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An Overview of Climate Tech

How emerging technologies are transforming the energy sector and creating opportunities for decarbonization and value creation.

Introduction

The Industrial Revolution transformed the global landscape, driving economic growth and societal progress for centuries. Today, we stand on the cusp of another transformative era, fueled not by steam and coal, but by a new wave of innovation: Climate Tech. This rapidly evolving field isn't just about mitigating environmental concerns; it's about unlocking a $2.5 trillion annual market opportunity by 2030[1]. Imagine cleaner, more efficient industries, resilient infrastructure, and millions of green jobs – that's the power of Climate Tech, and its impact on our future goes far beyond the next few decades. It's about building a sustainable and prosperous world for generations to come.

Climate Tech tackles two crucial challenges: decarbonizing difficult-to-change sectors and cleaning up existing fossil fuel infrastructure. Sectors like steel and cement are notorious for their high emissions, and Climate Tech offers innovative solutions to reduce their carbon footprint. Additionally, while renewable energy sources are increasingly prominent, petroleum-based power generation will continue to play a role in the near term. Climate Tech steps in here, providing solutions to decarbonize this existing infrastructure and ensure a smoother transition to a cleaner future.

In this article, we will look at the key trends and drivers of the Climate Tech boom, three key areas promising meaningful impact, and highlight a few companies that are at the forefront of each. We will end our discussion by considering the challenges new technologies encounter in the market. Ultimately, Climate Tech is a young but growing market, and will need more collaboration, diversity, data, and education among different stakeholders to realize its potential for creating positive change and value.

What is Climate Tech

Climate Tech is not merely a collection of technologies; it represents a multifaceted approach to mitigating and adapting to the challenges posed by climate change. This expansive field encompasses solutions across various domains, from emissions reduction and carbon capture to enhanced energy efficiency and the proliferation of renewable energy sources. Each industry presents unique challenges and opportunities, demanding a tailored

[1] Breakthrough Energy 2022, Emerging Clean Technology Industries in the U.S. will Boost Global Decarbonization and Economic Opportunity, https://breakthroughenergy.org/news/emerging-clean-technology-industries-in-the-u-s-will-boost-global-decarbonization-and-economic-opportunity/

approach within the broader Climate Tech framework. Time and resources are limited so it is important to consider where Climate Tech can have the biggest impact.

The International Energy Agency (IEA)[2] offers valuable insights into prioritizing these diverse interventions. By analyzing emissions data, we can identify the sectors with the most significant impact: transportation (28%), electric power (26%), industry (23%), commercial and residential buildings (13%), and agriculture (10%). This data serves as a roadmap, guiding the deployment of Climate Tech solutions where they can make the most substantial difference. Big target emissions also mean big opportunities.

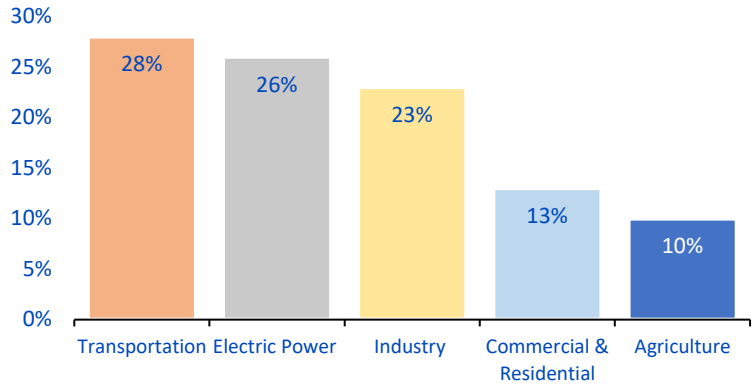

Figure 1 2021 U.S. GHG emissions by Sector. Source: IEA

How Large is the Climate Tech Market

Turning targets into opportunities requires broad-based interest followed by capital. The Climate Tech market is experiencing a surge of interest and funding from both public and private sources. Driven by growing awareness of the climate crisis, as highlighted by the IPCC[3] and widely reported in media, stakeholders across government, industry and the public are increasingly turning to Climate Tech solutions.

This surge is being fueled by abundant capital inflows from venture capital, private equity, and corporate sources. Grants, loans, and subsidies are also available through government incentives such as the Infrastructure Investment and Jobs Act of 2021, and the Inflation Reduction Act 2022[4]. According to a report by PwC[5], global investment in Climate Tech totaled $638 billion in 2023, while the IEA[6] indicates $1.7 T was invested in renewables and transmission infrastructure in 2023. Notably, this exceeds the $1.1 T invested in oil and gas globally during the same period. However, some sectors may be receiving outsized capital investments relative to their emissions profiles. The transportation sector is attracting almost half of startup funding from 4Q'22 through 3Q'23 despite it being responsible for 28% of U.S. emissions[7]. The hope here is that as specific technologies reach technical feasibility and cost effectiveness, greater convergence among emissions targets and clean tech funding will result.

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[2] IEA, Energy Statistics Data Browser https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=CO2%20emissions&indicator=CO2BySector.

[3] IPCC Climate Change 2023 Synthesis Report https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

[4] MIT Technology Review, How a Half-Trillion Dollars is Transforming Climate Technology, https://www.technologyreview.com/2023/08/16/1078014/ira-funding-one-year-climate-technology/

[5] PwC, State of Climate Tech 2023, https://www.pwc.com/gx/en/issues/esg/state-of-climate-tech-2023-investment.html

[6] IEA, World Energy Investment 2023, https://www.iea.org/reports/world-energy-investment-2023/overview-and-key-findings

[7] PwC, State of Climate Tech 2023, https://www.pwc.com/gx/en/issues/esg/state-of-climate-tech-2023-investment.html

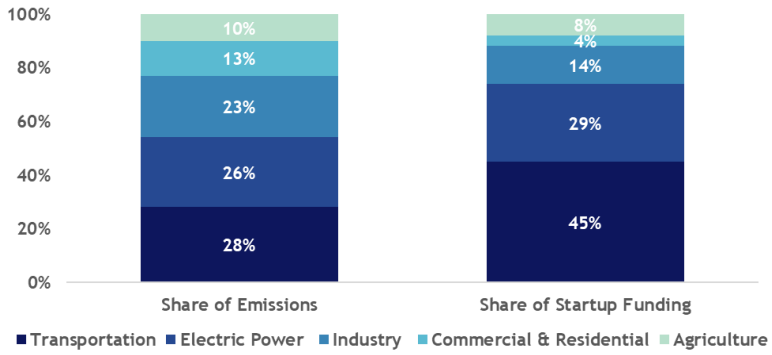

Figure 2 Share of emissions by sector vs share of startup funding from 4Q'22 to 3Q'23 by sector. Source: EPA, PwC

Key Areas of Opportunity

As of today, six areas are receiving the most attention: EVs, Long Duration Energy Storage, Clean Hydrogen, Direct Air Capture, Green Steel and Small Modular Reactors (SMRs). A report by BCG and Breakthrough Energy Ventures[8] estimated these technologies could enable up to a 20-gigaton reduction in global emissions by 2030, creating a $2.5 trillion global market and up to 1 million U.S. jobs. Among this array of Climate Tech opportunities, three stand out as particularly promising: Carbon Capture Utilization and Sequestration, Renewable Energy Expansion, and Industry and Manufacturing.

Carbon Capture, Utilization and Sequestration

Carbon Capture Utilization and Sequestration (CCUS) technologies aim to significantly reduce emissions by capturing and using or storing CO_2 emitted from industrial processes. Instead of releasing CO_2 into the atmosphere, where it contributes to global warming, carbon capture and utilization converts CO_2 into valuable products like fuels, building materials, and chemicals, or sequesters it into permanent storage locations such as depleted oil and gas reservoirs. This not only reduces the carbon footprint of emissions-intense industries but may also lower the cost to capture carbon by creating new revenue streams and markets for low-carbon products. This may be vital to scaling CCUS, as simply storing captured carbon might not be enough to make CCUS economically viable. The cost of capturing emissions could hurt the project's finances, making it difficult to implement CCUS on a large scale. This could either lead to higher prices for consumers (green premium[9]) for low-carbon options like green steel and cement or make the whole project impractical.

Despite the question of cost, momentum is gaining in CCUS. According to the Global CCS Institute[10], there are currently 196 CCUS projects in the development pipeline worldwide, a growth of 44% year-over-year, and with a total potential capture capacity of 243.9 Mtpa[11]. However, many of these projects are pre-commercial, may not come online until sometime in the 2030's, and require government subsidies to lower the considerable capital costs. Additionally, the capacity of these projects is significantly below the 1.2 GT CO_2 per year that is required by 2050 according to the International Energy Agency[12]. Given the sizeable opportunity to reduce emissions via CCUS, there has been significant interest in developing novel technologies that may become compelling on the back of sustained incentives or subsidies. The U.S. Inflation Reduction Act provides significant subsidies for CCUS. Straight

[8] Breakthrough Energy 2022, Emerging Clean Technology Industries in the U.S. will Boost Global Decarbonization and Economic Opportunity, https://breakthroughenergy.org/news/emerging-clean-technology-industries-in-the-u-s-will-boost-global-decarbonization-and-economic-opportunity/

[9] Gatesnotes.com, Introducing the Green Premiums, https://www.gatesnotes.com/Introducing-the-Green-Premiums

[10] Global CCS Institute, Global Status of CCS 2022, https://status22.globalccsinstitute.com/wp-content/uploads/2022/11/Global-Status-of-CCS-2022_Download.pdf

[11] Million tonnes per annum

[12] IEA, Carbon Capture, Utilization and Storage, https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage

sequestration is eligible for an $85/ton federal income tax credits while conversions of CO2 into useful products can secure a $60/ton tax credit. Given these incentives, companies that are pioneering new CCUS technologies are:

- LanzaTech[13] uses microbes to ferment waste gases from steel mills and refineries into ethanol and jet fuel. The company claims that its technology can reduce emissions by up to 85% and particle emissions by over 95% when compared to conventional fuels. LanzaTech has already produced over 20 million gallons of low-carbon fuels, and has partnered with companies like Virgin Atlantic, ArcelorMittal, and Indian Oil to scale up its technology and reach new markets.
- Fuel Cell Energy Inc. (FCEI) has developed a polycarbonate fuel cell which both captures CO_2 from combustion waste streams and generates power that produces valuable co-products like hydrogen. Most CC technologies are power users; however, this technology is unique in being a net power generator. FCEI's technology will now be demonstrated at a pilot plant being built at ExxonMobil's Rotterdam refinery[14]
- Twelve[15] uses electrochemistry to turn CO_2 and water into plastics, fertilizers, fuels, and other products. Twelve has received funding from the Chan Zuckerberg Initiative, Microsoft Climate Fund, US Department of Defense, NASA, Shell, and others, and is working to commercialize its technology and expand its product portfolio.
- Climeworks[16] uses direct air capture technology to capture CO_2 from the atmosphere. Its marquee customers include BCG, Shopify, Stripe, Microsoft, and Coca-Cola. The company claims it can capture up to 36,000 tonnes of CO_2 per year per plant at up to 90% efficiency. Climeworks has partnered with Carbfix, an Icelandic company that mineralizes CO_2 and stores it underground, and On Power, a geothermal energy provider, to create the world's first negative emissions plant, which removes more CO_2 than it emits. The company has installed 18 plants in Europe[17] and aims to capture 1% of global CO_2 emissions by 2025.

Renewable Energy Expansion

This area focuses on scaling up renewable energy sources to replace fossil fuels, as well as the role of efficient batteries and smart grid technologies in enabling better integration and grid resilience for intermittent renewables. Renewable energy sources, such as solar and wind, have the potential to provide clean and abundant power for the world. However, they also face challenges such as variability, storage, and transmission constraints. To overcome these challenges, Climate Tech companies are developing innovative solutions such as battery packs and smart grid services to help balance the grid and optimize energy use. According to the International Energy Agency[18], renewable energy accounted for 26% of global electricity generation in 2021 and is expected to grow by 250% through 2030. However, this is still below the level needed to achieve the Paris Agreement goals, which requires rapid and deep decarbonization of the power sector. Although power generation of utility scale renewables is maturing and scaling, significant challenges remain in areas such as managing a growing number of DERs[19]. Integrating DERs and improving the capacity and performance of the grid is being approached from both a software and hardware angle, with varying levels of technology readiness and pathways to commercial scale. Two companies that are leading in this space are:

- Autogrid[20] is developing software that can manage DERs, such as rooftop solar, electric vehicles, batteries, and smart thermostats. The platform uses AI to aggregate, optimize, and control DERs in real-time, creating

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[13] https://lanzatech.com/

[14] ExxonMobil, https://investor.fce.com/press-releases/press-release-details/2023/ExxonMobil-to-Build-CCS-Pilot-Plant-with-FuelCell-EnergyUsing-Carbonate-Fuel-Cell-Technology/default.aspx.

[15] https://www.twelve.co/

[16] https://climeworks.com/

[17] Wikipedia, Climeworks, https://en.wikipedia.org/wiki/Climeworks

[18] IEA.org, Renewables 2030, https://www.iea.org/reports/renewables-2023

[19] Distributed Energy Resources; iea.org, Unlocking the Potential of Distributed Energy Resources, https://www.iea.org/reports/unlocking-the-potential-of-distributed-energy-resources

[20] https://www.auto-grid.com/

a flexible and responsive grid. Autogrid says that its platform can help utilities, energy retailers, and grid operators improve grid reliability, reduce costs, and increase customer satisfaction. Autogrid has partnered with several major energy companies, such as E.ON, Shell, National Grid and Total, to deploy its solutions across the world.

- Lumin[21] is providing smart management systems that integrate with home battery packs and residential solar installations. The company says that its system can optimize the energy use and storage of the home, as well as enable grid services, such as demand response and virtual power plants. Lumin claims that its system can help homeowners save money on their electricity bills, increase their energy independence, and reduce their carbon emissions. Lumin has partnered with Sunnova to integrate its smart panel and energy management platform into Sunnova's solar, storage and smart energy management system.

Industry & Manufacturing

Lastly, Climate Tech in the industry and manufacturing sector focuses on decarbonizing hard to abate sectors, such as steel, cement, and chemicals. These technologies can help reduce the energy and material intensity of industrial processes and increase the use of recycled and renewable inputs. According to the Environmental Protection Agency, industry accounts for 23% of CO_2 emissions, representing a large potential for meaningful emissions reductions through the adoption of novel solutions. However, current low carbon alternatives are priced above the traditional carbon-intensive supply (green premium[22]), creating a challenge for adoption at scale. Some of the companies that are working to lower the green premium and transform industry and manufacturing are:

- Boston Metal[23] uses molten oxide electrolysis powered by renewable energy to produce zero emissions steel. It plans to produce at competitive cost in the future. Boston Metal has received funding from the US Department of Energy, Breakthrough Energy Ventures, Microsoft Climate Fund, Aramco Ventures, and BHP.
- Solidia Technologies[24] uses a low-carbon cement formulation and CO_2 curing process to reduce the water use and carbon intensity of concrete production by up to 50%, addressing the carbon footprint of the cement industry which accounts for 2.5 Gt CO_2e per year[25]. Solidia's Cement hardens through exposure to CO_2, producing stronger and more durable concrete. Solidia has partnered with LafargeHolcim[26], the world's largest cement producer, to commercialize its technology.
- Electric Hydrogen[27] is developing the world's most powerful electrolyzers for critical industries to produce the lowest cost green hydrogen. Leveraging its 100 MW 'compete plant' design, Electric Hydrogen produces green hydrogen from renewable energy with a long-term price target of $1/kg. Hydrogen is a versatile and clean energy carrier that can be used to decarbonize various industrial applications, such as steelmaking, ammonia production, and synthetic fuels. Electric Hydrogen has secured funding from several prominent investors, such as BP Ventures, Breakthrough Energy Ventures, Amazon, and Microsoft's Climate Fund, to accelerate its growth and market penetration.

[21] https://www.luminsmart.com/
[22] Gatesnotes.com, Introducing the Green Premiums, https://www.gatesnotes.com/Introducing-the-Green-Premiums
[23] https://www.bostonmetal.com/
[24] https://www.solidiatech.com/
[25] IEA.org, Breakthrough Agenda Report 2023, https://www.iea.org/reports/breakthrough-agenda-report-2023/cement
[26] Holcim.com, https://www.holcim.com/media/media-releases/lafargeholcim-partnership-solidia-technologies-capture-CO2-building-materials
[27] https://eh2.com/

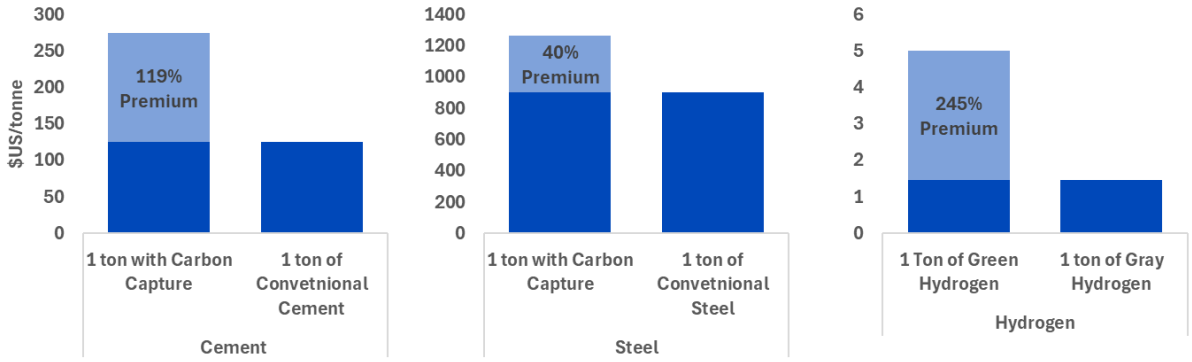

Figure 3: Green Premiums for Cement, Steel and Hydrogen. Sources: Breakthrough Energy, Focus-Economics, BNEF, IEA[28,29,30,31]

Challenges to Scaling Emerging Tech

While emerging climate tech companies offer promising emissions reductions in hard to decarbonize activities, scaling these innovative solutions presents a formidable challenge. The road from ideation to market adoption is paved with technical hurdles like low efficiency, high costs, and limited scalability. Regulatory hurdles, safety concerns, and even social resistance can further impede progress. To earn trust and acceptance, climate tech companies must demonstrate not only the feasibility, performance, and reliability of their solutions but also engage with diverse stakeholders to address potential environmental and social risks.

Moving beyond technical barriers, the subsequent commercialization pathways are often complex and uncertain. Identifying target customers, building partnerships, and creating sustainable business models are crucial steps fraught with unknowns. New technologies often face stiff competition from established, cheaper alternatives that are firmly entrenched in consumer and industry preferences. To overcome this, climate tech companies must effectively capture the value proposition of their solutions for customers and differentiate themselves from competing products, paving the way for market penetration and adoption.

However, the most pressing issue on scaling new technologies is cost. New technologies often require long development cycles with significant capital investments, making them difficult to finance and navigate through the infamous valley of death[32] between research and commercialization. This high capital intensity can deter investors, leaving innovative solutions stranded at the precipice of impactful change.

Beyond upfront costs, new technologies often necessitate entirely new supply chains and logistics networks. Imagine transporting carbon dioxide or hydrogen – it demands infrastructure vastly different from established oil and gas pipelines, requiring significant upfront investments at a national, even international scale. This adds another layer of economic hurdles in the near term.

However, there's more than a glimmer of hope. Public policy is a key enabler here. As these technologies mature and move down the cost curve, particularly with the support of government subsidies, the logistics and supply chain barriers may ease, paving the way for wider adoption. Ultimately, the challenge of scaling new climate tech might not be a fundamental cost issue, but rather a question of timing, scale, and pace of deployment.

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[28] Breakthrough Energy, https://breakthroughenergy.org/our-approach/the-data/#manufacturing
[29] Focus Economics, https://www.focus-economics.com/commodities/base-metals/steel-usa/
[30] BNEF, https://about.bnef.com/blog/green-steel-demand-is-rising-faster-than-production-can-ramp-up
[31] IEA, https://www.iea.org/reports/global-hydrogen-review-2023
[32] Plug and Play, Surviving the 5 Climate Tech Valleys of Death: A Guide, https://www.plugandplayapac.com/post/5-valleys-of-death-in-climate-tech-investing

Conclusion

Climate Tech is no longer a fledgling field; it's a rapidly maturing force brimming with innovative solutions to the climate crisis. Backed by a growing market, surging investment, policy support and passionate entrepreneurs, Climate Tech companies are tackling emissions across diverse sectors – from transportation and energy to agriculture, industry, and manufacturing. While challenges remain, the potential for positive change is immense. Climate Tech stands as a key driver in building a more sustainable future, and its success hinges on continued collaboration between governments, investors, corporations, and everyday people. With unwavering support, Climate Tech can pave the way for a greener tomorrow for generations to come.