

Carbon Capture

By: Austin Escamilla, Blake Benson, Hadley Medlock, Valentina Ortega, and Thomas Bockholt



Presentation Overview



- The Current Carbon Situation
- Direct Air Capture (DAC)
- Scaling DAC Projects
- Economics and Financials
- Real-World Implementation
- Present DAC News

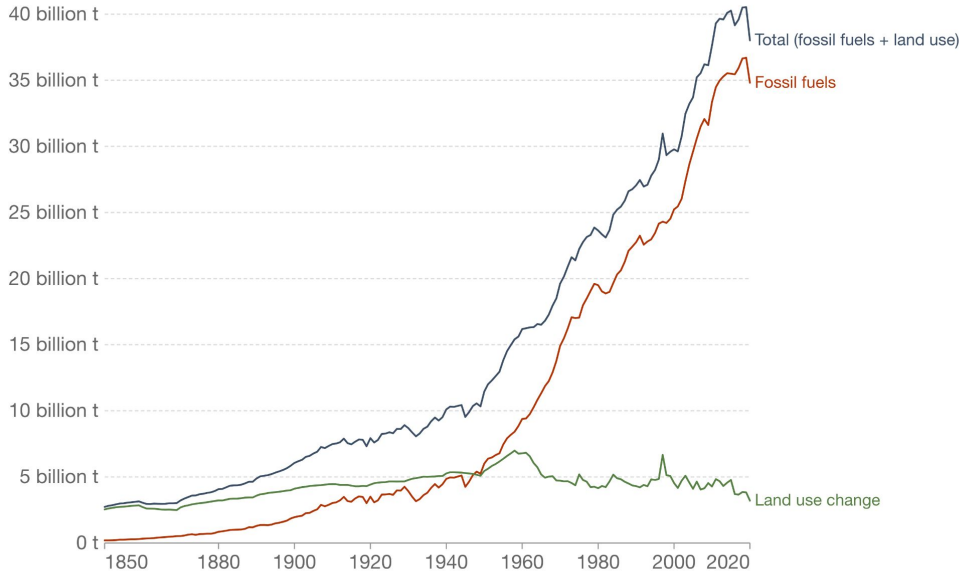


The Current Carbon Situation

Carbon Emission Trends



Global CO₂ emissions from fossil fuels and land use change



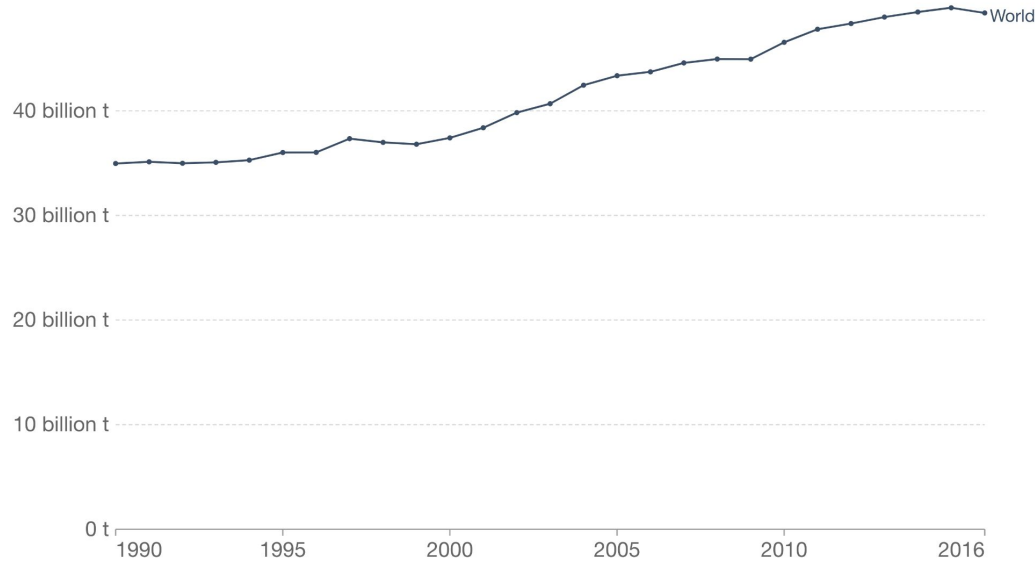
- Immense emission boost after the industrial revolution
- In 2020, we emitted over **34 Gigatons** of CO₂ from fossil fuels and land use
- Upwards trend: With current projections, we are far from reaching peak emissions
- Emissions are not declining, and we are not on trend to keep temperatures from increasing 1.5-2°C

Carbon Emission Trends



Total greenhouse gas emissions

Greenhouse gas emissions – from carbon dioxide, methane, nitrous oxide, and F-gases – are summed up and measured in tonnes of carbon-dioxide equivalents (CO₂e), where “equivalent” means “having the same warming effect as CO₂ over a period of 100 years”. Emissions from land use change – which can be positive or negative – are taken into account.

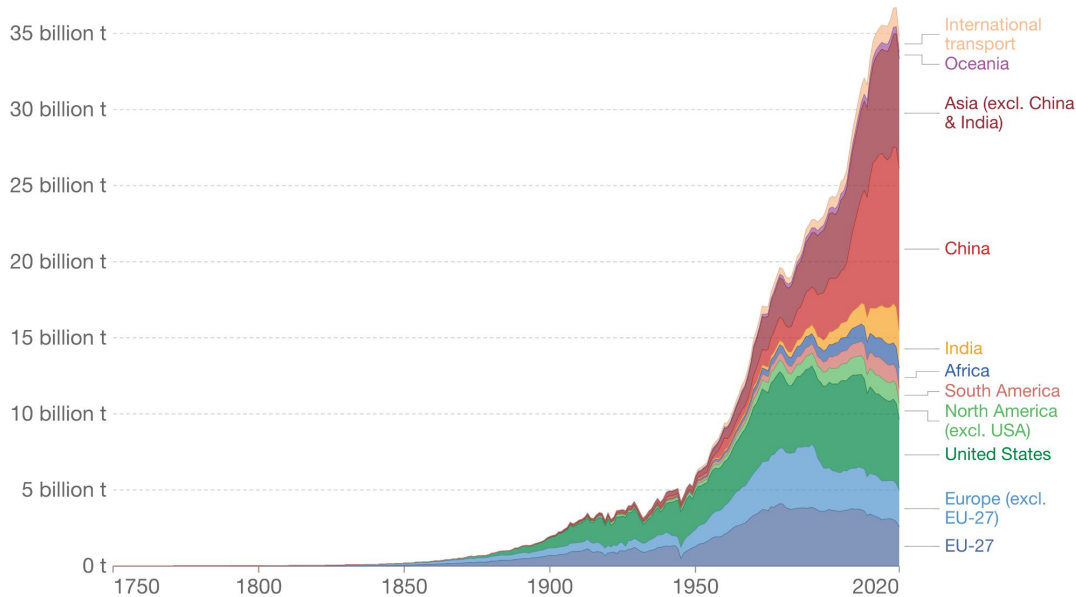


- Overall, total greenhouse gas emissions have roughly stabilized over the past decade
- No signs of emissions decreasing
- A continuation of this trend suggests a 2 degree warming by 2050

Carbon Emissions Vary by Region



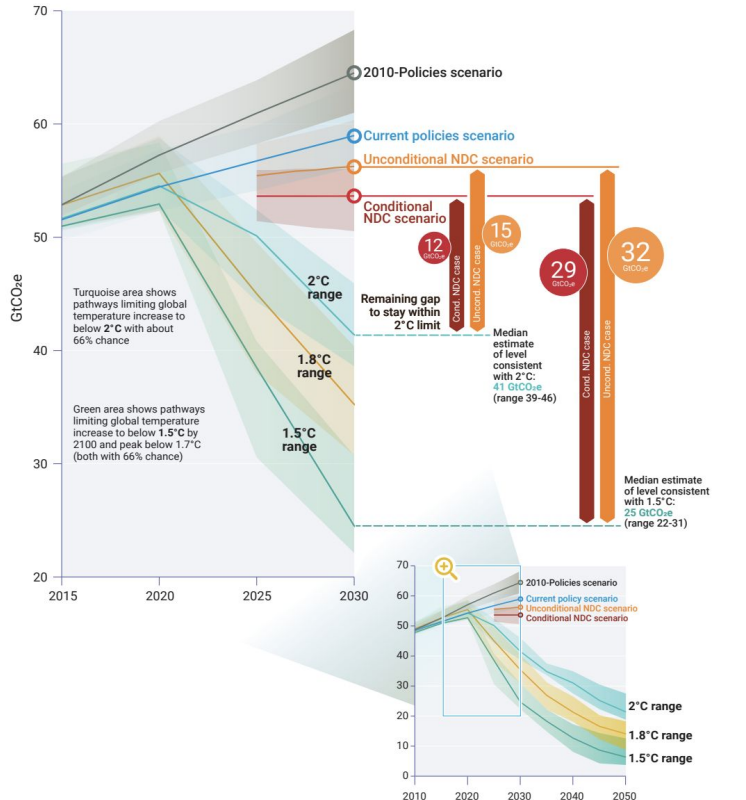
Annual CO₂ emissions from fossil fuels, by world region



- In 1900s, 90% of emissions were produced in Europe and the US
- In 2000s, there has been a significant increase of emissions from Asia (most notably China)
 - Now, Europe and the US account for less than a third of all emissions
- **Who is responsible?**

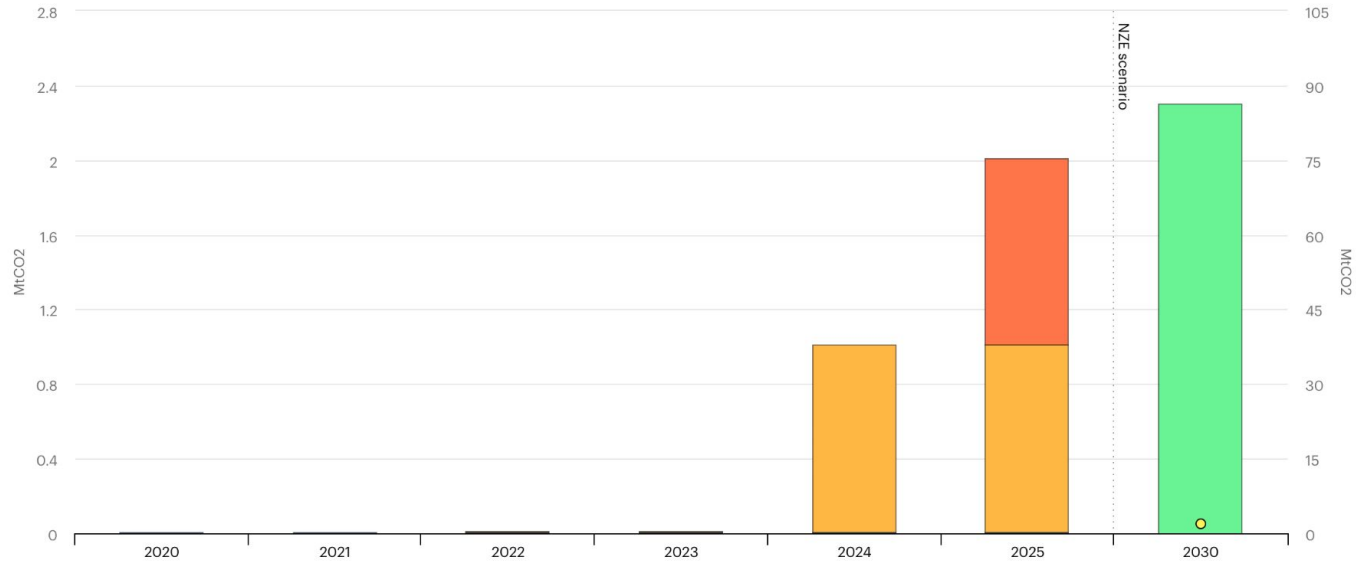


Paris Agreement Pledges



- There is a current gap in global progress towards Paris Agreement goals
- Emission cuts needed to meet Paris Agreement goals are drastic
 - Up to 32-34 Gt yearly
- An alternative solution is to reduce existing carbon in the atmosphere to offset emissions
 - Carbon capture technologies
 - **Direct air capture (DAC)**

CO₂ Capture by DAC in the Net Zero Scenario

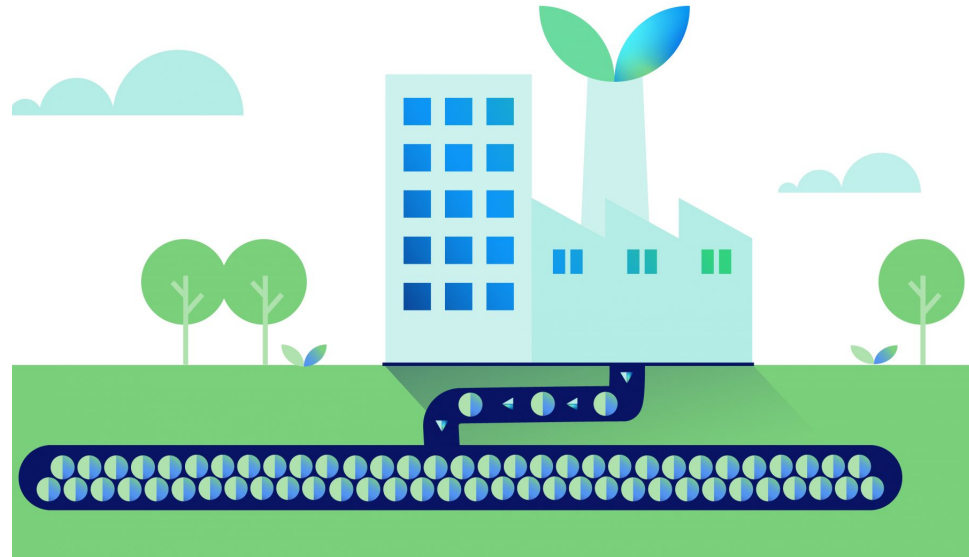


● Operating capacity ● Advanced development ● Early development ● NZE ● 2025 level

The Promise of Direct Air Capture



- Can work alongside existing technologies to not only reduce emissions but extract CO₂ directly from the atmosphere
- Does not place all the burden on select few countries to drastically reduce emissions
- Sustainable, flexible, and stable source of negative emissions throughout transition to renewables





Direct Air Capture

What is Direct Air Capture?



“Direct air capture (DAC) technologies extract CO₂ directly from the atmosphere. The CO₂ can be permanently stored in deep geological formations (thereby achieving negative emissions or carbon removal) or it can be used, for example in food processing or combined with hydrogen to produce synthetic fuels.” - IEA

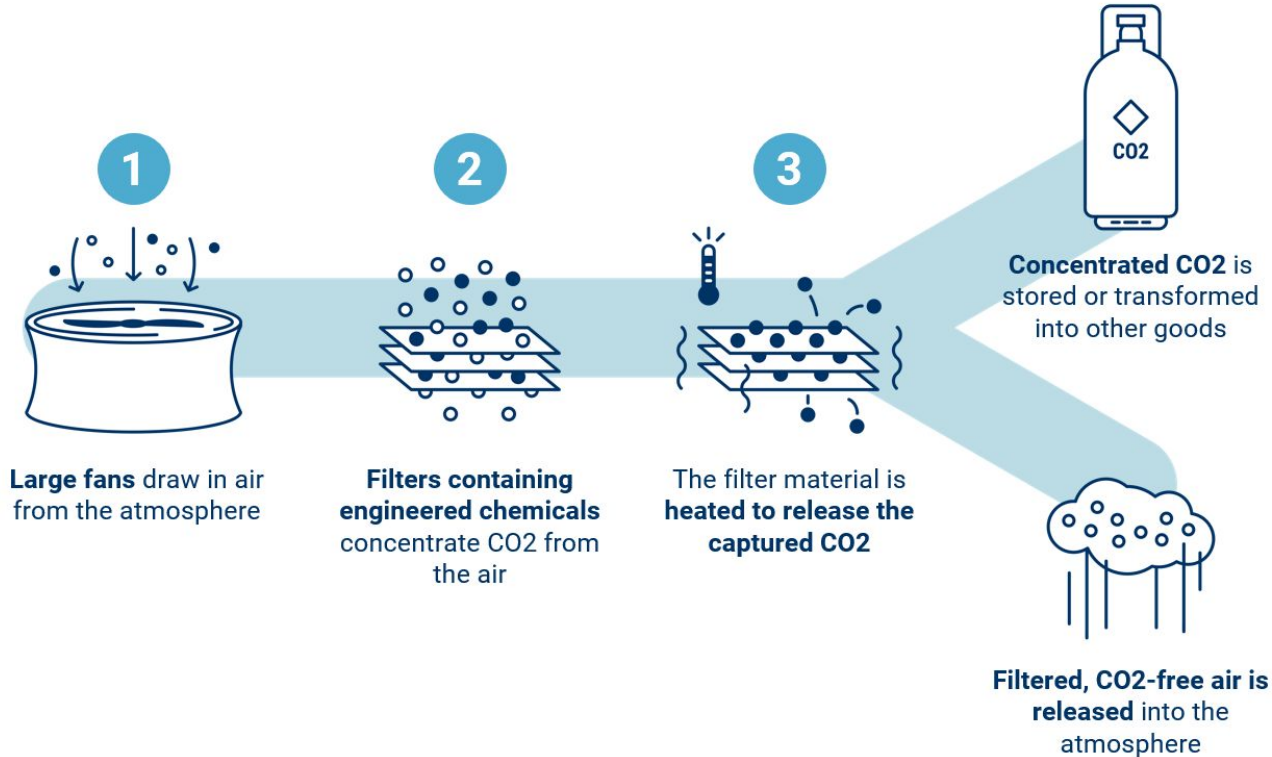
Liquid DAC

- Pass air through chemical solutions (e.g. hydrogen peroxide) which removes CO₂
- System re-integrates chemicals back into the process by applying high-temperature heat to the solution
- Rest of the air passes through the system and is returned to the environment

Solid DAC

- Uses solid sorbent filters that chemically bind with CO₂ and separate it from air
- Filters are heated and placed under a vacuum in order to release the concentrated carbon dioxide
- Captured CO₂ is used for economic sources or put into storage underground

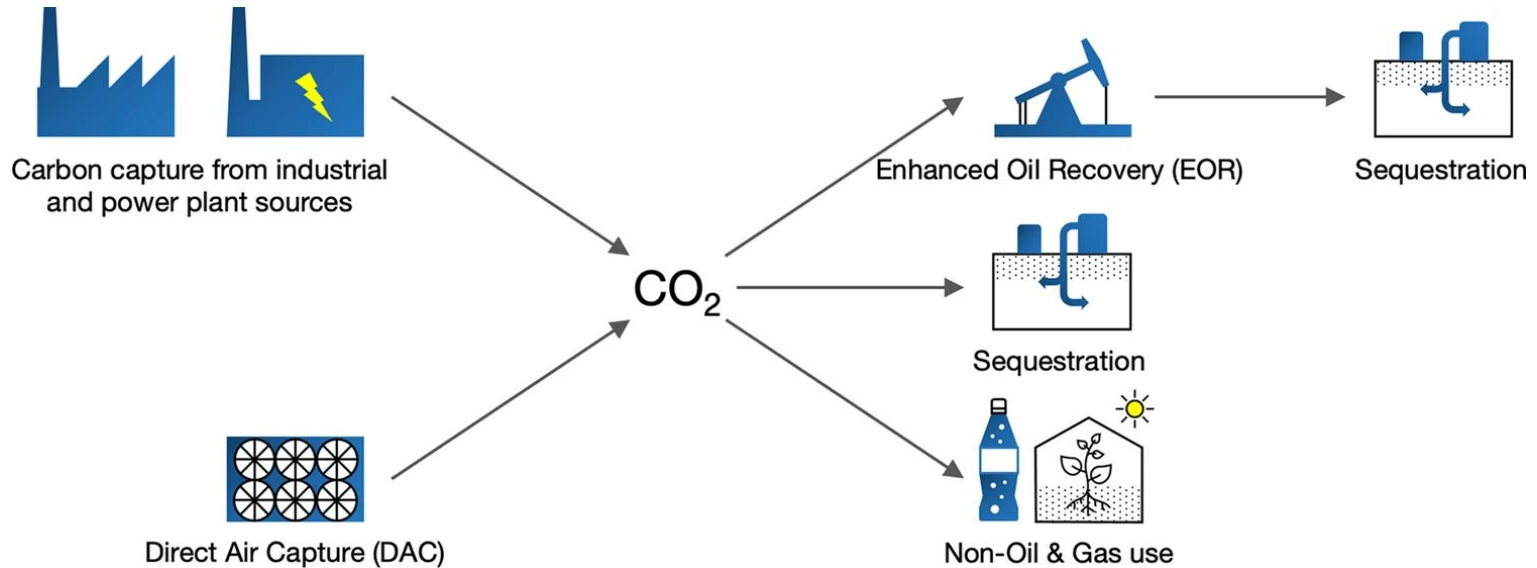
3 Basic Steps to Direct Air Capture



How is Captured Carbon Utilized?



Captured CO₂ can be stored underground (mineralized and kept for thousands of years) or put back into the economy (Coca-Cola bottling plants, pipelines, greenhouse fertilization, fuel production).



Direct Air Capture v. Point Source



Direct Air Capture

Captures CO₂ From Ambient Air 1

Fans draw in ambient air and filter captures CO₂

Diluted CO₂ 2

CO₂ is a trace gas (0.04% of atmosphere)

Negative Emissions 3

20% of CO₂ emissions are unavoidable



Point Source

Captures CO₂ During Emission 1

Filters CO₂ directly from plant before it enters smokestack

Highly Concentrated CO₂ 2

Flue gas from power plants is 8-12% CO₂

Emissions Reduction 3

Helps prevent CO₂ from entering atmosphere



Scaling DAC

Current Direct Air Capture Capacity



Direct Air Capture Efforts

19 Direct Air Capture Plants Worldwide

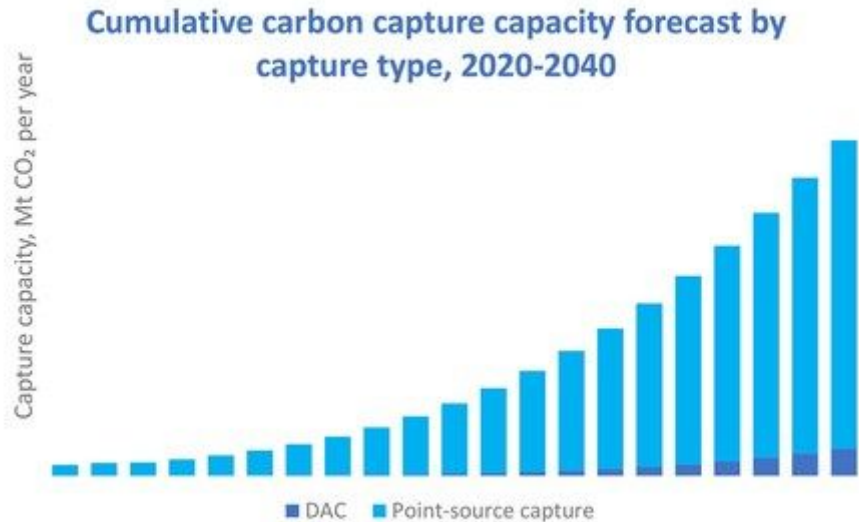
0.01 Mt CO₂/year pulled from DAC

World's Largest Plant- 4kt CO₂/year

Carbon Dioxide Emissions

34 Gigaton
CO₂ Emission
per Year

Issues with Scaling



DAC is Limited by a Few Factors

- Powering DAC systems in environmentally responsible ways
- Usage for pulled carbon
- Limited tons per year
- High Costs
- Little established infrastructure

Why Scale?



Increasing Scale is Crucial for the Direct Air Capture Industry

- Cutting emissions alone cannot solve the problem
- World is still reliant on fossil fuels
- Small, modular units
- Unique possibility for removal vs reduction is an important tool



Current Scaling Efforts



The DAC Industry Stands to Benefit with Further Scaling Efforts

- Each generation increases efficiency
- World's first Mt CO₂/year plant in development
- Crude producers interested in enhanced oil recovery
- Interest in R&D





Economics and Financials

The Early Costs



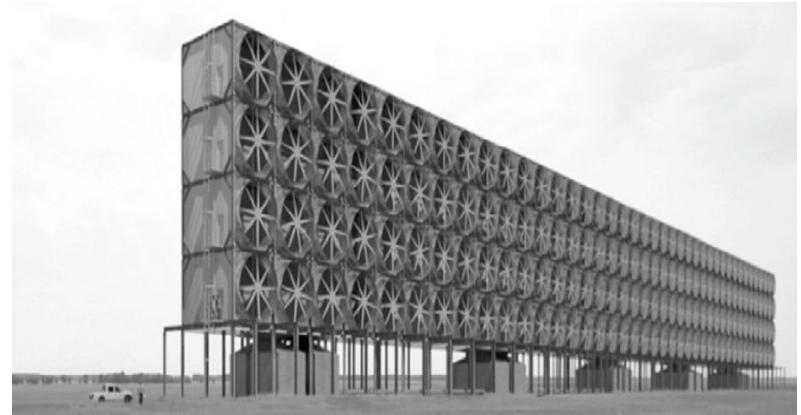
Current Costs are High, but Should Drastically Reduce with Time

Climeworks

- Direct Costs of \$600-\$800 per ton of carbon
- Sold via carbon credits through subscription service
- Extremely high compared to market price of carbon and other carbon initiatives

Why?

- Industry still in its infancy
- There has not been enough time for significant innovation and technological advancement
- High R&D costs



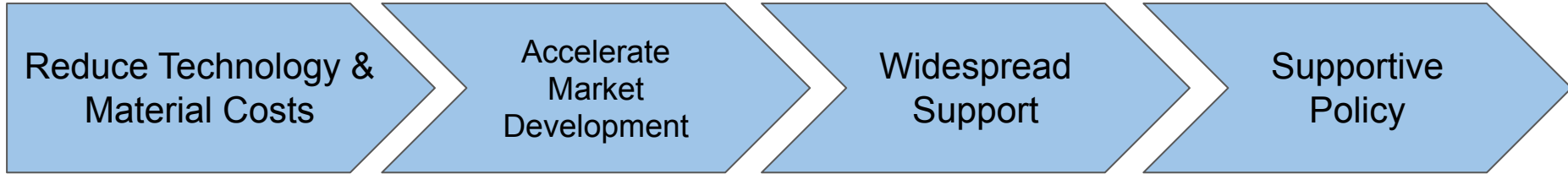


How Do We
Reduce Costs?

Private Investment is Key



Acceptance and Investment in DAC Technologies Has Been Largely Driven by Private Sector





“ I’ve been told by venture capitalists — investors I respect for their grasp of technology, and who have a deep understanding of climate change — that direct air capture could turn out to be **among the world’s biggest industries by midcentury.** ”

- Jon Gertner, PBS



Real-World Implementation

Orca DAC Plant: Climeworks in Iceland



“We’re mining the sky because there’s too much carbon in it” - Christoph Beuttler, Climeworks



Background



World's biggest plant

Not Climework's first

- Pilot plant in Switzerland in 2017
- Packaged collected carbon for use in fertilizers, fizzy drinks, and synthetic fuels

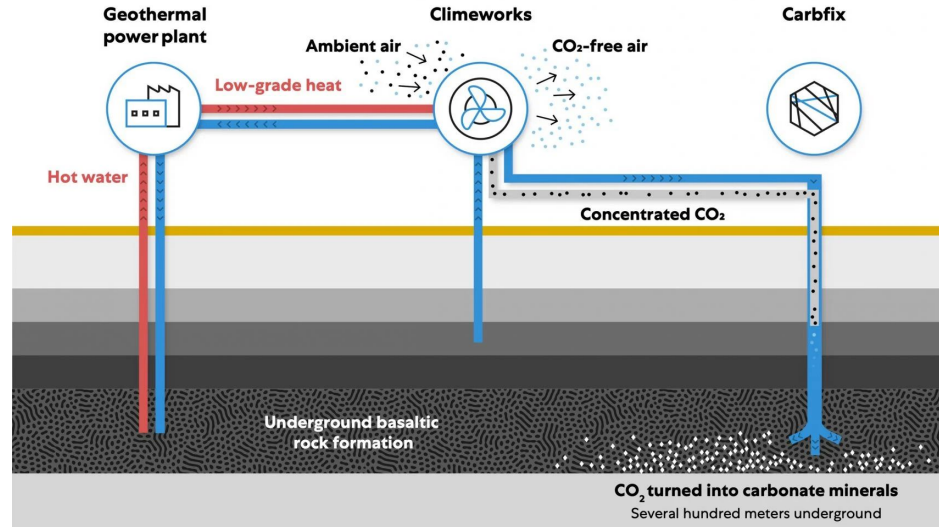
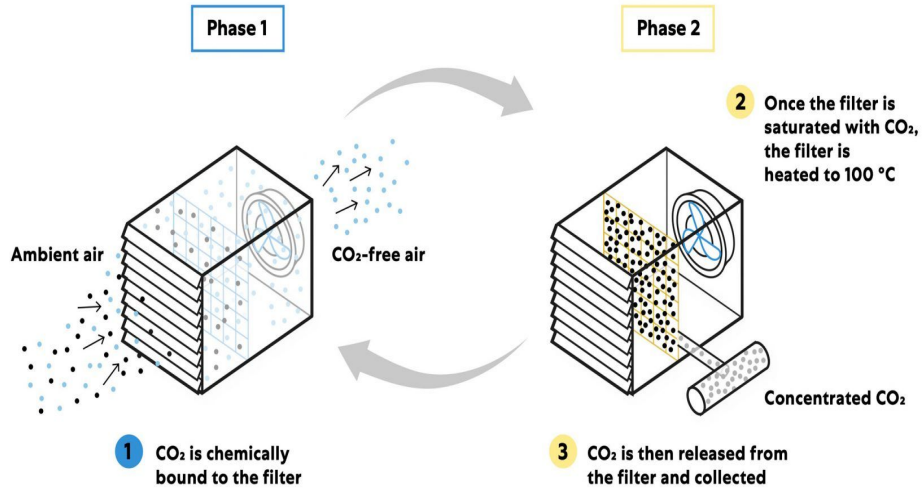
Entirely run on renewable energy

- Can be replicated in an area with similar capacity for renewable energy and storage

Plans to achieve megaton removal capacity by second part of decade

\$600 - \$800 per metric ton of carbon

How it Works





Carbon Capture



- Carbon Engineering
 - Partnering with 1PointFive to engineer the world's largest DAC plant in Texas
 - Will capture 1 million tons of CO₂ annually
- Mosaic Materials
 - Breakthrough sorbent material called metal-organic frameworks (MOFs)
 - Ability to improve DAC systems
- Svante
 - Innovation in rapid absorption using solid filter from MOFs can cut capital costs of existing carbon capture tech in half
 - Partnering with Climeworks to adapt this tech for DAC



Present DAC News



Elon Musk Announces \$100M XPRIZE Competition

01 The Incentive

Funded by Elon Musk and the Musk Foundation, this \$100M competition is the largest incentive prize in history, an extraordinary milestone

02 The Competition

The four-year global competition invites innovators and teams to create solutions that can pull carbon dioxide directly from the atmosphere or oceans, and sequester it durably and sustainably

03 The Prizes

- \$50 million paid to the single Grand Prize Winner
- \$30 million to be distributed among up to 3 runners up
- \$5M to student teams in the Fall of 2021

November 12, 2021



BCG Signs Direct Air Capture Partnership With Climeworks



BCG, a leading consulting firm, has committed to net-zero by 2030



10-yr agreement to purchase Climeworks' CO₂ removal service



BCG is setting an example for the fast adoption of technological carbon removal



COP26 Set an Aggressive Target of Reaching Net Zero by 2035

US and China Release Joint Statement

U.S.'s commitment to reach 100% renewable electricity by 2035 and China to "phase down" coal in the second half of this decade

Commitment to Direct Air Capture

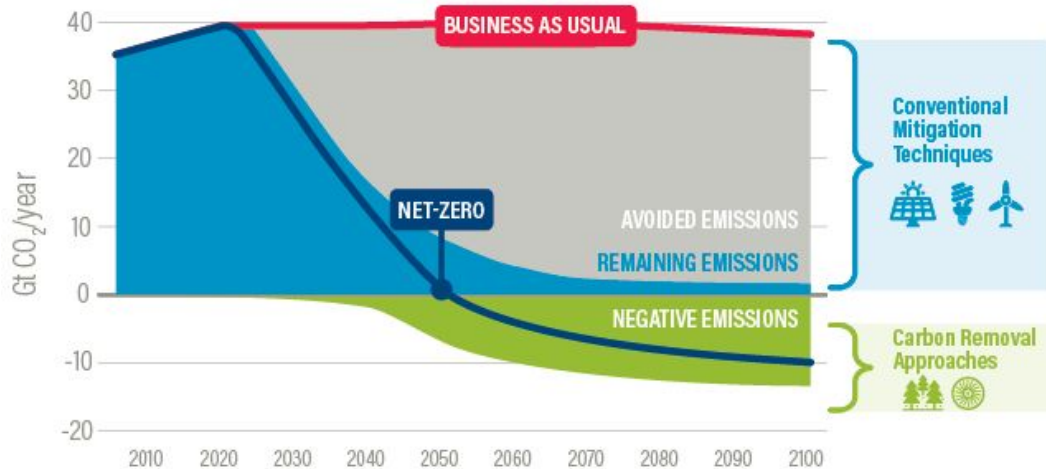
Both countries will collaborate to develop direct air capture technologies, an industry still very much in its infancy



November 15, 2021



Bipartisan Infrastructure Bill Invests Billions in Carbon Capture



\$1.2 Trillion Bipartisan Infrastructure Bill

President Biden signed a bill for funding the country's physical infrastructure, with a focus on energy and natural resources infrastructure

\$3.5 Billion Dedicated to CO₂ Removal

Bill appropriates \$3.5 billion for CO₂ removal demonstration projects and carbon capture pilot projects over the next five years



Third Derivative Launches “First Gigaton Captured”

Environment Press Release

Third Derivative and the Grantham Trust Launch First Gigaton Captured to...

BOULDER, Colo., Dec. 8, 2021 /PRNewswire/ -- Today, Third Derivative (D3), a global climate technology startup accelerator, announced a...



Removing 10 Gt of CO₂ annually would cost more than \$5 trillion per year at current price with DAC technology



Goal of the partnership is to bring the cost of durable carbon removal down to less than \$100 per ton



Initiative aims to ensure carbon removal approaches can achieve 10 billion tons of carbon capture by 2050



Thank you! Questions?