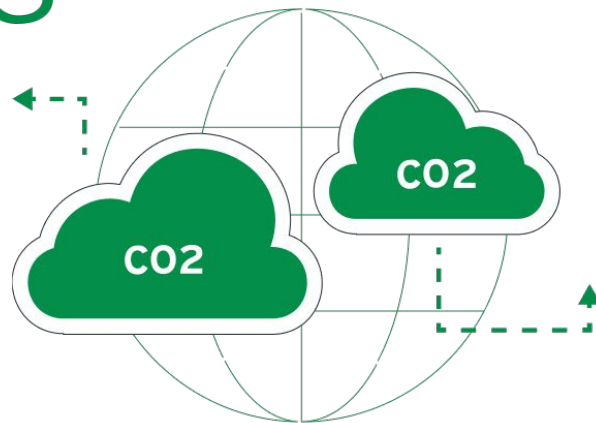


# AlliedOffsets

Carbon Dioxide Removal Report  
**Summer 2023**



# Who are we?



The world's **largest database of information** for the carbon offsetting industry.



The world's only provider of **keyword and table search** of over 5000 Project Design Documents that gives users instant access to over **65,000 project documents**.



The market's most comprehensive, **project-level pricing estimates** for carbon credits covering 99% of the global market.

# The Need for CDR

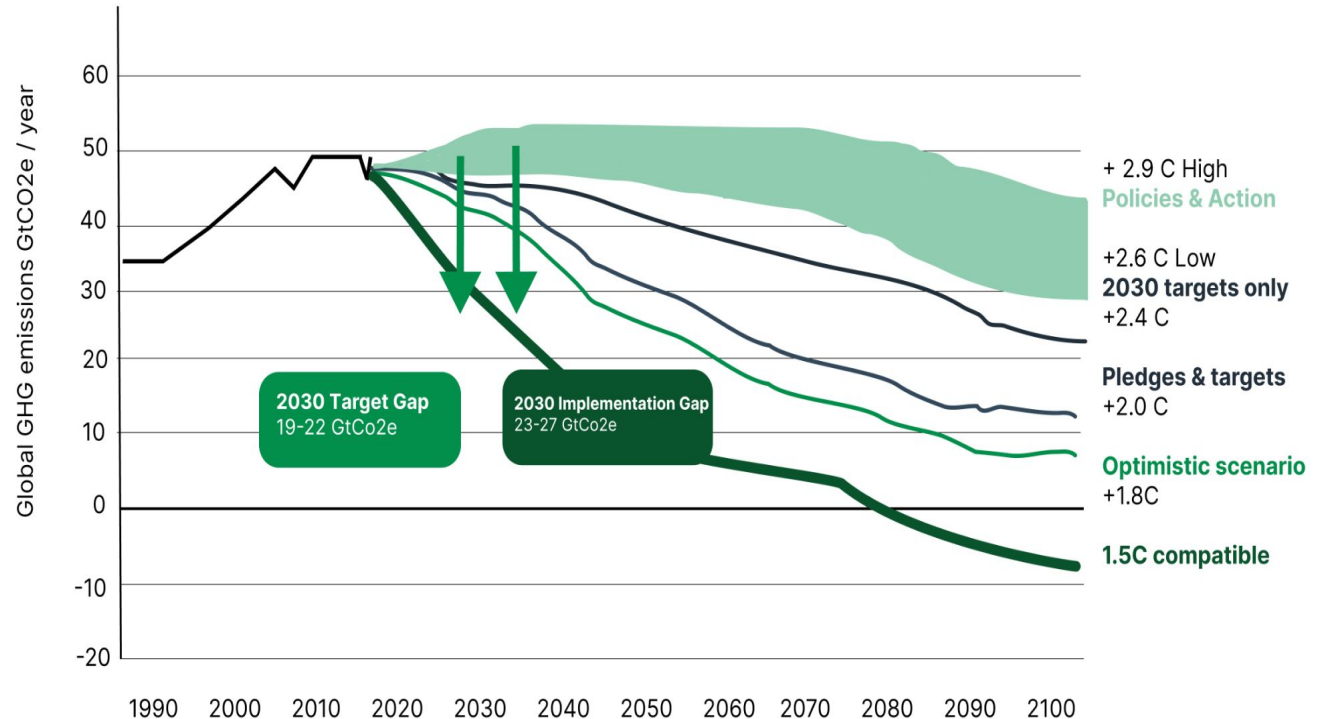
National Determined Contributions (NDCs) of greenhouse gas reductions are insufficient for 1.5C target.

Climate action tracker has taken the IPCC projections and shown a **19-23 GtCO<sub>2</sub>/ye** emissions gap every year after 2030. Therefore CDR needs to be scaled to quickly fill that gap.

## 2100 Warming Projections

Emissions and expected warming based on pledges and current policies

Warming projected by 2100  
Nov 22



# What we have done in CDR



We have **500 projects** in our CDR database and data on

8

## Resellers

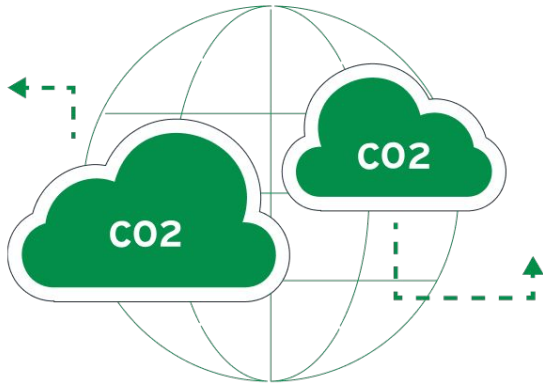
reselling credits from 65 different projects, with 101 transactions

87

## Different corporate buyers

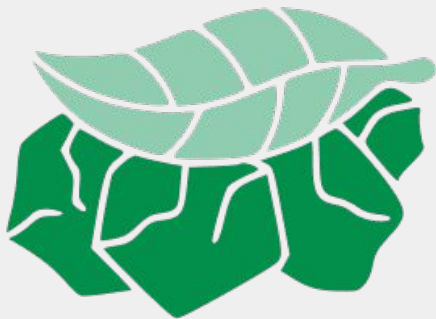
making 564 CDR project purchases, totalling at 3.8 million credits

# Technology Overview



# Biochar

[Biochar](#) is charcoal that is produced by heating organic material such as wood, crop residues or manure in a low-oxygen environment through pyrolysis.



- Potential residence time of 2000 years and sequestration potential of 1.8 - 4.8 GtCO<sub>2</sub>/y
- Over 60 industrial uses, most notably as a soil amendment and water filter.
- One of the only CDR technologies on the 17 registries in the VCM
- 30 projects registered on Puro.earth.

## AlliedOffsets Data

**Number of Projects:** 61

**Buyers:** Zurich, Priva Capital, Zendesk, Shopify, Microsoft, Klarna

**Sizable Project Locations:** USA (38%), UK (13%)

**Average Price per Credit:** \$250

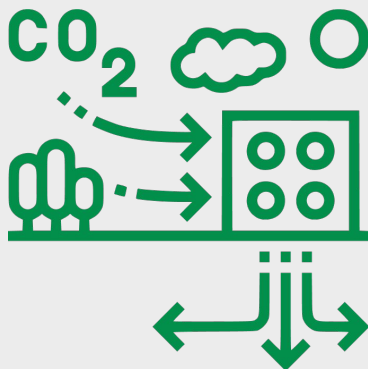
## Barriers to Scale

Biochar is considered to be the CDR technology with the **highest scalability potential** due to low finance and MRV requirements. With the caveat of **land** – biochar requires high amounts of biomass to be grown in order to create it.

# Direct Air Capture



[Direct Air Capture \(DAC\)](#) is a process that captures CO<sub>2</sub> directly from the atmosphere, and is typically coupled with carbon capture and storage to store the CO<sub>2</sub> deep within geological reservoirs.



- Estimated to sequester 60MtCO<sub>2</sub>/ye by 2030
- Today is at 0.01 MtCO<sub>2</sub>/ye.
- 19 plants in operation worldwide
- 2 Main types of DAC, that differ by physical CO<sub>2</sub> separation mechanism; Liquid-DAC, and Solid-DAC.

## AlliedOffsets Data

**Number of Projects:** 82

**Buyers:** Square, Microsoft, Priva Capital and Klarna  
**Sizeable Project Locations:** USA (47%), Canada (14%), UK (11%).

**Average Price per Credit:** \$886

## Barriers to Scale

DAC is one of the most expensive CDR technologies due to its infrastructure and energy costs. It takes up to 10GJ to capture 1tCO<sub>2</sub>.

# BECCS

Bioenergy and Carbon Capture and Storage (BECCS) creates energy out of biomass and sequesters CO<sub>2</sub> in 2 ways:

1. By avoiding using fossil fuels for our energy source which are geologically scaled (millions of years), and using biomass instead which is (on the scales of 10-50 years)
2. By using carbon capture and storage (CCS) storing carbon deep in the ground.
  - Estimated ~ 40 Mt CO<sub>2</sub>/yr by 2030



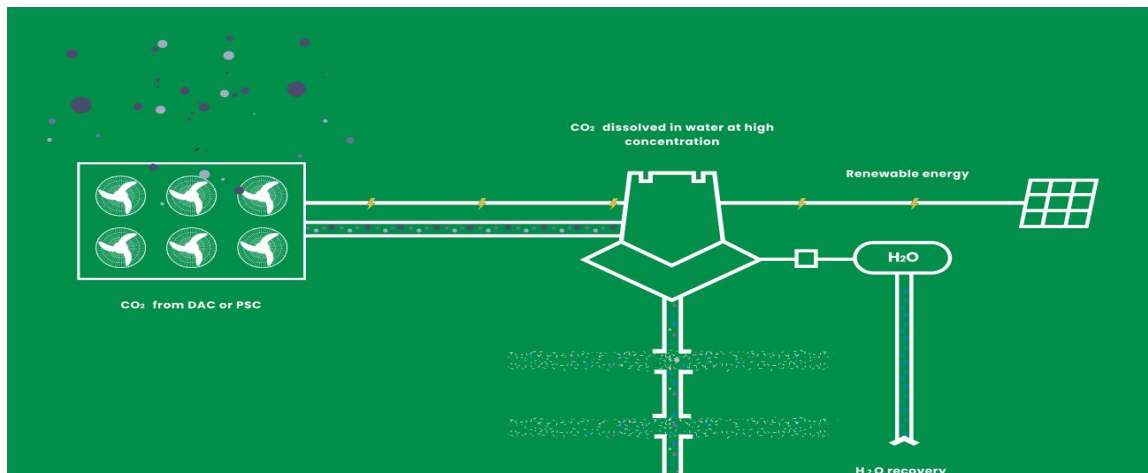
## AlliedOffsets Data

**Number of Projects:** 15

**Buyers:** Stripe

**Sizable Project Locations:** USA (64%), Sweden (14%)

**Average Price per Credit:** \$300



## Barriers to Scale

**Finance:** continuous infrastructure investment needed to scale

**Land:** Feedstock for BECCS competes with land that can be cultivated for food

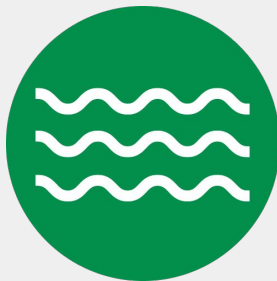


# Ocean Alkalinity Enhancement

[Ocean Alkalinity Enhancement \(OAE\)](#) is a process that involves adding alkaline substance such as crushed limestone or olivine to the ocean to increase its alkalinity. This:

1. Increases the amount of CO<sub>2</sub> that the ocean can store
2. Counteracts ocean acidification which will drastically affect marine life, that if killed off will significantly accelerate climate change.

Theoretically can sequester 1-15 MtCO<sub>2</sub>/year and is currently in small scale demonstration trials and tests.



## AlliedOffsets Data

**Number of Projects:** 4

**Buyers:** Shopify, Stripe

**Sizable Project Locations:** USA  
(100%)

**Average Price per Credit:** \$1750

## Barriers to Scale

**Knowledge Barriers:** OAE is one of the most uncertain technologies owing to the complexity of the ocean system, there is less scientific consensus owing to its technical immaturity.

# Enhanced Weathering and Mineralisation



Enhanced weathering and mineralisation captures and converts CO<sub>2</sub> into stable carbonate minerals.



There are two subtypes

1. **In-Situ:** CO<sub>2</sub> is captured, typically with DAC and diffused into fluids that are pumped to mineralise mafic rocks deep underground. Storage potential of millions of years.
2. **Enhanced Rock Weathering:** Ultramafic rocks are mechanically ground up, either freshly or from mine waste, exposed to CO<sub>2</sub> and utilised in concrete or spread out over agricultural land. 2-4 GtCO<sub>2</sub>/yr potential.

## AlliedOffsets Data

**Number of Projects:** 23

**Buyers:** Stripe, Frontier, Eden DAO, Klarna

**Sizable Project Locations:** USA (100%)

**Average Price per Credit**

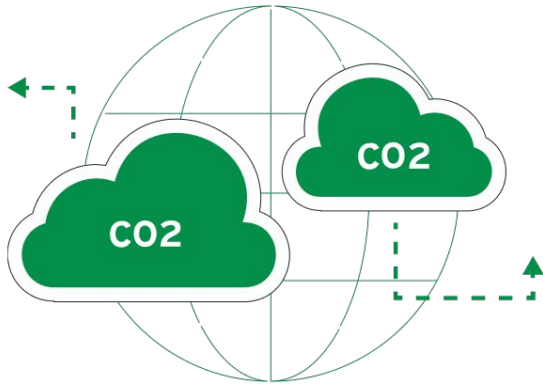
- In-Situ: \$280

- Ex-Situ: \$435

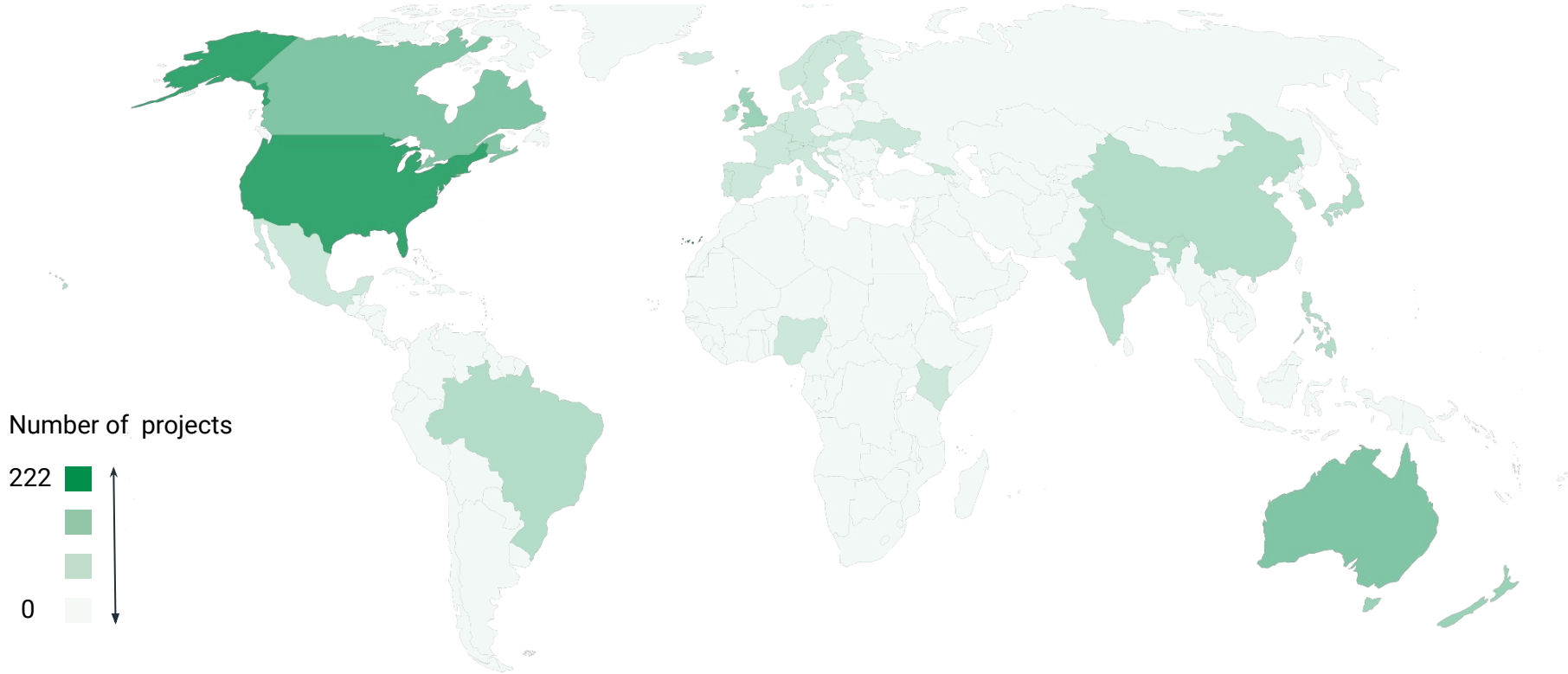
## Barriers to Scale

In-Situ: Government funding due to high upfront infrastructure costs. Ex-Situ: Commercial innovation; finding alternative markets to sell carbonised ultramafic rocks to decrease cost

# Data Overview



# CDR projects by region



# CDR projects by city

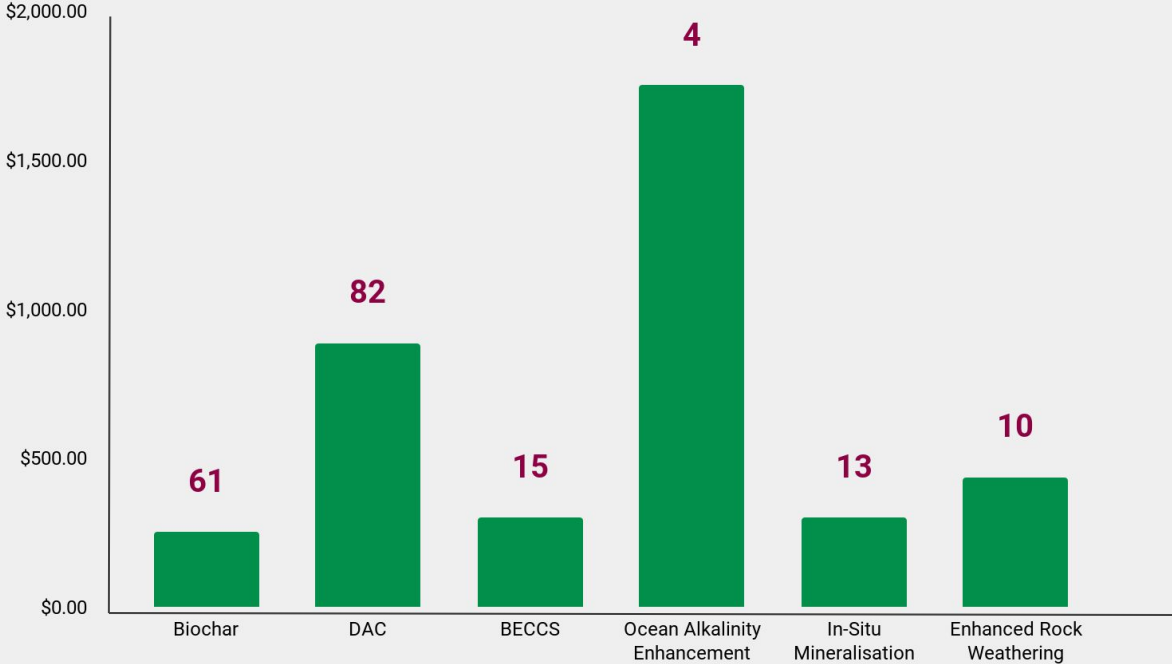


# Average Price by Methodology



Average price per tonne

■ Number of companies



*\*Although our database contains 500 projects, the number of projections depicted on this slide is less than 500. This is because the graph only includes the most powerful and scalable solutions, and certain methodologies like electrochemical ocean, carbon capture, or utilization are not represented here. These exclusions are intentional to highlight the most impactful solutions in this report.*

# Buyer Data



Methodology	Number of Different Buyers	Number of Credits	Number of total transactions
BECCS	3	2,760,000	3
DAC	48	491,000	112
Biochar	33	104,365	117
Ocean Alkalinity Enhancement	5	5,804	5
Enhanced Rock Weathering (Ex-Situ)	9	4,340	54
Enhanced Rock Weathering (In-Situ)	4	2,673	6

# Reseller Data - Which data is most popular?



Methodology	Number of Resold Projects	Average Resale Price \$/tCO2
Biochar	29	\$234
DAC	5	\$598
Ocean Alkalinity Enhancement	2	\$255
Enhanced Rock Weathering	8	\$264



Frontier is an Advanced Market Commitment (AMC) that is backed by 15 large corporations such as Alphabet, Shopify and Meta. **AMC's are designed to send a signal to researchers, entrepreneurs and investors that there is a growing market for new technologies** and that there are buyers that are willing to buy credits from these technologies at their initial price. This allows the technologies to drop their price through technological maturity and economies of scale putting them in a disposition to be adopted by the wider global market.

## How does it work?

Frontier prepurchases credits from early-stage piloting technologies, offering low-volume pre-purchase agreements to accelerate development. Suppliers receive funds upfront, before tons have been delivered.

The applications for these pre purchases operate in 6 month cohorts and can be viewed on [Frontier's website](#). **On average 23% of applications are successful with an average cohort size of 25 applicants out of the 5 cohorts. The most common successful technologies are DAC and ERW which compromise 34% and 30% of total successful applicants respectively.**

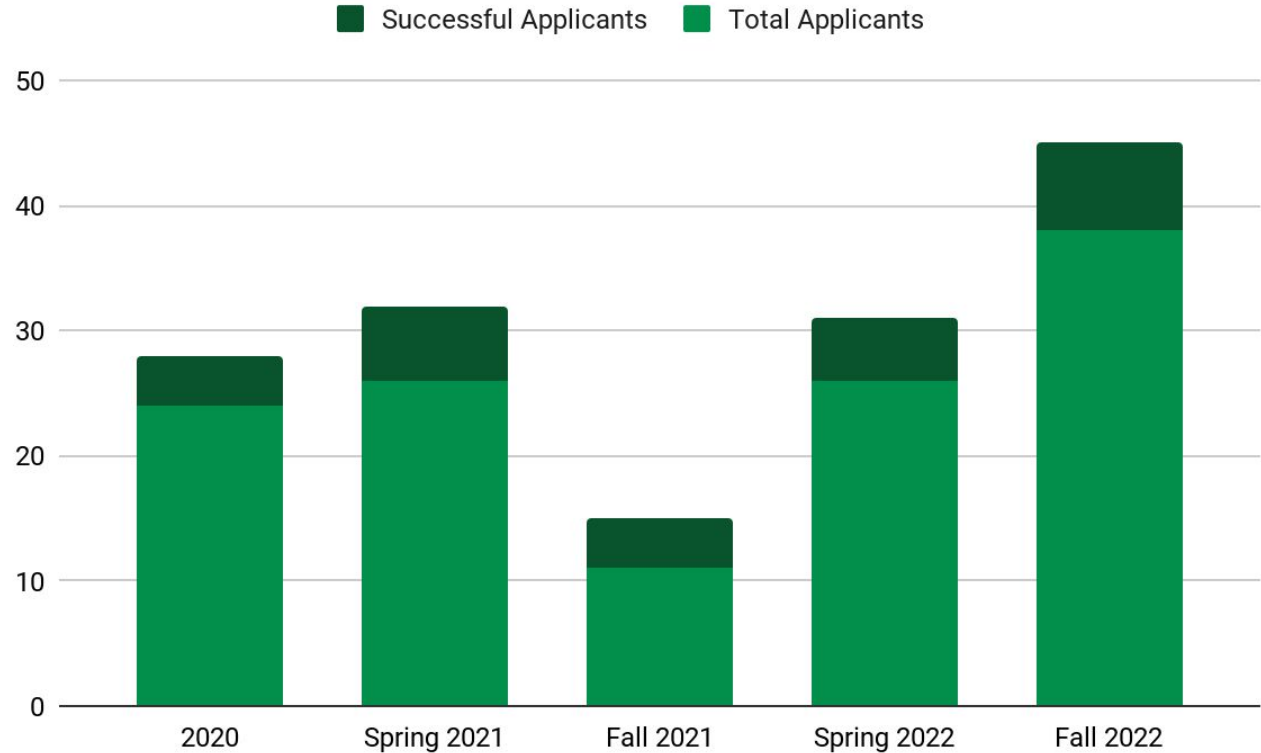
**The following section contains an overview of the cohort success to total applicant ratios and 3 case studies (Biochar, ERW and DAC), of applicants who have applied multiple times to frontier**, highlighting the difference in their delivery and price projections upon reapplication. The data from re-entry provides an overview of the CDR startup scene and outlines what we can expect from initial vs reworked projections of price and delivery velocity on tCO2/ye.

# Frontier Cohort Applications



**23%**  
Average success rate

**125**  
Total number of applicants



# Greensand, Enhanced Rock Weathering- Projections tCO<sub>2</sub>/ye (2020 - Spring 2021)



Greensand is an ERW company based in the Netherlands which has 2 product lines of olivine gravel sand. For the second application, Greensand realised that their market would be better for finer grained sand as they would have more buyers in the sand infill market. However, that change resulted in a price change of \$105 due to the energy required to grind the olivine to a finer grade.

Greensand is currently seeking a more suitable product market fit to optimize its operations. The process of grinding ERW, although highly effective, incurs significant expenses. To counterbalance these high costs, Greensand recognises the need for innovative commercial solutions, rather than relying solely on technological advancements, as reducing costs through technology alone is not the most readily achievable approach for this particular technology.

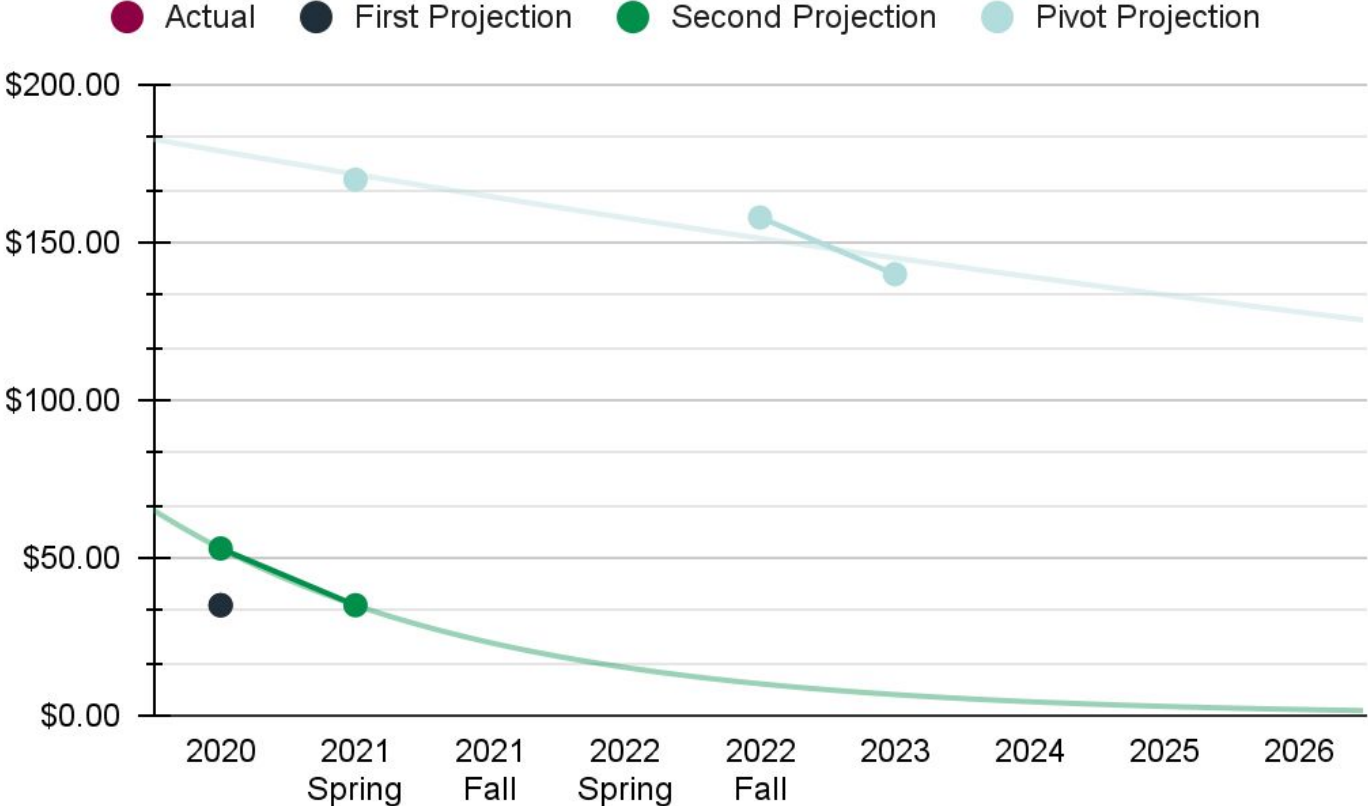
## 1. 0-4mm grade olivine sand

- Expected Price: \$35/tCO<sub>2</sub>
- Applications: Olivine as road or railside gravel or sand

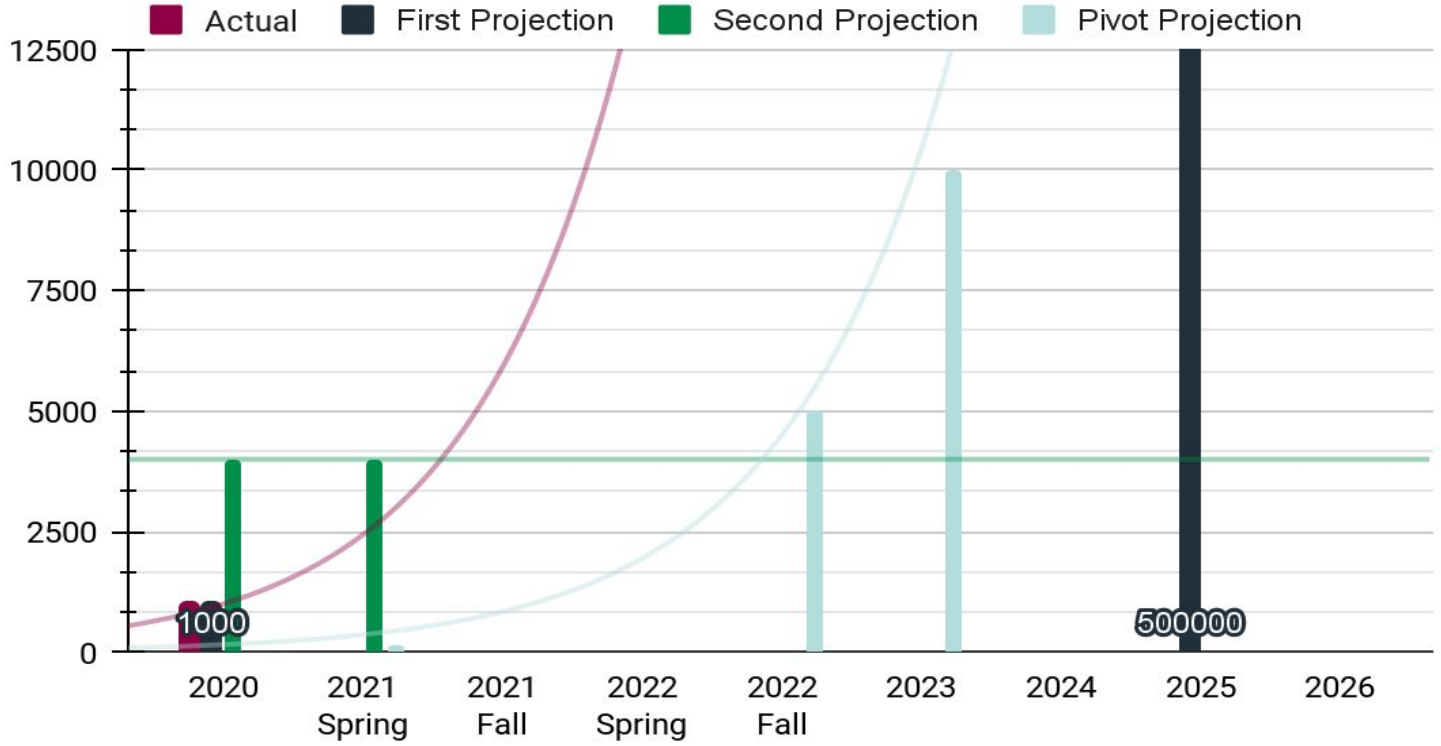
## 2. 180 - 800 mu sand

- Expected Price: \$140/tCO<sub>2</sub>
- Applications: Sand infill for sports grounds

# Greensand, Enhanced Rock Weathering - Price (2020 - Spring 2021)



# Greensand, Enhanced Rock Weathering - Projections tCO2/ye (2020 - Spring 2021)



# Carbonfex, Biochar - Projections tCO<sub>2</sub>/ye (2020 - Spring 2021)

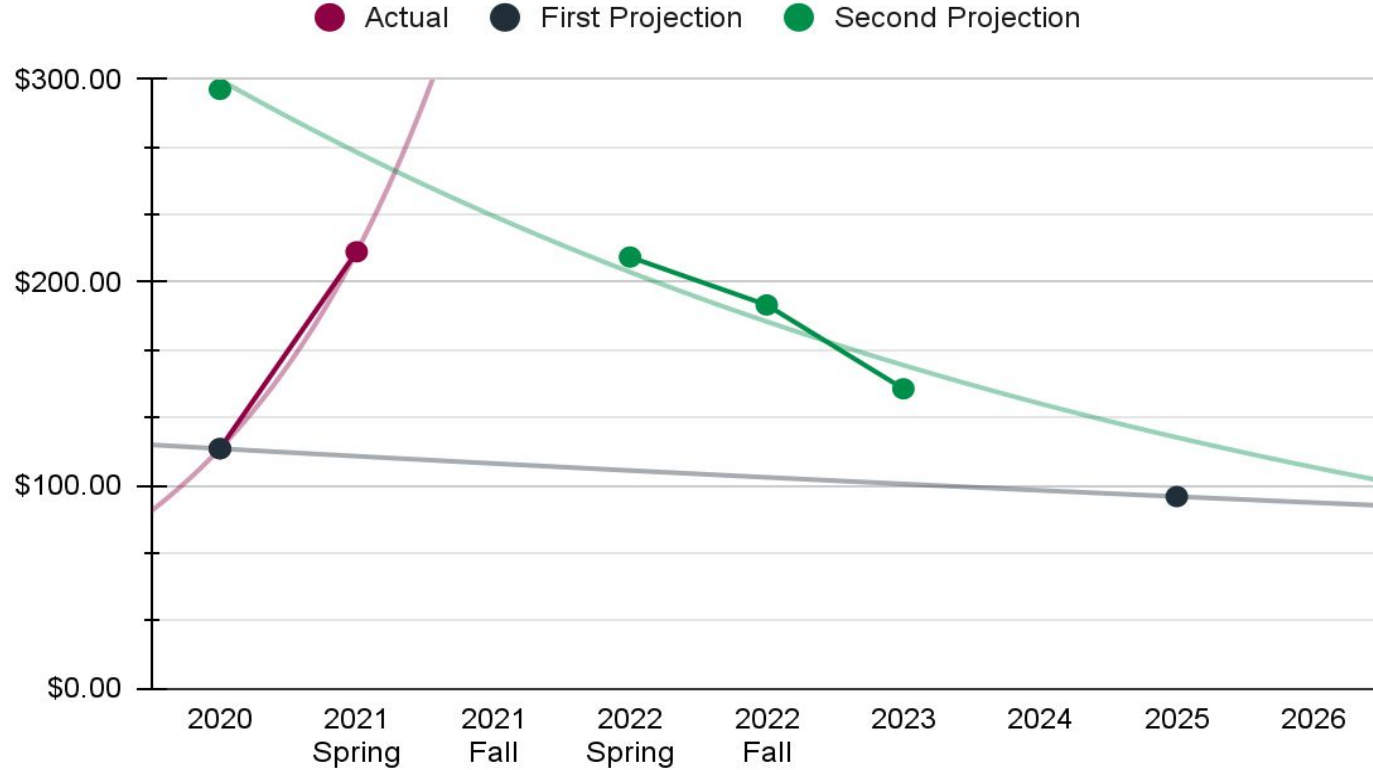


Carbonfex is a biochar company based in Finland, they are primarily using biochar in water treatment, stopping eutrophication by removing phosphorus and nitrogen from various agricultural and industrial effluents. The biochar is then being loaded and recycled into agriculture to improve food and water security.

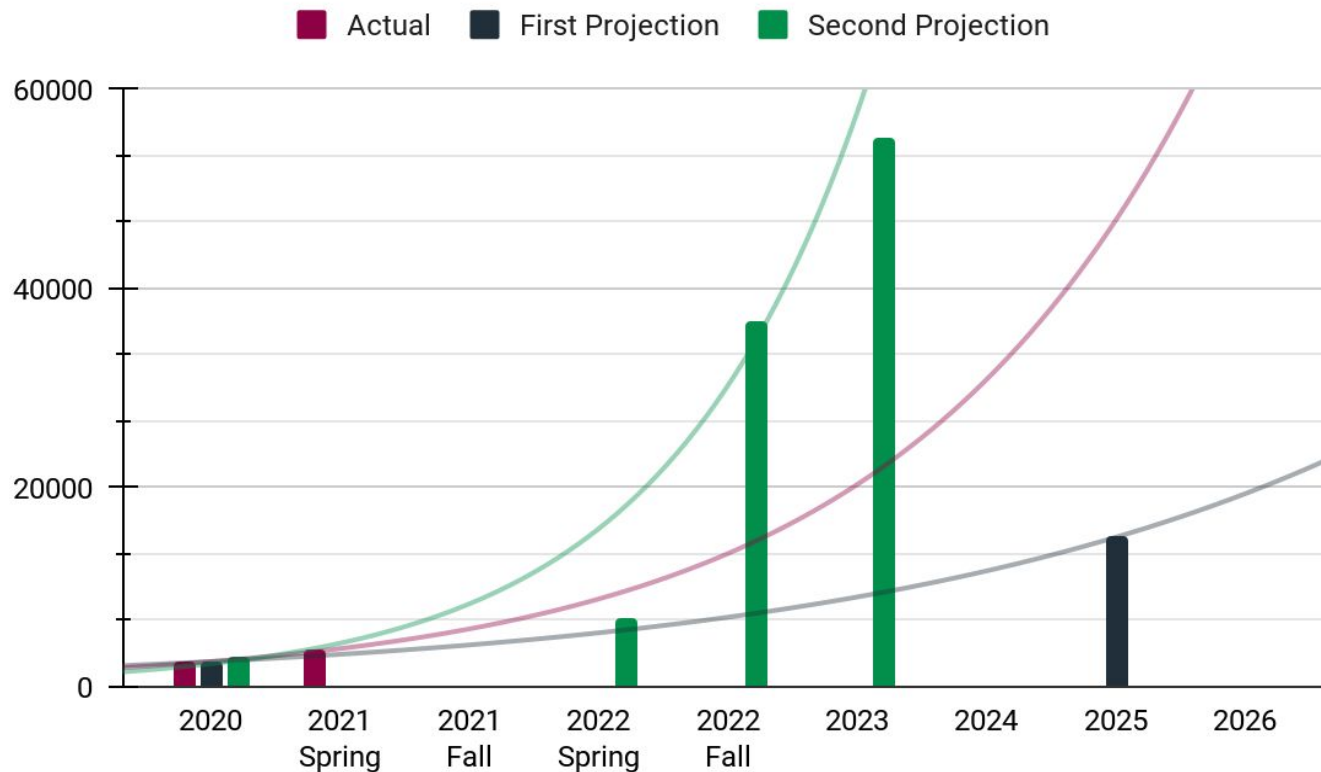
What we can see from the price and delivery curves is that Carbonfex has gone from an optimistic cost in their 2020 application and redrafted that in 2021 giving a higher and more conservative cost considering more research into the development of their pyrolysis technology.

Carbonfex has also increased their predicted delivery indicating that their technology has become more efficient.

# Carbonfex, Biochar - Price (2020 - Spring 2021)



# Carbonfex, Biochar - Projections tCO2/ye (2020-Spring 2021)





# Noya, Direct Air Capture - Projections tCO<sub>2</sub>/ye (Fall 2021 - Fall 2022)



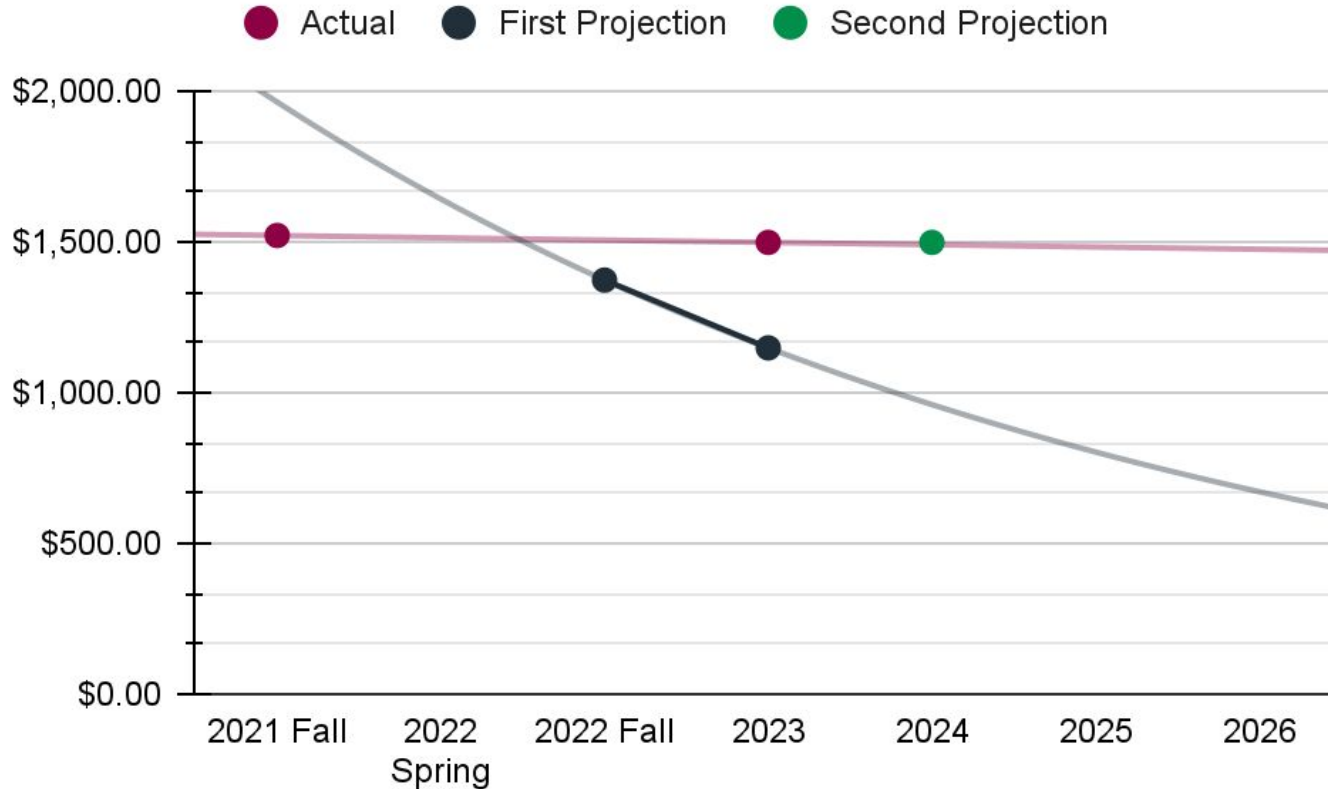
Noya is a US based company working on retrofitting industrial equipment such as cooling towers into DAC plants.

In terms of price, Frontier in Fall 2022 has stopped asking for price dropping projections and asked for levelised prices. However it would be most probable that Noya will continue to drop price similar to its first price projection in 2021.

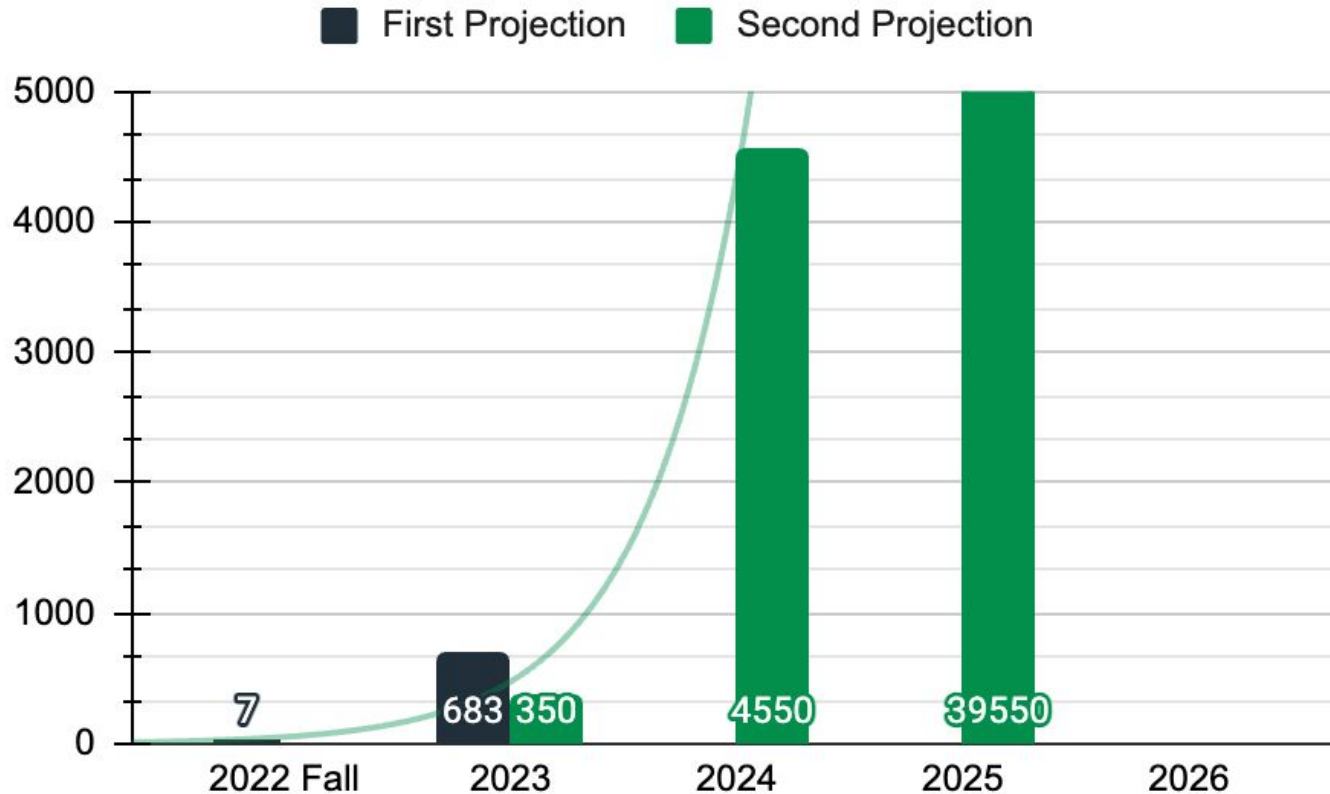
Noya's first projections in 2021 were focussed on the credits that would be created from testing the feasibility of their technology with 7 credits in 2020 and 683 in 2021.

In the second delivery projection, the scale of operations increases exponentially compared to the first set of projections, indicating a refinement in the R&D costs.

# Noya, Direct Air Capture - Price (2020-Spring 2021)



# Noya, Direct Air Capture - Projections tCO2/ye (Fall 2021 - Fall 2022)



# Overall trends



The case study trends show that initial projections for price/tCO<sub>2</sub> of many CDR projects are optimistic and too low. Secondary projections of price/tCO<sub>2</sub> indicate that initial costs are higher but fall below initial projections within a few years due to scaling. Delivery velocity for CDR projects see a drastic increase in secondary projection from their primary estimations. Showing at minimum a 2 fold increase from initial projections.

For Noya (DAC) and CarbonFex (Biochar) both developers project increases in price and delivery velocity in their second application. These prices are higher but see a stronger negative slope which falls under the first projected price while delivery velocity sees a much higher exponential slope than the initial application. This is possibly explained by either increase in R&D over the 6 months period and reassessing price for initial costs, or more economic scalability studies have been done by developers suggesting higher upfront costs in equipment cause scale which can offset costs faster with economies of scale and learning with higher delivery rates.

For Greensand (ERW) this trend is matched for delivery for similar reasons, price however does not match the trend because of the pivot in product market fit.

Commercial innovation for ERW is not uncommon as the mining and grinding of the minerals is extremely expensive and they need to find adequate markets to pay for the material to drop the cost. Additionally creating smaller grain size sand is more costly but sequesters carbon at a faster pace.

# Report Summary



According to data by the [IPCC and climate action tracker](#), even if we were to follow the most optimum reduction policy scenarios and pledges we will not meet the 1.5 degree target by 2050.

**The development of a CDR industry is critical to close the 19-23 GtCO<sub>2</sub>/ye emissions gap from 2030 to reach this target.**

Five of the most promising technologies are biochar, DAC, BECCS, Ocean Alkalinity Enhancement and mineralisation (Enhanced Rock Weathering (ERW)). The highest volume of companies in the VCM are DAC (82) and biochar (62), with average prices of \$886/tCO<sub>2</sub> and \$250/tCO<sub>2</sub> respectively.

Frontier, an advanced market commitment initiative has pre purchased credits from 26 CDR projects to date and has an application success rate of 23% and average cohort size 25 has funded mostly DAC (9) and ERW (8) projects.

Data from Frontier's reapplicants show trends that project developers tend to have optimistic low prices and relatively low delivery velocity for their initial projection. Under reapplication, developers have changed those to higher initial prices with stronger negative slopes but with higher delivery velocity. Indicating that companies are looking at higher upfront costs to scale to a critical mass where they can receive those economies of scale which increase delivery velocity and drop prices.

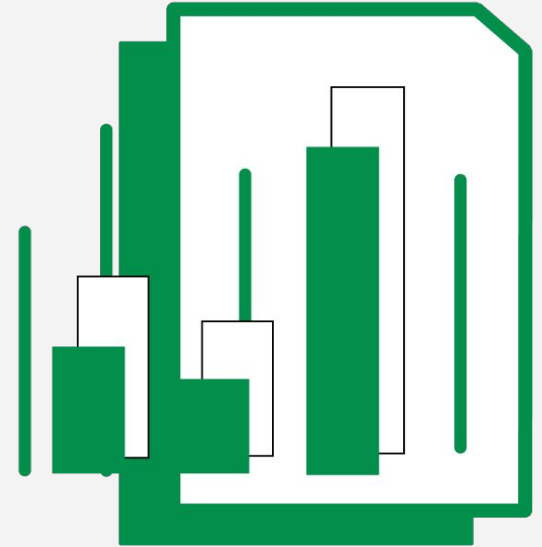
Want to learn more about the CDR market?



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# Data sources

- [Climate Action Tracker data](#)
- [AlliedOffsets DataBase](#)
- [Stripe & Frontier Removal Applications](#)
- [CDR.FYI](#)

