



2024

# CIRCULAR CARBON MARKET REPORT

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Analysis of Current Market Trends, A Retrospective  
on the Industry, and Lessons to Carry Forward



**Circular Carbon Network**  
AN XPRIZE INITIATIVE



# ABOUT CCN

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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 report is to analyze the annual investment and growth trends within the Circular Carbon sector.

## THROUGH OUR DATA ON 1,089 COMPANIES, WE CATALYZE ACTION BY HELPING:

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- › Investors find Circular Carbon companies that fit their thesis
- › Corporates identify potential startup innovation partners
- › Entrepreneurs feature their company to an investor audience
- › 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 into four main categories: CO<sub>2</sub> removal, CO<sub>2</sub> conversion, point source capture, and Circular Carbon market infrastructure (CCMI). [See Definitions](#)

It is important to highlight that we do not cover emissions 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 “climatetech” and “carbon” narratives of other market reports and analyses.

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.

# ACKNOWLEDGEMENTS

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We gratefully acknowledge the contributions of all those who made this report possible:

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# TABLE OF CONTENTS

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## 05 [Executive Summary](#)

---

## 07 [Past: A Retrospective on Circular Carbon](#)

- › 1960s - 2004 - The Birth of Circular Carbon
  - › 2005 - 2014 - The CleanTech 1.0 Era
  - › 2015 - 2017 - Paris Agreement Catalyzes Climate Action
  - › 2018 - 2020 - Carbon Removal Deemed Necessary by Scientific Consensus
  - › 2021 - 2023 - A Tipping Point for Circular Carbon
- 

## 20 [Present: 2024 Circular Carbon Market Trends](#)

- › Trend 1 - Fewer New Companies Entering the Space
  - › Trend 2 - Fewer Number of Deals, But Increasing Amounts
  - › Trend 3 - More Later Stage Deals
  - › Trend 4 - Larger Rounds for Growth Capital
  - › Trend 5 - Sub-Sector Activity Remains Steady
- 

## 32 [Future: Lessons to Carry Forward](#)

- › Emissions Check-In
  - › Lessons Learned and Greatest Opportunities
- 

## 37 [Circular Carbon Timeline](#)

---

## 51 [Methodology](#)

# EXECUTIVE SUMMARY

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At this important moment, mid-decade and only five short years away from 2030 net-zero goals, we look at the critical path for the Circular Carbon industry. This capstone report is intended to provide leaders across the industry and beyond with useful data and insights that have been informed by XPRIZE's decade of work in the space, first with the NRG COSIA Carbon XPRIZE (2015-2021) and followed by the XPRIZE Carbon Removal (2021-2025). We dive into the history of Circular Carbon, looking at the key inflection points that have driven its growth, and provide useful data and insights that can be applied to accelerate the achievement of our climate goals.

The report is organized into three sections: a retrospective of the past, current market trends, and lessons to carry forward. We look at the early milestones that formed the building blocks for the emergence of a Circular Carbon industry, and the formation of nearly 1,000 new companies in the space over the last decade. The report also analyzes deal data from 164 Circular Carbon companies who raised capital in 2024 comparing trends to previous years. We also interviewed leaders in the Circular Carbon space who were critical to the industry's growth (listed in [Acknowledgements](#)), and they contributed their insights on the key future lessons to carry forward.

## **Past: A Retrospective**

The Circular Carbon industry has undergone meaningful transformation in recent decades, marked by continuous progression in the underlying technology, investment models, and industrial use cases. The foundations of the industry were laid in the 1970s with early Carbon Capture and Storage (CCS) and Enhanced Oil Recovery (EOR) projects, which proved the economic viability of Circular Carbon. Key drivers of growth since then have come in the form of international policy efforts, growing public awareness of climate change, and market-driven solutions for climate action. The Cleantech 1.0 era also proved critical for the development of Circular Carbon initiatives, financing renewable energy in a way that has gained considerable momentum. More recently, global negotiations and technology innovations have been supported by a surge of investment and key policy developments, positioning the industry for continued growth.

## **Present: 2024 Circular Carbon Market Trends**

Reflecting the remarkable interest that Circular Carbon has now garnered, cumulative Circular Carbon investment over all time reached \$27.7B in 2024, with \$6.6B deployed last year – an increase from 2023 (\$5.3B). As further detailed in this report, however, there are clear changes taking place in the way capital is being deployed in the sector. Most prominently, many signs are pointing to investors' focus transitioning from early stage innovations to more project deployment and scaling. This is evident through the slowing of new early stage investments and an increase in later stage deals. While there is still significant technology development happening, it is more consolidated than it was earlier in the decade. Other top trends of 2024 include a smaller number of companies being founded, capital moving toward later deal stages, and steady activity across Circular Carbon categories.

# EXECUTIVE SUMMARY

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## Future: Lessons to Carry Forward

Looking ahead, it is critical to realize that progress is possible. The industry evolved out of almost nothing, and this was done by collaborating across organizational and industry boundaries to figure out what the next steps had to be - and then taking them. These need to continue to be foundational tactics used in the future. The remainder of the decade will likely see a doubling down of investment into companies working on existing technologies with the capacity to overcome the barriers to scaling – in a way that is both economically viable and politically palatable. Those companies that are able to bring lessons of communications and a focus on infrastructure development will be prime for explosive growth when future funding waves come.

As you will see throughout this report, the Circular Carbon industry has come a long way. To make a meaningful climate and economic impact, Circular Carbon solutions must overcome barriers related to demand, capital, infrastructure, and public acceptance. There must be a focus now on global deployment so it can become a widespread, industrialized, and international industry. Please share this report with others in your network, including researchers, investors, corporate actors and other stakeholders; and use this data to catalyze conversations about how to continue to turn promise into progress for Circular Carbon.



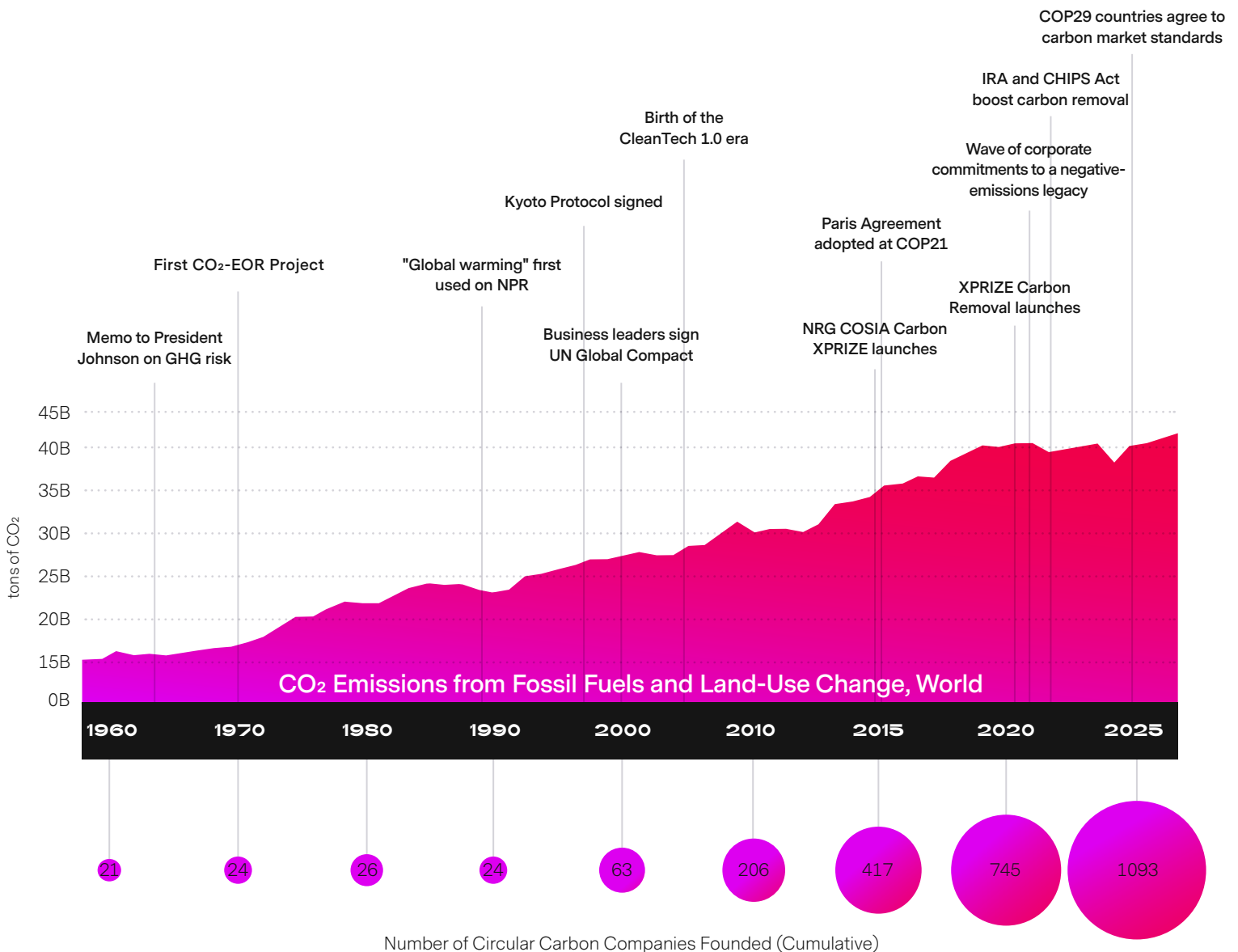
# **PAST:**

A RETROSPECTIVE ON  
CIRCULAR CARBON

# INTRODUCTION

The Circular Carbon sector has evolved significantly over the past few decades, driven by the urgent need to mitigate climate change and the vision of integrating these solutions into modern economic frameworks. Continuous innovation has shaped the sector, with technical breakthroughs and applications expanding across various end markets over decades. This progress is evidenced by the growing number of companies in all stages of technology maturity, commercial deployment, and revenue generation over this timespan. Corporate investment, global policy, and private capital have all played an interwoven part in this history, fueling both research and scaling efforts. This retrospective section explores the historical trajectory of Circular Carbon, highlighting the lessons learned from past efforts and examining how multi-stakeholder collaboration will continue to drive progress.

For an in-depth retrospective on the history of Circular Carbon, visit the [Timeline](#) section.





# 1960s - 2004

## The Birth of Circular Carbon

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More than 60 years ago, evidence first emerged of the potential for carbon dioxide (CO<sub>2</sub>) to trigger a global crisis. In a memo to President Lyndon Johnson, the Scientific Advisory Committee of the Task Force on Environmental Pollution outlined the risks posed by the “greenhouse gas effect” and even suggested the need for geoengineering solutions to address it. It would take many decades and a trillion tons of additional carbon emissions before the world would begin addressing CO<sub>2</sub> as a critical issue at a global level.

The problem of CO<sub>2</sub> control in the atmosphere is tackled by proposing a kind of ‘fuel cycle’ for fossil fuels, where CO<sub>2</sub> is partially or totally collected at certain transformation points and properly disposed of.

— Cesare Marchetti, *On Geoengineering and the CO<sub>2</sub> Problem*, 1977

“Circular Carbon” is the concept of directly cycling carbon-based molecules within industrial value chains or in natural cycles. The term “carbontech” encompasses technologically enabled means of capturing, utilizing, and/or storing carbon, whether derived from the atmosphere or ongoing emissions, while “carbon removal” refers to the durable removal of carbon from the atmosphere through technological, biological, or geological means. **The discussion of Circular Carbon throughout this report encompasses the parts of this overall ecosystem of solutions that directly cycle carbon-based molecules and address climate change in a material way.** This ecosystem was not built in a day, or even a decade. It took many years of trial and error to be in the position it is in now – on the cusp of scaling.

One of the earliest efforts to reuse carbon dioxide was the development and application of Enhanced Oil Recovery (EOR)<sup>1</sup>, a process initially developed in the 1970s to improve oil extraction from mature fields, a process now considered controversial by many in the context of current climate science around the need for massive carbon reduction. By injecting carbon dioxide into depleted oil wells, additional oil reserves could be recovered that would otherwise remain inaccessible. Often, the injected carbon dioxide remained trapped underground, stabilizing the depleted reservoir. Regardless of criticism that would come many decades later, these early experiments in EOR established the framework in which **carbon dioxide could be viewed as both a tool for economic value creation and a component of a beneficial environmental management strategy.**

<sup>1</sup> “9.2. Commercial Carbon Dioxide Uses: Carbon Dioxide Enhanced Oil Recovery,” [Netl.doe.gov](https://www.netl.doe.gov).

The first large scale CO<sub>2</sub>-EOR project, named SACROC, was developed by Chevron. It piped natural sources of CO<sub>2</sub> from Colorado to Texas, injecting 175 million tons of CO<sub>2</sub> between 1972 and 2009.<sup>2</sup>

Inspired by the results of the EOR projects that had come before them, several early innovators in the 1990s pioneered and proved the concept of capturing CO<sub>2</sub> from industrial sources and storing it geologically, whether for EOR or for pure carbon mitigation purposes, known as Carbon Capture and Storage (CCS). Extensive infrastructure was built (pipelines, monitoring technologies, and injection wells), laying the foundational assets needed for much of the emerging Circular Carbon sector that exists today. These projects also pioneered harnessing the diverse capital streams needed to support and de-risk Circular Carbon opportunities. One of the most influential examples of this occurred at the turn of the century: the Weyburn Project began as an interdisciplinary scientific research project on the geological storage of CO<sub>2</sub> in Saskatchewan, Canada, and, over time, was successfully converted into a commercial project.<sup>3</sup> The transition from research-based efforts and funding to commercial operations would become a replicable model in the years to come. The success of this and other early projects proved that **CCS could be economically and commercially viable without government subsidies** and also birthed more focused research on capturing low-concentration CO<sub>2</sub> from industrial plants (point source capture).

The Kyoto Protocol, ratified near the turn of the century, marked a pivotal moment in the global awareness of climate change. It legally bound developed nations to reduce greenhouse gas emissions, using a market-based system of carbon credits to pay developing nations to deploy emissions-reduction projects. **These frameworks, specifically the Clean Development Mechanism, introduced the idea of a market-driven solution to climate action** and fostered a new industry around carbon capture and utilization, and the early development of nature-based solutions. This period saw a confluence of policy, economics, and science that laid the groundwork for future climate negotiations and increasingly innovative sustainable development strategies.

#### TAKEAWAYS:

- ▶ Focused on creating economic value, early EOR and CCS projects de-risked some of the tech and infrastructure necessary for today's growing Circular Carbon ecosystem.
- ▶ The Clean Development Mechanism introduced the idea of a market-based solution to climate action that would be expanded and refined in many forms over the coming decades.

<sup>2</sup> "[Carbon Capture and Storage: History and the Road Ahead](#)," *Engineering*, vol. 14, July 2022.

<sup>3</sup> "[7.5.2. Weyburn Project](#)," Netl.doe.gov

# 2005 - 2014

## The CleanTech 1.0 Era

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By the mid 2000s, the devastation of Hurricane Katrina, the release of Al Gore's documentary *An Inconvenient Truth*, and the ongoing international debates at the United Nations climate negotiations, among other factors, started to increase the pressure for more aggressive climate change action. With energy prices soaring and concern over potential carbon reduction regulations becoming a reality, a wave of investment surged in the pursuit of a clean energy transition. Power companies faced the dual obligation of keeping the electricity that their customers needed affordable while also beginning the shift away from coal. Several of these forward-looking energy companies played a part in supporting the beginning of the energy transition effort. Notable investments surged into renewable energy during the **“CleanTech 1.0” era, a period from 2005 to 2011 that marked a pivotal shift in industry awareness of clean energy and the beginning of climatetech.** This funding spurred innovation in energy research and ignited a wave of early cleantech and Circular Carbon startup activity.

During this time, there was a strong sense that venture capital was the right solution to meet this moment. However, the dot com boom had accustomed investors to fast and large returns from relatively capital-light investments. Five years into the new century, many of these same Silicon Valley investors turned their pocketbooks toward cleantech. Collectively, venture capitalists poured more than \$25B into clean energy technologies from 2006 to 2011.<sup>4</sup> These cleantech projects, however, were both capital- and time-intensive, and the path to sustainable profits was not clear from the still-emerging demand for clean energy solutions. In part **due to the unrealistic capital outlays and return schedules, more than half of these investments would be lost** in a short amount of time. This collapse highlighted the risks of overinvestment in unproven cleantech solutions. Of course, several macroeconomic forces were also at play, including the fracking boom (which drove down oil prices), the financial crisis, and the Great Recession of 2008.

Although the era is often referred to as a “bubble that burst,” **CleanTech 1.0 delivered critical successes and valuable lessons for what was to come.**

CleanTech 1.0 presented a replicable model that could be built upon for project development, created expertise around new financing structures, and level-set the longer investment time-horizons required. Perhaps most significantly, the rapid development and growth of wind and solar energy production laid the groundwork for the renewable energy availability required to develop the Circular Carbon market today.

Parallel to this activity, Circular Carbon technologies also started to garner more research and development. One driver of this was the Virgin Earth Challenge that was launched in 2007. This initiative was one of the first large-scale efforts focused on carbon removal, and helped to bring Circular Carbon concepts closer to the

<sup>4</sup> [“Venture Capital and Cleantech: The Wrong Model for Clean Energy Innovation,” SSRN Electronic Journal, 2016.](#)

forefront of climate discussions. However, the potential competitors at the time were all relatively new and untested, and their projects were not yet ready for broad deployment. Ultimately, the Virgin Earth Challenge ended without a winner.

With global emissions continuing to rise, two key areas of development in technology and markets occurred during this period that would enable greater action today:

**1** Several companies had already taken the leap in developing early commercial pilots of direct air capture (DAC) technology, notably Climeworks, Carbon Engineering, and Global Thermostat. These early pilots focused on proving the feasibility of capturing CO<sub>2</sub> directly from the atmosphere, but funding remained limited for such early-stage, high-risk approaches. While high costs were a major concern of this burgeoning concept, these early movers in the space laid critical groundwork for future solutions.

**2** Based on the market-based concept laid out in the Kyoto Protocol, various trading mechanisms aimed at reducing emissions were established, such as the Chicago Climate Exchange (2003-2010), the Gold Standard's Voluntary Emission Reductions (VER) program (2006), and the Verified Carbon Standard (VCS), launched in 2005. The European Union's Emissions Trading System (EU ETS) also began in 2005, signaling a shift toward a more structured global approach to carbon markets. As these efforts gained momentum, it became clear that innovative solutions for both carbon removal and emissions reductions were not only possible but increasingly essential to addressing the climate crisis. These early markets were not without flaws, but they established a global framework for carbon trading.

However promising, most **Circular Carbon technologies only existed on a pilot level** and faced significant challenges in scaling due to their technological complexity, early-stage development risks, and lengthy pathways to achieving ROI.

There were also several other barriers to increasing the pace of commercialization of the sector, including the lack of high-quality deal flow, a dearth of investors to syndicate deals, geographic dispersion, and a misalignment of entrepreneur and investor expectations around valuations. In addition, a general lack of urgency underpinned the initial slow development of the Circular Carbon sector. Despite these obstacles, the advancements of early Circular Carbon efforts highlighted the promise of turning carbon from waste into value and laid the foundation for broader adoption.

## TAKEAWAYS:

- › The CleanTech 1.0 era was doomed by unrealistic capital expectations and unclear market signals for demand. At the same time, we learned critical project development skills, the importance of stakeholder alignment, and the techno-economic frameworks necessary for success.
- › The maturation of solar and wind energy production into large-scale, successful, commercial industries established a positive model for the clean economy, built project and finance competency across the sector, and created an increasingly large pool of low-carbon energy.
- › Early efforts in DAC technology and market-based mechanisms laid critical groundwork for future climate action.

# 2015 - 2017

## Paris Agreement Catalyzes Climate Action

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At a time when a basic understanding of the importance and potential of Circular Carbon was essentially zero (outside of niche industrial sectors), key moments played a critical role in elevating the global awareness of the need for new solutions, particularly in finding win-win-win ideas like Circular Carbon to address the threat of climate change. Little by little, the idea of taking captured carbon and using it to create value in products and industry evolved further from those very early CCS projects. For example, captured carbon was increasingly being used in various industrial applications, such as in chemical fertilizer as a source of urea; in manufacturing for the production of plastic, adhesives, and coating; and in the beverage industry as a substitute for natural sources of CO<sub>2</sub>. Still, these initial carbon utilization efforts were focused on creating economic value, not necessarily stabilizing the atmosphere. That shift – from a pure economic play to a combined strategy that included climate-positive processes – grew over many decades because of the growing awareness of the climate crisis.

In August 2015, XPRIZE announced the \$20M NRG COSIA Carbon XPRIZE to catalyze climate action and incentivize the development of new carbon utilization technologies that could generate value from the abundant waste of CO<sub>2</sub>. This helped generate new excitement and R&D efforts around Circular Carbon technologies and spur new collaboration and investment across government, academia, and the private sector. Developed for the prize, two new carbon utilization test centers, the Wyoming Integrated Test Center (ITC) and the Alberta Carbon Conversion Technology Centre (ACCTC), became active and served as magnets for innovators and a budding community of Circular Carbon pioneers. Many of these early adopters started to develop clear business models and show real market potential, which attracted further investment and competition.

The NRG COSIA Carbon XPRIZE yielded two winners, **CarbonCure Technologies** and **CarbonBuilt**,<sup>5</sup> both with solutions aimed at reducing the CO<sub>2</sub> emissions associated with traditional concrete, the world's most abundant human-made material that accounts for 8% of all global CO<sub>2</sub> emissions.<sup>6</sup>

In parallel, large organizations and policymakers started pursuing more proactive strategies related to climate and sustainability. The Science Based Targets Initiative, which shaped many early corporate pledges, was established in 2015. The first non profit dedicated to carbon removal, the Center for Carbon Removal (now Carbon180), was also founded in 2015.

<sup>5</sup> ["XPRIZE Announces the Two Winners of \\$20M NRG COSIA Carbon XPRIZE, With Each Team Creating Valuable Products Out of CO<sub>2</sub> Emissions,"](#) XPRIZE, 2021.

<sup>6</sup> ["Concrete Needs to Lose Its Colossal Carbon Footprint,"](#) Nature, 2021.

By the time we arrived in 2015, it generally felt like there was nothing happening in the space, yet we had known about the problem for 60 years as emissions continued to grow.

— Noah Deich, Founder and Executive Director of Carbon180 (2015-2020) and Deputy Assistant Secretary of Carbon Management at the U.S. D.O.E. (2022-2024)

As 2015 came to a close, 196 nations came together in France's capital to negotiate and sign the **Paris Agreement**, a momentous global commitment to work collectively toward limiting emissions to 1.5°C. This landmark agreement was the first time a group of nation states legally committed to collectively combating climate change. Set up with a similar vision as the successful ban of chlorofluorocarbons (CFCs) under the Montreal Protocol, the International Negotiating Committee of the Intergovernmental Panel On Climate Change (IPCC) coordinated the commitment of member states to act in the interest of human and environmental safety, even in the face of scientific uncertainty.

The increased global awareness around the scale of the climate challenge in the wake of the Paris Agreement helped spur momentum around the research and development of new Circular Carbon solutions in the following years, though still in a somewhat sporadic and decentralized manner around the world. Despite the growing momentum of the sector, there remained **significant debate around the need for decarbonization only (versus carbon removal)**. The steep learning curve required to understand, explain, and perfect carbon capture, utilization, and removal technologies persisted, making the sector's core value proposition sometimes difficult to convey to broader audiences.

The general consensus at this time was that decarbonization alone would be sufficient to meet global climate targets. **However, the speed required to achieve this was already unrealistic, given the limited progress that had been made despite more than 25 years of research highlighting the urgency of the climate issue.** Meanwhile, oil and gas industries continued investing trillions into their infrastructure, making clear the complexity of a path forward.

#### TAKEAWAYS:

- ▶ Significant momentum began occurring during this time, capped by the Paris Agreement that would continue to govern global collaboration and goal-setting for the years to come.
- ▶ It became evident that providing clear pathways to value through early Circular Carbon products was necessary to get investors on board. The Carbon XPRIZE competition highlighted companies that had a promising path to large commercial markets (i.e. concrete) and thus gave a positive example of how the sector could evolve and be successful.

# 2018 - 2020

## Carbon Removal Deemed Necessary by Scientific Consensus

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In 2018, the IPCC issued [a groundbreaking report](#) stating that all pathways to meeting the goals outlined in the Paris Agreement would require carbon removal. **This marked the first time that the global scientific community reached a public consensus on the necessity of carbon removal.**

All analysed pathways limiting warming to 1.5°C with no or limited overshoot use CDR [carbon dioxide removal] to some extent to neutralize emissions from sources for which no mitigation measures have been identified and, in most cases, also to achieve net-negative emissions to return global warming to 1.5°C following a peak (high confidence). The longer the delay in reducing CO<sub>2</sub> emissions toward zero, the larger the likelihood of exceeding 1.5°C, and the heavier the implied reliance on net-negative emissions after mid-century to return warming to 1.5°C (high confidence).

— IPCC, *Special Report on Global Warming of 1.5°C*, 2018

This report kicked off a wave of unprecedented attention and interest from corporations, global policymakers, and entrepreneurs. There were seemingly endless waves of sustainability and net-zero commitments and announcements, involving system-level analyses of organizational emissions and the creation of long-term pathways to achieve reductions and removals over decades. Two significant factors, the consolidation of the Voluntary Carbon Market (VCM) and the enhancement of policy incentives, underpinned investments during this time:

- 1 The use of the carbon market was an intermediary tool for these entities to transition to net zero. Until this point, carbon credits were limited in volume and primarily focused on renewable energy and emissions reduction projects such as high GWP gas projects, cookstove projects, and international forestry projects under REDD+. An uptick in activity began around 2018, a trend that has continued with increasing year-over-year transaction volumes through today. However, the early versions of both voluntary and international credit markets lacked the standardization, monitoring, and scale to support significant carbon sequestration and removal projects. **Increased scrutiny of the carbon markets** began to influence the domestic marketplace as buyers, investors, and project supporters demanded higher durability and transparency. This necessary introspection period began the assessment of integrity required to move us forward in the future.

## 2

The growth in Circular Carbon innovation through this time period was bolstered by the 2018 enhancement of **the 45Q tax incentive**, which was updated to support the development and deployment of DAC technologies. Roughly \$1B in 45Q credits were claimed before 2020, with momentum continuing over the following four years to utilize an additional \$1B. This **bipartisan legislation** provided crucial funding leverage for nascent technologies to scale, provide jobs, and gain visibility. While there continues to be measurement, reporting, and verification (MRV) issues around these types of projects, this policy mechanism accelerated the movement of these technologies out of the gate.

Driven by voluntary carbon-offsetting initiatives from corporations, the growing carbon removal market and the policy incentives of 45Q drove new interest, innovation, and funding around carbon removal solutions. Several early carbon removal companies, mostly biological and geochemically focused, bet on this initial uptick in demand and were well-positioned to take advantage of the funding wave in the following years.

Building on decades of global efforts to advance awareness and progress in carbon removal science, the long-term effects of the COVID-19 pandemic catalyzed action in many societal sectors. The temporary environmental changes seen during the shutdown, the clear link between health and the environment, and a rare sense of global vulnerability and connectedness built a sense of urgency for people, organizations, and corporations to take action. This materialized in various ways, including a new wave of momentum pouring into the Circular Carbon sector. This interest launched a surge of private capital and saw use cases flourish and corporate commitments grow exponentially. Corporate demand for net-zero solutions also drove the growth of CDR solutions, evidenced by the number of pledged companies increasing from the hundreds to the thousands within four years.

### TAKEAWAYS:

- › Policy incentives created leverage points for broadening private-sector funding.
- › Global carbon market scrutiny began to hone the concept of more measurable results-driven climate solutions and how those can be incentivized in a market-based framework.
- › The COVID-19 pandemic drove impact-driven investment efforts that carried into the next few years.



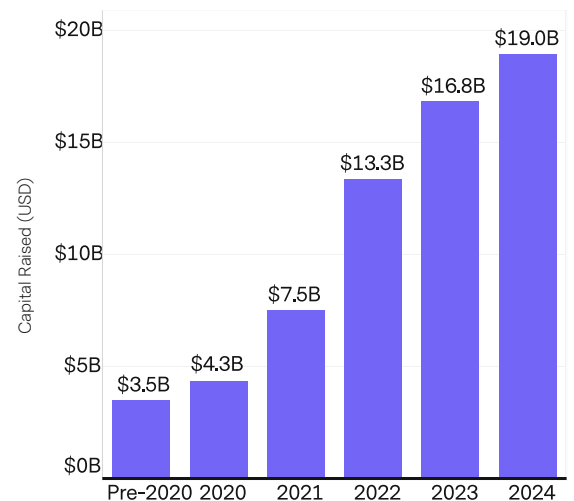
# 2021 - 2023

## A Tipping Point for Circular Carbon

The Circular Carbon sector quickly entered a phase of rapid growth during, and coming out of, the pandemic. Private capital, investment, and corporate commitments continued to outpace previous years. Monumental U.S. policy was passed with the Inflation Reduction Act, which further expanded the 45Q tax credit, and the Bipartisan Infrastructure Law, which contained \$12B to fund a set of technological CDR efforts, including \$3.5B to build DAC hubs in the U.S., \$2.5B for carbon sequestration facilities, and \$310M for CO<sub>2</sub> utilization.<sup>7</sup> **This commitment balanced the careful fulcrum of government and private capital**, de-risking investments to help propel startups beyond their initial funding rounds.

Our data shows that prior to 2020, startups working on carbon removal solutions collectively raised \$3.5B in VC and PE. By comparison, five years later, cumulative investment into carbon removal startups reached \$19B.

VC & PE Funding in Circular Carbon (Cumulative)



As evidence of the explosive growth, the amount of workers in the sector grew dramatically. For example, the number of people working in the Circular Carbon sector grew from approximately 200 total full-time workers before 2018, to a point in the early 2020s where a single DAC company might employ 200 individuals alone. Then, the same year that XPRIZE announced the winners of the carbon utilization prize, **it announced a new \$100M prize focused only on carbon removal**. The competition did not offer a single “silver-bullet” solution, but demonstrated that the necessary technological foundations for large-scale carbon removal were rapidly advancing. It also highlighted the critical need for further investment, policy support, and public-private partnerships to turn these innovations into widespread, impactful solutions. Venture funding met the moment, deploying capital into Circular Carbon companies at record levels. By 2023, private capital investment had reached \$17B, more than double the amount from 2021.

Public awareness of climate change and climatetech also seemed to grow in 2020. The scale and frequency of climate impacts continued to affect the global community in increasingly threatening ways – from food insecurity

<sup>7</sup> “Carbon Removal in the Bipartisan Infrastructure Law and Inflation Reduction Act,” World Resources Institute, 2022.

to wildfires, from extreme weather to new diseases – which compounded the challenges that directly jeopardized livelihoods. Around this time, critical conversations arose around climate justice, emphasizing the need for holistic and inclusive solutions that address environmental, social, and economic concerns within the communities where carbon removal projects were located. Each climate solution has its own unique set of implementation considerations, but the principles of human rights, two-way communication, and sustainable development are concurrent throughout.

Carbon removal is advancing at an unprecedented pace, but scaling responsibly requires more than technological breakthroughs and financial backing. We must ensure these projects create tangible and equitable benefits—good jobs, economic growth, and climate resilience. Without public trust and responsible deployment, we risk slowing progress at a time when urgency is critical.

—Steve Oldham, CEO of Captura

During this tipping point for carbon removal, **the supply-and-demand equation for high-quality carbon credits became exponentially more complex.** On one side, an injection of venture funding into carbon removal companies put direct tension on the carbon market, which in turn increased the pressure on corporate buyers for procurement policies of these credit products. On the other side, a level-setting of expectations of suppliers for MRV of carbon removal credits occurred in rapid fire, where sector-wide MRV was researched and argued over very publicly. As a result, pricing and costs fluctuated.

Amid a leadership vacuum regarding questions of what a high-quality carbon credit consists of, multidisciplinary organizations such as the Integrity Council for the Voluntary Carbon Market (ICVCM) were founded. The number of intermediaries, brokers, and private rating agencies increased significantly to fill the dearth of advice that both suppliers and buyers were seeking. **Everyone was asking the same question: “What is a high-quality carbon credit?”** Answering this question became crucial for driving purchases and creating a trustworthy market where buyers without in-house sustainability teams could participate with confidence.

These uncertainties in the carbon markets posed significant challenges for startups operating on constrained short- or mid-term funding runways. The launch of Frontier in 2022, a monumental advanced market commitment of \$1B for carbon purchases, aimed to catalyze the supply and demand of high-quality carbon credits. The commitment

of the founding members – Stripe, Alphabet, Meta, Shopify, and McKinsey – was a stake in the ground that proved that demand existed and aimed to de-risk follow-on action from less proactive buyers. Microsoft led the way as the largest buyer of high-durability carbon credits, constituting 80% of the market in 2024.<sup>8</sup> **Despite the initial momentum, however, the number of new buyers entering the market began to slow,**<sup>9</sup> leaving a small group of established players making the bulk of high-quality carbon credit purchases.

If you solve for the demand, you can solve for the financing. If you solve the financing, you can solve supply. If you solve supply, you can solve the problem.

—Philip Moss, CIO of ClimeFi and Former Head of NextGen

Scaling the Circular Carbon economy in time to address the worst effects of climate change is the crux of the issue we collectively face today. Just four years ago, the sector's major challenges were a steep learning curve and limited connectivity of key ecosystem players; these barriers have since been broken. We now face an even greater challenge: the urgent need to accelerate funding and scale solutions in an environment where the problem and solutions are well understood but the will to catalyze this action with patient capital may be waning. Transforming our energy and materials economy on a global scale requires an unprecedented change in our global systems and infrastructure. **Executing a shift to a Circular Carbon economy is a monumental effort, too large to be executed solely by a small community of technologists and investors.** Corporate entities can increase carbon market participation and make strategic acquisitions of technologies and projects that get them closer to net zero. International policy can drive the incentives necessary to grow carbon into a trillion-dollar market opportunity. A successful path forward will prioritize community engagement while ensuring economic and technical performance, creating a strategy capable of driving widespread adoption and long-term impact.

## TAKEAWAYS:

- › Government investment de-risked the industry, and private capital followed.
- › This tipping point focused on supply-side roadblocks, with too little demand-side activity.
- › Refocusing on demand for Circular Carbon remains a critical challenge – keeping a balance between forward movement and high-quality impact is imperative.
- › Getting to scale requires much broader participation and mobilization outside of the Circular Carbon community.

<sup>8</sup> “[Ten Insights for Buyers from Our 2024 Voluntary Carbon Market Report](#),” *Carbon Direct*, 2024.

<sup>9</sup> “Durable CDR Purchasing Trends” figure in “[2024 Q3 Durable CDR Market Update - Time to Build the Base](#),” *CDR.fyi*, 2024.



**PRESENT:**

2024 CIRCULAR CARBON  
MARKET TRENDS

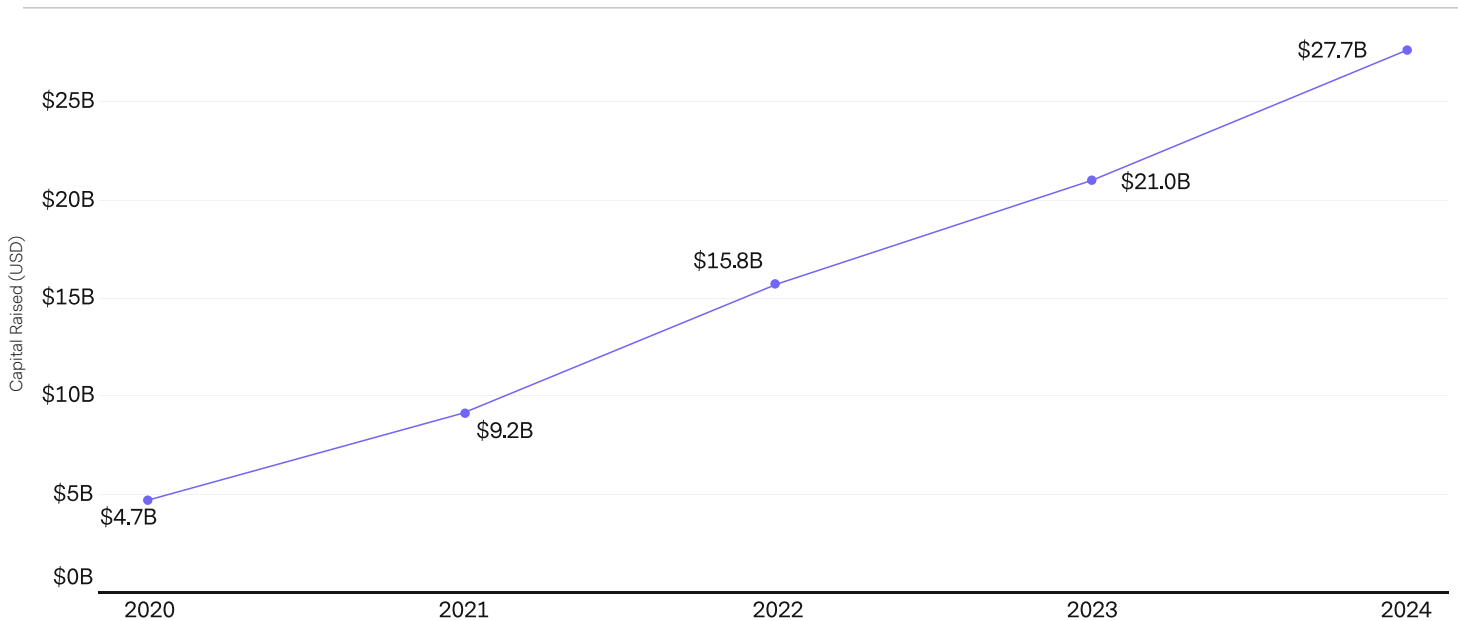
# 2024 CIRCULAR CARBON MARKET TRENDS

We are midway through a decade of meaningful global activity and five years away from a major 2030 milestone. The fate of scaling critical climate solutions is yet to be determined. With science warning us that we have approximately one decade left to shift our trajectory away from catastrophic climate outcomes<sup>10</sup>, the progress achieved in even a few months is paramount.

## 2024 Circular Carbon Numbers

Deals Closed to Date:	Deals Closed in 2024:	Deals Closed Since 2020:
<b>\$27.7<sub>B</sub></b>	<b>\$6.6<sub>B</sub></b>	<b>\$23.9<sub>B</sub></b>

### Cumulative Deals Closed to Date <sup>11</sup>



Nearly \$28B has been raised in the Circular Carbon sector across private equity, venture capital, project/debt finance, corporate, government and philanthropy, with the vast majority of capital (87%) being deployed since 2020. While there has continued to be positive year-over-year growth in the sector, the rate of growth has slowed, from a peak of 384% growth between 2020 and 2021 to 25% between 2023 and 2024. With the funding frenzy of 2021-2023 cooling off, the dynamics of capital deployment in 2024 reflects a shift happening within the sector. Generally,

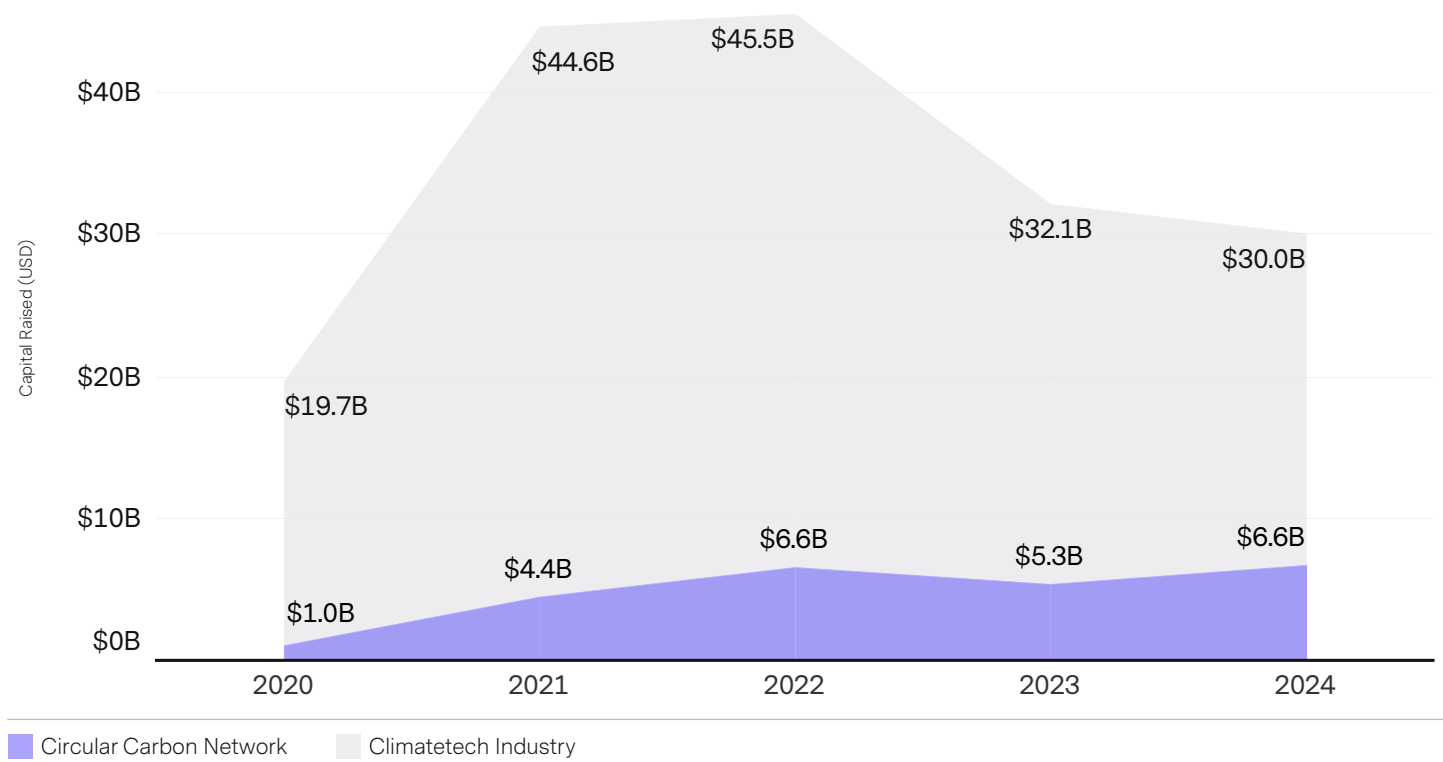
<sup>10</sup> Our data contains Circular Carbon deals closed between 2002 and 2024.

<sup>11</sup> In last year's report, there was \$2.8B in deals from companies we have since removed for fit or that were not independently verified by our team. This accounts for the difference in total 2023 capital raised between the reports.

the fundraising environment was more risk-averse in 2024, tempered by macroeconomic uncertainties of inflation, energy prices, and the U.S. election. Many fund managers held back and doubled down on the familiar, making strategically safer investments.

To scale solutions through 2030, the sector requires a doubling down in growth capital as opposed to a plateau. As the trends in this section will elaborate, the data shows the beginning of a shift happening in private capital deployment from early stage investments of a broad spectrum of solutions to growth capital deployment of proven technologies and teams. Overall capital raised numbers have not moved significantly, but the stages of funded deals have started to distinctly shift toward growth. We hope to see the amount of capital in later stage deals continue to grow over the next 5 years as those companies scale.

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



To help contextualize the investment numbers into Circular Carbon, we also looked at the cumulative number of deals closed in 2024 for the climatetech sector (as defined by [Sightline Climate](#) and their reporting on capital activity within that sector). The above graph shows total climatetech funding in gray and Circular Carbon’s share in purple. While overall capital raised numbers don't paint the whole picture, the data shows an overall stabilization of private capital into both sectors from the funding boom earlier in the decade.

Where Circular Carbon is relatively nascent – having seen an explosion of new innovation in recent years – **the 2024 data signals the beginning of a shift that goes beyond the broader economic tightening.** The combination of trends outlined below indicate that the sector is approaching an inflection point from early stage technology development to project deployment.

Overall, there is a similar amount of money going into a smaller number of deals across all categories, showing some continued demand for a diversity of projects across pathways and Technology Readiness Levels. However, we mostly see signs of consolidation in the market, with more capital and an increasing number of deals going to later stage companies. In addition to investors' focus on advancing more mature technologies, it is possible that the trend toward larger deal sizes also indicates an increasing fluency of the sector. Also, it is possible that there is a shift in perspective toward the project-level risk versus a focus on overall technical risk.

In this snapshot of private capital for climate solutions, there is a leveling off of funding. While the deployed capital of the last four years moved many companies to early commercialization stages, **those vested companies now require essential growth rounds to scale, yet are standing on the unstable ground of limited and unclear demand.** Most companies in carbon removal, for example, do not have diverse revenue options and are not viable without carbon market revenue streams. Additionally, the growth rounds and project financing necessary to move these projects toward megaton levels of carbon removal have a very different type of risk profile than those first rounds.

Investments in previous years were largely dominated by early stage deals that underwrote technology development, whereas now there is an increase in larger deals that signify a greater focus on reliable and proven deployment. **There is still significant technology development taking place, but it is happening at a slower rate and in a more consolidated manner.** This is not surprising considering the explosive growth between 2020 and 2022. This is underscored by the top trends of 2024, which include a smaller number of companies being founded, capital moving toward later deal stages, and steady activity across Circular Carbon sub-sectors.

The more mature companies in the space will continue to be successful in securing capital and will be able to continue to operate through the next four-year cycle, but the market must send clearer signals that the demand is there. Private capital is shifting to fewer, more mature companies that will survive this business cycle, but is drying up for earlier stage technologies. **Regardless of stage, larger corporations must start taking an interest in strategic acquisitions that signal more exits in Circular Carbon.**

**Trend 1: Fewer New Companies Entering the Space**

**Trend 2: Fewer Number of Deals, But Increasing Amounts**

**Trend 3: Deal Stages Are Maturing**

**Trend 4: Larger Round Sizes for Growth Capital**

**Trend 5: Sub-Sector Activity Remains Steady**

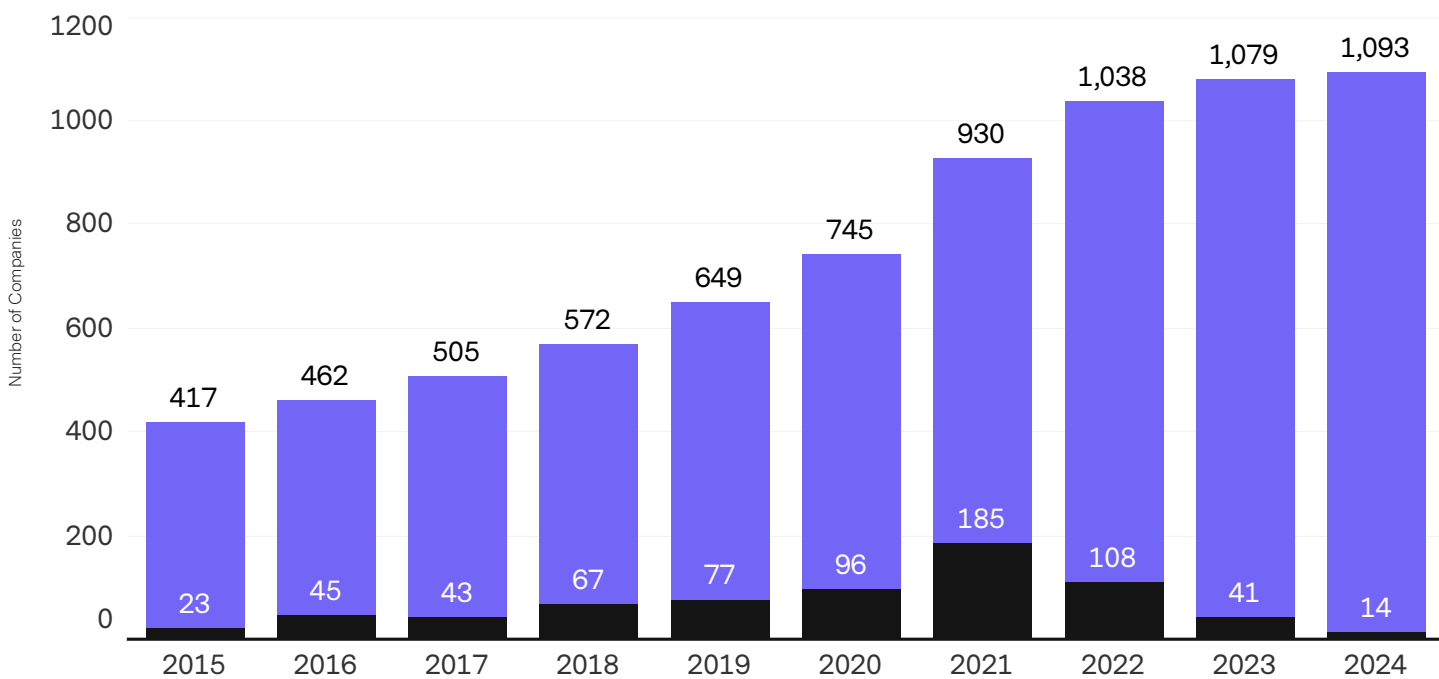
# TREND 1

## Fewer New Companies Entering the Space

The number of new companies entering the space continues to decline this year, as in recent years. Based on the ever evolving dataset of companies in the Circular Carbon Innovator Index, the largest year of growth was 2021, with 185 new companies founded. This was followed by 108 in 2022, 41 in 2023, and just 14 in 2024. It is worth noting that our data is based on when a company closes their first pre-seed round of funding, so there usually is a slight lag between when a company is founded and when they show up in our research.

The market demand signals in 2021 had strong tailwinds, and now capital is deployed more conservatively and is harder to acquire in the early stages. The early sector companies founded between 2015 and 2019 were in a good position to take advantage of the wave of momentum that came in these most recent years, as evidenced by the trajectory of companies like Climeworks and Twelve. The weight of the whole sector has shifted toward increasing expectations for execution and deployment.

### Number of Companies Founded YOY and Cumulative



■ All Companies ■ New Companies

Amount of Companies in the CCN Index with Year Founded Data: 90%

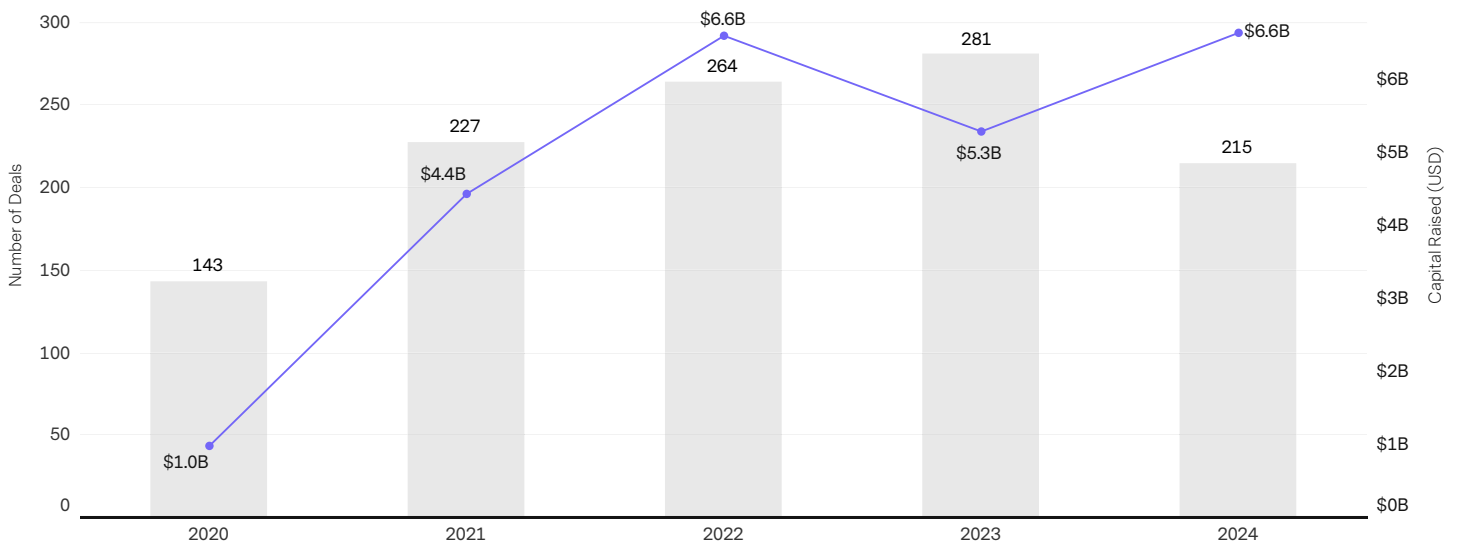


# TREND 2

## Fewer Number of Deals, But Increasing Amounts

While the amount of capital deployed has slightly increased from last year, the number of deals in both early and later stages has shrunk from 2023. Both the average deal size (\$25M in 2023, \$41M in 2024) and the median deal size (\$4.9M in 2023, \$5.6M in 2024) have increased significantly from last year. This increase in deal sizes signifies a maturing field of investors and greater focus on proven development and deployment.

### Deals Closed Since 2020 YOY



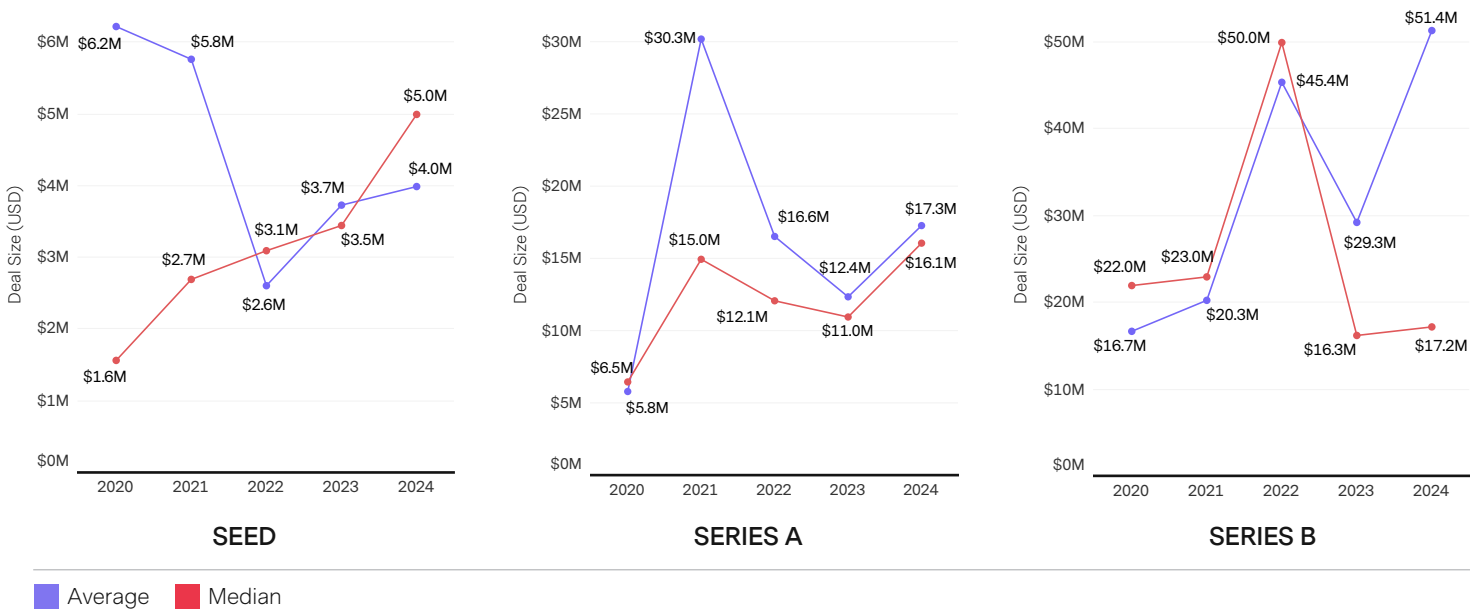
# TREND 3

## Deal Stages Are Maturing

In looking at the average and median deal size across Seed, Series A, and Series B, we see a snapshot of how deal dynamics are changing over a four-year period. In Seed and Series A, the average and median have increased, even though there were fewer deals in 2024, indicating that deal sizes are generally larger across the board (rather than a few large outliers pulling the number up). In Series B deals, the average has skyrocketed, likely due to the larger number of \$50M+ deals like those from Air Company, Heirloom, and Interatec ([see Top 10 largest deals](#)). We expect that the Seed and Series A charts will continue to have their median and average move closer together, while Series B will continue to stay at a distance or move even farther apart.

This is further evidence of more focused and tailored investment theories over time. It may indicate the high capital intensity of hardtech that becomes more expensive to deploy in later stages than in early ones, and an increased use of bridge rounds as a remedy. It also might signify the distribution gap between lower and higher capex companies.

### Average and Median Deal Size YOY



### MATURING FUNDING ROUND EXAMPLES

#### › 44.01

2020: Pre Seed, Undisclosed  
 2021: Seed, \$5M  
 2024: Series A, \$37M

#### › Air Company

2020: Pre Seed, \$8.5M  
 2022: Series A, \$30M  
 2024: Series B, \$69M

#### › Mission Zero

2021: Grant Funding, Undisclosed  
 2022: Seed Round, \$5M  
 2023: Grant Funding, \$1.7M  
 2024: Series A, \$28M

#### › Pachama

2020: Seed Round, \$5M  
 2021: Series A, \$15M  
 2022: Series B, \$55M  
 2023: Series B, \$9M

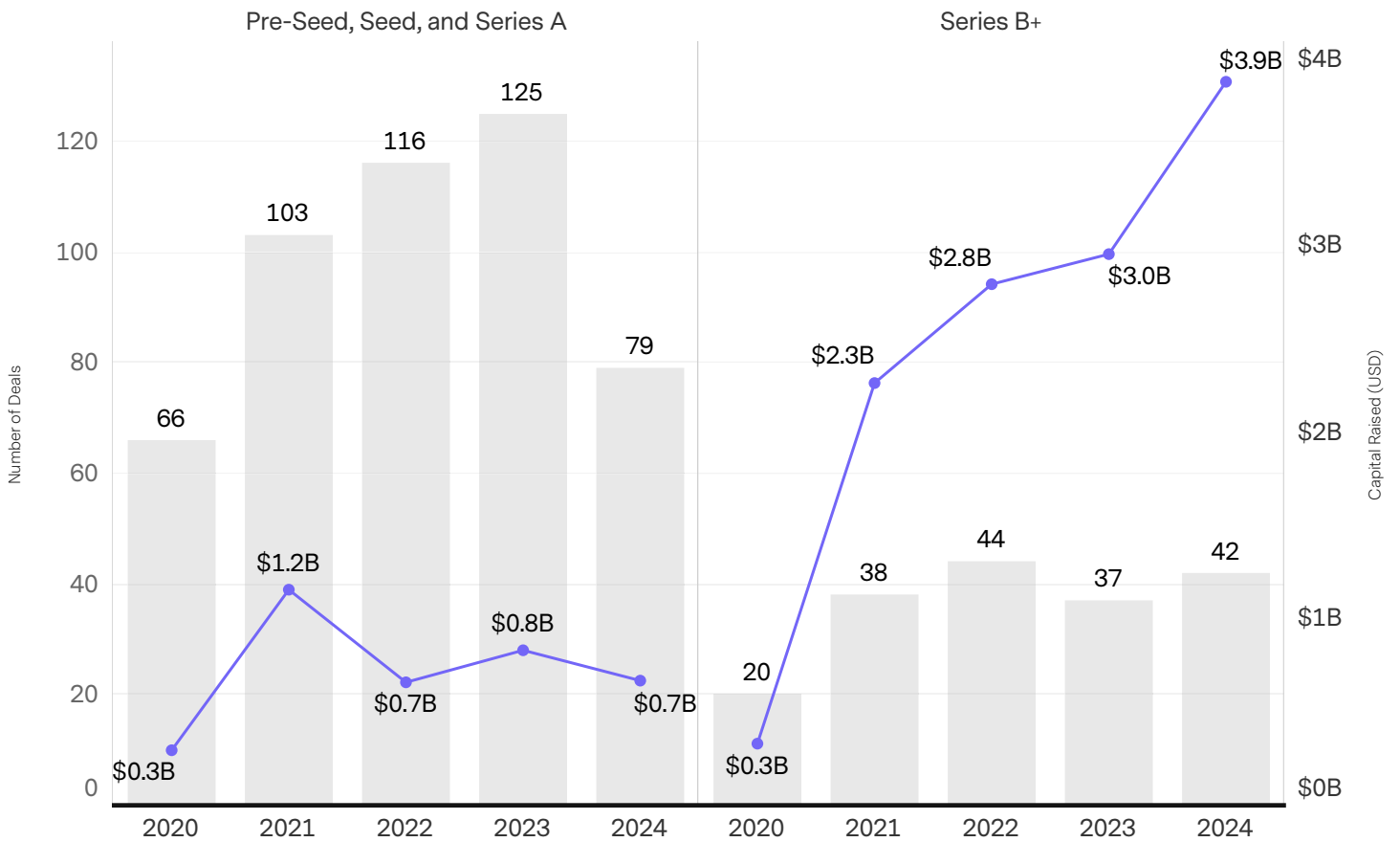
# TREND 4

## Larger Round Sizes for Growth Capital

The following chart shows the actual amount of capital raised in early stages (Pre-Seed, Seed, and Series A) versus later stages (Series B-G and Debt Financing). As expected in an investment sector that is shifting its focus to deployment, the number of Pre-Seed, Seed, and Series A deals have declined by 40%. However, the total capital going into early deals is fairly on trend with the previous two years.

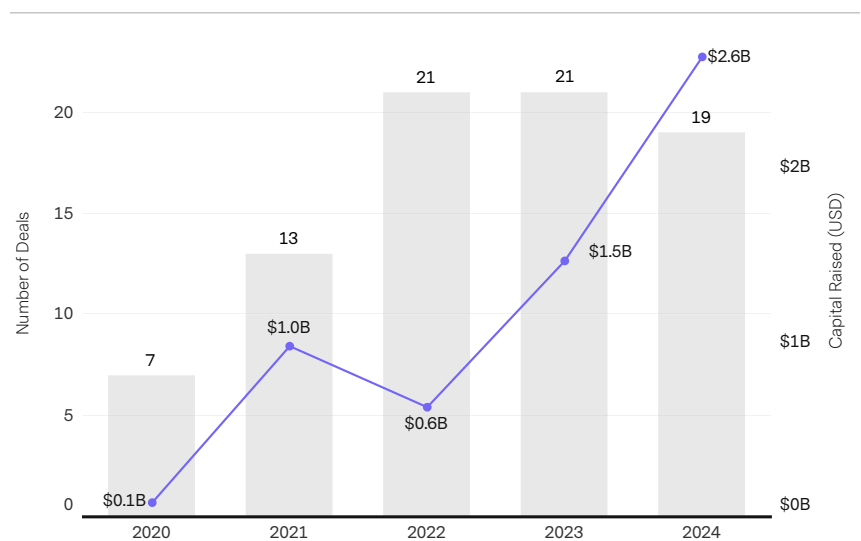
Markedly, the number of Series B+ deals (including B-G) has stayed fairly consistent since 2021, but the amount of capital continues to grow. More money overall has been deployed into later stage solutions but in nearly equal numbers of deals, meaning much larger round sizes for growth capital (between 2023 and 2024, we saw a 30% increase in total funding despite only a 14% increase in the number of deals).

Deal Breakdown YOY by Investment Stage



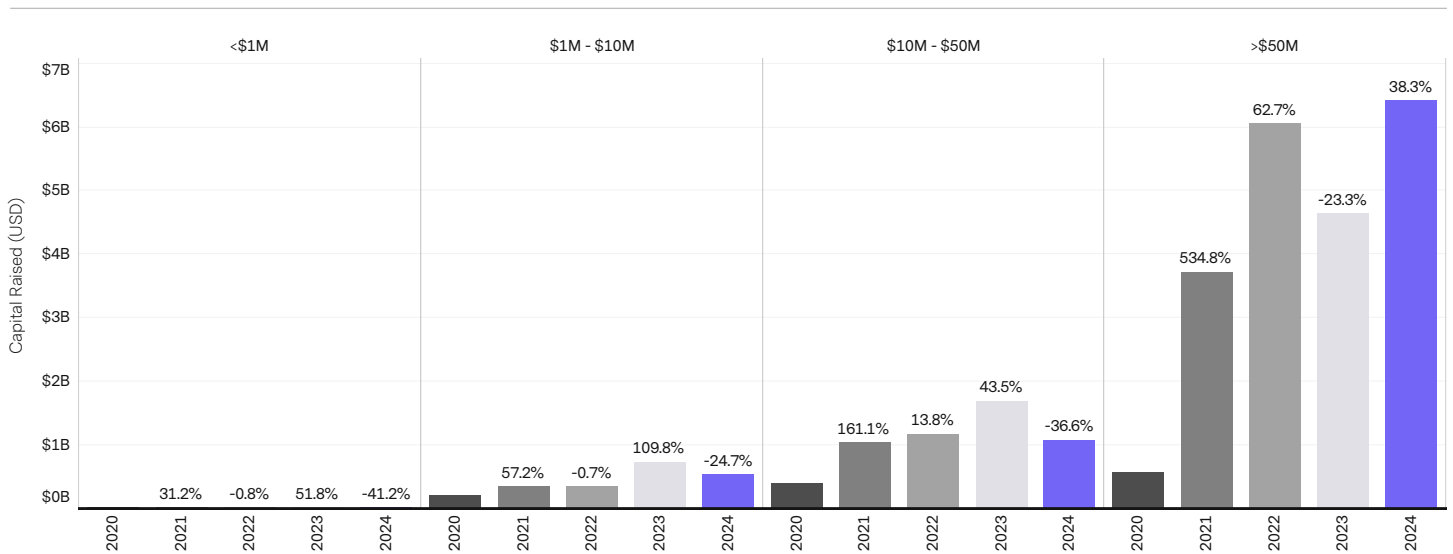
In Debt Financing (Post IPO, Debt, Mezzanine) – a more focused indicator of scaling – we see the gap between value and quantity grow even larger, an indication that few companies have yet made it to this part of the funnel.

Debt Finance Deals Closed YOY Since 2020



When looking at final round-size amounts, the total amount raised in larger, \$50M+ rounds has increased 38% from last year, while total funding in rounds less than \$50M has decreased by 25% or more.

Percent Difference of Capital Raised YOY by Round Size

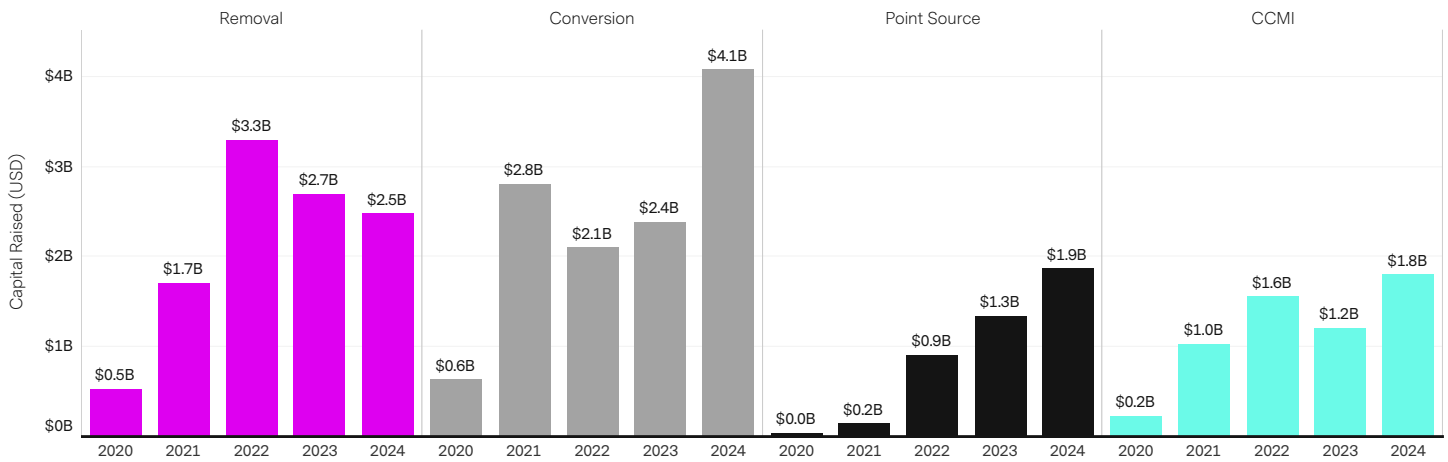


# TREND 5

## Sub-Sector Activity Remains Steady

Overall, there is a continued upward trend in money being put into all sectors (see [Definitions](#)) except for carbon removal (a 7% decrease from 2023). Conversion funding specifically increased by 71%, Circular Carbon market infrastructure (CCMI) funding increased 50%, and point source capture funding jumped 46%. It is encouraging that these trendlines are mostly steady or growing in each category, with continued activity across all sub-sectors despite fewer Circular Carbon deals in 2024.

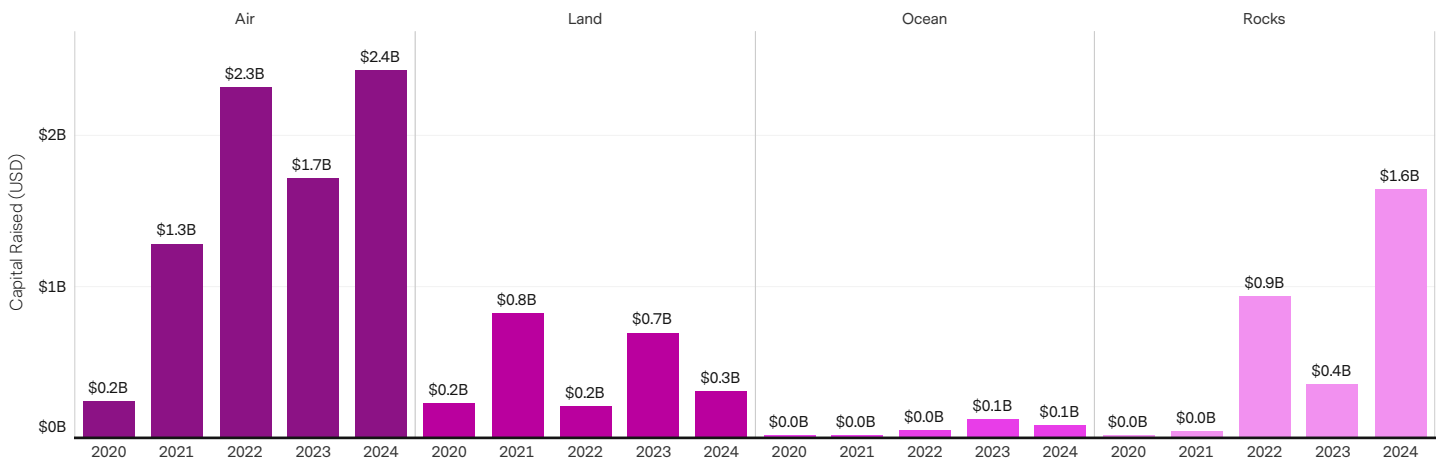
## Capital Raised by Solution Type (2020-2024)



Note: If companies fit more than one of our category descriptions, they are included in the deal counts for both categories but not in the total capital raised numbers, which is why you might notice the sum of category capital raised exceeding total capital raised for 2024.

Within the carbon removal sector, while the land and ocean categories saw a slight decrease in funding, the air and rocks categories actually saw significant growth, thanks in part to a few funding rounds of more than \$100M. The rocks category, in particular, demonstrated this – the top deals in this category (11% of the total number of deals) accounted for 89% of the capital raised in the category in 2024.

## Capital Raised in Removal (2020-2024)



### \$100M+ DEALS IN AIR AND ROCKS

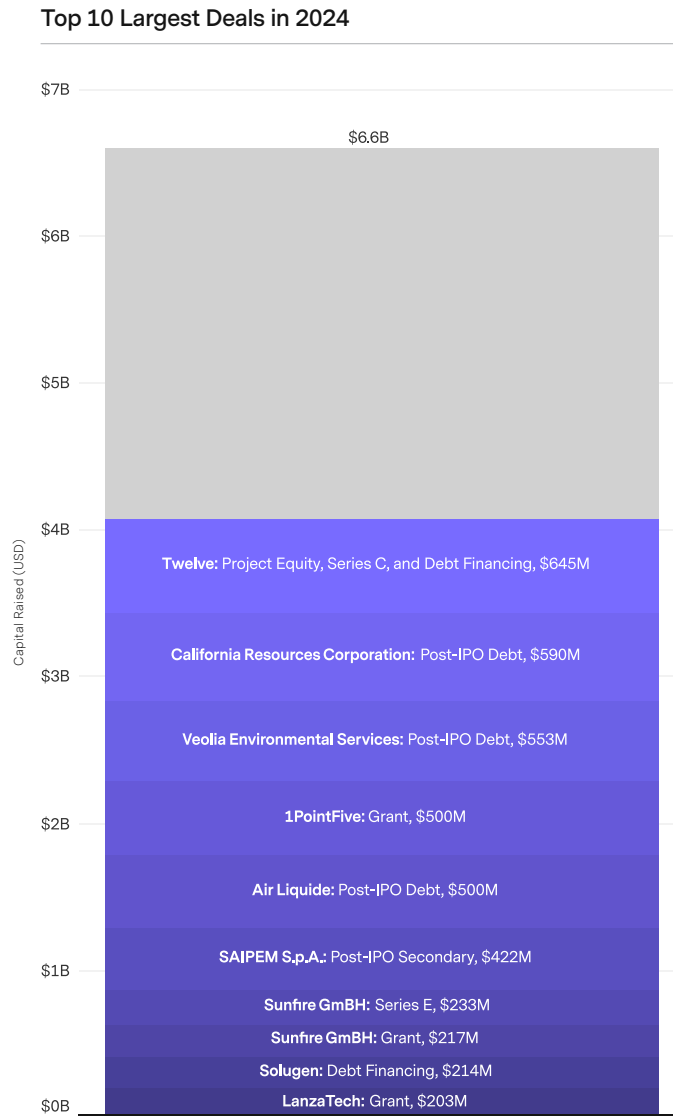
California Resources Corporation  
- Post-IPO Debt, \$590M

1PointFive -  
Grant, \$500M

Heirloom Carbon Technologies  
- Series B, \$150M

# Top 10 Deals in Circular Carbon

As mentioned several times, larger deals were dominant this year. Below are the top 10 largest deals in Circular Carbon in 2024.



## DEAL CALLOUTS

- ▶ **Air Liquide** successfully issued a \$500M green bond under the Group's Euro Medium Term Note program, signaling investor confidence in the company's decarbonization technology and projects. This funding will help support Air Liquide's suite of carbon capture technologies.
- ▶ **1PointFive's** South Texas DAC hub has received up to \$500M from the U.S. Department of Energy to help scale DAC technology, crucial for achieving net-zero emissions and combating climate change. Located on the King Ranch in Texas, the project aims to remove 500,000 metric tons of CO<sub>2</sub> annually, with potential for future expansion, while supporting local workforce development and broader decarbonization goals.
- ▶ **Twelve** secured \$645M to scale its CO<sub>2</sub> conversion technology, which transforms captured CO<sub>2</sub> into sustainable aviation fuel and e-chemicals. With plans to build AirPlant One, a facility producing E-Jet fuel, and partnerships with airlines, including Alaska Airlines and British Airways, Twelve aims to cut aviation emissions by up to 90%.

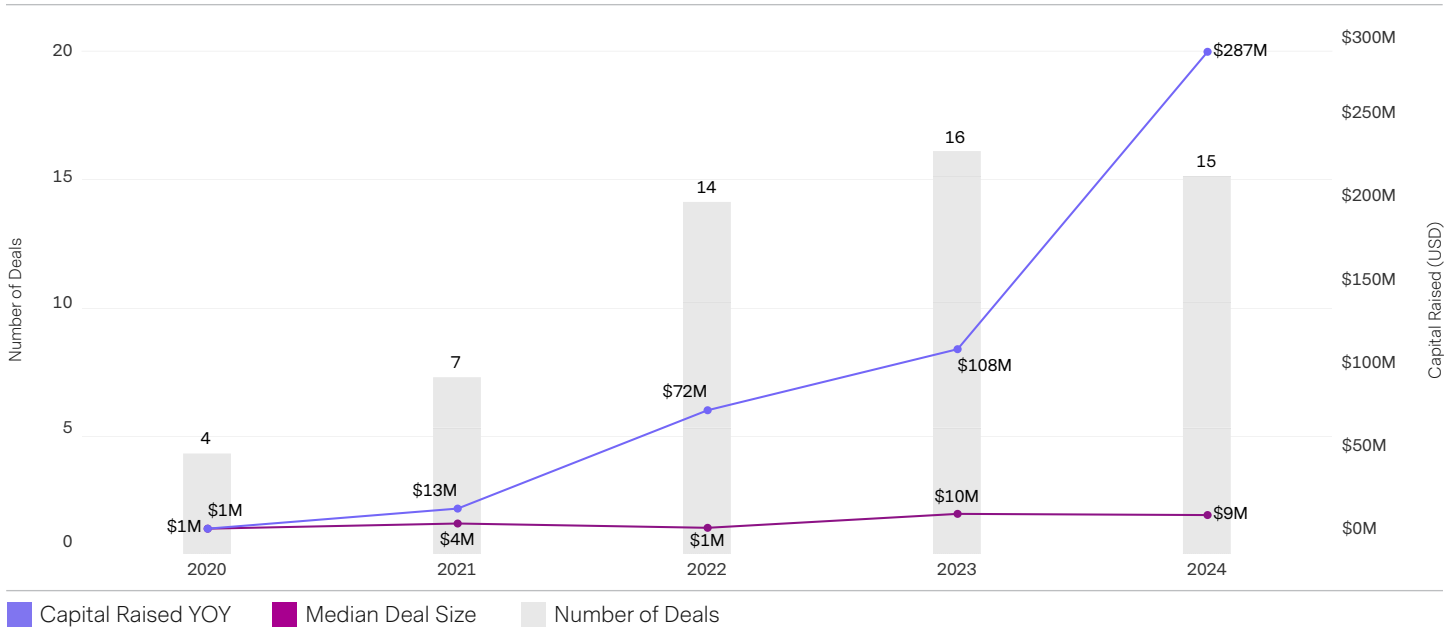
# Profile of XPRIZE Finalists

We took a closer look at market leaders in the carbon removal sector, the finalists of the XPRIZE Carbon Removal, to see the impact of the incentive prize model on capital formation. [You can see a full list of the finalists here.](#)

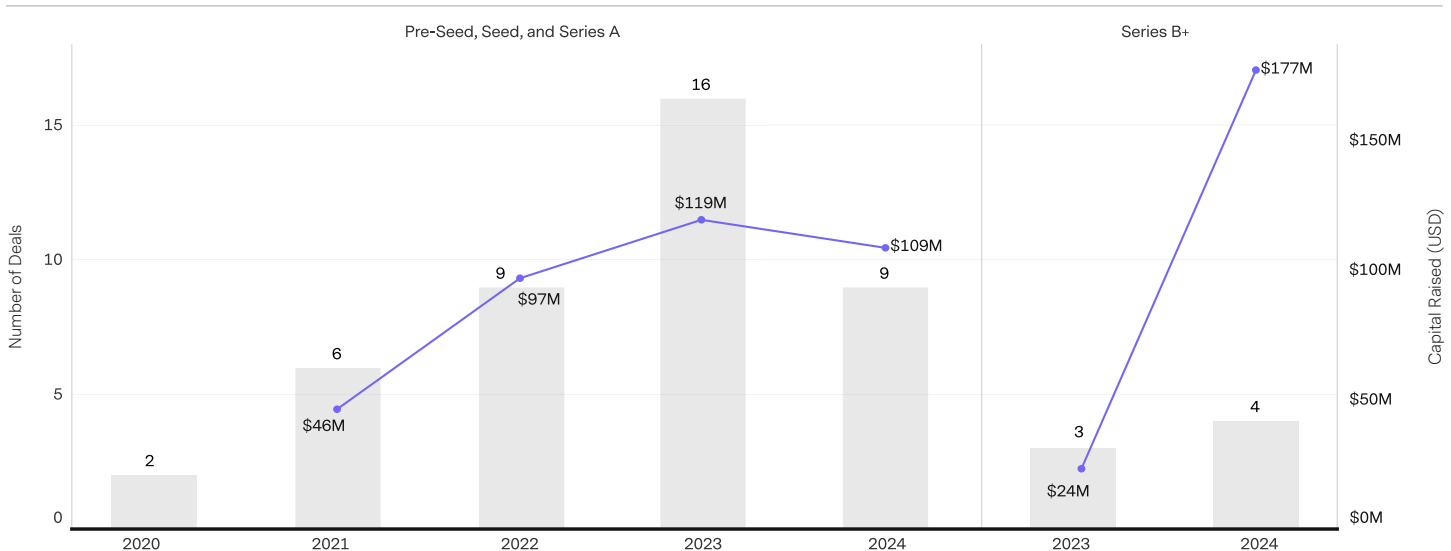
In general, we see similar statistics playing out in this smaller sample size, with more capital going into fewer deals. There were only four Series B+ deals from the 20 finalists in 2024, but with a big boost to the total capital raised due to one deal from Heirloom. Heirloom is a DAC company that closed a \$150M round in late 2024 to scale its innovative technology for capturing atmospheric CO<sub>2</sub>.

## Top 20 Finalists of XPRIZE Carbon Removal

Deals Closed YOY Since 2020



Deals Closed YOY Since 2020 by Investment Stage





**FUTURE:**

LESSONS TO CARRY FORWARD



# FIRST, AN EMISSIONS CHECK-IN

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In order to limit the most severe effects of climate change, **we need to reach net-zero emissions by 2050, and net-negative emissions shortly thereafter.** To do this, we need to remove 100 billion to 1 trillion tons of CO<sub>2</sub> from the atmosphere by 2100 (IPCC).<sup>12</sup> With current global annual emissions at around 41.6 billion tons of CO<sub>2</sub>,<sup>13</sup> the math tells us that even if we started deploying Circular Carbon solutions at scale today, we would still need to see an annual growth rate in reductions and removal capacity of more than 55% of current emissions to avoid a 1.5°C global temperature rise.<sup>14</sup> **Delaying deployment at scale, even by a few months, has measurable and exponential effects.**

The harsh truth is that between the beginning of the Circular Carbon sector and now, emissions have only increased. More to the point, we have emitted 1 trillion tons of CO<sub>2</sub> just since the 1992 Rio Earth Summit (a precursor event to COP). The global energy transition is more challenging than most originally anticipated. It requires consistent effort, innovation, and collaboration.

Nothing about the energy transition is cheap, easy, or inevitable. That is the work.

— Julio Friedman, Chief Scientist at Carbon Direct

The history of the Circular Carbon sector, however, provides some hope. Progress has been substantial over the last decade, driven by significant technological advances, a funding infusion of private and public investment, and policy achievements domestically and internationally. We sit at close to \$28B dollars of money, public and private, invested into Circular Carbon solutions, and those supply-side innovators have grown the integrity and progress of the sector exponentially, especially over the last four years. However, significant barriers remain, particularly around permitting, infrastructure, and public acceptance.

<sup>12</sup> Section C.3 in “[Summary for Policymakers — Global Warming of 1.5 °C](#),” *IPCC*, 2018.

<sup>13</sup> “[Global Carbon Project Briefing on key messages Global Carbon Budget 2024](#),” *Global Carbon Budget*, 2024.

<sup>14</sup> Exhibit 2 in “[How Global Business Could Mitigate Climate Change](#),” McKinsey Sustainability, 2020.

In 2010, the Circular Carbon Economy basically didn't exist. Over the life of the two XPRIZE carbon-related prizes, the work of countless innovators in technology, policy, finance, commerce, and civil society has brought to life a vibrant ecosystem with the potential to both address our world's most critical environmental challenges and provide a foundation for a prosperous and sustainable economy for the future. While there is a tremendous amount of work remaining to make this a reality, the remarkable progress we've made already should give us confidence we can succeed. We must.

— Nicholas Eisenberger, Co-Founder of the Circular Carbon Network and Managing Partner at Pure Energy Partners

Now, mid-decade, the sector is poised to scale, riding on the coattails of recent capital infusions at a time when we cannot let momentum wane. **Looking ahead, it will take a doubling down of effort and resources to anchor the second half of the decade in taking us to meaningful removal and emissions-reduction capacity.** Moving forward, a combination of continued innovation, supportive policy frameworks, and community engagement will be essential to meet the global carbon removal targets necessary.

# LESSONS LEARNED AND GREATEST OPPORTUNITIES

The CleanTech 1.0 era gave us valuable go-forward lessons that made Circular Carbon and ClimateTech quicker and, in some cases, more seamless. Now, as we look ahead at the pressure to perform against a multitude of 2030 emissions goals, the stakes are higher and, furthermore, the cost of failing to reach tangible progress is monumentally higher. **We cannot afford to fail.** Reflecting on trends from our report, key contributors and industry leaders (listed in the [Acknowledgements](#) section) we have gathered a list of lessons to take forward.

1

## REAL PROGRESS IS POSSIBLE

Decades upon decades of successful progress from cross-sectional participation proves that progress is attainable. Multi-stakeholder collaboration remains essential to building out the full Circular Carbon ecosystem.

2

## **FOCUS ON DEMAND**

Weak demand doomed CleanTech 1.0. There must be a balanced and well-documented demand for what Circular Carbon solutions are putting out there, both publicly and corporately. Now is the time to build the breadth of the market and motivate action from second movers. Focus on outcomes instead of pathways to get there. Create reliable demand signals to get to where we need to be and work backwards.

3

## **ECONOMICS HAVE TO COME FIRST**

Altruistic commitments will not prevail in the long run. Products must be competitively priced for any alternatives, demand for exits must exist, and the cost of participation cannot be overly burdensome. Relying on economies built on capitalistic principles to “do the right thing” is not going to get us there.

4

## **OPPORTUNITY, NOT COST**

Carbon removal is still characterized as a cost, and no one wants to spend money to fix something that doesn't materially impact them today. When the industrial sectors embrace Circular Carbon as an opportunity, the market will flourish. The industrial sectors need to see this as an opportunity to trade carbon credits across the planet. Changing the narrative from a problem to an opportunity is critical to shifting public perception.

5

## **LOOK BEYOND INNOVATION**

At the mid-decade point, the challenge is not as much about innovation as it is about the will and motivation to pay for the scale of challenges like building out infrastructure and public acceptance. In some sense, that is incredibly easy and, in other senses, it's incredibly challenging. There is so much intelligence behind Circular Carbon development that if we just take the action to do it and pay for it, the kinks in the tech will work out. We need to deploy capital to scale at the hundreds-of-billions-of-dollars level.

6

## **BECOME BIPARTISAN**

In order to remain relevant, the sector needs to be continually refining and articulating its value proposition to key audiences to gain nonpartisan support across political cycles. In 2010, the U.S. legislature failed to pass a climate bill that pointed to the possibility of carbon pricing and, in 2022, the IRA passed without one Republican vote. To become bipartisan, any policy incentives developed need to match what the market needs.

7

## **DON'T UNDERMINE THE IMPORTANCE OF PUBLIC COMMUNICATION**

Building trust with local communities and addressing their concerns is critical for the success of carbon removal projects. Public engagement is not a short-term effort but an ongoing process. Decarbonization and carbon removal are essential to the 1.5°C pathway, and until there is no more argument about this, there will continue to be community-level resistance. For carbon removal to become a transformative force in society, developers must engage in consistent community messaging that addresses the appropriate allocation of project risks, benefits, and impacts.

## 8

### SHIFT THINKING FROM TONS TO SCALING CONSTRAINTS

Scaling relies on more than the numbers; it is not logarithmically grown. Address the barriers to scaling carbon removal now by addressing the cost of materials, the cost of energy, the availability of land and water, and the challenge of securing the public's trust. For example, in DAC, there should be concerted efforts to focus on removing public resistance and renewable energy competition (AI), as well as obtaining access to necessary CO<sub>2</sub> pipelines. Projects that can successfully navigate these growing constraints will be able to scale to climate relevant proportions.

## 9

### ABUNDANCE AND PATIENCE IN CAPITAL

According to [Bessemer Venture Partners](#), a successful CleanTech 1.0 startup required 11 years to get to an IPO and more than \$1B of funding across their lifecycle to do it. Analysis within the 2024 XPRIZE [Getting to Gigatonne Report](#) reveals the average time from founding to kilotonne scale is six years, and from kilotonne to megatonne scale is seven years, with an average of 13.5 years across the top 100 teams. Investment in climate requires both an abundance of patient capital and a clear path to exit.

## 10

### CROSS-SECTOR COLLABORATION IS ESSENTIAL

Like many new industries, the Circular Carbon sector needed a variety of key stakeholders - from entrepreneurs to investors, policymakers, corporates, and civil society players - to lean in and collaborate to get it off the ground. That is largely what the Circular Carbon Network itself, the two carbon-related XPRIZES, and many of the other complementary efforts mentioned in this report have been all about: getting the necessary gears of a new system to start turning together. This remains even more critical for the next phase of the sector - scaling up rapidly and at historic speeds and levels to meet the challenge of climate change in the time we have.

Significant barriers remain around demand, infrastructure, and public acceptance of Circular Carbon. In order to make a climate-and economic-relevant impact, Circular Carbon solutions will need to focus on global deployment, becoming part of a widespread industrialized and international industry.

The next decade will likely see more refinement of existing technologies and a deeper commitment to scaling the solutions that are both economically viable and politically palatable. Companies that are able to internalize and execute against the lessons presented in this section will emerge from this dry period stronger, making them primed for explosive growth when the tides return. While the industry has made significant strides since the days of the first EOR project launch, the work ahead will require sustained commitment and patience. Breakthroughs and scaling will take time, and the focus must remain on long-term solutions, not just short-term wins.

Though not without significant challenges, including the risks associated with any actions we take, there should be no doubt that the risks of inaction are far greater. We can, and must, see the Circular Carbon vision become a reality.

The background features a large black rectangular area on the left side. To the right, there are several overlapping geometric shapes in shades of grey and pink. At the top right, there are three nested, slightly offset grey shapes that resemble a stylized 'G' or a series of parallel lines. Below these, there is a large pink shape that is partially obscured by a grey shape above it. At the bottom, there are more pink and grey geometric shapes, including a prominent pink diagonal line. The overall design is modern and minimalist.

CIRCULAR CARBON  
**TIMELINE**

# CIRCULAR CARBON TIMELINE

## Milestone Key:

● Policy and Advocacy Changes   ● Technology Milestones   ● Funding Rounds or Money Movement   ● Corporate Commitments   ● Negative Issues

1965

● **Memo to President Johnson on GHG risk:**

The Scientific Advisory Committee of the Task Force On Environmental Pollution outlined in a memo the risks posed by the "greenhouse gas effect" and suggested the need for geoengineering solutions to address it.

1972

● **First large scale CO<sub>2</sub>-EOR project:**

Developed by Chevron, SACROC piped natural sources of CO<sub>2</sub> from Colorado to Texas, injecting 175 million tons of CO<sub>2</sub> between 1972 and 2009.

1989

● **Global warming first used on NPR:**

Noah Adams, former host of All Things Considered, used the phrase in a story about Al Gore.

1997

● **UNFCCC's Kyoto Protocol Set the International Stage for Targets:**

The protocol established binding goals for industrialized countries and the European Union to reduce their greenhouse gas emissions between 2008 and 2012 to 5% below 1990 levels.

2000

● **Business leaders sign UN Global Compact:**

A voluntary commitment by CEOs to take steps to implement UN goals, notably creating the SDGs or [Sustainable Development Goals](#).

2006

● **International Biochar Initiative Launched:**

Now led by Wendy Lu Maxwell-Barton, the nonprofit was first formed in 2006 to foster stakeholder engagement and ethical practices supporting biochar systems. [Read More](#)

● **Birth of Cleantech 1.0 era:**

A period of increased investment and innovation in clean technologies that lasted until roughly 2011.

2007

● **Virgin Earth Challenge Launched:**

Virgin offered a \$25M prize to anyone demonstrating viable technology for permanently removing carbon dioxide. Finalists were announced in 2011, although a winner was never declared. [Read More](#)

● **First CO<sub>2</sub> Mineralization Company Was Founded:**

Carbfix began operations. [Read More](#)

2009

● **Global Carbon Capture and Storage Institute Launched:**

The Institute was supported by initial funding from the Australian Government to accelerate the development of carbon capture and storage (CCS) technology globally.

● **First DAC Companies Were Founded:**

Carbon Engineering, Climeworks, and Global Thermostat were founded and raised the first significant private capital for direct air capture (DAC).

2011

● **Carbon Capture Coalition Launched:**

The Coalition began with the goal of building bipartisan support in the U.S. for policies that accelerate CCS at both state and federal levels.

2014

● **First CCUS Project Launched:**

Boundary Dam in Canada became the world's first commercial-scale power plant to successfully use carbon capture, utilization, and storage (CCUS). It captures 1 million tons of CO<sub>2</sub> annually.

2015

● **Paris Agreement was Adopted at COP21:**

The Agreement, adopted by 196 nations, legally binds countries to limit warming below 2°C. [Read More](#)

● **Mission Innovation Launched:**

This multi-national initiative was announced at COP21 to accelerate public and private clean energy innovation. [Read More](#)

2015

● **NRG COSIA Carbon XPRIZE Launched:**

The \$20M competition to convert captured CO<sub>2</sub> into products catalyzed two large test centers: the Wyoming Integrated Test Center and the Alberta Carbon Conversion Technology Centre.

● **Science Based Targets Initiative Launched:**

SBTi established a framework for ambitious corporate action toward a net-zero economy.

● **First CCS Projects in the UAE Began:**

ADNOC partnered with Masdar in 2009 to pilot CO<sub>2</sub> injection, creating new opportunities in the carbon market.

● **First Dedicated Carbon Removal Nonprofit Launched:**

Carbon180 (formerly known as the Center for Carbon Removal), was launched to focus on scaling carbon removal solutions through policy interventions.

2016

● **The Global CO<sub>2</sub> Initiative Launched in Davos:**

One of the first think tanks focused on Circular Carbon, the Global CO<sub>2</sub> Initiative launched with a seminal report on the economic opportunity represented by carbon utilization. (The initiative later became a research center at the University of Michigan.)

● **Commercialization Success Achieved:**

CarbonCure began commercializing its carbon utilization technology for concrete, which locks CO<sub>2</sub> into building materials, offering a scalable CCUS application.

● **IKEA Made a Pledge:**

IKEA pledged to become 100% renewable, both in terms of sourcing and producing its own energy, by 2020. The company aimed to achieve a climate-positive footprint by 2030.

● **The World's Largest LNG+CCS Initiative Launched:**

Chevron's Gorgon Project in Australia began injecting CO<sub>2</sub> into deep underground reservoirs. While it highlighted the potential of large-scale CCS, the project raised lingering concerns about its high cost, long-term effectiveness, and environmental impact.



2016

● **Startup Growth:**

46 Circular Carbon startups were founded.

2017

● **Multi-Stakeholder Circular Carbon Effort Launched:**

The Circular Carbon Network was formally launched as an initiative of XPRIZE to help accelerate commercial activity and investment in the emerging sector.

● **Climeworks Opened the World's First Commercial DAC Plant:**

In Switzerland, Climeworks launched the world's first commercial DAC plant, capturing about 900 tons of CO<sub>2</sub> annually and selling it to greenhouses for agricultural use. [Read More](#)

● **A Carbon Capture Plant Came Online:**

Petranova, a carbon emissions reduction system, began operations and delivered captured carbon for enhanced oil recovery to oil fields in Texas. The project would go on to eventually miss their financial and sequestration targets. [Read More](#)

● **Unilever Pledge Set a New Standard:**

Unilever adopted Science Based Targets to reduce the company's carbon footprint by 50% by 2030. Unilever's aggressive push set new benchmarks for large multinational companies.

● **The Kemper Clean Coal Power Plant Failed:**

The Kemper County Energy Facility, initially designed to capture and store CO<sub>2</sub> emissions from coal combustion, was abandoned after challenges with complex technology and cost overruns.

● **AirMiners CDR Community Formed:**

The community's aim is to support entrepreneurs and innovators working on carbon removal.

● **Startup Growth:**

43 Circular Carbon startups were founded.

2018

● **The IPCC Called Carbon Removal Necessary:**

The IPCC released a report outlining the impacts of warming above 1.5°C. The report emphasizes that reaching net-zero greenhouse gas emissions by 2050 requires not only reducing emissions but also significant carbon removal efforts, in all pathways.

## 2018

- **The First Enhanced Weathering Project Launched:**

Project Vesta introduced its ocean-based carbon removal concept, aiming to accelerate natural weathering by spreading olivine sand on coastlines, enhancing the ocean's capacity to absorb CO<sub>2</sub>.

- **The National Academies Assessed Emerging Technologies:**

Negative Emissions Technologies and Reliable Sequestration highlighted the need for scalable, cost-effective solutions and robust monitoring, catalyzing policy discussions, research funding, and investment in negative-emissions technologies.

- **U.S. Expanded the 45Q Tax Credit:**

The expansion of the U.S. 45Q tax credit increased incentives for capturing and storing CO<sub>2</sub>, offering up to \$50 per ton for storage and \$35 per ton for utilization, stimulating investment in CCUS projects. [Read More](#)

- **The First Peer-Reviewed Cost Paper Was Published:**

Carbon Engineering published new research showing affordable costs for DAC solutions at scale (\$94 to \$232 per ton of CO<sub>2</sub>).

- **California Made a Pledge:**

Governor Jerry Brown signed Executive Order B-55-18, committing California to carbon neutrality by 2045.

- **Startup Growth:**

87 Circular Carbon startups were founded.

## 2019

- **Landmark DAC Investment Was Made:**

Carbon Engineering raised \$68M in private equity for their DAC technologies.

- **Amazon Made a Pledge:**

Amazon co-founded the Climate Pledge with Global Optimism, committing to reach net-zero carbon emissions by 2040, 10 years ahead of the Paris Agreement goals. Amazon committed to 100% renewable energy by 2025.

- **Stripe Announced a Negative-Emissions Commitment:**

Stripe announced its pledge of at least \$1M per year to pay for the direct removal of carbon dioxide from the atmosphere and CO<sub>2</sub> sequestration in secure long-term storage.

- **Shopify Announced Sustainability Fund:**

Shopify committed to spending an annual \$5M on environmental investments, including at least \$1M toward carbon sequestration, kickstarting the demand for the carbon market. [Read More](#)

- **Puro.Earth Launched First Framework for Verified Carbon Removal:**

The Puro Standard was introduced as the first standardized methodology to certify engineered carbon removal and issue CO<sub>2</sub> Removal Certificates. [Read More](#)

- **Energy Future Initiative Issued Carbon Removal Roadmap:**

Former U.S. Energy Secretary Ernie Moniz's think tank, EFI, issued a report recommending significant increases in government funding for carbon removal research and development. [Read More](#)

- **Startup Growth:**

77 Circular Carbon startups were founded.

- **Microsoft and Amazon Joined the Carbon Removal Market:**

Microsoft launched its \$1B Climate Innovation Fund, creating a model for corporate involvement in CDR and CCUS. Amazon made a similar \$2B commitment to climatetech, including carbon removal.

- **First DAC Climate Mobilization Summit Was Held:**

More than 70 DAC pioneers and supporters met virtually for two days during the COVID-19 pandemic, representing the first large DAC-focused gathering to date and eventually catalyzing the launch of the multi-stakeholder [DAC Coalition](#), which has grown to more than 120 members since its founding. [Read More](#)

- **Counteract Was Founded:**

Counteract was established to overcome barriers of scaling carbon removal solutions by investing across all CDR solution types.

- **A Surge in Net Zero Pledges:**

Microsoft, Shell, BP, JP Morgan, Nettle, Ford and Google all made public net zero commitments.

- **Startup Growth:**

95 Circular Carbon companies were founded.

- **U.S. Government Granted Stimulus for CCUS:**

The U.S. Bipartisan Infrastructure Bill allocated more than \$12B for carbon management efforts, including four DAC hubs and permits for carbon sequestration and \$2.7B for nature-based solutions. This marked one of the largest government commitments to promoting large-scale carbon management to date. [Read More](#)

- **Facebook Made a Pledge:**

Facebook announced its commitment to achieving net-zero emissions for its value chain by 2030, with an emphasis on carbon removal initiatives and sustainability projects.

- **PepsiCo Made a Commitment:**

The company committed to reducing greenhouse gas emissions across its value chain and aiming for net-zero emissions by 2040.

- **Carbon-To-Value Initiative Was Founded:**

Carbon-To-Value Initiative, a collaboration between NYU's Urban Future Lab, the Boston-based Greentown Labs cleantech accelerator, and the global engineering firm Fraunhofer, is focused on catalyzing the carbontech industry through partnerships and investments. [Read More](#)

- **Climeworks' Orca Plant Became Operational:**

In September, Climeworks launched the Orca DAC plant in Iceland, the largest in the world at the time, capable of capturing and storing 4,000 tons of CO<sub>2</sub> annually in basalt rock.

- **ExxonMobil Increased its Goals:**

After years of criticism over its climate policies, ExxonMobil increased investments in CCS technologies, aiming to capture more than 100 million metric tons of CO<sub>2</sub> annually by 2040. However, critics pointed to this as insufficient without a reduction in oil and gas production.

- **Mission Innovation Launched a Carbon Dioxide Removal Mission:**

Announced at COP26, the group's goal is to enable 100 million tons of technological CDR per year by 2030.

- **XPRIZE Carbon Removal Launched:**

In April, XPRIZE Foundation announced the \$100M XPRIZE for Carbon Removal, sponsored by the Musk Foundation, to accelerate the development of scalable carbon removal solutions.

## 2021

- **Northern Lights CO<sub>2</sub> Storage Facility Broke Ground:**

Norway launched the Northern Lights project to create an open-source CO<sub>2</sub> storage infrastructure capable of handling CO<sub>2</sub> from across Europe, a key step in Europe's CCUS strategy.

- **Global Carbon Removal Partnership Launched:**

Led by the Global South, the multi-stakeholder initiative was announced at COP26 to support the scaling of carbon removal solutions, drive market narrative, and catalyze corporate action. [Read More](#)

- **Startup Growth:**

184 Circular Carbon startups were founded.

- **CDR.fyi Was Founded:**

The CDR.fyi platform launched, making carbon removal offtakes market data accessible, with a mission to accelerate the global deployment of durable carbon removal technologies.

- **Heirloom Raised \$53M:**

The DAC company's Series A funding was led by Breakthrough Energy, a Bill Gates-founded investment firm. [Read More](#)

## 2022

- **Lowercarbon Capital Announced \$350M Fund for Startups:**

The fund's purpose was to invest in carbon removal startups looking to scale their technology. [Read More](#)

- **Carbon Removal Partners Was Founded:**

The company was established to grow the carbon removal market by investing in and collaborating with leading entrepreneurs.

- **CHIPS and Science Act Increased DOE Investment into Carbon Removal:**

The U.S. CHIPS and Science Act allocated \$1B for carbon removal R&D.

- **Inflation Reduction Act (IRA) Boosted Support for Carbon Removal:**

The U.S. passed the Inflation Reduction Act, distributing additional public funding for CDR efforts and increasing the 45Q tax credit to \$85 per ton for storage, \$60 for utilization via CCS, \$180 per ton for storage, and \$130 for utilization via DAC.

- **NextGen CDR Was Created:**

BCG, LGT, Mitsui OSK Lines, Swiss Re, and UBS launched an initiative in Davos to purchase \$1M tons of certified permanent CDR by 2025, allowing CDR projects to sell the credits they generated to credit-worthy counterparties while helping to standardize removal offtakes and build market credibility.

- **Carbon Business Council Was Founded:**

More than 40 leading carbon-management startups joined together to create a seat for growing companies at the policy table. The council has grown to more than 100 members since its founding. [Read More](#)

- **Largest Planned DAC Facility in the U.S. Was Announced:**

CarbonCapture announced plans for Project Bison, a DAC facility in Wyoming intended to capture 5Mt CO<sub>2</sub> per year by 2030.

- **World's First Net-Zero Shipping Pledge Made:**

Maersk, the shipping giant, committed to net-zero emissions by 2040 for its entire business, including its direct and indirect emissions.

- **First Large DAC Carbon Removal Purchase Made:**

Airbus announced a purchase of 400,000 tons of carbon removal credits from 1PointFive over four years.

- **The Frontier Fund Was Created:**

Stripe, Shopify, Meta, and other tech companies launched the Frontier fund, committing \$925M over the next decade to purchase permanent carbon removal credits and stimulate innovation in the space.

- **Climeworks Raised \$650 Million:**

This was the largest-ever funding round for carbon removal technology, signaling investor confidence in the future of scalable carbon removal solutions.

- **First Movers Coalition Launched CDR Track:**

FMC members committed to purchasing 50,000 tons of carbon dioxide removal to be achieved by the end of 2030, stimulating market demand.

- **Integrity Council for the Voluntary Carbon Market (ICVCM) Launched:**

ICVCM was set up to create a global standard for high-integrity carbon removal, enhancing market credibility.

2022

● **A Pledge Was Reversed:**

After facing pressure from state governments in the U.S., BlackRock softened its stance on climate pledges. CEO Larry Fink declared the company would continue investing in fossil fuels due to energy security concerns, causing backlash from environmental advocates.

● **Startup Growth:**

108 Circular Carbon startups were founded.

2023

● **Remove Was Launched:**

Formerly operating as Carbon Removal ClimAccelerator since 2021, the CDR accelerator focuses on supporting CDR startups as well as policy and ecosystem building activities in Europe, India, and sub-Saharan Africa. [Read More](#)

● **Department of Energy Invested \$1.2B in DAC Hubs:**

The U.S. government announced grants for Project Cypress in Louisiana (run by Batelle, Climeworks, and Heirloom Carbon Technologies) and another DAC plant in Texas (led by 1PointFive, Carbon Engineering, and Worley).

● **First Kilotonne-Scale DAC Plant in U.S. Launched:**

Global Thermostat launched the first operating DAC plant in the U.S. capable of capturing more than 1,000 tons per year.

● **VCM Scandals Led to Concerns Over Carbon Credit Programs:**

A series of scandals arose around the VCM, aimed at developers and trading platforms, alleging that retired carbon credits delivered little to no climate benefit.

● **First Major “Exit” of a CDR Company:**

Oxy purchased Carbon Engineering for \$1.6B.

● **Cancellation of Navigator CO<sub>2</sub> Ventures Pipeline:**

The cancellation of the proposed CO<sub>2</sub> transportation pipeline by Navigator Ventures marked a significant setback for large-scale CCS projects, highlighting ongoing challenges in facing pushback and getting regulatory approval.

● **World’s First Commercial-Scale Peridotite Mineralization Project Launched:**

44.01 launched its enhanced mineralization project in Oman, using basalt rock to permanently store captured CO<sub>2</sub>, contributing to permanent carbon removal at scale.

- **National Geographic Published CDR Cover Story:**

The magazine featured Carbfix, among others. [Read More](#)

- **Microsoft Made One of the First Large Carbon Removal Pre-Purchases:**

Microsoft announced a deal to purchase 2.67M tons of carbon removal credits from Ørsted over the next 11 years.

- **TotalEnergies Scaled Back Short-Term Emissions Targets:**

TotalEnergies reduced its 2030 emissions targets, causing environmental advocates to express concern about backtracking on net-zero goals. [Read More](#)

- **Carbon Removal Alliance Launched:**

More than 20 carbon removal companies formed the Carbon Removal Alliance to promote government policies supporting industry growth. [Read More](#)

- **STRATOS Project Broke Ground:**

The world's largest DAC project, with a planned 500,000 ton-per-year capacity (which is 14 times the size of the prior largest DAC plant, Climeworks' Mammoth) began construction in Ector County, Texas.

- **NextGen Made One of the First Large Carbon Removal Transactions:**

Announcing the pre-purchase of almost 200,000 tons of carbon removal credits, NextGen partnered with Summit Carbon Solutions (BECCS), 1PointFive (DAC), and Carbo Culture (biochar) for a diversified portfolio.

- **The Industry Called for CDR Standards:**

An open letter called for standards to assess the performance of different CDR approaches, signed by 70 representatives from different organizations. [Read More](#)

- **Carbon Removal Leadership Act (CRLA) Passed:**

The U.S. passed the Carbon Removal Leadership Act, encouraging federal agencies to purchase verified carbon removal credits, establishing clear demand signals for the market.

- **XPRIZE Announced 20 Finalist Teams from More Than 1,300 Competitors:**

XPRIZE chose finalists across the contest's four tracks (air, rocks, land, and ocean) to continue to the final stage of the carbon removal competition.

- **Canadian Government Announced Plans to Invest In Carbon Removal:**

The Canadian government plans to purchase \$10 million in carbon removal services between now and 2030.



- **Drax Transformed Business Plan for Large-Scale Carbon Removal:**

Drax launched a new company, Elimini, to advance BECCS for carbon removal.

- **An Ocean Carbon Removal Company Shut Down:**

Running Tide, which utilized macroalgae for carbon sequestration and later pivoted to sinking wood biomass, shut down after raising \$54M, due to lack of demand in the voluntary market. [Read More](#)

- **Carbon Dioxide Removal Purchase Pilot Prize Announced Semifinalists:**

The DOE announced 24 semifinalists to receive a \$1.2M prize to accelerate the carbon removal industry. [Read More](#)

- **White House Announced Voluntary Carbon Markets Joint Policy Statement and Principles:**

Leaders across U.S. federal departments released a set of guidelines to increase integrity of VCMs.

- **Large Investment in E-Jet Fuel Made:**

Twelve and Infinium raised a combined \$1.7B to convert carbon into jet fuels. [Read More](#)

- **High-Quality Carbon Removal Purchases on the Rise:**

Microsoft [disclosed its biggest carbon removal contract yet](#), a 10-year deal covering 3.3 million metric tons of emissions starting in 2028, at a BECCS installation being built in Stockholm.

- **Pledges Reversed:**

Initially setting ambitious targets for electric vehicle production, Toyota scaled back its 2026 target by 30% amid concerns around adoption. Microsoft, Amazon, P&G, Unilever, and Walmart were among 239 corporations to remove net-zero commitments from SBTi.

- **Countries Agreed to Standards for Centralized Carbon Market:**

At COP29, under Article 6.4, countries can trade carbon credits from emission-reduction projects, paving the path for a UN-supervised functional carbon market.

- **Project Bison Shut Down:**

CarbonCapture announced they were unable to secure enough carbon emissions-free energy for operation, losing out to competing AI data centers.

**2024**

● **Global 1000 CDR Challenge Launched at COP29:**

This challenge, launched by ClimiFi and XPRIZE, encourages corporations to purchase substantial carbon removal credits to help create demand in the market.

**EXPECTED**

**2025**

● **XPRIZE to Announce Carbon Removal Winners:**

\$50M will be awarded to the grand winner and \$30M will be distributed among up to three runners-up.

● **EU Carbon Border Adjustment Mechanism (CBAM):**

The EU's CBAM, a carbon tariff on imports, is set to take effect, incentivizing global industries to adopt carbon capture technologies to meet regulatory requirements.

● **Mammoth DAC Plant to Come Online:**

Climeworks' Mammoth plant is expected to begin full operations, capable of capturing 36,000 tons of CO<sub>2</sub> annually, representing a major leap in the scalability of DAC technology.

● **Mexico to Launch ETS:**

Following a pilot phase, Mexico's Emissions Trading System (ETS) is set to become mandatory in 2025. The system will regulate emissions from large industrial sources and is intended to support Mexico's goal of reducing greenhouse gas emissions under the Paris Agreement. [Read More](#)

● **STRATOS to Come Online:**

The plant is scheduled to start operating in Q2 2025, capturing and storing approximately 500,000 tons of CO<sub>2</sub> per year.

**2026**

● **Japan to Make ETS Mandatory:**

Japan's national GX Emissions Trading System, designed to help it reach its target of net-zero emissions by 2050, will become mandatory in 2026. The system will initially cover the industrial sector and eventually expand to other sectors. [Read More](#)

**2027**

● **EU to Expand ETS:**

The European Union is expanding its ETS program, introducing a separate scheme called ETS2, which will cover emissions from road transport and buildings. The new scheme is expected to launch fully by 2027, with initial reporting beginning in 2025. It targets fuel suppliers, rather than end consumers, and aims to achieve a 42% reduction in emissions from covered sectors by 2030. [Read More](#)

The background features a large black rectangular area on the left side. To its right, there are several overlapping geometric shapes in shades of red and grey. At the top right, there are three nested, light grey trapezoidal shapes pointing downwards. Below these, a solid red shape is partially visible. At the bottom, there are more overlapping red and grey shapes, including a prominent diagonal red band. The word 'METHODOLOGY' is centered in white text within the black area.

# **METHODOLOGY**

Our methodology defines Circular Carbon companies as those that are directly removing CO<sub>2</sub> from the air or ocean, capturing it straight from the source, making valuable products from reused CO<sub>2</sub>, or supplying the essential infrastructure for these activities. In brief, we define these categories in the following ways:

**CO<sub>2</sub> Removal:** CO<sub>2</sub> removal includes approaches that result in removal of carbon dioxide (CO<sub>2</sub>) from the atmosphere.

**Sub-Sectors:**



**Air:** 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.



**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.



**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.



**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).

**CO<sub>2</sub> 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 CO<sub>2</sub>, 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.

# 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 CO<sub>2</sub> 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 CO<sub>2</sub> 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. 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 indices 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:

**Overlapping Data:** Thirty-four percent (368) of index respondents chose to select more than one solution type. 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 CO<sub>2</sub> conversion that has raised a \$30M round will be represented within both the point source capture column and CO<sub>2</sub> 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.