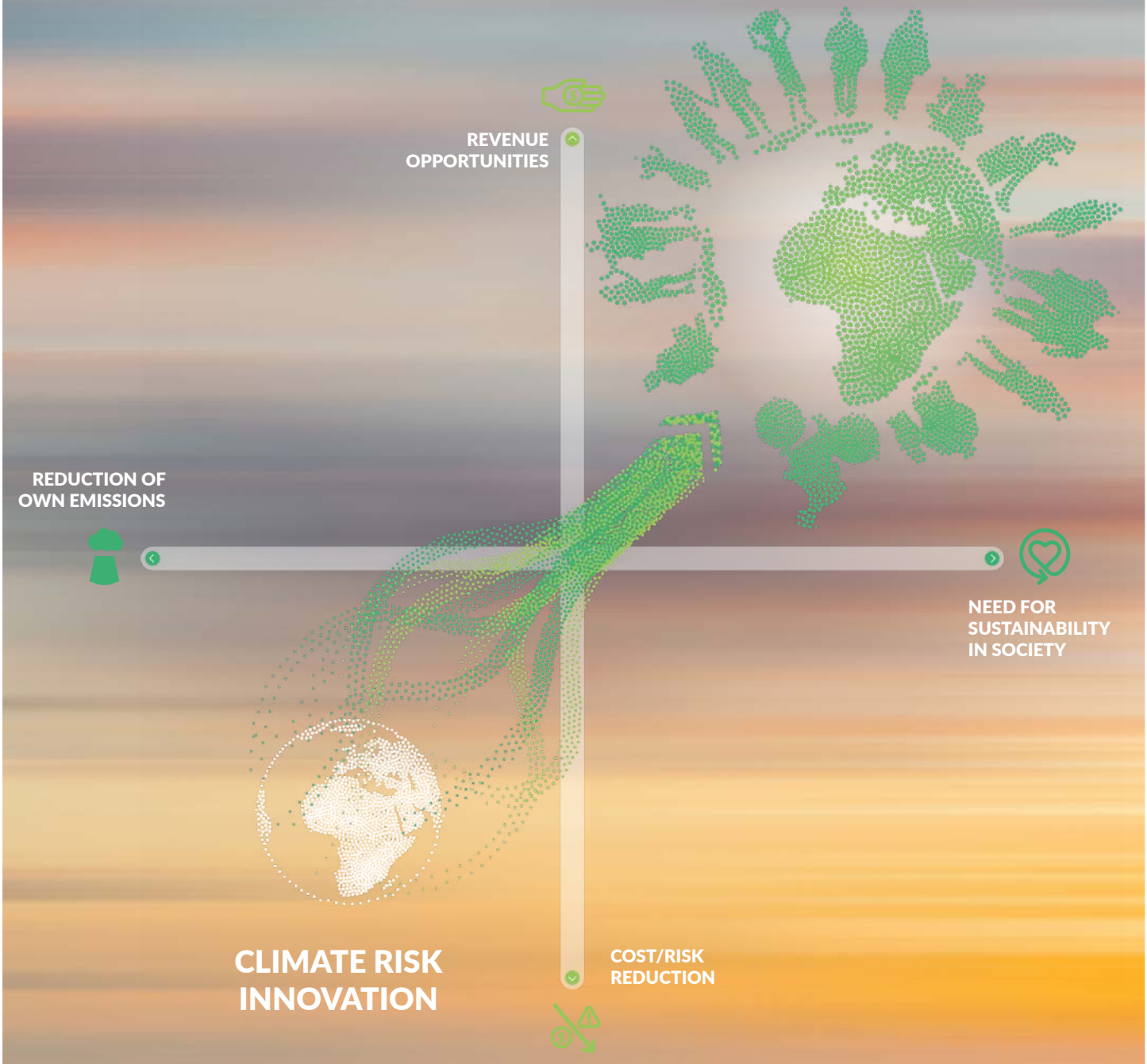
THE NEXT GENERATION OF CLIMATE INNOVATION

Using a climate innovation framework to flip the script from challenge to opportunity



MISSION INNOVATION

RISE

BCG BOSTON CONSULTING GROUP

BCG Green Ventures

CONTENTS:

THE NEXT GENERATION OF CLIMATE INNOVATION

Using a climate innovation framework to flip the script from challenge to opportunity.

Project coordinators: Dennis Pamlin and Marco Duso

Written by: Kanika Chandaria, Jakob Dahlqvist, Marco Duso, Michel Frédeau, Jay Hennessy, Jesper Nielsen, Dennis Pamlin, Cornelius Pieper, Raju Sarma and Danielle Ullner

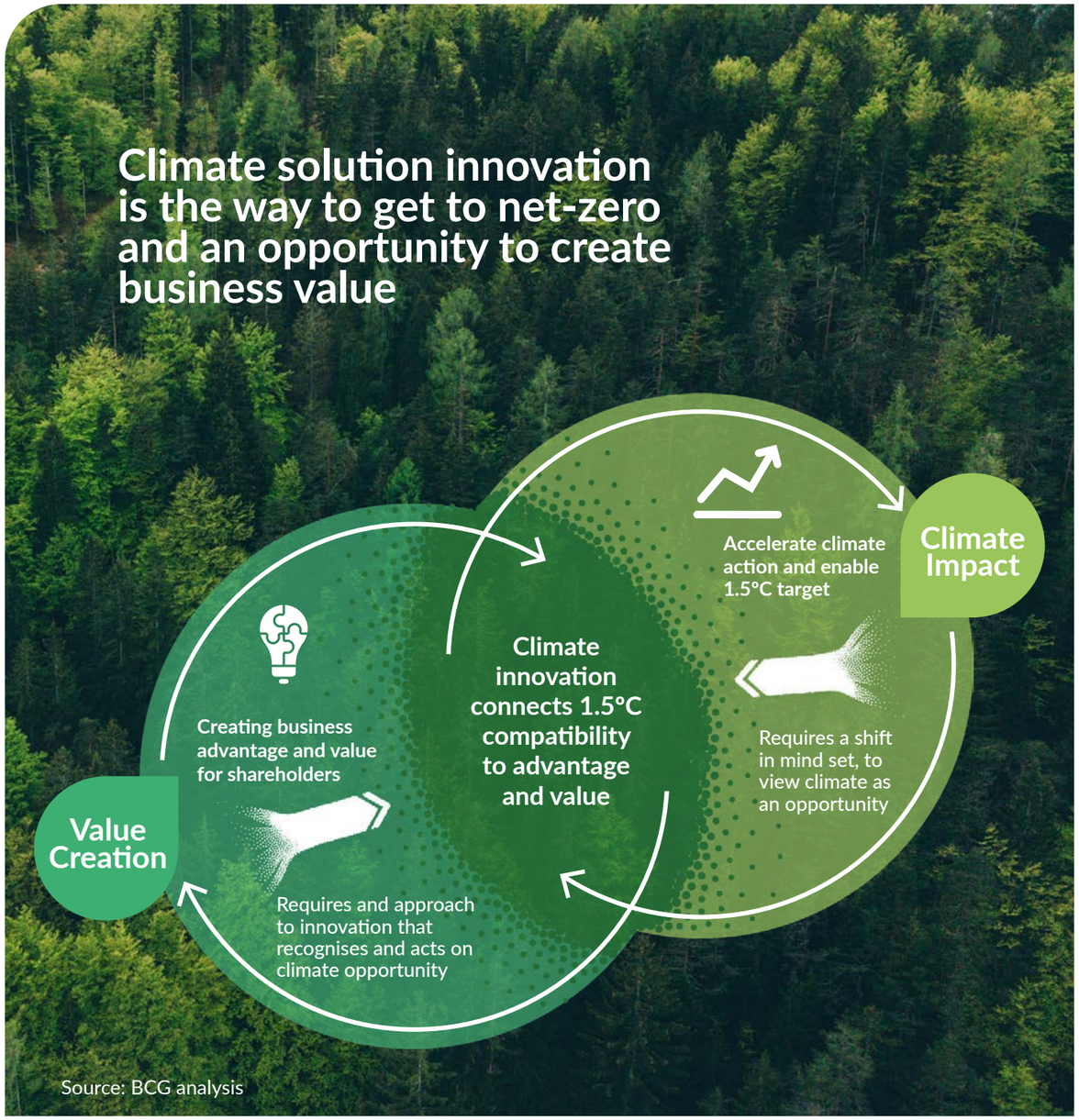
1

THE CASE FOR CLIMATE INNOVATION

With innovation, a 1.5°C low energy demand (LED) scenario not only becomes achievable, but provides an abundance of value creation opportunities

Innovations needed for a 1.5°C global sustainability pathway:

At COP26 in Glasgow the UNFCCC launched the UN Climate Change Global Innovation Hub (UGIH).[1] For the first time in 26 years a door was opened at the center of international climate negotiations for solution providers that can demonstrate how they can deliver sustainable 1.5°C compatible solutions for a future with 10-11 billion people. At the core of The Global Innovation Hub is an expanded innovation agenda. This expanded innovation agenda represents a shift from a static problem approach, where the focus is on reducing problems in existing systems, to a dynamic solution approach where the focus is on solution providers that can deliver on human needs in a sustainable way.



Six years before COP26, world leaders met in Paris and agreed to limit a global temperature rise by the end of the century to well below 2°C and to pursue efforts to limit the temperature increase even further to 1.5°C. In 2018, the Intergovernmental Panel on Climate Change (IPCC) warned that global warming must not exceed 1.5°C above pre-industrial temperatures to avoid the catastrophic impacts of climate change. To achieve this, greenhouse gas (GHG) emissions must halve by 2030 and drop to net-zero by 2050. Further progress was made during COP26, with 90% of the world now committed to net-zero versus only 30% in 2019.[2] However, a large abatement gap still persists, and even more important commitments must now translate into action in a sustainable way. The world needs emission reduction at a speed and scale that will require unprecedented levels of innovation. One institutional response to the expanded innovation agenda was the launch of Mission Innovation at the meeting in Paris. Mission Innovation was established based on the realisation that the world needs clean energy innovations.[3]

A fast-rising number of governments, companies and other key players are committing themselves to net-zero goals for carbon emissions to meet this objective. US, India, China, South Korea and Japan have joined Sweden, UK, France, Denmark, New Zealand and Hungary in making a public pledge to achieve net-zero by 2050 (albeit with India committing to do this by 2070 and China by 2060). Still the main focus of most strategies and initiatives is a static problem approach where the best that countries can do is reach zero.

The US, under the Biden administration, is making commitments and setting targets to move in a net-zero direction: the first ambition is to reach a ~50% reduction in GHG emission in 2030 compared to levels from 2005. Further ambition is to reach net-zero emissions economy-wide by no later than 2050. And it is not just governments. Companies too are challenging themselves to make this transition. Over 5,200 companies worldwide have joined the Race to Zero initiative by the UN and are thus working to reduce their emission at the pace and scale necessary.[4] Again, the main focus of most strategies and initiatives is based on a static problem approach where the focus is on reducing scope 1-3 emissions and the best a company can reach is zero.

Figure 1: An expanded innovation agenda

Each new commitment from existing stakeholders to reduce their own emissions, rather than focus on solutions to human needs, can be a step in the right direction. However, aggregated they can establish a static problem approach with several challenges.

1. **Strategies that only remove carbon from existing systems are not enough to achieve a sustainable 1.5°C compatible pathway as such a system will be too resource intensive, too unequal and continue to undermine poverty reduction, biodiversity, and other SDGs.**

2. **Many of the static problem commitments are based on business-as-usual strategies where unproven technologies, such as carbon capture, utilisation, and storage (CCUS), reach a scale and price that might not materialize, and will allow them to continue without any significant changes. In order to support sustainable innovations, strategies that deliver net-zero without technical carbon capture should be the reference and the carbon capture strategies should be approached as a back-up.**

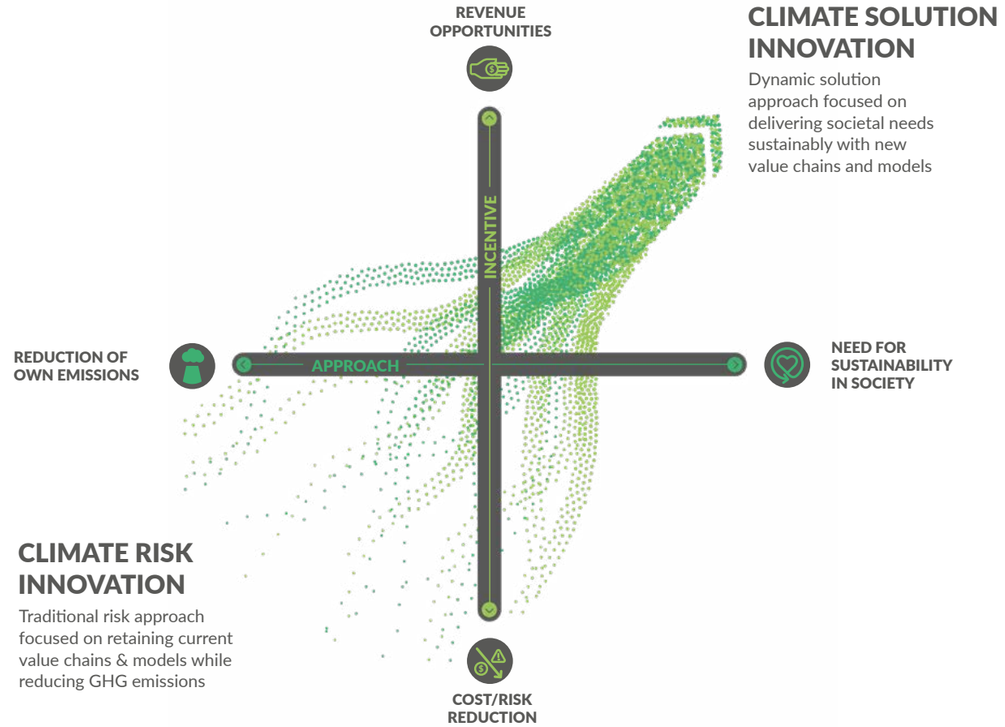
3. **Strategies based on a static problem approach tend to deploy tools that support improved versions of existing products, such as most environmental labels, environmental taxes and investment decisions based on existing sectors. While such strategies can deliver improvements in existing systems they tend to undermine opportunities for a new generation of solutions.**

4. **The main challenge with the static problem approach is, however, a combination of all the above and can be called "the fossil free typewriter dilemma", where existing unsustainable production and business models are assumed as the default option, and smart new solutions that support global sustainability are ignored or marginalised.**

In IPCC's 1.5°C special report a pathway was explored for the first time where the focus shifted from only improving existing systems, to a broader innovation agenda, where more resource efficient ways of providing for human needs were in focus.[5] This pathway, the P1 or Low Energy Demand pathway, demonstrated that a 1.5°C compatible pathway is not only possible without using carbon capture technology, but is also much better at delivering on other global sustainability goals, as well as opening up for innovations based on business model innovations such as sharing, circular and modular design.[6]

Annual GHG emissions are now 50 gigatons above net-zero levels (when the amount of greenhouse gases produced equals the amount removed from the atmosphere) and even if we disregard these caveats, scaling existing technologies would still leave about a third of annual global GHG emissions

Figure 2: Climate innovation crossroads



to address. The reality is that too few governments and companies are acting decisively to put in place the robust policies and roadmaps required to meaningfully and innovatively deliver on sustainable net-zero ambitions. Beyond commitments, we also need new technologies, business models and policy initiatives if we are to achieve net-zero by 2050, and we need them faster than currently envisioned. Exploring how the innovation space can be expanded to encourage deeper, faster, and more sustainable solutions is therefore vital.

Climate change, and the necessary emission reductions, is often presented as an intractable problem and risk, but it can, and must, be solved. In the solution lies big opportunity for businesses, investors and governments. While we know the current approach will not fill the gap, there is an achievable pathway to get there and it starts with navigating the climate innovation crossroads (see Figure 2).

As part of this mindset shift, we need to reframe the way we approach both the problem and solution. If we assume a static risk approach to the changes required, the question is about how those emitting greenhouse gases (GHG) today can continue to do what they do without greenhouse gas (GHG) emissions. With society going through a fourth industrial revolution, the world needs to move beyond only the need for reduced emissions, as such an approach will undermine more impactful innovation and other sustainability goals. Instead, we must assume a dynamic solution approach that is about how we can deliver the needs that are required for a world of 10-11 billion people in a sustainable way. Doing this will require more active assessment of areas previously deemed "unattractive" due to early Technology Readiness Levels (TRLs), or innovations outside existing Overton windows, where efforts and investment of resources didn't match high decarbonization and economic potential.

> *"Traditional corporate social responsibility and philanthropy are inadequate for our times. Leaders must rethink what a business is and how it drives change in the world."*
>
> *– Paul Polman and Andrew Winston, HBR, The Net Positive Manifesto September-October 2021*

While we ultimately will require multiple approaches to achieve what is needed to deliver there are great untapped opportunities in the top right quadrant of what we call “climate solution innovation”.

Three areas with examples to demonstrate how the focus on needs and solutions is rapidly increasing are:

1. **Business**

Incubators and accelerators: Leading incubators and accelerators are assessing and increasing the avoided emissions potential and 1.5 °C compatibility.[7, 8]

Leading large companies: A growing number of companies have begun assessing avoided emissions and 1.5°C compatibility, and leading CEOs are exploring ways to deliver what is needed.[9, 10, 11]

Business groups: WEF will explore how major emitters can add a solution approach by asking those responsible for “30% of the problem” to explore what percentage of the solutions they can provide.

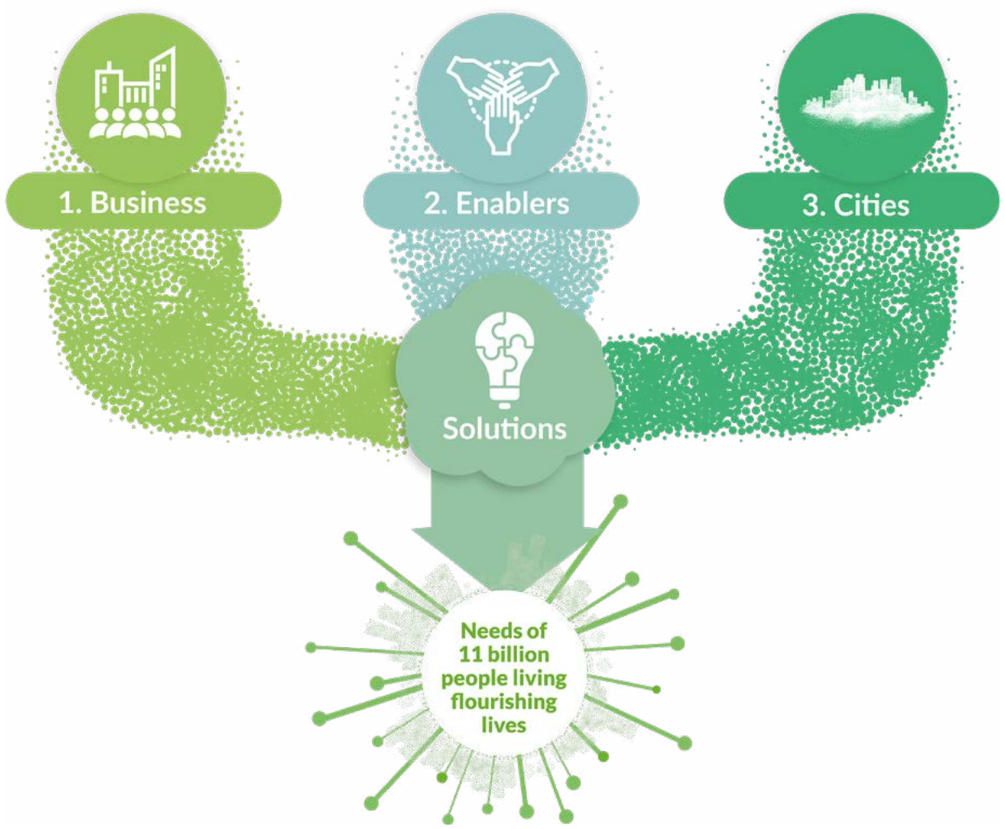
2. **Enablers**

The financial sector: The Net-Zero Alliance is exploring how to have a measurable positive impact and have a dedicated work stream for “Financing Transition Targets”.[12]

Media companies and advertisers: Different initiatives and studies explore how media and advertising companies can have a positive impact.[13]

3. **Cities**

UN-Habitat and Global Covenant of Mayors will focus on matchmaking and methodology development to assess contributions from solution providers and enablers that can be scaled.[14]



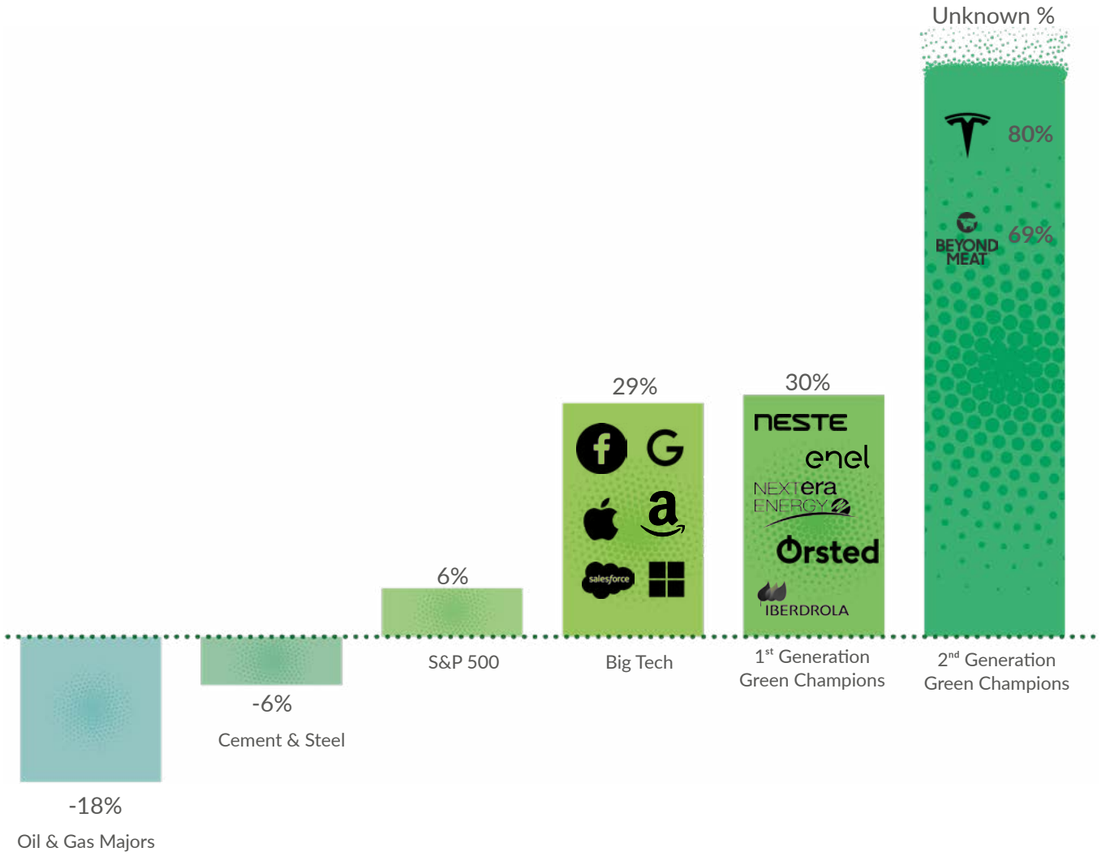
There’s value in emissions reduction:

Climate innovation is a huge opportunity to create value for all stakeholders involved. With a dynamic solution perspective, where companies are approached as solution providers that focus on fundamental societal needs, companies can create business advantage and value by accelerating climate action to future-proof their business and help meet the 1.5°C target envisioned in the Paris Accord. Investors can profit from new climate change initiatives that promise longer-term success. Governments can also boost economic growth with support for what we call climate solution innovation. Here’s how we can have our climate cake and eat it too.

Seismic shifts are beginning to occur in government policies and public-and-private sector initiatives. Consider a few examples. In September 2020, China’s President committed his country to achieving carbon neutrality by 2060. This is an enormous challenge for the world’s biggest annual carbon emitter, but a recent BCG analysis found that China has economically attractive and socially viable pathways to achieve its de-carbonization goals.[15] The total cost will be substantial – 90 trillion to 100 trillion RMB (or about $13.5 trillion to $15 trillion) through 2050, but the investments

Figure 3: Climate is a major value creation opportunity – First generation of 'green champions' is performing at big-tech level

3-year average TSR (Oct 2017-2020), simple average of companies within each category



Note: As of 25.11.2020, based on data ending in October. TSRs use company reporting currency. Beyond Meat is a 1-year TSR. The Following companies were considered: 1. Oil and Gas Majors - BP, Shell, Eni, Exxon, Chevron, Total and Equinor 2. Cement & Steel consists of 732 companies with Steel or Concrete as primary classifications. 3. S&P 500. 4. Big Tech - Apple, Google, Facebook, Amazon, Salesforce, Microsoft. 5. 1St Generation Green Champions - Enel, Neste, Iberdrola, Orsted, NextEra. 6. 2nd Generation Green Champions - Tesla, Beyond Meat (1 Year TSR only) Source: S&P Capital IQ; BCG Value Science (R) Centre

will have a material benefit for GDP, contributing 2% to 3% over the first half of the century. Green technology investments alone will account for more than 2% of China's GDP by 2050. Far from hindering economic growth, decarbonization could in fact stimulate the economy.

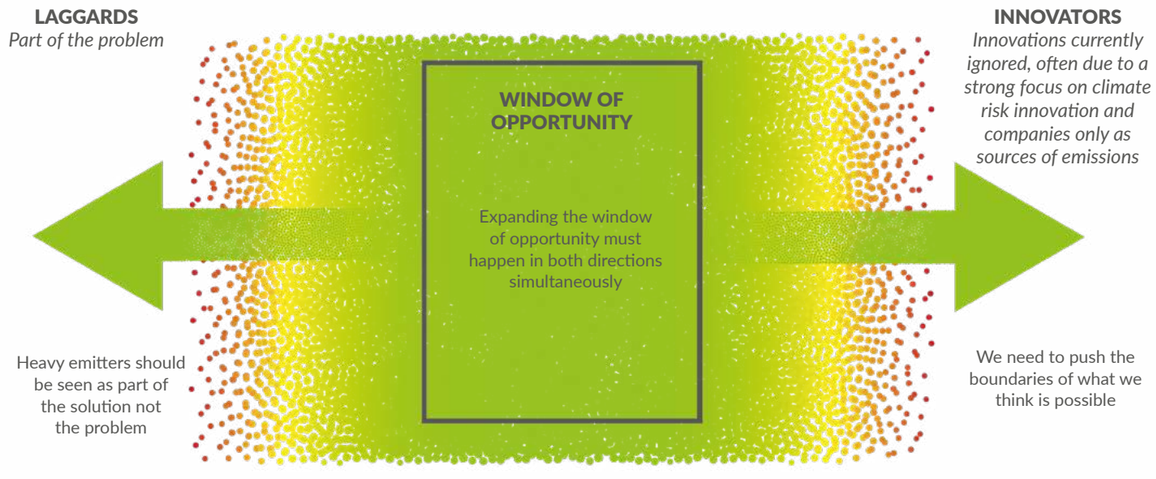
As part of its Green Growth Strategy, South Korea provided early support for battery storage projects. Investment in R&D enabled breakthroughs in stable multicycle charging and support for early integrated battery deployment. Lithium-ion battery costs declined nearly 90% from 2010 to 2019 and South Korean battery producers captured a leading market share by 2013.

In terms of shareholder returns, the first generation of "green champion" companies is winning in the climate transition and performing at levels similar to those of big tech firms such as Facebook, Amazon, Apple, Netflix, and Google. Between October 2017 and October 2020, companies such as Enel, Neste, Iberdrola, Orsted, and NextEra Energy generated annual total shareholder returns on the order of 30%. Beyond this first generation, the returns for an emerging second-generation of "green champions", such as Tesla and Beyond Meat, were 70% to 80%. (See Figure 3). The current value of Tesla alone outstrips the combined market cap of the nine largest car companies globally. While the results of these "green champions" are spectacular, it is also key to acknowledge that the narrative must ultimately shift to not only focus on maximizing return on investment but also on success in fulfilling the needs of society – for example, mobility, nutrition, energy, etc.

These "green champions" and other forward-looking companies are demonstrating that a new generation of climate innovation has a strong focus on value creation. They are showing how to create new revenue streams by entering new markets or developing offerings that cater to high priority economic and social needs. They are winning customer preference and strengthening their brands through positive environmental and societal contribution. Early movers are using scale and market position to create network effects and lower costs. Innovators are building more resilient business models by reinventing in the most critical parts of the value chain, reducing exposure to increasing costs and regulatory constraints. They are enhancing stakeholder value from all angles including their employees, customers and investors and thereby delivering greater returns.

Lots of progress has been made on commitments and initial actions but the challenge ahead will be to achieve these commitments in the required time frames for climate action. Going forward, we fundamentally need, and should unilaterally desire, a huge wave of climate-driven innovation in its widest possible meaning, from business models to technology and breakthrough science. We will need to continue expanding the window of opportunity to support the innovators in transforming the art of possible, and to also push the laggards in becoming part of the solution (see Figure 4). Moreover, we must remember that innovation should complement, and come in addition to, changes in policy frameworks, investment models, leadership, and other areas of climate action, not replace it.

Figure 4: Innovation heatmap



2

THE CLIMATE SOLUTION INNOVATION CANVAS

A new wave of climate-driven innovation – from technologies to business models –to win in the fourth industrial revolution and avoid resource intensive system lock-in

"While breakthroughs in technology are critical to generate new opportunities, not all companies need to play in the breakthrough tech fields. Equally important, or even more important, is business model innovation"

The climate solution innovation canvas:

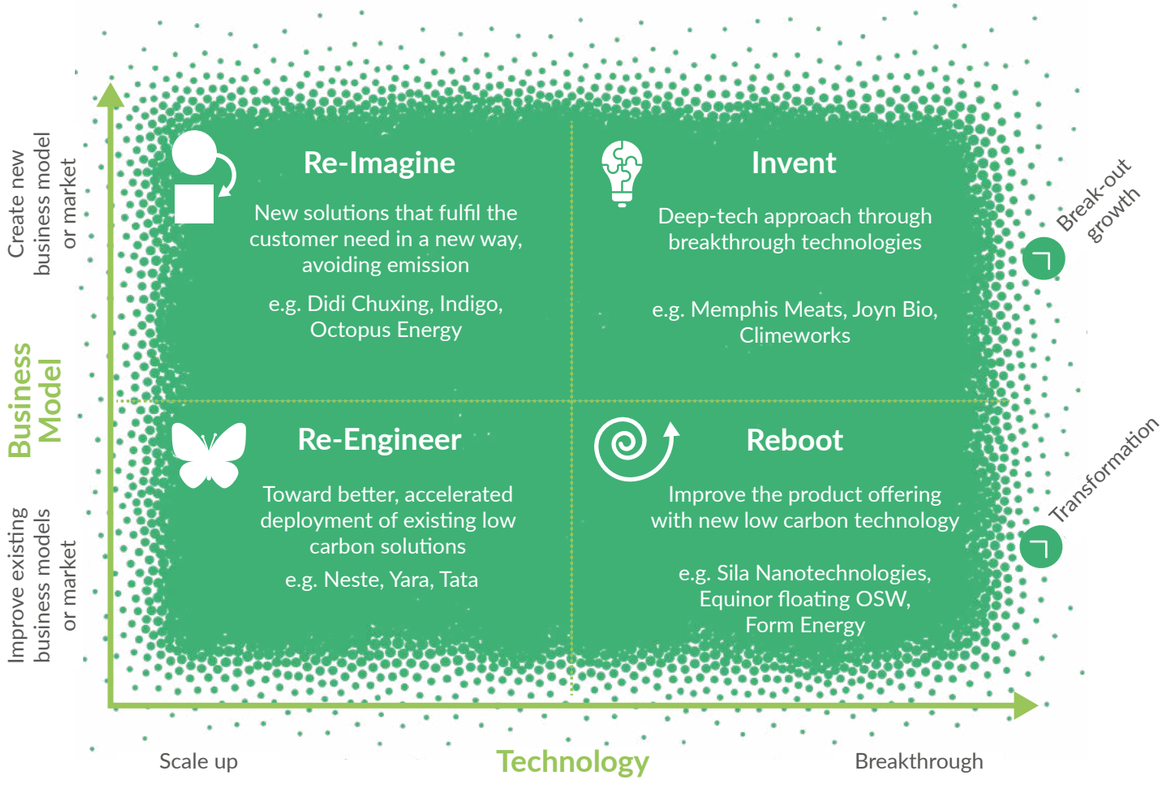
Companies can choose from various approaches to climate innovation, but they are well advised not to limit their ambitions to one or two options. They can look within to improve their existing business models and markets or create brand new ones. Equally, they can participate in scaling up existing technological solutions or supporting in the development of more disruptive ones, including partnering with academia, entrepreneurs, or others in the innovation ecosystem to help build, validate and scale breakthrough technology. These choices lead to four quadrants of potential climate action, all focused around re-framing climate activity as an opportunity for individual and societal success, rather than as a hindrance to growth (see Figure 5).

Companies can use a wide range of opportunities to fulfil the objectives in each of these quadrants, starting from improving their own processes and products (e.g. reducing carbon emissions associated with their own activities or phasing out carbon-intensive products), to influencing interdependent parties to broaden their sphere of impact (e.g. exerting control over the product life cycle, sending demand signals to suppliers, or taking the lead to inspire broader industry action), all the way through to providing the enabling tools to support others in achieving their net-zero ambitions (e.g. by providing high-quality, low-carbon alternatives or by creating tools that improve visibility and support better decision making). In all instances, though, companies need to move away from looking at themselves as sources of emissions and see themselves as solution providers for fundamental societal needs.

Today, many companies are taking climate action and have already made progress in improving climate-related metrics and reducing carbon emissions. However, most of the time, this action is taken by adopting proven, mainstream approaches such as switching to renewable energy supply in current business operations, rather than developing new ways to have climate impact. In many of these instances, applying existing and proven technology is assumed to be the only relevant part of the innovation equation for a given company to consider. While these approaches can indeed

Figure 5: Climate solution innovation canvas:

There are multiple approaches to value creation



be beneficial for the climate, they are more what we consider stable stakes in climate action, rather than "climate innovation" for the purpose of this report. It's also important to recognize that companies don't necessarily need to develop *new*, breakthrough technology to innovate. Breakthrough developments in climate tech, such as storage, materials, distribution, will continue to be integral in creating new value creation and climate impact opportunities, but not all companies will need to play in breakthrough tech fields. There still remains huge potential in deploying and scaling-up existing low energy demand technologies to accelerate climate action, and even greater potential linked to business model innovation where delivery on needs in society and revenues are disconnected from increased numbers of products.

There will also be opportunity for companies to contribute to future breakthrough technologies. Time and again with climate innovation, we have seen rapid, exponential technology development in areas such as solar, onshore wind and lithium-ion battery storage and, correspondingly, plummeting prices both in terms of production and storage. The costs of solar PV production and storage, for example, have fallen by around 90% in the last decade. This pattern has been seen in other high-tech industries such as drones and DNA sequencing. For the latter total U.S funding for R&D until first success in 2000 amounts to approximately $2.7 billion sequentially, after this the cost per unit has fallen from $20-25 million/unit in 2006 to around $1000/unit today. Companies therefore will have a role to play in supporting innovation and making technology more accessible by bringing down price.

To successfully achieve in driving real climate innovation, companies should take a holistic approach to both technology development and the way they do business, inside and out. Developing new business applications, revenue models, value propositions and markets often requires as much effort, and deserves as much emphasis, as developments in new technology.[16] Companies can look to transform how they deliver value by finding new ways to fulfil their customers' existing needs whilst having a lower carbon impact. For example, Orsted and other green energy giants have phased out oil, gas and coal to transition to 100% renewable energy, meeting their customers same energy needs through a lower carbon alternative.[17] They did not invent these technologies, but merely spotted the opportunity to deploy and scale.

Companies can also fundamentally change their business model to focus on needs-based innovation, designing new markets or models according to existing pain points. In the agriculture sector, for example, we have observed the growth of vertical farming taking farming to a new level of precision and productivity with minimal environmental impact and virtually zero risk.[18] Whilst this transformation is being led by new players such as AeroFarms, they are taking a needs-based approach and serving the basic need of nutrition by applying existing precision farming technologies to deliver an all-around better-quality product from colour to texture, quality, flavour, and of course, environmental impact. Imagine how this approach can be applied to other essential needs such as mobility, light, shelter and business. Altogether, considering innovation in terms of both technology and the underlying business model will result in a wider spectrum of climate approaches to achieve net-zero.

On the following pages we explore the opportunities – and what leading companies are already doing – in each area of the climate solution innovation canvas.

Re-engineer:

The climate transition is quickly changing the context for most businesses. Those that can successfully innovate will outperform others and secure long-term value by moving quickly towards better, accelerated deployment of existing low carbon solutions. Customers and investors are embracing companies that demonstrate viable solutions.

Consider the example of Neste, which has leveraged technology that can transform fats into molecules which can replace fossil fuels to help customers reduce GHG emissions. Neste has developed renewable fuels for road, air, and marine transport, as well as for chemicals (including base oils and plastics).

Originally the state oil company of Finland (the Finnish government continues to own about 35%), Neste set a vision of becoming the world's leading producer of renewable diesel in the early 2000s and has transformed its business to make the transition from oil and gas to renewable fuels. Neste began production of 100% renewable diesel in 2010 and has since expanded to three global production facilities. It owns 1,000 gas stations in four countries, including Finland's first low-emission service stations, which feature renewable diesel and electric vehicle charging. It also offers GHG emission reduction services to customers as part of Neste Engineering Solutions. In 2020, it helped customers reduce GHG emissions by 10 million tons, the equivalent of removing 3.5 million passenger cars from the roads for a full year. Neste's ambition for a second wave of growth is to become a global leader in renewable and circular solutions. In 2020, Neste RE was launched: a 100% renewable and recycled raw material for plastics and chemicals production. This product will enable tackling climate change through reducing the need to use virgin fossil resources, while it also provides a new solution to the end-of-life related challenges the polymers and chemicals industries are facing today. Neste hopes to reach the ambitious target to process annually over 1 million tons of waste plastic from 2030 onwards.

Neste generated overall revenue growth of 6% to €15.8 billion in 2019 with renewables revenue rising 24%. With more than 25% of its revenue considered "clean," the company has earned high ESG ratings from investors and others. Neste is, however, also a company that needs to address significant high-carbon and resource intensive lock-in challenges as the company currently is depending on a resource intensive and wasteful society.

In a completely different industry, Norwegian chemicals company Yara is using satellite technology to help farmers around the world optimize fertilizer use to maximize yield and minimize waste and cost. Established in 1905 as Norsk Hydro, the world's first producer of mineral nitrogen fertilizers, Yara today offers crop nutrition products and solutions. In more recent years, tightening fertilizer regulations globally have restricted usage and created a need to better manage usage and efficacy of crop nutrition products. Consumer pressures for more sustainable practices in agriculture and food value chains have added to the push for producers to feed the world in more responsible ways. In 2008, Yara's new CEO, Jørgen Hole Haslestad, declared "The company has many exciting opportunities to pursue, for instance when it comes to the environment, where we contribute to better balance in agricultural development and deliver some interesting industrial solutions to environmental problems."

Yara's portfolio of digital farming solutions enables farmers to increase the yield and quality of their harvest while reducing environmental impact. For example, AtFarm allows farmers to monitor crop growth through satellite images and receive precision fertilization recommendations from Yara's agronomic algorithms. Yaralrix is a precision farming tool that allows farmers to measure crop nitrogen requirements in real-time using their smartphones. Yara Water Solution uses crop sensing technology to increase nutrient and water use efficiency.

From a business point of view, Yara's embrace of satellite and digital technology has enabled the company to drive sales of current crop nutrition products using data, while also hedging their bets against further tightening of regulations by developing new revenue sources from digital solutions.

A few lessons on climate-inspired business re-engineering can be drawn from Neste and Yara. First, climate action should be firmly embedded in a company's strategy, purpose and culture. This goes beyond simply signing pledge. It means having a plan, making climate action part of the business, and regularly reviewing progress against KPIs, just as is done in every function and business unit. Neste have done this through setting a vision to become the world's leading producer of renewable diesel. This new purpose should be used to shift perceptions of their external valuations. Management needs to develop a new shareholder-value story with clear articulation about the potential for long-term value in low carbon businesses. Secondly, companies should seek to anticipate changes of context, risk and opportunity, looking ahead to see whether policy could benefit or hinder their transformation, and how to capitalise on ongoing action. Yara, for example, had already developed digital farming tools which allowed them to quickly adapt. Thirdly, companies can transform to strengthen their competitive advantage, by providing new products, or reaching new customers. To transform, companies must remember that they need the right capabilities to succeed, including innovation-oriented talent and an open approach to partnerships and coalitions. Finally, even if there are interesting examples of companies shifting perspective, significant challenges exist to move beyond current unsustainable structures where initial revenues tend to come from systems that are fundamentally unsustainable.

Re-boot:

Oft-times, existing constraints thwart new technologies from reaching their full potential. It takes an additional innovative solution to break through barriers or present a new way of solving a problem. Major climate change-combating technologies such as battery power and wind-generated electric power have established their viability in the marketplace but need a technological assist to move to the next level of impact.

In 2010, three former Tesla employees recognized that materials developed using nanotechnologies could dramatically increase the energy density of rechargeable lithium-ion batteries and enable smaller, lighter, longer-lasting electronic devices. This advance could have a major impact on the range of electric vehicles and advance mass adoption of affordable, long-range battery-powered cars. The resulting company, Sila Nanotechologies, has developed a silicon-based anode that replaces graphite in lithium-ion batteries. The new anode improves the energy density of batteries by 20%, meaning 20% fewer cells are needed in each battery pack, and the battery costs 20% less.

Sila products can be dropped into existing commercial battery manufacturing processes. Manufacturing partners can produce higher performing cells in their existing factories on current production equipment; they do not need to retool. In addition to electric vehicles, the improved battery technology has a range of other applications, including consumer electronics, electric power storage and transmission, and electrified flight, all of which have the potential to accelerate world's transition to renewable energy. As a result of strong partnership with Daimler, BMW and ATL amongst others, Sila was valued at ~$3.3 billion in May 2021.

A big constraint on wind-generated power is the construction of wind farms where there is a steady airstream and limited number of neighbours. Offshore locations are an attractive solution, but until recently constructing wind turbines in deep water settings, where winds blow strongly, was prohibitively expensive. Enter Equinor, with new technology that enables wind turbines to float on the ocean's surface and obviates fixed moorings. Motion controllers and sensors regulate the turbine blades in relation to wind speed, intensity, and direction, to prevent capsizing. Equinor's floating wind farm in Hywind, Scotland, the world's first, powers some 20,000 British homes. Floating wind can potentially power up to 12 million homes in Europe by 2030.

In both of these cases, as in others such as Form Energy which has developed long duration energy storage technology that could be a major missing piece in the clean energy puzzle, the key to the breakthrough was recognizing a bottleneck or significant constraint to emerging technologies, and innovating another new technology to remove or get around the barrier. The other key to success in innovation in this space is to use existing capabilities, experience and know-how; SILA leveraged their knowledge of EV batteries to ensure their products can drop into the existing commercial battery manufacturing process, and similarly, companies can innovate more successfully in areas that they hold either direct or transferable expertise.

Re-Imagine:

Satisfying changing customer demands, particularly those rooted in evolving views of climate change, may require re-imagining business models and services. Take mobility. Before the pandemic hit, many consumers were already rethinking the concept of single-car ownership and embracing alternatives that include renting and ride-sharing as they looked toward a future of autonomous vehicles and robotaxis.

Tech giants such as Apple and Google have been piloting autonomous driving, and major auto OEMs from GM to Volkswagen have been exploring autonomous vehicle manufacturing and mobility models. Upstarts turned unicorns, such as Uber, Lyft, BlaBlaCar, and Grab, were early mobility movers.

Another unicorn, Didi Chuxing, has pioneered mobility-as-a-service in China. Founded in 2012 as a taxi-hailing service, Didi rapidly expanded its portfolio of offerings to encompass AI, big data, smart city transportation and self-driving technology. It serves more than 550 million users across Asia Pacific, Latin America, and Russia and before the pandemic was completing more than 10 billion passenger trips a year. It's multimodal mobility-as-a-service platform attracts more active users that drive higher utilization rates, which attracts more active drivers and vehicles through improved profitability. Ultimately riders experience a better user experience via reduced wait times and costs.

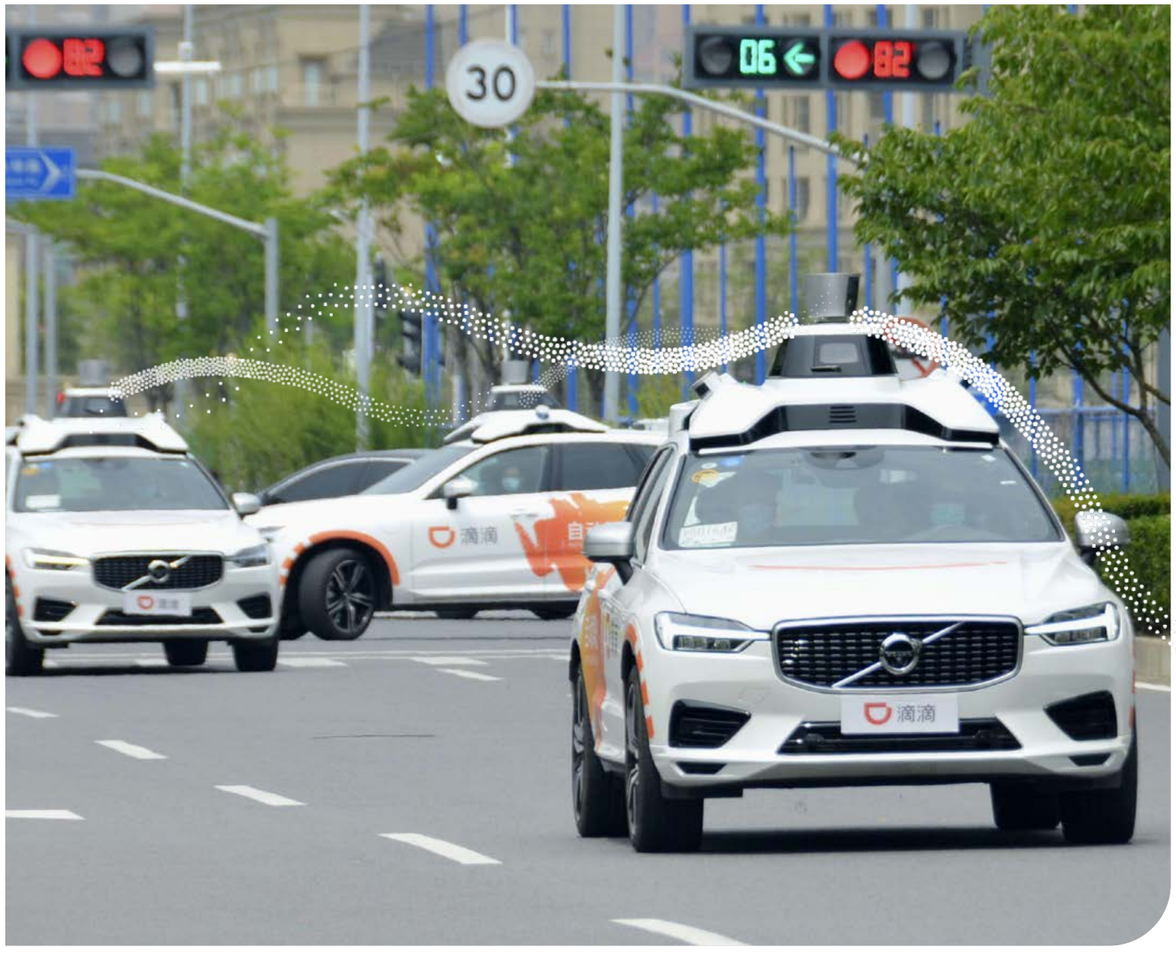
Didi offers a full range of app-based transportation and life services including ride-hailing and vehicle sharing for taxis, private cars, buses, limousines and bikes, food delivery and payment services. It's ecosystem-based approach accelerates adoption (the Didi app is embedded into the WeChat platform, for example) and accelerates innovation. The company is laying the foundation for the spread of autonomous, connected and electric vehicles, as well as smart cities. It is estimated to have reduced total car trips in China by 1 million a day, reducing gasoline consumption by 500 million liters a day and eliminating 13.5 million tons of CO_2 emissions a day. In June 2021, Didi raised $4.4 billion in U.S. IPO which resulted in a valuation of $73 billion on a fully diluted basis.

New models are making a business and climate change impact in other sectors as well. Indigo Agriculture offers farmers a package of innovative services that includes regenerative practices (data-driven recommendations from agronomists, patented microbiome seed treatments, and grain quality testing) and data science, satellite imagery, and analytics for measuring baseline levels of carbon in the soil. Terraton incentivizes farmers to use regenerative farming practices that increase carbon sequestration. The company has established partnerships with the Soil Health Institute, Rodale Institute, and the Ecosystem Services Market Consortium, among others, to collect data, measure carbon sequestration and quantify best practices.

Octopus Energy Group is an energy tech innovator providing customers easy access to 100% renewable energy through a cutting-edge digital platform, known as Kraken, that can pay customers to use renewable energy during periods when generation is high, thus avoiding paying higher costs when renewable supplies are low. The company has grown rapidly, now serving 1.9 million homes and 25,000 businesses in the UK alone, and operates in the USA, Australia, Germany and Japan. It intends to reach 100 million customers in multiple countries by 2025. (It has experienced better than 400% annual growth in its customer base since 2016.) In addition to a novel technology platform, Octopus owes a good part of its success to its customer-centric approach, not always the norm in the utility industry, which delivers best-in-market service and experience.

California-based Pachama was started by two technologists from Argentina with the idea of using the natural strengths of forests to combat climate change. Pachama leverages two key innovations. One is using satellite data, artificial intelligence, and automation to modernize carbon markets by accurately measuring the carbon forests store in real time. The company's AI and remote sensing platform enables independent verification of carbon captured in forests, enabling B2C and B2B customers to measure the impact of their carbon credit investments. The other is a marketplace platform that disintermediates middlemen and makes it much easier for local landowners to have their results certified and get paid for their reforestation efforts. Pachama democratizes its technology by allowing customers to access the satellite imagery and sensors that provide information on emissions and carbon captured on reforested land.

When re-imagining their business, these examples demonstrate that companies should focus deeply on the customer need before attempting to provide solutions; Octopus Energy changed the paradigm of the retail energy supply business with a deep commitment to customer centricity and operational efficiency, which allowed them to provide renewable energy to so many homes. Companies should also embrace a service perspective to re-imagine existing value chains, such as via market places like those created by Didi Chuxing and Indigo.



Invent:

Experts agree that we cannot reach net-zero by 2050 without the help of totally new solutions that offer significant advances over those currently in use. These solutions often include deep technologies[19] such as digitalization, new materials, and other scientific breakthroughs. Innovations based on deep tech can generate enormous economic value, but their ultimate impact extends far beyond the financial realm to everyday life.

They have the potential to fundamentally change everything from energy, transport, and agriculture to health, education and entertainment. Deep tech innovations can satisfy existing needs and create new models and markets, but incumbents that want to play will have to be willing to disrupt themselves before they are disrupted by others.

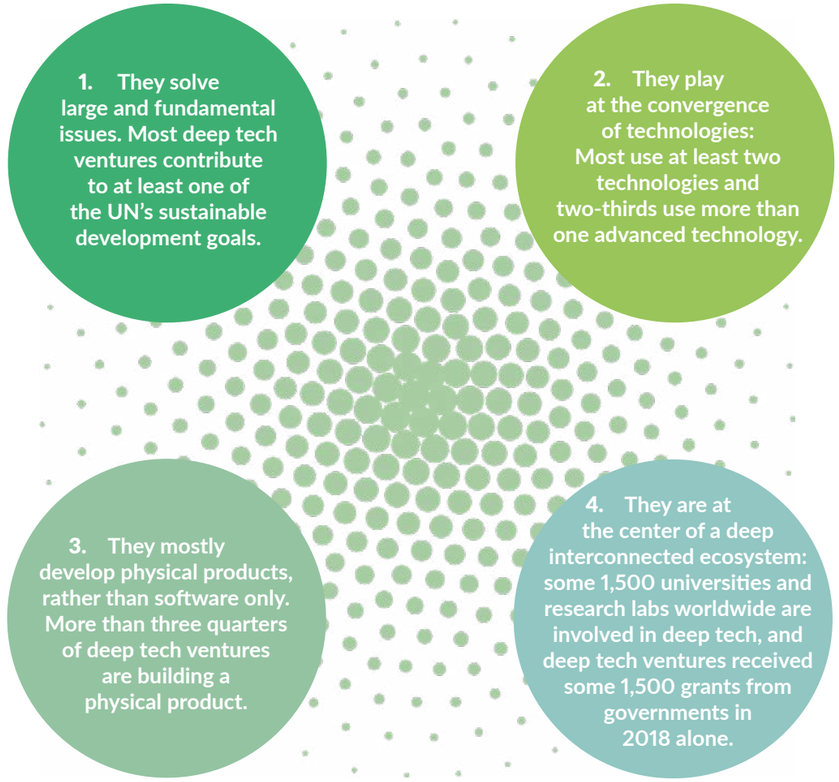
Consider two examples:
Joyn Bio, a joint venture between Ginkgo Bioworks and Leaps by Bayer founded in 2017, seeks to reduce agriculture's reliance on carbon-intensive and highly polluting nitrogen fertilizers. Joyn Bio leverages synthetic biology and gene editing techniques to engineer nitrogen-fixing microbes that enable cereal crops to convert nitrogen from the air into a usable form. The innovation is made possible by exclusive access to the genetic codebase and manufacturing capabilities of Ginkgo Bioworks as well as proprietary microbial strain library and industry know-how of Bayer.

Joyn's Bio's nitrogen fixation solution could eliminate industrially produced nitrogen fertilizers, which produce 3% of worldwide GHG emissions, and remove the need for Haber-Bosch process facilities that cost about $3 billion each to construct. The microbial engineering platform can unlock new climate opportunities to make agriculture more sustainable and cost effective.

Memphis Meats produces good-tasting and healthy meat products by harvesting them from cells instead of animals. Growing demand for meat and livestock farming that accounts for 15% of GHG emissions and 25% of earth's available landmass and fresh water. Cellular cultivation technology enables the engineering of real meat without the need for animals by farming stem cells. This results in a direct one-to-one substitution for structurally complex animal meat without added hormones and antibiotics, providing healthier and safer food. Eliminating the need to raise and slaughter actual animals involves significantly lower caloric input, water, land and energy use than conventional meat production.

Memphis Meats latest round of funding will enable it to open a factory in 18 to 24 months. While cellular cultivation technology is proven to cultivate edible meat while using up to 90% less land and water than conventionally produced protein, the path to commercialization will require collaboration from a full ecosystem of participants (including industry, retailers, regulators, and consumers).

Innovation in this space can seem opaque to many companies, but four characteristics combine to distinguish deep technologies from other fields of R&D:

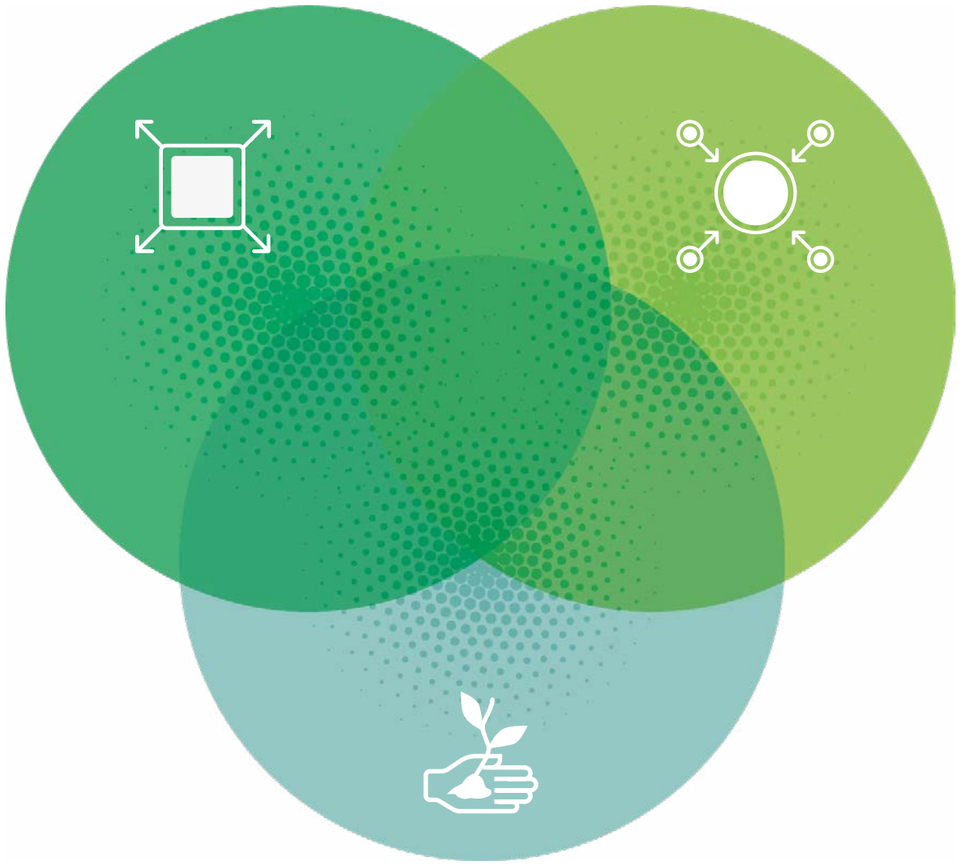


The biggest challenge for incumbent companies looking to invent new solutions is developing the capability to reimagine and rethink problems. As demonstrated by these case studies, companies can achieve significant return through direct innovation, or indirect contribution to it, but must remember three key learnings for success. Companies need to embrace science to unlock innovation, whether by partnering or developing in-house capabilities. Innovation systems (whether internal or external, such as labs or incubators) need to turn their focus from executing existing solutions to fixing new problems, taking a problem-oriented, entrepreneurial approach. Finally, companies or innovation systems will need to source long-term patient capital from a supporting ecosystem, or indeed contribute to it. At the moment, Fortune 500 companies devote less than 2%, on average, of their revenues towards R&D spend.[20, 21] This will need to change if innovation is to contribute to climate goals.

Figure 6: 3 lenses with which to identify canvas opportunities:

Need in the world
- Acute climate-related threats / frictions
- Changing customer needs / demands
- Shifting competitive environment
- Ecosystem driven pressure to reduce CO_2

Who we are
- Existing assets / expertise / strengths
- Surrounding ecosystem / partnerships
- Entrepreneurial culture & imperative to innovate
- Sustainability / climate mission



Our impact potential
- Potential to drive economic & climate impact
- Ability to unlock holistic value creation
- Opportunity to change the game

Not all innovation approaches are alike, there is an approach for everyone:

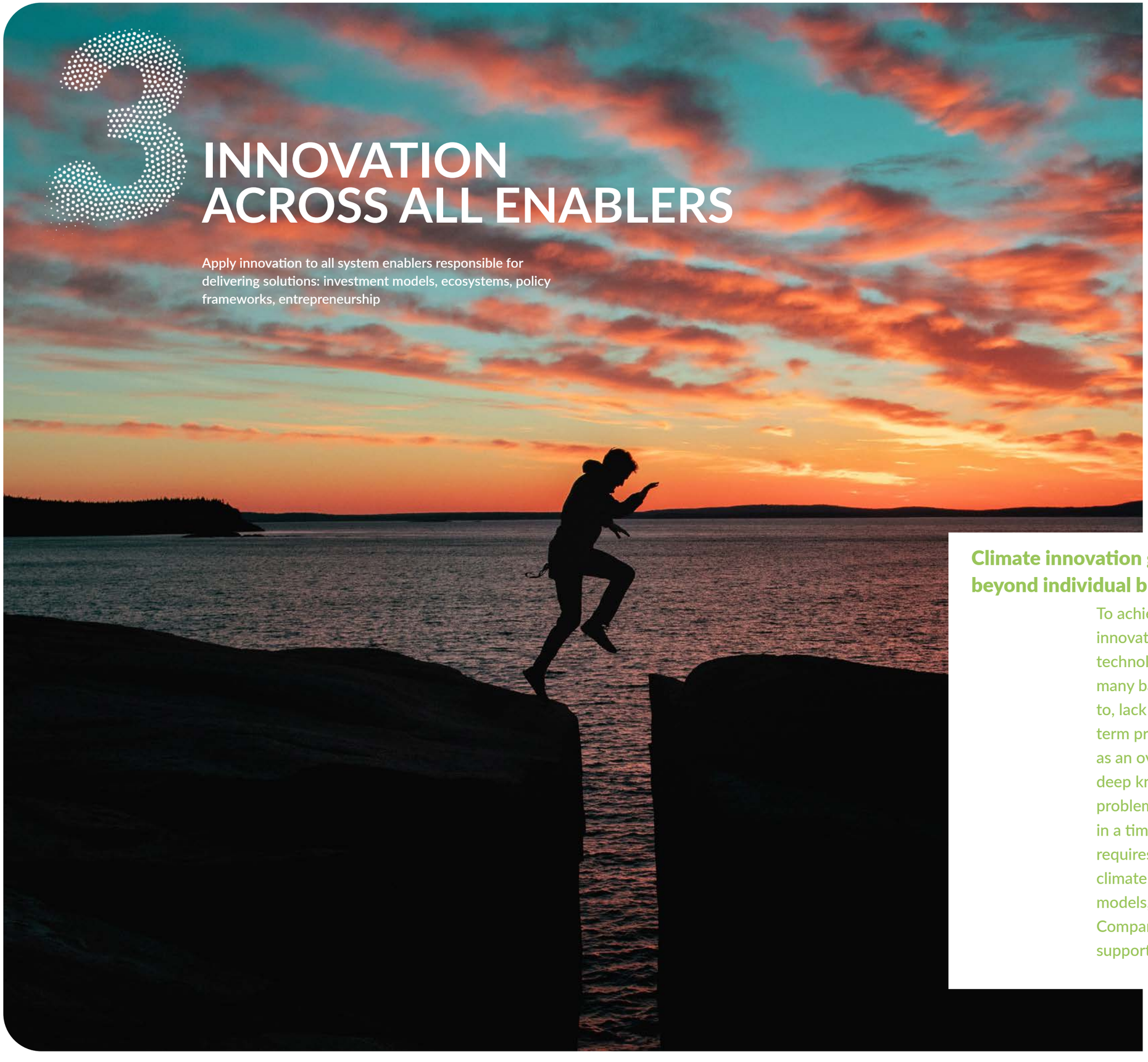
Incumbents and start-ups are not confined to one area of innovation: they can – and should – play in multiple areas at once, or explore opportunities in the four quadrants of the climate innovation canvas over time. Different approaches require different effort, risk tolerance, and capabilities, but what is clear, however, is that many incumbent corporations will need to pivot and reinvent themselves to some degree to make impactful climate action.

While this will entail making difficult decisions and short-term sacrifices, meaningful climate action will lay the groundwork for corporations to stay relevant and profitable in the long term.[22] From a macro point of view, new technologies and business models can have a much larger impact on achieving 1.5°C pathway but these models and technologies are not guaranteed and will not replace existing ones overnight. Individual companies can defend against competition and hedge their bets by playing in multiple areas. Understanding the spectrum of innovation approaches can help executives make effective choices to design climate action strategies and roadmaps that reflect their starting position, overall ambition and competitive advantage. They should apply three lenses to identify opportunities (See Figure 6).

The first lens is global human needs: the acute climate-related threats and how are these affecting customer needs and demands. How do they change the competitive environment and drive pressure on the business ecosystem to reduce carbon emissions?

The second lens is the company's own strength and capabilities. What are its existing assets and expertise? Can it bring the surrounding ecosystem or partnerships to bear? Does it have the entrepreneurial culture and imperative to innovate? Has it developed a climate mission and a vision for a sustainable future?

The third lens is its potential for impact. Can it drive both economic and climate impact? Does it have the ability to change the game? These are big questions for any company, but challenges of our time demand that businesses rise to the occasion. Those that respond will find ample opportunities to create substantial value – and reap the rewards from appreciative investors and customers – in the process.



3 INNOVATION ACROSS ALL ENABLERS

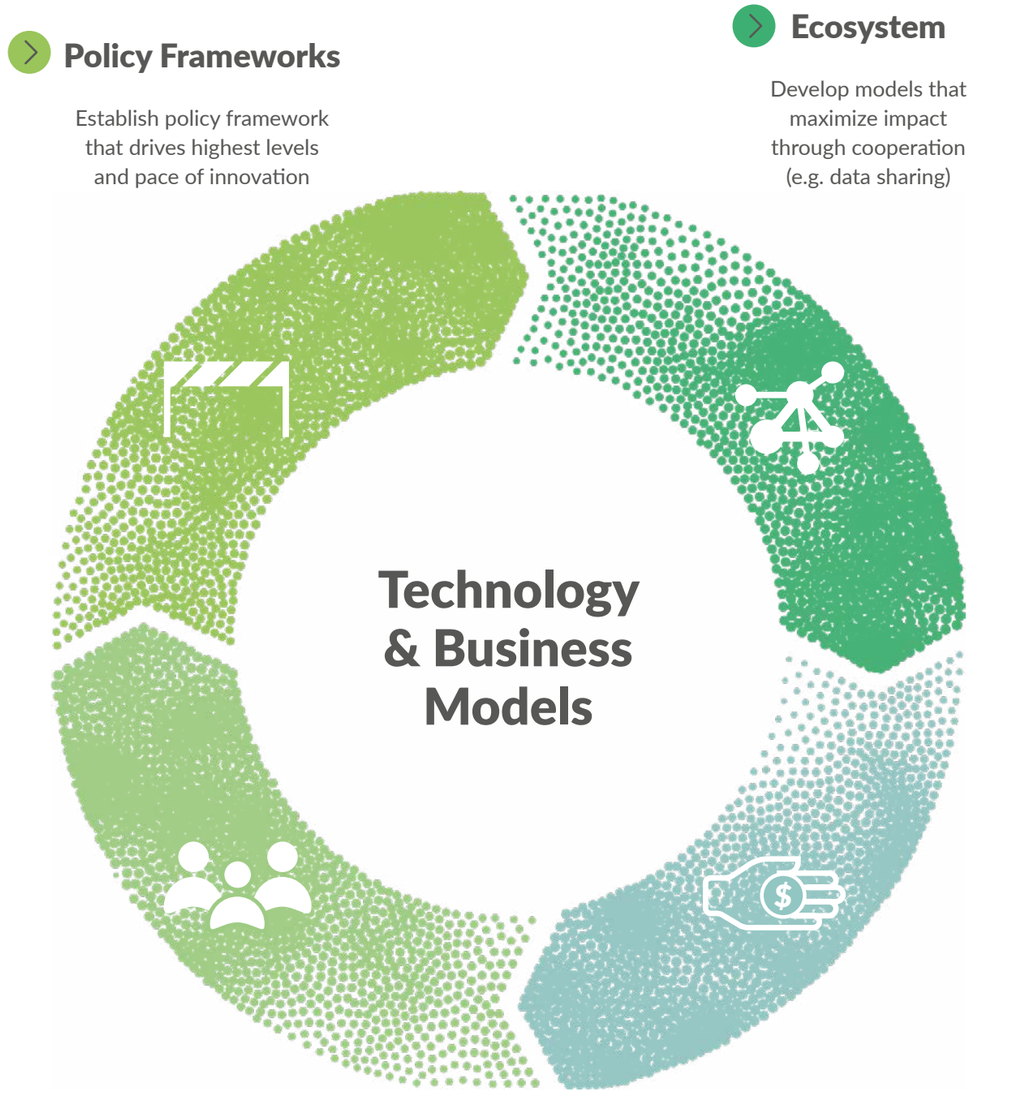
Apply innovation to all system enablers responsible for delivering solutions: investment models, ecosystems, policy frameworks, entrepreneurship

Climate innovation goes well beyond individual business:

To achieve transformational climate innovation, innovation is needed everywhere – not just in technology and business models. There are simply too many barriers to overcome including, but not limited to, lack of supportive regulatory frameworks, short term pressures and investment time horizons, as well as an overall absence of entrepreneurial ambition and deep knowledge to solve such fundamentally complex problems. Overcoming these barriers, moreover in a timeline needed to achieve net-zero by 2050, requires innovation across all critical enablers to climate action, from policy frameworks to investment models, ecosystem enablement and entrepreneurship. Companies cannot operate in silos to successfully support in driving this innovation forward.

Figure 7: Climate innovation goes well beyond individual businesses

Innovation is needed everywhere, not just in technology and business models

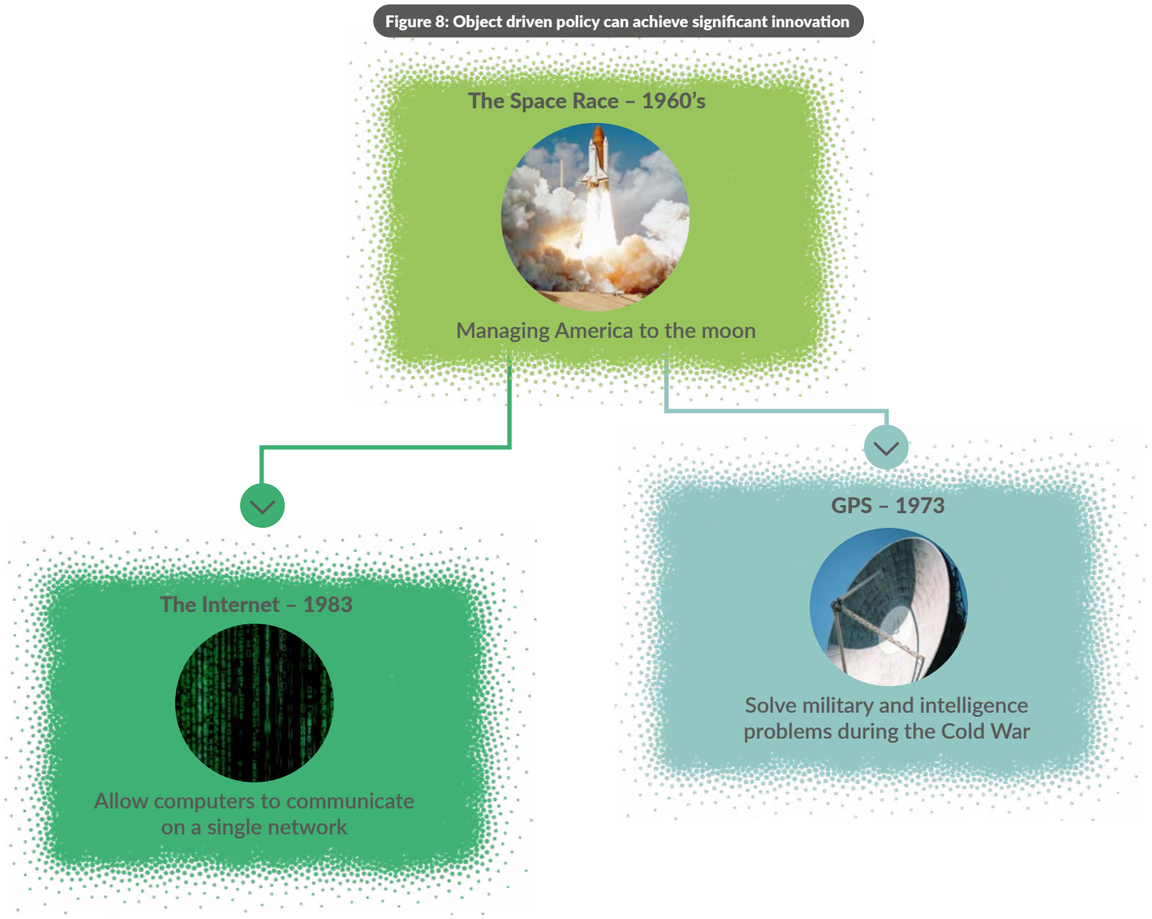


Policy needs to incentivize climate action:

The policy change for climate change narrative often targets carbon pricing as the silver bullet for tackling our challenges. While carbon pricing is a critical policy component to get right, it is insufficient as a standalone.

Indeed, carbon pricing is a flexible and cost-effective approach to optimizing existing systems and mitigating the impacts of climate change, and many governments, businesses and investors increasingly attribute a monetary value to climate risk through jurisdictions and internal carbon pricing methodologies. However, for carbon pricing to have maximum impact, it needs to be set at the right level and uniformly applied. Current pricing is well below the US$40–80/$tCO_2e$ by 2020, and US$50–100/$tCO_2e$ by 2030, that some experts believe is required to be consistent with meeting the goals of the Paris Agreement.[23] To achieve a low carbon future, we need to leverage a wider range of complementary and balanced policy levers – including not only exerting pressure on carbon-intensive products, technologies and practices to stimulate the transition, but also activating a range of enabling and incentivizing policies that support the development of scaling-up innovations which offer fundamentally different solutions and have the potential to completely circumvent system lock-in problems. This is about not only disincentivizing climate inaction, but also, more importantly, incentivizing climate action to achieve system transformative innovation.

In devising policy frameworks that are capable of truly changing the world, governments need to be bold and double down on what we call mission-driven policy. This concept is nicely illustrated by the US mission to land the first man on moon. The success of Project Apollo is without doubt one of the greatest examples of technological success in history that was made possible through sustained political support.[24] This mission-led "moonshot" programme required not only innovation in spaceflight but also innovation in nutrition (food safety), computing (state-of-the-art control systems) as well as clothing (insulation).[25] Likewise, the mission to solve military and intelligence problems during the Cold War resulted in the invention of the GPS that conveniently optimizes our route planning today. The takeaway for policymakers is that mission-driven policy, set with far-reaching intention, will result in the mobilization of dedicated resources and approaches to achieve innovative solutions to our greatest challenges.



Tackling climate change needs to be faced with the same level of intention and urgency as these moonshot missions. To achieve success, governments need to set mission-driven policy, increasing funding and set up initiatives to boost climate innovation. Instead of industry-specific policy that looks to correct for market failures we need widespread and mission-oriented policy that looks across industries to solve concrete technological and societal problems. With only $22 billion or 0.02% of the global economy spent on climate change,[26] equivalent to the amount Americans spend on gasoline in a single month, funding needs to increase at least fivefold to truly make an impact. Lastly, there needs to be an integrated and holistic effort to encourage the highest level of climate innovation – for example, via centres for climate innovation.

Across the world, governments have activated their support for climate innovation, albeit to varying degrees and using different approaches. China has perhaps been most involved. It supports its goals of achieving carbon neutrality by 2060 with fast rising R&D spending, including basic and applied research that is funded mainly by the government. Strong government direction and support for science and technology innovation parks have led to development of technology-focused R&D centers such as Nanopolis Suzhou, which hosts more than 200 private-investment firms, including numerous major international venture capital investors, and more than 300 nanotech companies (as of 2017).

In Europe both the EU and national governments fund R&D into advanced technologies that contribute to climate solution innovation. The EU's Horizon Europe program involves €26 billion for basic research, €53 billion for applied research, and €14 billion to support innovation and startups from 2021 through 2027. The purpose of the Joint European Disruptive Initiative (JEDI) is "to bring Europe in a leadership position in breakthrough technologies". To implement its increased climate ambition the Commission presented the first series of adopted files under the 'Fit for 55' package in July 2021. The package contains legislative proposals to revise the entire EU 2030 climate and energy framework, including the legislation on effort sharing, land use and forestry, renewable energy, energy efficiency, emission standards for new cars and vans, emission trading systems and the Energy Taxation Directive. These stricter legislation are likely to foster R&D within the private sector to comply to new regulations. As an example of ongoing initiatives in Europe at national level, Germany's government has agreed on a national hydrogen strategy to build up industrial generation facilities with a capacity of 5GW by 2030. Germany will provide €7 billion for the ramp-up of hydrogen technologies and an additional €2 billion will be invested in setting-up large-scale hydrogen production plants in partner countries. Next to that, "Climate Paths 2.0" was co-developed by BCG, with the Federation of German Industries (BDI) around 80 companies and associations. It includes a program proposal of ~20 instruments to enable sectors to achieve climate targets in 2030 and set a course toward GHG neutrality in 2045.

The change in administrations in the US is also bringing increased support for climate change initiatives. The US historically has looked to the private sector as the primary driver of innovative technology, although in May 2020 a bipartisan group of House and Senate members introduced the Endless Frontier Act. This act was passed in June 2021 and commits roughly $250 billion funding over 5 years for advanced R&D. It will establish a technology directorate at the National Science Foundation that would fund fundamental research in ten key technology areas, including AI, quantum computing and biotechnology, genomics, and synthetic biology. Next to this, the Infrastructure Bill passed in November 2021, will also contribute to a positive climate impact. It includes clean energy and grid-related investments, the ambition to build a national network of charging stations for electric vehicles and to expand access to clean drinking water and investments for cleaning up Superfund and brownfield sites and capping orphaned oil and gas wells.

Finally, the Build Better Act, still in Congress, foresees $555 billion in climate investment to help get more clean power from the wind and sun, speed the shift to electric vehicles, and increase efficiency in homes and workplaces. Even with the initiatives underway, most governments around the world can do more to establish policy frameworks that enable and incentivize climate innovation and reposition national economies toward value chains and models that are compatible with a 1.5°C world. While there are some universal best practices, it is also key to remember that there is no one-size-fits-all policy, and all policy needs to be thoughtfully designed based on regional, sectoral and even cultural characteristics.

It takes an ecosystem:

Climate change is by nature a systemic issue that requires the collective power of a cross-disciplinary ecosystem to solve and establish new rules of engagement. No single stakeholder can provide all of the capabilities and factors needed on its own to scale the meaningful transformation to tackle climate change.

Broad and deep ecosystems involving thousands of players are already taking shape to combat climate change, and advance technologies, such as gene editing, nanotechnology, and quantum computing, that promise solutions to some of our biggest social and economic challenges (See Figure 9). These ecosystems encompass not only corporates, but investors, start-ups, governments, universities, research institutions and other facilitators, and each type of participant has a distinct and important role to play in accelerating the speed and scale of change needed to amplify climate impact:

1. **Incumbents possess the deep industry knowledge, technical and commercial capabilities and scale to pilot new solutions and drive demand**

2. **Innovators have the raw entrepreneurial ambition as well as the agility and speed to find new product-market fit**

3. **Investors provide the capital, network as well as the tools and processes to support innovators in validating and scaling their ventures more quickly**

4. **Academia brings the cutting-edge research, technology, IP and talent to make new solutions technically feasible**

5. **Governments set the right policies to foster an environment that supports ground-up innovation and can also provide direct investments for R&D**

Since ecosystems are ultimately collaborative organisms, a big part of the challenge for each player is find the way in which it can best contribute to, and profit from, its participation. Moreover, each player has to be willing to involve stakeholders that they are traditionally not used to collaborating with.

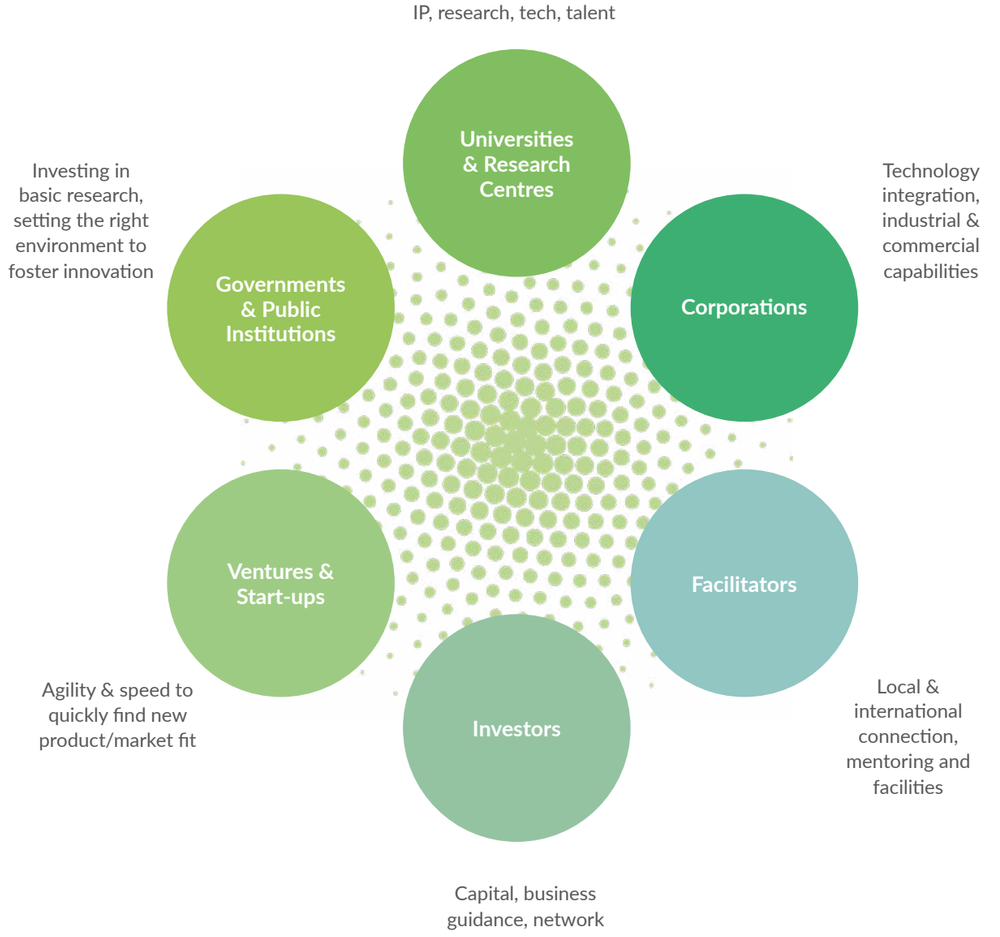
Figure 9: Ecosystem action can accelerate the speed and scale of change needed to amplify climate impact:

Ecosystems overcome barriers via collaboration and risk sharing mechanisms

Ability to overcome technical, economic or other structural barriers that come with long-term technology development via polling resources and investment

Coalitions can coordinate support for more ambitious climate policies and build pressure for emission reductions

Ecosystem action can generate demand signal through joint pledges, kick starting a competitive playing field needed for other companies to take action



Source: World Economic Forum: The Net Zero Challenge: Fast-Forward to Decisive Climate Action; BCG Analysis

A winning climate innovation ecosystem requires that participants have shared vision with aligned short and long-term goals, know-how to help advance a particular technology or market, and the capability to develop a full circle view of each stakeholders' priorities. Ecosystem action can support climate innovation in overcoming the significant technical, economic and structure barriers that often come with long-term technology development, via collaborations across value chains or industry peers, for example. Through this collaboration, they can establish sharing mechanisms to spread risk that would otherwise be too high for single companies to bear alone. They can generate a demand signal through joint pledges, kickstarting a competitive playing field needed for other companies to take action and they can also help garner the support for more ambitious climate policies, building greater societal pressure for emission reductions.[27]

Let's take disruption in the fashion industry as an example to highlight the importance of collective ecosystem action. The opportunity for climate tech to disrupt the fashion industry is huge: 20% of global freshwater pollution is caused by the dyeing process of textile, 1.2 Gt CO_2 is released in the atmosphere by the fast fashion industry and 80% of textile waste could be avoided at the knitting or weaving stage but there is a ~$25 billion USD investment gap per year required to finance a step change in sustainability. To achieve innovation at scale, it requires collective action from all stakeholders to overcome critical barriers (see Figure 10). This includes: facilitators nurturing targeted industry consortium's to address misaligned incentives between brands and manufacturers, brands to strengthen their advocacy and support for sustainability to create awareness for the opportunity, supply chain partners to forge partnerships with innovators to help provide a more structured pathway for them to succeed, start-ups to create more targeted use cases and practical implementation plans to help brands understand and ultimately support breakthrough innovations, investors to mobilize more patient capital to help innovators compete with commoditized prices of existing solutions and the public sector to strengthen policy framework to drive systemic change and catalyse more investment.

A climate opportunity innovation approach provides an opportunity for the fashion and apparel sector to redefine itself beyond improved materials and recycling of low-quality clothing. In a sector that has been driven by shorter and shorter fashion cycles and marketing, customers are "depowered" rather than empowered. This is especially true for younger consumers, as by linking increased consumption to the increase of self-worth a tension is created with empowered individuals who embrace sustainable lifestyles.[28]

However, instead of only looking at the fashion industry as a problem, a climate opportunity innovation approach can turn the need for sustainable lifestyles to an opportunity. Acknowledging the full effect from the apparel industry (Figure 10 below) it becomes obvious that the material and recycling is just small part of the impact. In order to assess the full impact the volume produced and the lifestyle promoted/ enabled must be part of the equation. Exploring how the need for sustainable lifestyles can be a business opportunity is something leading companies like Houdini and Patagonia are already exploring with a climate opportunity innovation approach, but with a climate risk innovation approach the innovation will continue to be limited to material and circularity initiatives.[29, 30]

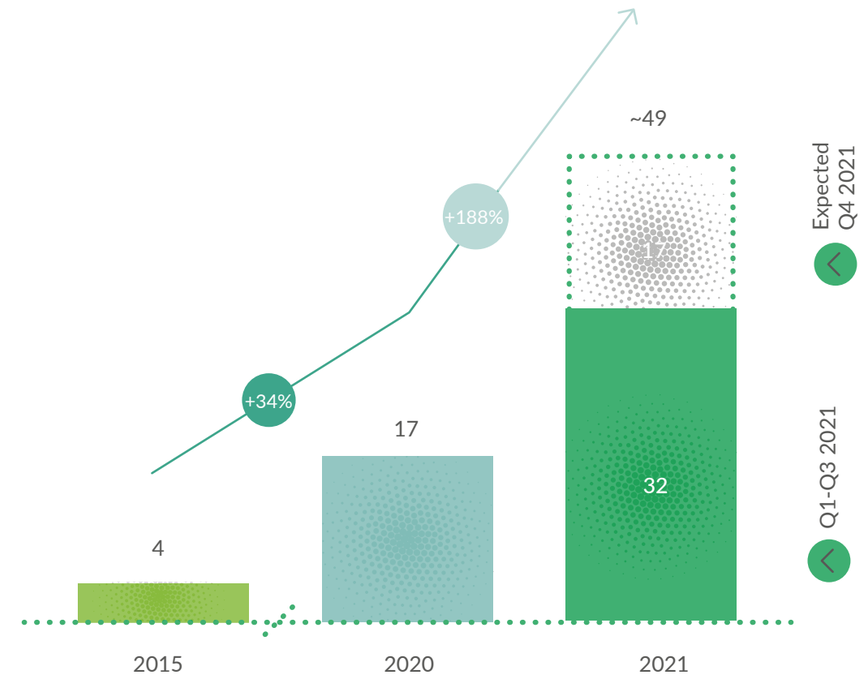
Figure 10: Full impact of fashion/apparel companies

Investors need to take a longer-term horizon:

Venture capital investment in climate technology is growing five times faster than the average rate of investment across all industries. Climate investment soared from $418 million in 2013 to $17 billion in 2020.

We identified more than 75 funds that are already taking a variety of approaches to climate investment, including focusing on general climate technology, high-impact technology, vertical technology, and deep technologies (see Figure 12).[31] But all this money is still fraction of the estimated $1.5 trillion in private equity and venture capital that was available in 2020.

Figure 11: Venture capital investment climate tech is growing at 5x average growth rate across all industries



30+ Green Unicorns Valued >$1 Billion

- Octopus Energy
- Beyond Meat
- Impossible
- Northvolt
- Pivot Bio
- SILA Nanotechnologies
- Arrival
- OVO
- Apeel
- Tesla
- Grove
- Plenty
- Redwood Materials

Figure 12: Recent large deals in climate tech

Company	Description	Funding Date	Funding Amount	Post Valuation
Northvolt	Lithium-ion battery for EV	09-06-21	2,750	11,750
Rivian	Electric vehicle manufacturer	19-01-21	2,650	27,600
SVOLT	Lithium-ion battery for EV	30-07-21	1,586	5,589
Weltmeister	Electric vehicle manufacturer	09-09-20	1,470	
Redwood Materials	Sustainable battery technology	18-08-21	777	3,777
Enovate Materials	Electric vehicle manufacturer	13-10-20	736	
Leapmotor	Electric vehicle manufacturer	12-07-21	696	
Didi Bike	Bike sharing platform	19-02-21	600	
SILA Nanotechnologies	Battery technology for EV	07-01-21	590	3,300
Li Auto	Electric vehicle manufacturer	24-06-20	550	4,050
Indigo Agriculture	Microbiomes to improve crop yield	22-06-20	535	2,755
Guangzhou Ziaopeng Motors Technology	Electric vehicle manufacturer	20-07-20	500	
Swell (Energy Storage)	Solar energy, storage and VPP	10-12-20	450	
BETA Technologies	Electric planes	24-05-21	426	1,458

The various segments of the investment community can do more. Venture capital funds, and their limited partners, can expand their comfort zones to adopt the kind of problem-focused approach taken by most climate innovation ventures. For example, Flagship Pioneering applies a hypothesis-driven innovation processes based on existing technologies to imagine products or reimagine value chains. It helped start or nurture more than 100 scientific ventures, resulting in over $34 billion in aggregate value.

Deep tech investors also need to reset their expectations – which does not necessarily mean accepting lower returns. They can extend fund lifetimes to allow sufficient time for R&D to be de-risked and the resulting products to launch. They can recognize the greater complexity of technology and business models involved and spread their investments across technologies and sectors. They will also need to fill gaps in skills and understanding of technology by building inhouse expertise & networks. For example, Breakthrough Energy Ventures is a fund with a 20 year time horizon backed by Bill Gates and other notable limited partners, including Xavier Niel, Jeff Bezos, Jack Ma, Masayoshi Son, Richard Branson, Michael Bloomberg, and Vinod Khosla. It was created in 2016 and after having backed 45 startups with it's first billion dollars, it raised another billion dollars to pursue this mission. About 90% of its portfolio consists of deep tech ventures geared toward climate change or sustainability goals.

More funds are combining investment with active support and assistance. SOSV, which invests in about 150 new startups a year, has an accelerator programs that includes a network of 1,000 global mentors and an alumni community of more than 2,000 founders around the globe who have deep market and technical expertise. The program provides access to an extensive infrastructure of laboratory and maker spaces, and SOSV introduces start-ups to sector-specific corporate partnerships and later stage venture firms focused on the same verticals.

For their part, private equity firms can emphasize the SDG impact of climate tech ventures to their investors and the companies that they invest in. Blackrock's CEO, Larry Fink, took a big step in this direction when he wrote to company CEOs in 2020 that "Climate change has become a defining factor in companies' long-term prospects." Private equity managers can de-risk their portfolios with ventures that will inevitably disrupt incumbents and shift or create new value pools. They can also fill gaps in skills and understanding of technology by building in-house expertise & networks. Sweden's EQT Partners, for example, describes itself as "a purpose driven global investment organization" that has "decided to align all investment decisions in support of achieving the United Nations Sustainable Development Goals (SDGs) as well as ownership actions to drive the development of the portfolio companies in this direction."

Public equity and debt managers will also have a part to play, as once technology and market risks have been overcome, climate tech can shift from equity-based financing to debt, enabling greater capital firepower. Public equity could already take on greater risk in investing in climate tech, driven by environmental and societal good, but in the future the potential for 'safer' investment will be ever greater. Even today, Generation Investment has worked to overcome risk by adopting an approach based on a decision-making process that fully integrates sustainability analysis and a focus on long-term performance, allowing for significant investment into this space.

These examples all show the potential for a new investor archetype for climate technology, which draws upon the successes of pioneers in this space. The ideal investor archetype would bridge the gap between traditional venture capital and private equity, and have a longer fund lifetime, stretching from around 15 to 20 years, to provide sufficient time to de-risk R&D and launch products. This would also require a goal and returns narrative that focuses more on longterm value creation across a broad range of stakeholders than on short-term cashflows and immediate returns. The stakeholders involved would need to be involved in a mixed shareholding structure to generate the greatest buy-in across the ecosystem, combining governments, funds, and corporates, and the archetype would need more flexible financing vehicles, such as rolling funds or SPACs. To achieve the greatest chance of success, the ideal investor archetype would build deep technical capabilities through multi-disciplinary teams, including scientists and environmental regulators. This talent would then help set KPIs that were appropriate for the specific circumstances of deep tech climate ventures, circumstances which include higher barriers to market entry and complex climate issues.

This investor archetype requires support from key stakeholders along the venturing and financing journey. Governments and institutions would be needed to provide or incentivise R&D funding, innovation hubs and talent production, and would, perhaps only initially, need to subsidise industry segments to give these investors the greatest possible chance for success. Private equity firms, pension funds and sovereign wealth funds across the market would need to provide support in de-rising the market and supporting growth and scale, including catalysing future M&A trends. Corporates would also need to provide support by committing to greater climate tech investment so that they can act as an accelerator for go-to-market and partnerships.

Entrepreneurs will lead the charge:

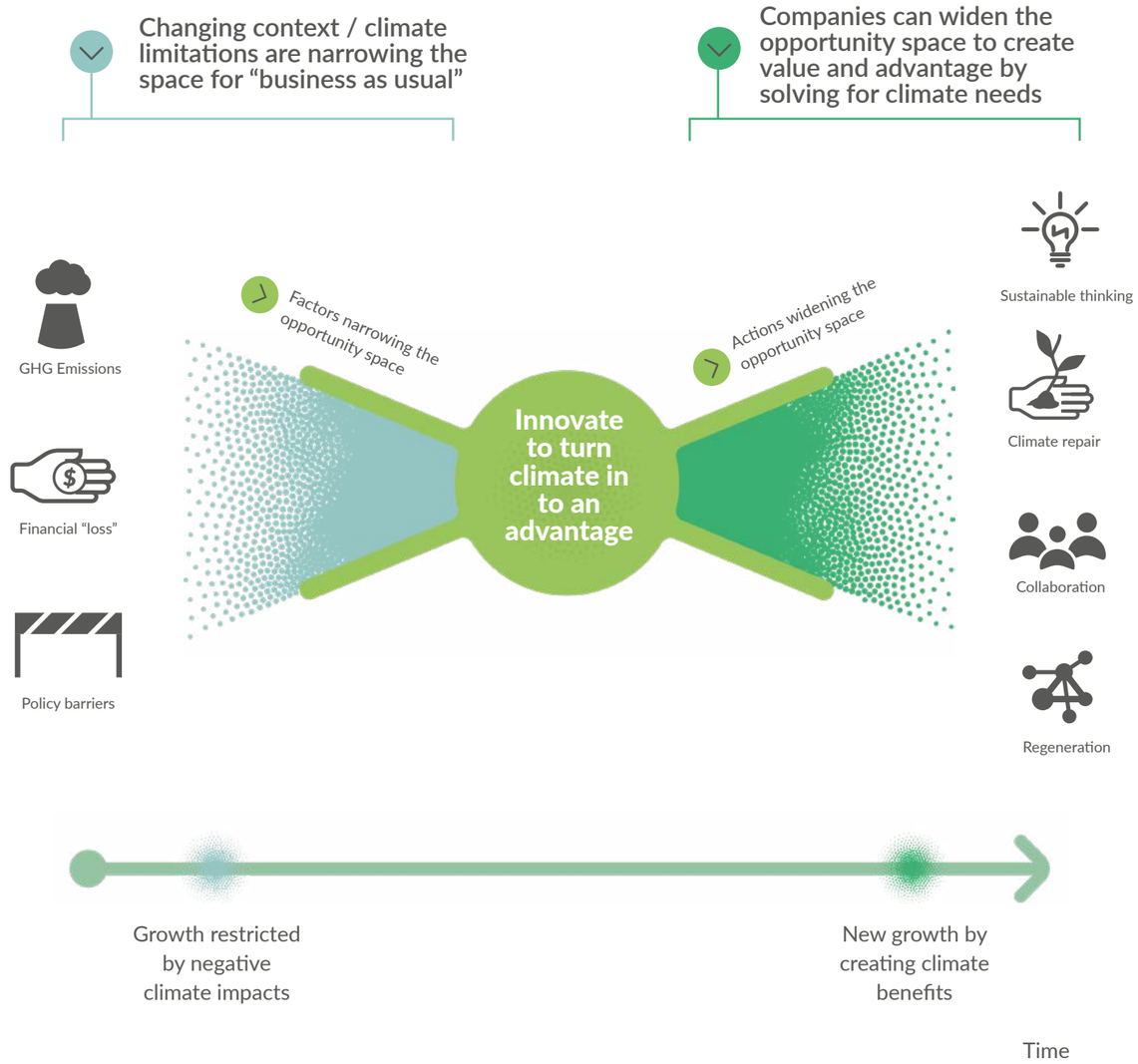
Climate innovation will be led primarily by entrepreneurs, whether within existing companies or externally. This means that corporates have a major role to play in fostering entrepreneurship and can reap the benefits of this in return.

To encourage entrepreneurship and innovation internally, corporates can use four key techniques. Firstly, they can embed climate purpose into their core mission and ensure leadership is bought-in, meaning those with entrepreneurial ideas in this space feel that their company's purpose will support them to develop their innovations. Secondly, corporates can invest into long-term R&D to enable a greater understanding of scientific and engineering breakthroughs and begin to build their own climate solutions. Thirdly, they can revisit fundamental problems and customer needs to arrive at new solutions and value pools, such as looking again at the customer journey and developing climate friendly solutions to existing pain points. Finally, corporates can foster internal entrepreneurship by creating programs or events that bring companies closer to the start-up and academic environment, such as creating accelerators, or speaker sessions.

Corporates can also capitalise on the opportunities presented by fostering external entrepreneurship. This could involve playing a strategic role in supporting entrepreneurs enter traditional industries with high barriers to entry, such as in the energy sector, or providing commercial know-how, deep market knowledge and ecosystem networks to test, adopt and scale new solutions. By supporting external entrepreneurs, corporates may get access to vital knowledge and expertise, or reap more direct financial benefits. Corporates could also develop more formal and proactive models of engagement to invest, incubate and partner during earlier development stages via tools such as innovation grants, business alliances, partnerships, accelerators, or direct investments. These models can also provide companies with clear rewards for their role in fostering entrepreneurship.

For corporates and other organisations, however, this will likely require a shift in mindset. Firstly, thinking must change from 'problem-first' to 'needs-first'. Where before organisations may have started with a problem, then tried to reduce it, they will now need to start with a clear need (in this case limiting global warming to 1.5°C), and then search for compatible solutions. It will also need a transformation from trying to use existing solutions and strengths, towards new option spaces, technologies and scientific advances to unlock previously nonexistent value. Secondly, organisations will need to use design thinking to find the product market fit. This may involve a Design, Build, Test and Learn process driven by new economics at each stage of innovation to reduce prototyping cost and time as well as technological and market risk. Finally, organisations should shift their mindset from the perspective that climate considerations hinder progress and limit growth, to the recognition that by widening the opportunity space companies can create value and advantage by solving for climate needs.

Figure 13: But it requires a change in mindset...



4

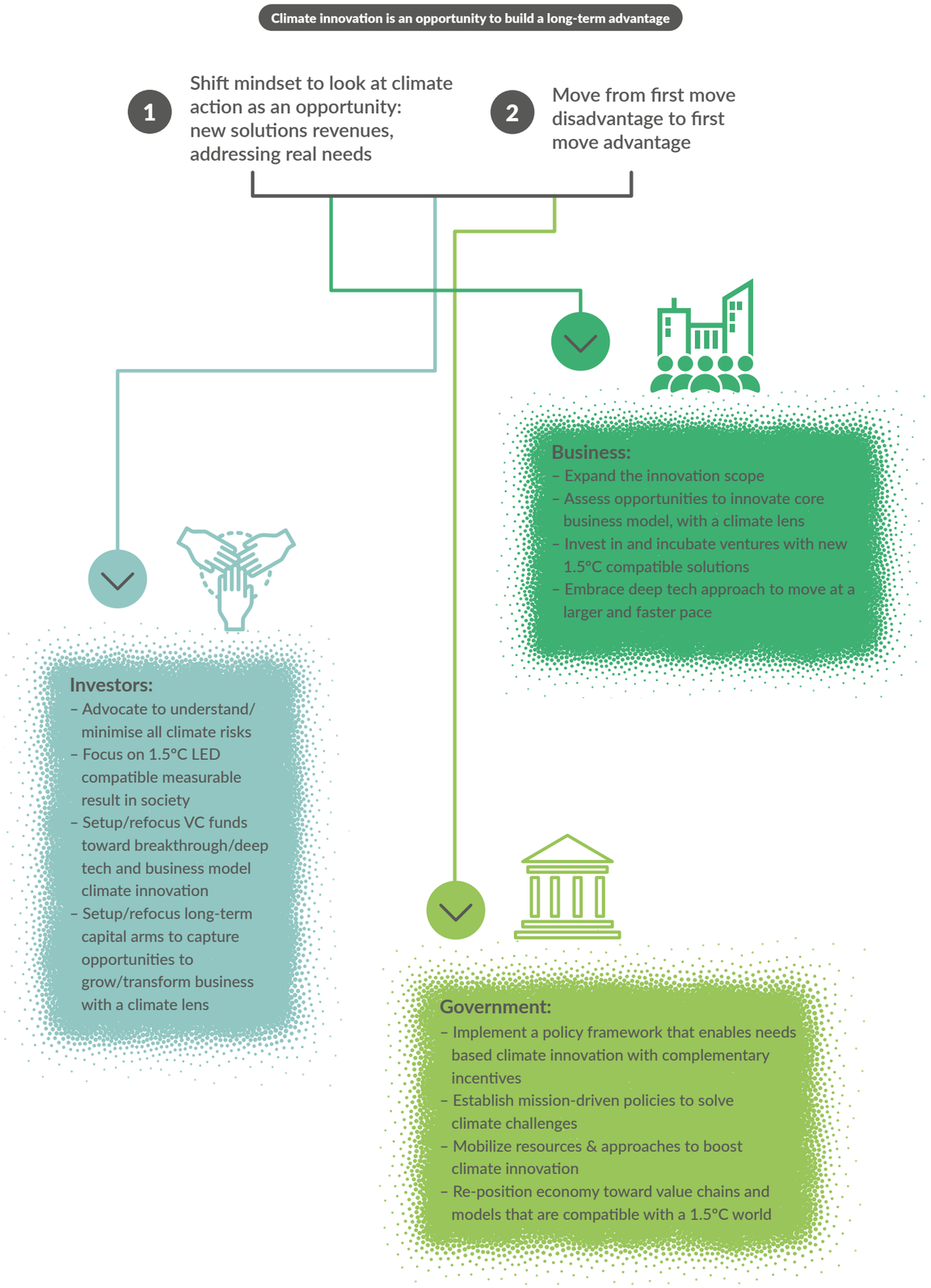
CONCLUSIONS AND ACTIONS

Climate innovation is an opportunity to build a long-term advantage

Recommendations:

Until now, many companies, governments and investors have seen climate actions and considerations as a hindrance; meeting targets may limit their growth, increase costs and see them fall behind competitors. However, evidence of climate innovation across the ecosystem has demonstrated that climate innovation should in fact be seen as a major opportunity to build longterm success and advantage. This can be done in two crucial ways. Firstly, organisations should shift their mindset to view climate action as an opportunity. Climate innovation can bring new offers, revenues, and solutions to address real needs. Secondly, organisations should not wait to act, and should consider that taking climate action will provide first move advantage, as demonstrated by the success of climate ventures so far.

This will mean something different for three different types of entities – businesses, investors and governments – who must act in concert to achieve decisive climate action.



Businesses should expand their innovation approach to capitalise on opportunities

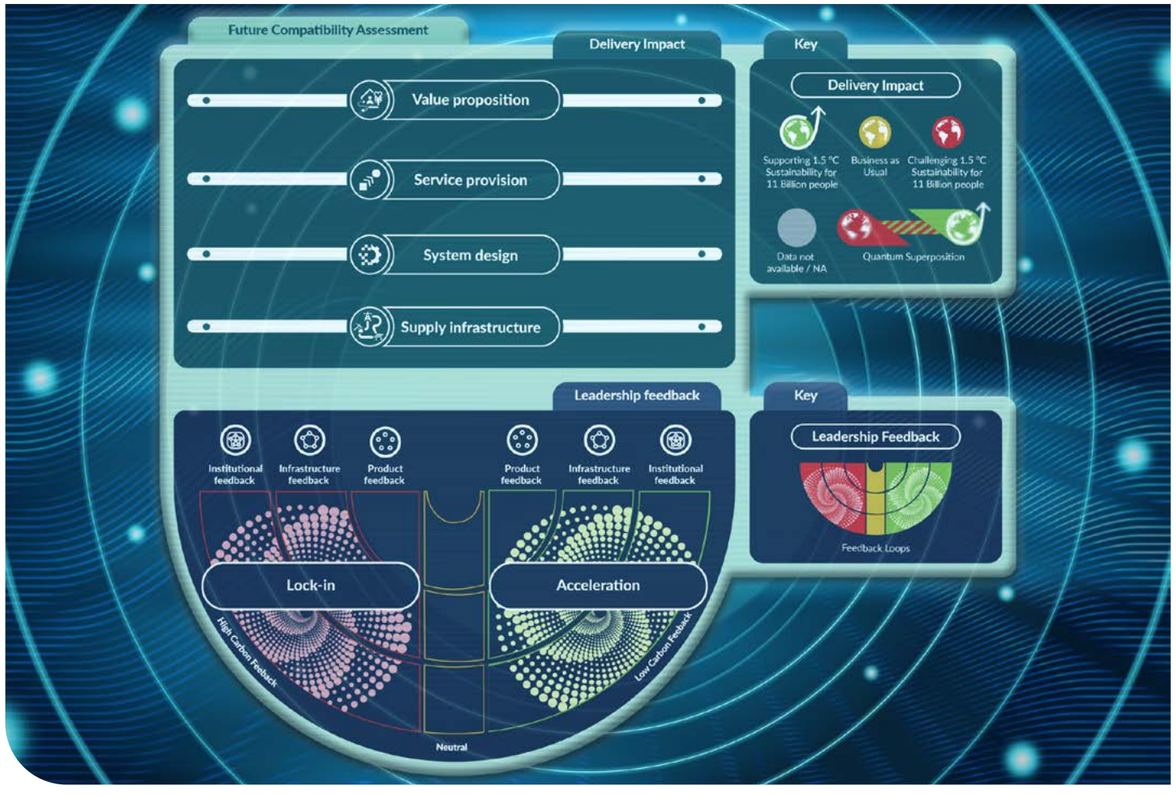
Businesses will need a mindset shift, seeing climate action as an opportunity rather than a limiting factor. By encouraging both internal and external entrepreneurship, corporates will be able to reap the rewards of climate action, rather than feel stymied by climate considerations. Initially, businesses should expand the innovation scope for 1.5°C compatible action, using the Climate Solution Innovation Matrix to identify current and future innovation opportunities, and using the expanded scope to encourage internal entrepreneurship.

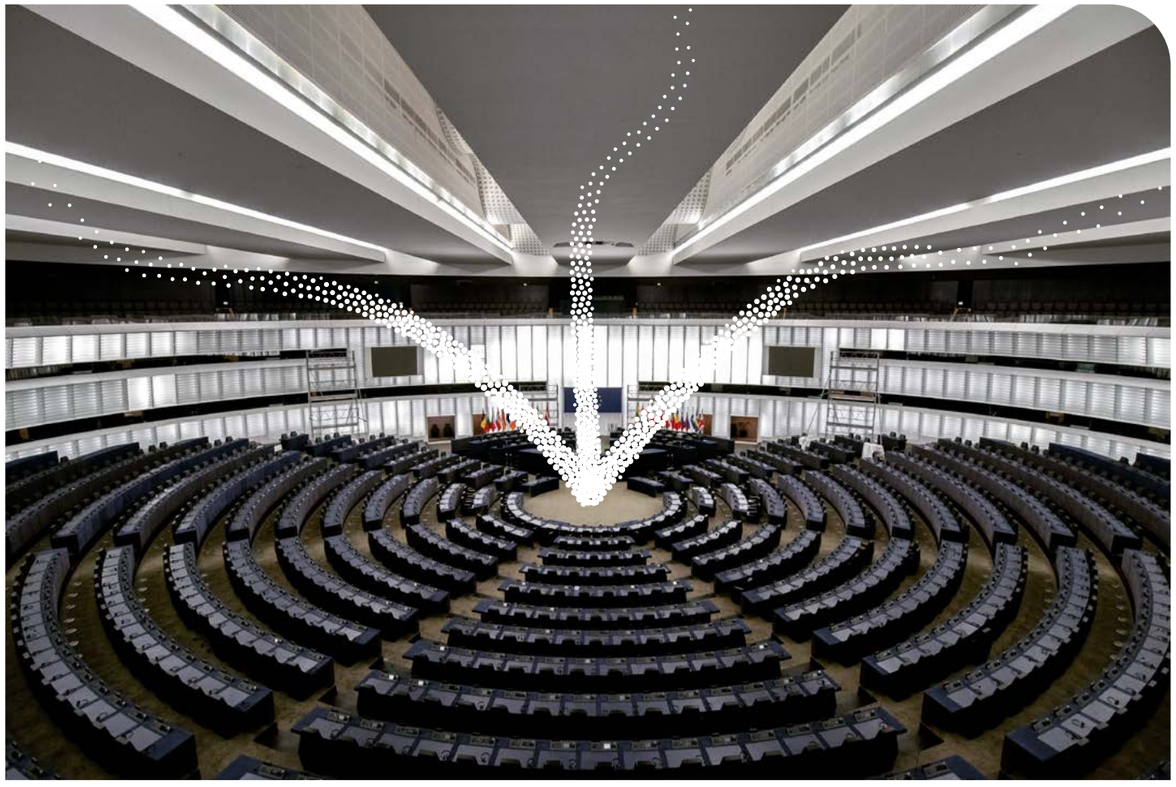
For example, by placing bets in all quadrants of the matrix, IKEA is both creating long-term opportunity and fostering innovation across the board. Businesses could also use this opportunity to assess whether there are ways to innovate their core business model. This may include leveraging the Climate Solution Innovation Canvas to assess how customer needs can be met in climate positive ways, and will result in innovation to remove any pain points. Businesses should embrace the deep tech approach to move at a larger and faster pace, scanning regularly for exponential technologies to enable deep tech innovation. VINCI has used this approach, putting initiatives in place to fast track entrepreneurship, identify growth opportunities and support the scale up of new technologies. Finally, businesses can foster external entrepreneurship, by investing in, incubating and scaling ventures with new 1.5°C compatible solutions. ABB, for example, fosters open innovation with an accelerator program, enabling entrepreneurial start-ups to access its expertise, network & facilities.

Investors should view climate innovation investment as an opportunity for growth:

There is a great opportunity for investors to see notable returns both short-term, but more significantly, over a longer timeframe. It will require decisive action from investors to capitalise on this opportunity.

Firstly, investors should advocate to understand and minimise climate risk, such as committing to reporting ESG and climate risks via industry-recognised bodies such as the TCFD. Blackrock is an investor who is already utilising this approach, integrating ESG into every investment practice, and working hard to increase transparency. Investors should also seek to ensure 1.5°C LED compatible measurable results in society, by moving beyond carbon content in portfolios and greening of instruments towards impacts on society. This may include MI's NCI leading methodology for the assessment of avoided emissions and 1.5°C compatibility. Next, investors should refocus their capital arms to capture opportunities to grow or transform businesses, using the Climate Solution Innovation Matrix to assess where to focus capabilities and investments. EQT has adopted this approach, explicitly building their investment philosophy around a dual mandate of creating financial returns alongside climate impact. Finally, investors should use owner directives to support a shift towards solution innovation via clear targets and reporting following the Climate Solution Innovation Matrix & Canvas. For example, Formica Capital has been exploring owner directives with the requirement of reporting and targets for positive societal impact. These actions will provide investors with new opportunities for growth and contribute to the wider ecosystem of climate innovation.





Governments should change policy to present opportunities from climate action:

Governments should play a key role in shifting the mindset towards climate innovation by adjusting policy frameworks to encourage and incentivise action across the ecosystem.

Firstly, governments should implement a policy framework that enables needs-based climate innovation with complementary incentives. This could be done by leveraging the Climate Solution Innovation Matrix for regulations to incentivise systemic transformative action, beyond carbon pricing, as seen in the EU, for example, where the EU Green Deal implements a comprehensive set of needs-based policy instruments, with the goal to make EU an exporter of low carbon solutions. Next, governments should shift from industry-specific policies to mission-driven policies to solve climate challenges, which could result in a plethora of indirect but related technological advancements. Governments should also mobilise resources & approaches to boost climate innovation, including increasing R&D funding, creating innovation hubs and bosting capabilities. In China, for example, the government supports its 2060 net-zero goal with strong support including substantial R&D funding and tech innovation parks linked to an export strategy. Finally, governments should adjust policy to re-position the economy toward value chains and models that are compatible with a 1.5°C world, using policies such as subsidies to support potential "green champions" in all quadrants of the climate solution canvas. This has been well-demonstrated by Germany, where the government has agreed on a national hydrogen strategy to build up industrial generation facilities with a capacity of 5GW by 2030.

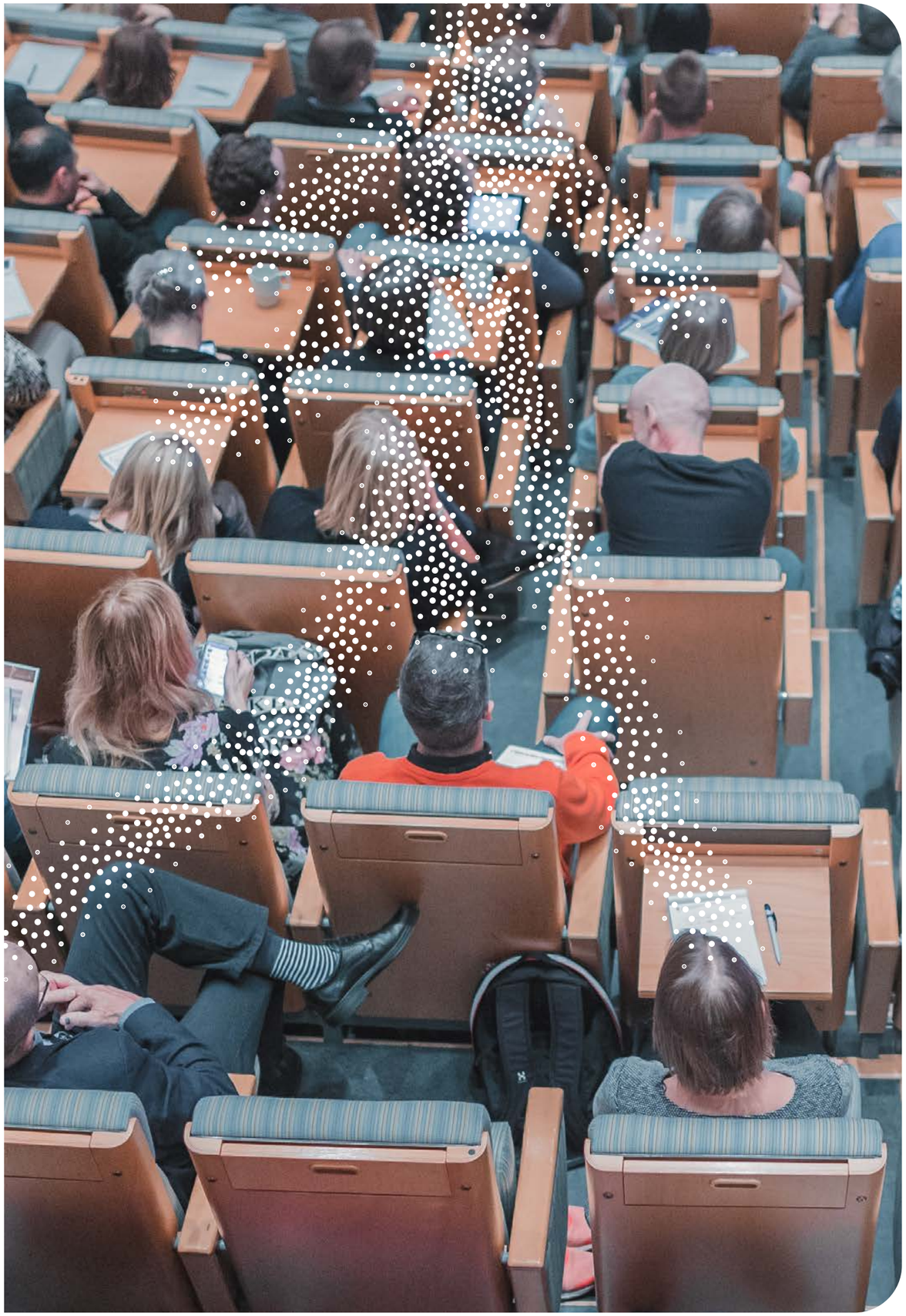
Entities across the ecosystem:

The benefits of a concerted effort for individual organisations are clear: an ecosystem gives organisations the ability to overcome technical, economic, or other structural barriers that come with long-term technology development via pooling resources and investment; ecosystem action can generate a demand signal through joint pledges, and kickstart the competitive playing field needed for other companies to take action; and coalitions can coordinate support for more ambitious climate policies and build pressure for emission reductions.

To reap these benefits, organisations will need to work together. Specific actions to do this may include partnering with similarly climate-ambitious organisations, creating joint pledges, or forming coalitions across governments, businesses, and investors.

Although even acting alone will present significant opportunities for organisations, for solutions to truly impact our climate, the entire ecosystem will need to work in concert, and at speed. The global response to the COVID-19 pandemic has shown how quickly and forcefully we can move when called to effective action. Few would have predicted a year ago that discovering, developing, and bringing to market not just one but multiple vaccines in fewer than 12 months was remotely achievable. By harnessing the power of science and advanced technology, entrepreneurship, smart policy, investment and the collaborative efforts of the ecosystem, we proved that radical progress is possible.

Climate solution innovation is no less urgent. And it offers an enormous opportunity to build economic models and individual company advantage for the long term. Businesses, investors, and governments all need to act now.



REFERENCES AND SOURCES

Business references:

Re-engineer:

1. Neste: Pivot to renewable fuels and chemicals
2. Yara: Digital farming solutions
3. Tata Energy: Setting up renewable microgrid network
4. Schneider Electric: Digital energy mgmt. platform

Re-boot:

1. SILA Nanotechnologies: Engineer materials to improve lithium-ion battery technology
2. Equinor: Floating off-shore wind technology
3. Form Energy: Ultra-low-cost, long-duration renewable energy storage

Re-imagine:

1. Didi Chuxing: Leading the revolution in transportation and automotive technology
2. Indigo AG: Terraton carbon marketplace
3. Octopus Energy: Digital platform to provide easy access to 100% renewable energy
4. Pachama: AI to protect ecosystems, restore forests and modernize carbon market

Invent:

1. Memphis Meats: Cell based meat
2. Joyn Bio: Nature co-design: ammonia
3. Commonwealth Fusion Systems: Commercialization of fusion energy
4. Climeworks: Direct air capture (DAC) and storage
5. SK batteries: Big bet in climate tech
6. China solar PVs: Big bet in climate tech
7. Pivot Bio: Nature co-design: ammonia
8. C16 Biosciences: Nature co-design: palm oil alternative
9. Geltor: Nature co-design: collagen production

Input from multiple interviews:

1. Tata Energy: Set-up of a renewable microgrid network'
2. Yara/AtFarm: Digital farming solutions
3. Indigo AG: Terraton carbon marketplace
4. LafargeHolcim: Net-zero construction and materials
5. Gingko Bioworks: Nature co-design; supported in C-19 vaccine
6. Breakthrough Energy: Supply-side tech innovation
7. EQT: Input to investor climate innovation
8. Mission Possible: Setup of horizontal cross-sector initiative
9. Strategyzer: Frameworks for business innovation
10. Gates Ventures: Approach to energy breakthrough innovation
11. UK Gov – BEIS: Energy Innovation Fund

External Sources:

1. SBMI: The Quest for Sustainable Business Model Innovation, BCG, Mar 2020
2. SBMI: Winning the '20s: Optimize for Social & Business Value, BCG, Jun 2019
3. SBMI: Building Competitive Advantage in a Sustainable World, BCG, Aug 2020
4. SBMI: Why the New Competitive Advantage Demand Sustainability, BCG, Oct 2020
5. Climate Innovation: Mission Innovation Framework Documents: Modules 1,2 and 3, Mission Innovation
6. Case for Action: The Net-zero Challenge: Fast-Forward to Decisive Climate Action, WE, Jan 2020
7. Tech: Fit For Net-Zero: 55 Tech Quests to accelerate Europe's recovery and pave the way to climate neutrality, Capgemini, Oct 2020
8. Tech: The State of Climate Tech 2020: The next frontier of venture capital, PWC, Sep 2020
9. Companies & Tech: Tough Tech: We can fix it – The founders, investors corporations and policies helping solve climate change , The Engine, MIT, Fall 2020
10. Policy: The Ten Point Plan for a Green Industrial Revolution, HM Government, Nov 2020
11. Policy: Why carbon pricing is not sufficient to mitigate climate change—and how "sustainability transition policy" can help, PNAS Opinion, Apr 2020
12. Policy: Here's how the US government can lead the word on climate change innovation, Gates Notes, Dec 2020
13. Policy: Korea's Green Growth Experience: Outcomes, Policy and Lessons Learned, Global Green Growth Institute, 2015
14. Policy: How COVID-19 Is Changing the Pace of Energy Transitions, BCG, Sep 2020
15. Investment Models: A running list of Climate Tech VCs, Climate Tech VC, Nov 2020
16. Investment Models: Draft 2025 Target Setting Protocol: U.N.-convened net-zero asset owner alliance, PRI, Finance UNEP Initiative, WWF, M2020, Oct 2020
17. Finance Sector: Our Planet: Too Big To Fail, WWF, 2019
18. Corporates: The role of business in climate change, FT, Dec 2020
19. Sustainable Companies: Who Are The 100 Most Sustainable Companies Of 2020?, Forbes, Jan 2020
20. Startups: Top VCs name the 46 climate-tech startups to watch in 2021, Business Insider, Jan 2021
21. Corporates: What will it take for the 75% of companies that don't have climate commitments to step up?, Fast Company, April 2020
22. Innovation: Lessons from Tesla's Approach to Innovation, HBR, Feb 2020
23. Innovation: IKEA: Making a $40 Billion Company Climate Positive, HBR, Dec 2020
24. Corporates: Leading a New Era of Climate Action, HBR, Jan 2020
25. Corporates: Tough Business Questions About the Climate Crisis, HBR, Jan 2020
26. Corporates: What Do People Really Believe About Climate Change?, HBR, Jan 2020
27. Corporates: Your Company's Next Leader on Climate Is…the CFO, HBR, Jan 2020

ENDNOTES

1. https://unfccc.int/topics/un-climate-change-global-innovation-hub
2. https://media-publications.bcg.com/bcg-executive-perspectives-inside-cop26-kickstarting-decade-of-delivery.pdf
3. http://mission-innovation.net/
4. https://unfccc.int/climate-action/race-to-zero-campaign
5. https://www.ipcc.ch/sr15/
6. https://www.ipcc.ch/sr15/chapter/spm/
7. https://ceiic.socialalpha.org
8. https://www.misolutionframework.net/pdf/report-incubators_accelerating_1_5c_climate_compatible_start-ups_with_picu.pdf
9. https://netpositive.world/
10. https://icca-chem.org/wpcontent/uploads/2020/05/addressing-the-avoided-emissions-challenge.pdf
11. https://gesi.org/research/smarter2030-ictsolutions- for-21st-century-challenges
12. https://www.unepfi.org/wordpress/wp-content/uploads/2021/10/aoa-progress-report-2021.pdf
13. https://www.skygroup.sky/article/behaviour-change-on-climate-can-be-driven-by-tvsays-sky , https://www.purposedisruptors.org/advertised-emissions
14. https://climatesmart.citieschallenge.org/
15. https://www.bcg.com/en-us/publications/2020/how-china-can-achieve-carbon-neutrality-by-2060
16. https://hbr.org/2019/12/real-innovation-requires-more-than-an-rd-budget
17. https://orsted.co.uk/about-us/worlds-most-sustainable-energy-company
18. https://www.aerofarms.com/
19. https://www.bcg.com/capabilities/digital-technology-data/emerging-technologies/deep-tech
20. https://www.strategy-business.com/feature/what-the-top-innovators-get-right
21. https://www.ideatovalue.com/inno/nickskillicorn/2019/08/top-1000-companies-that-spend-the-most-on-research-development-charts-and-analysis/#fortune500
22. https://hbr.org/2020/01/the-new-business-of-garbage?ab=seriesnav-bigidea
23. https://www.cdp.net/en/climate/carbon-pricing
24. https://history.nasa.gov/sp-4219/chapter8.html
25. https://www.wired.co.uk/article/government-moonshots
26. https://www.linkedin.com/pulse/heres-how-us-can-lead-world-climate-change-innovation-bill-gates/
27. https://www.weforum.org/reports/the-net-zero-challenge-fast-forward-to-decisive-climate-action
28. https://www.businessinsider.com/hm-ceo-climate-activism-threat-to-fast-fashion-bloomberg-2019-10?r=US&IR=T
29. https://api.houdinisportswear.com/storage/Houdini_Regenerative-Lifestyles-Halfearth-1_0.pdf
30. https://www.sciencedirect.com/science/article/abs/pii/S1066793800800640
31. https://climatetechvc.substack.com/p/-a-running-list-of-climate-tech-vcs
28. Circular Models: The New Business of Garbage, HBR, Jan 2020
29. Corporates: A Better Way to Talk About the Climate Crisis, HBR, Jan 2020
30. Corporates: Is Your Trade Group Blocking Climate Action?, HBR, Jan 2020
31. Innovation: Fermentation can help build a more efficient and sustainable food system – here's how, WEF, Nov 2020
32. Innovation, Rethinking Food and Agriculture 2020-2030, Rethinkx, Sep 2019
33. Innovation: European truckmakers to phase out diesel sales decade earlier than planned, FT, Dec 2020
34. ESG Investing: Companies That Fail to Measure Impact Will Be Left Behind, This Investor Warns, Barrons, Nov 2020
35. Finance Sector: A Fundamental Reshaping of Finance, Blackrock, Jan 2020
36. Finance Sector: Blackrock 2021 Stewardship Expectations, Blackrock, Dec 2020
37. Reporting: Sustainability Reporting: Convergence to Accelerate Progress, Blackrock, Oct 2020
38. Reporting: Task Force on Climate-related Financial Disclosures Forward-Looking Financial Sector: Metrics Consultation, TCFD, Oct 2020
39. Fossil Fuel Financing: Banking on Climate Change – Fossil Fuel Finance Report Card 2020, BankTrack, Mar 2020
40. Policy: Special Report: Global Warming of 1.5°C, IPCCC, Mar 2020
41. Innovation: Vinci in a Nutshell: Innovation For A Sustainable World, Vinci, Jun 2018
42. Policy: To change the world, governments need to launch new moonshots, Wired, Jul 2019
43. R&D: What the top innovators get right, PwC, Strategy&, Oct 2018
44. Policy: FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies, The White House, Apr 2021
45. Investment Models: Climate-Tech VC Investing Tops $17bn in 2020, Bloomberg NEF, Mar 2021
46. Investment Models: Why investors are raising climate tech funds at a torrid pace, Pitchbook, July 2021
47. R&D: The Cost of Sequencing a Human Genome, National Human Genome Research Institute, Nov 2021
48. Corporates: Neste's renewable products helped customers to reduce greenhouse gas emissions globally by 10 million tons in 2020, Neste, Feb 2021
49. Corporates: Neste RE enables a future where all plastic products can be made of renewable and recycled materials – and the future starts today, Neste, Nov 2020
50. Corporates: CNBC DISRUPTOR 50- 34. Sila Nanotechnologies, CNBC, May 2021
51. Investment Models: China's Didi raises $4.4 bln in upsized U.S. IPO, Reuters, Jun 2021
52. Policy: House Passes Historic Climate Action in Build Back Better Act, NRDC, Nov 2021
53. Investment Models: Bill Gates-Led Fund Raises Another $1 Billion to Invest in Clean Tech, Bloomberg, Jan 2021

MISSION INNOVATION

mission-innovation.net

Dennis Pamlin
Head, Mission Innovations, Net-Zero Compatible Innovations Initiative

Jakob Dahlgyist
Project Leader, Mission Innovations, Net-Zero Compatible Innovations Initiative

RI.SE

misolutionframework.net

Jay Hennessy
Senior Project Leader, Mission Innovations, Net-Zero Compatible Innovations Initiative

Andreas Johansson
Thought-leader support, Mission Innovations Net-Zero Compatible Innovations Initiative

BCG

BCG Green Ventures

bcg.com/en-gb/

Marco Duso
Partner, London

- Founding team of BCG Green Ventures, leading in
- UK and Europe
- Extensive experience in climate tech
- WEF Fellow, Climate Action

Kanika Chandaria
Venture Architect Lead, London

- Founding team and acting COO of BCG Green
- Ventures

Raju Sarma
MD & Partner, Manhattan Beach

- Leads BCG Green Ventures globally
- Part of original BCG Digital Ventures
- founding team

Jesper Nielsen
MD & Senior Partner, London

- Leads BCG Climate & Sustainability in Europe,
- Middle East, Africa , South America

Cornelius Pieper
MD & Partner, Boston

- Founder BCG Centre for Climate Action,
- supporting clients with transition to a low-
- carbon economy

Michel Fredau
MD & Senior Partner, Paris

- Global head of climate & environment

February 2022