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23

CIRCULAR CARBON MARKET REPORT

2023 Analysis



Circular Carbon Network
AN XPRIZE INITIATIVE

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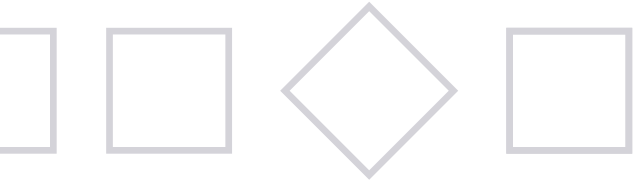
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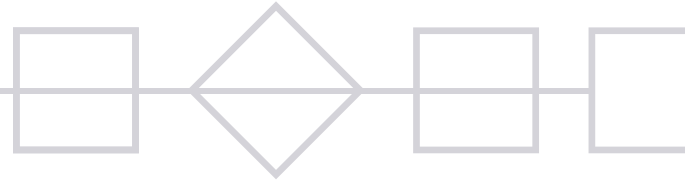
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EXECUTIVE **SUMMARY**

EXECUTIVE SUMMARY



According to the Intergovernmental Panel on Climate Change ([IPCC](#)) estimates, the world will need to remove multiple gigatonnes of carbon dioxide from the atmosphere annually by 2050 in order to effectively curb the impacts of climate change. Doing so will require rapidly scaling the Circular Carbon industry.

To date, Circular Carbon companies have cumulatively raised \$25.4B USD. While 2023 was a challenging year for capital markets, including the first decline in Climate Tech since 2021, investment into the Circular Carbon sector grew \$370M in 2023, with a total of \$8B in closed deals. This private sector activity was boosted by the recent robust support of the public sector through programs like the Inflation Reduction Act.

The Circular Carbon Network (CCN) Innovator Index, which now includes data on nearly 1,000 companies, showed steady growth across all cohorts. Later stage companies were responsible for just over half of the \$8B raised in 2023, but companies founded since 2021 still represented \$2B of capital raised last year. Carbon removal companies led the way on many metrics, including total capital raised (73%), number of companies founded, and reported revenue in 2023. In fact, early stage carbon removal companies raised 13% of all capital reported within the larger [Climate Tech sector](#) in 2023 and Boston Consulting Group recently estimated the market for durable carbon removal alone could reach [\\$10B - \\$40B](#) by 2030.

As you will see throughout this report, the Circular Carbon industry is showing many encouraging signs of growth. CCN and XPRIZE remain committed to tracking this data and collaborating with companies, investors, and ecosystem stakeholders to improve the analysis and disseminate the findings widely. The urgency of the climate crisis will require exponential growth of Circular Carbon companies in record time, and it will take unprecedented levels of collaboration and capital to get there and build this new industry responsibly, from the ground up.



INTRODUCTION

INTRODUCTION

ABOUT CCN

The Circular Carbon Network (CCN) is a nonprofit initiative of XPRIZE that has been collecting primary market data within the Circular Carbon economy since 2018. CCN's goal is to help accelerate the sector's growth and realize its full economic and climate potential. Our open-sourced data facilitates informed action between innovators and capital providers. The purpose of this annual report is to analyze the annual investment and growth trends within the Circular Carbon industry, inclusive of carbon removal, carbon conversion, point source capture, and market infrastructure companies.

Through our data, we catalyze action by helping:

- ▶ Investors find Circular Carbon companies that fit their thesis
- ▶ Entrepreneurs feature their company to an investor audience
- ▶ Corporates identify potential startup innovation partners
- ▶ Inspire collaboration between supporting catalyst organizations and innovators

The sector that we cover in the CCN indexes is defined by the term "Circular Carbon," a vertical we break down to four main categories: Carbon Removal, Carbon Conversion, Point Source Capture, and Circular Carbon Market Infrastructure (CCMI).

It is important to highlight that we do not cover emission reduction or mitigation solutions, renewable energy, electric vehicles, or digital infrastructure for emissions reduction. Therefore, this report represents a view into a highly focused emergent market, one that can sometimes become engulfed within the larger Climate Tech and carbon narratives of other market reports and analyses.

Our methodology defines Circular Carbon companies as those that are directly removing carbon from the air or ocean, capturing it straight from the source, making valuable products from reused carbon, or supplying the essential infrastructure for these activities. In brief, we define these categories in the following ways:

Carbon Removal: Carbon Removal includes approaches that result in removal of carbon dioxide (CO₂) from the atmosphere.

Carbon Conversion: technologies that convert captured carbon oxides into economically valuable products such as chemicals, fuels, building materials, plastics, and bioproducts.

Point Source Capture: technologies allowing a large emissions source to capture and divert CO₂, preventing it from being emitted into the atmosphere.

Circular Carbon Market Infrastructure (CCMI): companies that provide essential and direct support to Circular Carbon companies and the Circular Carbon ecosystem. Within Infrastructure companies there can be significant overlap between service types, and additionally, other types of solution providers often also provide a type of CCMI.

For full definitions and examples of solution types, see the [Definitions](#) section.

DATA COLLECTION & ANALYSIS METHODOLOGY

Origin and Evolution of the Indexes

While the CCN databases were originally built in 2019 with a focus on carbon capture and utilization during the NRG COSIA Carbon XPRIZE, we have expanded our focus to include carbon removal since the launch of the XPRIZE Carbon Removal in 2021. Thus, among other sources, this report includes data on the 287 qualified competitors from the [Milestone Round of the XPRIZE Carbon Removal](#) conducted in 2022. As part of this expansion, some of the data taxonomy has been updated, including adding new carbon removal pathways, product categories, process types, and more. We believe this expanded effort provides a uniquely detailed resource to the marketplace.

Collection Methods

This report represents the data collected through the Circular Carbon Network by multiple methods.

1 | Data is self-reported by market participants through surveys in response to our direct outreach, and that information is verified and approved by our data team for index fit.

2 | We perform internal quantitative and qualitative research from publicly available information on innovators, deals, and capital providers, including information from [Crunchbase](#). This data is added to the index directly by our team.

3 | We work with other industry partners in a cross-sharing of market data that is relevant to our indexes and useful to their catalytic activities in the space.

Limitations

We also recognize the limitations of our analysis. While we have supplemented self-reported data with publicly available research where possible, undoubtedly, not every company active in the space is included. There are also analytical approaches to consider when reading through the data, including:

➤ **Data Coverage:** Since not all questions are completed by each innovator, there might be a coverage gap for each analysis point. When applicable, we display this number with the respective chart as “Data Coverage %”.

➤ **Overlapping Data:** A quarter (253) of index respondents chose to select more than one solution type (see [Definitions](#)). In instances where the solution type is used to classify the context of another data point, both of the categories are represented with that data point. For example, a theoretical company that does both point source capture and carbon conversion that has raised a \$30M round will be represented within both the point source capture column and carbon conversion. We believe this provides a more accurate representation of each of the sector verticals. Note that this method was not used to sum any data points.

Please note that the information contained in this report is for informational purposes only and is not intended to be, nor should it be construed or used as, investment, tax, or legal advice. CCN does not provide services as an investment advisor, investment analyst, broker-dealer, market-maker, investment banker, or underwriter.

The Circular Carbon Network is not a commercial data research service but a market catalytic, nonprofit initiative that relies on collaboration, data sharing, and direct outreach and surveys to improve the depth and richness of our indexes.

WE HOPE YOU FIND THIS DATA AND OUR ANALYSIS, SUMMARIZED IN THIS REPORT, TO BE USEFUL.

JOIN THE NETWORK

- [Submit a company and/or deal](#) to the Innovator Index
- [Join our network](#)
- Explore the [Innovator Index](#)
- [Contact us](#), if there is something else we can help you with
- Access the [Deal Hub](#) (for Accredited Investors)

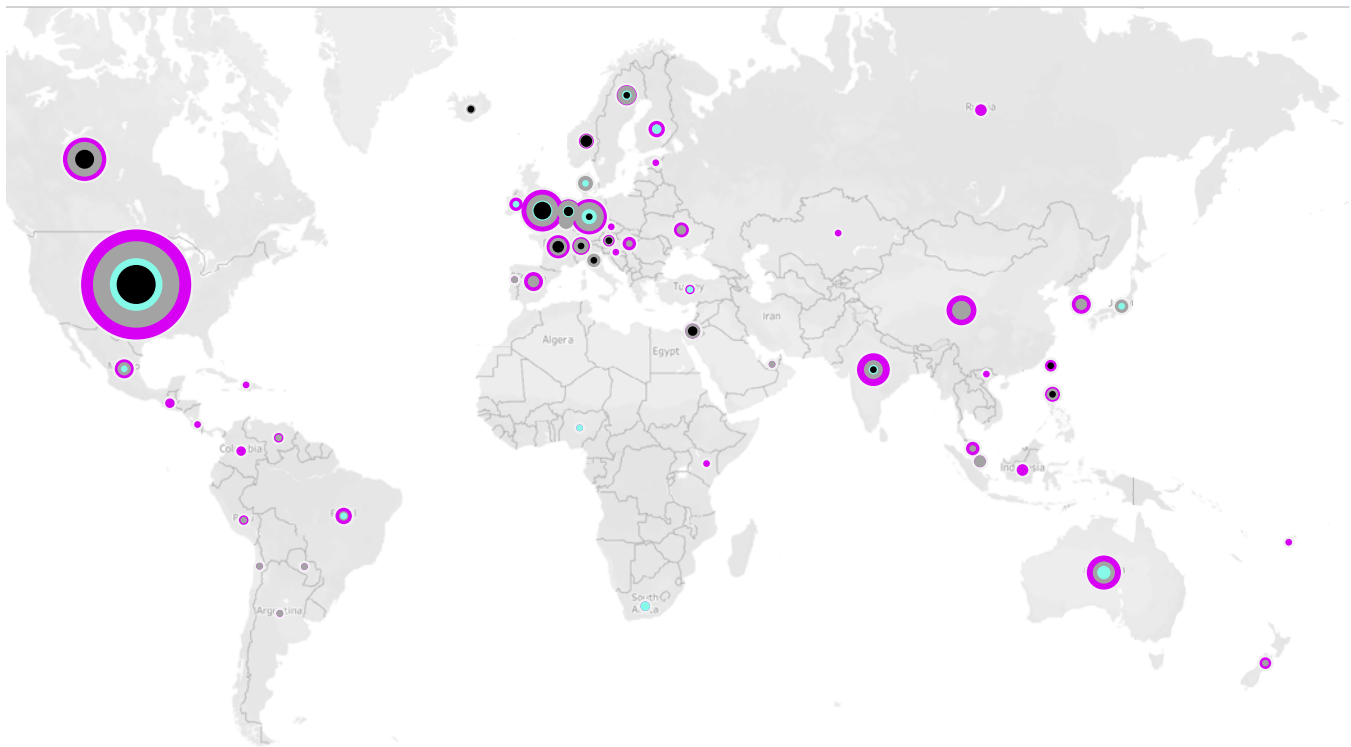
CCN INDEXES

Innovator Index

Companies

Number of Companies	Countries Represented	Reported Capital Raised to Date
997	55	\$25.4B

Location of All Innovators In the Index by Solution Type



© 2024 Mapbox © OpenStreetMap

■ CO₂ Removal ■ CO₂ Conversion ■ Point Source Capture ■ CCMI

We analyze innovators working in Circular Carbon using several criteria. First and foremost, the solution must be a Circular Carbon one — classified as either carbon removal, carbon conversion, point source capture, or market infrastructure.

From there, we look for companies that are actively engaged at minimum in building a commercial company, which can mean they have an active demonstration operating or in progress, or have secured seed or pre-seed funding. We then solicit key details about these companies and their status, pathways, and needs.

Deal Hub

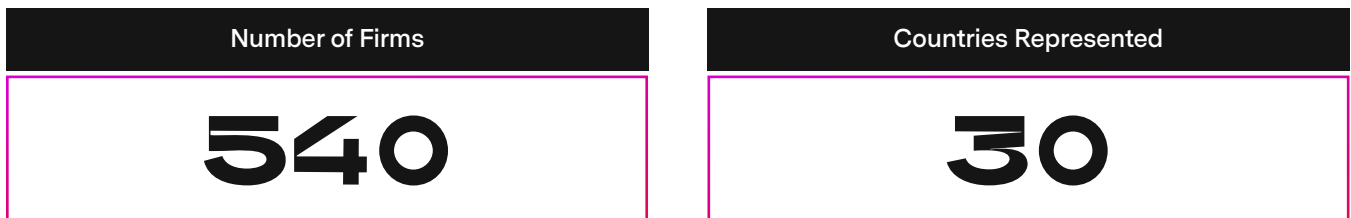
Historical and Available Deals



The Deal Hub is designed specifically to address the needs of capital providers and Circular Carbon companies seeking capital. It features investor-relevant information about live investment opportunities. We seek to increase deal flow by maintaining this list of active investment opportunities, accessed by accredited and approved investor members. The Deal Hub is a combination of directly reported deal data by companies to CCN, and researched data from publicly available data about closed deals. Only approved companies that are in the Innovator Index can participate in the Deal Hub.

Capital Index

Investors and Funders



The CCN Capital Index tracks capital providers who are currently active or interested in Circular Carbon investment opportunities. By tracking a broad range of data about the investment profiles, preferences, and performance of capital providers active or interested in the sector, we aim to accelerate and increase the flow of capital into the Circular Carbon economy.

The data for the Capital Index was compiled from a mix of direct responses by capital providers to a structured questionnaire and a review of publicly available information by our research team.

Catalyst Index

Supportive and Connective Organizations

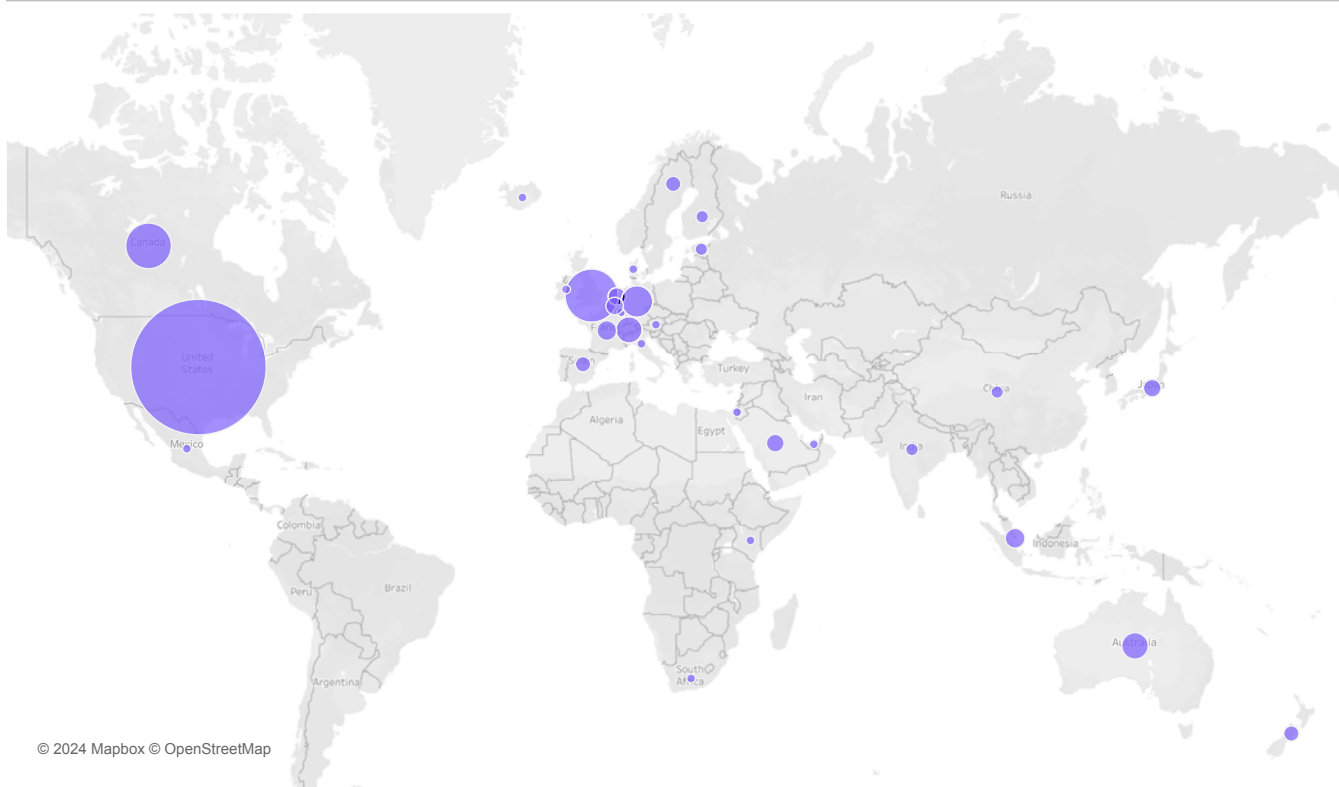
Number of Organizations

153

Countries Represented

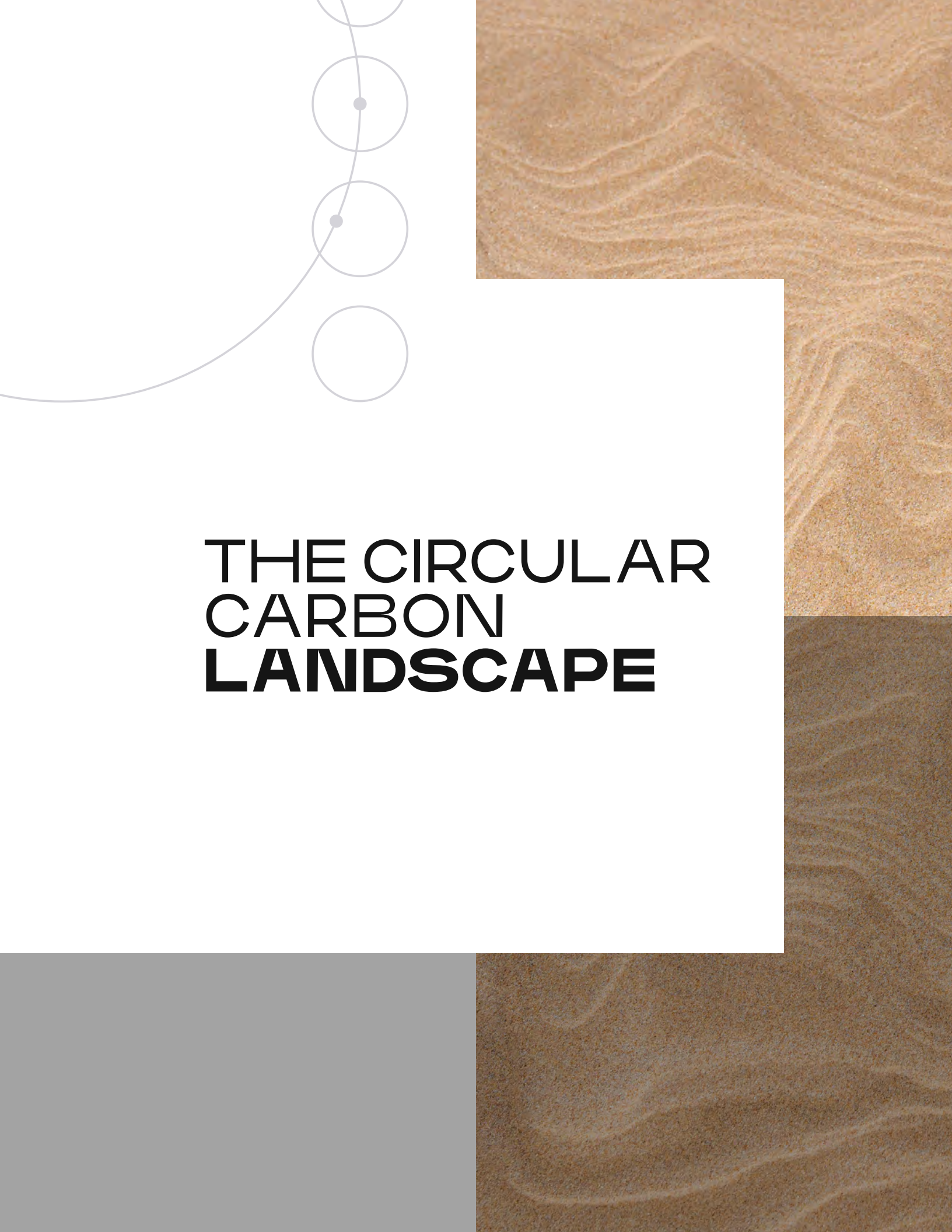
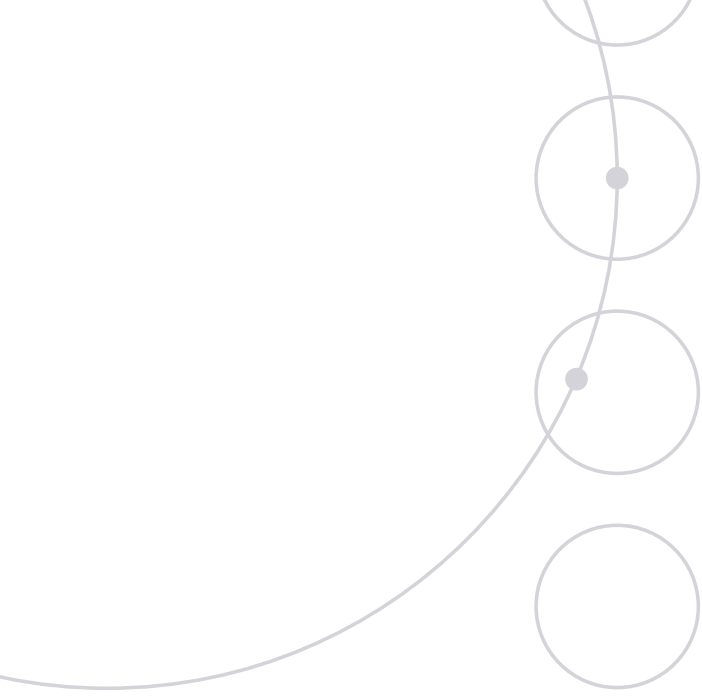
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Location of Catalysts In the Index



Market catalysts can take many shapes and forms — from nonprofit advocacy organizations to industry associations. These actors both help stitch together critical supportive infrastructure, and bring a level of vision, mission, and passion that a new space needs to survive and thrive.

The Catalyst Index is designed to help market participants of all types better understand and access the services, expertise, resources, and support that the growing number of enabling organizations in and around the Circular Carbon sector offer. We report here on more than 150 organizations that play a significant role in supporting the growth of the sector.



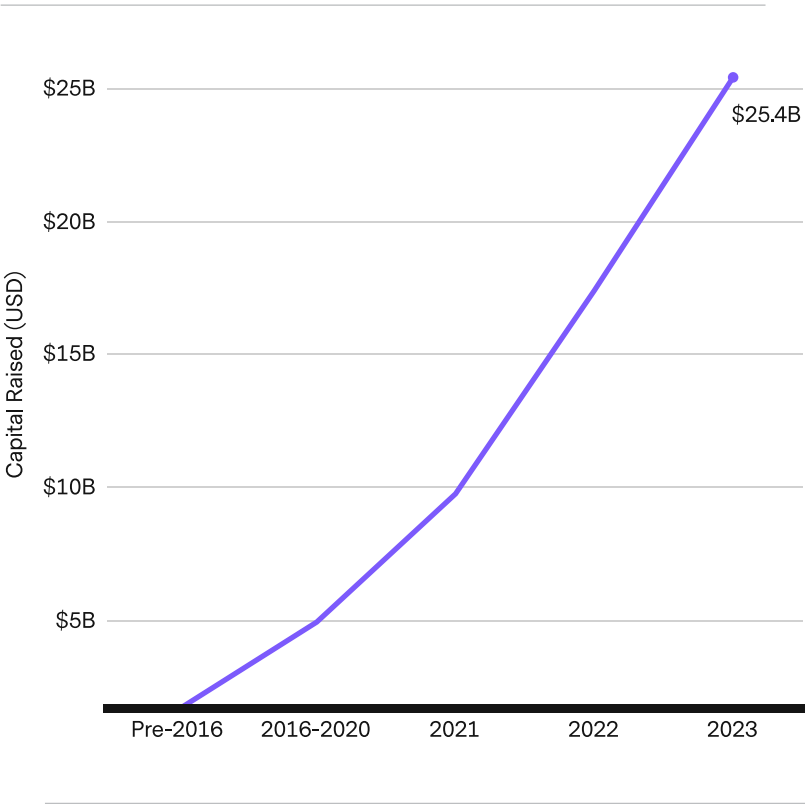
THE CIRCULAR CARBON **LANDSCAPE**

THE CIRCULAR CARBON LANDSCAPE

CAPITAL RAISED BY INNOVATORS



Cumulative Deals Closed to Date



Cumulatively, \$25.4B in capital has been raised to date by Circular Carbon companies¹. The majority of capital raised has been over the last 36 months. This data comes from both primary data collected by CCN and supplementary researched data on closed deals from publicly available sources.

Data Coverage: 78.25%

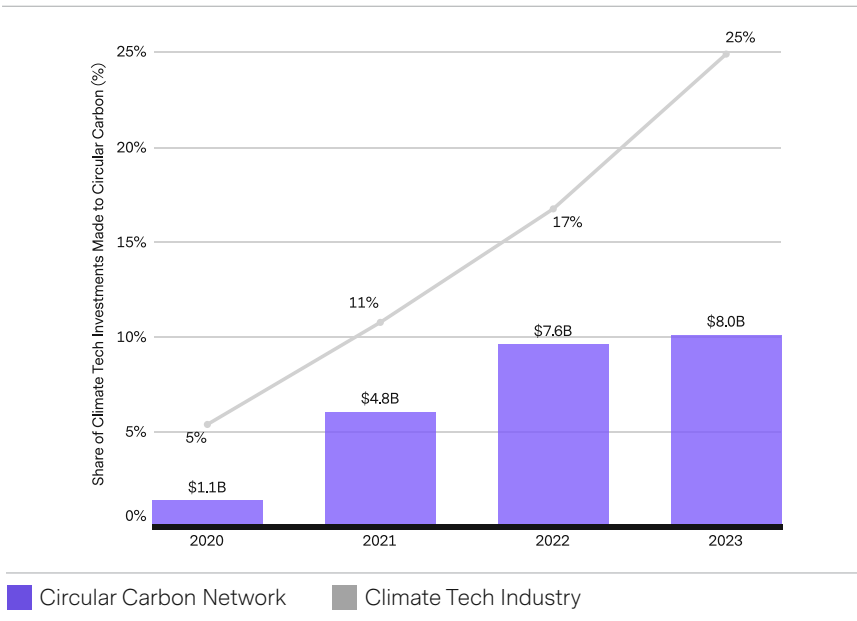
¹ The \$25.4B cumulative deals closed to date is a combination of directly reported deal data by companies to the CCN Deal Hub as well as researched data from publicly available sources on historical deals. We would like to note that in the CCN Innovator Index survey, companies self-reported a slightly higher figure of \$26.8B in total capital raised to date, but those discrepancies are not appearing in publicly available data and have not been verified by our research team. It is possible that the difference comes from non-dilutive capital sources, which we do not track through the Deal Hub. Throughout this report, we reference the verified closed deals dataset (which totals \$25.4B).

CIRCULAR CARBON AND CLIMATE TECH INVESTMENT TRENDS

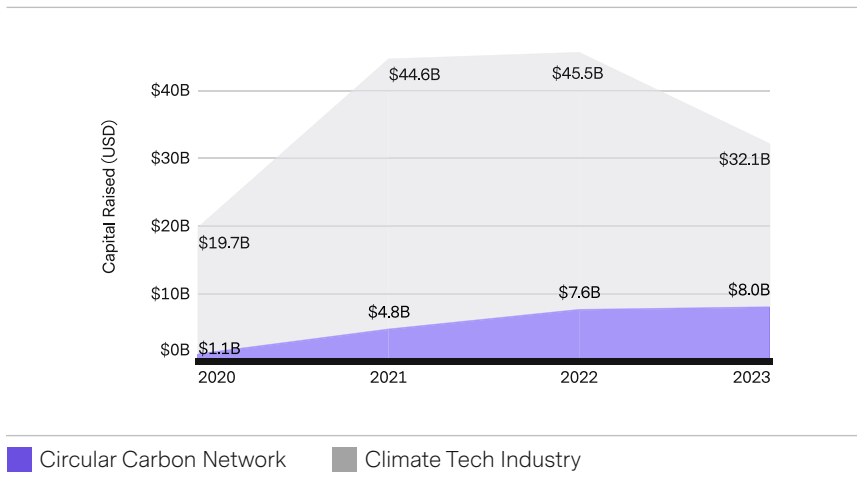
To contextualize this data, we compared the capital raised by Circular Carbon companies in recent years against the overall capital raised in the Climate Tech sector (as reported by [Sightline Climate](#)). Total investment in Circular Carbon between 2021 and 2023 was four times the cumulative investment from all years prior. By 2023, investment in Circular Carbon constituted 25% of overall investment in Climate Tech, as outlined in the first chart below. Circular Carbon companies have been taking up an increasing portion of the broader sector for the last four years.

The second graph below shows the year-over-year capital raised by Circular Carbon companies against the wider Climate Tech sector. While Circular Carbon investment has been growing each year, the wider Climate Tech sector saw a decline in the last year.

Share of Climate Tech Investments Made to Circular Carbon



Capital Raised by Circular Carbon Companies vs. All of Climate Tech

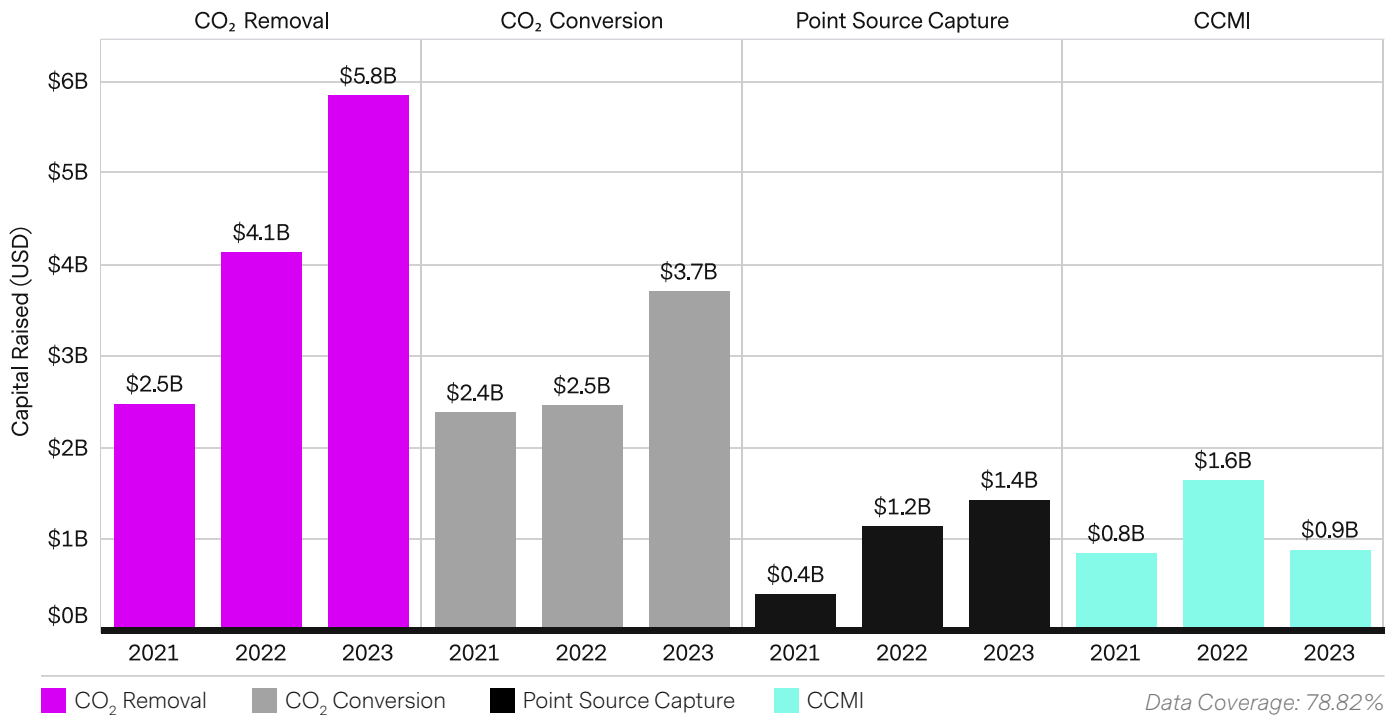


Climate Tech Industry Data Source:

[Sightline Climate](#)

Data Coverage: 85.51%

Deals Closed by Solution Type by Year



*Sum adds up to more than totals because companies are classified as more than one solution type.

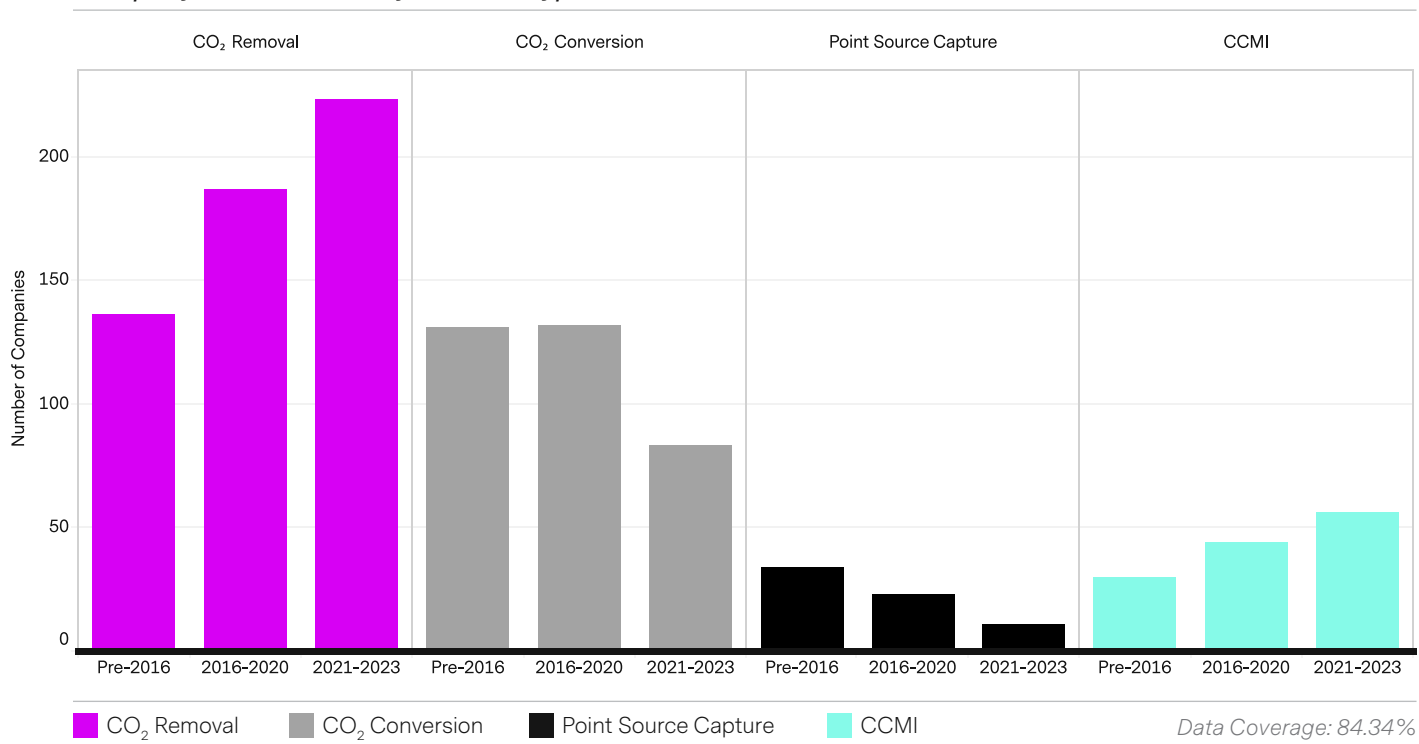
This chart addresses the amount of capital raised within each solution type over the last three years. Notably, the data reveals that in 2023 both removal and conversion solutions showed significant positive growth in the amount of capital raised. Specifically, removal solutions secured \$1.7B more capital than in 2022. This capital was distributed across 138 more carbon removal-specific deals than the previous year, and the median deal size also increased.

Carbon Removal Deal Dynamics

	2022	2023
Total Removal Capital Raised	\$4.1B	\$5.8B
Median Carbon Removal Deal Size	\$2M	\$3.2M
Number of Deals	196	334

COMPANIES FOUNDED OVER TIME

Company Year Founded by Solution Type



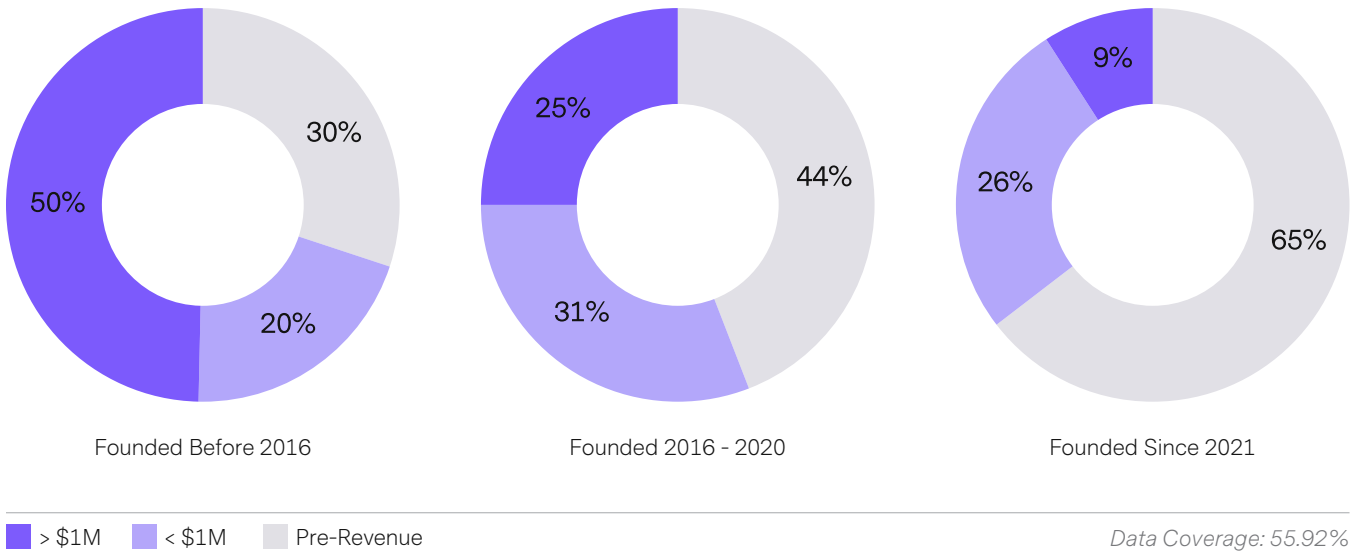
Overall the strongest pattern of growth (as measured by companies founded over time) is within carbon removal companies. As the climate crisis has steadily moved to the forefront of the global agenda over the last 8 years, so have major signals from the government as well as growing interest from investors. This positive trajectory makes a lot of sense. Conversely, the number of new carbon conversion companies founded has slowed. It is possible that this change represents the shift in attention to carbon removal over the last 36 months, or that carbon conversion and utilization companies are starting to identify more as removal companies to stay relevant.

On the other hand there has been a marked decrease in the number of new point source capture firms being founded. However, as we will discuss later, this sector continues to secure steady capital. It is possible that the slowing of company formation could be attributed to a more saturated point source capture market.

Lastly, there is a consistent pattern of new company formation over time in market infrastructure companies. These businesses primarily cover direct essential services to the sector (carbon measurement and accounting, offset registries, project intermediaries, service providers, etc.), and they mark \$3.9B in total capital raised over time. This is an impressive amount of capital going into market infrastructure for Circular Carbon companies, and could signal more sector stability.

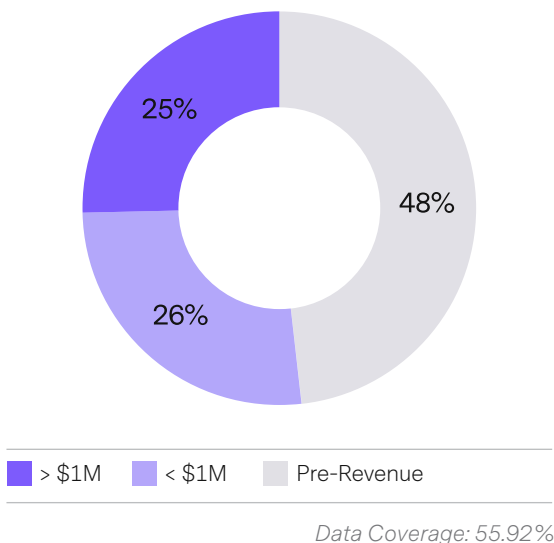
A GROWING NUMBER OF COMPANIES ARE GENERATING REVENUE

Reported Revenue of Innovators in Our Index by Founding Year



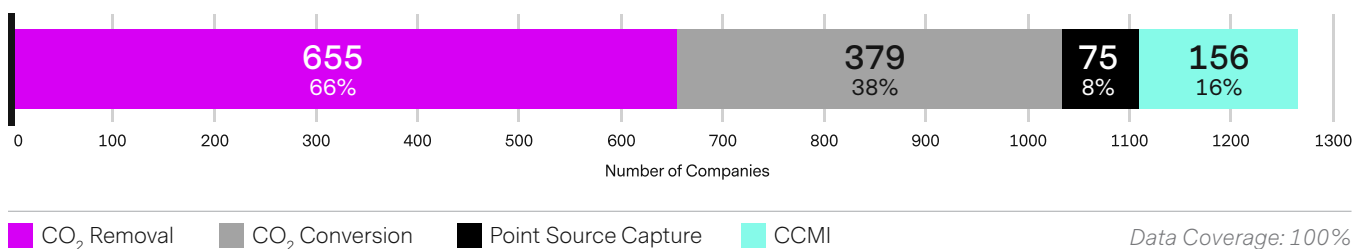
The CCN data on reported revenue reveals that 50% of companies founded prior to 2016 are making more than \$1M in revenue. Even as the majority of newer companies are not yet generating capital, it is encouraging that once companies can pass through one or two valleys of death, there are gains to be achieved in this industry.

Reported Revenue of All Companies



Roughly half of all companies in Circular Carbon are generating revenue. This number has grown over time, and is certainly an encouraging sign (the number of companies generating revenue increased by 123 since 2022). One quarter of reporting companies are generating more than \$1M, and roughly half are still pre-revenue, with most of those in the early stages of entrepreneurship (yet this can extend to both newer and older companies depending on TRL developments and other factors).

Company Breakdown by Solution Type



Of the 997 companies on the Innovator Index, more than half are carbon removal companies and more than a third are conversion companies. This year we added 391 companies to the index from new data sources including the XPRIZE Carbon Removal and other partners, as well as self-reported additions. The majority of those additions are based in North America, and 28 of the 391 were new companies founded in 2023. Carbon removal companies make up more than half of all Circular Carbon companies, with conversion at 38%, and CCMI and point source capture as the remaining quarter.

Due to some extensive research and verification work done on the Indexes this year, we also removed 93 companies that were previously listed. Companies were removed for several reasons, including no longer being in operation or being reclassified more appropriately to the Catalyst Index. Additionally, some data points have been modified from previous annual market reports as a result of this ongoing research and verification.

Solution Type Combinations

About a quarter of all Circular Carbon companies on the Innovator Index report using a combination of solution types, with removal and conversion being the most common. Many companies in this space are using direct air capture and converting it into products for building materials or industrial processes; or taking biomass and applying it to agricultural or forest soil.

Examples of solution types using a combination of approaches and specific company examples within each category, include:

Solution Type Combination + Company Examples	Companies	% of Companies
Conversion + Removal CarStorCon Technologies Mercurius Biorefining	205	81%
Conversion + Point Source Carbonade Carbon8 Systems	11	4%
Removal + Point Source EPFL Carbon Team Cool Ventures	9	4%
Removal + CCMI Azolla Biodesign, LLC Carbonaught PTY	9	4%
Conversion + Removal + CCMI CarbonCure Technologies MCi Carbon	8	3%
Conversion + Removal + Point Source Blue Planet Cambridge Carbon Capture LTD	3	1%
Conversion + CCMI Carbon to Stone FeyeCon	3	1%
Conversion + Removal + Point Source + CCMI Twelve	2	1%
Grand Total	253	100%

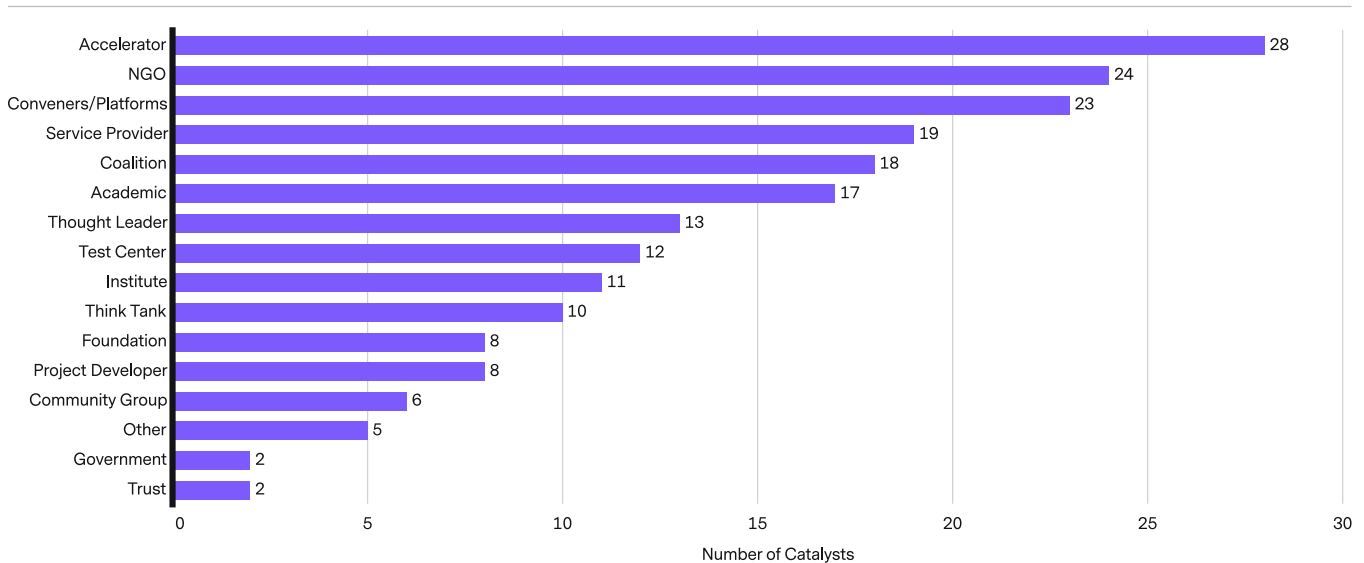
CCMI WITH OTHER SOLUTION CATEGORIES:

Several companies in our index have chosen to self-identify with more than one category. It is especially common for the combination to include the Circular Carbon Market Infrastructure category along with Point Source Capture, Carbon Removal and/or Carbon Conversion. This is because the definition we use for circular carbon market infrastructure includes companies who offer specialized climate technology services, companies who develop projects or offer consulting services and companies who develop software platforms (e.g. SaaS). One particular example of this is FeyeCon, who offer their patented supercritical technology service to a number of industrial customers. Or Carbonaught, who works to source and spread basalt rock on farmlands and use their proprietary software for measurement and verification. Additionally, many of the companies in our index are pre-commercial innovators and may still be finding their niche in the Circular Carbon industry, so it is not uncommon for a technology developer to offer consulting services as well.

Please note: Companies are listed here as illustrative examples of work being done in this space but this is by no means an exhaustive list.

CATALYST ORGANIZATIONS CONTINUE TO INCREASE

Catalyst Organization Types



Catalyst organizations play a vital role in the Circular Carbon ecosystem by offering indirect support through various means. This may include advocating for new policies and funding, accelerating the growth of early stage businesses, and developing new standards for ensuring quality and transparency within the industry.

Catalyst examples include accelerators and incubators, research institutions, state-funded programs, and academia. Often operated as non profit entities, these organizations prioritize advancing the Circular Carbon economy and not commercialization. Their efforts are instrumental in driving systemic change and fostering innovation across the sector. We currently track 153 catalyst organizations across 17 countries. Accelerators are the most represented type of catalysts by number (28), and NGOs second (24). We also see that the top core support activity provided by catalysts was technology, research and development. New catalysts continue to come online all the time, and here are a few highlights from 2023.

NEW 2023 CATALYST ORGANIZATIONS

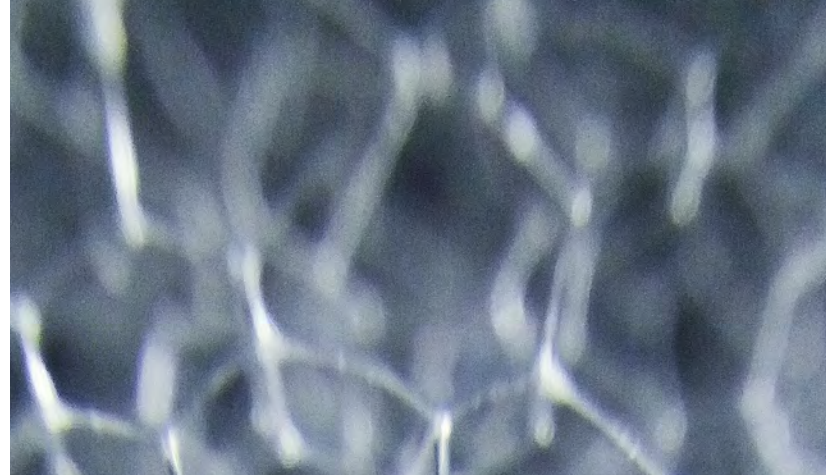
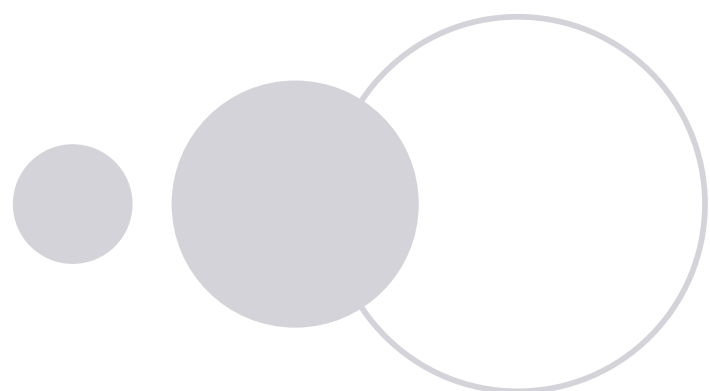
Remove - Carbon Removal Accelerator: Offering €50k of non-dilutive funding, Remove is Europe's first accelerator focused solely on carbon removal technologies. The program spun out of the Sustainability in Business Lab and ETH Zurich.

Carbon Removal India Alliance (CRIA): A consortium of organizations and individuals developing carbon removal technology, conducting research and engaging with policy in India, which has the potential to provide 10-30% of the world's durable atmospheric carbon dioxide removal (CDR).

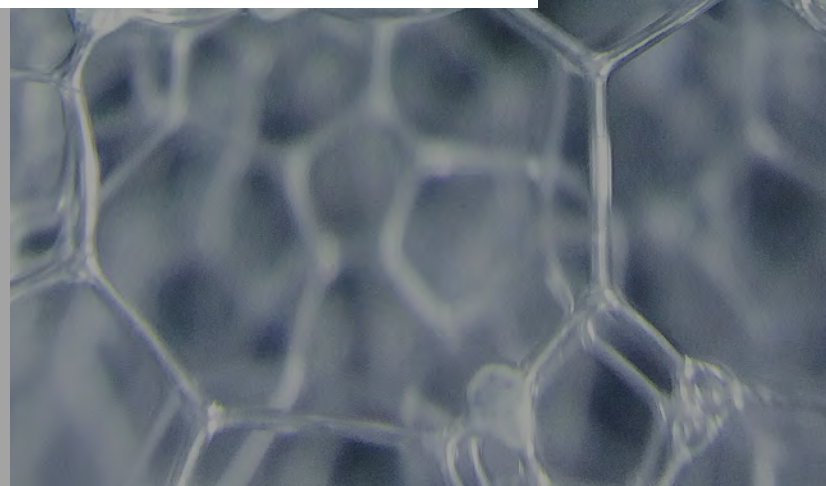
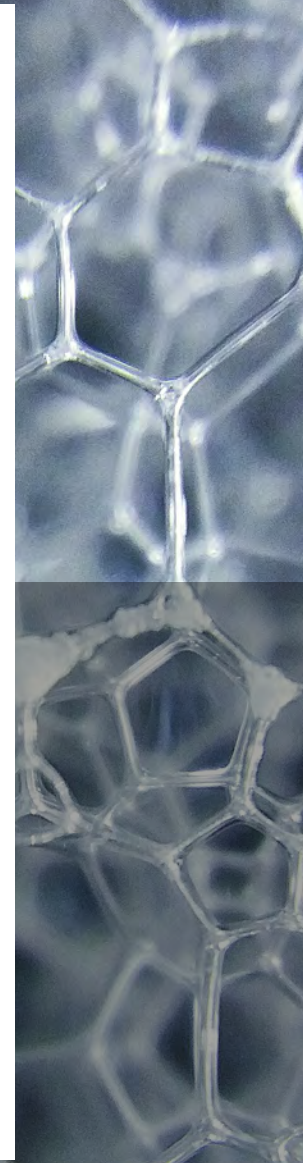
Carbon Removal Canada: Carbon Removal Canada envisions a future where Canada fully leverages its strategic advantages as a carbon removal leader to support the world in meeting global climate targets. Carbon Removal Canada shapes policies that enable Canada to rapidly and responsibly scale CDR to meet national climate goals while catalyzing a net-negative emissions world this century.

Carbon Unbound: The largest carbon-focused summit with events in NYC and London, bringing together business leaders, investors, buyers, and policy makers to discuss the future of carbon removal.

Please note: Companies are listed here as illustrative examples of work being done in this space but this is by no means an exhaustive list.



2023 INVESTMENT TRENDS



2023 INVESTMENT TRENDS

CONTINUED STEADY GROWTH IN CIRCULAR CARBON INVESTMENTS

Companies

328

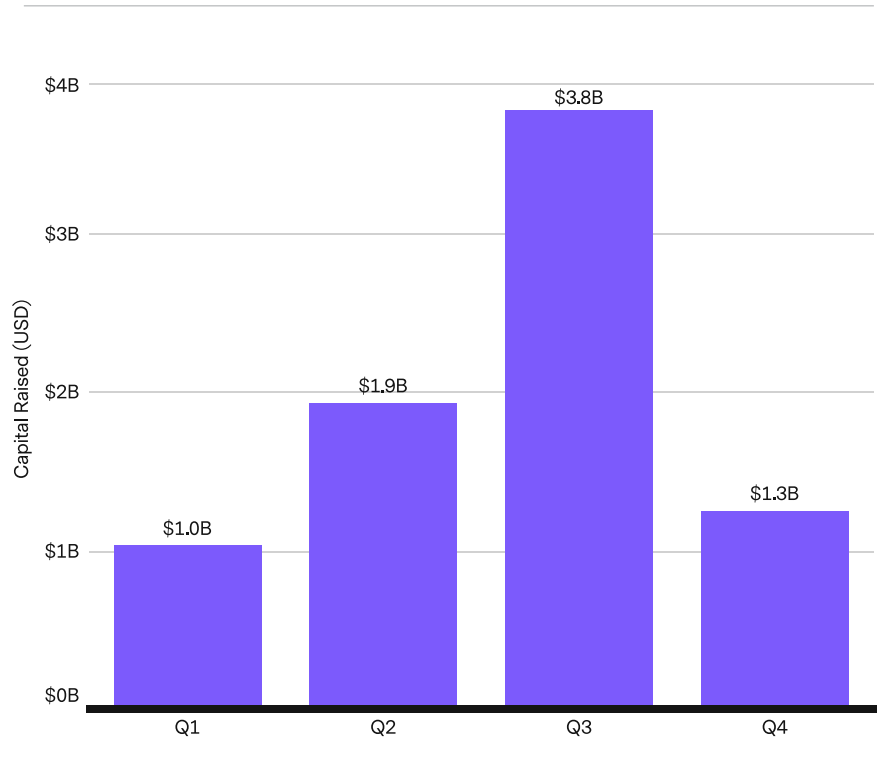
Deals

455

Total Value of Deals Closed in 2023

\$8B

Quarterly Breakdown of Deals Closed in 2023

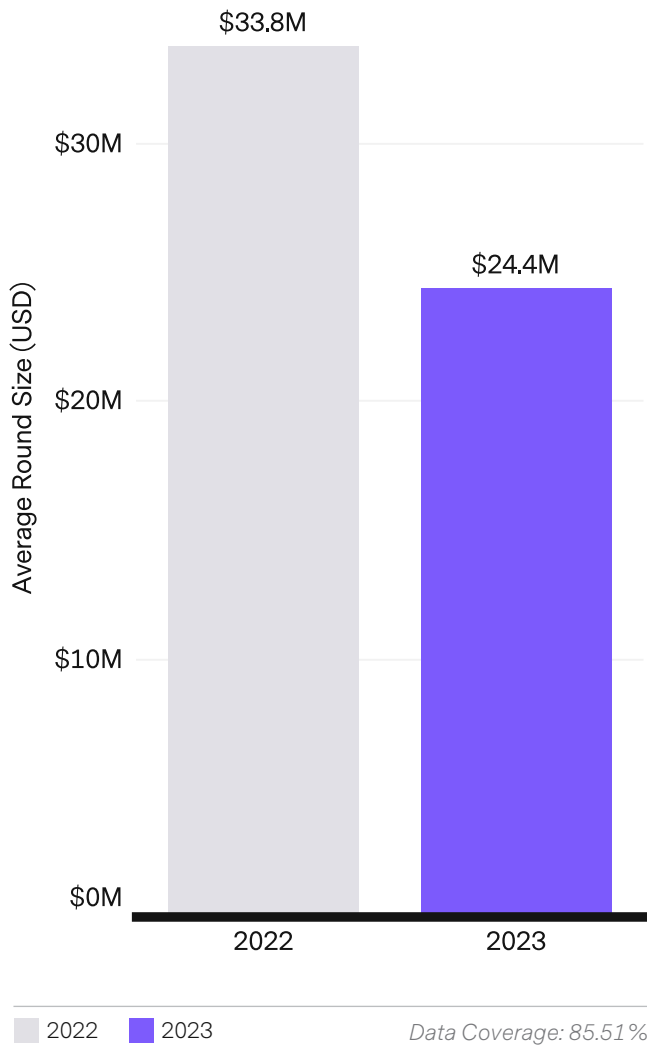


Data Coverage: 85.51%

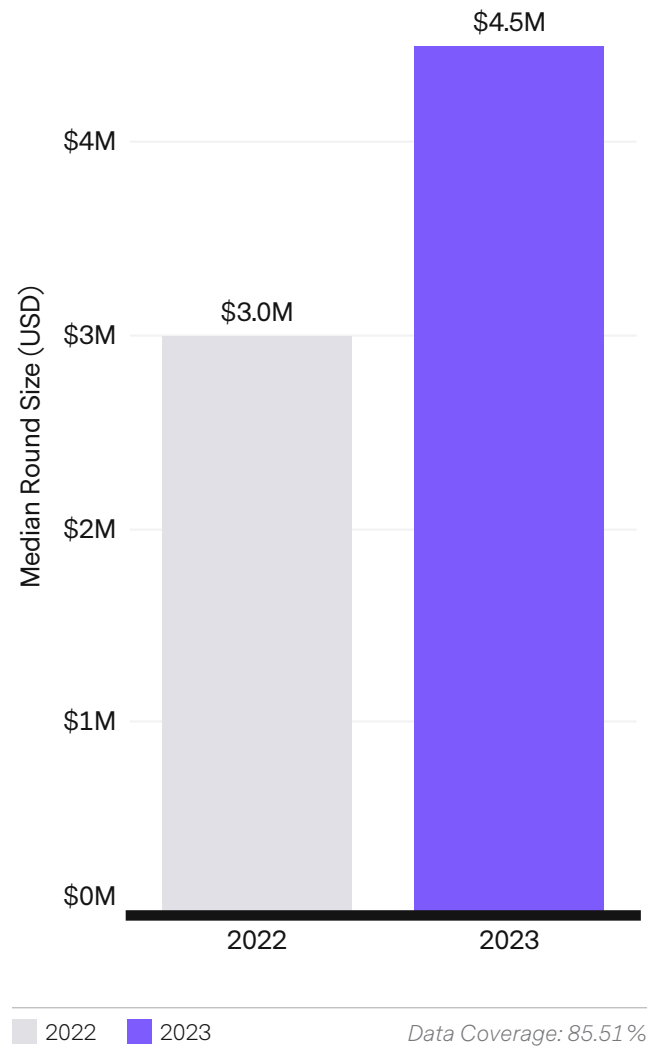
DEALS IN CIRCULAR CARBON OVER \$500M INCLUDED IN THIS DATASET

\$1.1B	\$675M	\$542M	\$514M
Carbon Engineering (Mergers and Acquisitions)	Net Power (Post-IPO Equity)	Saipem (Post-IPO Debt)	Low Carbon (Debt Financing)

Average Round Size Raised by Innovators, 2022 vs. 2023



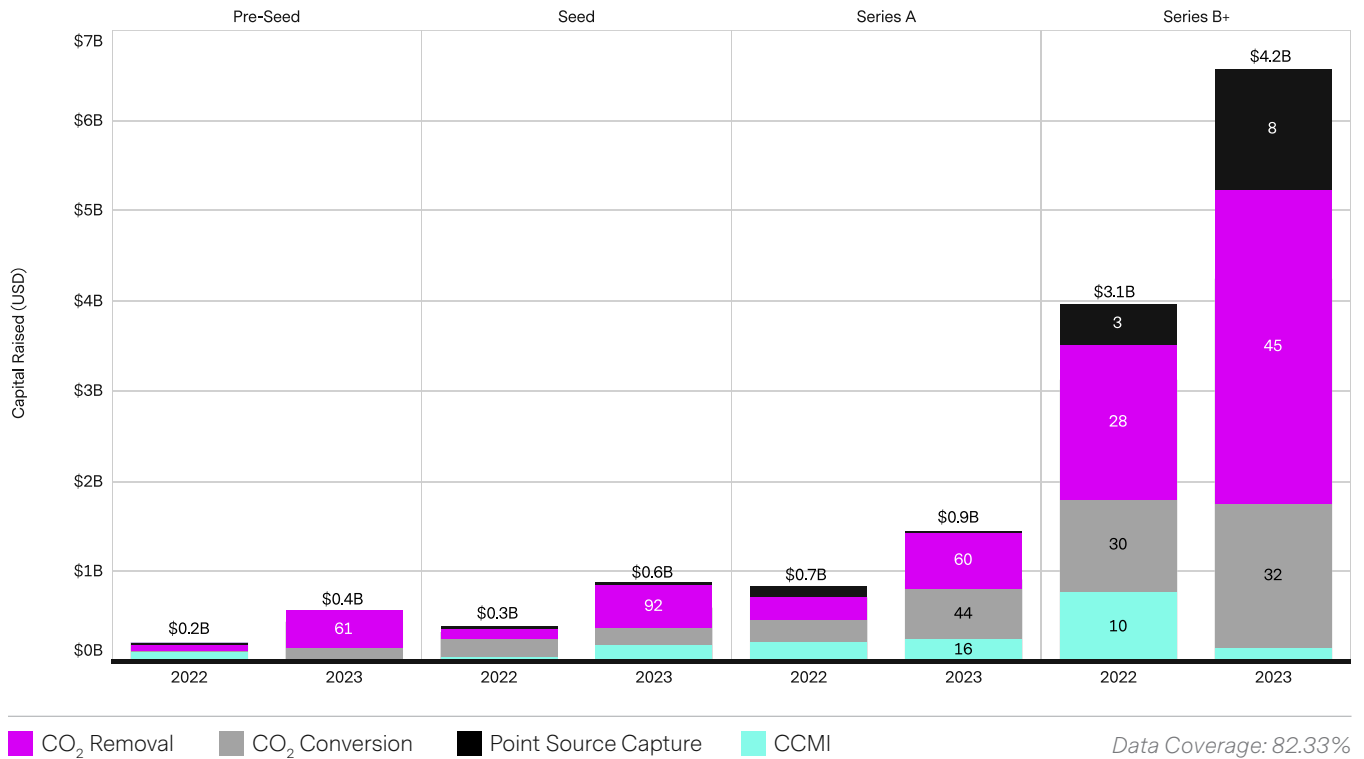
Median Round Size Raised by Innovators, 2022 vs. 2023



The average deal amount slipped lower than last year's average by \$9.4M. In general, there is more capital spread out over more companies this year. However, the median deal numbers grew in a healthy direction, increasing by \$1.5M. Encouragingly, there was a total of \$2B raised by 127 new Circular Carbon companies (founded since 2021).

EARLY STAGE CAPITAL IS INCREASING

Number and Amount of Deals In Each Investment Stage by Company Solution Type, 2022 vs. 2023

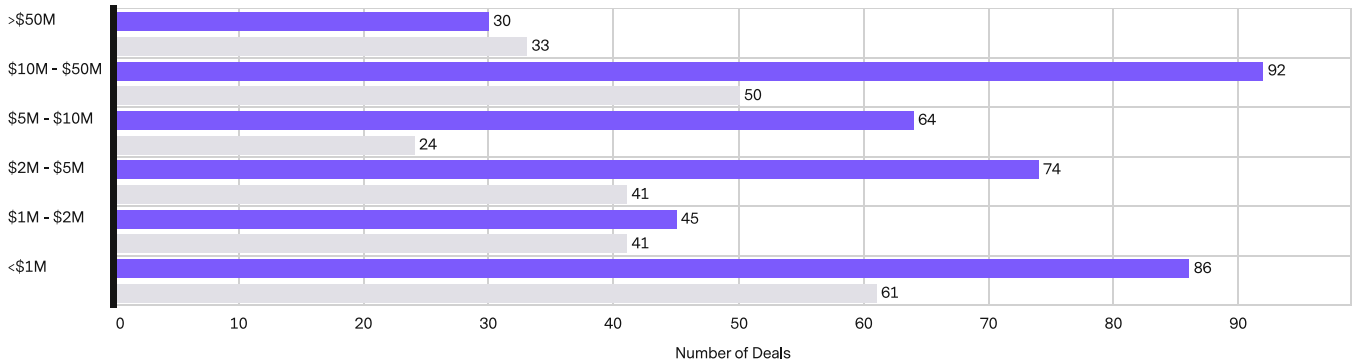


Within earlier investment stages, there was a total of \$1.9B deployed across all solution types in Pre-seed, Seed, and Series A, over 237 companies. As compared with last year’s data, there is an encouraging upward trend in the number of deals across these early company stages, especially given the more tumultuous investment environment. In particular, the number of Series A deals almost doubled. Overall, the number of early stage companies represent 72% of all companies with deals, and 24% of all capital raised.

Deals of Series B+ include B-G, as well as Post-IPO Debt and Equity, Debt Financing, Mergers & Acquisitions, and Mezzanine Debt. Capital in this group also grew year over year by roughly \$1B, totalling \$4.2B in 2023². Obviously these companies are garnering much larger rounds, and we are excited to see so many removal companies represented within this group.

² Listed 2023 deals do not add up to \$8B because the chart does not include the following stage options: Angel, Equity Crowdfunding, Funding Round, Grant, Initial Coin Offering, Non-Equity Assistance, Private Equity, and Venture - Series Unknown.

2023 Round Sizes



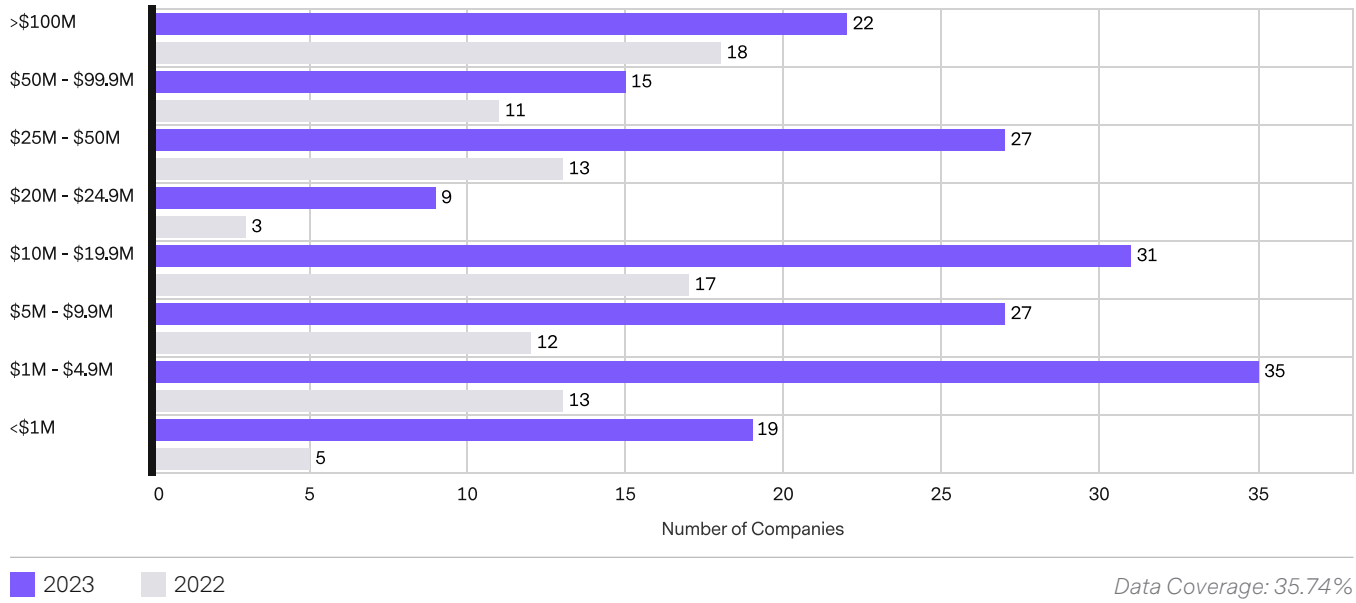
■ 2023 ■ 2022

Data Coverage: 85.51%

As far as amounts go, the deals that closed for less than \$2M increased by 28% from 2022, totaling to just over a quarter (131) of all deals tracked. On the other end, the number of deals closing between \$2M-\$50M all increased by 86% from last year, indicating a maturing market that is poised to grow even more rapidly. Overall, there is healthy growth across all round sizes, and generally speaking, more companies are moving toward higher closed round amounts this year.

MEDIAN VALUATION AMOUNTS DECREASING

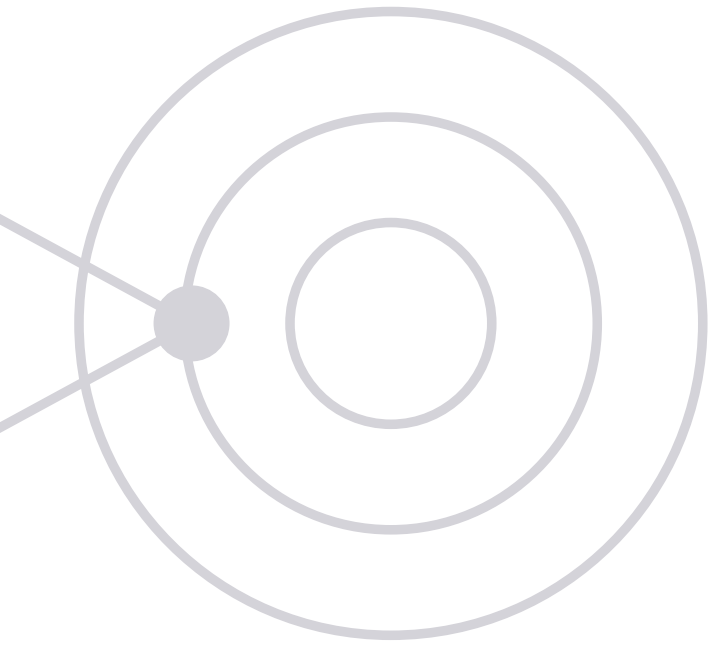
Valuation Ranges of Companies with Deals, 2022 vs. 2023



	2022	2023
Total Valuation	\$112.6_B	\$109.5_B
Median Valuation	\$15.0_M	\$10.0_M
Companies	226	328

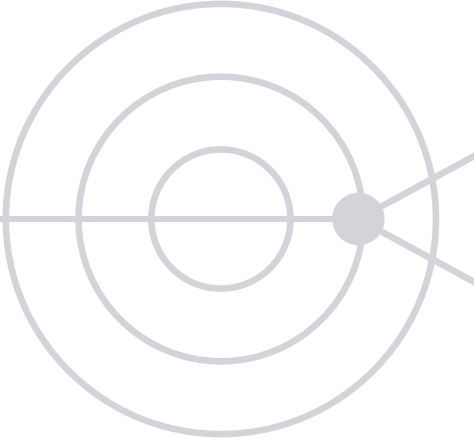
The total valuation of all 328 companies with deals in 2023 is \$109.5B. Of those, 11% have a self-reported valuation of \$50M or higher.

Most of the increases we saw in valuations (as a percentage of total responses) were at the lower end of the spectrum; the number of <\$1M valuations grew by 280%. In terms of overall distribution within companies who provided us with this data, 60% of companies with 2023 deals reported their valuations were below \$20M, while the rest (40%) reported valuations of \$20M or more. Even with this shift from last year's data, the median valuation for companies with a closing deal decreased in 2023 by \$5M.



FOCUS ON **REMOVALS**

FOCUS ON REMOVALS



DEALS CLOSED AND COMMERCIAL STAGES IN 2023

2023 Deals Closed by Carbon Removal Pathway*

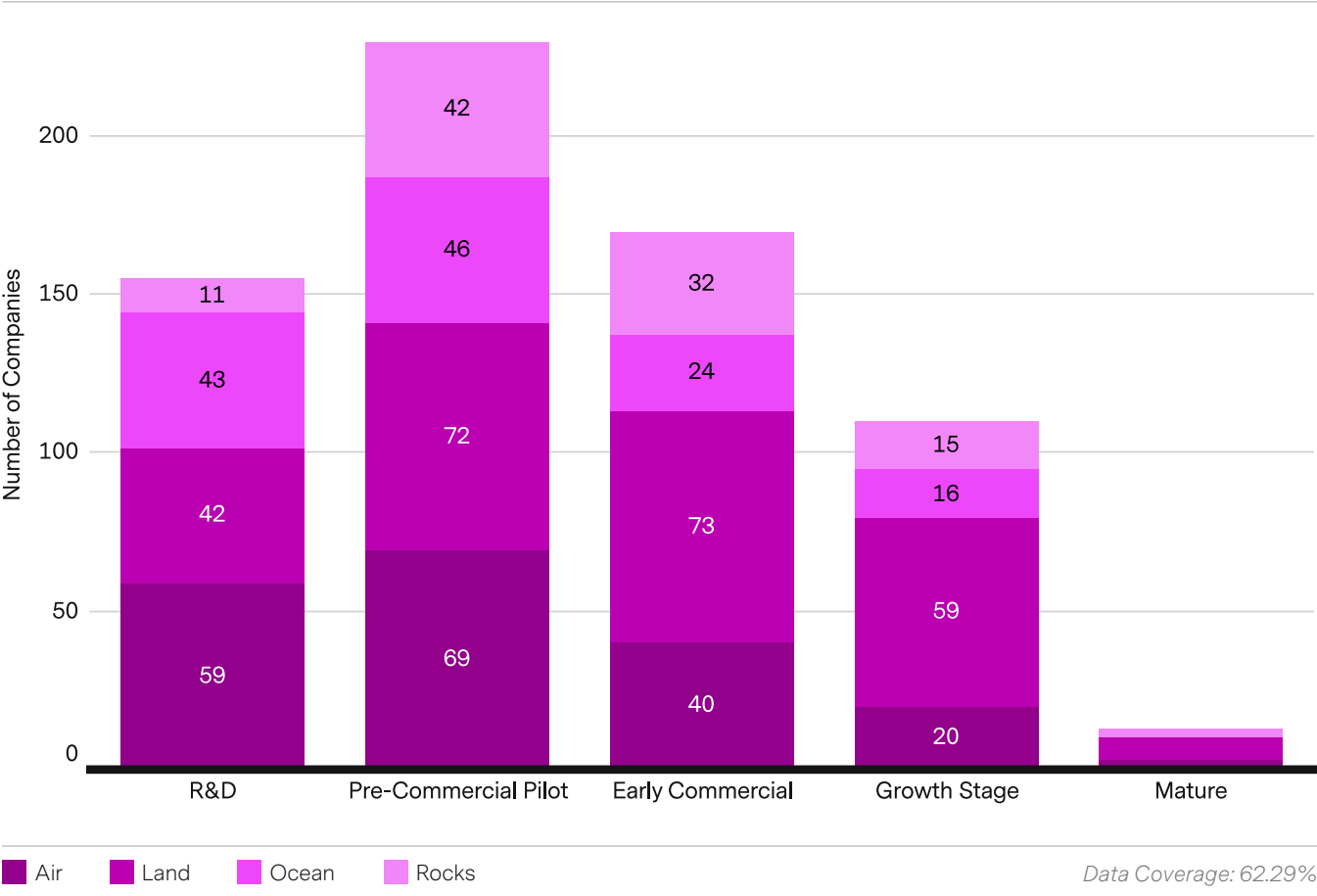


Data Coverage: 67.48%

Of the \$8B raised by Circular Carbon companies in 2023, \$5.8B came from carbon removal deals, warranting a deeper dive into the data. Carbon removal can be broken down into several high-level categories: Air, Land, Ocean, and Rocks (see [Definitions](#) section for a more detailed description of each category and examples of companies in each). Notably, the Oceans category remains low in capital raised, likely due to the emerging nature of this solution type. As market indicators slowly increase (such as the [DOE commitment](#) in Q4 2023), hopefully funding to this solution type continues to grow over time.

* Total capital raised amounts to more than \$5.8B as several companies identify with multiple solution types.

Number of Removal Companies In Each Commercial Stage by Solution Type

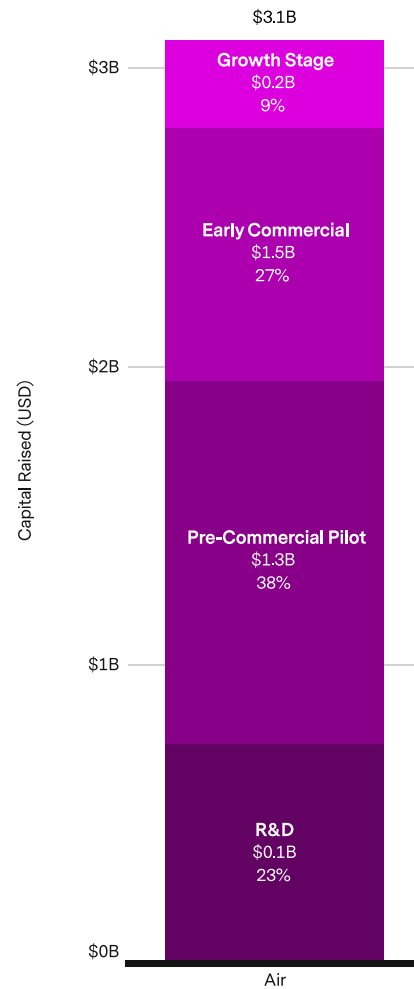


Of all removal companies that we have tracked, those that are in early commercialization phases (R&D, pre- or early demonstration) have received over half of all Circular Carbon funding in 2023. That means 173 early stage removal companies received roughly \$4.1B in capital this year. To put this number in perspective, [Sightline Climate](#) reports that all of Climate Tech together raised \$32B in 2023.

DIGGING INTO DAC

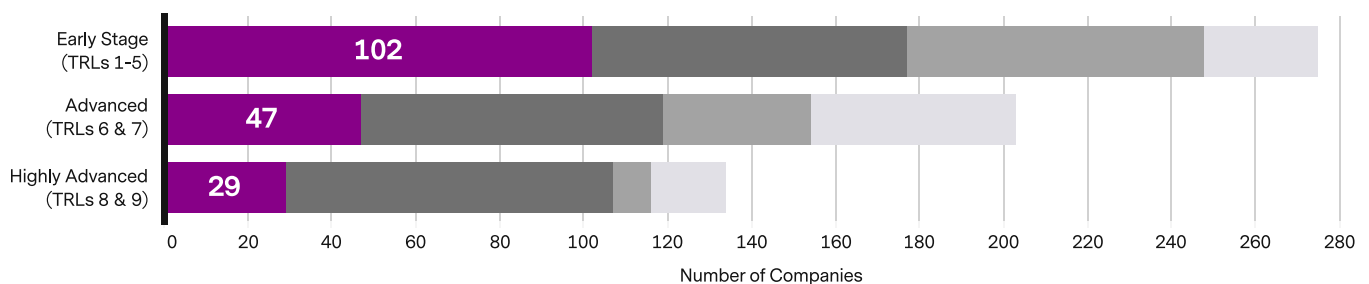
Direct air capture (DAC) companies have garnered more than half of the capital raised in 2023 by carbon removal companies overall, \$3.1B of \$5.8B. With a median and average TRL of 5, this signals that investors are becoming more confident in the pathway ahead for carbon tech. We can attribute this to significant recent government backing coupled with the increased focus on the integrity of the Voluntary Carbon Markets, and both corporate and [government initiatives](#) to get carbon removal to below \$100/ton.

2023 Air Deals by Commercial Stage



Data Coverage: 41.43%

Removal Company TRLs

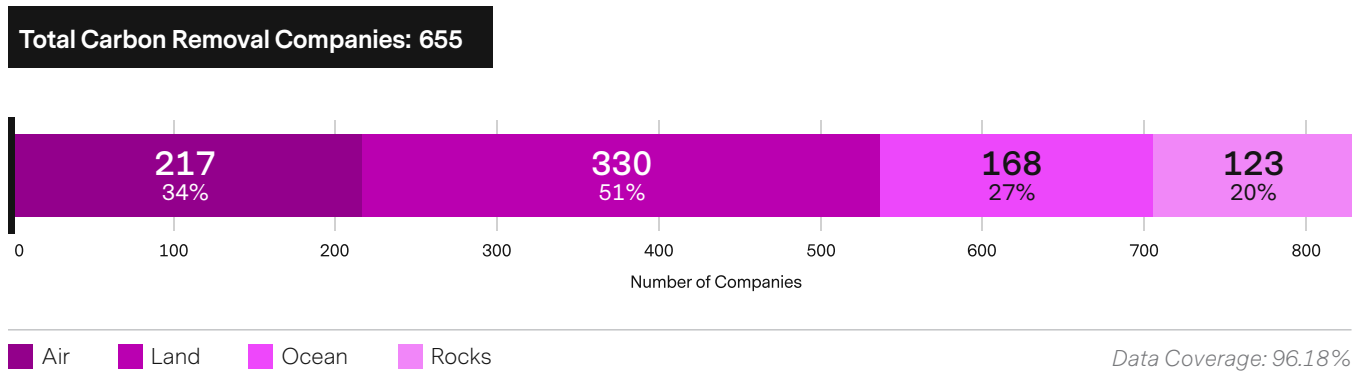


■ Air ■ Land ■ Ocean ■ Rocks

Data Coverage: 69.92%

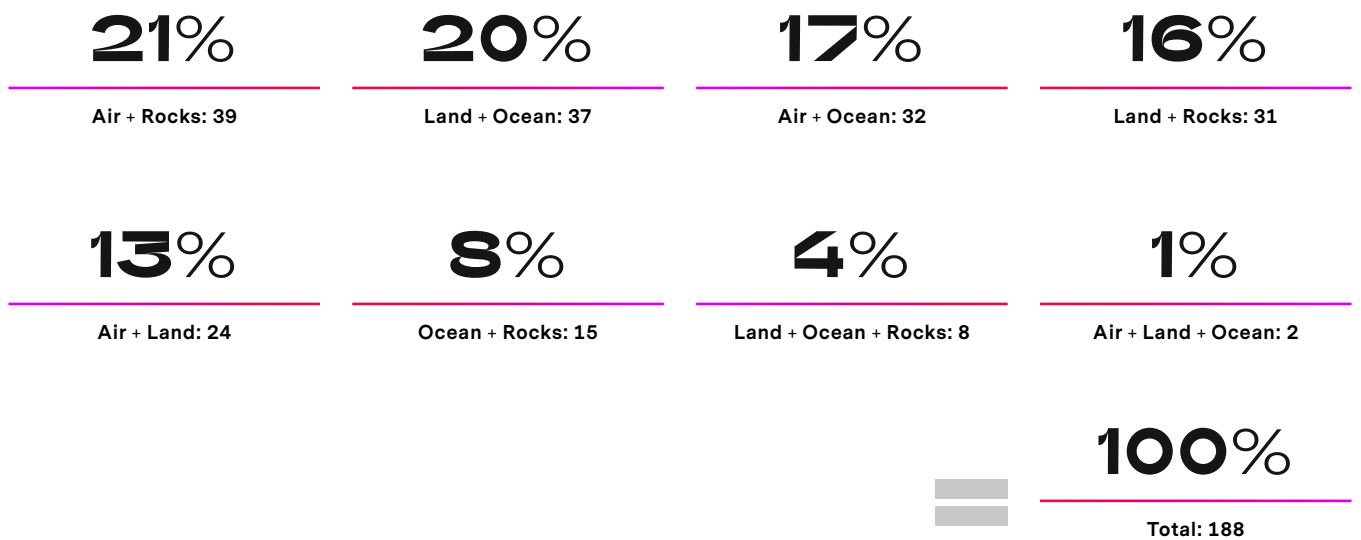
REMOVALS LANDSCAPE

Number of Carbon Removal Companies



The carbon removal pathways outlined here mirror the breakdown of the XPRIZE Carbon Removal (see full [Definitions](#)). Overall we see the two largest categories by far are Land (51%) and Air (34%) dominating the landscape. Note that these percentages do not add to 100% because of solution type combinations. Reporting companies have the ability to select more than one solution type, and 188 companies chose a hybrid removal solution.

Removal Type Combinations of Innovators



Data Coverage: 96.18%

Air and Rocks companies are the most commonly combined categories, with 39 companies working within these solutions. Overall, Land solutions are the most commonly combined and also stand alone the most often.

Air + Rocks Solution Examples

As the most commonly combined categories, this group of companies are both removing carbon directly from the air and storing it permanently underground via in-situ mineralization processes. The majority of these removal processes involve engineered carbon removal and direct air capture. However, a few companies within this group leverage nature-based carbon removal methods, converting byproducts into a stable form ready for geological storage.

Who is doing this?

44.01 - 44.01 specializes in the sequestration of carbon in geological formations through enhanced in-situ mineralization. Their primary aim is to showcase viable, easily accessible, secure, and scalable carbon storage within peridotite formations. Peridotite, a rock known for transforming climate-damaging carbon into stable, inert carbonate minerals, serves as the focal point to initiate large-scale carbon capture and storage—an indispensable weapon against climate change.

CARBA - CARBA employs plants to extract carbon, converting their byproducts into a durable, solid carbon form. This carbon is subsequently sequestered underground, ensuring its stabilization for potentially thousands or even millions of years.

Land + Ocean Solution Examples

Storing carbon in low or absent-oxygen environments - oceans - through the decomposition of organic matter, creating stable carbon compounds like peat or lignite (anoxic biological carbon sequestration).

Who is doing this?

CARBONIFEROUS - Carboniferous's Anoxic Biological Carbon Sequestration (ABCS) process accelerates the natural process of organic carbon burial by collecting and processing agricultural byproducts (biomass purchased from farmers via BiRCS pathways) and storing them in deep, hypersaline, anoxic basins below the oxygenated ocean.

Sequestering carbon through enhancing natural seaweed or kelp growth, and circulating that into land-based animal feed.

Who is doing this?

SYMBROSIA - Symbrosia harvests *Asparagopsis*, a genus of red algae. These algae contain secondary metabolites, particularly bromoforms, which can inhibit methane production in the digestive systems of animals when added to their feed in small quantities - sequestering carbon through the growth of seaweed and reducing overall emissions by being integrated into their feed.

Please note: Companies are listed here as illustrative examples of work being done in this space but this is by no means an exhaustive list.



**REVENUE
DRIVERS:
THE CARBON MARKET AND
PHYSICAL PRODUCTS**

REVENUE DRIVERS: THE CARBON MARKET AND PHYSICAL PRODUCTS

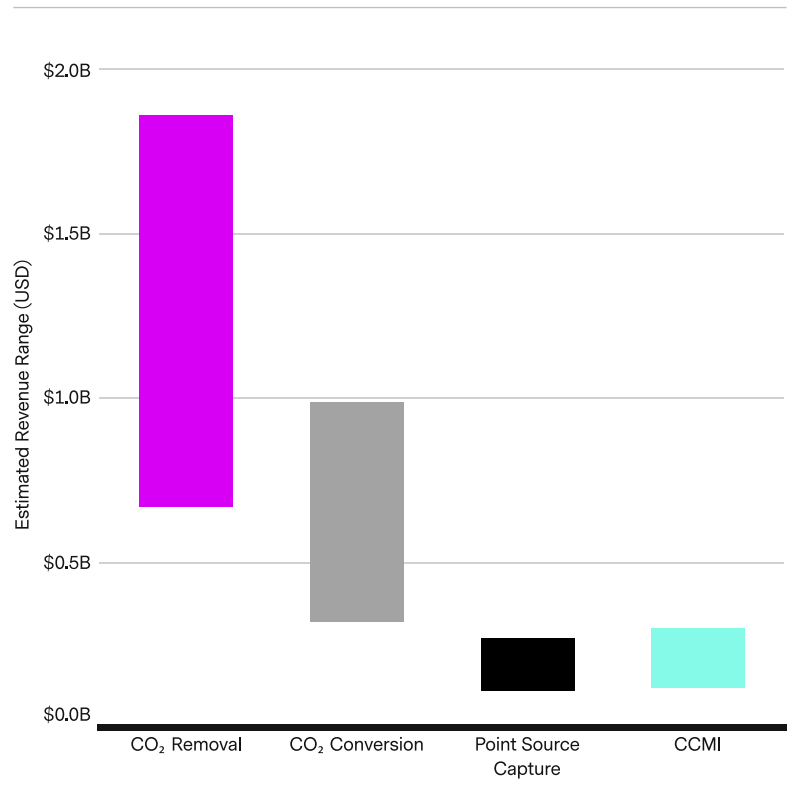
REPORTED REVENUE

\$1.3B - \$3.3B

Based on data reported in 2023, Circular Carbon companies are cumulatively generating between one and three billion dollars in revenue. The range presented here represents the sum of each end of reported revenue ranges. As our primary data (the source of this information) is collected in ranges, we are not able to break this down to a more specific number. Additionally, data coverage on this primary data question is 56%, which means that the range is likely higher than these reported numbers. This range of numbers can be thought of as a floor of the revenue being generated within Circular Carbon solutions instead of total addressable market.

Further breakdown of this data shows us that reported revenue is highest among removal companies, and they also have the largest range of reported revenue. Since removal solutions are so diverse in capital intensity and deployment, this is not surprising. Conversion companies also have a fairly large range, with lower reported revenue than removal companies. Generally, point source capture and CCMI companies report having narrower and lower revenue ranges.

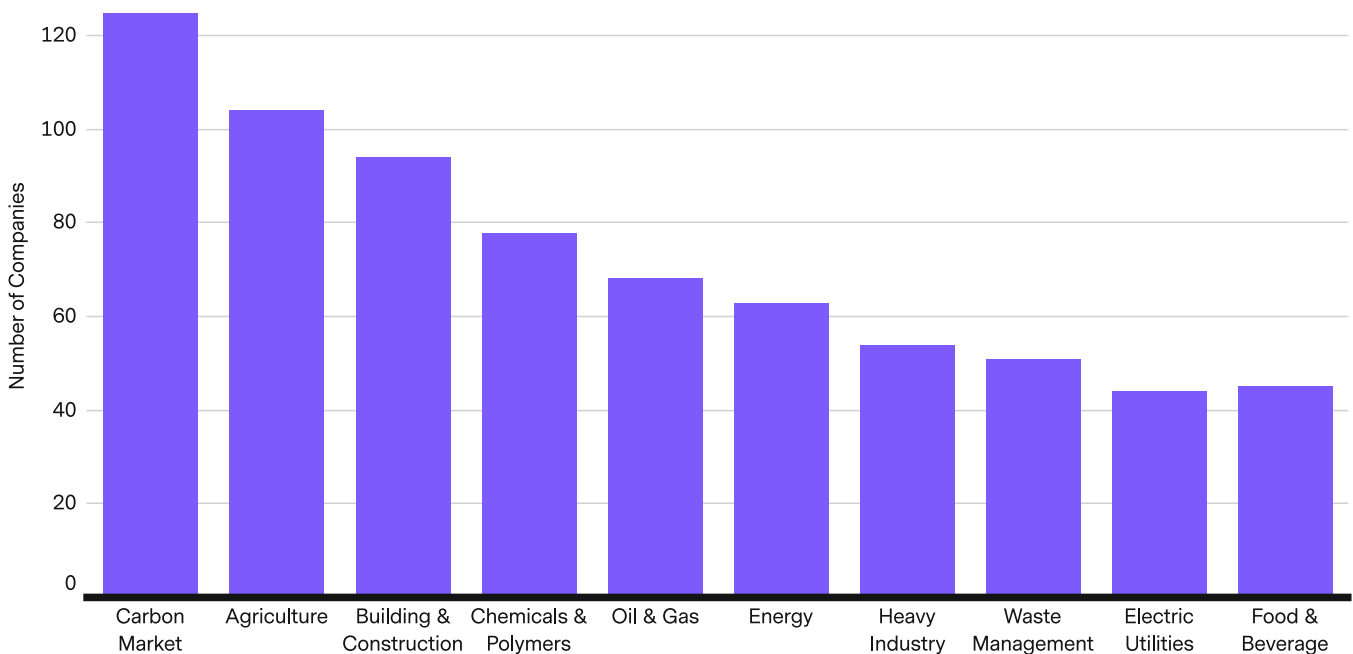
Cumulative Reported Revenue Ranges by Solution Type



Data Coverage: 55.92%

AGRICULTURE AND THE CARBON MARKET ARE BIGGEST TARGET INDUSTRIES FOR CIRCULAR CARBON COMPANIES

Even though many companies have taken advantage of the robust government support recently made available to this sector, the revenue for Circular Carbon companies eventually must come from one of two sources: selling physical products or selling carbon credits. In the CCN survey, companies are asked to identify their target industries for sales and revenue in a multi-select question.



Data Coverage: 32.73%

The carbon market has consistently been at the top of this list. Since 2021, the carbon market has remained the top selection, indicating that the majority of companies are looking to, or already rely on, this revenue. Agriculture, chemicals/polymers, and building/construction are the highest target industries for physical products. There are also 98 companies in the Index with a combined revenue model of selling credits and products.

Overall, the group of companies targeting or already using the carbon market have a higher percentage of companies indicating they generate revenue, while the group of companies making a physical product has raised much more capital on average (despite reporting less revenue generation).

THE CARBON MARKET

There are 125 companies that report utilizing or targeting the carbon market as a source of revenue. They have indicated that they are interested in or are already utilizing both the traditional voluntary carbon market registries (such as [Verra](#) and [American Carbon Registry](#)) as well as newer carbon market mechanisms (such as [advanced market commitments](#) and [Puro](#)). These companies span from nature-based removals to hybrid approaches (such as carbon stored in buildings), as well as direct capture and removal technologies. They represent \$2.7B raised to date, and 54% report to be generating revenue.

PHYSICAL PRODUCTS

683 companies indicated that they make a physical product. This covers the conversion of carbon into valuable products such as chemicals and fuels, carbon fibers, or vodka, or the production and distribution of biochar and algae-based soil amendments. Additionally, anything that is a by-product of a natural process is also considered a product. These companies represent \$20.9B raised to date, and 34% of them report generating revenue. It is interesting to note that the companies making physical products that are pre-revenue represent \$3B of capital raised to date.

NON-CONVERSION / UTILIZATION COMPANIES THAT MAKE A PRODUCT

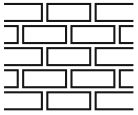
Carbon conversion companies were not the only companies that indicated making a physical product. An additional 297 carbon removal and point source companies indicated they are making a physical product. Interestingly, these companies are mostly working to create machines or materials that will eventually convert carbon into a product. Some examples of these companies include:

[287K](#) / [Envirohome](#) / [Global Thermostat](#) / [Mission Zero Technologies](#) / [Susteon](#)

Please note: Companies are listed here as illustrative examples of work being done in this space but this by no means an exhaustive list.

The most common product types fall into these categories:

Please note: Companies are listed here as illustrative examples of work being done in this space but this by no means an exhaustive list.



Building Materials (27%)

Carbon dioxide can be mineralized into carbonates that serve as a building material component, particularly in concrete production. This utilization helps offset carbon dioxide emissions associated with traditional manufacturing processes.

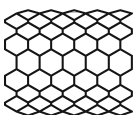
Examples:

Carbon Capture in Cement Production: Cement production is a significant source of carbon emissions. Techniques are being developed to capture carbon emissions directly from industrial processes like cement production. This captured carbon can then be mineralized and used in the production of eco-friendly building materials.

CarbiCrete - CarbiCrete is a carbon removal technology company whose patented technology enables the production of cement-free, carbon-negative concrete.

Development of Carbon-Based Building Blocks: Scientists are working on developing new building blocks or aggregates using carbon as a raw material. These blocks have the potential to replace traditional materials, further reducing the environmental impact of construction.

Vartega - Vartega recycles carbon fiber at scale, creating a drop-in replacement for virgin chopped carbon fiber for thermoplastic compounding. Sourcing carbon fiber from multiple dry fiber and prepreg scrap origins, the company maintains identical mechanical properties of the original carbon fiber in a less costly and ESG-friendly solution. Vartega offers this carbon fiber in short fiber configurations, tailor-made for applications in thermoplastics (polyamide and polyolefin most commonly), non-woven fabric, and molding compounds, with a range of sizing chemistries to fit the application.



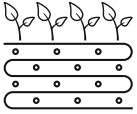
Advanced Materials (25%)

Innovative methods convert carbon dioxide into advanced materials like carbon nanotubes or graphene. These materials possess unique properties useful in high-tech industries such as electronics and aerospace.

Examples:

C2CNT - Carbon dioxide undergoes a direct conversion into carbon nanotubes—microscopic yet robust fibers utilized in various applications like electronics and lightweight composites. This innovation drives a growing market shift toward advanced, lighter materials.

Twelve - Twelve is the Carbon Transformation Company, on a mission to build a fossil-free future. Their revolutionary electrochemical technology uses existing carbon dioxide to produce hydrocarbons essential for various products typically derived from fossil fuels. This innovative process fundamentally alters the approach to tackling climate change, curbing emissions, and closing the carbon loop.



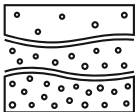
Biochar (23%)

Carbon dioxide undergoes pyrolysis—biomass heated in a low-oxygen environment, creating biochar, a stable form of carbon that is often used to improve soil fertility. This stable carbon-rich material enhances soil fertility and acts as a carbon sink by sequestering carbon from the atmosphere.

Examples:

1point8 - 1point8 produces biochar in Latin America using self-developed pyrolysis systems to sell carbon removal certificates and pays local farmers to distribute the biochar on their fields—increasing soil fertilization and nutrients. 1point8 will be one of the first suppliers of biochar in Latin America.

PYREG - A systems manufacturer and Biochar Carbon Removal Technology (BCR) provider for the recycling of biomass residuals, using environmentally friendly carbonization systems. Their more than 50 plants worldwide remove more than 30,000 metric tons of carbon dioxide annually.



Soil Additives (22%)

Captured carbon dioxide can be utilized in chemical reactions to produce soil additives like calcium carbonate or potassium bicarbonate. These additives regulate soil pH and provide essential nutrients for plant growth.

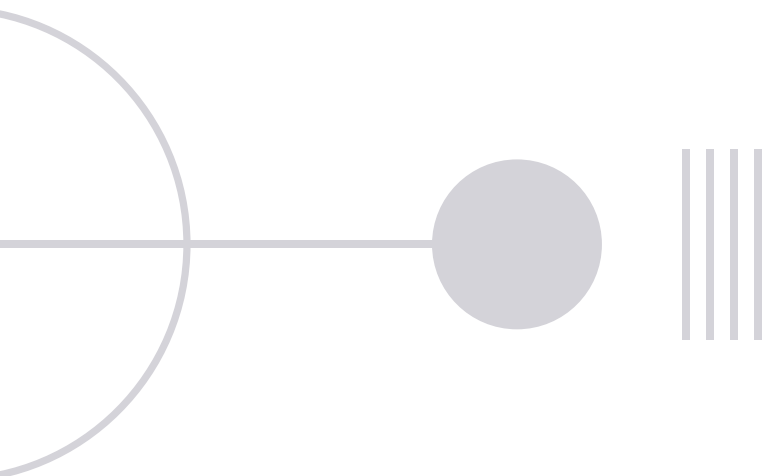
Examples:

ARCTECH - ARCTECH sequesters carbon via enhanced photosynthesis to be used to increase the PH and fertility of soils.

Bison Underground - Bison Underground is transforming unusable organic material from farms—such as off-season cover crops, stalks, stems, and leaves—into a nutrient-rich substance suitable for deep placement within agricultural soils. By converting carbon-rich organic material from crop waste, it is then injected into the soil using narrow vertical columns reaching a depth of 3 feet, employing specialized metal tines. This strategic process minimizes carbon release into the atmosphere from surface decomposition, instead sequestering it within the soil for long-term storage.

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DEFINITIONS



DEFINITIONS

CARBON REMOVAL

Carbon Removal includes approaches that result in removal of carbon dioxide (CO₂) from the atmosphere.

Air:

Air-based CDR describes a class of technologies designed to remove carbon from the air. The process typically involves using chemical reactions or filters to capture carbon from ambient, or outdoor, air. After the carbon is trapped, it can be stored using various carbon storage techniques or used for other purposes such as synthetic fuel production, carbon-negative materials, or enhanced plant growth.

Further Classifications

Solvent-based direct air capture - Solvents are pumped through a high-surface-area contactor where the solvent absorbs carbon out of the air. The solvent can then be pumped into another process where the carbon is extracted, and the solvent is reused.

Solid sorbent direct air capture - Solid sorbents selectively capture carbon from the air during a “sorption” cycle, then the carbon is extracted in pure form during a “desorption” cycle.

Electrochemical direct air capture - Electricity is used to selectively separate carbon from the air, producing a pure stream.

Membrane-based direct air capture - carbon is physically filtered from the air using membranes.

Illustrative Examples

Mission Zero Technologies: Mission Zero are developers of the next generation of direct air capture (DAC) technology delivering carbon from the air for use or storage. The process is scalable, modular, and compact, and is economically viable at any deployment scale from 1000 tons/year upward. With 3-5 times lower costs and energy consumptions compared to today’s DAC solutions, Mission Zero is helping to change our relationship with carbon by unlocking it as an affordable and accessible commodity to be circularized.

Carbon Engineering: Carbon Engineering is focused on developing megatonne-scale DAC technology at a low cost so that it can have the greatest impact on emissions

Land:

Plants are an effective way to efficiently capture carbon from the atmosphere by leveraging photosynthesis. Further, biomass can provide an effective vector for sequestering carbon durably in standing biomass and soils, or by converting biomass into another form (energy, durable products, bio-oil, etc.) to facilitate durable sequestration.

Further Classifications

Thermal conversion of biomass - This includes the production of biochar, bio-gas and bio-oil for storage.

Biological conversion of biomass - A number of products can be produced from biomass using biological processes like fermentation and anaerobic digestion.

Biomass to energy - Coupling biomass-fueled electricity or heat generation with carbon capture and storage.

Biomass direct burial - Sequestering biomass directly underground, ensuring that future emissions of carbon and other greenhouse gasses generated by decomposition are not released.

Biomass sequestration in the built environment - Bio-based construction materials can effectively sequester carbon in buildings and other structures.

Terrestrial ecosystem restoration and management - Restoring and maintaining standing carbon stocks like forests, peatlands, wetlands, etc.

Agricultural & grassland CDR - Utilizing crops as a means of carbon capture, and soil as a means of sequestering carbon.

Carbon capture and storage from biogenic sources - Photosynthesis is used to capture carbon in the form of plant matter (biomass). Pure carbon can be extracted from the biomass.

Illustrative Examples

1point8: Utilizing a process of biomass pyrolysis, certifiable biochar is generated, effectively storing carbon for extended periods, often spanning several hundred years. Through an innovative pyrolysis reactor design, complexity and production expenses are significantly reduced, achieving a remarkable 20-fold decrease in costs.

Andes: Andes has created beneficial microorganisms that are added to the soil along with agricultural seeds, such as corn and wheat. These microorganisms grow with plant roots and accelerate the conversion of carbon into minerals. With rainfall, these minerals move deep into the soil, making room for annual carbon removal.

Ocean:

There are a variety of mechanisms to capture and sequester carbon in the ocean: Some ocean CDR pathways leverage biological systems to capture and sequester carbon, while others leverage technologies to extract carbon from the seawater.

Further Classifications

Macroalgae cultivation - This includes growing and harvesting kelp and other “seaweed” to accumulate carbon in biomass.

Microalgae cultivation - This includes managing the growth of phytoplankton.

Biomass sinking - Managing the transfer of biomass from the surface ocean into the deep ocean, where the carbon will be sequestered.

Artificial upwelling/downwelling - Managing the transfer of carbon-rich water down into the deep ocean, or the transfer of nutrient-rich water from the deep ocean to the surface.

Ocean alkalinity enhancement - Mining or synthesizing alkaline materials, and adding them to the ocean to react with dissolved carbon in the seawater.

Nutrient fertilization - Adding nutrients to nutrient-limited areas to facilitate the growth of phytoplankton or other biomass.

Electrochemical carbon separation - A number of electrochemical methods can be used to separate carbon from ocean water.

Ocean ecosystem restoration - Restoring marine ecosystems sequesters carbon in standing biomass and other aquatic life.

Illustrative Examples

Running Tide: Running Tide is employing materials, including macroalgae and terrestrial biomass, to enhance natural carbon removal processes of kelp and other ocean removal. The growth process captures carbon via macroalgae's photosynthesis, and Running Tide facilitates sinking materials into the deep ocean.

Atmocean: Atmocean has created a system of wave and salinity-driven downwelling tubes which relocate upper ocean water containing this excess carbon to the intermediate and deep oceans, where it is isolated for decades to centuries, delaying its respiration and allowing greater absorption of atmospheric carbon in the surface ocean.

Rocks:

The concept of using rocks to remove carbon from the atmosphere is based on the fundamentals of mineral carbonation. This process can be seen occurring naturally over thousands of years as carbon dioxide reacts with certain types of rocks to form stable minerals, a process called weathering. By accelerating this process, we can harness the power of these reactive minerals to remove carbon dioxide on a much faster timescale. Rocks-based methods can be divided into two broad categories: those that happen underground (known as in-situ mineralization) and those that happen above ground by exposing crushed rocks to carbon bearing gasses (known as ex-situ or surficial mineralization).

Further Classifications

Ex-situ mineralization of mined rocks - Reactive rocks are mined, crushed, and otherwise treated to enhance the rate of carbon capture.

Mineralization of mine or industrial waste - Carbon can be reacted with tailings from industrial processes to sequester the carbon and treat the tailings.

In-situ mineralization (mafic or ultramafic mineralization, etc.) - Carbon is injected into reactive reservoirs where the carbon is permanently converted into carbonate minerals.

In-situ storage in sedimentary reservoirs - Carbon is injected into deep reservoirs where high confining pressures keep the carbon contained for millenia.

Calcination of minerals with Carbon capture - This involves using high temperatures to break down minerals into carbon and mineral oxides—which can then be used to capture more carbon.

Illustrative Examples

UNDO: UNDO operates as an enhanced rock weathering carbon removal enterprise. Their method involves augmenting and expediting the process of dilute acid naturally descending onto mountains, forests, and grasslands. During this

process, carbon engages with rocks and soil, undergoing mineralization and securely converting into carbonate form. Their approach to enhanced rock weathering entails spreading crushed basalt rock across farmland. This action amplifies the surface area of the rock, ensuring immediate interaction with the carbon generated by plant roots and soil microbes, and accelerating the carbon sequestration process.

Vaulted Deep: Vaulted Deep is focused on sedimentary geological sequestration. The technology takes organic, carbon-bearing waste that would have decomposed above ground, emitting carbon and methane, and injects it underground for permanent carbon removal. A broad range of organic wastes includes biosolids, agricultural and livestock waste, and paper sludge. A “slurry” is created and injected for permanent carbon removal.

CARBON CONVERSION

Technologies that convert captured carbon oxides into economically valuable products such as chemicals, fuels, building materials, plastics, and bioproducts.

Biological Process:

Utilizing the metabolic capabilities of living organisms, such as microorganisms or plants, to transform carbon dioxide into organic compounds or biomass through various enzymatic or biochemical pathways.

Illustrative Examples

Visolis: Visolis leverages biology to craft top-tier materials, employing an integrated approach that merges biological innovations, chemical catalysis, and scalable processes to foster novel bio-based manufacturing platforms, culminating in the creation of genuinely carbon-negative products for the future.

Electrochemical Process:

Utilizing electricity to drive the transformation of carbon dioxide into valuable products.

Illustrative Examples

OCO Chem: OCO Chem transforms and stores electric energy as chemical energy, employing an OCOchem electrolyzer device to bind carbon with hydrogen from water, and creating a secure liquid organic molecule, formate. Subsequently, this stored energy can be easily transported and released as hydrogen via an OCOchem reformer.

Thermochemical Process:

Using heat-driven chemical reactions to convert carbon-containing compounds, such as carbon dioxide, into useful products or materials.

Illustrative Examples

Red Rocks Biofuels: Red Rock Biofuels converts woody biomass into jet, diesel, and naphtha fuels.

Mineralization Process:

Harnessing natural or engineered chemical reactions to transform carbon dioxide into stable mineral forms used for industrial purposes.

Illustrative Examples

Fortera Globa: Fortera Globa separates carbon from waste during the cement creation process, converting it into “ReAct,” a precipitated calcium carbonate polymorph, which can be blended into ASTM C150*, C595*, or C1157 cements or mixed into concrete during batching.

Photochemical Process:

Using light energy to drive chemical reactions, typically involving carbon dioxide, to generate valuable compounds or fuels.

Illustrative Examples

New Iridium: New Iridium’s oxidation process converts bio-ethanol to acetic acid, and its photocatalysis technology, mimicking nature’s approach, uses light energy to upcycle carbon into valuable products through light-driven carboxylation chemistry, producing carboxylic acids.

POINT SOURCE CAPTURE

Technologies allowing a large emissions source to capture and divert carbon, preventing it from being emitted into the atmosphere.

Amine Capture:

A chemical absorption method that uses amine compounds to selectively capture and separate carbon dioxide from industrial emissions.

Illustrative Examples

C-Capture: C-Capture captures carbon from a power station flue gas to be sent for storage in geological reserves, or utilized in some way.

Carbon Quest: Carbon Quest offers on-site carbon capture specifically for new building construction.

Membrane Separation:

Utilizing specialized membranes to selectively separate and concentrate carbon dioxide from industrial exhaust gasses.

Illustrative Examples

Osmoses: smoses enables energy producers to separate gases with higher product recovery and higher energy efficiency via membrane separation.

CIRCULAR CARBON MARKET INFRASTRUCTURE

Approaches that provide essential and direct support to Circular Carbon companies and the Circular Carbon ecosystem marketplace. Within Infrastructure companies there can be significant overlap between service types.

Project Developer:

Project developers are entities involved in various aspects of Circular Carbon initiatives. They engage in facilitating, overseeing, or managing carbon removal projects, offering diverse services such as project financing, legal support, and technical expertise. These developers are instrumental in navigating the multifaceted aspects of Circular Carbon initiatives, ensuring successful implementation from inception to operation.

Illustrative Examples

Deep Sky: Deep Sky is a Canadian state-backed venture building infrastructure to scale carbon dioxide removal systems in a tangible way, by bringing together partners in the carbon removal space and offering them space and resources for their tech. They're focused on technologies that meet three key criteria: Pathways to low energy intensity, simplicity and focus of the technology, and scalability of supply chain.

Pachama (Carbon Credits): Pachama trains machine-learning models using satellite imagery, Lidar, radar and field plots to estimate the carbon stored in forests today and into the future. Using satellite data to compare nearby areas, Pachama observes what would have happened without a carbon project.

Technical Service Provider:

Technical service providers offer specialized expertise and support in the implementation, monitoring, and maintenance of carbon removal projects. They bring technical innovation and practical solutions, and contribute essential services, including but not limited to product suites, monitoring and verification technology, carbon market data analysis, and project optimization.

Illustrative Examples

CarbonFuture: CarbonFuture provides a product suite for carbon removal, MRV, and other software needs to enable carbon removal and purchasing of removals. CarbonFuture Marketplace and CarbonFuture MRV+ can be integrated into any product experience, including ERP systems. This integration streamlines the management of carbon removal projects and the procurement and retirement of carbon removal credits, eliminating any friction in the process.

Yard Stick: Yard Stick’s MRV software provides a web-based dashboard to which farms can upload field boundaries, select the methodology they want to use for their project, and generate point data. Yard Stick can then produce a sample plan aligned with major carbon methodologies.

Carbon Credit Marketplaces and Registries:

These platforms act as marketplaces or registries where carbon credits generated from various carbon removal projects are bought, sold, tracked, and retired. They provide a transparent and regulated environment for trading carbon credits, enabling businesses and organizations to invest in and manage their carbon footprint through the purchase and use of these credits.

Illustrative Examples

Puro.earth: Puro.earth is scaling the Carbon Dioxide Removal industry by connecting buyers with suppliers physically capturing carbon from the atmosphere and stabilizing it in a durable storage. Puro.earth focuses only on engineered carbon removal (non-nature-based removals).

Nori: Nori is constructing an open-source market infrastructure designed to facilitate carbon removal projects in quantifying and monetizing their efforts. Through a voluntary marketplace operating on blockchain technology, the platform aims to facilitate direct connections between carbon removal suppliers and buyers. This initiative is geared toward enhancing efficiency and cost reduction within the carbon removal ecosystem.

Project Financier / Financial Enabler:

Project financiers or financial enablers play a pivotal role in providing capital or financial instruments to support Circular Carbon projects. They facilitate funding for the development, implementation, and scaling of carbon removal initiatives, often investing in projects that might otherwise face challenges securing financial backing, thereby accelerating the growth of the carbon removal sector.

Illustrative Examples

CUR8: CUR8 is on a mission to remove 1 billion tonnes of carbon. They combine financial and scientific expertise to build high-quality and diverse carbon removal portfolios that enable companies to invest in carbon impact with confidence and reach net zero. They are market-makers for carbon removals, accelerating market development by unlocking financing for the most innovative carbon removal projects to scale.

Flowcarbon: Flowcarbon is financing the future of carbon solutions through pioneering project finance and technology, project development and credit portfolio services. They are defined by their full-scope approach, cutting-edge products and a global team with world-class expertise spanning project development, project finance and carbon credit sales.

Software / Platform Developer:

These companies focus on developing software solutions, platforms, or applications tailored to the needs of the carbon removal space. Their technological innovations encompass diverse functionalities, including project management tools, carbon tracking software, API integration, analytics platforms, and other digital solutions aimed at enhancing efficiency, transparency, and scalability.

Illustrative Examples

Watershed: Watershed’s software platform works to accelerate the fight against climate change by helping businesses measure, reduce and report their climate emissions strategy.

Patch: Patch is building the infrastructure for a sustainable economy, starting with an API for carbon removal and climate action. They partner with a broad range of projects across both nature-based and non-nature-based solutions.