CLIMATE TECH INVESTMENTS: AN OPPORTUNITY FOR EUROPE

WORLD FUND

MAY 2023

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FOREWORD

There has been a major rethink in recent years about the role of investing in helping us reverse global warming. Awareness of the consequences of the climate crisis is growing, given the increasing number of natural disasters, such as the floods in Europe in 2021[1] – which in Germany alone killed 186 people and caused damages estimated at €33 billion[2].

Driven by the Green Deal in Europe, the Inflation Reduction Act in the US, and numerous regulations to help drive the climate transition, investment opportunities are opening up. To achieve the European Union's goal of reducing greenhouse gas emissions by 55% by 2030, an investment of €1 trillion a year is needed[3].

This funding could be used to back a broad range of innovative deep-tech solutions to either replace traditional emission-heavy offerings, like batteries replacing combustion engines or alternative proteins replacing animal products or alternative methods to save emissions during the design and fabrication process, like leveraging AI or quantum computing.

However, climate tech funding still falls short. Estimates show that globally only about 16% of climate finance needs are currently being met, which means that climate finance must increase by at least 590% – to $4.35 trillion annually by 2030[4] to meet our climate targets.

There are many reasons why this gap still exists. One prevailing cause is the limited knowledge about which opportunities climate investments offer and how climate impact can be assessed and embedded in the investment process. With this whitepaper, we have created a report based on the current state of science catering to a set of asset classes that not only want to fulfil their responsibility towards society and environment but also take advantage of financial opportunities.

Venture capital carries a particular responsibility within the climate transformation. To achieve the transformation of Europe's domestic industry, 29% of emission reductions by 2030 need to come from new technologies[5]. By 2050, 50% of emission reductions need to come from technologies that yet must be developed[6]. Such technologies require sufficient funding to be widely researched and first developed at lab-scale, before promising technology businesses can emerge and scale.

The time for the next major transformation has arrived, and just like previous ones, this green transformation originates with entrepreneurship and venture capital.

We have lost a lot of time, but it is not too late to prevent the worst consequences of the climate crisis.

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EXECUTIVE SUMMARY

Climate risk is increasingly threatening the environment, societies, and the global economy. After years of insufficient action to mitigate the impact of climate change, stakeholders across the board are now taking action. As governments are stepping up and their climate commitments materialise, the economy faces a new environment created by an increasing and tightening set of climate-related policies, laws, and the introduction of carbon taxation and pricing mechanisms.

The global economy, therefore, has no choice but to decarbonise. Delaying action will have severe economic costs, with climate-related damages reaching trillions of dollars and projected losses in global GDP of up to 25%[7]. Yet the new environment also yields opportunities for those who act. Already today, studies find that positive climate performance can translate into superior financial returns. In the next decade, climate solutions are predicted to create a multi-trillion dollar market[8].

In Europe, we have the ambition and policies in place to take a leading role in the net-zero transition. However, to capture this significant market opportunity, Europe needs to translate its ambition into action by putting in place the right incentives and simplicity for the economy to act. This will create an environment for European climate technologies to scale and prevail against international competition. In return, this can provide an attractive opportunity for investors.

Already today we see financial stakeholders across public and private equities taking action to capture the return potential of climate-aligned opportunities. Public market research suggests both a significant financial return potential as well as resilience in challenging market environments[9,10]. Initial studies on private market climate investments, although less transparent, indicate a significant performance uptick compared to the cleantech 1.0 investment period[11], as well as increasing investors' interest manifesting in green valuation premiums[12].

While the selection of asset classes to deploy capital depends on the risk-return appetite of an investor, some asset classes, like venture capital, benefit from significant climate action tailwinds, such as the need to invent 50% of the technologies to deliver on the 2050 emission reduction targets[13].

When selecting investment opportunities, a scientific approach that complements the traditional investor toolkit will be the key to selecting solutions with high climate alignment that can yield the prospect of significant scale-up and with this an attractive return potential.

One scientific approach to measure the climate and economic potential of a technology constitutes the assessment of a technology's 'Climate Performance Potential (CPP)'. Applying this approach in currently underfunded, yet high-emitting sectors, such as the food, agriculture and land use sector (FALU) and the industrial sector can help to discover technologies with high emission-saving and economic potential. Showcased examples include a mycofermentation-based alternative protein production technology offered by Enough Foods and a novel battery recycling method offered by Cylib.

This paper follows a three-fold intent to provide the reader with:

- A coherent overview of the European climate market opportunity (section A),
- Research on the financial return potential of climate technologies (section B), and
- Guidelines on how investors could capture this climate return opportunity (section C).

4 — THE MARKET OPPORTUNITY:

CLIMATE ALIGNMENT IS EXPECTED TO BECOME INCREASINGLY VALUABLE

A – THE MARKET OPPORTUNITY:
CLIMATE ALIGNMENT IS EXPECTED TO BECOME INCREASINGLY VALUABLE

"To limit anthropogenic warming the world must cut its emissions in half by 2030, and then continue to net-zero emissions before mid-century. Every tenth of a degree matters a lot, and it is the cumulative CO2 emissions which count."[14] – Stefan Rahmstorf, IPCC Lead Author & Head of Research at Potsdam Institute for Climate Impact Research

1. Climate risk impacts our environment, societies, and economy

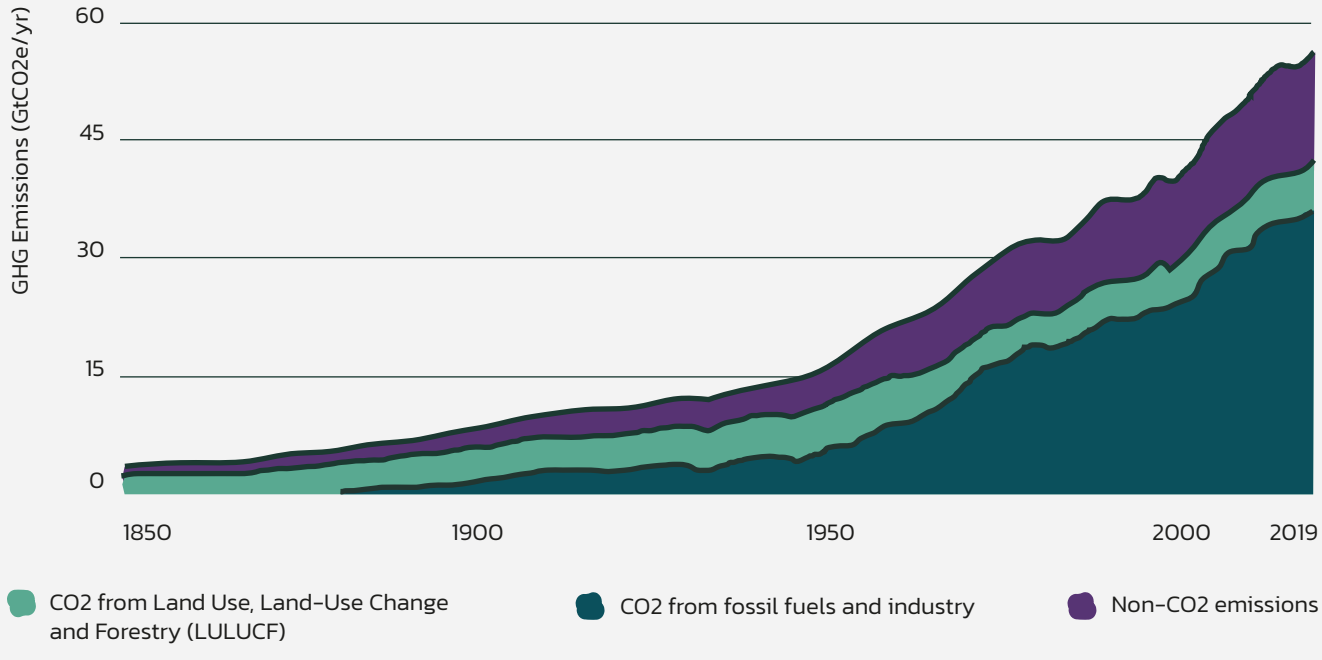
a. Climate risk threatens our environment and societies

The 2023 report by the Intergovernmental Panel on Climate Change (IPCC) paints a sobering picture of the present-day impacts of rising temperatures. It also projects potential catastrophic outcomes if humanity fails to rapidly and significantly curb greenhouse gas emissions. The most recent effects are becoming evident through rising sea levels, melting glaciers, scorching heat waves, and intensifying natural disasters.

Anthropogenic climate change has led to widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere. The detrimental consequences of these changes include significant losses and damages to both nature and people's livelihoods and disproportionately affect the most marginalised which vulnerable communities around the world.

The latest IPCC report provides an unparalleled level of clarity and evidence on how humans caused the 1.1°C increase in global temperatures since the onset of the industrial era. Global surface temperatures have "increased faster since 1970 than in any other 50-year period over at least the last 2000 years"[15]. However, to limit global warming to the 1.5°C Paris Agreement target, GHG emissions must peak before 2025 at the latest and decline by 43% by 2030[16]. Yet, under current efforts for climate change mitigation, GHG emissions are projected to increase in nearly all considered scenarios, resulting in temperature increases of 2.0–2.6°C by 2050.

Global net anthropogenic GHG emissions (1850–2019)[17]



Source: IPCC, AR6 Climate Change 2023, 2023

Greenhouse gas emissions are projected to continue to increase

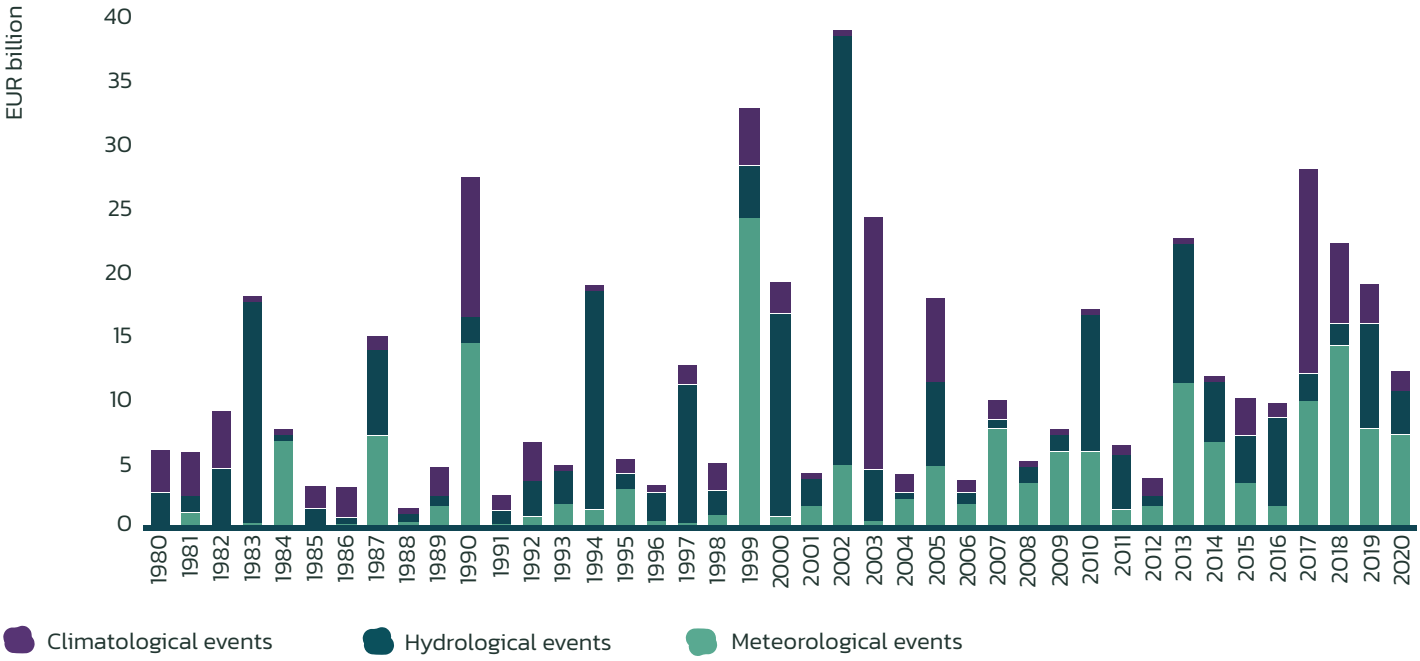
In 2019, global net emissions of GHG emissions reached 59 billion tonnes of CO2 equivalent (GtCO2e). This represents a 12% increase compared to 2010 and a staggering 54% increase compared to 1990. The good news: The annual growth rate of GHG emissions slowed from an average of 2.1% per year between 2000 and 2009 to 1.3% per year between 2010 and 2019. The largest share of emissions with the highest growth rate originated from fossil fuel combustion and industrial processes, followed by methane.

According to the report, the only way to stop global warming will require all sectors to undergo a rapid decarbonisation transformation. Even with radical reductions in emissions, a discernible slowdown in global warming will take around two decades. The losses and damages incurred are projected to worsen with each incremental increase in global temperatures.

b. Our inaction already comes at a cost to today's economy

On top of its impact on the environment and societies, the climate crisis also impacts our economy. Climate-related extreme events have already caused $1.3 trillion worth of damage over the past decade alone[18]. In the EU, climate-related damages of the last decade amount to €145 billion, according to a study by the European Environment Agency (EEA)[19]. The EEA study (2017) states that weather and climate-related extremes accounted for approximately 80% of the total economic losses attributed to 'natural hazards' and are projected to increase in the future.

Annual economic damage caused by extreme weather events in the EU (1980-2020)[20]



Source: IPCC, AR6 Climate Change 2023, 2023

c. *Action is needed to avoid costs of up to a quarter of global GDP*

"The cost of inaction far exceeds the cost of action."[21] *– Børge Brende, World Economic Forum President, Davos 2022*

In the future, the global economy stands to incur much bigger losses resulting from climate change, if we don't start to act. Several institutions (NGFS, OECD, IMF, SRI) have made their estimations on insufficient action on climate mitigation. Forecasts vary from a 4% decrease in global GDP by 2050 – if the Paris Agreement targets of <2°C are met[22] – to up to 25% in the worst-case scenarios[23]. Under the most severe scenario, Europe stands to lose around 11% of its GDP and the US almost 10%, with China at risk of losing almost 24% respectively[24]. With the projected trajectory of temperature increases of 2.0–2.6°C by 2050 under current efforts for climate change mitigation, the global economy stands to lose between 11–14% of global GDP.

However, this impact can be partially mitigated. There is a "benefit of investing in a net-zero economy", says Jérôme Haegeli, Swiss Re's Group Chief Economist. "For example, adding just 10% to the $6.3 trillion of annual global infrastructure investments would limit the average temperature increase to below 2°C."[25] On a global level, this would save around 2.9% of GDP loss. Thus, climate action is imperative for governments and businesses alike.

Simulating for economic loss impacts from rising temperature in % GDP, relative to a world without climate change (0°C)[26]

	Temperature rise scenario, by mid-century			
	Well-below 2°C increase	2.0°C increase	2.6°C increase	3.2°C increase
	Paris target	The likely range of global temperature gains		Severe case
World	-4.2%	-11.0%	-13.9%	-18.1%
Europe	-2.8%	-7.7%	-8.0%	-10.5%

Note: Temperature increase are from pre-industrial times to mid-century and relate to increasing emissions and/or increasing climate sensitivity (reaction of temperatures to emissions) from left to right.

Source: Swiss Re, "Economics of climate change risks threaten millions of jobs", 2021.

2. Global climate action gains momentum and puts pressure on the global economy

"There is a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all. The choices and actions implemented in this decade will have impacts now and for thousands of years."[27] *– IPCC, AR6 Climate Change 2023*

To mitigate the impact of climate change, stakeholders across the board are accelerating their efforts. Governments and businesses are more and more setting ambitious targets and increasing their capital allocations. In areas where the progress of translating these targets into action is slow, others, including courts and activists, are stepping in.

a. Political action is increasing, but regulatory gaps remain to be addressed

The Paris Agreement of 2015 – a landmark climate deal between 196 countries – marked the start of a new wave of political efforts to mitigate the impacts of climate change. The agreement sets out a global framework to mitigate climate change by limiting global warming to below a 2°C target, yet striving to limit it to 1.5°C. In addition, it seeks to enhance countries' capabilities to manage the impacts of climate change and support them in their mitigation and adaptation efforts. It does not specify any CO2-reduction targets for the respective signatories.

Since then, efforts have increased, with governments worldwide setting voluntary net-zero targets. Today, more than 70 countries – which account for 78% of total emissions – have committed to net-zero targets. This includes the biggest emitters, China, the United States and the EU. However, the IPCC report still notes that net-zero pledges differ "in terms of scope and specificity, and limited policies are to date in place to deliver on them"[28].

The IPCC report (2023) warns that global policies in place by the end of 2021 will not achieve the emission cuts needed and are projected to exceed 1.5°C by 2050 and reach 3.2°C by 2100[29]. Another report by the IEA (2021) shows that existing commitments would only result in a 20% reduction in emissions by 2030, falling short of the necessary cuts to maintain the possibility of achieving net-zero emissions by 2050. To put this into perspective, closing this gap to achieve net-zero emissions by 2050 would require an estimated $4 trillion in annual investments over the next decade[30]. Similar projections have been made by Bloomberg NEF, which estimate that only about 16% of current global climate financing needs are being met, requiring an increase by at least 590% – to $4.35 trillion annually by 2030 - to meet our climate targets[31].

b. Courts and activist investors are stepping in successfully where stakeholders fail to take swift action

Although there is an abundance of climate pledges from governments and companies alike, these are often associated with unclear roadmaps and timelines for their implementation. Over the span of 2009 to 2021, there has been a significant rise in climate-related court cases, with more than 1,400 cases filed globally seeking climate action from companies or governments, according to a study by the WEF and BCG (2022)[32]. This represents a sixfold increase in the number of climate cases over a decade.

Recent notable cases include courts in the Netherlands mandating the government[33] - and with Shell for the first time companies[34] - to introduce stricter emission-reduction targets. A second example is Germany's federal constitutional court ruling that the government should provide a more detailed national emissions-reduction plan[35].

"Since the German Constitutional Court's historic climate ruling, intergenerational climate justice has become a constitutional right of all German citizens. A new climate law mandates that the country should be climate neutral by 2045. Strategic environmental legislation can put the government under pressure to decide on concrete climate mitigation measures for all sectors that have to deliver. That includes sectors of the economy like transportation and buildings, where emissions are still stagnant or even rising. Climate litigation can advance a legal framework that enables a more rapid transformation towards a carbon neutral economy."[36] *– Sascha Müller-Kraenner, CEO Deutsche Umwelthilfe (Environmental Action Germany)*

In addition, there is the phenomenon of activist investors: An activist investor is an individual or group that acquires a significant ownership stake in a company to influence or change its policies, practices or management decisions in order to pursue certain goals. Recently, activist investors are increasingly exerting influence on companies. One recurring example includes using board member elections as a means to accelerate climate action, while shareholders are successfully pushing for greater transparency and disclosure on carbon-related issues. A study by Ernst & Young (2021), a global accounting and consulting firm, revealed that there has been a significant surge in support for proposals on environmental and social topics – including climate change – among Fortune 100 companies during their 2021 annual shareholder meetings. As of June 30, 2021, over 20% of environmental and social shareholder proposals that went to a vote received majority support, compared to only 12% in 2019 and a mere 3% in 2016[37].

Engine No.1 overrules oil giant Exxon Mobil, installing four new directors on board to drive climate action

In June 2021, activist investor Engine No. 1, achieved a significant milestone by successfully installing three new directors on Exxon's board, with the aim of pushing the energy giant to reduce its carbon footprint.

Supported by major institutional investors such as BlackRock, Vanguard, and State Street, Engine No. 1's efforts overruled Exxon's leadership, setting a precedent for smaller activist investors to impact corporate decision-making.

BlackRock stated, "We believe that Exxon's long-term strategy and short-term actions related to the energy transition need improvement to mitigate climate risk and safeguard long-term shareholder value."[38]

This development reflects a shift in the perception of shareholder activism, as investors can now steer companies towards increased alignment with sustainability goals through the promise of increased shareholder value in the long term.

The New York Times[39] suggested the positive impact of Engine No. 1's campaign on the performance of Exxon's shares, which at that time have reversed years of underperformance and increased by over 45% from December 2020 to June 2021. This performance continued to improve over the last years[40], also enhanced by macro-trends such as inflation, the Russian war in Ukraine, and the intensifying energy crisis.

3. Deep Dive: The European policy approach

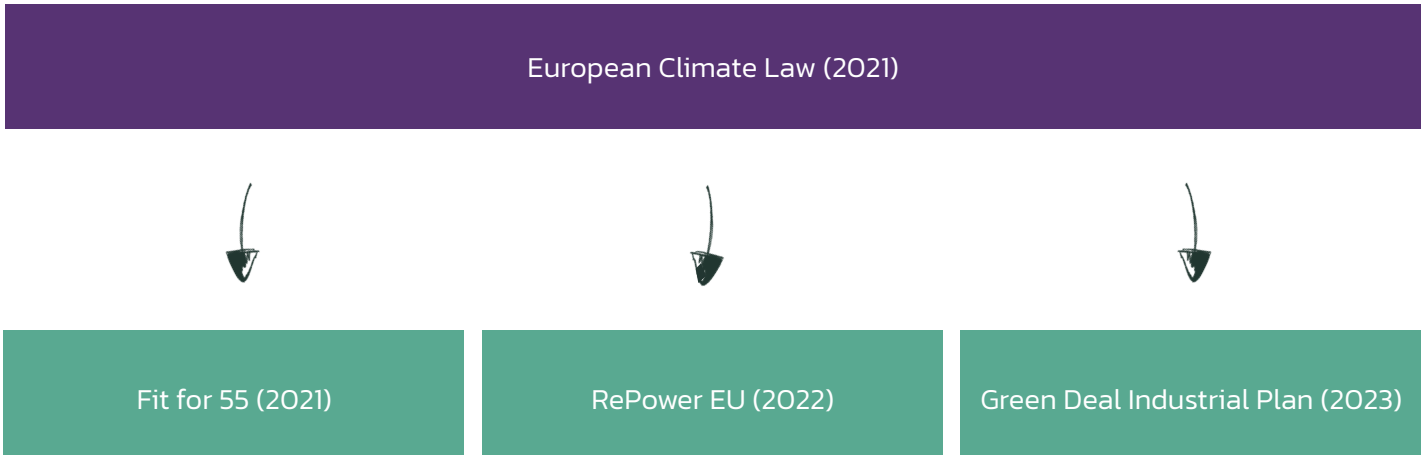
In cooperation with Cleantech for Europe

a. Europe is leading in climate ambition and action

"We, Europeans, are excellent at making science with money. But we are not so good at making money out of science."[41] *– Ursula von der Leyen, President of the European Commission*

Europe pledged to become the first climate-neutral continent by 2050. The European Green Deal (2020), a comprehensive and ambitious plan to achieve climate neutrality by 2050, lays the foundation for a sustainable and competitive net-zero transition of the European industry. It entails a series of policy initiatives and measures across various sectors, including construction, biodiversity, energy, transport, and food production. The main objective is to make adaptation smarter, faster, and more systematic, and to support European action for climate resilience[42]. The European Climate Law, the first legislative proposal following the EU's Green Deal, is anchoring the net-zero commitment by 2050 and directing all EU policy on the green growth strategy. It provides predictability and transparency for public authorities, industry, and investors.

The European policy approach for climate[43]



Source: Cleantech for Europe & World Fund, 2023

The European Climate Law is being complemented by three additional policy packages. This includes the Fitfor55 regulation package (2021), laying out the roadmap on how to achieve 55% reductions by 2030 through the deployment of clean technologies, sectoral targets, and phase-outs of polluting technologies. Part of that package is, amongst other measures, the revision of the carbon pricing scheme currently underway[44], the carbon border adjustment mechanism formally approved in April 2023, and the renewable energy targets passed in April 2023.

Secondly, the REpower EU Plan is the European Commission's plan to make Europe independent from Russian fossil fuels before 2030 in light of its invasion of Ukraine. It is a plan for energy savings, producing clean energy, and diversifying the EU's energy supply.[45] Whilst it is not a climate package per se, it has increased the ambition of a number of policies relating to clean energy.

"For policymakers, clean technologies are not only about climate anymore. They are also a lever to improve our energy security, and an opportunity to build industrial leadership in the next decades."[46] *– Jules Besnainou, Executive Director of Cleantech for Europe.*

The four pillars of the Green Deal Industrial Plan (GDIP) for a net-zero economy[47]

1 

Regulation

Create a conducive and streamlined regulatory environment to enable a fast up-scaling of the net-zero industries

3 

Skills

Ensure that skills growth across all sectors keeps pace with technological innovation

2 

Funding

Provide funding for net-zero industries through a temporary adaption of state aid rules and improved access to EU resources

4 

Trade

Foster strong and resilient supply chains, including on critical raw materials, through trade agreements and multilateral organizations

Source: Deloitte, "Paving the way for the EU's green industrial policy for the net zero age", 2023

The most recent package currently under discussion is the European Green Deal Industrial Plan (GDIP), which sets targets in industrial manufacturing to enable a European leadership position. It is based on four pillars: A predictable and simplified regulatory environment, speeding up access to finance, enhancing skills, and open trade for resilient supply chains. It also includes an electricity market reform to ensure low-cost electricity for green industries and a Critical Raw Materials Act to ensure access to input materials required to manufacture key technologies. The EU also set a 2030 target of producing at least 40% of the clean technologies, like solar power and wind, needed to achieve the net-zero transition.[48] Some key developments within the GDIP include the Zero Industry Act, the Electricity Market Design reform, and the Critical Raw Material Act, along with a reform of State Aid guidelines.

Europe is increasing its efforts to create a level playing field for European and international companies

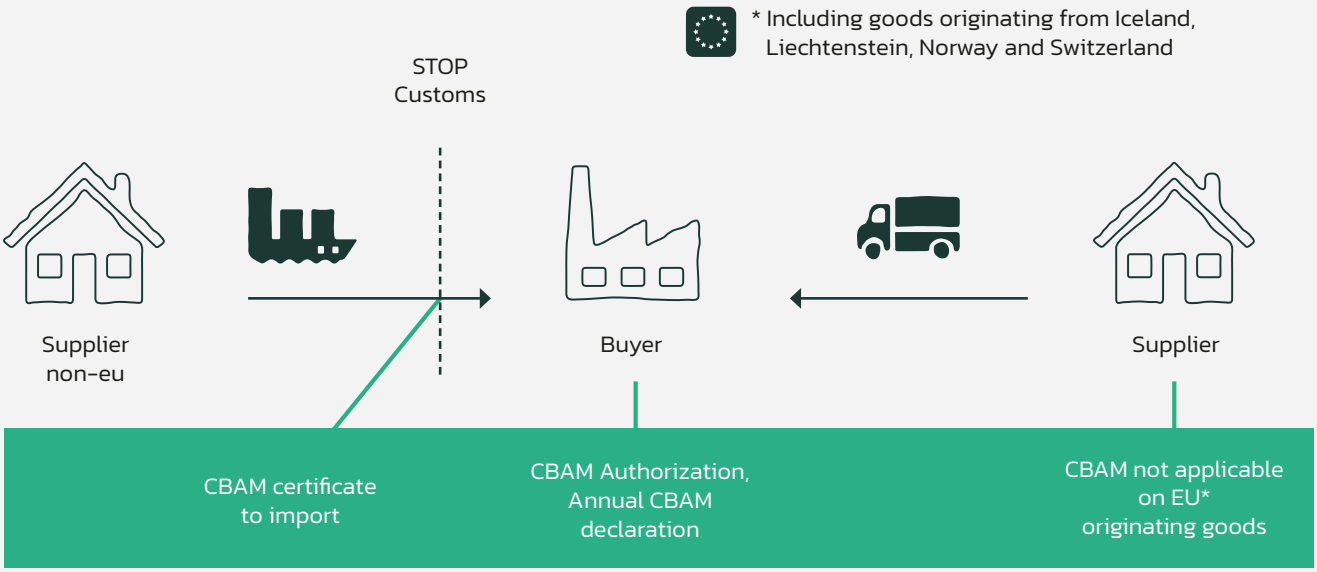
"Creating a sound regulatory framework and setting the right incentives are key. This applies to funding of research and development, to the structure of capital markets, but also to the regulatory framework for climate protection. Here we should rely on the strengths of our social market economy. Climate protection works best using price signals. This is why the further development of the European Union Emissions Trading System is so crucial."[49] – Danyal Bayaz, Minister of Finance of Baden-Württemberg

The EU's Emissions Trading System (ETS)[50] is the cornerstone of the bloc's efforts to reduce greenhouse emissions. Over the period from 1990 to 2020, greenhouse gas emissions in the EU decreased by 32. Improvements in energy efficiency, increased utilisation of renewable energy sources, and a switch away from coal-based generation were cited by Eurostat[51] as major contributors to this trend.

Established in 2005, the ETS is the world's first and largest major carbon market. It is based on the rationale that trading carbon allowances encourages the cheapest decarbonisation measures to be implemented first, creating a market for emissions reductions and then progressively tackling harder-to-decarbonise sectors. In practice, the ETS is complex and not as fluid as envisioned, with varying rules for different industries and a massive loophole where large industry players receive free allocations for their emissions. This was initially designed to protect them from unfair competition of imports, but has turned into a de-facto subsidy of tens of billions of euros per year and has slowed the green transition of heavyweight industries. However, with the latest overhaul of the ETS, and the establishment of the EU's Carbon Border Adjustment Mechanism (CBAM), this will no longer be possible. The gradual implementation of the CBAM is aligned with the phasing-out of free allowances allocated under the ETS[52].

The EU's Carbon Border Adjustment Mechanism (CBAM) is a groundbreaking tool that addresses the problem of carbon leakage and the associated free allowances for industrials, by putting European producers on a level-playing field with

The mechanics of the EU's Emissions Trading System (ETS)[53]



Illustrative purpose only, does not reflect all the details.
Source: EY, "The EU – CBAM Carbon Border Adjustment Mechanism", 2021.

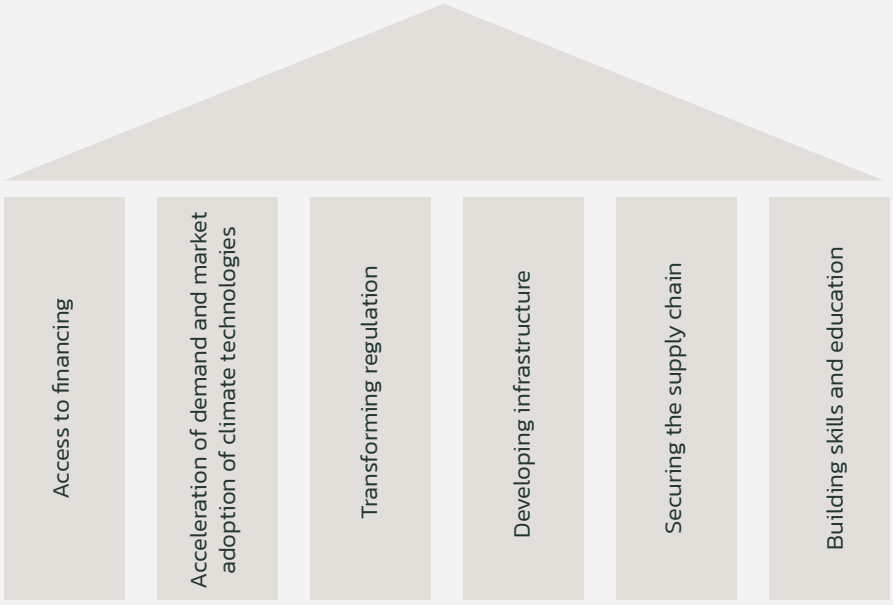
importers. Under the agreement being rolled out, it establishes a fair price on the carbon emissions associated with the production of carbon-intensive goods that enter the EU and also aims to incentivise trading partners from non-EU countries to decarbonise their manufacturing industries. This mechanism aims to make the carbon price of imports equivalent to the carbon price of domestic production, safeguarding the EU's climate objectives from being undermined.

By putting a price on carbon for imports, the CBAM aims to level the playing field and hold producers from non-EU countries to the same standards, preventing carbon leakage risks, where their producing industries could have a competitive advantage due to lower emission standards. The CBAM is a significant step towards promoting fair competition and driving global efforts towards a more sustainable and low-carbon future.[54]

b. Yet Europe requires simpler and more consistent policy to implement its ambition

As stated above, Europe has the ambition and policies in place to achieve the net-zero transition. However, it still struggles to put in place the right incentives with simplicity. With global competition, Europe has a short window to become the home of climate technologies and keep its tech sovereignty. To achieve this goal, Cleantech for Europe developed an action plan based on six pillars of change: Access to financing, accelerating market adoption of climate technologies, simplifying regulations, developing infrastructure, securing the supply chain, and building the necessary skills and education. Policymakers need to work closely with industry stakeholders and other relevant actors to overcome these challenges and create an environment that is conducive to the adoption and deployment of climate technologies. Even though the GDIP addresses exactly these challenges, there is still room for further development.

Europe's six pillars for change – Jules Besnaiou, Executive Director Cleantech for Europe



Source: Cleantech for Europe

Pillar 1: Access to financing

Investments in climate technology are still happening too slowly, both at the public and private level (for a detailed assessment, please refer to Section B). While Europe is doing great in early-stage funding for climate technologies, there is a need to close the funding gap for scale-ups. Policymakers need to reorient funding mechanisms to support the scale-up of clean technologies, as this is crucial for deploying decarbonisation technologies at scale.

Pillar 2: Acceleration of demand and market adoption of climate technologies

Clear targets and phase-outs, as well as incentives such as carbon pricing and public procurement rules that support innovative technologies, encourage corporates to adopt climate technologies.

Pillar 3: Transforming regulation

Regulation needs to be more transparent, simple and consistent. It includes simplifying and speeding up access to financing and IP protection to enable faster development and deployment of climate technologies. It is critical to align and integrate regulations that facilitate the scaling up and wide deployment and adoption of climate technologies across countries within the European Union.

Pillar 4: Developing infrastructure

Building the necessary infrastructure is critical to ensure that climate technologies can be deployed effectively and integrated into an existing system. Examples include installing power grids to support renewable energy deployment or transforming the gas network into a hydrogen network. This requires significant investment and planning.

Pillar 5: Securing the supply chain

The availability of critical raw materials and manufacturing capabilities within the EU, as well as a diversification of the supply chain, is needed to avoid disruptions in production and to ensure the supply for the growing demand of climate technologies.

Pillar 6: Building skills and education

Building the necessary skill set for developing, deploying and maintaining climate technologies is essential. To execute the climate transition, the workforce needs to be well-equipped through appropriate training and education.

In comparison: Learnings from the US and China

US approach: Financial incentives with clear sector priorities

While European action has its foundation mostly in regulation with strict targets and phase-outs, the US takes an approach of mostly financial incentives. The US demonstrates that financial incentives can work. Europe can learn from this effort, especially in terms of clarity and ease of access to financing.

The success is paying off: More than half (45 out of 81) of Cimate Tech unicorns are US-based companies, compared to only 19 and 17 unicorns in China and Europe respectively[55].

With the Inflation Reduction Act (IRA) the US has mobilised at least €337 billion to deploy on the decarbonisation of the energy, transport and hydrogen sectors, potentially even investing

Chinese approach: Coordinated efforts and planning security for the market

China, on the other hand, excels at coordinated industrial policy to build industries through their five-year plans. Europe can draw some lessons from this coordinated, holistic approach that provides planning security to the market.

China strategically incentivise the growth of emerging industries, such as battery and solar. Solar, which already appeared as a priority in their 12th Five-Year Plan (2012-2015) and continues to be a strategically important sector[57]. Today, China dominates the global solar panel manufacturing industry, with over 80% of the market share across all manufacturing stages and the world's top 10 suppliers of solar PV manufacturing equipment being located in China[58].

over €700 billion[56]. They have clear sectoral priorities, transparently communicating the level of investments in the respective sectors. Also, the rules and criteria to access this financing are extremely simple, straightforward, and most importantly very predictable for investors, which allows for long-term strategic investments.

This success is based on a comprehensive approach that aims to create all the necessary elements of industry growth by aligning their policies, simplifying regulations, easing access to finance, creating demand, and providing the necessary infrastructure. By aligning its policies and actions towards promoting specific industries, China has been able to drive scale, fostering the conditions for significant transformation and growth in key sectors, and enabling industry success.

4. The economy will play a major role in implementing climate ambitions

a. Climate action creates a new environment for the private sector

"Climate change, more specifically the risk of not decarbonising our end-to-end supply chain at a speed that matches our customers' and investors' expectations, was in 2020 confirmed by our executive leadership as one of the top enterprise risks to Maersk."[59] *– Maersk Sustainability Report, 2022*

Companies are reacting to net-zero pledges by governments with pledges of their own. By the end of 2022, one-third of the world's largest publicly-traded businesses have made net-zero commitments, a study by the UN shows. However, only half of those provide transparency on how targets are embedded in their corporate strategy. The other half of businesses have merely announced net-zero targets or, in some instances, have only expressed their intention to establish such targets[60].

The future regulatory landscape remains uncertain, with the potential for more stringent regulations on the horizon. Companies need to factor in current and anticipated regulations to ensure compliance and avoid financial penalties. This includes increased carbon pricing, regulation of existing core business activities, and emissions reporting obligations. According to S&P Global, large global companies could face up to $283 billion in carbon pricing costs and risk 13% of their earnings by 2025[61].

In addition, regulation is tightening companies' financing environments. The Non-Financial Reporting Directive (2022)[62] requires large public-interest companies to disclose additional data on their social and environmental impacts. Financial institutions are increasingly basing their investment decision on these reportings. The most prominent example is the $1.2 trillion-strong Norwegian sovereign fund, which announced its own commitment to net-zero,, forcing net-zero alignment to the thousands of companies in its portfolio[63].

"Companies must consider the decarbonisation of their operations within a 5-10 year timeframe. The European Green Deal, along with the Fitfor55 Package and the Green Deal Industrial Plan, leave no room to escape. It is imperative for companies to take concrete actions and demonstrate tangible progress towards their sustainability goals to gain trust and credibility with stakeholders, including investors, customers, and the broader public"[64] *– Jules Besnainou, Executive Director of Cleantech for Europe*

Further, liability risks and penalties arise for companies when failing to adequately address changing legal and regulatory expectations related to climate disclosure and compliance[65]. Reputational risks due to increased public scrutiny, changing

consumer trends and technological innovations, as well as material risks as a direct consequence of climate change, can not be disregarded either.
However, those companies that adapt to the new environment and take an active role in the climate transformation also have the opportunity to benefit from their leadership.

"At BASF we want to play an active and responsible role in shaping the transformation toward a climate-neutral society: By adaptation activities such as energy- and resource-efficient processes and product development to reduce greenhouse gas emissions. This also requires a political and regulatory environment that promotes innovation in climate protection, makes it possible to develop new processes that are competitive internationally and, above all, resolutely drives forward the expansion of renewable energies."[66] *– Melanie Maas-Brunner, Board Member and Chief Technology Officer of BASF*

b. *Financing can be a critical enabler to accelerate climate action*

"As regulators and governments start increasing their focus on the environment, and as humanity as a whole agrees that we have climate issues that need to be addressed, that focus is only increasing. So, what we are seeing with 'climate-focused' investments is actually a move towards a new status quo."[67] *– Erik Seebusch, Partner & Global Strategy Leader VC & Growth Equity, Mercer*

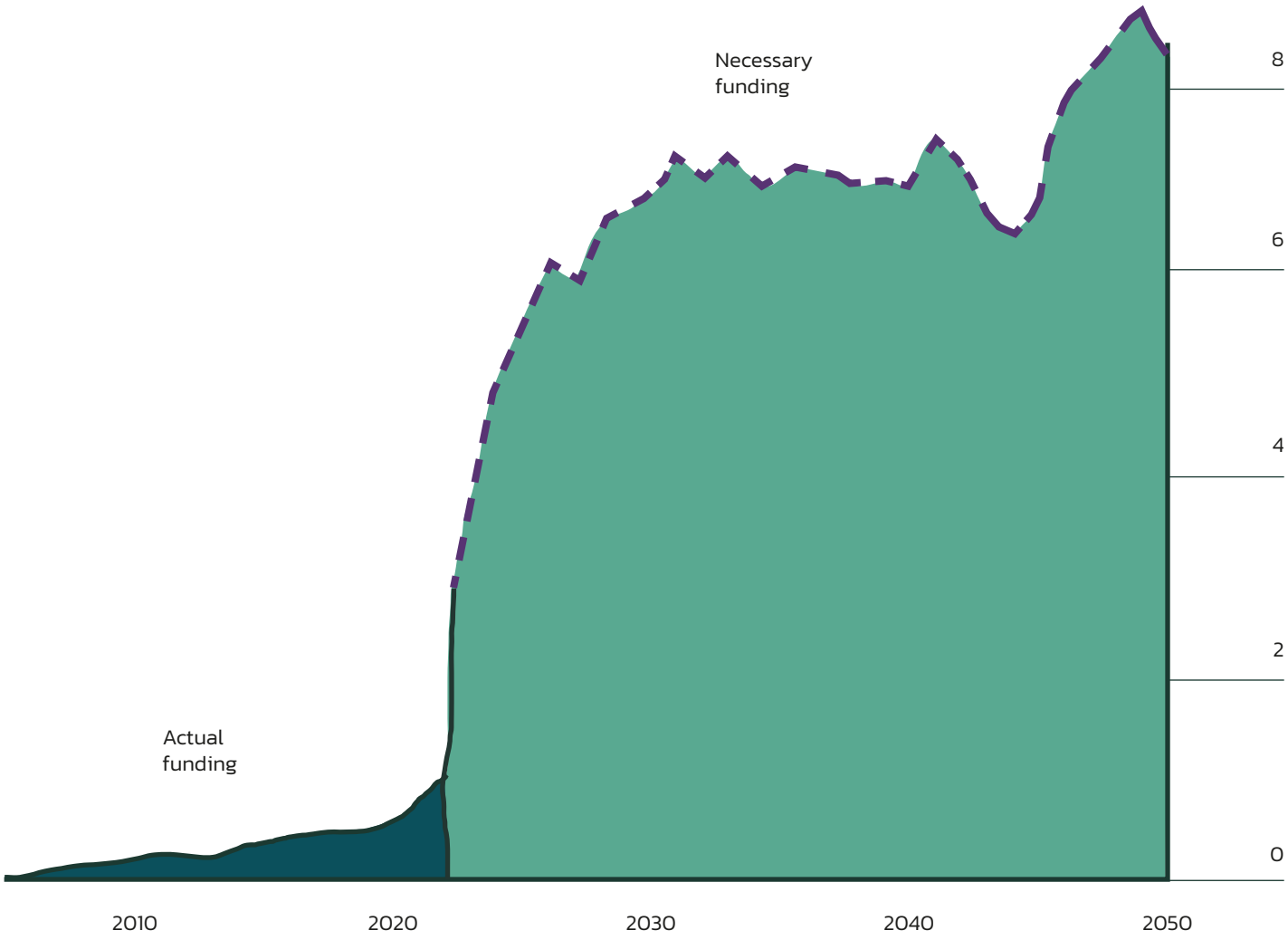
While companies need to cope with the new environment, financing is a "critical enabler" to accelerate climate action and can incentivise private investors to double down on their investments. GDIP and IRA are currently leading with commitments of €1 trillion[68] and €337 billion (potentially up to €700 billion), respectively[69]. Unfortunately, global climate funding still falls short, compared to what is needed to reach our climate targets. Bloomberg's energy researcher (BloombergNEF) has estimated that only about 16% of climate finance needs are currently being met, which in turn means that climate finance must increase by at least 590% – to $4.35 trillion annually by 2030[70].

The current lack of funding presents a significant barrier to progress according to the IPCC report[72]. While global climate finance flows have increased, the report highlights that funding for fossil fuels still surpasses that of climate adaptation and mitigation. It emphasises that there is enough global capital available to close investment gaps, but barriers hinder its utilisation for climate action. The report also suggests that reducing these barriers would require clear signalling and support from governments. This includes public financing, as well as decreased regulatory market barriers and stronger alignment of public and private financing. In addition to this, central banks, investors, and other financial actors can also play a role in changing the underpricing of climate-related risks and reducing disparities between available funds and required amounts. This way, perceived risks of climate investments for private investors could be decreased.

However, this still leaves a funding gap for private investors to follow up on significant public investments.

Climate funding gap: Real vs needed investments in climate tech ($tn)[71]

Investment falls far short of what is needed to reach net-zero by 2050



Source: BloombergNEF, "Energy Transition Investment Trends 2023", 2023

5. Conclusion: Climate action will create a multi-trillion dollar investment opportunity within the decade

The window for climate action is rapidly closing, with our environment, societies and the global economy at risk. As outlined above, regulators will increasingly close this action gap. Delaying action has severe economic costs, with climate-related damages reaching trillions of dollars and projected losses in global GDP of up to 25%. While climate action puts significant pressure on the private sector to adapt to the new environment, it also includes a significant upside. Beyond our findings above, all major market influencers – from Goldman Sachs[73], to Morgan Stanley[74], to Blackrock[75], to McKinsey[76], to BCG[77] – agree that climate solutions will be a multi-trillion dollar market by 2030.

B – THE FINANCIAL CASE:

CLIMATE ACTION IS ALREADY BEING REWARDED TODAY

B – THE FINANCIAL CASE:
CLIMATE ACTION IS ALREADY BEING REWARDED TODAY

The previous section discussed a future where climate alignment will become increasingly valuable to our economy. Governments create the necessary environment for companies to benefit from aligning with climate targets by enabling a growing market for climate solutions and services. Investors that support climate action could benefit from capturing this opportunity.

However, the economic value of these is not just a future expectation. A share of positive environmental performance can already be observed in today's economy. Consumers, particularly in Europe, acknowledge the scientific consensus, demand climate alignment, and are willing to pay green premiums[78]. This demand is mirrored by shareholders as well. Most prominently, Larry Fink, CEO of BlackRock, stated in his annual letters to investors from 2021 and 2022 BlackRock's clear and determined changes in allocation based on climate related factors. This was reiterated in his 2023 letter: "For years now, we have viewed climate risk as an investment risk. That's still the case[79]." Rephrasing risk into opportunity: "I believe the decarbonising of the global economy is going to create the greatest investment opportunity of our lifetime[80]."

In this section, we will therefore focus on public and private markets' participation in this investment opportunity and their financial return potentials.

1. The public market is doubling down on ESG and climate opportunities and their return profiles

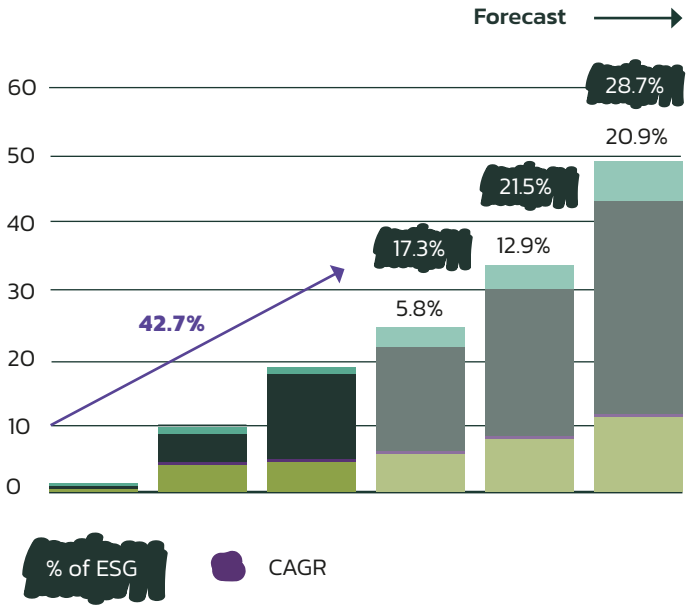
a. Public markets increasingly channel investments towards ESG aligned companies

One indicator pointing towards shareholders' interest in climate alignment can be found in the recent rise of ESG (Environmental, Social, and Governance) aligned public market allocations. While 'E' is only one of the three ESG criteria, 60% of institutional investors see environmental aspects as at least equally prevalent to other ESG aspects, with the majority seeing it as the most prevalent aspect[81].

The appetite for ESG investments is evident in the number of total assets under management (AuM) in ESG-aligned funds, which reached $18.4 trillion in 2021. This is almost a doubling from $9.4 trillion in 2020, ultimately bringing ESG considerations from niche into the mainstream market. In terms of geographies, Europe takes the lead with $12.8 trillion of ESG AuM, which is 69.6% of the global ESG AuM. This puts ESG allocations at a growth rate significantly higher than general market growth, with PwC models estimating a 21.5% ESG asset share in total AuM by 2026. However, there is concern that asset managers might have classified funds as sustainable for marketing purposes without meeting ESG standards, like in the case of Deutsche Bank's subsidiary DWS[82].

Global ESG AuM by region ($tn)[83]

	2015	2020	2021	2026 Low	2026 Base	2026 Best
Asia-Pacific	0.2	0.7	1.0	2.1	3.3	5.0
Europe	1.1	4.7	12.8	14.3	19.6	25.7
Latin America	0.0	0.0	0.0	0.1	0.2	0.3
Middle East & Africa	0.0	0.1	0.1	0.2	0.3	0.4
North America	0.8	3.8	4.5	7.7	10.5	16.3
Total	2.2	9.4	18.4	24.4	33.9	47.6



Source: PwC AWM '22

Beyond the uptick in ESG funds, institutional investors are increasingly seeing ESG compliance as a must-have criterion, with 89% having considered rejecting investments in a manager with ESG shortcomings. Overall, PwC found that the demand is evolving faster than the supply, with 88% of institutional investors believing that asset managers should be more proactive in setting up new ESG products.

It is important to point out that recent greenwashing controversies on ESG-labelled funds[84] do not contradict investors' interest in ESG products and ESG-performing assets as shown by the PwC research. Rather, the recent events are expected to lead to more rigorous ESG performance analytics, resulting in a more evidence-driven market environment. This correction was needed to help the market become less prone to greenwashing claims and truly cater to investors' demand for positive ESG performance.

b. *ESG and especially climate-aligned public companies outperform their peers*

In order for the public investors' demand for ESG (and climate-aligned) investments to further increase, investments need to yield attractive returns. In the following section, we will outline several public market research findings and perspectives as indicators for assessing financial returns of ESG investments. The following three observations summarise the outcomes of the analysis:

(1) ESG funds and stocks tend to outperform non-ESG
(2) Spotlight on environmental stocks: Climate-aligned stocks show outperformance
(3) Within a given sector, Climate-aligned leaders outperform their peers

Note

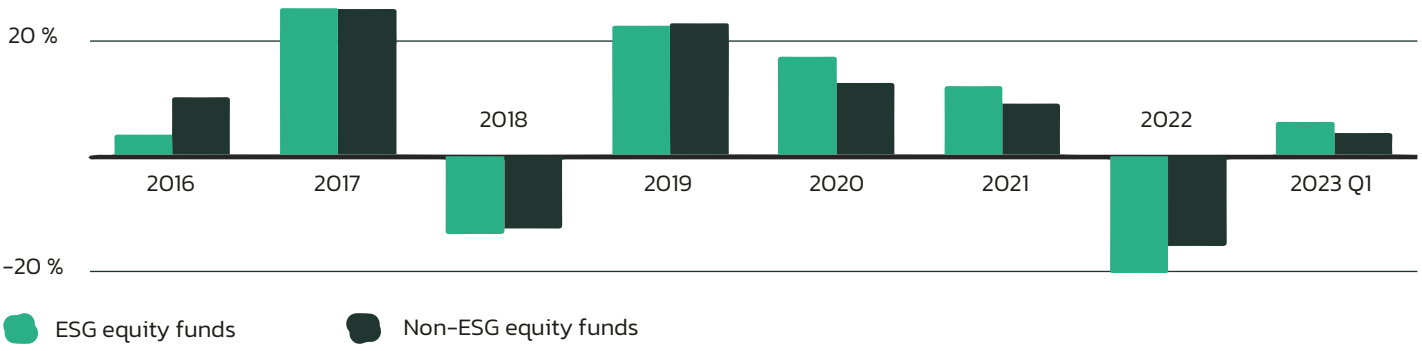
Russia's invasion of Ukraine strongly correlated with the performance of Oil & Gas companies. For this reason, 2022 will regularly appear as an outlier in the studies below. For 2023 and beyond, a regression to the mean is possible, but the current data is limited.

(1) ESG funds and stocks tend to outperform non-ESG

PwC research[85] shows that 60% of institutional investors report that ESG has already resulted in higher yields in their investment performance compared with non-ESG equivalents. 75% are even willing to pay a fee premium. With regard to portfolio construction, 90% of asset managers are convinced that integrating ESG will improve overall returns in the long run.

The performance data confirms these claims. According to studies by Refinitiv, a leading financial research institution, ESG funds have regularly outperformed their non-ESG peers in 2019, 2020, 2021, and 2023[86].

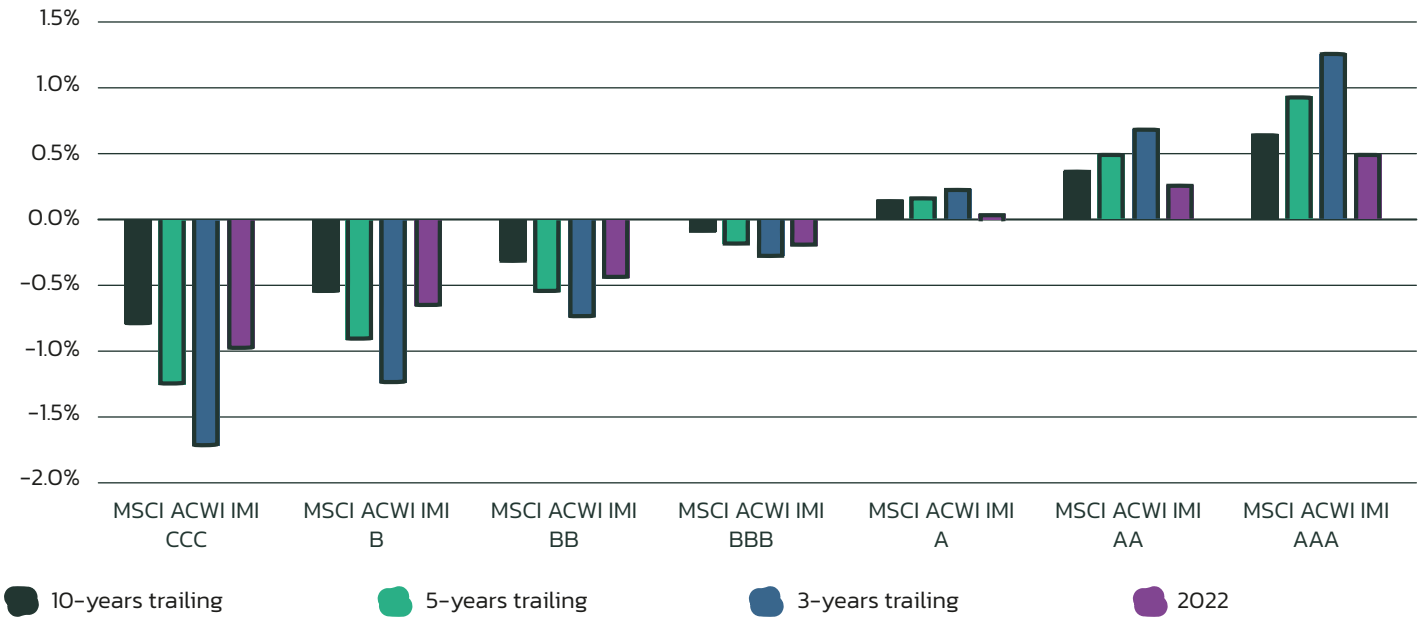
Performance of ESG vs non-ESG equity funds[87]



Note: Performance in percentage terms; 2023 performance is as of March 31
Source: Reuters, "Banking turmoil dampens shine of ESG funds at end of strong Q1", 2023

In another study, MSCI[88] analysed performance against ESG ratings on a company level and found that companies with higher ESG ratings drove superior returns. MSCI's methodology assumes that companies with a high ESG score tend to have higher climate alignment[89]. They categorised companies along their ESG ratings from AAA to CCC and compared the active return contributions. While the return contributions in 2022 were not significantly different, in all longer periods there was a significantly larger return contribution by companies with an ESG rating of AA or AAA; see graphic below.

Historical return delta by ESG rating[90]



Source: MSCI, "ESG Ratings Financial Performance Blurred but Still Present in 2022", 2023

Besides PWC's research, Refinitiv and MSCI data, S&P[91], Morningstar[92], and Blackrock[93] all arrived at similar conclusions regarding the outperformance of public ESG funds.

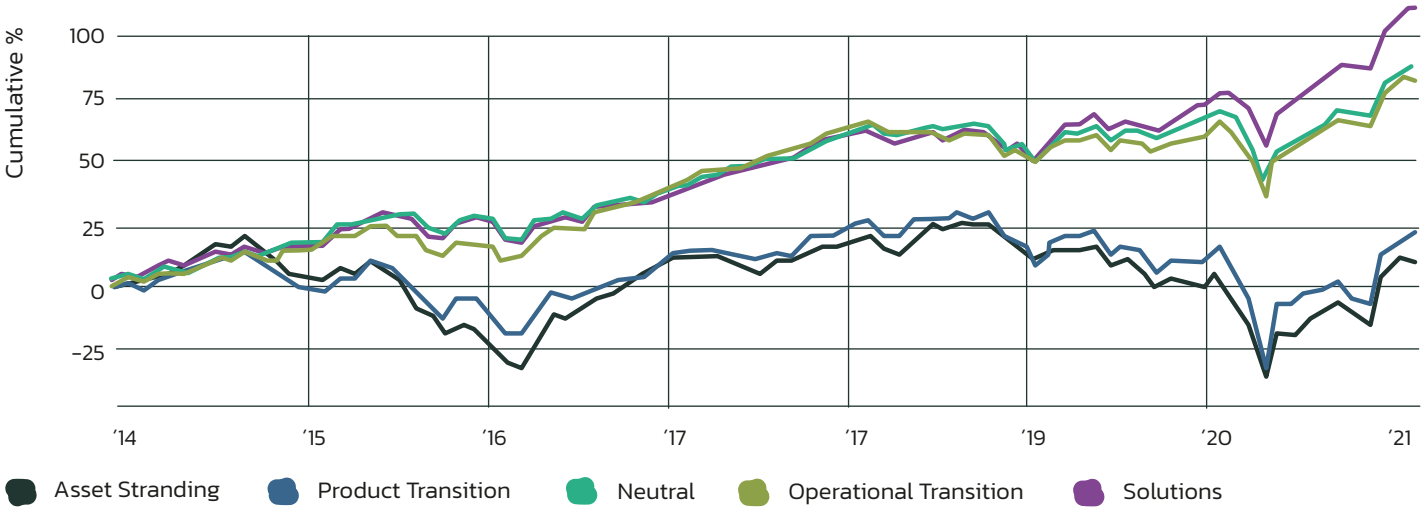
(2) Spotlight on environmental stocks: Climate-aligned stocks show outperformance

Within ESG placements, relevant research focused on the performance of environmental stocks, as demonstrated in a recent study published in the Journal of Climate Finance[94]. The study considered Scope 1-2 emissions intensity, which measures total emissions per unit of revenue, and analysed stock performance from 2010-2021.

Using emission intensity as a proxy for environmental performance, or climate alignment, the study found an outperformance of climate-aligned stocks for six of the G7 countries ranging from 23% for Canada to 110% for France. US green portfolios had a cumulative return of up to 70% higher than that of brown portfolios. The notable exception is Italy, where brown stock returns have been higher on average than green stock returns over the same period.

A similar indication was found in a study by MSCI[95] that classified stocks into five different categories of climate transition risk. It was found that the stocks in the highest climate risk category *Asset Stranding* consistently had the weakest performance. In contrast, the *Solutions* category showed the highest performance over the study period from 2014-2021. This can provide a proof point for correlation between stock-specific returns and companies' climate transition-risk profiles.

Cumulative stock performance of different climate transition risk categories[96]

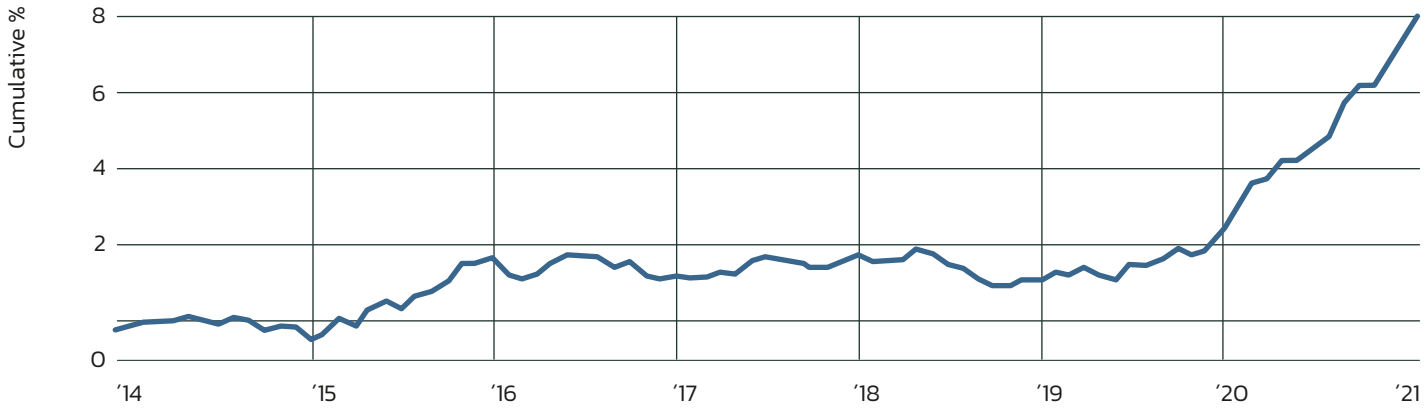


Source: MSCI, "Foundations of Climate Investing: How Equity Markets Have Priced Climate Transition Risks", Journal of Portfolio Management, 2021

To further explore the financial impact of climate alignment, MSCI has developed the Low Carbon Transition score ("LCT score") that aggregates a variety of climate-relevant risk factors, such as through scope 1/2 and upstream and downstream emissions, but also climate opportunities, such as through manufacturing or selling products with positive climate performance. Based on the LCT score as a proxy for climate-transition risk profile, or climate alignment, MSCI applied LCT scores as a hypothetical driver in their primary GEMLT[97] model for public stocks to study cumulative returns. This means that other factors driving performance are taken into account, such as industry, style, and currency. Overall, high LCT scores showed a positive cumulative return. While the outperformance was relatively small in the first five years of the study from 2014–2019, it accelerated substantially from 2020.

Cumulative returns of the low carbon transition score[98]

Multivariate regression by MSCI accounting for factors such as industry, region, or style



Source: MSCI, "Foundations of Climate Investing: How Equity Markets Have Priced Climate Transition Risks", Journal of Portfolio Management, 2021

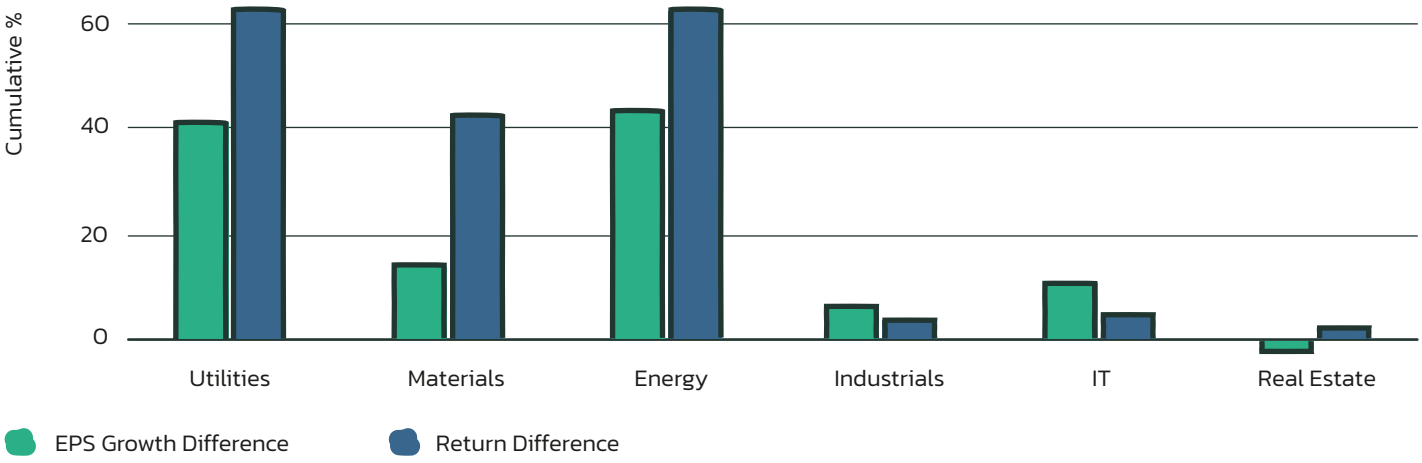
Other recent studies conducted by Amundi[99], Right. Based on Science[100], or BlackRock[101], have found similar effects.

(3) Within a given sector, climate-aligned leaders outperform their peers

Another way to understand the financial value of climate alignment is to compare competitors within categories and study the correlation between how they perform on climate and financial indicators.

MSCI evaluates the performance of companies with better Low Carbon Transition scores with their peers, where the LCT score aggregates a variety of climate performance and risk indicators. In fact, the previously cited regression analysis from MSCI already factors out certain variables such as industry, currency, or geography to observe only the LCT score impact on stock performance. That suggests that the outperformance holds within direct comparisons in a given category. One indicator that contributes to the LCT score has a particularly strong contribution within each category: The Green Revenue Share. The Green Revenue Share of a company is used as a proxy for development and rollout of green technologies. MSCI identified green revenue as a potential transmission channel. Overall, the earnings growth and return difference of companies with a large share of green revenue showed to be higher than their peers with a low share of green revenue. This effect from climate performance was particularly observable in the utilities, materials, and energy sectors[102].

Top quintile in green revenue share vs bottom quintile per sector[103]
Between 2015 and 2021, stocks with higher Green Revenue Share performed better in earnings per share growth and returns within a given sector



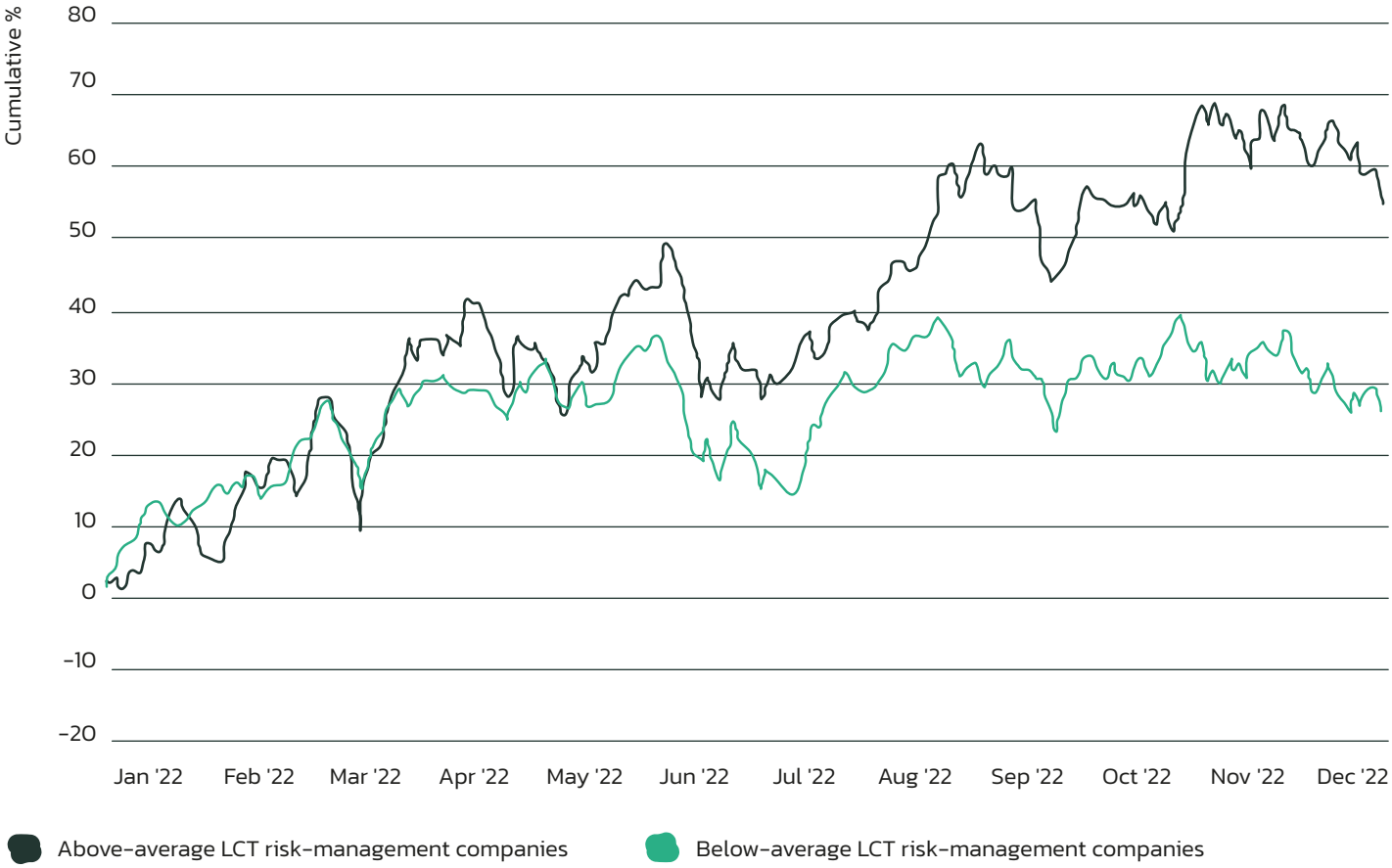
Source: MSCI, "Foundations of Climate Investing: How Equity Markets Have Priced Climate Transition Risks", Journal of Portfolio Management, 2021

The Ukraine war's impact on companies in the energy sector based on level of LCT risk-management

One particularly interesting case is the performance within the Energy sector in 2022. For the sector, the invasion of Russia in Ukraine meant a significant uptick in performance, widely regarded as a win for Oil & Gas companies. However, within the energy sector (excl. Russia), it is notable that energy companies with above-average strategies to manage a low-carbon transition performed better than their below-average counterparts.

Performance of energy-sector constituents excluding Russian energy companies[104]

Energy companies with above-average strategies to manage a low-carbon transition outperformed their peers



Source: MSCI, "Did Low-Carbon-Transition Strategies Differentiate Energy Companies?", 2023

New climate-change-relevant-events, such as regulation or catastrophic events, reinforce the outperformance of climate-aligned stocks

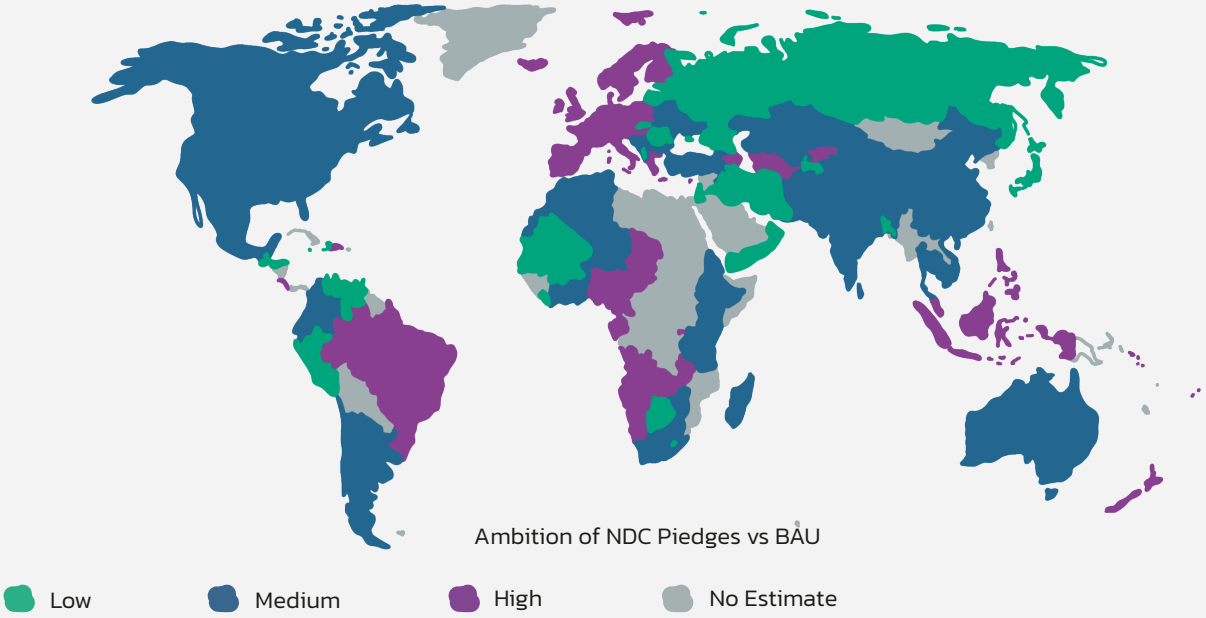
Already in the 1921 paper "Risk, Uncertainty, and Profit", University of Chicago economist Frank H. Knight explained that risk is present when the set of potential future events is known and occurs with measurable probability. Uncertainty is present when the complete set or likelihood of future events is indefinite or incalculable. While risk is predictable and can be priced efficiently in an efficient market, uncertainty cannot be priced accurately due to unknown probability distributions for future states. While climate change is portrayed as a risk in the public, it remains largely uncertain in how it relates to our resources and regulations. But the more we learn about climate change, IPCC report, with every new technology, catastrophe, and policy, climate change and its implications increasingly turn from uncertainty into a priceable risk. In fact, such economic transmission channels have been studied by MSCI[105], concluding a measurable effect of two drivers: Government policies and green technologies (the latter has been covered already in the previous section). The financial impact was observed on both earnings-per-share growth as well as cumulative stock returns, with the highest regional effect in developed markets excluding the US.

The impact of climate-related news on stock performance:

In a science-led study based on Refinitiv data[106], the authors analysed the daily returns of S&P 500 stocks, their emissions intensity, and an indicator measuring unexpected climate change concerns of same-day publications. The researchers found that, all other things being equal, green firms outperform brown firms when there are unexpected increases in climate change concerns. Furthermore, they found that the conditional exposure to shocks in climate change concerns is, for most industries, the same for firms belonging to the same industry, and apply even to firms that do not disclose their greenhouse gas emissions.

The impact of climate policies on stock performance:

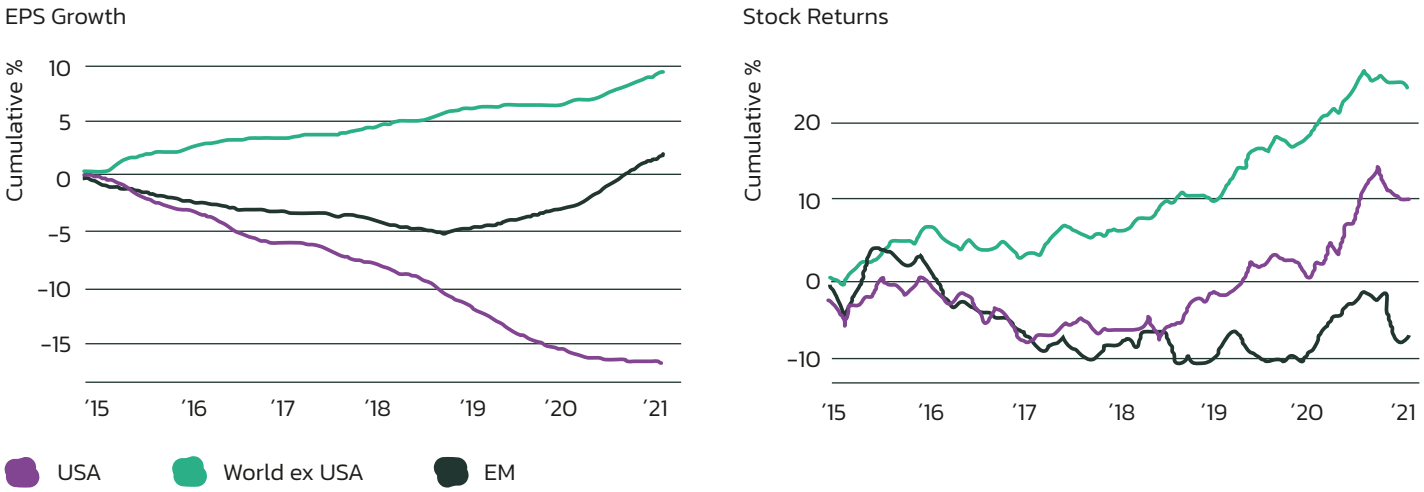
Target level of nationally determined contributions (NDCs) relative to 2030 business-as-usual (BAU) emissions per region[107]



Source: MSCI, "Foundations of Climate Investing: How Equity Markets Have Priced Climate Transition Risks", Journal of Portfolio Management, 2021

Within the above mentioned MSCI study from 2021[108], another studied transmission channel was climate policies. The above heatmap shows the current climate pledges with respect to the current emission. The key finding was on geographic exposure as a proxy for climate policy risks. Their segmentation included the US, Developed Markets without the US – Europe is roughly 75% of this group – and Emerging Markets. They found evidence of geographic exposure as a climate risk driver particularly rewarding companies with stronger carbon performance outside of the US. The study reflects the impact of President Trump's more relaxed climate policy approach, as well as Europe's leading positioning in climate ambition. In developed markets excluding the US, they found both strong earnings growth and better returns for carbon-efficient companies, as shown in the following two graphics (see graph below).

Top quintile in carbon efficiency vs bottom quintile[109]



Source: MSCI, "Foundations of Climate Investing: How Equity Markets Have Priced Climate Transition Risks", Journal of Portfolio Management, 2021

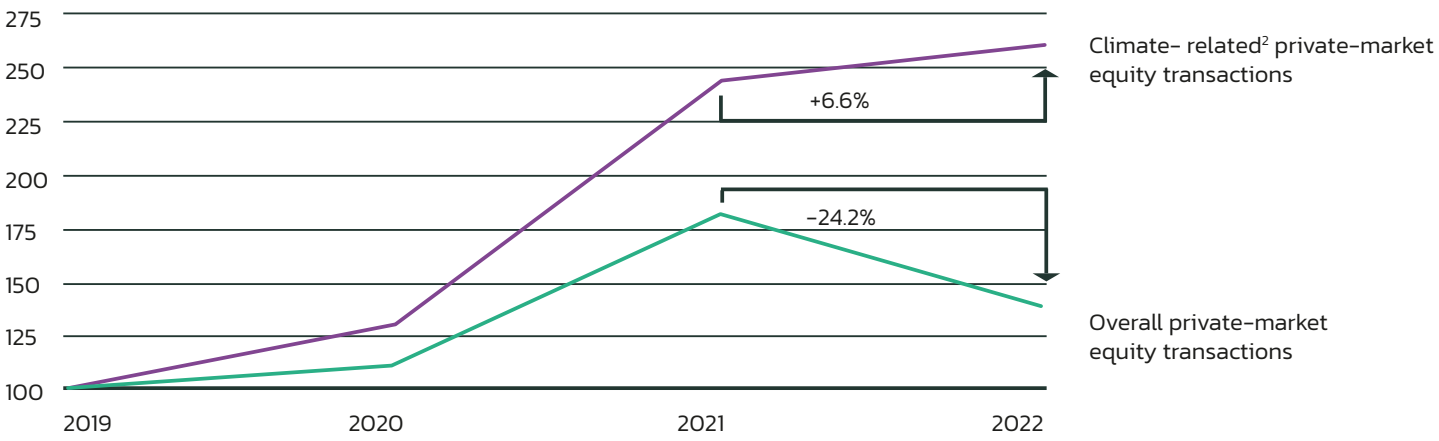
2. The private market is showing significant inflows with increasing returns

a. Within private markets equity investors are increasing allocations towards climate-aligned companies

Also within private markets, equity investors are increasingly shifting allocations to climate-aligned companies.

McKinsey analysed global Pitchbook data from private market equity investments through Venture Capital, Private Equity, infrastructure, and public grants. Overall volume in climate related deals increased more than 2.5 times, from about $75 billion in 2019 to about $196 billion in 2022[110]. For the crisis year 2022, the 6.6% growth for climate-related deals shows resilience and stands in contrast to the -24.2% decline in overall transaction volume for private equities.

Private-market equity deal volume[1,111]

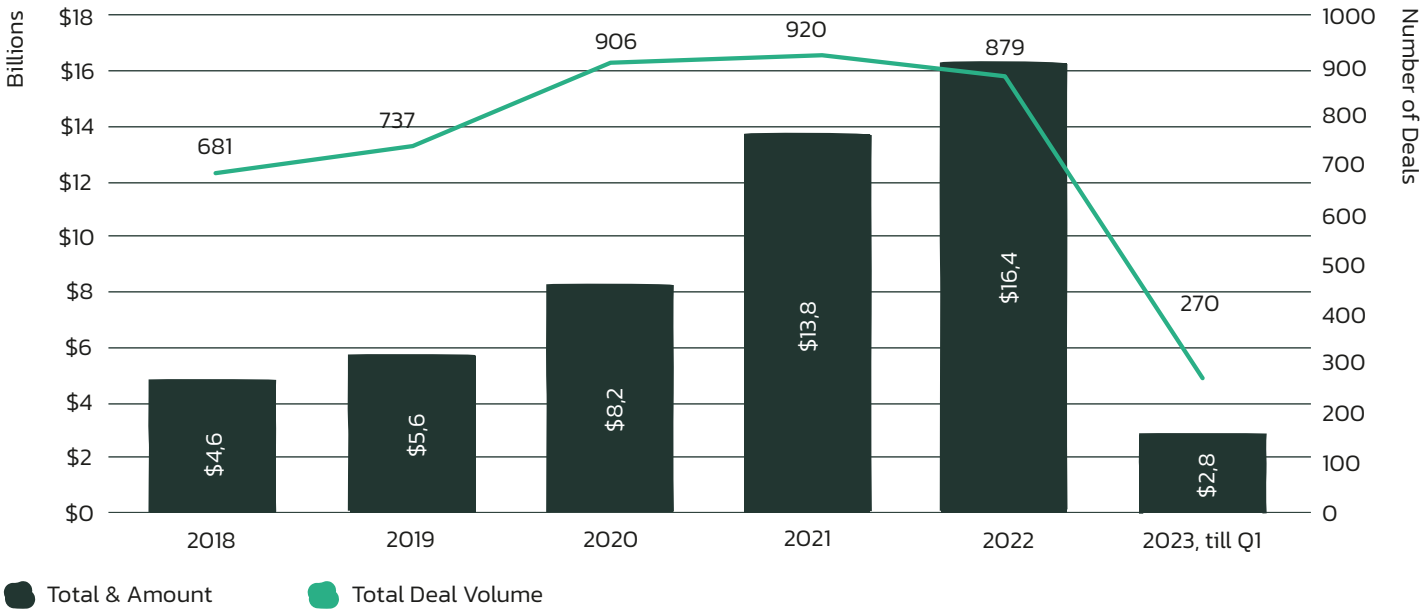


1 Includes completed buyout/leveraged buyout, growth/expansion, private investment in public equity, add-on, accelerator, angel, seed, early-stage venture capital, later-stage venture capital, grants and infrastructure investments.
2 Includes sudsegments: Transport, buildings, power, water, agriculture and land use, consumer, oil and gas decarboniration and sustainable fuels, hydrogen, waste, industrial decarbonisation, and carbon management.

Source: McKinsey, "Climate investing: Continuing breakout growth through uncertain times", 2023

In Europe we see a similar picture of growth that peaked in 2022. In this year European and Israeli climate tech companies received funding of $16.4 billion[112].

Deal amount and volume in Europe and Isreal until 2022[113]



Source: Cleantech Group, 2023

"ESG and climate concerns from LPs are probably at an all-time high. This interest is only growing in importance year after year and that is making it harder for large managers to ignore it in their underwriting of assets. The interest level has increased generally and the number of those for whom it is front of mind has increased. Looking at the future, there will be a point in time where everyone will have a concern on impact and it will simply become status quo."[114] – Erik Seebusch, Partner & Global Strategy Leader VC & Growth Equity, Mercer

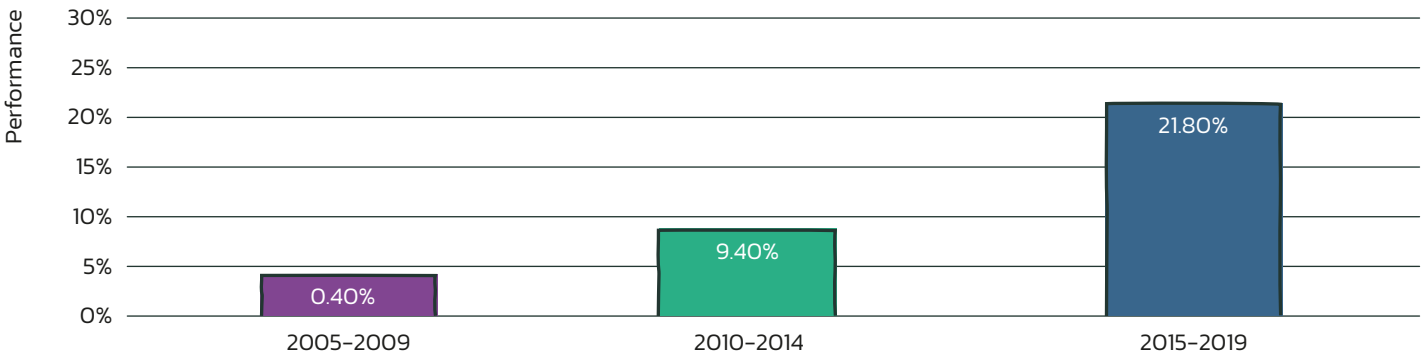
b. *Climate-aligned private market equities perform in line with the overall PE/VC universe and allow for green valuation premium*

"At Atomico, we believe that technology has a significant role to play in tackling the global climate crisis, and as such, investing in climate solutions represents an important part of our strategy. We see a significant opportunity to invest in both software and deep-tech/hardware solutions, across the B2B and B2C spectrum. We are excited by numerous aspects of climate technology, from energy, mobility and the carbon markets to supply chain, logistics and manufacturing. As many of these spaces are rapidly evolving, we are excited by founders across the space who are versatile, commercially minded, and ready for speedy expansion."[115] – Terese Hougaard, Partner at Atomico

While private market performance data is limited compared to public market data, large investment firms, such as Cambridge Associates conduct studies based on their databases. A relevant study conducted by Cambridge Associates[116] shows that climate aligned VC-and PE-backed companies delivered consistently strong performance since 2015: Investments done by VC/PE firms in the time period of 2015-2019 performed at a pooled gross IRR of 21.8% at the time of the study. This stands in clear contrast to the performance of Cleantech 1.0 investments done between 2005-2009 performing at 4% pooled gross IRR. In 2013 a strong uptick in pooled gross IRR[117] led to an overall recovery of performance in 2010-2014 to 9.4% pooled gross IRR. Performance data alludes to the new market environment (as outlined in section A) that was not yet established during the Cleantech 1.0 period.

Performance of climate tech VC/PE investments[118]

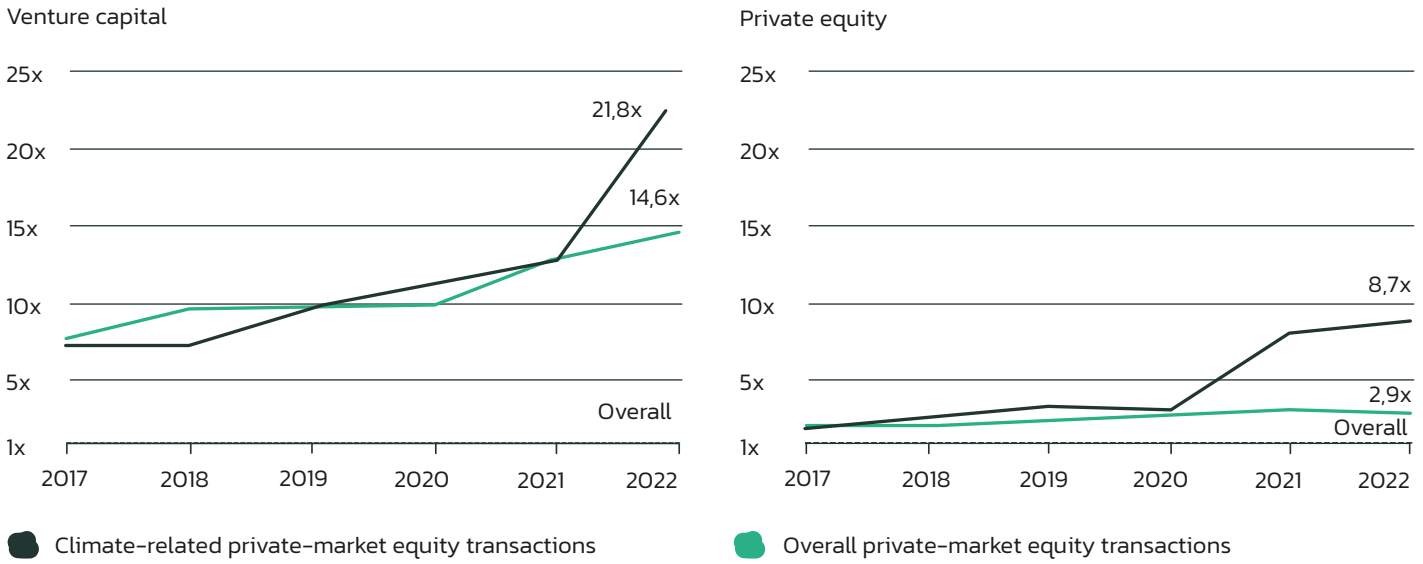
Pooled gross IRR (%) of deals in global VC/PE investments into climate tech companies



Source: Cambridge Associates, Climate Tech Company Performance Statistics, 2023

In addition to return uplifts in recent years for climate-aligned private companies, studies such as the below McKinsey analysis also imply an uptick in valuation for those assets compared to overall market transactions[119]. This green premium constitutes an additional upside potential for returns from increasing exit multiples in the upcoming years.

Median revenue multiple in private-market equity transactions[120]



Source: McKinsey, "Climate investing: Continuing breakout growth through uncertain times", 2023

3. Conclusion: Public and private investors increasingly allocate to the ESG and climate space, capturing attractive return potentials

Across public and private equities, financial stakeholders are taking action to capture the return potential of ESG and climate-aligned opportunities. The availability of public market data allows for high transparency to analyse the performance of ESG and climate-aligned funds and stocks. Research shows both a significant financial return potential as well as resilience in challenging market environments. The private market for climate investments, although less transparent, indicates not only increasing investors' interest but also a significant uptick in performance compared to the cleantech 1.0 investment period and could yield additional future return potential from increasing market interest.

C –
A Guideline for Investors:

PRINCIPLES FOR CAPTURING THE CLIMATE RETURN OPPORTUNITY

C – A GUIDELINE FOR INVESTORS:
PRINCIPLES FOR CAPTURING THE CLIMATE RETURN OPPORTUNITY

The above sections provide evidence for the hypothesis that climate alignment, and therefor climate services and solutions, provide be a promising opportunity to investors. In fact, all major banks and consultancies agree that climate technologies and solutions will become a multi-trillion euro market within this decade. Research concludes that investors can find attractive financial return potentials in the climate space.

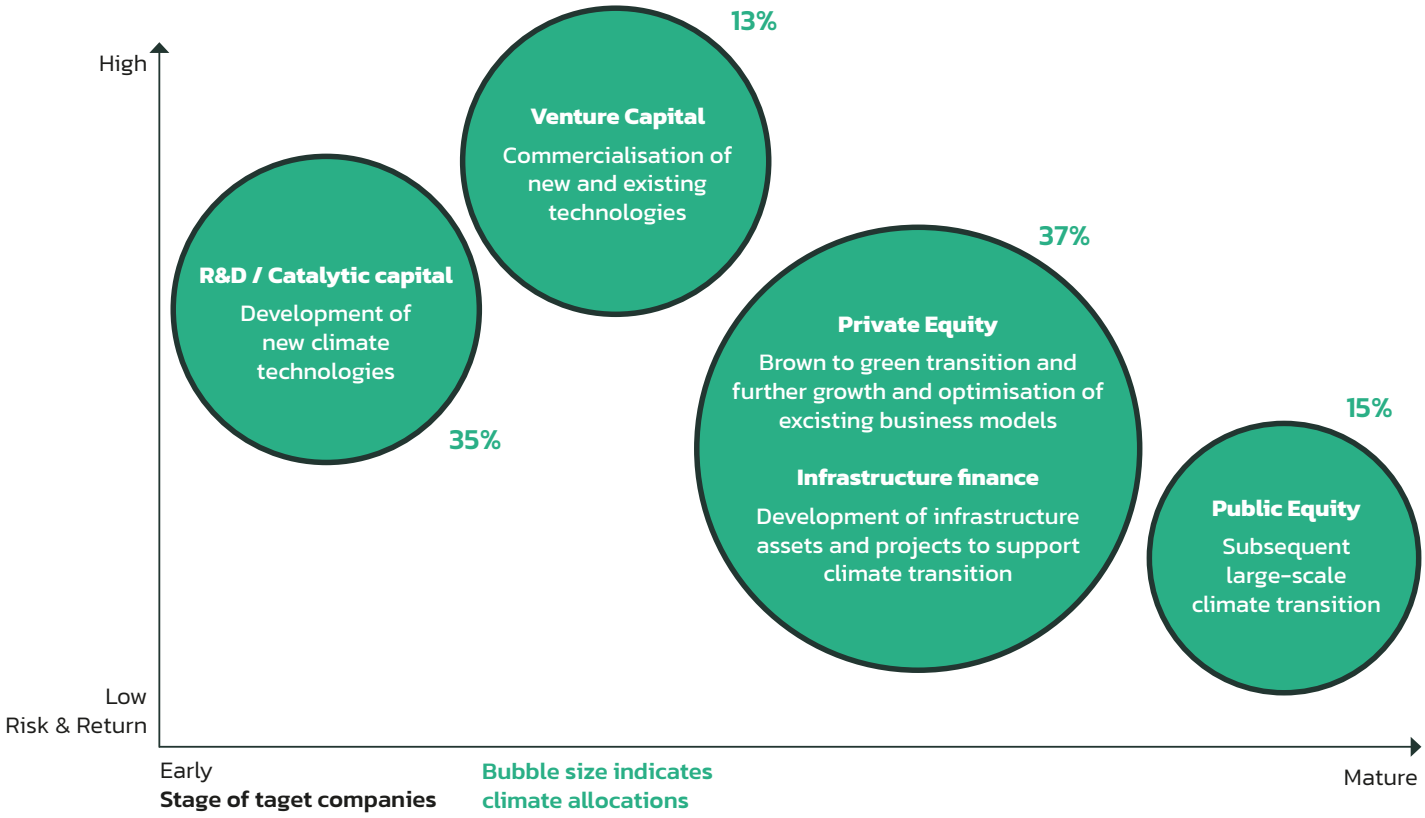
"As governments and regulatory bodies start requiring more regulation around this space and as technology advances and organisations in this market evolve, there is more opportunity for investment in all areas. As these investments mature and exit we are likely to see significant returns, but that isn't any different from any other maturing venture or PE opportunity – it's just that climate is such a substantial one."[121] *– Erik Seebusch, Partner & Global Strategy Leader VC & Growth Equity, Mercer*

The approach to capturing this climate opportunity depends on an individual investor's appetite for risk and return. In order to deliver on the ambitious targets outlined above, the climate transformation will require 1) fast paced, 2) well-directed action. This could, in return, add significant value for businesses and investors alike.

1. The roles of different asset classes in the climate transition

The full asset class stack offers an abundance of climate opportunities for investors. While differences in risk and return profiles are well known to the experienced investor, the role of different asset

Overview of different asset classes and their role in climate transition[122]



Source: World Fund based on research of this paper, 2023.

classes in financing and profiting from the climate transition are worth exploring in order to develop a broader thesis.

The first question concerns the type of businesses required to enable the climate transition. We need to finance existing climate solutions to allow them to scale their positive impact. In addition to existing solutions, plenty of complex climate problems need to be solved by technologies that still need to be developed.

One of the key differences between asset classes lies in the degree of novelty of the climate solutions that they fund. Hence, an investment strategy can favour to capture value from solving climate alignment problems that are unsolved otherwise (often called a high "additionality" of a solution) or to capture value from scaling up an existing and proven solution with lower risk and faster (yet potentially lower) returns.

The following subsections will explore the relevant asset classes and their current states and roles as they relate to the climate transition, in increasing order of tech maturity that they tend to finance.

a. R&D and Catalytic Capital

Profile: Very high risk • Lower return expectations • Long term return horizon

Role in climate transition: To achieve the transformation of Europe's domestic industry and support its green transition, 29% of reduced emissions need to come from new technologies — i.e. technologies that are yet to be developed — by 2030 and 50% of reduced emissions by 2050[123]. Such technologies need to be widely researched and first developed at lab-scale before any commercially viable use case can emerge and scale.

Current funding status: Since 2014, the EU spent >€58 billion in climate tech R&D from the Horizon 2020 pilot program. This initiative will be extended by Horizon Europe with over 35% of its €95.5 billion budget going into climate R&D from 2021 until 2027[124]. This is topped by €100 billion per annum from national R&D budgets. Overall, this asset class has been primarily driven by public players, whereas equity-based catalytic capital investors are minor[125] (corporate R&D budgets were not included in these numbers).

Globally, this brings the EU to a leading position in terms of R&D capital deployment and therewith technological foundations on which to build businesses. However, to avoid losing this leading tech position, we need to ensure relevant follow-on funding to de-risk and scale those technologies.

Return outlook: Given the less attractive profile for primarily returns-driven investors, this asset class is predominantly driven by not purely financially-driven investors like governments, philanthropists, academic institutions, and corporate innovation.

b. Venture Capital

"The climate tech sector saw record levels of investment last year despite the macroeconomic and geopolitical headwinds which adversely affected levels of investment in the tech sector more generally. Estimates suggest that climate tech funding represented more than a quarter of every venture dollar invested in 2022. We've seen this trend continue into 2023, with the number of climate tech deals increasing in Q1, driven, in particular, by an increase in early-stage investments. We expect the climate tech sector to receive increasing attention as net zero efforts continue to ramp up in the years ahead."[126] *– Howard Palmer, Partner at Taylor Wessing*

Profile: Very high risk • High return expectations • Mid term return horizon

Role in climate transition: Supporting the fast technological and commercial de-risking of innovative climate tech solutions.

Deep dive: VC's role in the wider economy

As seen in section A, there is an urgency for action that the climate reality and therewith policy will mandate on our economy. This action will not only come from existing players but requires new technologies to step in. It is therefore worth looking deeper into the role of venture capital in financing this market opportunity.

There is accumulating evidence that fast-paced and tech-driven transitions are particularly driven by ventures. For instance, the latest transformative disruption of the internet industry entirely changed our world as we know it and was primarily venture-driven. Four out of the ten most valuable companies of our global economy are venture-backed and emerged from this transformation. Further, venture-backed companies have a market capitalization of 77% in software- and computer-related services, and 67% in electronics and computer manufacturing[127].

"Startups must become the drivers of transformation; otherwise, it will not happen fast enough."[128] *– Andreas Kuhlmann, Head of the German Energy Agency (dena)*

Hence, in an environment of fast change, incumbent companies are not the driving forces of change but rather face the risk of disruption. This is often called the "Innovator's dilemma" coined by the Harvard Professor Clayton Christensen. He introduces the theory that incumbent companies are often unwilling or unable to pursue disruptive innovations that may cannibalise their existing business models. This is because they are more focused on maximising short-term profits – especially when listed at public markets – and serving existing customers and investors than on investing in new or unproven technologies or business models.

This has played out drastically, and companies that were once category-defining leaders were wiped out by ventures with new technology or competitors that worked with these ventures. Examples include Kodak, Blockbuster or Nokia.

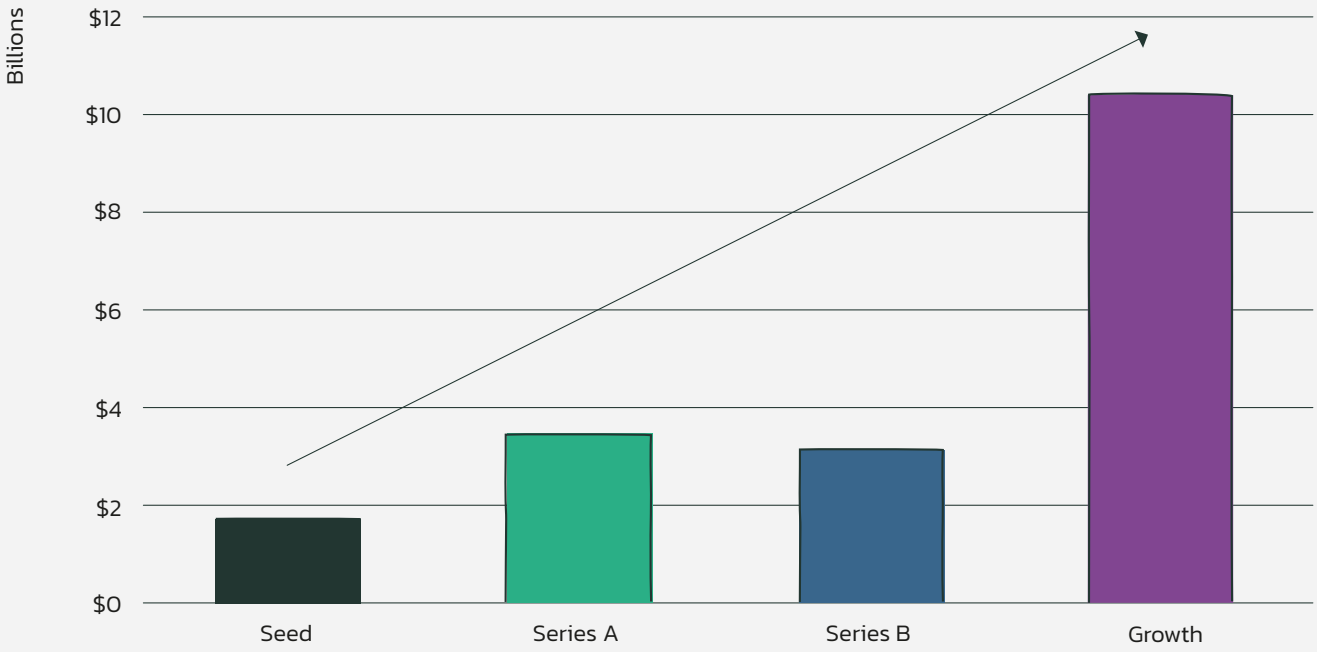
This disruption theory is also applicable to the climate transition, as it can provide insights into the ways in which innovative startups and new technologies are disrupting traditional fossil fuel-based industries. A well-known example is the speed-up of the shift towards electric vehicles driven by Tesla that increasingly put pressure on incumbent car manufacturers to follow. Companies that fail to adapt to these changes may be vulnerable to disruption by more climate-resilient competitors, highlighting the importance of proactive adaptation to the physical risks of climate change (as indicated by the studies in section B).

Current funding status: Capital allocation and deal activity in European climate tech VC has been rising in recent years and has been resilient during crisis compared to generalist VC funding (as established in section B). However, climate tech still only represents 13% of total VC funding, despite median round sizes being larger than that of general tech[129].

Deep dive: Understanding the gap within the gap - Series B funding gap

At first glance, European climate venture funding directly reveals a significant gap at the Series B stage:

European climate tech startup funding by stage, 2022[131]

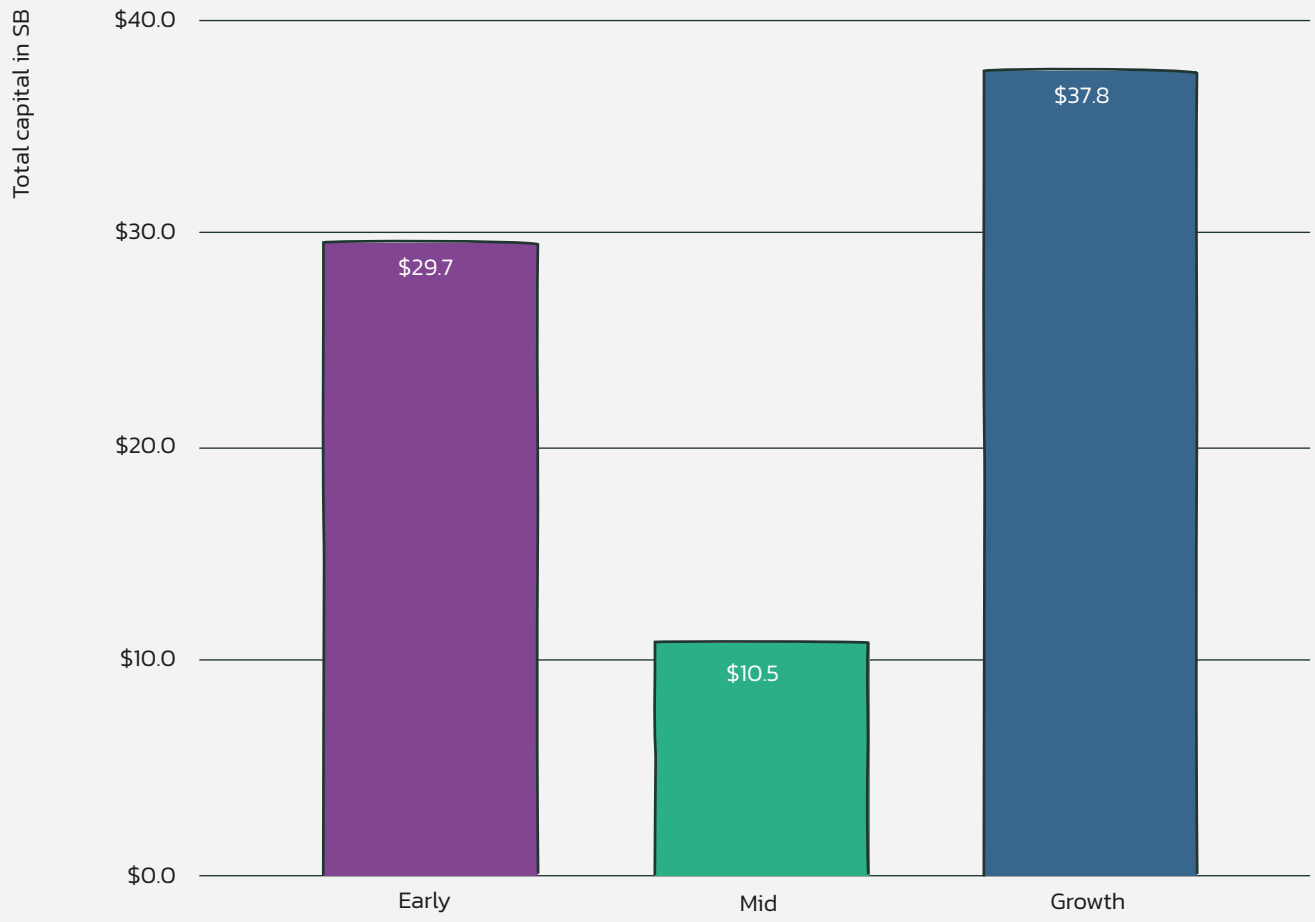


Source: Cleantech Group, 2023

With increased dry powder in early-stage climate tech funding, companies can raise Seed and Series A capital to prove their business. For software or capital-light companies, this will be enough to prove customer traction and subsequently raise from a large pool of generalist capital (see section B). However, given the physical nature of the climate alignment challenge, a large portion of companies and value creation will require a hardware approach. In fact, research from IDC suggests that in the next 5 years, 60% of revenues in the tech category will be generated by hardware[132], and most think tanks agree that 30-60% of solutions to the climate transition will need to come from novel technologies. Evidently, climate tech startups are more than twice as likely to have a significant hardware component compared to the typical startup[133].

While hardware and deep tech companies can leverage early-stage funding to prove a novel technology at a prototype scale or find early pilot customers for exploratory purchases, they unavoidably hit larger capital barriers when trying to prove commercial success. Namely, they need to finance a pilot plant on the way to reaching a first-of-a-kind (FOAK) plant. Based on calculations from Deanna Zhang, over 18,000 startups[134] would need FOAK type financing. Aggregating conversion rates based on sector benchmarks, over 1,900 will reach the FOAK stage, implying a $150-190 billion funding need for pilot and FOAK plants in climate tech. This stand in stark contrast to the new funds that were raised between 2021-2022, as analysed by CTVC:

Climate funds raised in 2021 and 2022[135]



Source: CTVC, "New dry powder for a new climate", 2022; data compiled by USV, "Building Out the Climate Capital Stack", 2023

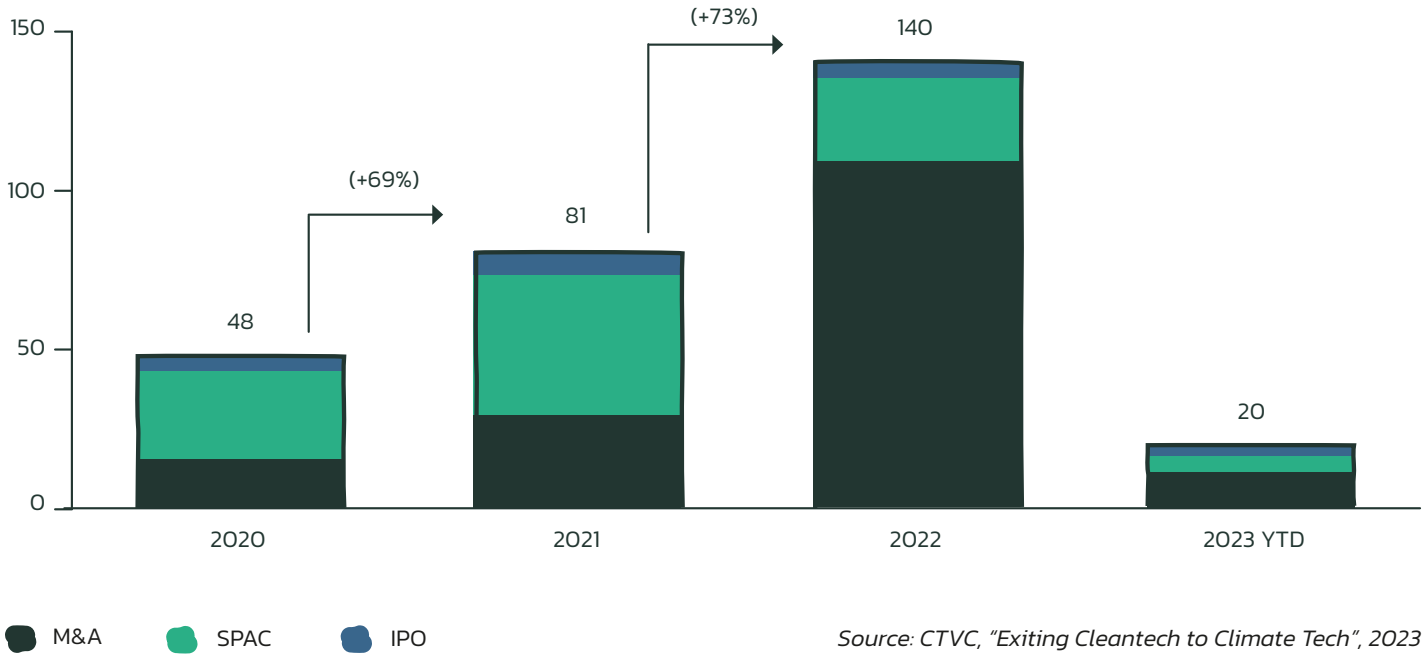
While Series B investors that exist are often not dedicated enough to (hardware) climate tech, infrastructure funds can't afford to take such risks in their well-established fund models despite having trillions in assets under management (see next subsection). A fund targeting this gap would need to combine a dedicated fund strategy and an experienced management who understands the unique challenges and opportunities of such novel infrastructure investments and plant building. It should also prioritise projects that have the potential for significant impact as both an impact and financial driver. Additional features of such funds could be a strong foundation of resources and support, including mentorship, funding, and access to specialised equipment and facilities, as well as strong ties to equity-free public financing:

To bridge the European scale-up gap, the European Tech Champions Initiative was launched in 2023, allocating an initial €3.75 billion to finance the commercialisation of high-tech startups. The goal is to keep innovations in Europe to "reinforce its strategic autonomy and competitiveness"[136]. To achieve this, the EU has committed to mobilise at least €1 trillion in public and private investments until 2030[137]. More than half the funds will be directly sourced from the EU budget and the EU Emissions Trading system. The remainder will be obtained through the InvestEU program, which aims to encourage private investments in higher-risk projects through an EU budget guarantee and national co-financing[138].

Return outlook: VC is an illiquid asset class and fund lifetimes are anchored at 10+ years. Typical return expectations are 12–20% IRR or higher[139]. The primary source for realising returns are IPOs and acquisitions by financial sponsors or strategic investors.

Research from CTVC shows that climate tech exits have increased 70% p.a. in the last two years, yielding 289 exits since 2020. At 57% of all activities, the primary source of exits were acquisitions. 105 acquisitions were through corporate buyers. Among the most active buyers were Shell, Schneider Electric, and Blackrock. In line with sections A and B, acquisition appetite of corporates is likely to increase[140].

Count of climate tech exits across M&A, SPAC, and IPO since 2020[141]



Source: CTVC, "Exiting Cleantech to Climate Tech", 2023

c. PE & Infrastructure

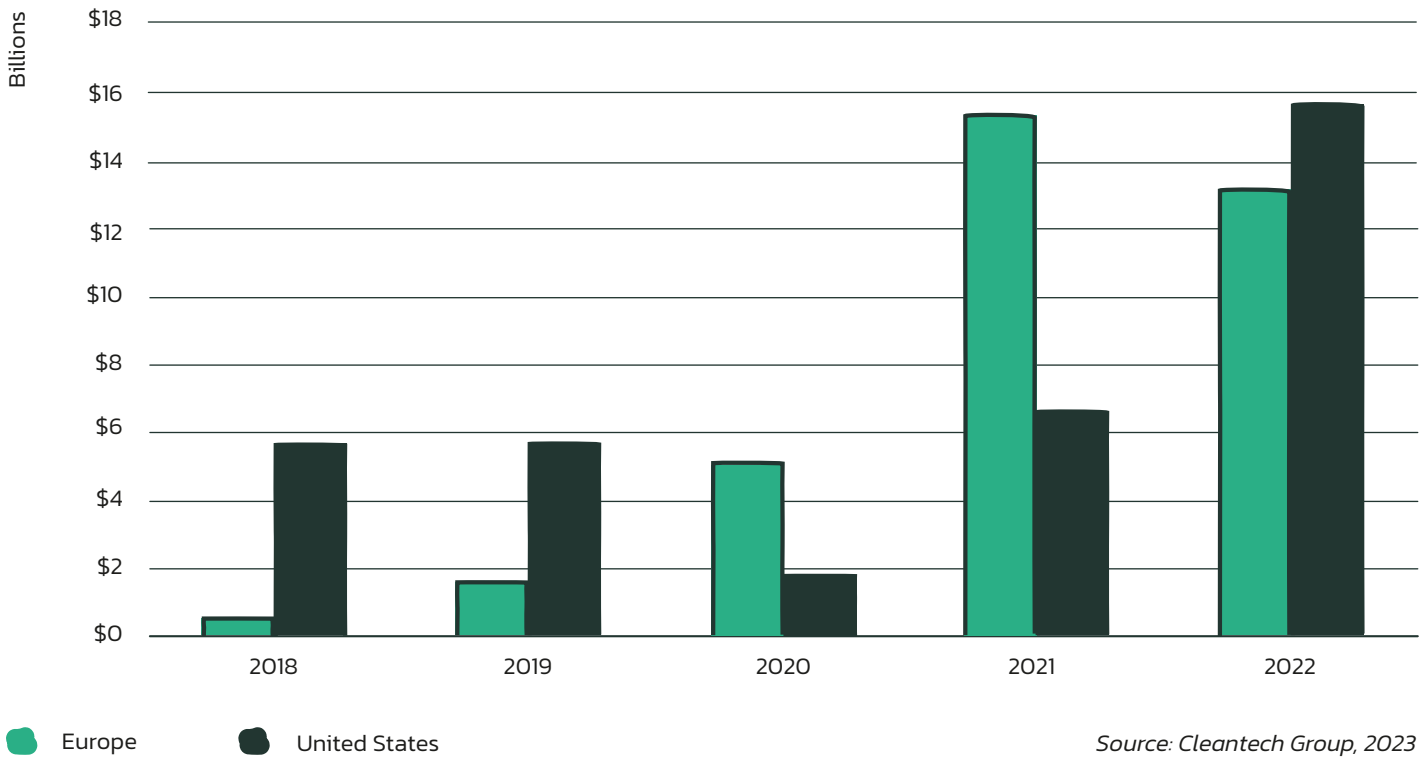
Profile: Medium risk • Solid return expectations • Long term return horizon

Role in climate transition: Financing more mature companies or projects that have a clear path to commercial-scale production and adoption. Both asset classes can also be used to support the transition of large corporations from brown to green, which will have a significant positive climate impact.

In Europe, the EU GDIP discussed in section A means a particularly large opportunity for this asset class.

Current funding status: PE & Infrastructure allocations to climate tech targets have increased sharply in 2022 in both Europe and US. There is a lot of capital to deploy into targets that proved their economic viability, with the top 100 infrastructure funds raising $1 trillion between 2017–2022[142]. While most are not climate-dedicated, the last years produced a few large funds entirely dedicated to scaling climate solutions, such as Brookfield's $15 billion fund[143], TPG's most recent $7.3 billion fund[144], General Atlantic's $3.5 billion fund[145] or Summa's $2.6 billion fund[146]. Within the asset class, out of a sample of 81 GPs, a study of the Dutch pension PGGP fund found that 37% have now achieved a "very high" ESG score only possible with climate-aligned investments[147]. Overall, deployments and dry powder remain only a fraction of the infrastructure funding gap discussed in section A.

Climate Tech Buyout & Infra Transaction Volume[148]



Source: Cleantech Group, 2023

"We don't have the data yet to correlate performance neatly, for several key reasons. There are different approaches in the market, whether on impact, carbon neutral, ESG, and so on – there isn't a standard yet. Secondly, while lots of entrepreneurs want to do good for humanity and the world, their companies still need some time to grow, evolve and PE needs to exit, so the data is a tad young for that to have happened.

In general, we see more flows for impact for PE rather than on VC, and looking at the impact capital flows, we see more flows for Infrastructure and Private Equity.[149] *– Erik Seebusch, Partner & Global Strategy Leader VC & Growth Equity, Mercer*

Return outlook: Infrastructure and private equity returns typically range between 10–20% IRR, whereas infrastructure investments have a slightly lower risk-return profile given the nature of investments relying on long-term performance drivers, such as PPAs for utilities[150]. In recent years, valuations have shown a premium for climate-related investments both for Venture Capital and Private Equity transactions[151] as mentioned above. These premiums indicate increasing investor interest in the space and could yield more attractive upsides for companies at exits.

d. Public Equities in Europe

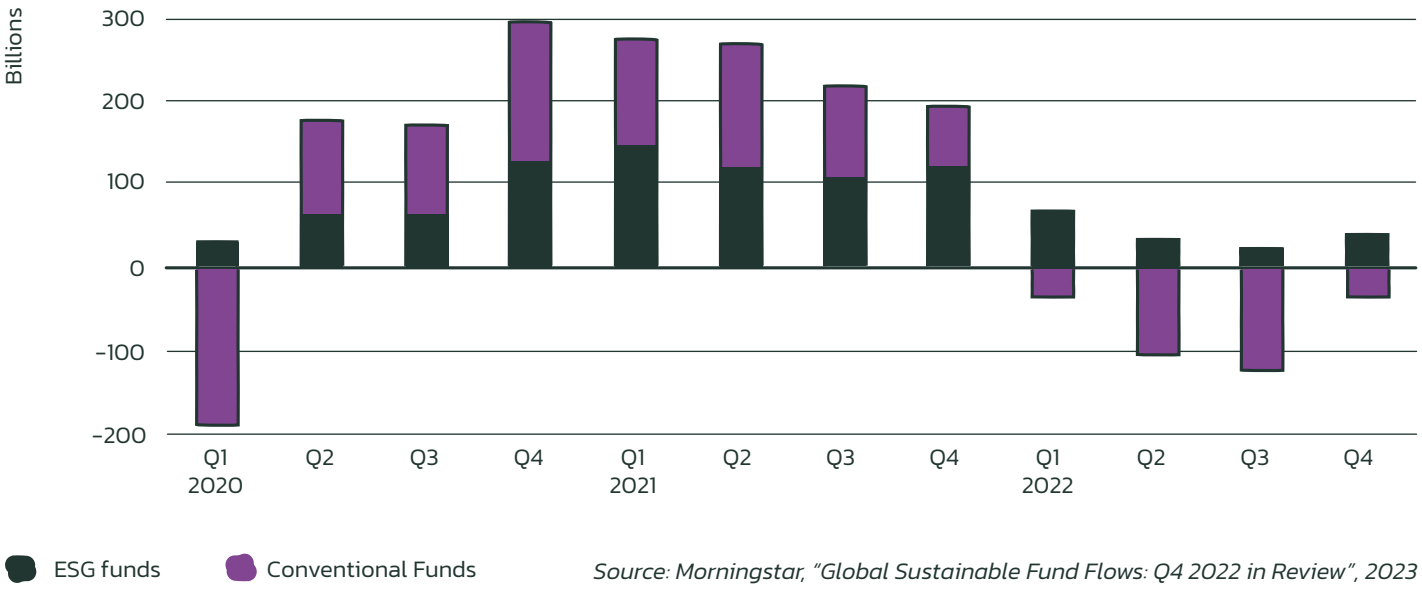
Profile: Low to medium risk • Solid return expectations • Short to medium term return horizon

Role in climate transition: Existing public companies will need to transition towards climate alignment primarily by means of R&D, M&A, and procurement of climate services. This role is in fact a primary engine of the climate opportunity, given that the capitalization of this asset class is over 130% of global GDP[152] and is responsible for 23 Gt of GHG emissions[153] per annum.

Current funding status: Investor appetite for ESG (as a proxy for climate) has been very strong in recent years, with a doubling from 2021 to 2022 and clear leadership in Europe, as section B showed. However, the demand for high-quality – defined by stricter ESG performance requirements – ESG public equity funds is not yet met, see section B.

Due to market uncertainty resulting from the Ukraine invasion, global investment funds saw a sharp outflow of assets. However, in the second half of 2022, while non-ESG funds faced net outflows of $158 billion, ESG funds added $63 billion. These funds even increased their inflow vs the previous quarter in Q4 2022, showing how strong the demand for ESG is amongst investors even in a crisis situation[154].

ESG fund flows vs conventional fund flows[155]



Source: Morningstar, "Global Sustainable Fund Flows: Q4 2022 in Review", 2023

Return outlook: Because ESG funds often allocate a higher concentration to volatile technology stocks, they often exhibit a higher beta to the market, meaning their returns are also more volatile compared to funds covering the whole economy. As seen in section B2, ESG funds outperformed their non-ESG peers in bullish years but underperformed in bearish years. In general, however, the diversification through many holdings and the maturity of the companies in the fund mean that risk is greatly reduced compared to earlier-stage investments.

e. Summary

The above asset classes cater to the different risk-return appetites of investors. While early R&D investments have a significant impact, they only yield low returns. VC offers a significant opportunity to fund and scale new solutions at high risk-return profiles. Private equity, infrastructure, and public equity investments will yield a (slightly) lower risk-return profile and contribute their climate impact in supporting the "brown to green" transition and in establishing the infrastructure that new solutions will need to scale.

2. The role of science to support allocation decisions towards climate alignment

Within a given asset class, there is still a manifold of climate-related opportunities that have sprung up over the last few years. Hence, careful selection is key.

In contrast to other investment themes, climate requires additional assessment tools. On top of typical economic and asset-specific criteria, an investor interested in deploying capital in the climate transition needs to develop a solid understanding of the underlying climate science of a proposed target as outlined in the following subsections.

a. Develop and manage investment target areas

Climate alignment of a sector is not only a physical challenge – best understood by science – but also a regulatory risk as targets, penalties and incentives will increasingly follow the scientific lead, as established in section A. In addition, non-financial reporting infrastructure is becoming increasingly aligned to reflect the scientific mechanisms of a company's environmental footprint or climate performance. This means that on the one hand, additionally to the cost of purchasing a product, an environmental cost will also be reported and paid. On the other hand, a positive climate outperformance can entail attractive opportunities both for the company and its investors (see section B).

As a result, looking at the science, in particular at reports such as from the IPCC, allows us to understand Climate Performance Potential of transforming sectors and subsectors at risk. With this, they hint towards future attention of governments, corporates and other players that will create an attractive high risk-return playing field for investors. Different sectors come with different challenges that will require different lenses, e.g. the industrial sector will have alignment issues when it comes to energy and water use, ecotoxicity, and waste, whereas the agricultural sector needs to tackle soil depletion and harvests that are at risk due to droughts. The larger the challenge, the more urgent it will become over time, the larger the potential risk-return reward for solutions.

b. Identify promising technologies and climate alignment pathways

Within a certain target sector, depending on the physical challenges of the vertical, focusing the scientific lens on a subset of climate performance KPIs of a business model or technology will become a crucial part of an investor's thesis and their investment process. Such KPIs need to take into account a variety of drivers. These include sectoral and environmental challenges, and regulatory targets for that sector.
For instance, when defining KPIs for the agricultural industry, one should consider biodiversity and soil management indicators, such as nutrient availability, workability, oxygen availability to roots, nutrient retention capacity, toxicity, salinity, and rooting conditions. Other factors could be land stewardship and community involvement dimensions, in line with a regenerative future. A comprehensive set of scientific KPIs allows an investor to identify opportunities that go beyond short-term traction but will receive tailwinds from primary challenges in making agriculture climate-aligned, consistent with increasing regulations from the Common Agricultural Policy, and most importantly resilient to future climate impacts.

But setting the right climate performance KPIs is only the first step. This needs to be tied back into the sector level by building a more holistic thesis of the transformation of a sector, the interactions of different technologies, and the total market transformation potential in order to assess the Climate Performance Potential of technologies for different industries. Note that these are usual investment considerations in economic terms. However, translating these into climate performance is crucial to capture the value of the climate opportunity. As opposed to a more economic analysis, the instruments to assess these climate performance mechanics should be found by the scientific method. Building competence to organise and interpret scientific data will become a core characteristic for dedicated climate tech investors.

For instance, take the widely discussed Hydrogen opportunity in the transport sector. Looking through a climate lens yields a clear hypothesis: While hydrogen is a promising energy carrier, for a wide range of applications it is not the most efficient solution. Hydrogen fuel cells have significantly lower end-to-end efficiency compared to battery-powered alternatives, which means that more energy input is required to produce the same output[156]. This comes ultimately on top of a wider range of scientific and economic limitations of current hydrogen supply chains, from green hydrogen availability to practical storage and transportation options to

current scalability[157]. These limitations of the Climate Performance Potential of hydrogen will ultimately translate into limitations of its economic performance potential, as additional energy losses and transportation challenges result in significant costs compared to alternatives.

As mentioned above, a crucial theme in assessing the economic potential of a climate technology is understanding its technical feasibility and defensibility. Overall, the harder the scientific challenge of solving an important climate problem, the more valuable a potential solution. This logic is the basis upon which emerging deep tech has built their thesis, as outlined e.g. by MIT (2022)[158] or BCG (2021)[159]. However, if the problem becomes too hard to solve or technologies to solve the problem have not yet been developed, it is important to factor such barriers into the theory of change for the transformation of that sector.

c. Manage and mitigate investment risks

Lastly, it is important to mention that focusing on few or even just on one climate dimension can come at the expense of others. One example that has reached a wider public discussion is tree planting: While trees can be an excellent climate solution on many dimensions from emissions to biodiversity to social co-benefits, if done wrong, they can do more harm than good[160]. Going back to the hydrogen example, the European Commission has proposed to produce 10 million tonnes of renewable hydrogen by 2030[161] and estimates that around 500-550 TWh of renewable electricity is needed to meet that ambition. This corresponds to 14% of total EU electricity consumption[162] and thus poses a significant extra pressure to transition the European energy mix towards renewable electricity, which may lead to the extension of the usage of fossil fuels for other uses of energy. All of this brings us into ESG territory: Risks and negative environmental impacts of a technology or business model need to be factored in to avoid short-sighted investments.

Deep dive: World Fund's CPP methodology – a scientific tool to assess a technology's climate and economic potential

The European climate tech VC World Fund has developed a methodology to assess and manage climate performance by combining

a. The quantification of the emissions reduction potential
b. A qualitative assessment of other climate performance metrics and
c. A consistent theory of change and comparative assessment

a. The quantification of emissions reduction potential

For World Fund, the primary quantified climate performance indicator is the emissions reduction potential. In line with the IPCC (see section A), World Fund views emissions as a key proxy for climate change mitigation. As a result, World Fund's thesis – in line with the IPCC findings – is that emissions are one of the key metrics that will be targeted by future government regulation and companies to tackle the climate crisis and to create value for the environment, humanity, and increasingly also the economy. For this reason, indicators quantifying emissions have the most abundant and high-quality scientific data. Focusing on emissions reduction therefore allows an investor to rely on an extensive body of existing scientific literature and expect a higher validity of the assessment compared to less prominent or less quantitative assessment criteria.

Translating this into the context of (new) climate technologies:

b. Starting Point: A bottom-up carbon performance assessment

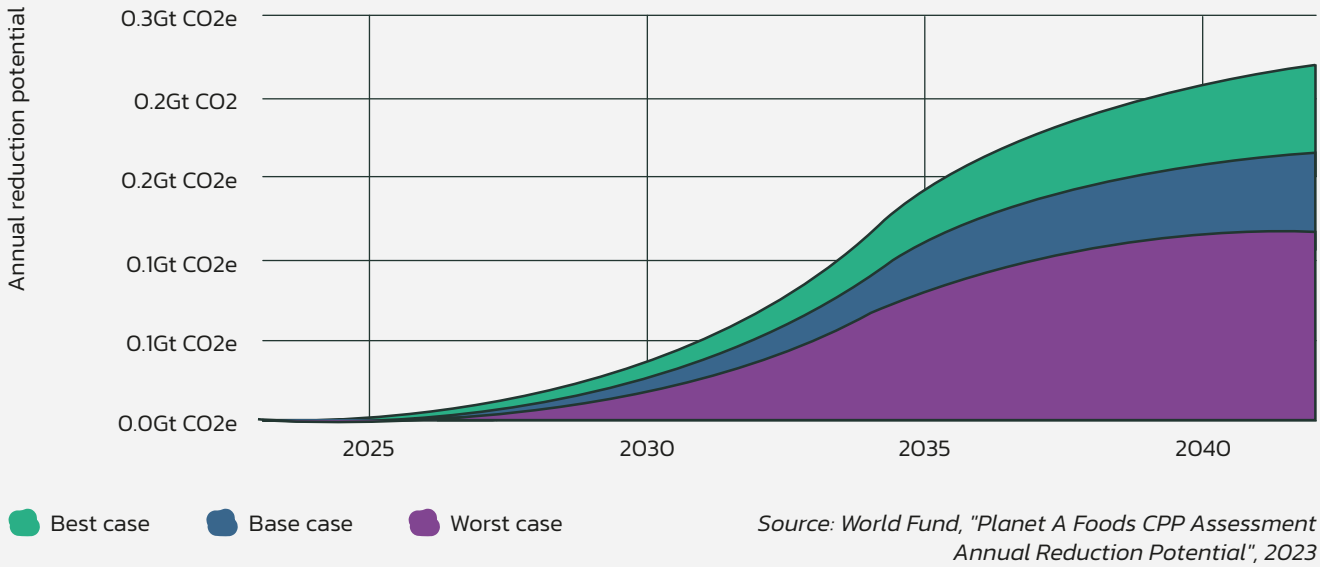
The carbon performance of a technology solution itself is first assessed bottom-up. This means that a functional unit of the solution needs to be determined in order to then calculate its unit impact. The impact per unit is calculated as the sum of emissions displaced or added per unit deployed in comparison to each unit deployed by the incumbent technology. The evidence for the existence of this impact on the industry, as well as the quantification of it, is typically sourced from scientific literature or databases in combination with proprietary data of the company providing the climate technology. Once the unit impact is calculated, the operational forecast of the company providing the technology can be used to generate a glimpse into the short-term emissions reduction potential of the company. The result is often called planned impact (see Project Frame Glossary[163]). This can then be compared to other companies that are addressing the same or similar markets to see the real additionality of the solution.

However, company forecasts tend to be of lower validity, particularly the earlier the company stage or the further into the future it projects. A long-term horizon helps to shift the scope from the short-term opportunity to the big picture – the overall total addressable emissions potential of a technology. This is in line with the traditional venture capital approach of making winner-takes-all bets in disruptive market opportunities. This introduces the role of the top-down approach in quantification.

c. Second Layer: A top-down impact potential assessment

In order to develop an informed quantification for the emissions reduction potential, World Fund turns to a top-down assessment. The top-down impact potential combines three additional time- and market-based elements. First, the unit-based impact becomes a function of time and needs to be projected into the future, factoring in externalities such as changes in electricity grid emissions intensity. Second, the yearly incumbent, or business-as-usual, market emissions need to be quantified and projected into the future. Third, the expected technology penetration curve will be modelled as follows: All major innovative technologies have been shown to approximate an S-curve by technology diffusion theory. Such an S-curve can be parametrized by a few basic assumptions on the market.

Climate Performance Potential in projected yearly emissions reductions[164]



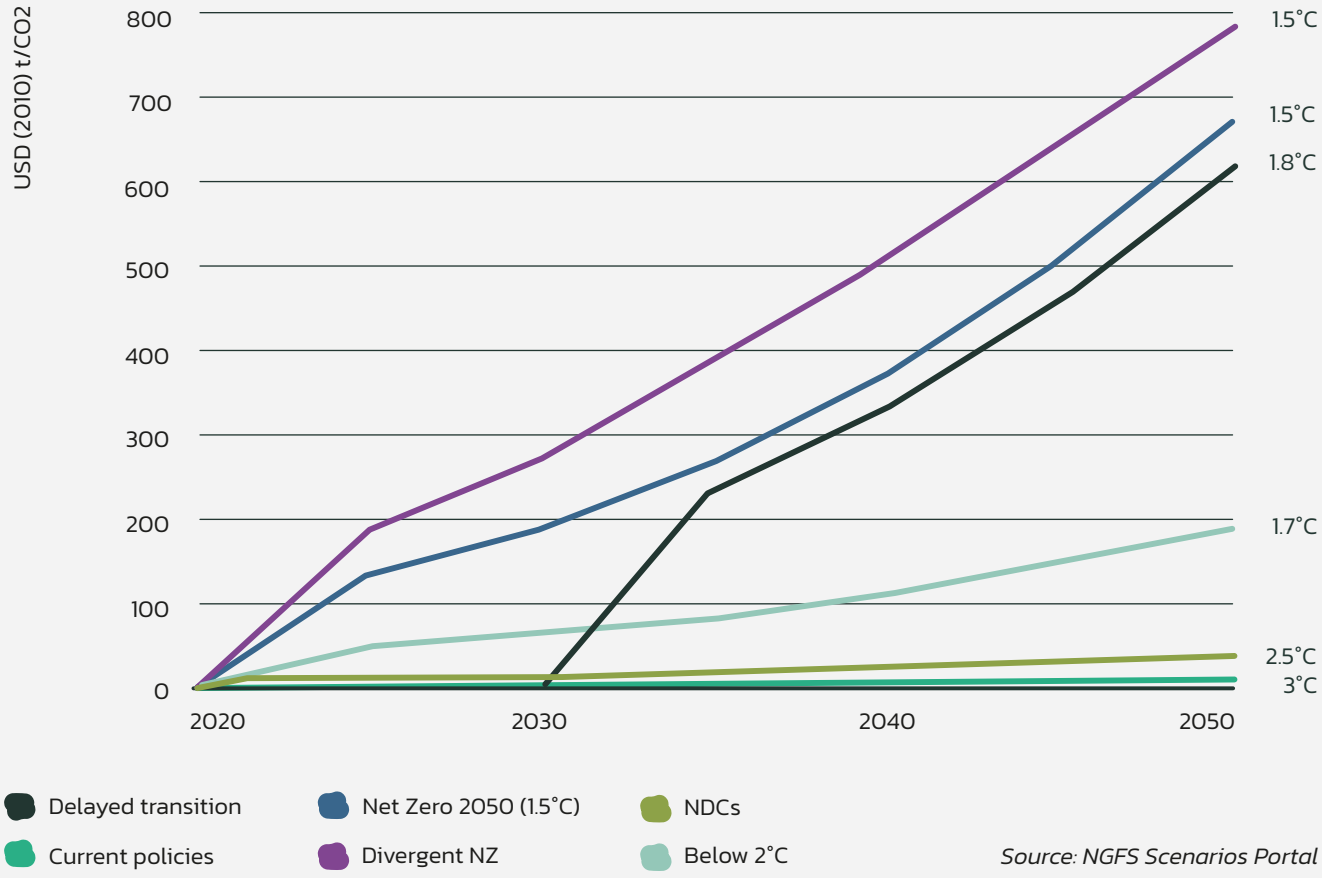
Source: World Fund, "Planet A Foods CPP Assessment Annual Reduction Potential", 2023

d. Translating emission reduction potential into financial value

After using the unit-based carbon performance in a top-down projection as described in the previous subsections, it allows an investor to leverage the benefits of working with quantified emissions. They can be used to translate scientific findings into economic value. CO2e emissions pricing has not just been a financial value of climate implemented in various geographies, but also a well discussed policy instrument to effectively tackle the climate transition (some of the empirical evidence is outlined in this article arguing for a carbon price[165]). Hence, by looking at CO2e emissions, a link could be established between the Climate Performance Potential and the financial opportunity. Different institutions estimate a variety of carbon price projections. Arguably one of the most influential financial think tanks, the Network of Central Banks and Supervisors for Greening the Financial System, that includes 91 central banks, modelled carbon price projections for different scenarios.

It is clear that only the catastrophic hot house scenarios would prevail with a carbon price of

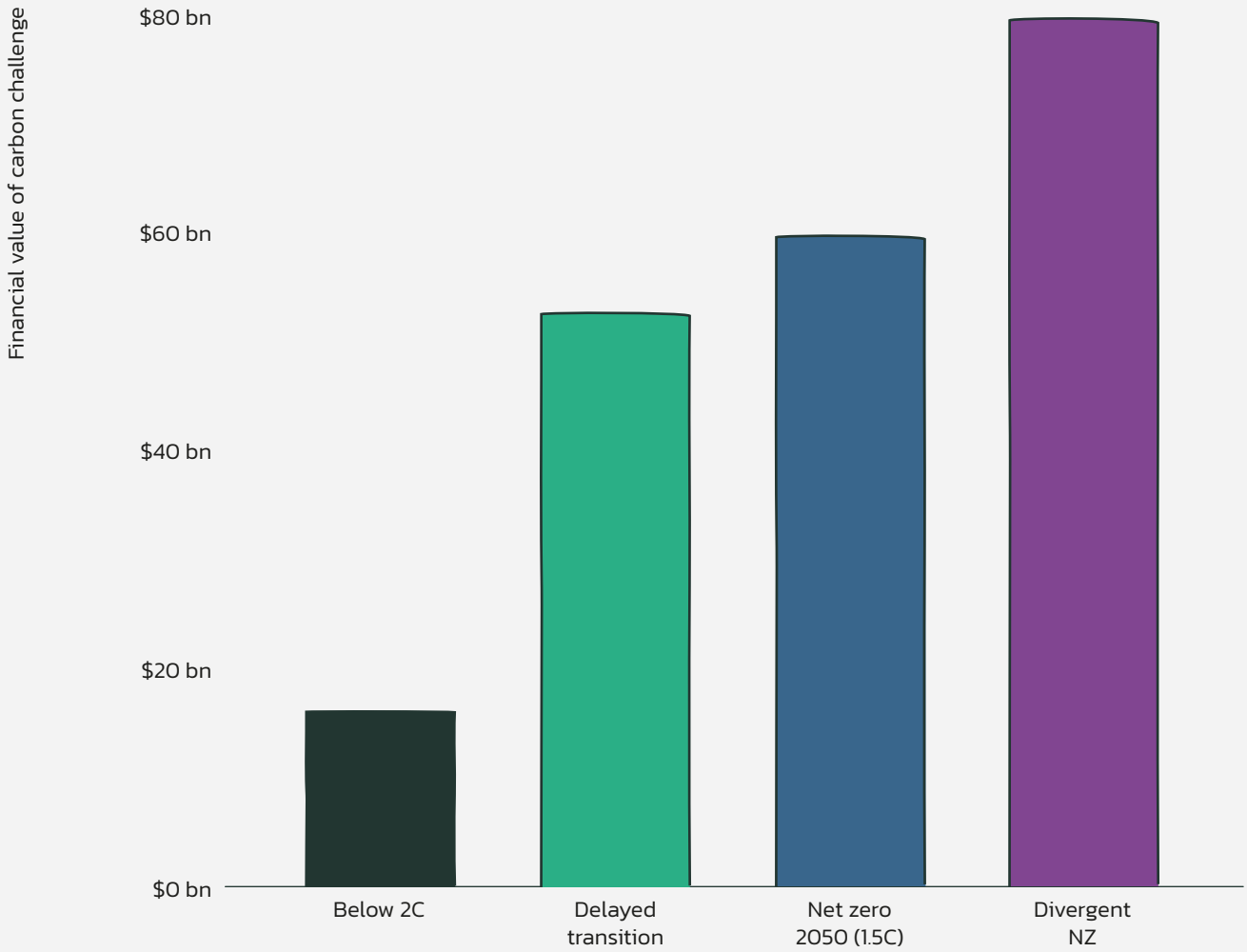
Carbon price development in different scenarios[166]



Source: NGFS Scenarios Portal

<$100 per t CO2e. In the scenarios of fast, precise climate action that will allow us to remain in control of our climate as established in section A, the price for a ton of carbon is estimated to be at roughly $330, $375, and $500. In the case of the above graphic 'Carbon price development in different scenarios', a solution that we have already assessed with a Climate Performance Potential of 160 Mt CO2e emissions could result in a financial value of $16-80 billion, as displayed in the following figure:

Financial opportunity for a 160Mt CO2e emissions reduction potential for different carbon price scenarios[167]



Source: NGFS Scenarios Portal; World Fund,"Planet A Foods CPP Assessment Annual Reduction Potential ", 2023

e. A qualitative assessment of other climate performance metrics

It is important to also consider other factors that could lead to additional cost or risks of a technology that might be hidden when only looking at one dimension – in this case, emissions. As outlined in section A, climate change is a highly complex and multidimensional challenge. Not only will other relevant social or environmental dimensions be increasingly priced into our economy, but they also pose a risk through second order emissions. Therefore, other dimensions such as biodiversity, ocean health, or water use are factored into World Fund's Climate Performance Potential methodology as binary 0 or 1 factors. This means that a solution needs to impact other dimensions non-negatively, as well as not pose significant risks that cannot be mitigated. This is determined in a qualitative approach assessing the scientific literature, gathering knowledge of industry experts, and comparing the technology's impact to not just the incumbent but also other potential decarbonisation pathways and scenarios (e.g. electrification vs hydrogen).

f. A consistent theory of change and comparative assessment

Focusing on just one technology solution and comparing it only to the business-as-usual, often worst case scenario, can provide a falsely optimistic picture for many solutions. It is important to also perform a comparative assessment of different solutions which compares their overall impact on the existing systems in the short, medium, and long term. Investing in a solution that is incrementally better than business-as-usual, but an inferior decarbonisation solution to a technology that will reach maturity in the next 2-3 years can pose a significant investment risk. Companies with solid initial growth could ultimately be displaced before an exit can be realised or they could be penalised for causing lock-in effects[168].

Having these different technology solutions mapped out allows an investor to decide which one is most aligned with the fund's theory of change. This is continuously developed as part of the fund's vision for a transitioned economy. Such a thesis-driven approach allows consistency across the portfolio, which is a key theme for dedicated climate investors. Instead of investing into transitory technologies, World Fund only invests in solutions that embed into their framework of a transitioned economy and the theory of change leading to it.

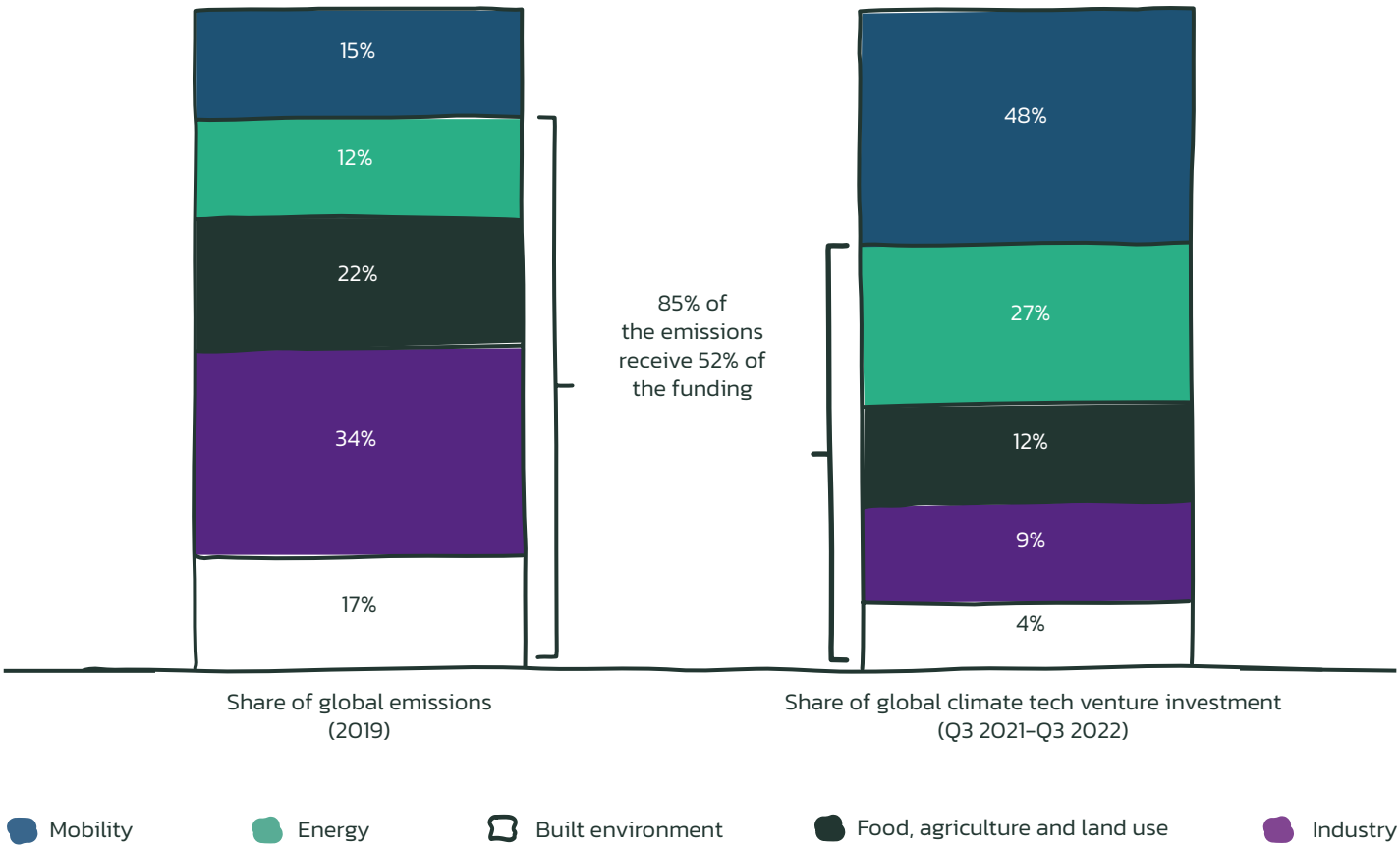
3. Sectors through the lens of climate performance potential

a. Untapped potential to unlock

As described above, when including a scientific approach – such as the Climate Performance Potential – into the investment decision-making process, investors get the chance to uncover attractive investment spaces and identify high potential technologies. While overall allocation of funds into climate tech has been increasing significantly in recent years (as described in section B), the investments made through these funds are not yet sufficiently taking scientific decision-making approaches into account, which can be observed in a mismatch in allocations relative to the climate transition challenge. In 2022, 85% of global emissions only received 52% of global climate tech investments[169]. There has been a clear over-allocation in easy-to-access trend sectors, such as (e-)mobility, which only accounts for 15% of global emissions, yet

received 48% of last year's funding. However, other high emitting sectors such as Industry (34% of global emissions) and food, agriculture and land use (22% of global emissions) only receive 9% and 12% of funding respectively. This offers a high untapped investment potential that is yet to be unlocked.

Share of global emissions and climate tech venture investment by sector[170]



Source: PwC, State of Climate Tech, 2022

The following two sector case studies are meant to summarise how the principles outlined in the previous subsections can be applied to sectors with a high decarbonisation challenge and help to identify investment opportunities in such sectors.

b. Investing in Food, Agriculture and Land Use – Enough Case Study

The food, agriculture and land use sector accounts for 22% of global emissions[171]. Additionally, the sector also uses 70% of global freshwater and 50% of habitable land[172]. The two areas that need to change the most to reduce the cost to the environment are our approach to agriculture and the selection of food we consume. Regarding the former, it will be crucial to introduce an efficient and regenerative agricultural system, while on the latter, especially alternative protein sources will play a significant role.

Deep Dive: Solutions for the decarbonisation of food consumption

The reduction of the consumption of food that has

a detrimental impact on the environment, such as meat or cocoa, has a direct positive impact on our environment. However, it is important to not neglect the broader importance of a healthy balanced diet, which includes the need for proteins.

Therefore, one of the main trends is a shift away from animal based food to alternatively produced proteins. From a systems perspective, animal agriculture is hugely inefficient by wasting caloric energy[173], water, and land resources[174] in the process of transforming plants through an animal into a dish. It has been the primary driver of deforestation in numerous parts of the world[175] that want to keep up with the supply of crops and cattle. Unless stopped, much of the Amazon forests could desertify, releasing >50 Gt of carbon into the atmosphere in 30 to 50 years[176] and triggering irreversible climate tipping points[177].

Emission saving potential from alternative proteins

The shift to fermented, plant-based proteins and cultivated meat could cut up to 6.6Gt of emissions[178]. Additionally, this shift has the highest per dollar leverage of any sector, with an estimated 4.4 kgs of CO2 saved per dollar invested. This is three times greater leverage than the next-highest emitting sector[179]. The global market size is expected to be $267 billion by 2030, 3.6x what it was in 2020[180].

Alternative proteins are also increasingly supported by government funding, as policymakers acknowledge their role in food security, environment protection, and as a boost for the global economy.[181]

Today's adoption bottleneck of alternative proteins

Established alternatives like plant-based have gained market share over recent years. Still, customers of these products are mostly higher-income, higher-educated customer groups[182]. As a result, alternative protein products are not yet gaining enough traction to replace animal protein at scale.

Consumer acceptance of meat alternatives is hindered mostly by the preference for real meat (51%), taste (27%), price (25%), the products being too processed (21%), and texture (20%)[183].
Products based on most used proteins like soy and pea face limits in their functionality. They have a distinct off-taste that needs to be covered by flavour-enhancing additives and are dependent on other additives like methylcellulose or heavy processing to get to the desired texture[184]. This negatively impacts pricing and how clean the label is, which are both important factors influencing consumers' decision. Another major bottleneck in the alternative protein market is production capacity of alternatives beyond pea and soy. Many companies struggle with the challenge to simultaneously excel on technology and branding, which hinders their ability to scale.

In order to overcome these challenges, the Good Food Institute (GFI) sees a clear innovation agenda that needs to be addressed including infrastructure investments, B2B offerings, technical advancements, perfecting tasty, crave-able products with nutritional advantages, and the development of cost-efficient solutions[185].

Solution Spotlight - The case of Enough Food

ENOUGH®

Enough Food[186] is an ingredient supplier for mycofermentation-based protein. With its B2B business model and a highly experienced management team, Enough is well placed to enable a variety of B2C products in the future, leveraging on strong partnerships with Tier 1 food producers.

Enough's product targets a wide variety of use cases, including whole-cut meat alternatives, mince, hybrid solutions or dairy alternatives, e.g. eggs, dairy, and seafood. Additionally, it caters to the customers' pain points of texture, taste, cost, and a clean label.

The product is neutral in taste and has a fibrous texture, which enables food companies to use it as an ingredient to produce products with improved sensory and functional attributes, bringing them much closer to parity with animal products.[187] Because of these favourable attributes, food companies do not need to rely on large quantities of additives, like flavourings to cover any off-taste or methylcellulose to improve texture. This caters to consumer requests for clean labels and no processing as well as reducing costs of production.

Alternative proteins are much more efficient to produce because they don't require raising animals, with fermented proteins forecast to be 10x cheaper than animal proteins by 2035[188]. Already at current scale, Enough's product can be sold as an ingredient to B2B customers at a cheaper price point than chicken breast[189,190].

Mycoprotein is a complete protein with all 9 essential amino acids and high digestibility, rich in fibre and minerals, no fat (<1g/100g), no sodium, no cholesterol, and very low allergy incidence. Compared to common plant proteins such as soy, mycoprotein digestibility is higher and its allergy incidence much lower[191], those being two major limitations of plant proteins. The mycoprotein amino acid profile and protein digestibility is comparable to highest-grade animal sources of protein (milk, chicken, egg, and beef)[192], while also presenting comparable positive proven impacts in cholesterol, sugar, and insulin blood levels compared to animal sources[193].

www.enough-food.com

c. Investing in Industry - Cylib Case Study

The industrial sector accounts for 34%[194] of global emissions. These emissions primarily stem from mining raw materials as well as processing them into finished goods. The variety of materials and processes include many which are hard to decarbonise. Different parts of the sector will require different routes to decarbonise. For the decarbonisation of mining raw materials, alternative low-emission materials and circular economy models offer attractive solutions. For the challenges to decarbonise the manifold of production processes, solutions such as industrial heat, material innovation or increasing energy efficiency need to be developed and scaled. For the purpose of this case study, we will focus on the decarbonisation potential of raw materials.

Deep Dive: Solutions for the decarbonisation of raw materials

As stated above, alternative materials are the first path towards decarbonising raw materials. While a variety of alternative solutions are currently developed, it is still early days for the invention of technically viable, low emitting, and highly scalable solutions for all materials. The second route towards decarbonisation of raw materials is recycling or remanufacturing of

existing materials or products. This approach allows for both the avoidance of emissions from mining raw materials and the prevention of emissions from end-of-life treatment.

The recycling market has been growing significantly in recent years[195]. This is not only driven by an increased number of regulations promoting a circular economy approach but also by other material intensive markets evolving rapidly in light of the climate transition. For example, the rapidly increasing demand for EVs over the next 20 years projects that there will be 1,850 kilotons[196] of ready-to-recycle material by 2030 and 20,500 kilotons by 2040 from both end-of-life lithium-ion batteries and production scrap. This could provide ample feedstock for recycling initiatives but also put a strain on the current supply. Indications of this supply crunch are already visible, as the battery material shortage is leading to increasing battery prices for the first time in history. Shortages will unfold in the coming years through drastic supply gaps of up to 50% for Lithium, Cobalt, and Copper[197]. For additional incentivisation and prevention, the EU is introducing recycling rates for batteries; 65% of the total battery, 90% of Nickel/Cobalt/Copper, and 35% of Lithium will be required to be recycled by 2025[198]. Further, the EU passed the extended producer responsibility[199] (EPR) for OEMs (Original Equipment Manufacturers). Therefore, car manufacturers, for example, have to ensure that the batteries they sell are recycled, refurbished or repurposed after use.

Emission-saving potential from recycling

Recycled raw materials for battery recycling, despite undergoing energy-intensive treatment, are 67%[200] less emitting than raw materials. This could be further improved with process optimisation and efficient energy use[201]. Moreover, with recycling plants located close to cell manufacturing facilities in the EU, the supply chain becomes more reliable due to reduced dependency on individual states and long-distance transport of materials[202]. The co-location of recycling and cell manufacturing is additionally limiting the dependency on specific parts of the world for raw materials. This allows for more reliable supply chains. Furthermore, it is more efficient to retrieve the raw materials from end-of-life batteries than in their natural occurrence. This is because material content in batteries is usually higher than in their natural occurrence.

Today's bottlenecks in tackling the recycling challenge

Currently, ordinary lithium-ion recycling facilities either have a selective focus on certain key materials, typically Nickel, Cobalt, or Copper, or only have the capabilities to complete parts of the recycling process. Often only the mechanical pre-treatment part is conducted, which results in black mass production rather than high-quality usable materials. However, more sustainable projects with holistic recycling processes based on new technologies are currently developed and tested.

A solution to unlock the emission-saving potential from recycling – The case of Cylib

Cylib[203] is an Aachen-based battery recycling startup led by Lilian Schwich[204]. Lilian founded and led the lithium battery recycling research group at RWTH as well as gained industry experience from working for a leading battery recycling consultant. World Fund invested into Cylib in 2023.

Cylib ecologically optimised their approach to the nascent customer experience in this sector by offering a holistic end-to-end recycling process of batteries, providing marketable raw materials as output.

Cylib uniquely combines the advantages of known thermal, mechanical and hydrometallurgical process technologies with new proprietary technologies into one holistic process. Their process has proven in the lab to show higher yields on recycling efficiency and is more sustainable across a number of factors, including energy and water usage, compared to existing processes. As a bonus, their process is even carbon-negative. This capability places Cylib among the few suppliers able to achieve EU mandated recycling rates for battery materials while minimising the environmental footprint.

With this, Cylib can be seen as a prime example of new technologies that can unlock a significant emission-saving potential and simultaneously reduce environmental footprint.

www.cylib.de

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THIS IS NOT THE END.