CLIMATE CHANGE BUSINESS JOURNAL®

Climate Change Industry Overview

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Climate Change Industry Braces For More Disruption

The U.S. climate change industry grew 9% in 2024 to $530 billion, according to Climate Change Business Journal's annual model of the climate change industry. The tables and charts in this review summarize the key numerical trends of the industry and key segments that impact overall growth. The 9% growth in 2024 is down noticeably from the previous three years as detailed by segment on the table on page 3. Declining growth rates in the sales of electric vehicles was a significant reason for the transportation segment, the industry's largest, falling below the double digit growth line and only growing 5% in 2024. Growth in renewable energy and clean power, the third largest segment, was over 20% in revenues in 2024, and improvement over the previous three years, but not enough to keep overall climate change industry growth in the United States above 10%.

These two influential segments are profiled from a statistical standpoint later in this review, and their trajectory will likely be increasingly influential to climate change industry growth for the rest of the 2020s, given the result of the 2024 presidential election. The second and fourth largest climate change industry segments, energy efficiency technology and services and green buildings, also failed to produce double-digit growth in 2024 according to CCBJ analysis. A valid argument exists that these segments could be excluded from the core climate change industry, as saving or conserving energy or producing less energy-consuming assets in the built environment may not be seen as being part of the solution, but more as just incremental efforts to minimize the problem. However, we do continue to include these segments, but also to produce segment specific breakdowns to allow more selective analysis.

Climate Change Industry Overview 2024

CCBJ's annual assessment of the climate change industry quantifies segment fluctuations and the impacts of political change. The U.S. climate change industry grew 9% in 2024 to $530 billion, lagging recent growth but most executives remain optimistic about long term drivers in their business. Features in this edition summarize public transit, carbon markets and biogas, with executive Q&As on oil & gas carbon capture, hydrogen infrastructure, VC investment, decarbonization, restoration, climate grants, factory farms and law firms' take on energy transition

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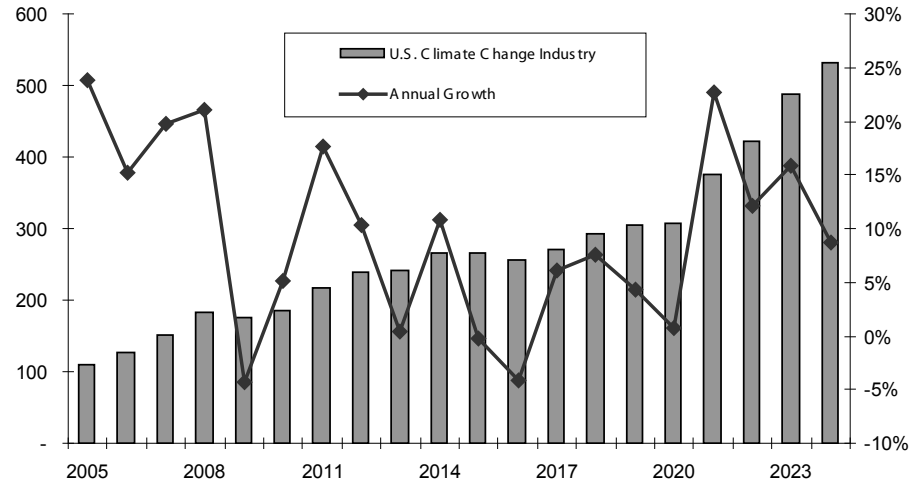
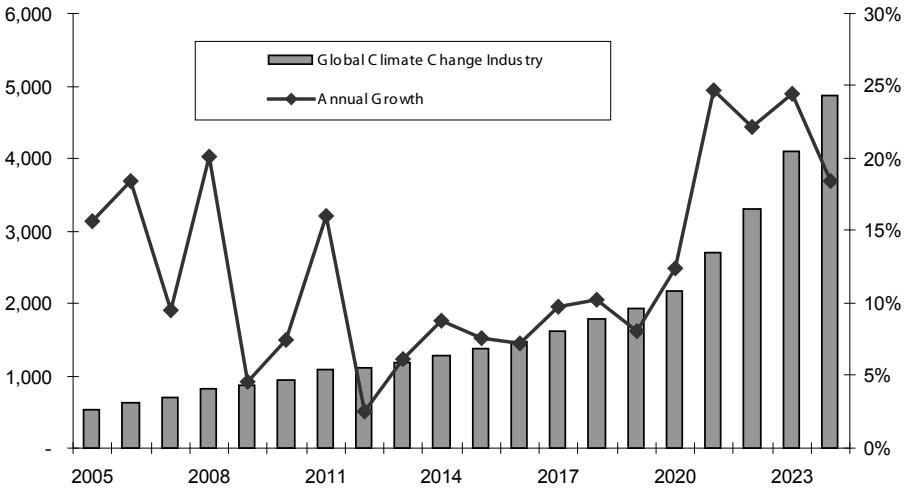
U.S. Climate Change Industry in $bil & Annual Growth

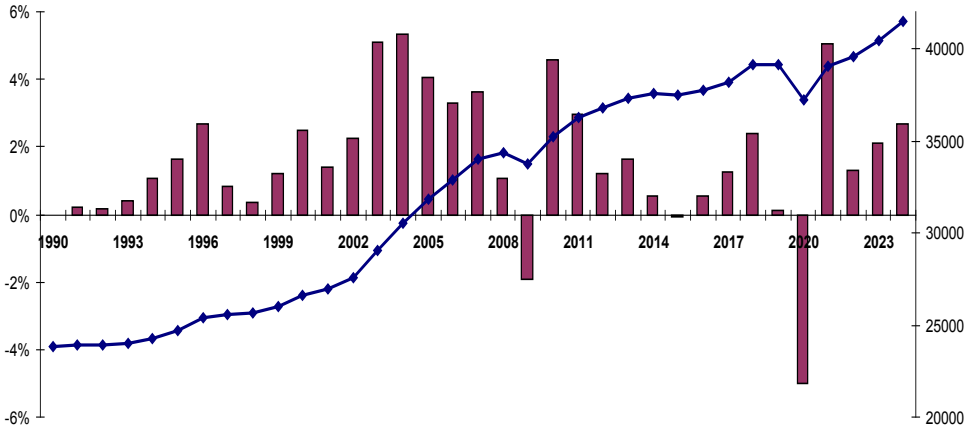


Global Climate Change Industry in $bil & Annual Growth



Source: Climate Change Business Journal; Environmental Business International, Inc., San Diego, Calif.

Global Emissions in CO2e & Annual Change from 1990-2024



Source: CCBJ derived from Energy Institute Statistical Review of World Energy

Zero Carbon Capital Bets on 'Hard Science' and a Sweep of Early Stage Companies in a More Mature Climate Tech 2.0

Zero Carbon Capital is an early stage venture capital firm backing European companies building innovative, scientific solutions to the biggest, hardest challenges of decarbonisation. We make pre-seed and seed investments across sectors, from agriculture to industrial processes, and energy to carbon dioxide removal. ZCC works with companies that have the potential to build big businesses, and are addressing unsolved emissions areas of at least 500 Mt of CO2e per year. ZCC is a team of 5, all with science backgrounds and years of experience commercialising deeptech innovation. The founding partners have been investing in Climate Tech since 2016. ZCC has made 20 investments across two funds and are currently investing from a £20m fund.

Sarah Jones is a Principal at ZCC and is based in London. She holds a PhD in Bioprocess Engineering and has been supporting the commercialisation of scientific innovation in various roles. This includes working in university tech transfer offices at Imperial College London and the University of Oxford, at the Creative Destruction Lab accelerator, where she launched and led the Climate program, and now at ZCC.

CCBJ: How has climate tech VC evolved over the last decade?

Jones: During what is known as the Cleantech 1.0 boom and bust, $25bn of VC capital was invested in climate tech companies between 2006 and 2011, and by 2015 50% of the capital was lost. Between 2012 and 2016 investment in climate tech dropped because of the failures of Cleantech 1.0. Capital into climate tech then began to gradually rise with renewed interest in Climate Tech 2.0, which had a broader scope than the renewable energy focus of Cleantech 1.0. Capital into Climate tech peaked in 2021 with $76bn invested and is now more than 10X what it was a decade ago.

Climate tech investments are much broader now and include investments in transport, building, industrial processes, and food & agriculture in addition to renewable energy which was the focus a decade ago. There has been a boom in the number of climate focussed funds since 2021 with about $82bn in dry powder since Sept 2023 to deploy into climate tech. The climate tech investment ecosystem has also become more sophisticated, with many venture builders and accelerators feeding the sector, and a diversity in types of capital including CVCs playing a critical role and growth and infrastructure funds starting to invest.

Driven by international climate policy, corporate climate goals, tangible changes in climate, and successes in renewable energy and EVs, Climate Tech 2.0 stands a much higher chance of producing massive successes - for society and for our planet.

CCBJ: Describe the criteria Zero Carbon Capital uses to select pre-seed and seed companies for investment, particularly those with the potential to reduce emissions significantly?

Jones: Zero Carbon Capital invests in breakthrough scientific innovations solving the biggest challenges of decarbonisation. We invest in scientists who are entrepreneurs and who are vision aligned with us in using scientific innovation as one of the levers to solve climate change.

We look for companies who have an Emissions Reduction Potential (ERP) of at least 500 Mt/yr of CO2e by 2050, meaning that their technology could displace this amount of GHG emissions when at scale. High impact emissions areas are linked to large markets and the potential to be massively scalable companies. The startups we invest in have highly defensible technologies that are competitive in terms of cost and performance with fossil incumbents and other new competing technologies.

CCBJ: What are the major challenges in commercializing scientific innovations for decarbonization, and how does Zero Carbon Capital help overcome these?

Jones: Scientific innovation takes time and there can be setbacks. It's really important for founders to keep up momentum once they have investment money and be transparent with their investors. They need to identify when their product is good enough to start scaling and avoid spending too much time perfecting their prototype. It's also important that they get as much non-dilutive money as they can.

The ZCC team are all scientists and so have a good understanding of the technologies our portfolio companies are developing. We have years of experience commercialising deeptech innovations. We help our startups to develop key metrics and milestones to progress from pre-seed to Series A and beyond, and offer support on their technoeconomic analyses as well.

Scaling can be challenging as manufacturing facilities have high capital requirements. There are various options that startups can take to de-risk this. Modular technologies are easier to scale because they are lighter on capital as you prove the technology works and benefit from manufacturing learnings and cost reductions.

Contract Manufacturing Organisations (CMOs) are useful partners to test your product and customer demand at mid-scale before you build your own manufacturing plant. Some startups form joint ventures with a customer to build a manufacturing facility together through a commercial agreement. It's important for scientific teams to hire a project manager or a C-Suite with experience at industrial scale.

ZCC works very closely with our portfolio companies supporting them with their deeptech and scaling challenges and connecting them with follow-on investors who

can continue to support them as they grow. We have a wide network of VCs, CVCs and later stage funding options who we can introduce to our startups when they are ready.

CCBJ: What are some of the most promising hard science-based technologies Zero Carbon Capital has invested in?

Jones: ZCC has invested across a range of sectors including energy, transport, agriculture & food, chemicals, industrial processes, and carbon capture. All of our investments have a hard science innovation at the core which will disrupt fossil fuel and high-emissions incumbents.

We have noticed that high impact scientific innovation for climate tends to fall in three buckets, which are reflected in our portfolio - electrochemistry, biotechnology, and engineering. Our latest stage investment is Echion Technologies who successfully raised a £29m Series B to scale the production of their novel anode materials for Li-ion batteries. And our most recent investment is Kairos Carbon, who spunout from the Deep Science Ventures venture builder and are building a hydrothermal carbon removal process that converts sludgy waste into clean water, valuable minerals, and CO2 to be permanently stored.

CCBJ: Are there specific industries or sectors where Zero Carbon Capital sees the most potential for impactful decarbonization technologies in the near future?

Jones: Food production accounts for a quarter of our global GHG emissions, yet agriculture is still an underserved sector in climate-tech VC. Two major sources of GHG emissions are nitrous oxides emitted from the overuse of fertilisers on crops, and methane emissions from livestock. ZCC is interested in the innovations arising to solve these two emissions areas. We have invested in NetZeroNitrogen, who have engineered a nitrogen-fixing bacteria into crops to reduce fertiliser requirements, and Climate Crop who increase crop yield, and we are looking to support more breakthrough innovations in this space.

We are also exploring critical minerals and how we can affordably meet demand as we expand the electrical grid and make more EVs and other products that require minerals such as nickel, copper and lithium. ZCC's founding partner made an angel investment in Lilac Solutions, who recently raised £116m Series C for their Direct Lithium Extraction process to extract lithium from salt lakes. We are interested in exploring whether biomining could play a role in this sector as a highly targeted, and potentially low cost mineral extraction method.

CCBJ: How do government policies and regulations impact your investment decisions and the success of your portfolio companies?

Jones: Governmental policies and regulations are critical for enabling climate tech to succeed. ZCC has joined Cleantech for UK, a coalition of VCs and founders who advocate to the government to ensure the success of our sector as a critical part of reaching our global net zero goals. Governmental support for climate tech infrastructure projects, blended finance to bridge the First-of-a-Kind (FOAK) funding gap, updating regulation and reducing regulatory burden to enable critical technologies with urgency, building an industrial strategy that aligns with net zero are among the topics raised at Cleantech for UK.

CCBJ: What emerging technologies or fields of study are you most excited about that could significantly impact decarbonization efforts?

Jones: Biotechnology continues to rapidly advance with increased focus on synthetic biology and industrial and climate biotech. Most of our modern lives depend on carbon-based chemicals and products that today are largely made from petrochemicals. To remove the GHG emissions associated with petrochemicals we need to use alternative sources of carbon. CO2 captured from the atmosphere is one route, but this is thermodynamically challenging and will always have high energy costs. Another source of carbon is biological carbon. Advancements in bioengineering (like our portfolio company twig and Phycobloom), enzymatic processes that convert waste carbon sources to chemical monomers (like our companies Epoch Biodesign and Level Nine) and other breakthroughs in biotechnology will enable cost competitive bioproducts to replace petrochemicals.

Synthetic biology has also emerged as a key sector in climate tech with a focus on alternative proteins. To replace methane emissions and land use change emissions associated with livestock farming, entrepreneurs and scientists are working on ways to produce meat and dairy in the lab using animal cell culture (lab-grown meat) and microorganisms (precision fermentation). Many are sceptical about these methods because of challenges with scaling and reaching price parity with livestock products. However, with recent reductions in cost and continued innovation in these areas, we think it's worth monitoring this space. As demand for food increases we will need more low emissions ways to grow all the protein we need. Our portfolio companies Multus Media and Nutropy are pioneering cost reductions in alternative proteins.

CCBJ: What are Zero Carbon Capital's strategic goals for the next five to ten years, and how do you plan to achieve them?

Jones: Zero Carbon Capital is on a mission to back exceptional founders with deeptech, hardtech climate innovations that will put us on track to stay within 1.5°C of global heating. We have dry powder to invest in another 4 to 6 companies in our current fund and will be raising our third fund next year.

ZCC's long term vision is to contribute to a future where humans are thriving on a healthy planet with healthy ecosystems. Our mission is to support start-ups mitigat-

ing human-made impacts to the environment by leveraging the power of scientific innovation, starting with the most urgent issue ahead of us: climate change.

By 2030 we want to have backed 100 companies that align with our mission and vision and be supporting those companies to scale, graduate to later stage investors, and ultimately for their products to be widely adopted. ☼

ZCC Portfolio Examples

Zero Carbon Capital targets disruptive and scalable hard science-based decarbonisation technologies that can move the needle on climate change. A technology must either fundamentally fix a problem or remove a barrier to adoption of an existing decarbonisation technology. An emission reduction potential of 0.5 Gt CO2e per year at full scale deployment (at the latest by 2050) is a prerequisite. ZCC's preference is to invest as early as possible, often as the first institutional money in a company or alongside an angel round. typical first check ranges between £100k and £1m. Our sweet spot is £300-500k. LPs are a mix of international corporations, institutional investors, funds of funds, family offices, and high net worth individuals.

• **Kairos Carbon** turns waste into low cost carbon capture by turning sludgy waste into clean water, valuable minerals and CO2 to be durably stored as carbon removal at low energy requirements and cost. Given available volumes of carbon-based waste, Kairos Carbon will reach 0.9 Gt/year CO2 capture by 2050.

• **Cambridge Electric Cement** recycles cement and decarbonises secondary steel, targeting the 8% of global emissions caused by virgin cement production by recycling used cement in electric arc furnaces during the steel recycling process. The output from the EAF is recharged cement in place of slag and the recycled steel, decarbonising cement using existing infrastructure.

• **Aed Energy** couples novel thermal battery materials with smart photovoltaics to enable very low cost modular long duration electricity storage. Aed's target is to help the millions of current and future microgrids to move from diesel generators to intermittent renewable power while keeping the lights on.

• **Twig** makes ingredients found in everyday products using microbial fermentation instead of intensive agriculture or petrochemicals. By replacing palm oil and other ingredients, 1.2 Gt CO2e could be saved per year by 2050. Twig uses bioengineering and AI to rapidly achieve high yields, enabling cost competitive bio-ingredients.

• **NitroFix** make ammonias from water and air. Ammonia production today is responsible for 2% of global GHG emissions, and is a leading contender to decarbonise the shipping industry. By synthesising ammonia directly from water and nitrogen, NitroFix's electrochemical cells can make ammonia without carbon emissions at a low cost.

• **RepAir** has a modular, electrochemical solution to direct air capture of CO2 that promises to be both flexible and affordable.

• **Biozeroc** makes cement mimicking nature. Concrete is responsible for 8% of GHG emissions and cement is the main offender. Biozeroc use bacteria to create cementitious material in place bypassing the energy and process emissions of cement.

• **Anaphite** graphene batteries target EV range anxiety with novel methods for incorporating graphene into lithium ion batteries, increasing capacity and enabling faster charging.

• Multus Media is an affordable, low carbon cultured meat alternative using a 'smart growth' media.

• **Echion**'s niobium oxide tech enables ultra-fast charging (<10 min) and high power applications that are currently out of reach for lithium-ion batteries.

• **Exergy3** has built an innovative high-temperature, modular thermal storage system based on research at Edinburgh University. The system enables industrial facilities to move from gas to electricity, and they are building their first pilot at the Annandale Distillery in Scotland.

• **level nine** creates nanozymes that have advanced performance over enzymes or metal catalysts for processing biological feedstocks, such as lignin, into low emissions alternatives to petrochemicals.

• **NetZeroNitrogen** bacteria fix nitrogen from the air. Synthetic nitrogen fertiliser is responsible for 1 Gt CO2e/year in process and application emissions and NZN is harnessing naturally-occuring bacteria in plants to fix nitrogen directly from the air.

• **Actuation Lab** eliminates hydrogen pipeline losses with redesigned valves eliminate fugitive stem leaks.

• **ClimateCrop** enhance photosynthesis in crops. Land use change associated with growing crops accounts for over 2 gigatonnes of emissions per year. ClimateCrop edit the genes of crops to enable them to better use the energy from the sun and improve both yields and resilience.

Phycobloom's modified algae make affordable, carbon neutral jet fuel from the air. Long distance flight is critical to the modern world and fuel energy density requirements make electrification of such flights almost impossible.

Epoch BioDesign reinvent industrial processes like recycling that are inefficient and emit gigatonnes of CO2e per year by discovering and harnessing enzymes to achieve the same results with dramatically lower emissions.

Ionate supports adding more renewables to electricity generation by making the grid smart by managing power quality, using Ionate's Smart Transformer. ☼