BUILDING CLIMATE TECH ECOSYSTEMS: TRENDS, CHALLENGES, AND OPPORTUNITIES

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Executive summary

The 7th Oxford Entrepreneurship Policy Roundtable (OXEPR) in May 2022 examined trends, challenges, and opportunities for building Climate Tech ecosystems. In recent times, the global climate emergency has deepened the interest in climate-related solutions through innovation and entrepreneurship. Start-ups are introducing innovative climate technologies and business models across a diverse range of established industries. Since the history of venture capital tells us of the importance of entrepreneurial ecosystems to support entrepreneurs, the roundtable focused on the emergence of entrepreneurial ecosystems for Climate Tech, focusing mostly on the European and North American context.

The roundtable noted a significant increase in venture capital investment over the last seven years. This climate tech boom is frequently compared with the clean tech boom that ended in bust in 2005. However, there are clear differences, especially because industry incumbents show greater interest in adopting fresh solutions. This is due largely because of the increased societal and regulatory pressures to reduce carbon footprint across a wide range of industries. To make this new wave of climate tech ventures successful will require a supportive ecosystem. The roundtable identified three broad challenges: (i) patient funding models for climate tech ventures, (ii) new models of collaboration between start-ups and industry incumbents, and (iii) government and philanthropic initiatives catalysing new markets.

Concerning the need for new funding models, the roundtable participants noted that Climate Tech start-ups are often capital intensive and require more time to bring products to market. The process of de-risking such ventures is also different from other sectors, especially software. Developing hardware-based technologies requires multiple stages of piloting at increasingly larger plant sizes. Proving innovative technologies thus requires considerably more capital and time, challenging the traditional venture capital model. Investors are actively exploring alternative investment models, including

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lengthening fund investment horizons, and experimenting with several types of blended finance. This leads to a blurring of lines between purely commercial and impact-oriented venture investment models.

Concerning the collaboration between start-ups and industry incumbents, the roundtable noted that Climate Tech start-ups often cannot enter markets by themselves but rely on partnerships with industry incumbents. Established corporations also have a strategic interest in Climate Tech start-ups because they face increased pressures to act on decarbonization. Therefore, large corporations increasingly seek collaborations with start-ups to complement or improve their internal development capabilities. For this they can invest through traditional corporate venture capital initiatives. There are also novel investment models emerging. The roundtable examined one of them where an independent venture capital fund works with a consortium of non-competitive corporates. The venture fund scouts for strategically relevant investment opportunities, makes venture investments, and facilitates strategic partnerships between its investment companies and the established corporations in the consortium.

Concerning government initiatives, the roundtable noted that Climate Tech ecosystems are shaped not only by government regulation, but also by other government initiatives. In addition to the traditional support mechanisms, several governments are proactively fostering the development of new Climate Tech initiatives. They explicitly take a system's change perspective and focus on supporting catalytic investments that aim to create new markets. Government procurement policies are another instrument for initiating change, as government agencies are often important early customers for Climate Tech ventures. Beyond government, some philanthropic initiatives are also actively promoting the development of Climate Tech ecosystems. One prominent approach is the use of competitions and prizes, to focus entrepreneurial attention on specific challenges within the broader climate crisis.

Overall, discussions around these challenges highlighted the need for intermediaries supporting collaboration. They can play a role translating expectations and connecting the different parties to build ecosystems. Moreover, there is a broader interest in finding new organizational structures to better facilitate the venture investments required to tackle the challenge of Climate Tech.

Background

The Oxford Entrepreneurship Policy Roundtable (OXEPR) on "Building Climate Tech Ecosystems: Trends, Challenges, and Opportunities" was held in person in May 2022, convened by Gilles Duruflé, Thomas Hellmann, Niels Schneider, and Karen Wilson.[5] A selected group of 30 experts and practitioners on Climate Tech from Europe and North America participated in the roundtable.

In preparation for the roundtable the organisers gathered secondary data and reports on the current state of climate tech. In addition, the organisers, supported by University of Oxford students, held interviews with experts from finance, corporates, philanthropic organisations and governments as well as Climate Tech entrepreneurs. This document provides a summary of the key insights that emerged from the event.

Context

Climate Tech has seen a re-emergence in activity and interest from venture capitalists (VCs) in recent years.[6] In comparison to the first Clean Tech boom around 2005 which mostly focussed on clean energy production, with heavy investment into wind and solar power, today Climate Tech more broadly covers technologies that aim to mitigate climate change or offer adaptation solutions. The sector is now capitalising on increased urgency to adopt Climate Tech solutions. This comes from increased stakeholder pressure, with society, consumers, talent, investors, and governments all expecting incumbent corporate leaders to decarbonise their industries. The main channels of influence are legislation, consumer buying decisions, and the allocation of human and financial resources. Also encouraging for Climate Tech is the increased momentum of countries, municipalities, and companies of changing their net zero targets from 2050 to 2045 or even 2030 goals. All this gives hope for increasing and lasting business opportunities for those who innovate to tackle climate change.

Despite positive momentum, Climate Tech still faces significant hurdles to meaningfully reducing global greenhouse gas emissions. Entrepreneurial ecosystems play a crucial role in determining start-ups' successes through the availability of capital and talent, access to incumbents, and the regulatory framework.

Current state of Climate Tech

After the Clean Tech bust of 2005 had made many investors cautious of the sector, Climate Tech investments have picked up again since 2014. Apart from a plateau in 2019 and 2020, there has been steady growth of both deal count and capital invested, reaching 2143 and $29.3bn respectively in 2021 (Figure 1 in appendix).

[5] OXEPR is an annual event at the University of Oxford which convenes entrepreneurship experts, around a different topic every year. Prior Roundtables examined a variety of ecosystem challenges, including the scaling of tech start-up (Duruflé et al., 2017), the emergence of academic entrepreneurship (Duruflé et al., 2018), and the role of foreign venture investors (Bradley et al., 2019).

[6] In absence of a universally agreed definition we define Climate Tech as technology-based ventures which tackle climate change through commercialisation of innovation that replaces or mitigates activities with global warming potential, or offer solutions for adaptation to the effects of climate change. This definition is based on definitions of sustainable entrepreneurship (Cohen & Winn, 2007) and eco-innovation (Kemp & Pearson, 2007), with an emphasis on technological innovation.

With regards to capital invested the U.S. ($10.2bn in 2021) and Asia ($9.5bn in 2021) are leading due to larger and later rounds being funded. Europe is now catching up having increased its capital invested from $0.6bn in 2018 (for comparison US: $3.3bn, Asia: $6.3bn) to $7.8bn in 2021. Investors in the U.S. are funding Climate Tech across most stages and has an average deal size of $13m in 2021. Europe funds more early stage with an average 2021 deal size of $10.5m, while Asia is focussed more on later stage round with an average deal size of $29m. In terms of deal count, Europe and the U.S. are on par with 738 and 782 deals in 2021. Notably deal count has grown in relative terms in both the Asia region as well as Canada (Figures 2 and 3).

A maturing of the Climate Tech sector can be observed in the increase of later stage funding rounds. While in 2015 Seed rounds made up more than 86% of the deals with the remaining 14% going to Series A, in 2021 Seed rounds accounted for 54% of deals, Series A for 29%, Series B for 12% and Series C for 3% with the remainder spread over Series E to G. In terms of capital invested 44% of capital went into Series B round and 21% into Series A. Series E accounted for 14% of capital invested ($2.6bn) indicating some large scaling of Climate Tech start-ups (Figure 4).[7]

Another noteworthy development is the allocation of funding to different industries. PwC found that the sectors who are emitting most greenhouse gases (Built Environment and Manufacturing, making up 50% of emissions) currently receive the least amounts (4% and 9% respectively) of investment for Climate Tech. Disproportionally mobility and transport is receiving 61% of investment although it only accounts for 16% of emissions.[8] Correcting this imbalance could hold significant opportunities (Figure 5).

Financing and Scaling Climate Tech Ventures

Based on a search of the secondary literature, interviews with industry experts and the discussion of the round table, three broad themes emerged to describe how entrepreneurial ecosystems affect the success of Climate Tech ventures, namely (i) the financing and scaling of Climate Tech ventures, (ii) corporate-led innovation, and (iii) government and philanthropy. In this section we cover the first theme which examines the challenges of de-risking technology, the ecosystem elements needed for scaling, and the difficulty of accessing financing.

De-risking

Climate Tech is not a single vertical, but an attempt to change all industries in a way that makes them less polluting, especially with regards to greenhouse gas emissions. This effort requires scientific/technological innovation and consequently hardware ventures.[9] Hardware ventures are characterised by long timelines to market and high capital requirements. Participants noted that long term investments and large funding rounds per se are not unusual for VCs, with biotechnology as the obvious example, but that the nature of de-risking for Climate Tech is different from the usual VC model.

Climate Tech hardware ventures require long time spans and capital for the technical de-risking i.e., making the solution work (going from 0 to 1). This is more challenging than dealing with the market risk of scaling a company (going from 1 to n) for several reasons. First, laboratory scale successes often do not translate into larger processes; small errors in the laboratory scale can become catastrophic errors

[7] All data from Pitchbook.com
[8] PwC (2021)
[9] McKinsey & Co (2021)

on industrial scale. Secondly, de-risking at this stage requires a lot of experimentation and scientific equipment.[10] The university environment may thus be better suited to facilitate the learning. Participants of the roundtable advocated for longer experimentation times before ventures spin out of universities. It is also difficult to predict which laboratory scale approach will become commercially viable. Unlike software start-ups, many Climate Tech ventures cannot simply pivot to the next business model or technology approach.[11]

Ecosystem Elements for Scaling

With Climate Tech spanning multiple industries, markets and ecosystems are highly fragmented. This makes it more difficult for ventures to build out sales capacity. For example, it is difficult to hire experienced salespeople with established industry networks. Similarly, this makes it more difficult for companies looking for Climate Tech solutions to access existing clusters of Climate Tech. This fragmentation is also mirrored in the lack of angel investor networks, and limited access to mentorship. All this introduces frictions to scaling Climate Tech ventures.[12]

Climate Tech are typically not stand-alone solutions but need to be adopted by industry incumbents, including state-owned entities, such as large oil and gas corporations or utility companies. Directly disrupting such industries is rarely feasible and Climate Tech entrepreneurs have to work with gatekeepers, including governments, to access the industries that they are trying to innovate. The incumbents' resistance to change can thus introduce significant hurdles to the roll out and scaling of Climate Tech solutions.

Lack of Capital

The hardware dominance in Climate Tech poses further challenges to access to capital beyond those mentioned above. Most equity finance instruments are geared towards funding operational expenditure for growth. This paradigm builds on the underlying mechanism that in software ventures company value grows faster than the capital needs for operational expenditure. Scaling hardware ventures however requires large investments for capital expenditure to finance the infrastructure (e.g., plants) needed to scale the venture. These larger investments are also often needed before the venture can eliminate all technology risk. Consequently, company value often grows slower than capital needs in Climate Tech ventures, which poses challenges to the traditional VC investment model. Participants noted that different funding needs exist within the de-risking/learning phase, which requires patient funding, and the scaling phase, which sees the de-risked company grow and requires VC capital but also project finance to fund physical assets. It appears that a gap exists for funding between those two stages and the question of a potentially new asset class was raised. Further participants emphasised that with the need for vastly different types of funding along the venture journey, Climate Tech ventures need to consider their financing pathway like a supply chain. Ventures should thus consider which investor type will be best suited to finance the next stage and bring those onboard in the current financing round.

Foundation Based Venture Capital

One response to the challenge of scaling and financing Climate Tech ventures, has been foundation-based venture capital firms. Roundtable participants discussed an example of a foundation-based VC

[10] Nanda (2020)
[11] Startup Genome LLC (2022)
[12] Startup Genome LLC (2022)

model set up by high net-worth individuals to prove Climate Tech is a commercially attractive area. The VC arm runs two funds with a 20-year maturity to accommodate the longer time horizons in Climate Tech. It is run by scientists and engineers who have been operators in the past. The fund's due diligence is thus geared more towards understanding the scientific potential of the innovation, yet it remains clearly commercially minded. The combination of foundation capital and VC is meant to provide the right type of funding to the appropriate stage of the ventures. The philanthropic funding allows science-based ventures to experiment and de-risk, whilst creating a pipeline for the VC. When the ventures enter the scaling phase the VC arm can take over to support the Climate Tech solutions in becoming commercially viable ventures. However, the VC arm also needs to work with and educate other VC investors, with a goal to bring Climate Tech ventures into mainstream VC funding.

Corporate led Innovation

In this section we discuss the issue of corporate led innovation. We first examine the objectives of Climate CVC, then an example of a corporate venture capital (CVC), and finally an alternative approach of corporates forming a consortium to fund Climate Tech ventures.

Objectives of Climate CVC

Large incumbent corporations have recently taken more interest in CVC with a specific interest in technologies that could decarbonise their sector. The pressure for adopting Climate Tech in corporations stems from the increased consumer awareness for climate change. This has created pull demand for low carbon products. Climate Tech solutions that decarbonise the production and supply chain allow for companies to fulfil that demand. Another opportunity that makes working with start-ups particularly interesting lays in the hardware focussed nature of Climate Tech. Climate Tech solutions are often prohibitively expensive and require vast amounts of assets, resources, and regulatory approval that start-ups cannot provide. Incumbents, however, have access to those resources and possess the required credibility with regulators, placing them at an advantage when negotiating partnerships with Climate Tech start-ups. Incumbents can thus receive access to innovation on favourable terms.

At the same time corporates feel a real need to adopt Climate Tech. Consumers' pressures, current and future regulation on emission cuts and carbon prices put a real threat to the continuation of incumbents' businesses in their current polluting state. Aware of these threats corporate representatives reported that their organisations have set net-zero targets, but currently lack the technologies to make those a reality. Corporate venturing efforts are then used less for financial gain of the corporate (which will have a neglectable impact on their profit and loss) but to get access and insight on technologies that would allow them to decarbonise their operations.

Setting up a Strategic CVC to Decarbonise

The roundtable considered an example of a CVC initiative in one of the most polluting industries globally. The fund's objective is to find and accelerate Climate Tech relevant to the industry. The initiative was born out of the organisation's M&A department, but now operates independently. To give it the necessary management buy-in, the CEO sits on the investment committee of the CVC, a fact participants considered important to the success of the CVC endeavour. Cultural challenges within corporations were highlighted as obstacles to successful CVC activity. The more transformative a technology is the higher resistance to adopt the technology within the corporation appears to become. Often significant opposition to innovation brought by start-ups comes from the R&D department with

managers resisting it based on a “not-invented-here” logic. There is also the possibility that CVCs invest in promising IP but the corporate R&D department decides to 'shelve it', effectively stifling the innovation.

One open debate concerns the size and power that CVCs should have in a venture. Traditional VC participants at the roundtable advocated that CVCs only take minority shares in start-ups. However, a pushback from CVCs was that larger stakes in the start-ups are needed to get proper engagement from the corporates. They emphasized the opportunities for joint development agreements (JDAs). Climate Tech start-ups are often characterised by their scientific breakthrough but tend to struggle with identifying the best use-case for their technology and their position in the value chain. The JDAs with the CVC allows the start-ups to show greater transparency about their technology which in turn allows the CVC to identify the best use-cases for the technology in their setting. As mentioned above, Climate Tech is often not economical on small scale and thus struggles with market entry. The JDA can tackle this challenge by lowering the barriers to entry for the start-up. A close interaction between corporate and start-up also allows for sharing resources such as plants and talent, which start-ups would struggle to access otherwise.

Most CVC engagements challenge companies’ organisational culture. While close interaction between corporates and start-ups appears beneficial, it was noted to be difficult due to the different paces at which both parties operate, with start-ups being characterised by fast pace and quick decision making, and corporates by strong hierarchies and slower pace. With the above-mentioned need for C-suite buy-in, the CVC initiative is also vulnerable to cultural changes resulting from change in corporate leadership. When this happens, interest in start-ups fades, and start-ups closely aligned with the corporate are at risk of being stranded.

A Corporate Consortium-Based CVC approach

An alternative to the traditional CVC approach aims to offer solutions to some of the challenges described. The roundtable discussed an initiative involving an independent venture fund set up to identify solutions to a specific subset of Climate Tech problems. The fund is fully funded by a consortium of corporate partners that have a shared interested in this space. It is incentivised to find ventures that provide promising solutions to the problem at hand. Corporates in the consortium are selected so as to not compete with each other. The premise of this model is that a given technology will have several applications in different industries. The consortium thus benefits from trying out solutions across different markets. This approach uncouples the success of the VC fund from any one corporate leader. In doing so it ensures continuity of the fund’s activities and support for the start-ups.

Beyond identifying strategic investment opportunities, the VC, supported by a Cleantech Accelerator it has launched which acts as an intermediary, also connects the start-ups to corporates as early customers to support their market entry. Here the consortium setup holds the potential to address the power imbalance between corporates and start-ups.

Government and Philanthropy

The third theme explores the actions governments and philanthropic organisations in shaping Climate Tech ecosystems.

Government funding tools

The roundtable discussed several government initiatives which foster entrepreneurship through direct funding. In addition to funding research and the learning phase of start-ups, dedicated Climate Tech funds or fund of funds have been established to provide capital to Climate Tech start-ups. They range in size from $700m to $6bn and target innovation areas that governments aim to promote. Some participants noted that these funds can help to bridge the gap between grant funding and commercial funding, to support start-ups at the beginning of their scaling journey.[13] Business development banks thus hope to generate greater interest in Climate Tech from private market investors.

System change approach

Beyond the traditional government interventions of providing funding, the roundtable participants heard about new initiatives where government actors take a 'system change' approach. Rather than addressing failures in existing markets, governments seed new markets that incumbents wouldn't create themselves.

This can be done through introducing regulation that mandates or prohibits the use of certain technologies or limits the greenhouse gases that can be emitted. These constraints limit the ability of incumbents to continue business as usual and create the market for Climate Tech that allows the incumbents to comply with the new regulation. Beyond regulation, governments also consider subsidies to incentivise the use of new technologies and help start-ups reach scale to economic viability. However, participants noted that regulation is often cheaper to the government than subsidies and that new regulation often leads to an innovation push.

Finally, governments could play a role in innovation procurement, acting as a first customer to Climate Tech start-ups. The goal is to provide start-ups with revenues until they reach a scale that lets them compete with the existing solutions in the market. All these interventions follow the rational that Climate Tech needs support to bridge the gap between laboratory setting and access to capital markets.[14]

Non-governmental actors – Incentivising Science Innovators

Philanthropic organisations can also promote systems change. For example, they can direct scientific efforts into innovation areas of interest and seed new markets. The roundtable participants discussed an organisation that runs competitions inviting scientists to develop solutions to specific societal challenges. The competition provides price money at various stages of the technological development to gather numerous solutions to a problem and narrow them down along the innovation funnel. The prize money can then be used by the participants of the competition as seed money for a start-up commercialising their solution.

Another example of market seeding philanthropy is the concept of advanced market commitments. In such agreements a set of buyers declare that they will purchase a certain quantity of a novel good or service tackling a defined issue. The buyers make advance promises to establish a market and to allow the start-ups to focus their operations on a set of defined targets where the market is guaranteed.[15]

[13] Van den Heupel & Popp (2022)
[14] Bill Gates (2021)
[15] The Economist (2022)

Participants noted that these approaches can be fruitful but are not yet utilised on large scale in the Climate Tech space. More generally, promoting start-ups is not yet recognised as a means to tackle social and environmental challenges.

Concluding thoughts

The Oxford Entrepreneurship Policy Roundtable 2022 examined the challenges for Climate Tech, focusing on the emergence of supportive ecosystems. Several themes became apparent throughout the roundtable. On the one hand, left to its own devices the market lacks the mechanisms to solve the climate crisis on its own. On the other hand, systemic change to producer and consumer behaviour progresses too slowly given the urgency and speed of climate change. Instead, a middle ground must be found in a collaborative effort between start-ups, incumbents, investors, regulators, and policy makers to tackle the climate crisis. This highlights the need for intermediaries supporting collaboration. They can play a role translating expectations and connecting the different parties to build ecosystems. Moreover, there is a broader interest in finding new organizational structures to better facilitate the venture investments required to tackle the challenge of Climate Tech.

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Appendix

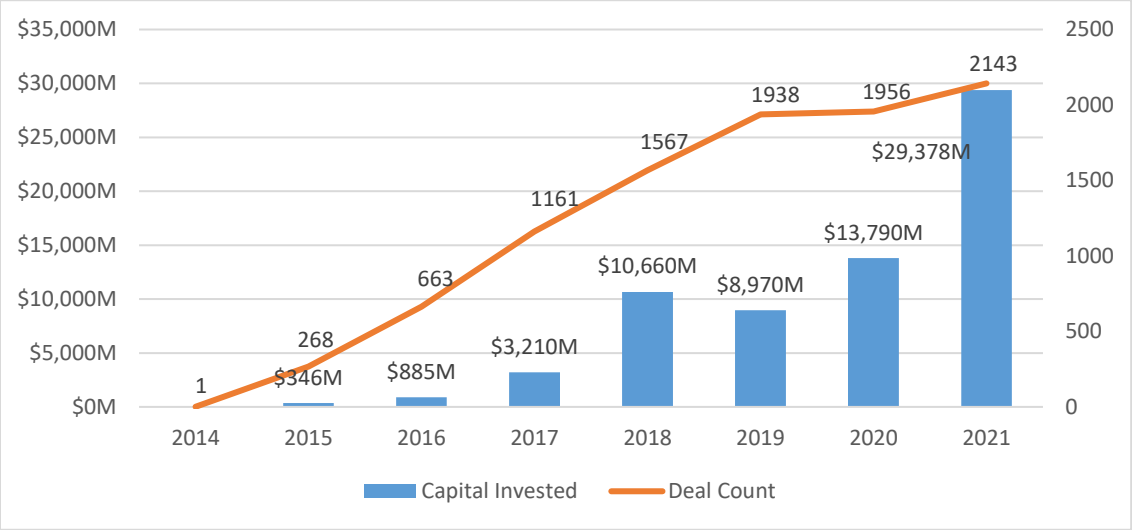

Figure 1: Development of global deal count and capital invested, over time. Source: PitchBook.com

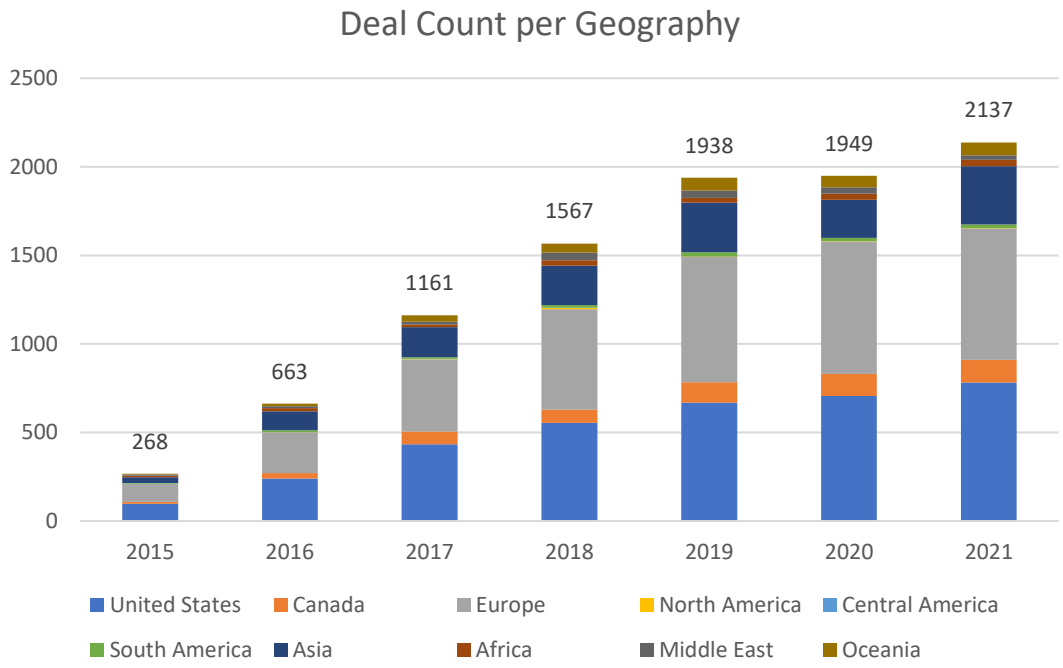

Figure 2: Deal count broken down by geographies. Source: PitchBook.com

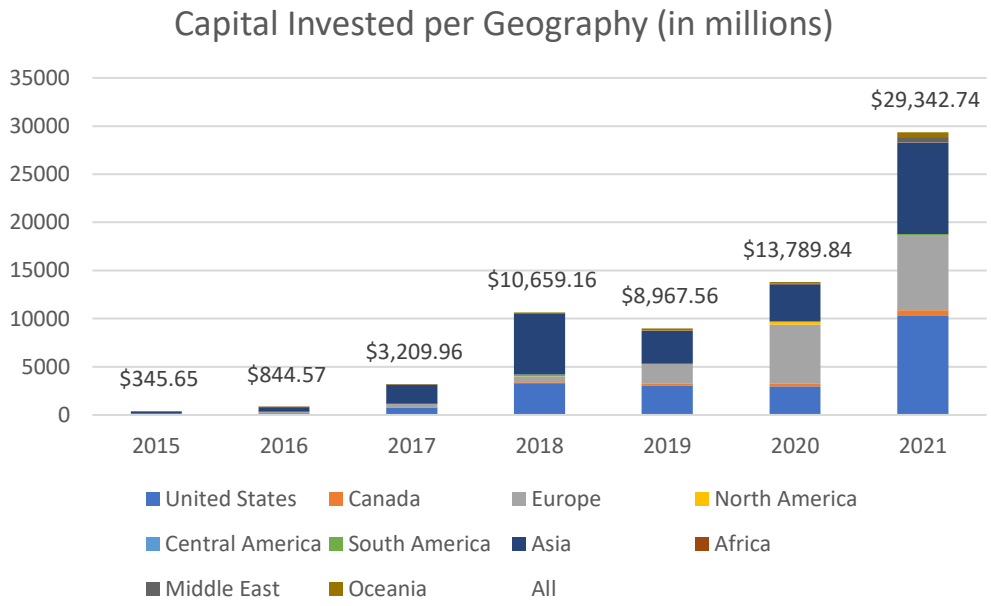

Figure 3: Capital invested (in millions) broken down by geographies. Source: PitchBook.com

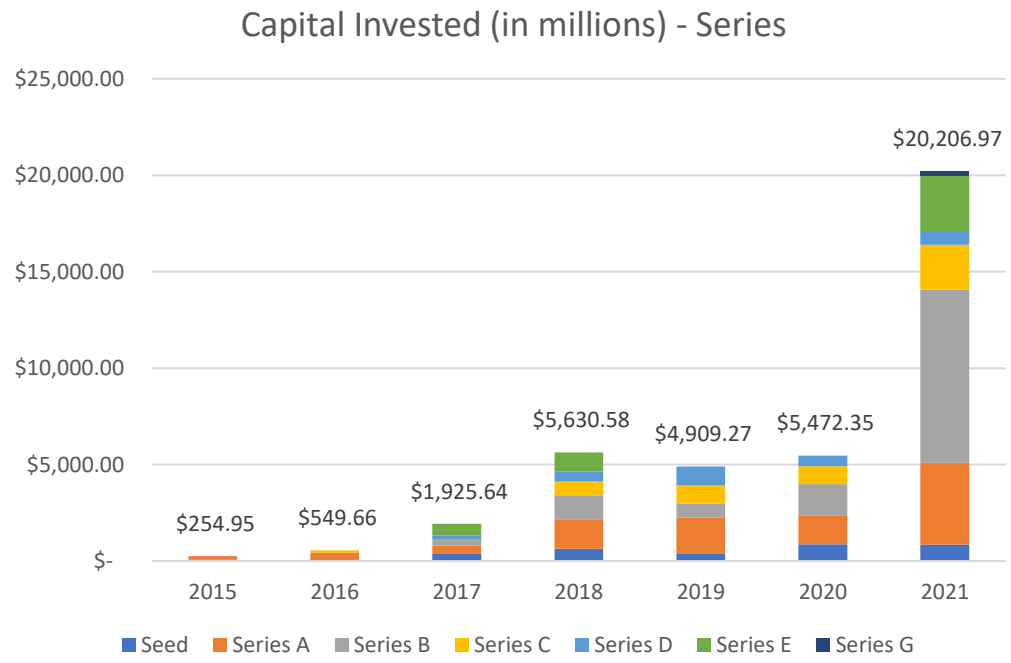

Figure 4: Capital invested (in millions) globally, broken down by series. Source: PitchBook.com

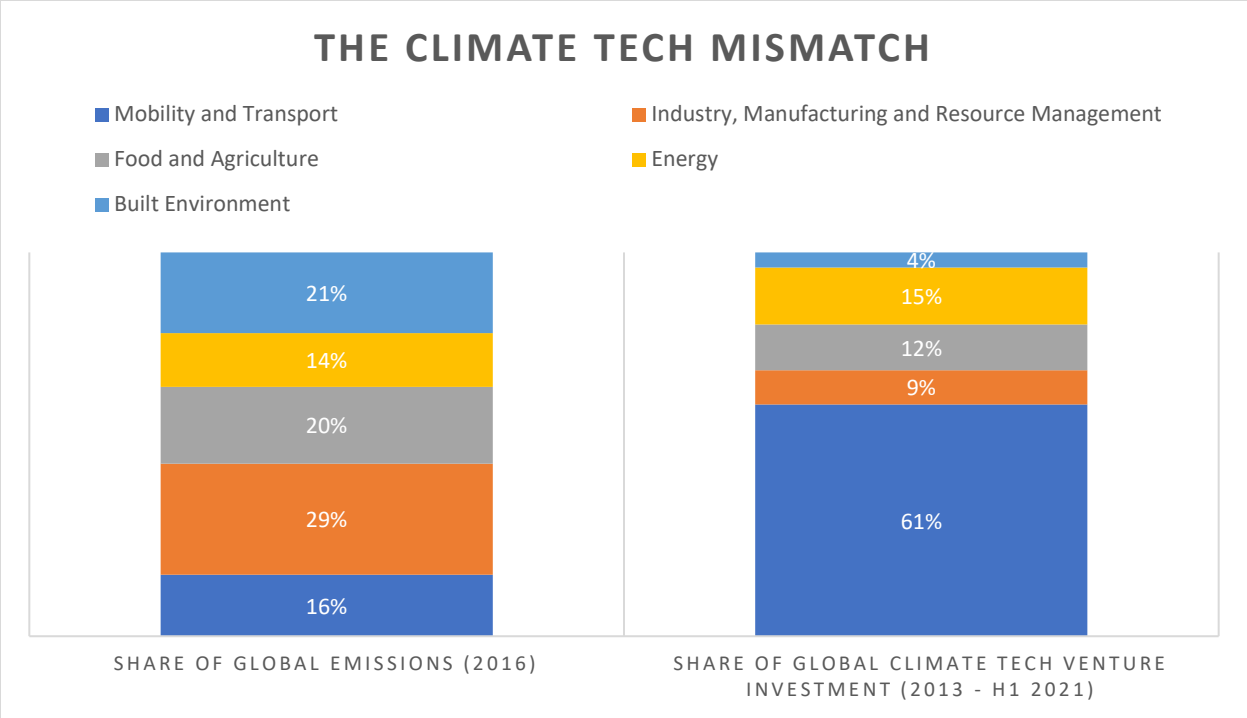

Figure 5: Mismatch of emissions and funding. Source: PwC (2021)