Content Overview

- Why do we need to remove CO2 from the atmosphere?
- How is CO2 being removed from the atmosphere?
- How is CO2 being stored?
- Method overviews, pros, and cons
- How much do companies sell carbon removal credits for?
- Is now the time to invest in carbon removal?
- Investment factors to consider

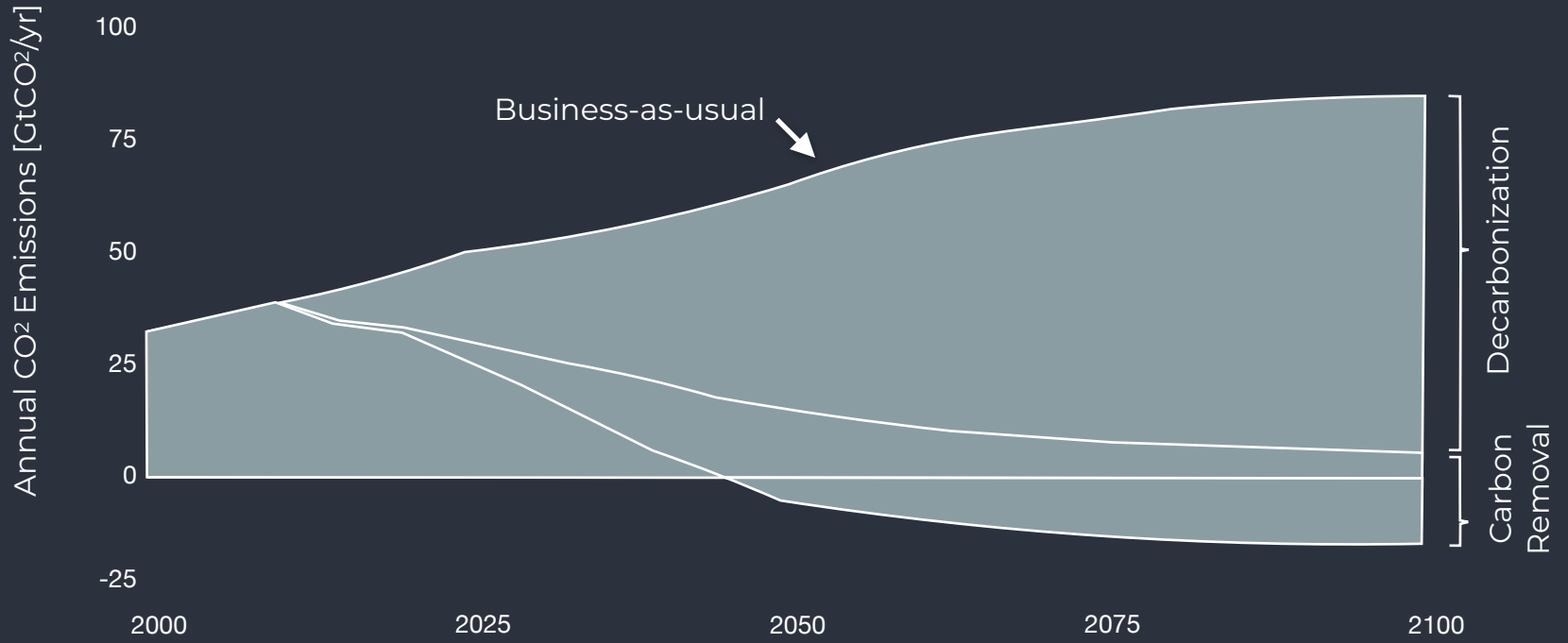
Climate change is a trillion dollar opportunity disguised as an existential crisis

Why do we need to remove CO_2 from the atmosphere?

reducing
carbon emissions

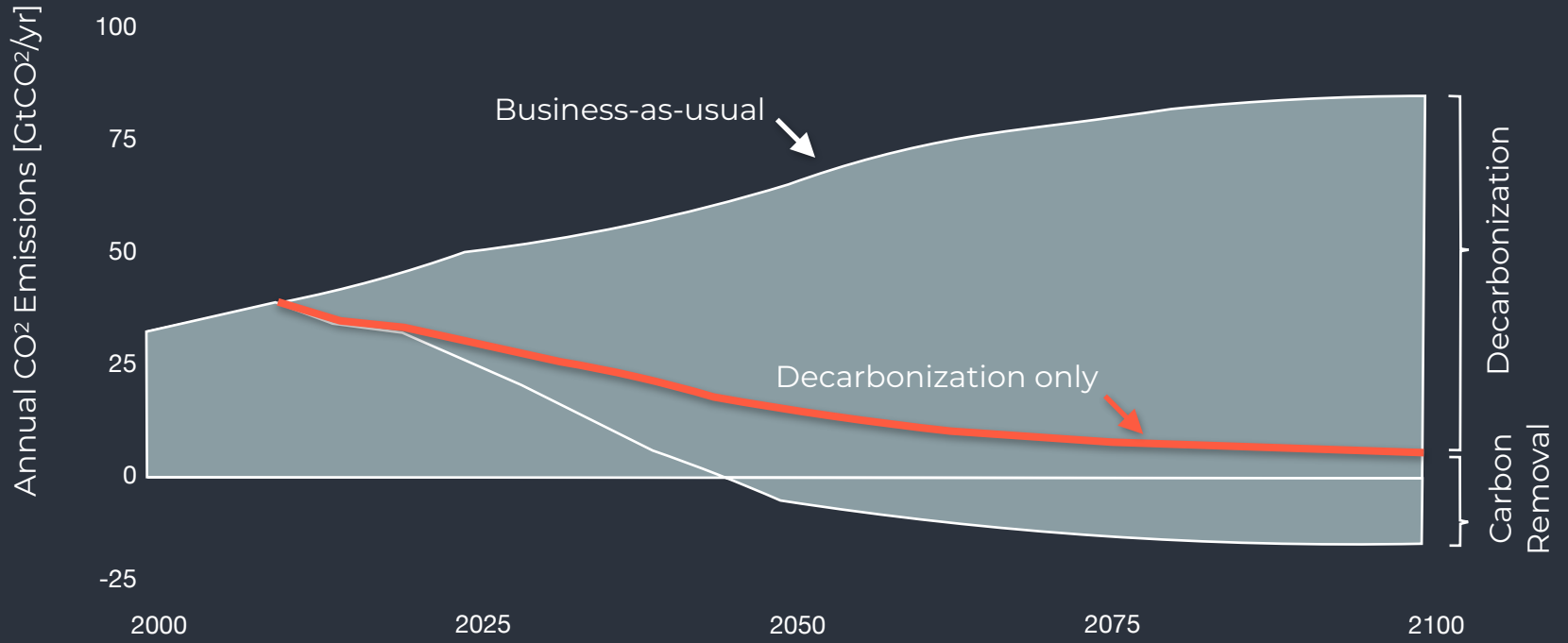
Because decarbonization
is not enough

Pathway Options



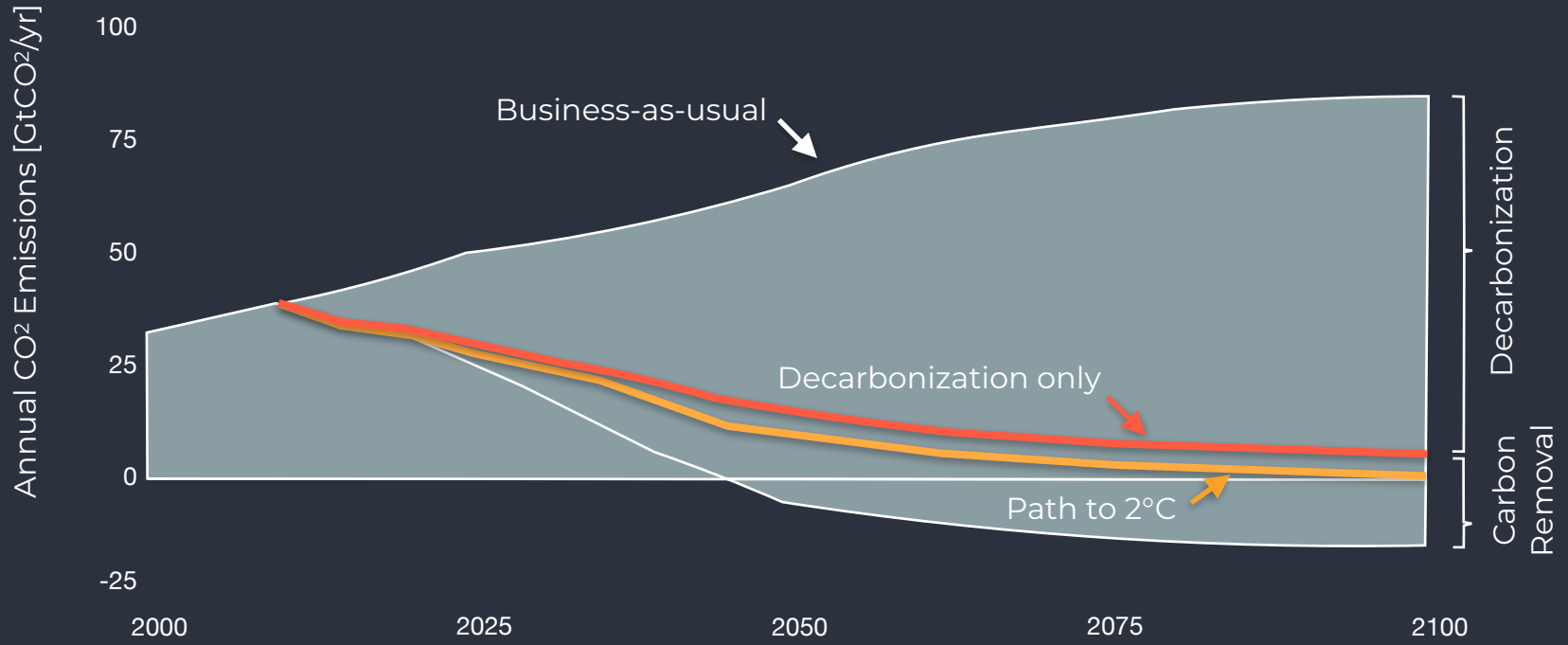
All pathways to stay below 1.5 degrees of warming require negative emissions technologies (Source: Modified from the IPCC Special Report on Global Warming 1.5C)

Pathway Options



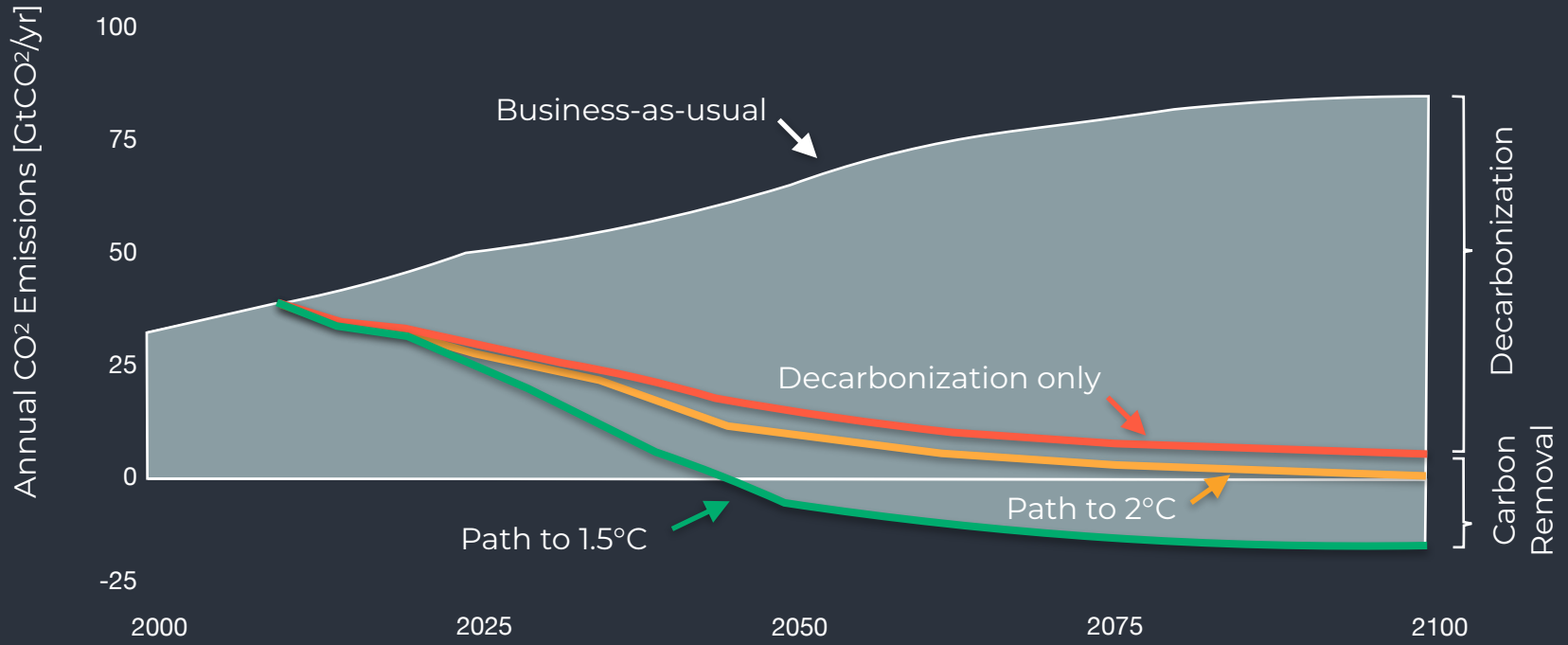
All pathways to stay below 1.5 degrees of warming require negative emissions technologies (Source: Modified from the IPCC Special Report on Global Warming 1.5C)

Pathway Options



All pathways to stay below 1.5 degrees of warming require negative emissions technologies (Source: Modified from the IPCC Special Report on Global Warming 1.5C)

Pathway Options



All pathways to stay below 1.5 degrees of warming require negative emissions technologies (Source: Modified from the IPCC Special Report on Global Warming 1.5C)

tactics to reflect sunlight
and reduce heating

Geoengineering just buys us time,
it doesn't solve the problem.

What's the difference?

Washington DC, USA

Taipei, Taiwan

Dubai, UAE

Mumbai, India

Our world at 1.5°C

Our World at 3°C

We have limited time...

What technologies remove CO_2 from the atmosphere?

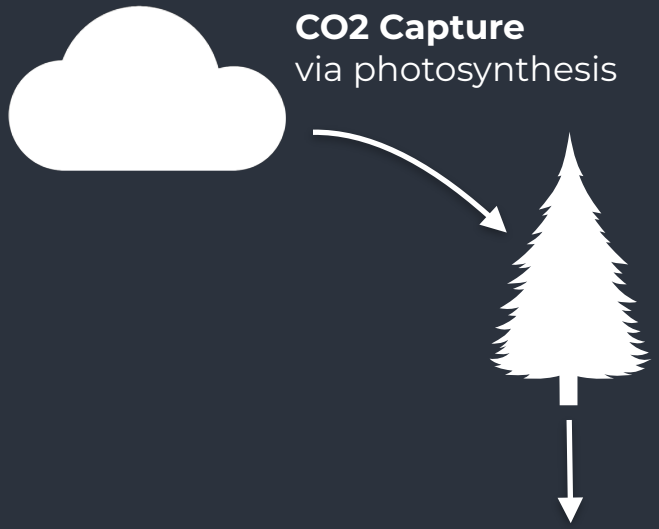
How is the CO2 stored?

How are companies making money?

Terrestrial Carbon Removal

CO2 Storage

Terrestrial Carbon Removal

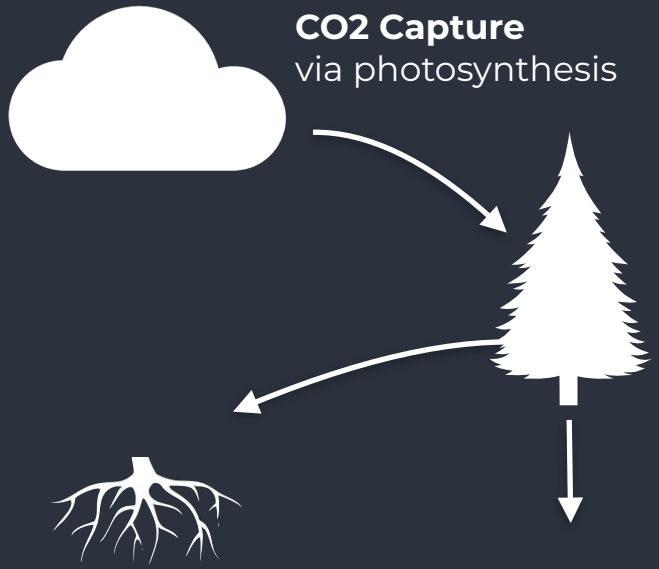


CO2 Capture
via photosynthesis

Forestry
via reforestation
50+ year permanence

CO2 Storage

Terrestrial Carbon Removal



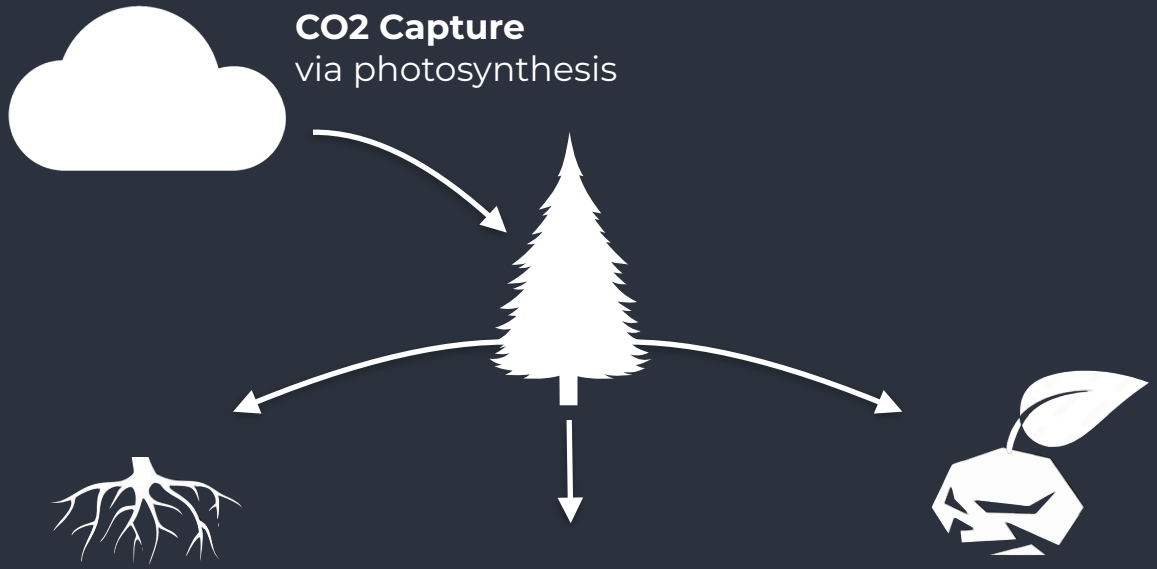
CO2 Capture
via photosynthesis

Soil Carbon
via regenerative ag
20 year permanence

Forestry
via reforestation
50+ year permanence

CO2 Storage

Terrestrial Carbon Removal



CO2 Capture
via photosynthesis

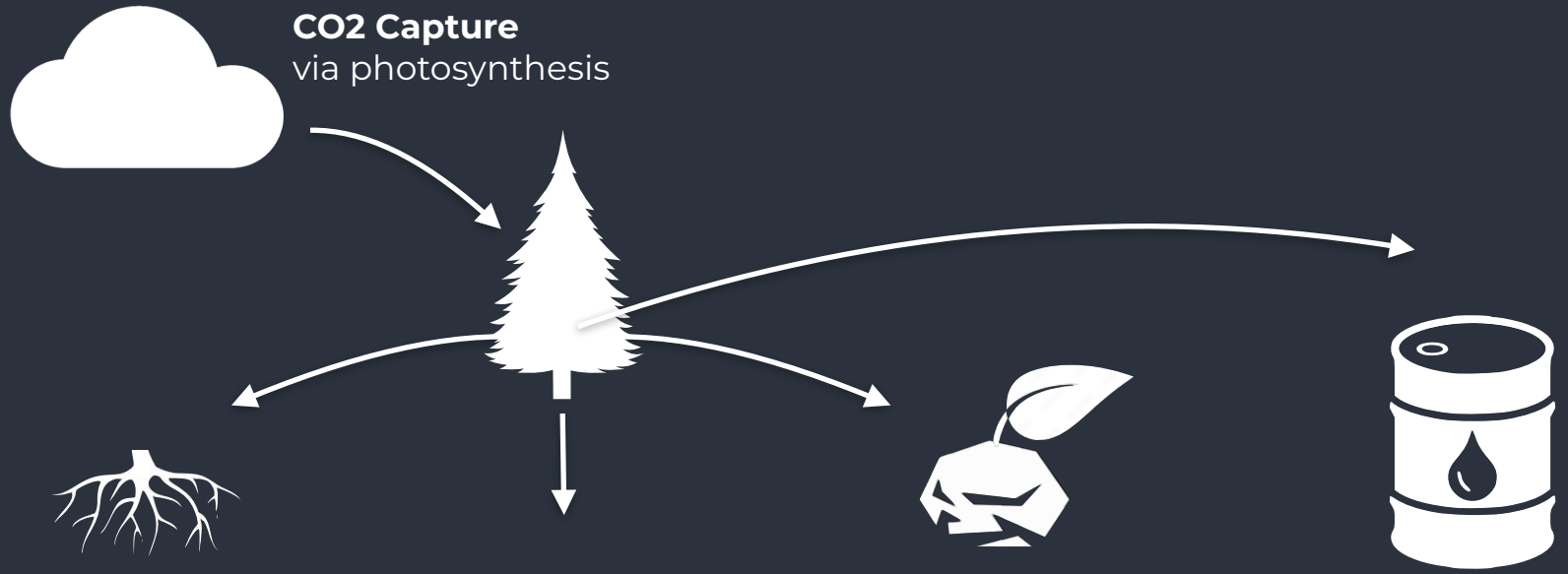
Soil Carbon
via regenerative ag
20 year permanence

Forestry
via reforestation
50+ year permanence

BioChar
via low oxygen burning
100 year permanence

CO2 Storage

Terrestrial Carbon Removal



CO2 Storage

Soil Carbon
via regenerative ag
20 year permanence

Forestry
via reforestation
50+ year permanence

BioChar
via low oxygen burning
100 year permanence

BioOil
via low oxygen burning
1000 year permanence

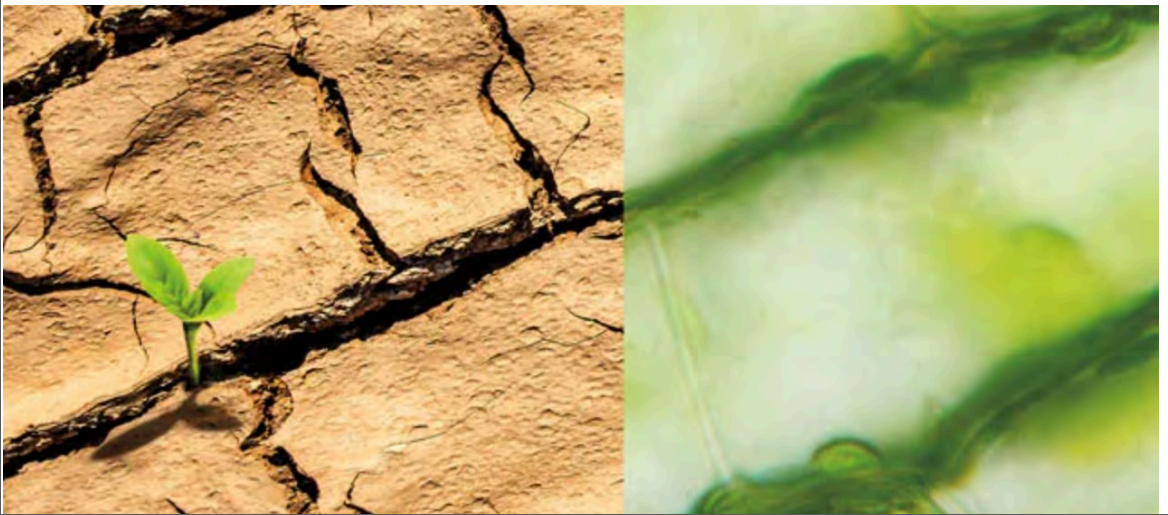
Terrestrial Carbon Removal

Type	Pros	Cons
Soil	Large potential sink 5GT of CO2e/yr	Reversal and measurement risk
Forestry	Low tech barrier, ecology value	Fires, land use, long time to removal
BioChar	Scalable, can be sold as a product	Feedstock availability, tech defensibility
BioOil	Scaleable, high permanence	Feedstock availability

Regenerative Ag

indigo™

Indigo Ag helps farmers generate income from carbon farming, provides a collection of biological products derived from plants to increase crop yields, and provides a digital application to make selling crops easier.



Forestry

Drone Seed is reforesting land after wildfires more efficiently using drones to reduce people requirements and expand the types of areas that can be reforested. Each tree replanted will uptake CO2 for the life of the tree.

BioChar

TAKACHAR CARBOFEX Carbon Cycle

These companies convert agricultural or wood waste biomass into biochar, a usable fuel, fertilizer, and carbon storage solution.

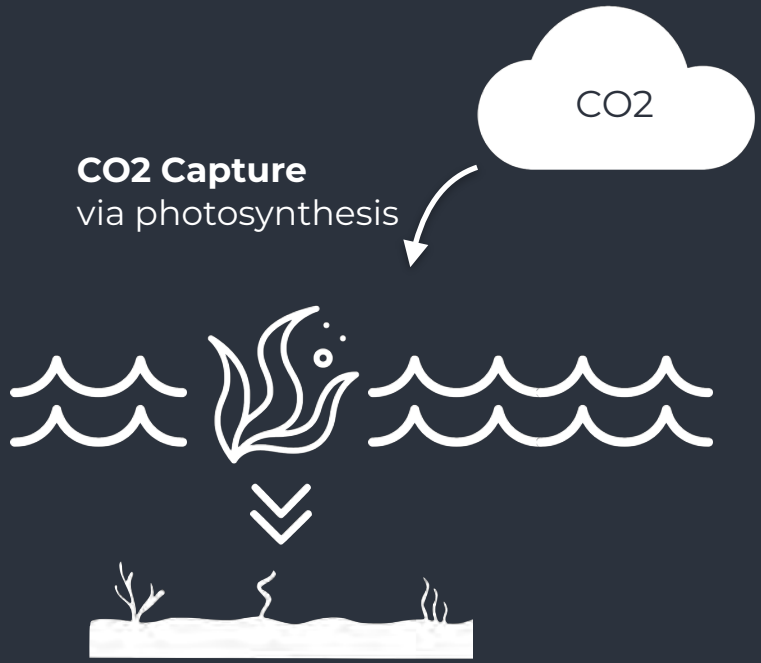
CHARM INDUSTRIAL

Charm uses plants to capture CO_2 from the atmosphere. Then they convert the biomass into a stable, carbon-rich liquid and then pump it deep underground.

Ocean Based Carbon Removal

CO2 Storage

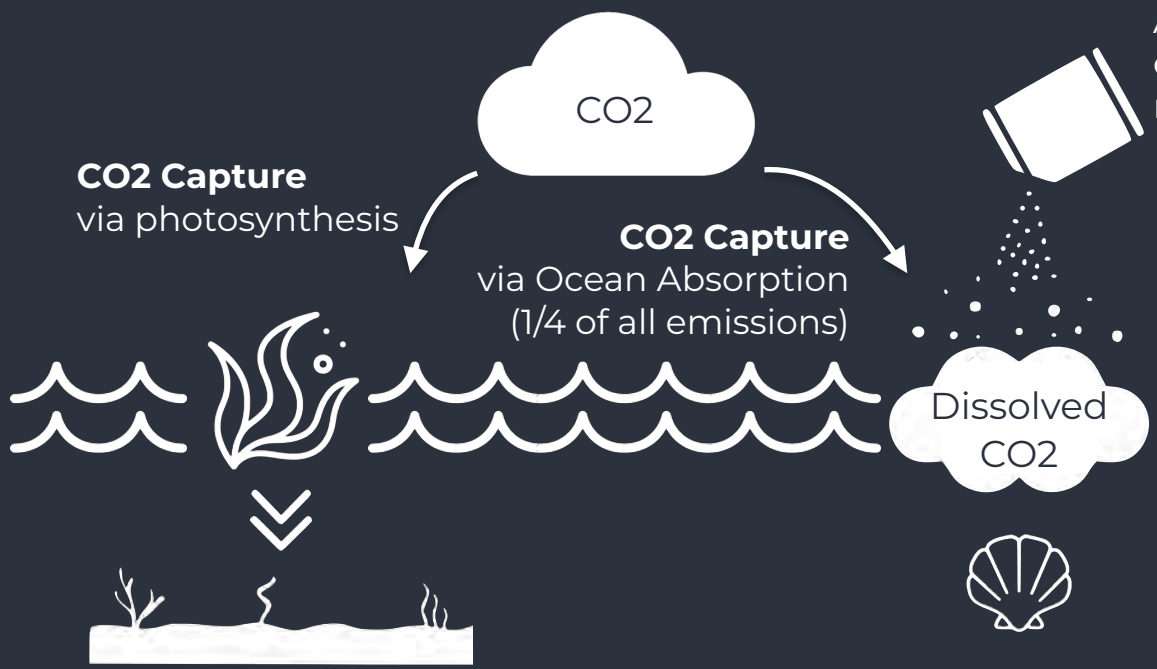
Ocean Based Carbon Removal



Seaweed Sinking
to the bottom of the ocean
1000? year permanence

CO2 Storage

Ocean Based Carbon Removal

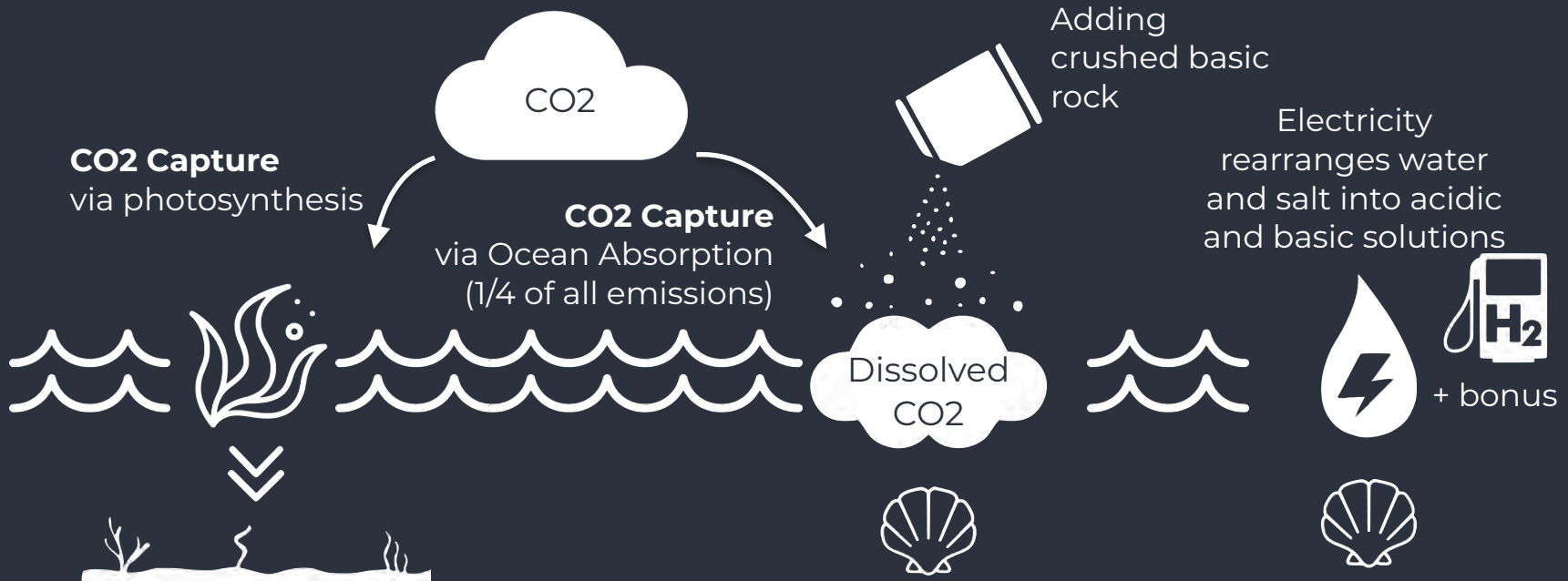


Seaweed Sinking
to the bottom of the ocean
1000? year permanence

Carbonate Formation
via Alkalinity Enhancement
1000 year permanence

CO2 Storage

Ocean Based Carbon Removal



CO2 Storage

Seaweed Sinking
to the bottom of the ocean
1000? year permanence

Carbonate Formation
via Alkalinity Enhancement
1000 year permanence

Carbonate Formation
via electrochemistry
1000 year permanence

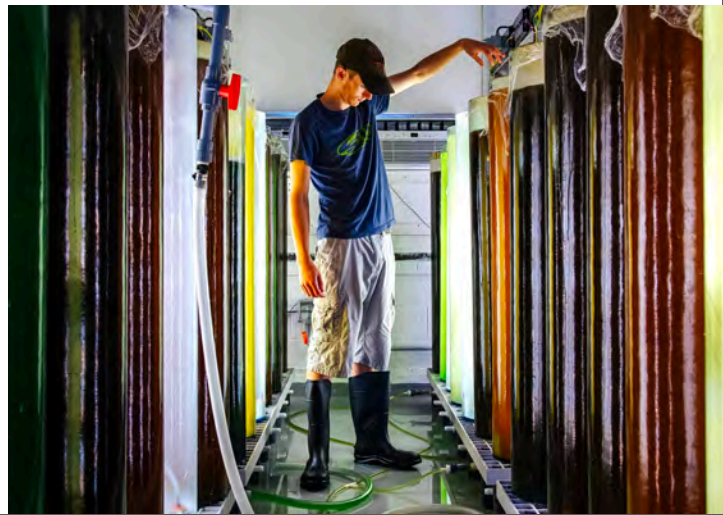
Ocean Based Carbon Removal

Type	Pros	Cons
Seaweed Sinking	Massive potential sink 1-10GT of CO2e/yr	Unintended ecology impacts, measurement risk
Ocean Alkalinity Enhancement	Low tech barrier, scalable, potential ecology co-benefits	Unintended ecology impacts, measurement risk
Electro-chemistry	Scalable, potential ecology co-benefits, secondary products	Unintended ecology impacts, measurement risk

Seaweed Sinking

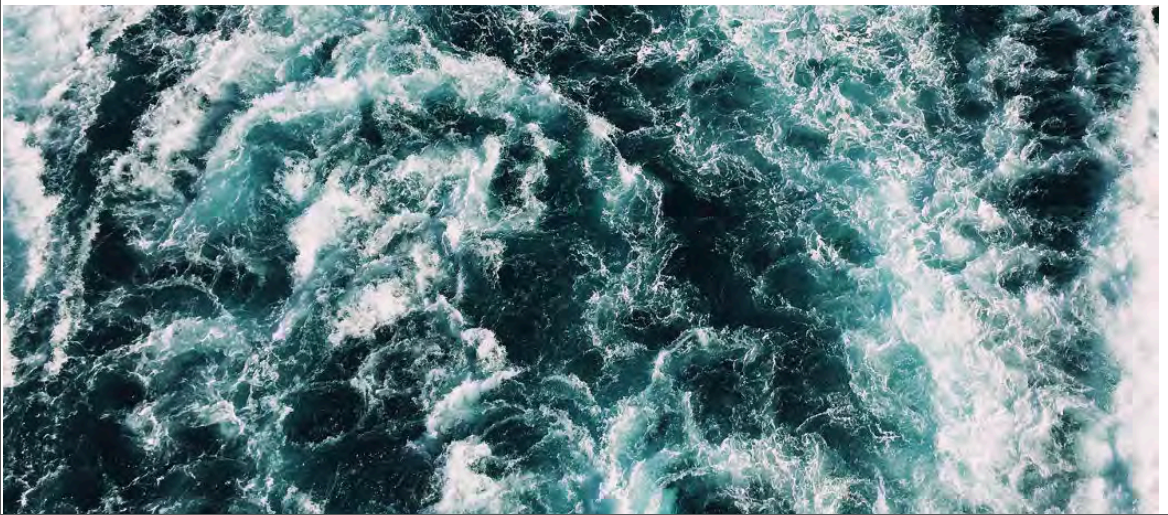
RUNNING TIDE

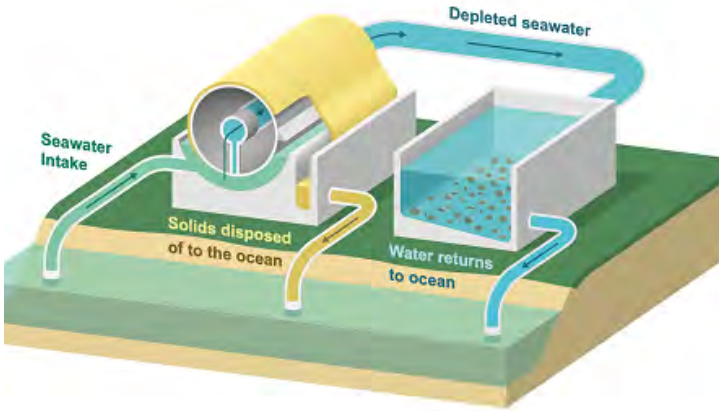
Running Tide creates biodegradable buoys grow kelp and after 3 months sink to the ocean floor to store the CO_2 for possibly millennia.



SEACHANGE

Seachange uses an electrochemical process to sequester CO_2 in seawater as carbonates, an inert material comparable to seashells, thereby enabling energy-efficient and permanent CO_2 removal.

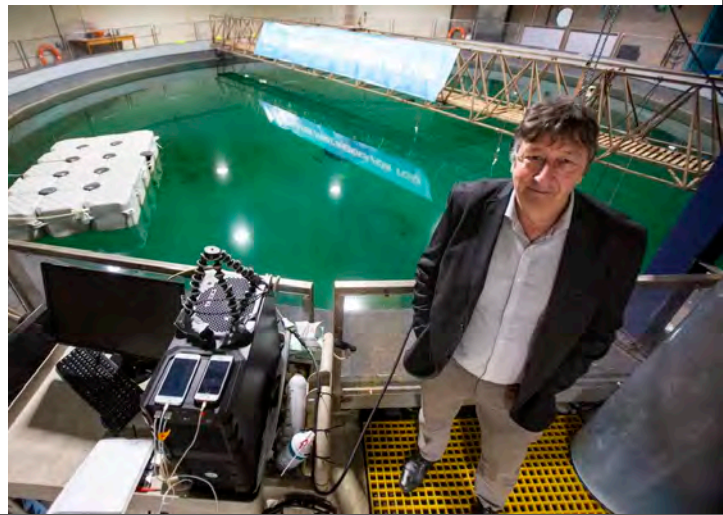




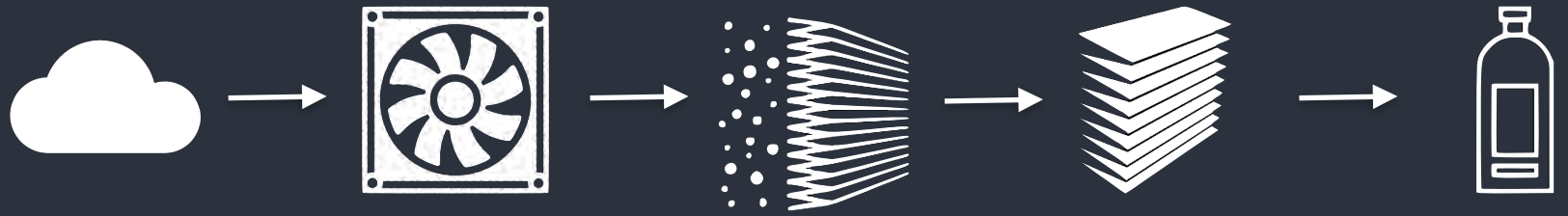
Ocean Alkalinity Enhancement

PLANETARY

Planetary Technologies uses basic rock waste from mining to sequester CO_2 in seawater as carbonates while simultaneously producing H2. They process the mining waste to ensure there are no toxins being adding it to the seawater.



Direct Air Capture - Carbon Capture



Ambient Air

Air intake
via fan

CO2 Capture
via a sorbent

CO2 Released
via heat, ph swing
or moisture swing

CO2 ready for
storage or use

NOTE: Direct Air Capture only captures, it does not store the carbon.

Direct Air Capture - Carbon Capture

Type	Pros	Cons
Centralized	Economies of scale, highly measurable, permanent storage options, US government will pay	Currently high $/ton, high infrastructure cost, storage partner required, limited location options
Modular	Deployable in more locations, highly measurable, permanent storage options, US government will pay	Currently high $/ton, storage partner required, transportation of CO2, maintenance of units is distributed

Centralized DAC

climeworks

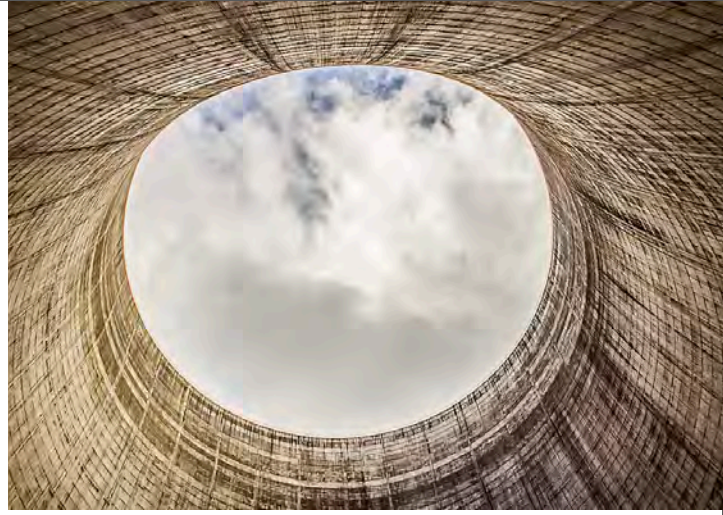
Carbon Engineering

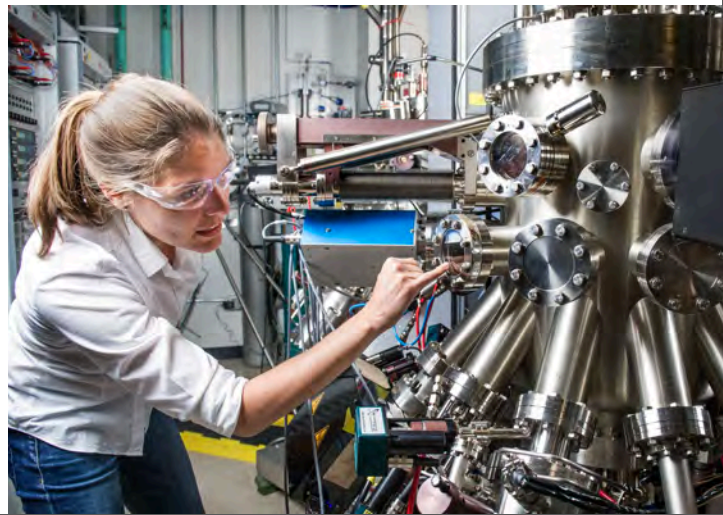
Both companies capture CO_2 from the air by building large plants with giant fan systems and sorbents. Their aim is to build facilities that can remove megatons of CO_2 per year.

Modular DAC

noya

Noya retrofits cooling towers to capture CO_2 and profit shares the carbon credits with the cooling tower owners. Their technology is far more distributed than centralized systems like Climeworks and Carbon Engineering.





Geologic Carbon Removal

Storage for CO2 captured another way

Captured CO2 via DAC

Carbonate Water

Pump into basic rock

Enhanced Rock Weathering

Crushed basic rock

Rainwater with CO2

CO2 Storage via carbonate formation
1000 year permanence

Geologic Carbon Removal

Type	Pros	Cons
Geologic Storage	High permanence, very large storage capacity, US government will pay	Requires specific geography, requires CO2 capture partner
Enhanced Weathering	High permanence, very large storage capacity, US government will pay, using managed materials	Requires sourcing material (from mines, demo sites, or concrete makers), requires CO2 capture partner

Geologic Storage

Carbfix 44.01

Both companies inject CO_2 + water underground into basic rock types that react and form carbonates over a few years.

Enhanced Weathering

carbin minerals

Carbin Minerals uses waste basic rock from mines and mixes it with CO2 rich water to form carbonates that stores carbon for thousands of years.

Product Based Carbon Removal

Captured CO2
via DAC

CO2 Storage via products
Permanence depends on product type

Product Options:
Detergents
Lenses
Diamonds
Car Parts
Concrete
Fabrics
Plastics
and more...

Product Based Carbon Removal

Pros	**Cons**
Makes it possible to manufacture products that would otherwise require CO_2 creation using emitting methods Can make products carbon negative	Not all products have high permanence Many are not considered removal (like fuels) because the CO_2 will be re-released when burned

Products

CarbonBuilt™

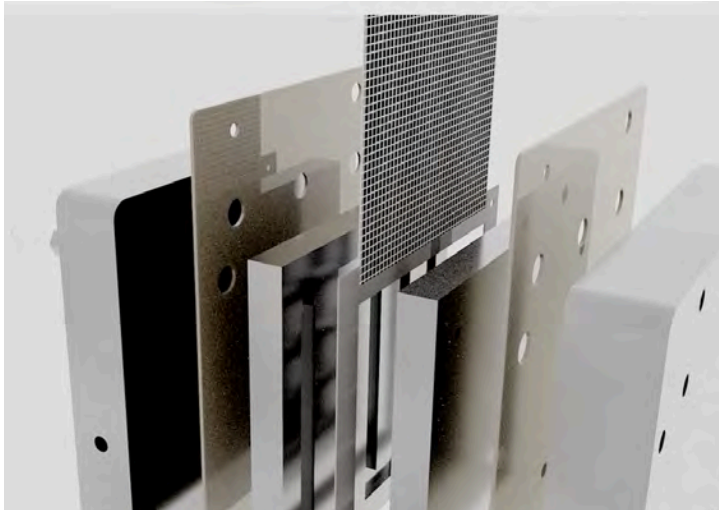
CARBON CURE™

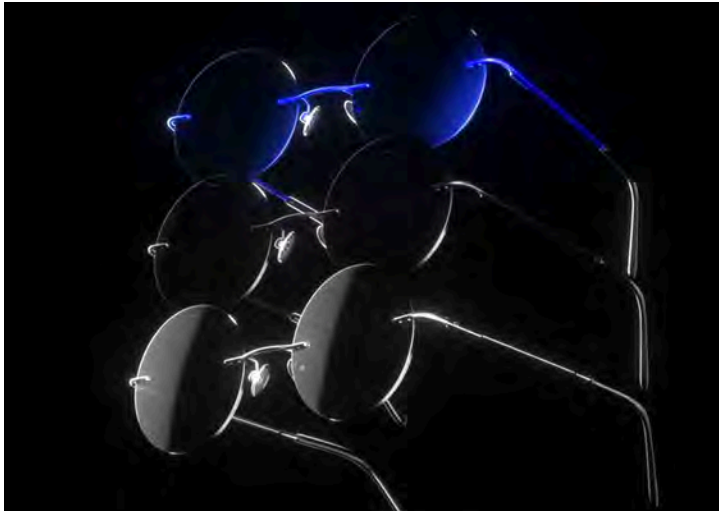
Both companies are injecting CO_2 into concrete during its production. The CO_2 mineralizes and is trapped for millennia timescale.

Products

twelve

Twelve is transforming CO2 into thousands of everyday products including glasses lenses, fuel, car parts, ethanol, and many other products.

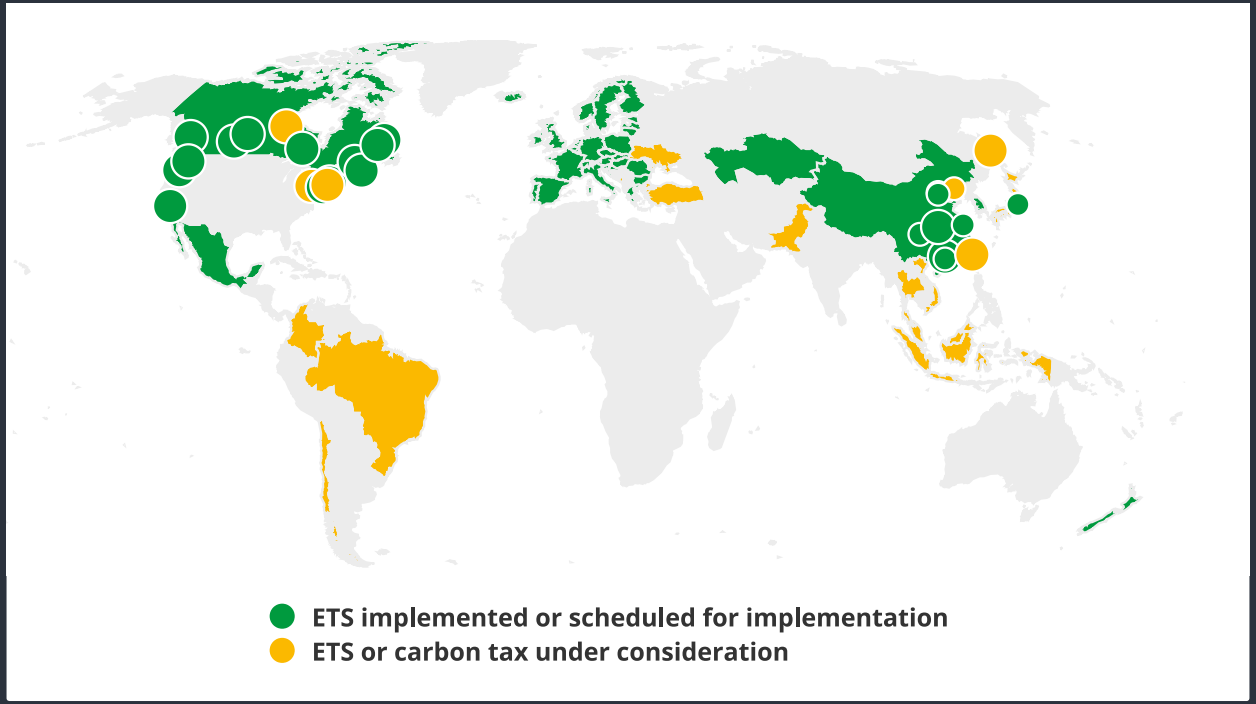




Voluntary Market - $1B in 2021

Soil Carbon <$50/ton	**Seaweed Sinking** $200-250/ton	**DAC - Modular + Geo** $500/ton
Forestry $20-100/ton	**Ocean Alkalinity Enhancement** $1000+/ton	**Enhanced Weathering** $200-300/ton
BioChar $100-500/ton	**Ocean Electrochemistry** $1600/ton	**Concrete Mineralization** $250/ton
BioOil $600/ton	**DAC - Centralized + Geo** $600-2000/ton	**Other Products** varies with permanence

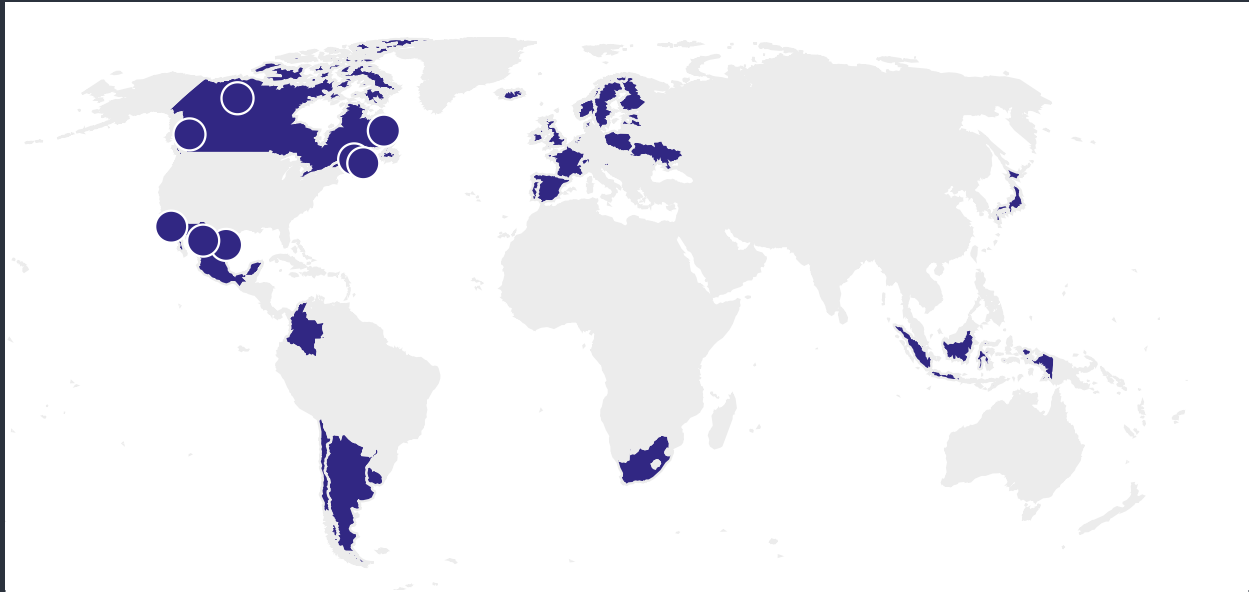
Mandatory Offset Market - $851B in 2021 Emissions Trading Schemes



https://carbonpricingdashboard.worldbank.org/map_data

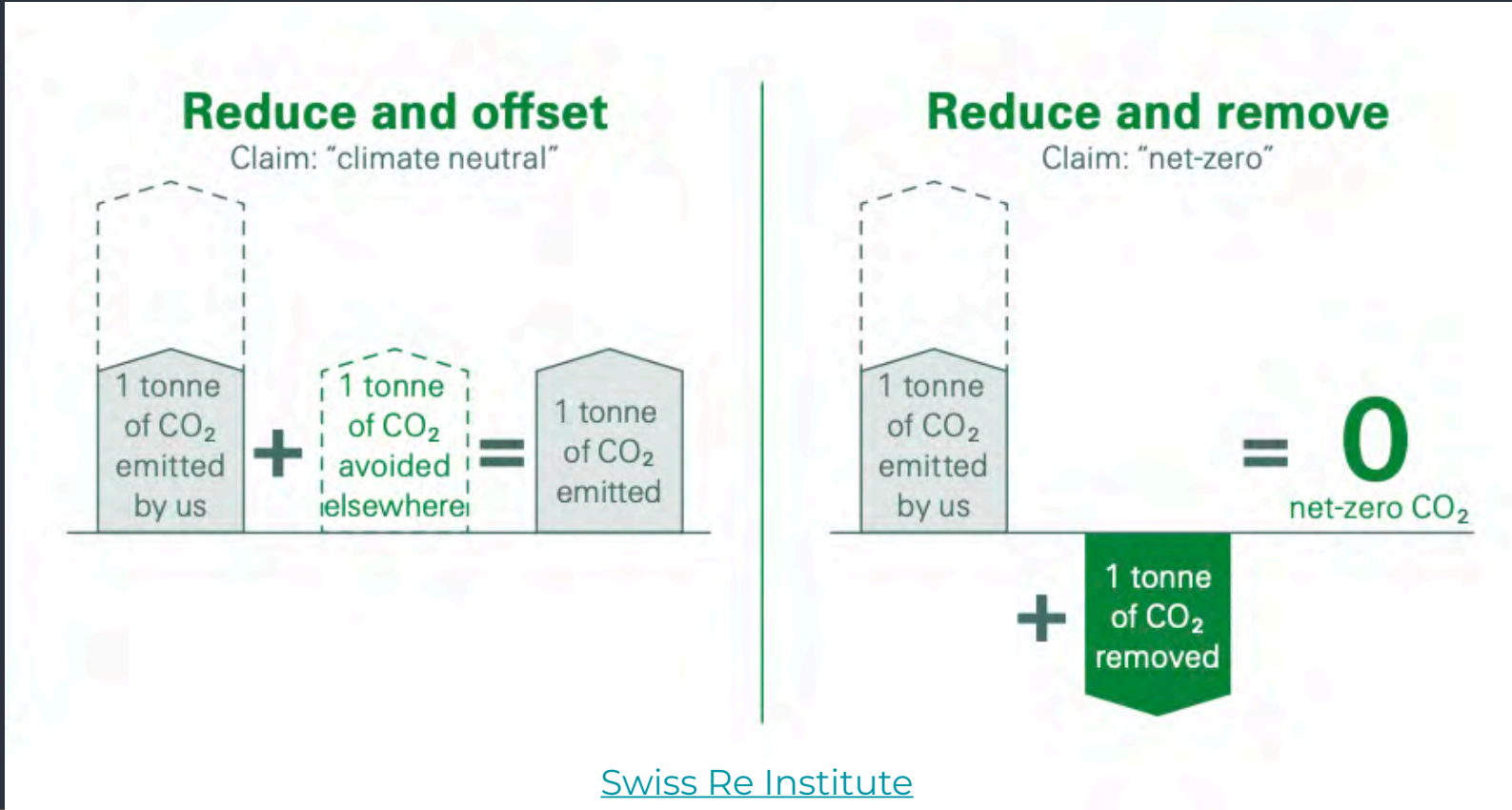
Mandatory Offset Market - $851B in 2021

Carbon Tax



https://carbonpricingdashboard.worldbank.org/map_data

Difference between Offsets and Removals



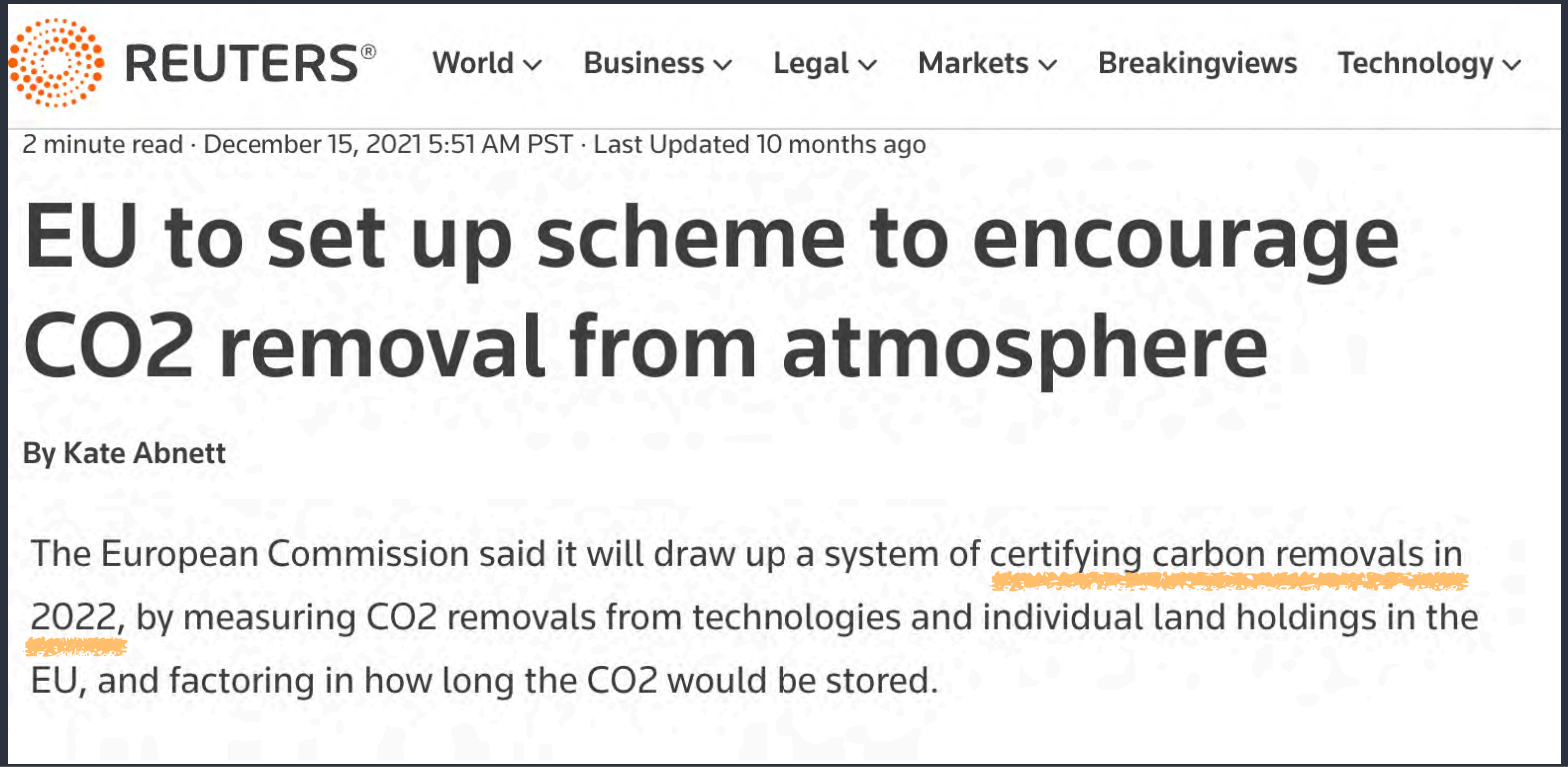
Swiss Re Institute

Mandatory Offset Markets

Carbon Credit Pricing by Type

Project Type:	Volume Sold (MtCO2e):	Average Price:	Price Range:
Wind	12.8	$1.9	$0.3 - $18
REDD+	11	$3.3	$0.8 - $20+
Landfill methane	7.9	$2	$0.2 - $19
Tree planting	3	$7.5	$2.2 - $20+
Clean cookstoves	3	$4.9	$2 - $20+
Run-of-river hydro	1.5	$1.4	$0.2 - $8
Water/purification	1.2	$3.8	$1.7 - $9
Improved forest management	0.8	$9.6	$2 - $17.5
Biomass/biochar	0.7	$3	$0.9 - $20+
Energy efficiency - industrial-focused	0.7	$4.1	$0.1 - $20
Biogas	0.6	$5.9	$1 - $20+
Energy efficiency - community-focused	0.6	$9.4	$3.3 - $20+
Transportation	0.5	$2.9	$2.2 - $6.8
Fuel switching	0.5	$11.4	$3.5 - $20+
Solar	0.3	$4.1	$1 - $9.8
Livestock methane	0.2	$7	$4 - $20+
Geothermal	0.1	$4	$2.5 - $8
Agro-forestry	0.1	$9.9	$9 - $11

Mandatory Markets Expand to Removals



REUTERS® World Business Legal Markets Breakingviews Technology

2 minute read · December 15, 2021 5:51 AM PST · Last Updated 10 months ago

EU to set up scheme to encourage CO2 removal from atmosphere

By Kate Abnett

The European Commission said it will draw up a system of certifying carbon removals in 2022, by measuring CO2 removals from technologies and individual land holdings in the EU, and factoring in how long the CO2 would be stored.

Mandatory Markets Expand to Removals

The EU has already created the basis for maintaining the distinction between removals and reductions by establishing a cap on the degree to which the EU climate goals will be fulfilled by removals before 2030 (225 $MtCO_2$)[2], and reaffirming the goal to reduce the consumption of fossil carbon energy by 95% (an absolute emission reduction) by 2050[3]. It has also committed to climate neutrality by 2050,

US Government Expands Support for Removals

Carbon Business Council

About Our Members Our Team Ethical Oath Policies News

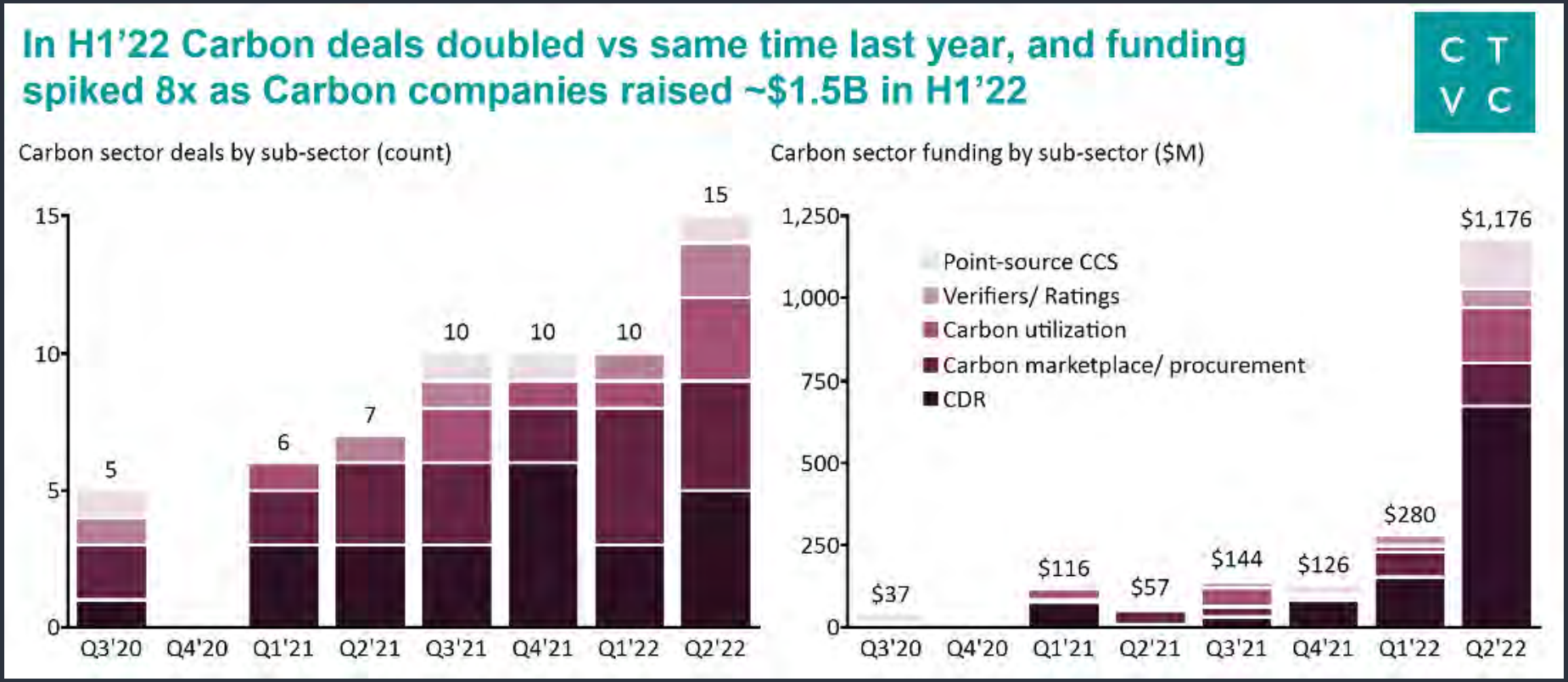
Carbon Removal Takes Major Step Forward

FOR IMMEDIATE RELEASE: August 16, 2022

The IRA increases 45Q tax incentives for carbon removal, from $50 a ton to $130 a ton for utilization and $180 for storage and direct air capture. The IRA also adds a direct pay option for 45Q and adjusts the size qualification, which streamlines the process for carbon removal companies and increases eligibility for startups. The IRA invests $20 billion in conservation programs at the U.S. Department of Agriculture, which can help advance carbon storage. The IRA provides billions of dollars in grants for the conservation and restoration of forests. The IRA's $5 billion appropriation to the Loan Program Office enables the office to issue guarantees on project loans up to $250 billion. The IRA is projected to reduce emissions by as much as 40% by 2030. IRA follows the passage of the CHIPS Act, which provides $1 billion in funding to carbon removal RD&D.

Is now the time to invest in carbon removal?

In H1'22 Carbon deals doubled vs same time last year, and funding spiked 8x as Carbon companies raised ~$1.5B in H1'22



CTVC 2022 Mid Year Update

CARBON REMOVAL PARTNERS	$50M Fund
LOWERCARBON CAPITAL	$350M Fund
Breakthrough Energy	$2B Fund
amazon	$2B Fund

Investment Factors

Climate Criteria	Permanence	How long are emissions removed from the atmosphere?
	Additionality	Would the emissions removal not have occurred otherwise?
	Leakage	What is the probability that removals activity could lead to shifting (e.g. deforestation increases in another location as a result of an afforestation project) with no net benefit resulting.
	Life Cycle Analysis	Does the method remove significantly more emissions than is emitted in the process?
	Verifiability	How is the company verifying emissions are actually removed?
Unintended Harms	Social/ Environmental Impacts	Are there unintended risks/stressors to people and the environment?
Co-Benefits	Environmental Justice	Has the local community consented to the development, implementation and maintenance? Are there environmental enhancements?
Scalability	Cost	$ / ton CO2e (now and in the future)
	Volume Potential	Are there scaling limitations? (land use, energy use, etc)

Closing Poll

https://www.menti.com/al8h1nq7fa1n

Thank you!
Questions?

Common objections

What if we are off in the number of GT of carbon removal we need? What if we need 100GT by 2050? What would the point be?

Opportunities in carbon removal

Genetic enhancement of crops

Measurement, verification, and reporting

Room temperature direct air capture

Resources

AirMiners Accelerator Launchpad: Launchpad.airminers.org

AirMiners Crash Course in Carbon Removal Boot Up: Bootup.airminers.org

Event Series Calendar: https://lu.ma/airminers

YouTube Channel: www.youtube.com/c/AirMiners

Carbon Dioxide Removal Primer: www.CDRPrimer.org

XPRIZE: https://www.xprize.org/prizes/elonmusk

Resources

Ocean Alkalinity Enhancement Explainer Video

Ocean Electrochemical Explainer Video