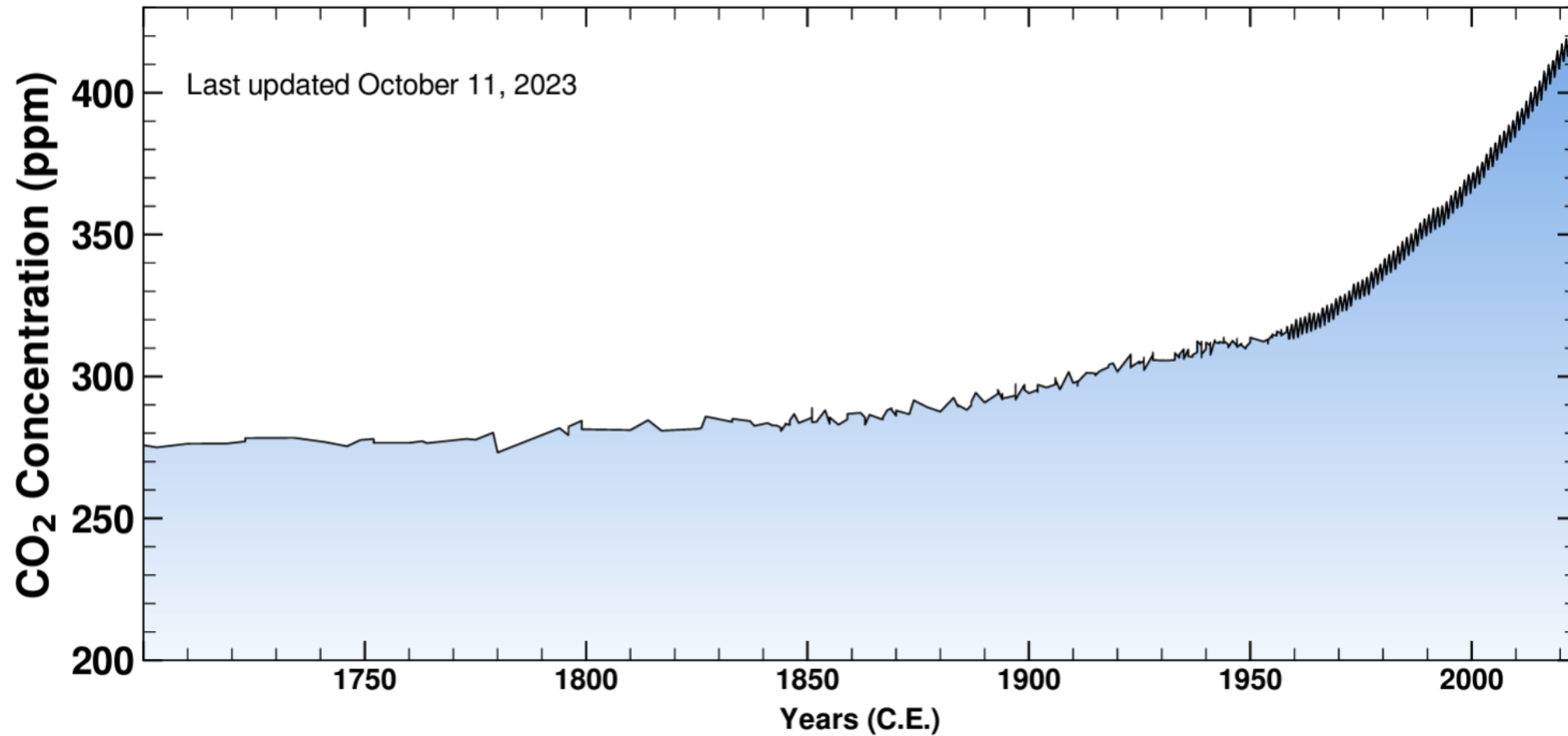
The Mauna Loa Observatory is an atmospheric baseline station on Mauna Loa, on the island of **Hawaii**, located in the U.S. state of Hawaii.



Since 1958, initially under the direction of Charles Keeling, followed by his son Ralph and later Elmer Robinson, Mauna Loa Observatory (MLO) has been monitoring and collecting data relating to atmospheric change

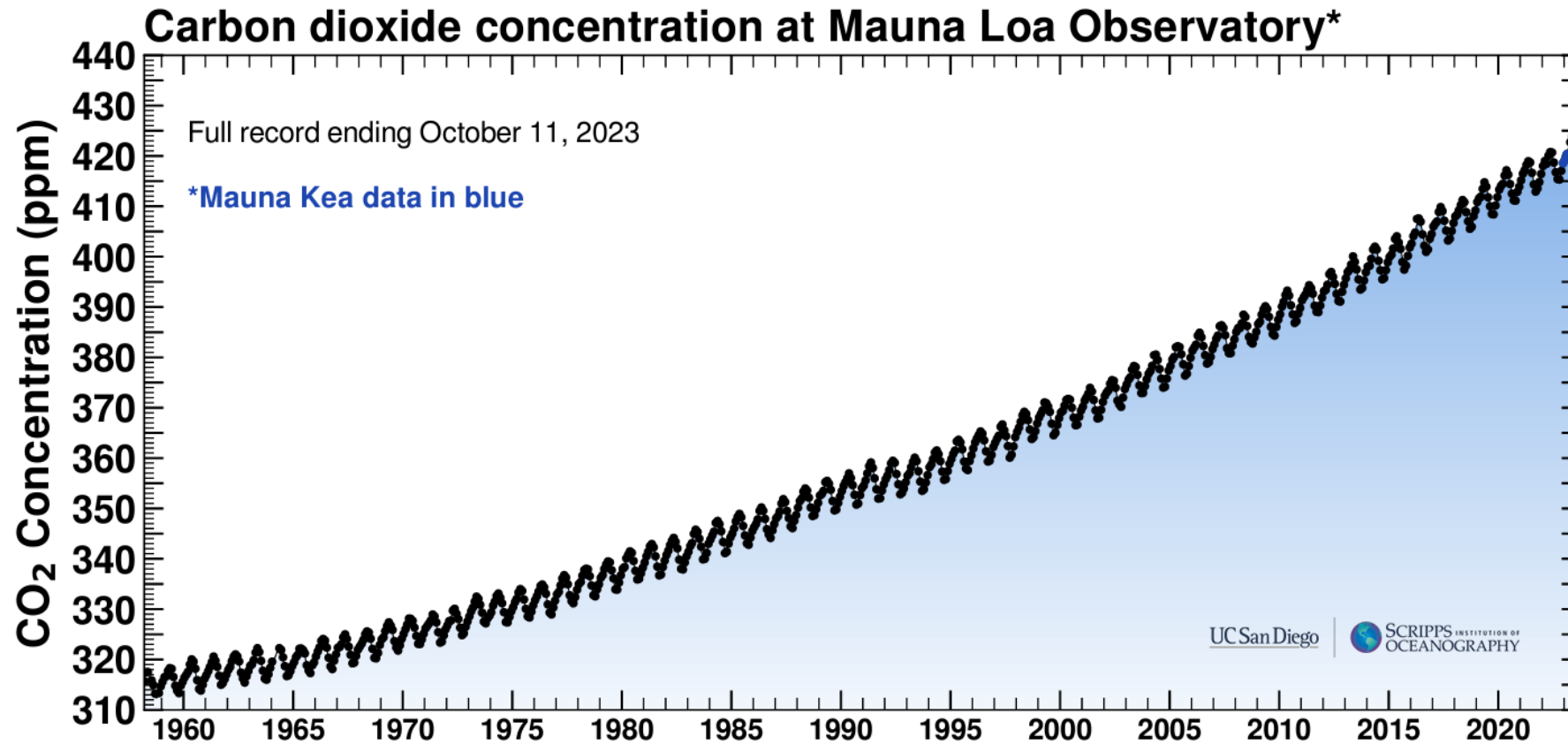
Sources: [Wikipedia](https://en.wikipedia.org/wiki/Mauna_Loa_Observatory)

Is the atmospheric carbon dioxide concentration really on the rise?



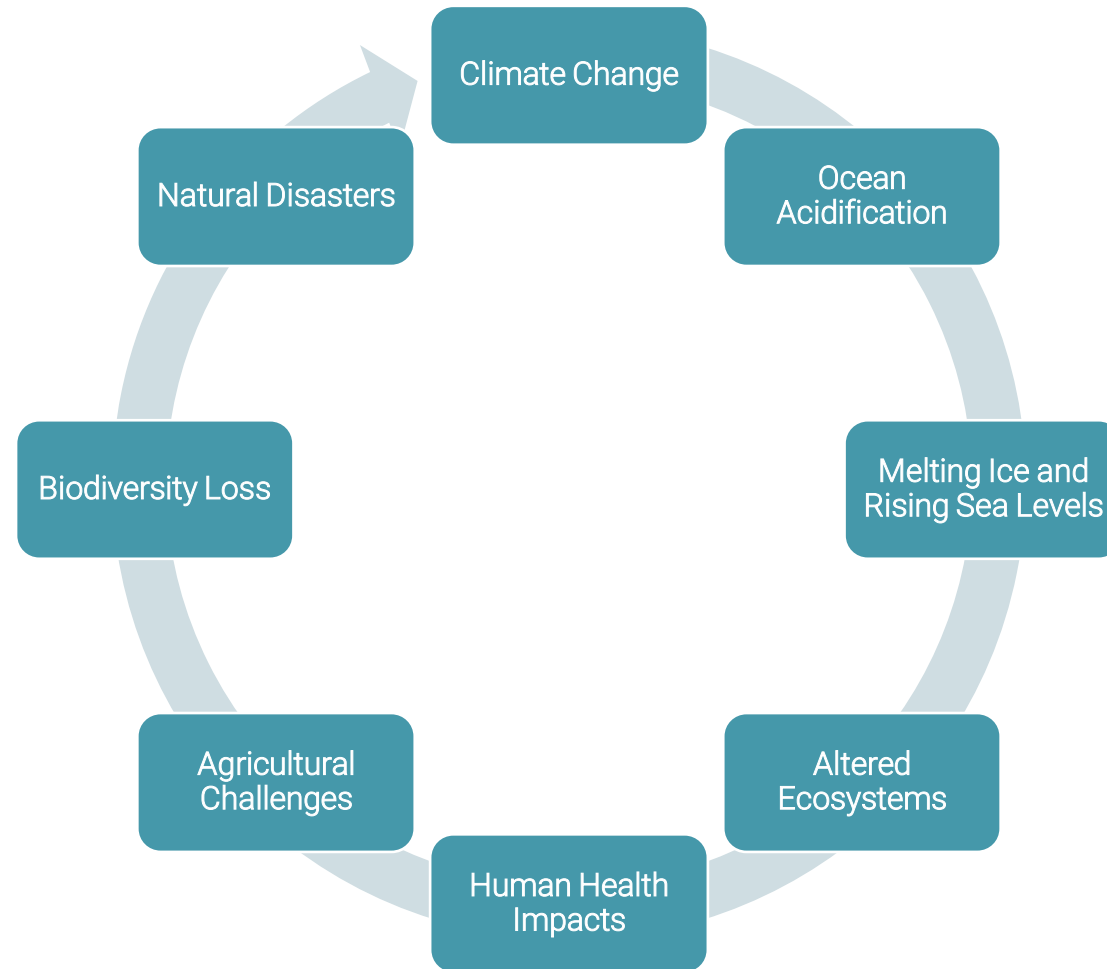
Sources:
<https://keelingcurve.ucsd.edu/pdf-downloads/>

Is the atmospheric carbon dioxide concentration really on the rise?



Sources:
<https://keelingcurve.ucsd.edu/pdf-downloads/>

Potential effects of elevated atmospheric carbon dioxide



Source:
[USGS Fact Sheet 2006-3074](#), By: Karen McKee

Sovereign nations and industry giants are committed to Net Zero 2050

Commitments have grown rapidly

8,000+

COMPANIES COMMITTED TO NET ZERO BY 2050¹

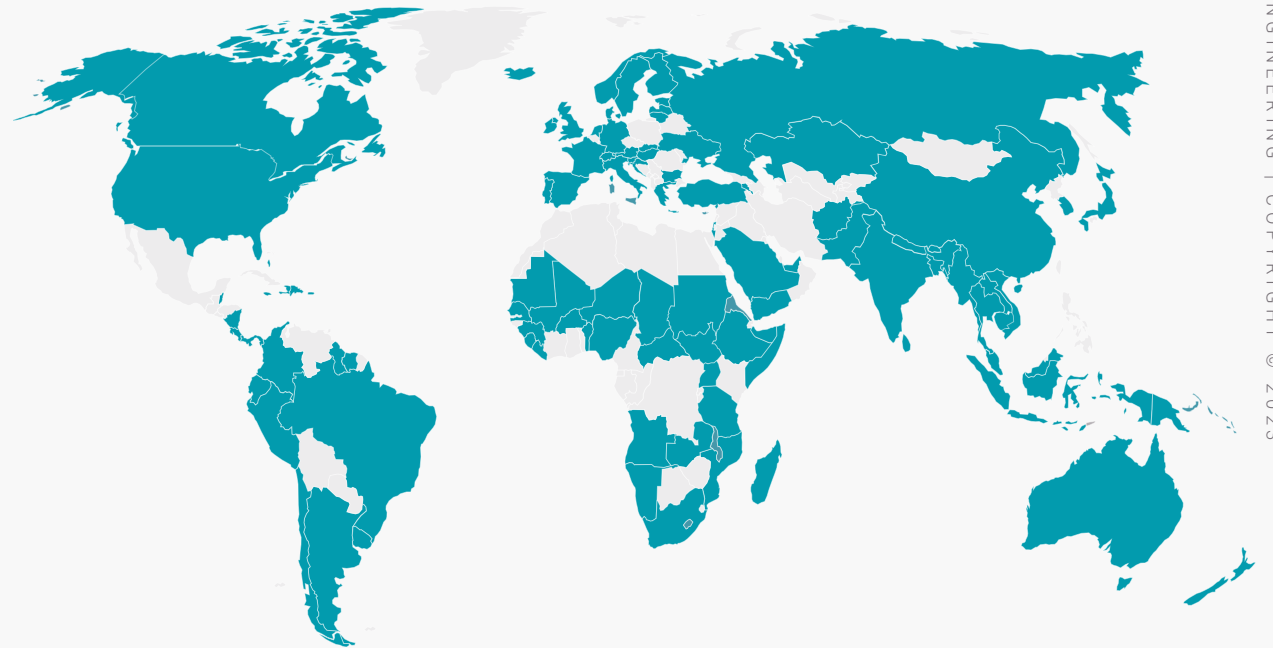
Commitments have increased more than 10x since 2019



100+

COUNTRIES COMMITTED TO NET ZERO TARGETS²

Commitments have increased more than 9x since 2018

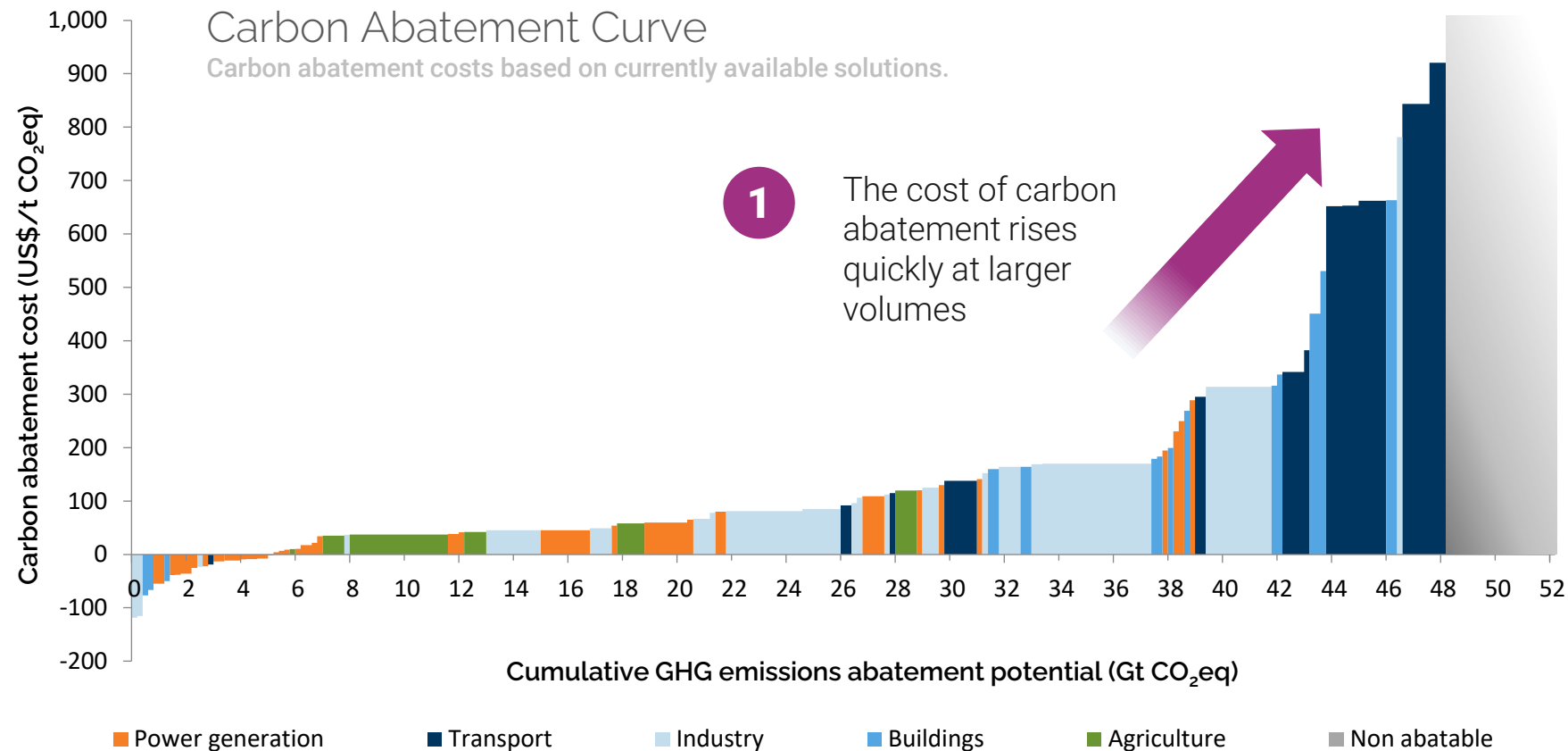


Sources:

1. UNFCC Race to Zero, last updated Sept. 2022

2. Energy & Climate Intelligence Unit, Net Zero Tracker. Represents countries with targets in-policy document, proposed legislation or law with regard to national net-zero commitments.

Three primary challenges in achieving net zero & climate restoration



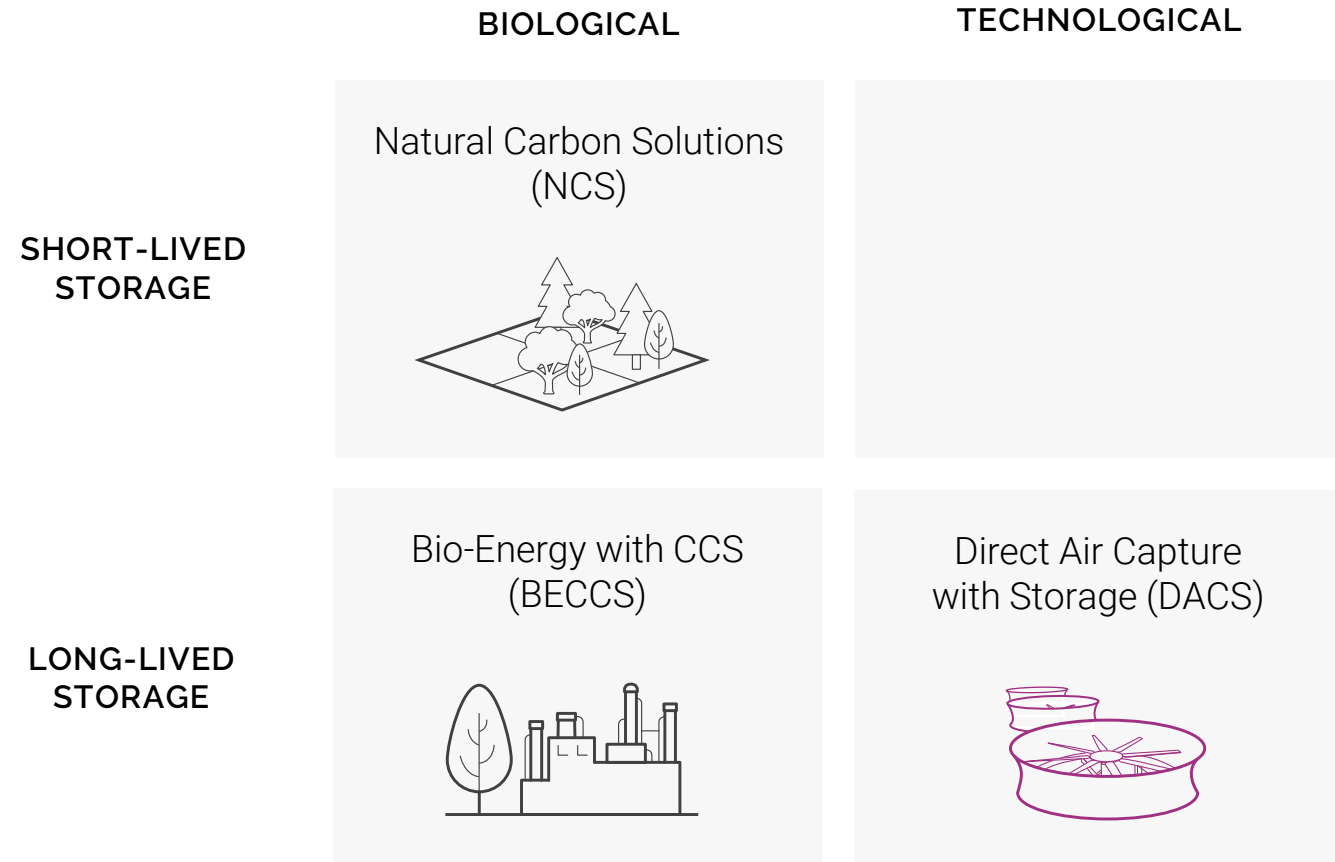
Sources:
Carbon abatement costs based on currently available solutions; data from Goldman Sachs, Carbonomics, November 2021

**THE NET ZERO CHALLENGE IS IMMENSE:
THE WORLD NEEDS STRONG LEADERSHIP AND ACCELERATED TECHNOLOGICAL SOLUTIONS**

Greenhouse gas removal (GGR)

There are three principal carbon removal options, also known as Greenhouse Gas Removals (GGRs).

Three principal carbon removal options



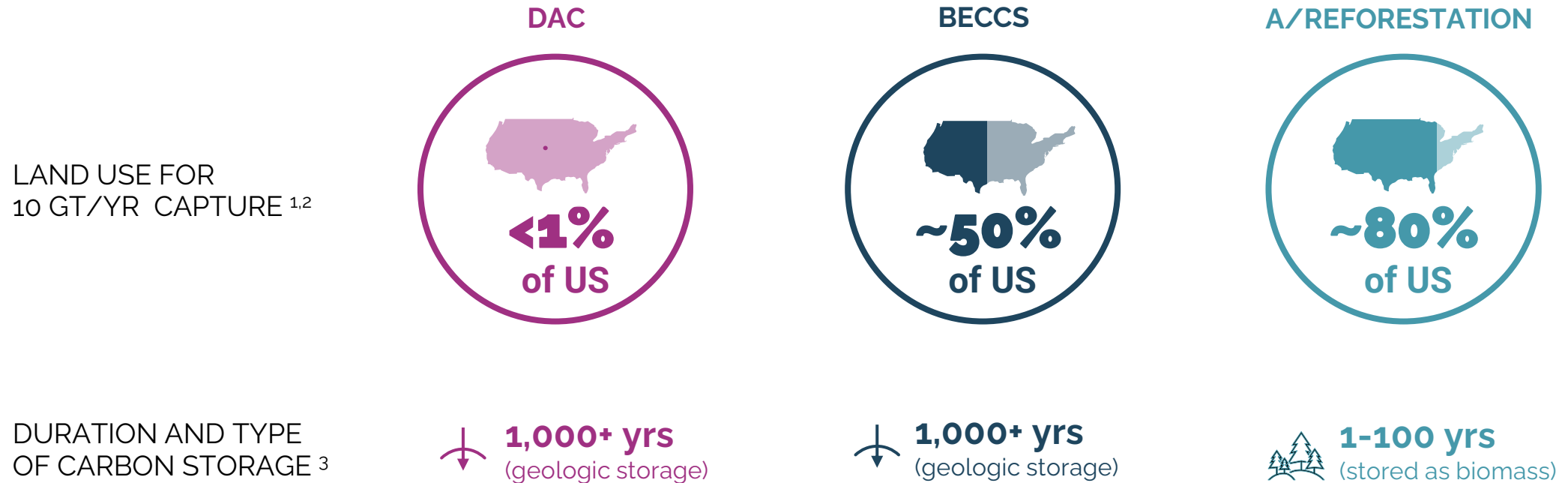
What is Direct Air Capture ?

- Direct Air Capture (DAC) technology is a process that captures carbon dioxide (CO₂) directly from the ambient air.
- It's a form of carbon capture technology designed to remove CO₂ emissions from the atmosphere, which can then be stored or utilized to help address emissions.



Favorably positioned versus other carbon dioxide removal solutions

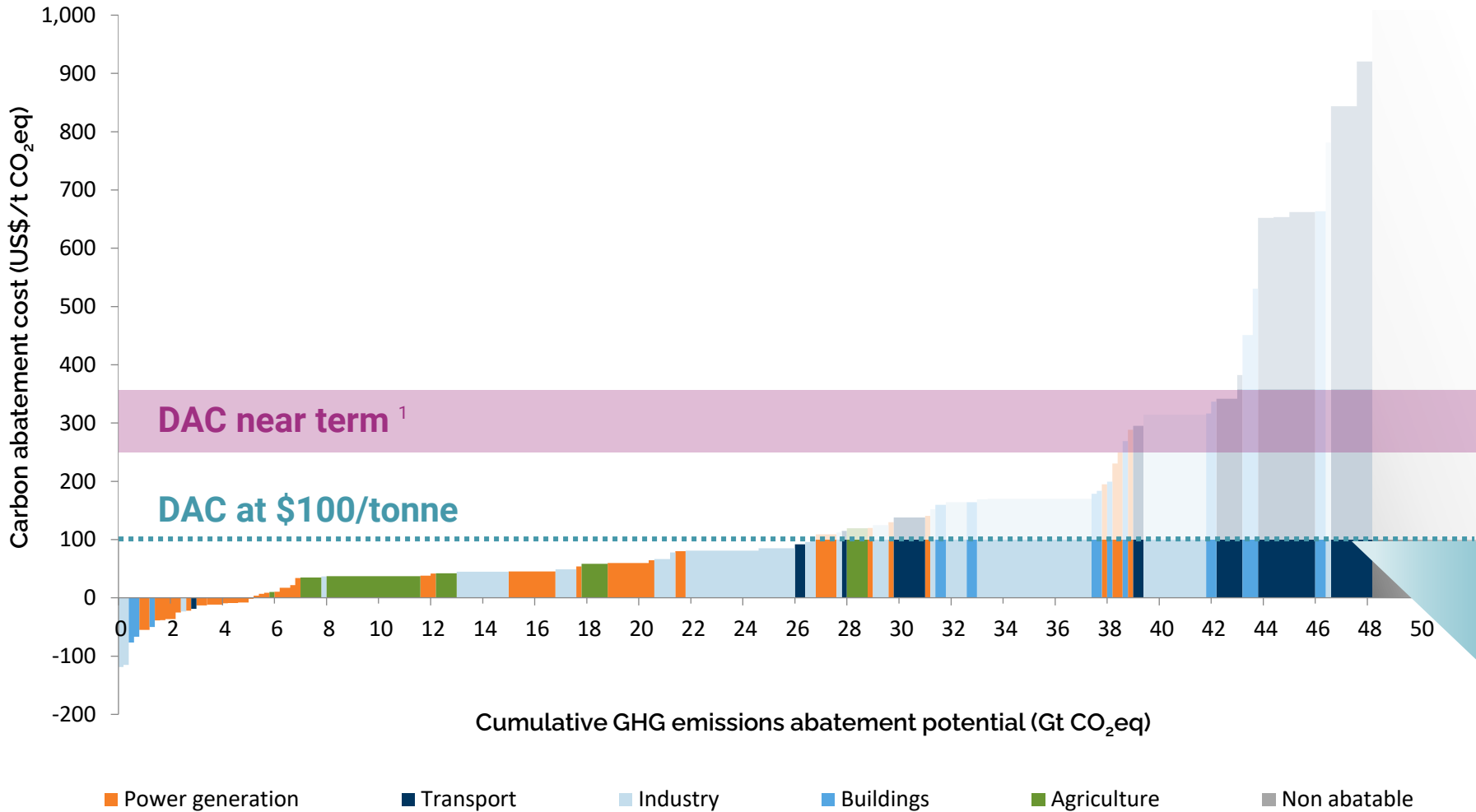
DAC has land use, permanence and environmental impact advantages



1. Brack, D, King, R. (2020), Managing Land-based CDR: BECCS, Forests and Carbon Sequestration. Glob Policy, 12, 45-56,
2. DAC includes land area for renewable energy, 0.04% for DAC plant only
3. A Bergman & A Rinberg (2021) "The Case for Carbon Dioxide Removal: From Science to Justice" CDR Primer, edited by J Wilcox, B Kolosz, J Freeman
4. Dooley, K., Harrould-Kolieb, E. and Talberg, A. (2021), Carbon-dioxide Removal and Biodiversity: A Threat Identification Framework. Glob Policy, 12: 34
5. Sabine Fuss et al 2018 Environ. Res. Lett. 13 063002

DAC can cap the cost of decarbonization

DAC provides an economic solution for distributed & hard to abate emissions



5-10 Gt/yr

Emissions with abatement cost >\$300/tonne

>10 Gt/yr

Emissions with abatement cost >\$100/tonne

\$Trillions/yr

Potential cost advantage over alternative solutions to achieve Net Zero

<\$100/tonne

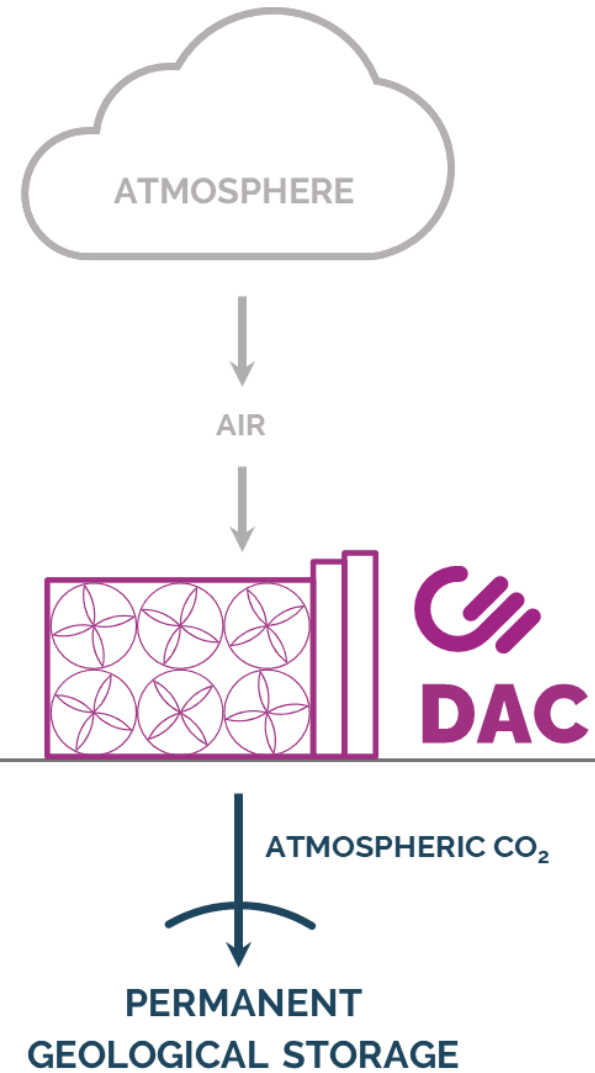
US DOE 'Carbon Negative Shot' stated long-term program goal

Carbon abatement costs based on currently available solutions; data from Goldman Sachs, Carbonomics, November 2021

1. DAC cost range shown based on current cost estimate for liquid sorbent DAC from McKinsey, June 2021, [How negative emissions can help organizations meet their climate goals](#), and is aligned with Oxy's announced 2025-2030 cost expectations for commercial deployments



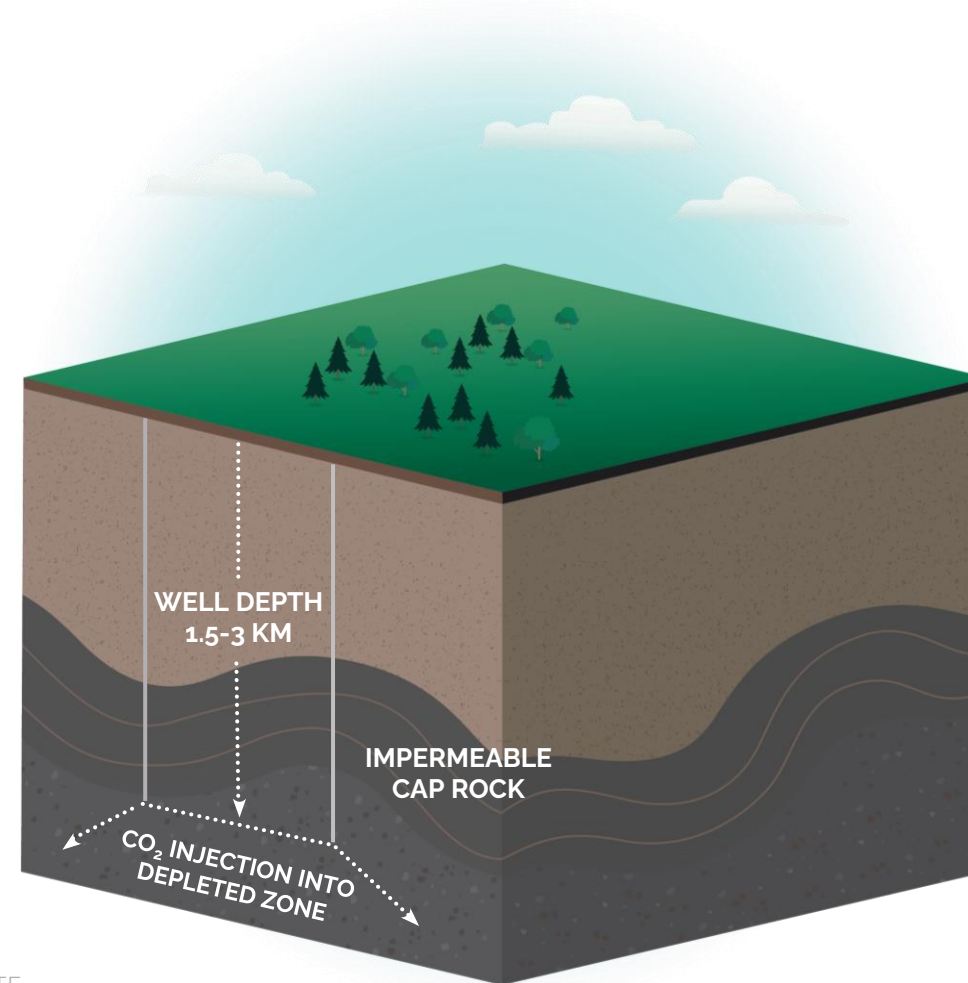
DAC enables permanent carbon removal



Safe,
measurable,
permanent

- ▶ Captured CO₂ is injected underground through a secure and highly engineered infrastructure to the porous injection reservoir
- ▶ At the top of a reservoir formation, an impermeable rock layer (i.e., cap rock) traps the compressed CO₂
- ▶ The CO₂ cannot permeate this rock layer to return to the surface

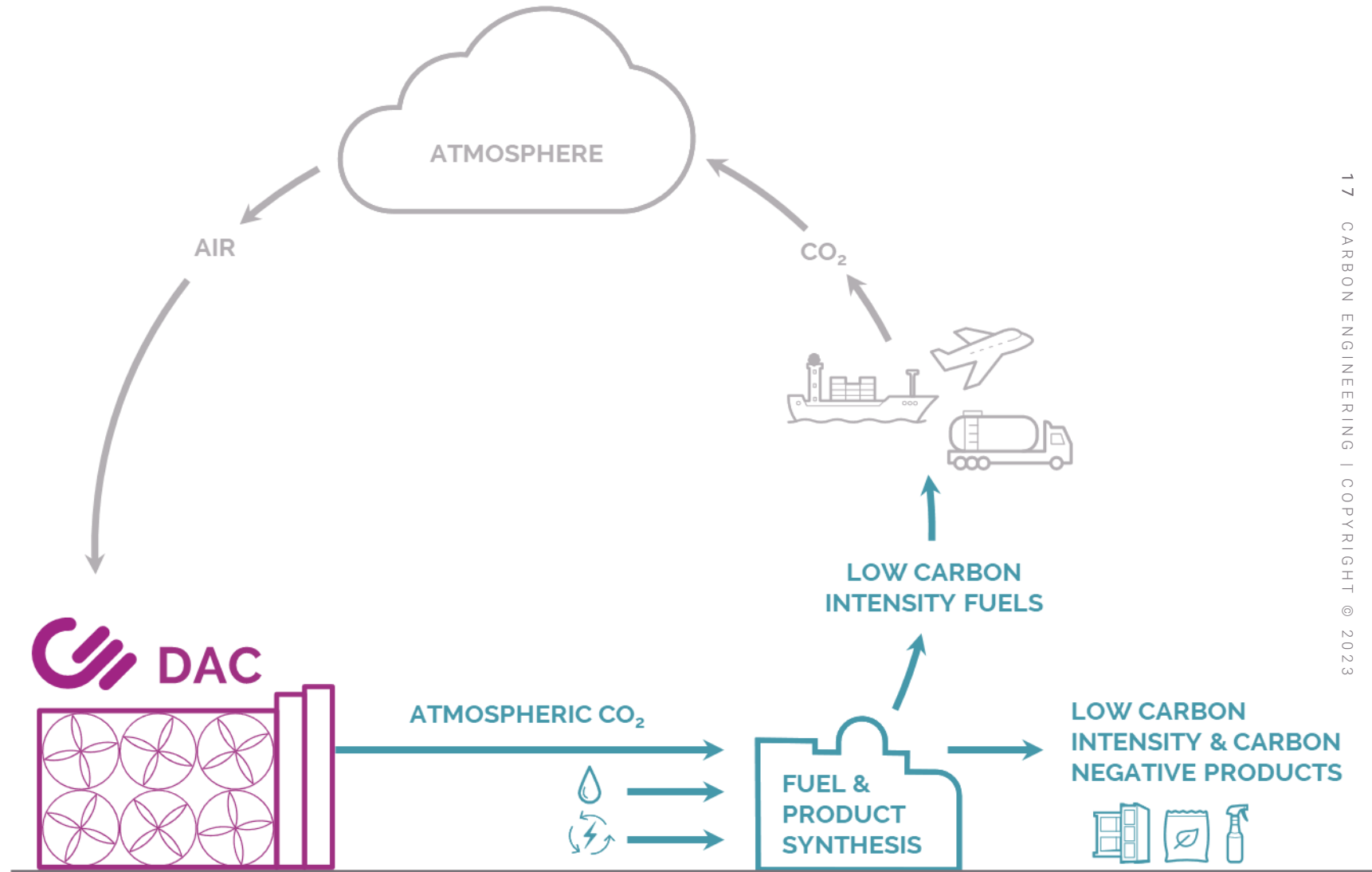
How Geologic Sequestration of CO₂ Works



Source: [GLOBAL CSS INSTITUTE](#)



DAC enables low carbon intensity products



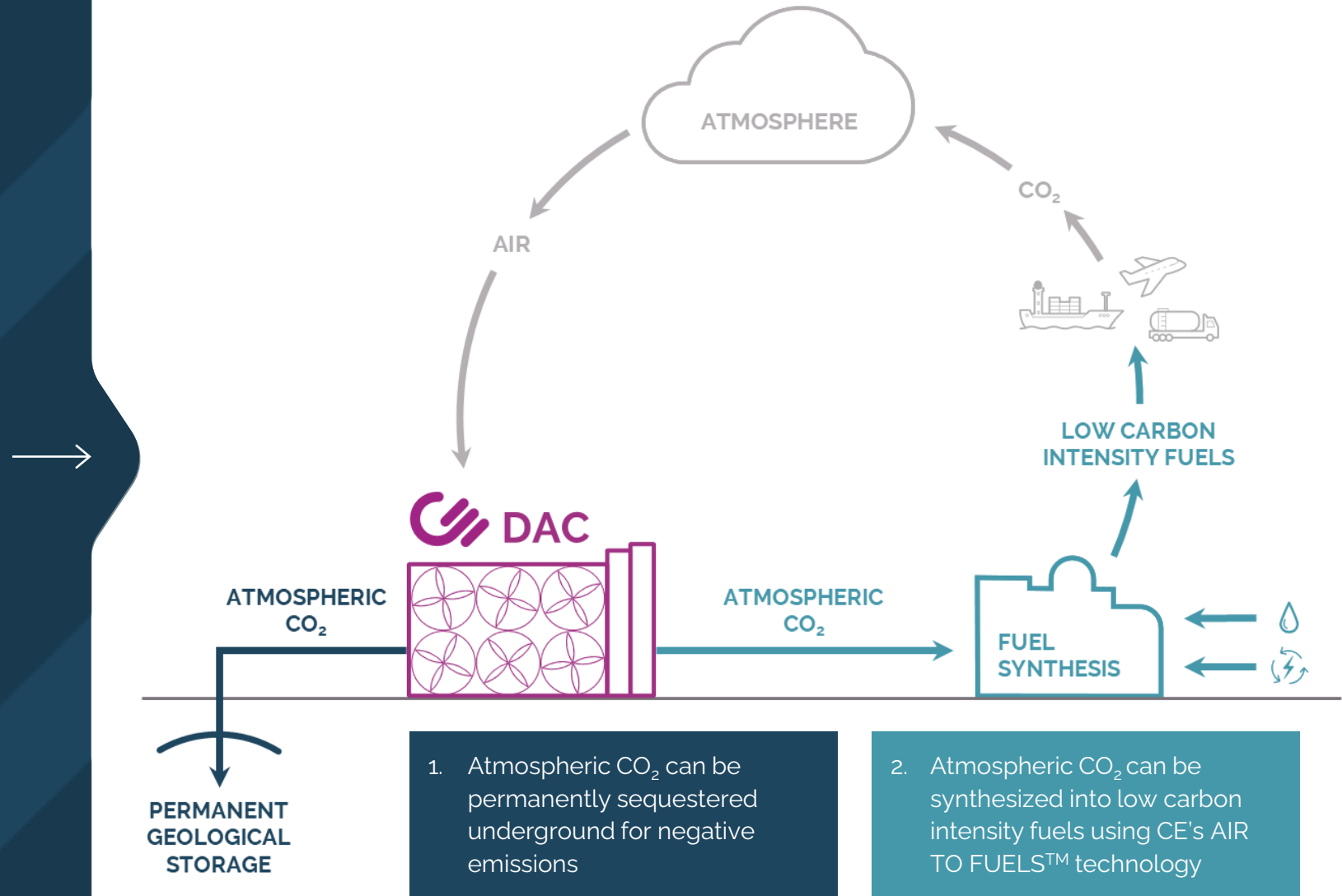
DAC CAN ADDRESS ANY CO₂ EMISSION, FROM ANY LOCATION AND ANY POINT IN TIME

Carbon Engineering brings solutions at climate-relevant scale

Direct Air Capture (DAC) & AIR TO FUELS™ technologies deliver:

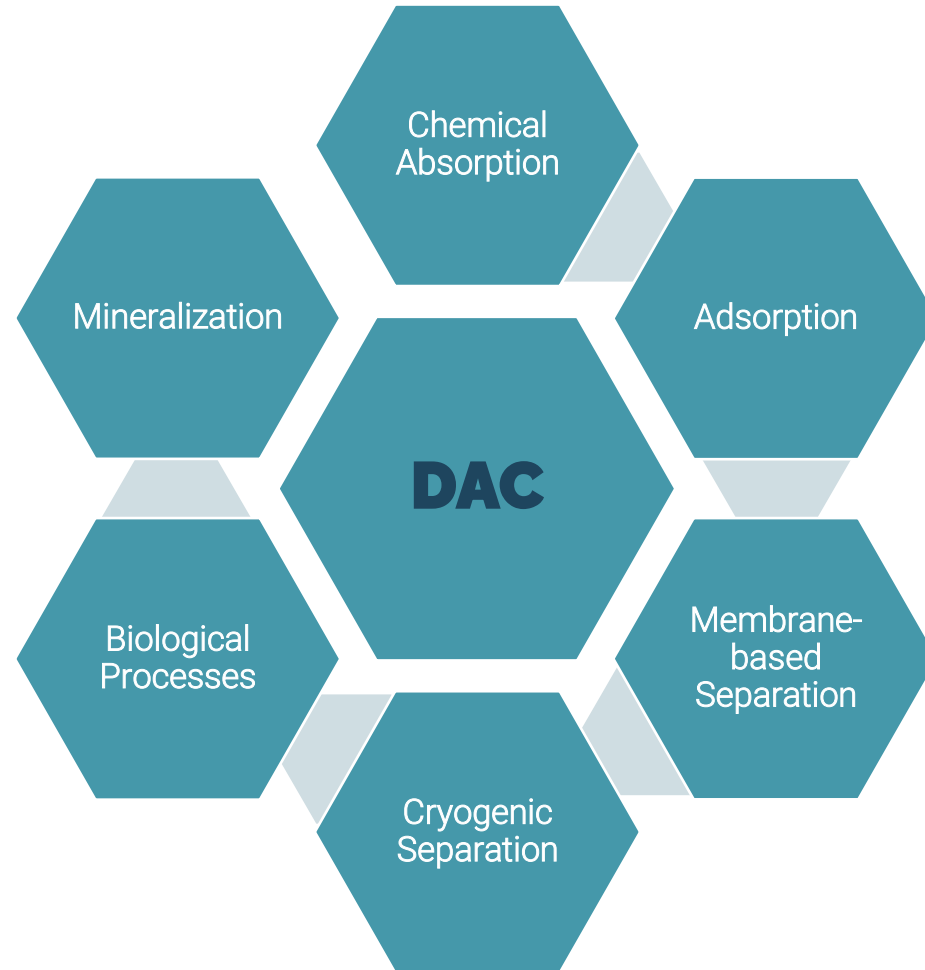
- ▶ **Permanent, climate-relevant volumes¹ of carbon dioxide removal** by capturing CO₂ from the atmosphere and working with partners to store it safely in underground reservoirs or durable products.
- ▶ **Drop-in compatible synthetic fuels** that use recycled atmospheric carbon to create fewer emissions than conventional transportation fuels.

¹ CE's commercial DAC plants can be engineered to capture millions of tonnes of atmospheric CO₂ per year, with each 1 Mt facility equivalent to the carbon removal work of approximately 40 million trees.



DAC CAN ADDRESS ANY CO₂ EMISSION, FROM ANY LOCATION AND ANY POINT IN TIME

Direct Air Capture (DAC) technologies



These pathways have varying levels of maturity and efficiency, and the choice of pathway may depend on factors such as the specific DAC technology, cost considerations, and the desired end use of the captured CO₂.

CE's DAC Technology



In this pathway, DAC facilities use chemical sorbents or absorbents that selectively capture CO₂ from the air.

These sorbents typically have a high affinity for CO₂ and release it when exposed to a higher-temperature environment.

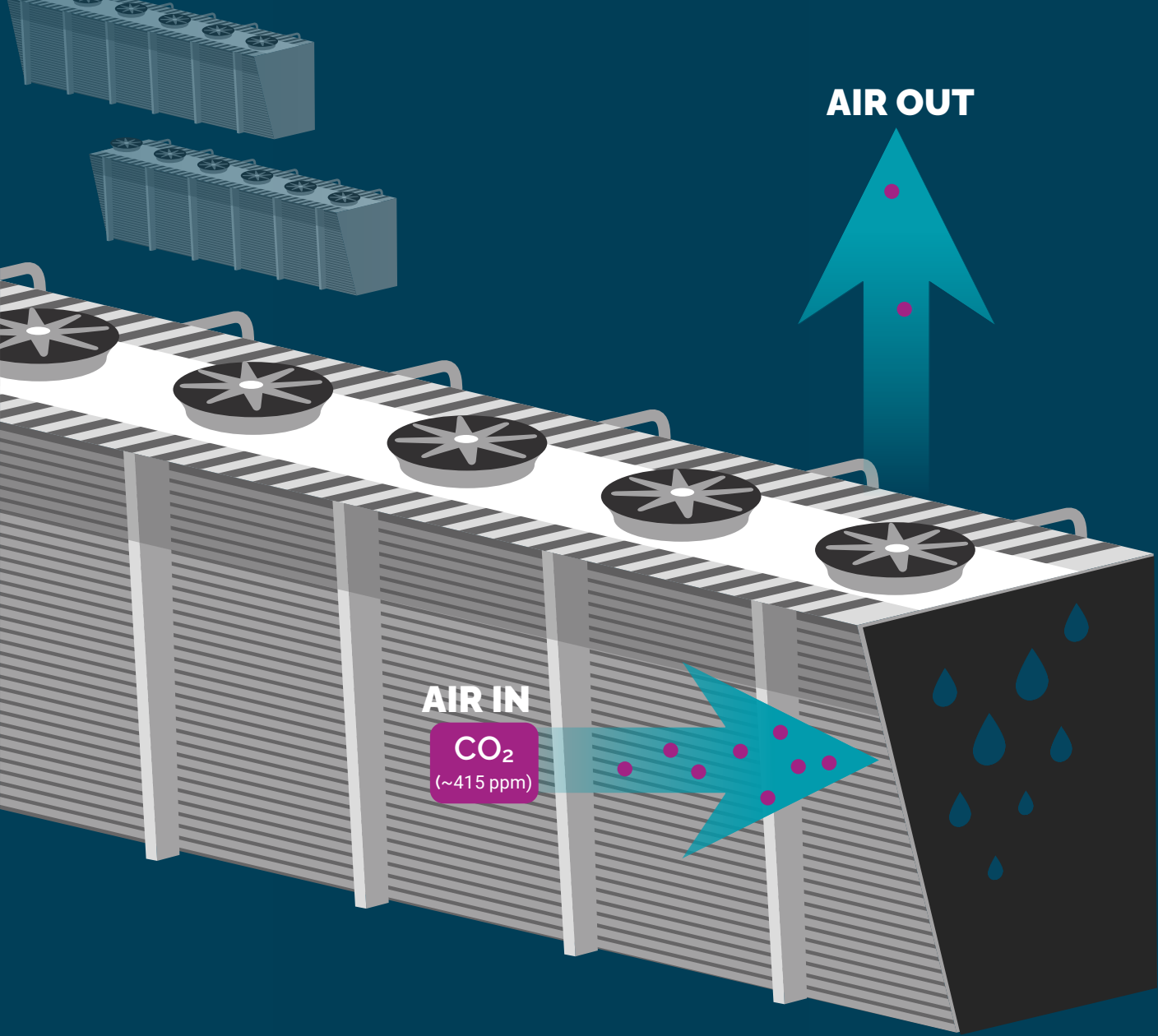
After capturing CO₂, the sorbents can be regenerated, and the captured CO₂ can be stored or used for various purposes.



CE's solutions bring...

- ▶ Emission reductions, and potential for negative emissions, by removing CO₂ from the atmosphere.
- ▶ Separation of emission from collection, enabling great flexibility in addressing carbon footprints.
- ▶ Large energy companies as committed investors, strategic partners and customers.
- ▶ Drop-in compatible fuel from air using scalable technology.

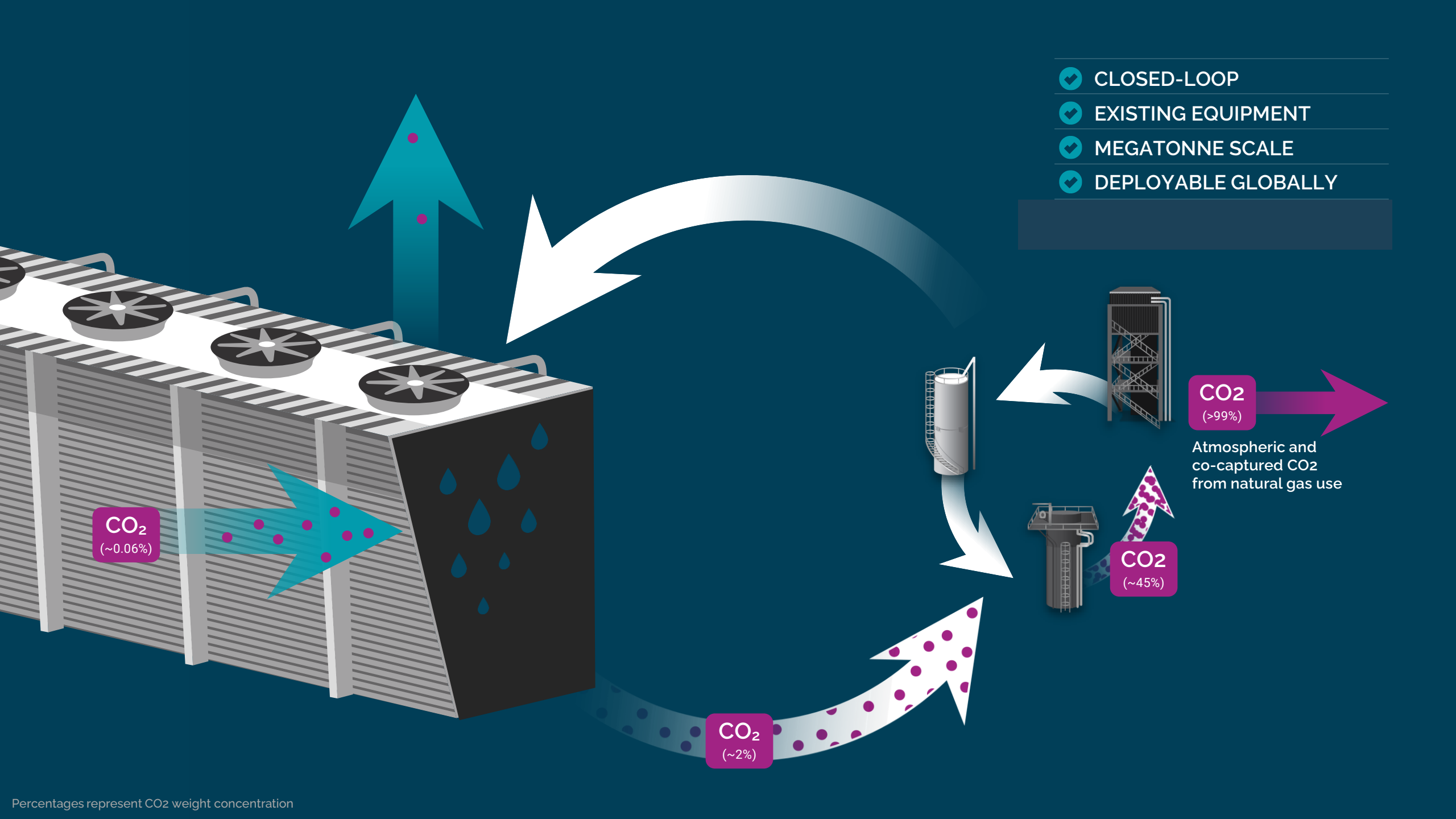




AIR OUT

AIR IN

CO₂
(~415 ppm)



Percentages represent CO₂ weight concentration

CE's process was designed to be deployed at scale

- 1 INDUSTRIAL EQUIPMENT WITH PRECEDENT**
- ▶ A combination of pre-existing technologies adapted and combined with patented innovations and proprietary know-how
 - ▶ Reduces scale up risk & improves cost estimation

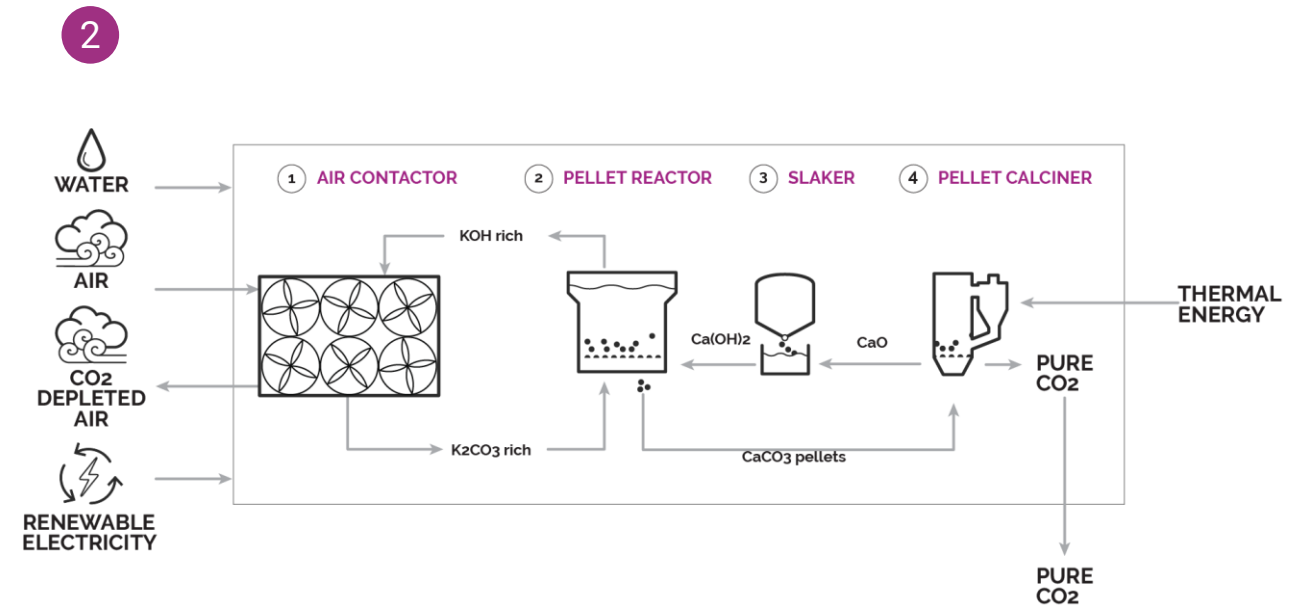
- 2 CLOSED CHEMICAL LOOPS**
- ▶ Non-volatile non-toxic chemical process
 - ▶ Meets environmental health and safety standards

- 3 FREEDOM OF LOCATION**
- ▶ Plants can be located where economics are optimum to take advantage of low-cost local energy or proximity to sequestration sites or demand centre

- 4 LICENSED PROCESS BUSINESS MODEL**
- ▶ Partners with experienced plant developers and world leading EPCs

1

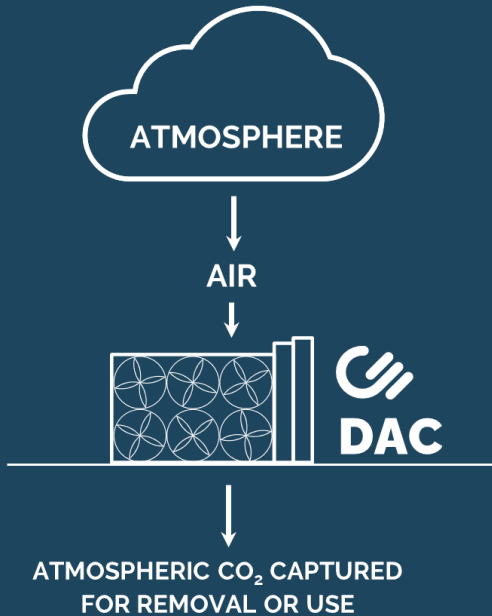
EQUIPMENT	INDUSTRIAL PRECEDENT
AIR CONTACTOR	Industrial cooling tower
PELLET REACTOR	Water treatment technology
SLAKER	Standard equipment for converting Calcium Oxide to Calcium Hydroxide
CALCINER	Refractory lined circulating fluidized bed calciners are commonly used in mining for ore processing





Pioneering large scale Direct Air Capture (DAC)

Can address any CO₂ emission, from any place and point in time



FOUNDING

12+ years development; 6 years pilot plant operations

MILESTONES

2015 DAC pilot plant built

2017 AIR TO FUELS™ pilot plant built

2021 Innovation and R&D centre built

2022 Construction begins for 1st commercial DAC plant

2025 1st commercial DAC plant expected operational

INTELLECTUAL PROPERTY

27 issued patents & 41 pending applications in 19 patent families in key jurisdictions

A technological missing piece

CE brings a solution with potential to address three key climate problems:

1

COST

Is cheaper than alternatives for many hard-to-abate emissions

2

GROWTH IN EMISSIONS

“Has the potential to be almost infinitely scalable”¹

3

NON-DISRUPTIVE

Can address any emission from any point in time; can offset today’s emissions and supports climate restoration through permanent removal of atmospheric CO₂



¹ Goldman Sachs – Carbonomics: The Future of Energy in the Age of Climate Change.

Benefits of large-scale deployment

✓ **COMMERCIALLY READY**



1st commercial DAC facility (in the US) to use CE's technology is already under construction targeted to be operational in 2025.

✓ **SAFE, MEASURABLE AND PERMANENT**



Industry leading partners who bring decades of skilled experience, pre-existing processes and proven infrastructure to safely capture & store CO₂ for 1000+ years.

✓ **SCALABLE**



Large-scale deployment enabled through equipment with industrial precedent and recirculated non-toxic chemical inputs in a closed loop.

✓ **TRANSITION READY**



Compatible with existing energy industry infrastructure, supply chains and workforce skillsets.

✓ **GLOBAL SUPPLY CHAIN BUILD OUT**



Compatible with existing energy industry infrastructure, supply chains and workforce skillsets, creating new opportunities for existing suppliers. For example, Siemens and Matheson.

Large scale deployment underway

PILOT PLANT

BUILT 2015

Piloted elements of CE's DAC technology.



INNOVATION CENTRE

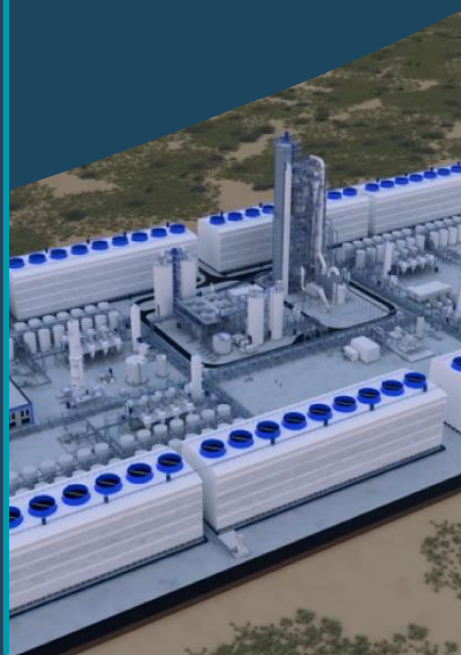
BUILT 2021

R&D platform for technological advancements to incorporate into commercial plants.



STRATOS PERMIAN SITE CONSTRUCTION UNDERWAY

Expected to be largest in the world.



SOUTH TEXAS DAC HUB

ENGINEERING UNDERWAY

Enables potential for 30 MTPA DAC



TEXAS

KING RANCH
106,000 acres
(DAC + Sequestration)

100 Mt by 2035

1POINTFIVE DEV. SCENARIO

Advancing feasibility studies and plant designs in other locations across the globe



Founding customers & supporters

Founding customers of permanent carbon removal through Direct Air Capture are playing a critical role in kickstarting the industry



“Achieving Net Zero could turn an existential risk into the greatest commercial opportunity of our time.”

- Mark Carney, UN Special Envoy on Climate Change




MORE INFORMATION CAN BE FOUND AT:

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 info@carbonengineering.com

 [Carbon Engineering Ltd.](https://www.linkedin.com/company/carbon-engineering-ltd)

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