THE GENEVA ASSOCIATION

INSURANCE FOR A BETTER WORLD

CLIMATE TECH FOR INDUSTRIAL DECARBONISATION: What role for insurers?

January 2024

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Maryam Golnaraghi, Director Climate Change & Environment, The Geneva Association

Contributing author:

Ignacio Belanche-Guadas, Research Intern Climate Change & Environment, The Geneva Association

The Geneva Association

The Geneva Association was created in 1973 and is the only global association of insurance companies; our members are insurance and reinsurance Chief Executive Officers (CEOs). Based on rigorous research conducted in collaboration with our members, academic institutions and multilateral organisations, our mission is to identify and investigate key trends that are likely to shape or impact the insurance industry in the future, highlighting what is at stake for the industry; develop recommendations for the industry and for policymakers; provide a platform to our members and other stakeholders to discuss these trends and recommendations; and reach out to global opinion leaders and influential organisations to highlight the positive contributions of insurance to better understanding risks and to building resilient and prosperous economies and societies, and thus a more sustainable world.

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Foreword

Limiting the global average temperature rise – and avoiding a climate catastrophe – will require transformation of a magnitude far greater than any humankind has ever undertaken.

Individual behavior modifications to minimise one's carbon footprint – such as reducing air travel – are important. But even the most successful version of these efforts will not be sufficient. Change is in the hands of big industries such as steel, cement, aluminum, aviation, shipping and trucking, which together contribute over 30% of global carbon emissions.

The transformation will require new technologies – and they will need to be deployed at scale. It is estimated that an annual investment of USD 7–9.2 trillion is needed to fund global decarbonisation.

What can insurers do? As this report lays out, through research findings and the results of a survey of C-level insurance executives, insurers have two main roles.

The first is risk management and underwriting: assessing project risks at an early stage and growing the body of data on climate tech risks are key to insuring them and to attracting the massive investment needed.

The second role of insurers is investing. Insurance companies have already become major investors in commercialised technologies like wind and solar power and green hydrogen. Increased investment is needed, however, in technologies which are at an earlier development phase as well.

Risk expertise and capital are not the only missing pieces. We also need policies that incentivise investment in and demand for low-carbon technologies. Regulatory frameworks and codes of practice will facilitate project replication. And, of course, collaboration – not only within transitioning industries, but also across stakeholder groups – will be essential to realising the unprecedented transformation needed for our resilient future.

Jad Ariss
Managing Director
The Geneva Association

Executive summary

The commercialisation and wide-scale deployment of new climate technologies must be expedited to achieve industrial decarbonisation.

In a series of recent reports, the Intergovernmental Panel on Climate Change detailed how close the world is to missing the 1.5°C global warming target and the need to reduce global emissions to achieve net zero by 2050. Surpassing the 1.5°C threshold could significantly increase the severity of climate-related impacts, highlighting the need for a well-planned, whole-of-economy approach to limiting the global average temperature increase over the next few decades.

This will require decarbonisation of the global economy within a short timeframe. While there has been some progress, the world has reached a critical moment for transformative action. Globally, substantial efforts are underway to expedite the decarbonisation of heavy industries, such as steel, aluminium, cement and aviation, which contribute to over 30% of global carbon emissions. Reducing greenhouse gas (GHG) emissions across sectors such as these requires the commercialisation and wide-scale deployment of a range of new climate technologies in the coming decade.

The annual investment gap between now and 2050 to fund this transition stands at USD 7–9.2 trillion. Closing this gap will require massive amounts of private capital; relying solely on public capital will not be sufficient. A significant portion of transition funding needs to be deployed towards financing climate tech innovation, commercialisation and market readiness.

Many of the climate technologies essential for industrial decarbonisation, such as green hydrogen, long-term energy storage and carbon removal (point source or direct air capture and storage), are still in the pre-commercialisation stages. Demonstrating and deploying these new technologies, which come with new, untested risks, is capital intensive. Their wide-scale commercial deployment also requires the development of standards and codes of practice for industry adoption and replication, which takes time.

Suitable risk management frameworks and related insurance solutions will be critical to mobilising the necessary capital for demonstration projects and ultimately enabling the commercial deployment of climate technologies.

Innovative risk management frameworks and insurance solutions will be critical to mobilising the capital needed for demonstration projects and commercial deployment.

To explore how re/insurers, as risk managers and investors, can help in this space, The Geneva Association launched the research project *Accelerating Climate Technologies for Industrial Decarbonisation and the Insurance Industry*. The outputs of this work are presented in two reports.

This first report sets the scene by describing the current climate tech landscape, and the challenges and opportunities associated with expediting the commercialisation and market readiness of new climate technologies, as well as the potential role of re/insurers. It offers perspectives from key stakeholders and insurance C-level executives on the benefits of and difficulties with engaging re/insurers in climate tech commercialisation from an early stage. The second report will address how such engagement can be achieved and present a novel 'Insurability Readiness Framework' (IRF), which provides a structured questionnaire for framing risks and related data needs through an insurance lens from the early phases of project development for any climate technology. The report will also demonstrate the use of the IRF for green hydrogen and carbon removal and storage projects.

Key findings of this report

- The traditional climate tech commercialisation pathway – the 'Technology Readiness Level' framework – does not consider a number of factors that hinder market readiness. As a result, wide-scale commercial deployment may be delayed or full market-deployment potential may not be realised.

- The development of industrial-scale pilot projects to demonstrate the viability of new climate technologies in an operational environment is capital intensive. Framing and assessing the risks and developing risk management frameworks from very early phases of project development is fundamental for attracting investors, expediting execution and achieving scale.

- Seven major developments are changing the climate tech commercialisation risk landscape:

  1. The launch of an Adoption Readiness Level framework by the U.S. Department of Energy, which offers a cohesive framework to measure the market readiness of climate technologies for commercial-scale deployment.

  2. Growing concerns around energy security, which have led to the launch of national strategies aiming to regulate and expand the extraction of rare earth and other critical materials needed to scale up the production of climate technologies.

  3. The emergence of government subsidies and transformative public policies, such as the Inflation Reduction Act in the U.S. and the New Green Industrial Deal in the EU, which are reshaping the economics and commercial viability of climate technologies for decarbonising heavy industries.

  4. The emergence of market-focused alliances engaging governments and corporations, which aim to expedite tech-specific market developments by identifying early adopters.

  5. Coordinated investment platforms that bring together philanthropic, private and public funding to provide more cohesive financial support to increase innovations and investment in first-of-a-kind operational pilots.

  6. The emergence of sustainable finance frameworks, taxonomies, disclosure regulations and alliances of net-zero institutional investors, which aim to mobilise private capital for financing the transition.

  7. Climate tech hubs that bring together technology developers and customers to leverage existing infrastructure systems, create a business marketplace and develop safety standards to expedite scaled deployment.

- Expediting the commercialisation and deployment of climate technologies over the next decade will require new ways of doing business at the project and industry levels.

  - At the project level, climate tech stakeholders (e.g. project developers, engineers, procurement and construction companies, investors, governments) need to collaborate with re/insurers from the early phases of project development to frame the risks and co-design innovative, holistic risk management and financing solutions to attract private capital. This would allow re/insurers to expand their expertise in this area, which is crucial given the lack of data on new climate technologies and their associated risks. However, re/insurers are traditionally only contacted downstream once the project has been designed and is pending financing. Mechanisms to engage re/insurers earlier on in the process therefore need to be developed.

  - At the industry level, as the technology reaches the early commercial deployment stage, re/insurers can play a critical role in collaborating with third-party technical validation, standard-setting and certification entities to develop robust, technology-specific risk management frameworks, standards, codes of practice and guidelines for industry adoption and project replication.

- Insight from the survey of re/insurance C-level executives sheds light on the challenges and opportunities around climate tech commercialisation and deployment as well as re/insurers' strategic priorities in this space. In a nutshell:

  - CEOs believe that property & casualty (P&C) re/insurers could play a role by engaging directly with project stakeholders from the pre-commercialisation stages. However, a number of factors currently hinder such engagement, including lack of data on untested risks and profitability concerns.

  - Larger P&C re/insurers are strategically investing to develop their internal capacities, for example by expanding risk-engineering services and underwriting solutions for demonstrated climate technologies, as well as strengthening data and risk analytics as a service. They are also investing in various research and development initiatives through internal innovation hubs and partnerships.

- Brokers play an important role in the commercial deployment stages, when technology-specific risks are well understood and insurance products and services have already been developed. However, a number of factors may hinder brokers' effectiveness in facilitating re/insurers' direct engagement with key stakeholders in the demonstration and early-deployment stages.

- As long-term institutional investors, re/insurers can play a strategic role by investing in the wide-scale commercial deployment of climate technologies. However, some respondents indicated that investments in the earlier stages could also lead to long-term benefits and opportunities for their companies and help shape their future investment strategies.

- Multi-lateral development banks play a key role in enabling institutional investors', including re/insurers', engagement in climate tech projects in middle- and low-income economies, for example by helping to source and structure investable-grade projects; enabling public-private partnerships and blended finance structures; and issuing guaranteed bonds and/or backing the creditworthiness of the project counterparts.

- Industry-level collaboration and cross-sectoral partnerships are essential to stepping up the insurance industry's contributions to accelerating the commercialisation and wide-scale deployment of new climate technologies.

1 Introduction

Introduction

Though funding for climate technologies is rising, there is still a significant investment gap to fund the transition to a decarbonised economy by 2050.

1.1 Background

Rising greenhouse gas (GHG) emissions, primarily resulting from human activities, are significantly impacting the Earth's climate system. The global average temperature has continued to rise compared to pre-industrial times, leading to biodiversity loss; changes in the frequency, severity and regional occurrences of extreme weather events; and trends such as sea-level rise and water scarcity, all of which can result in a wide range of health-related complications.[1] A well-planned, whole-of-economy approach to curbing GHG emissions is needed to limit the global average temperature increase to 1.5°C compared to pre-industrial levels over the next few decades and meet the goals of the Paris Agreement.[2]

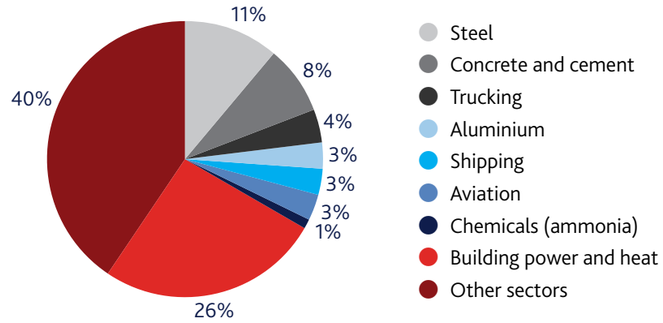
The world has reached a critical moment for transformative action. In 2018, the Intergovernmental Panel on Climate Change (IPCC) indicated that crossing the 1.5°C threshold could trigger far more severe climate-related impacts.[3] The IPCC's Sixth Assessment Report (AR6) presented scientific evidence on how close the world is to missing the 1.5°C target and the need to reduce global emissions by 45% by 2030 to achieve net zero by 2050.[4] However, the world is currently on the path to a 2.5–2.9°C temperature increase, though there are many uncertainties around this.[5] Considering the urgent need to decarbonise the global economy over the next three decades, and the short timeframe in which to do it, it will be necessary to significantly scale up decarbonisation efforts in the coming 10 years.[6]

Expediting the commercialisation and wide-scale deployment of a wide range of new climate technologies will be central to achieving industrial decarbonisation. Some high-emitting sectors, such as power and transportation, are already taking some measures, such as integrating renewable energy and investing in electric vehicle (EV) infrastructure, to curb their GHG outputs. However, reducing the carbon footprint of heavy industries (steel, aluminium, cement and concrete, chemicals, shipping, trucking and aviation), which contribute over 30% of global carbon emissions (Figure 1), still poses significant difficulties. These sectors, often-termed 'hard-to-abate' sectors, are facing complex decarbonisation challenges due to their intense energy usage. They will ultimately rely on new technologies, such as green hydrogen, long-energy duration systems, small modular nuclear reactors (SMRs) and carbon removal (point source capture, direct air capture, utilisation and storage), which remain in the pre-commercialisation stages.[7]

Significant efforts are underway to expedite the decarbonisation of 'hard-to-abate' industries over the coming decades.[8] To this end, Mission Possible Partnership (MPP)[9] has developed targets that need to be achieved by these sectors by 2030, as well as the range of critical cross-cutting technologies that will be required, to have a shot at meeting the goals of the Paris Agreement (Table 1).[10] This has highlighted the need to align priorities among public and private stakeholders to increase coordination to achieve these targets.

1 IPCC 2023.
2 United Nations (UN) 2016. The Paris Agreement is a legally binding international treaty on climate change, adopted by 196 Parties at the UN Climate Change Conference in Paris, France, on 12 December 2015 (COP21). The agreement entered into force on 4 November 2016 with the objective of holding 'the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change'.
3 IPCC 2018.
4 IPCC 2023.
5 The Economist 2023a.
6 Ibid.
7 MPP 2022.
8 World Economic Forum (WEF) 2022.
9 MPP is an alliance of climate leaders and companies: https://missionpossiblepartnership.org/

FIGURE 1: PERCENTAGE OF GLOBAL CARBON EMISSIONS FROM HARD-TO-ABATE INDUSTRIES



Source: Mission Possible Partnership[11]

TABLE 1: PROGRESS TOWARDS THE TECHNOLOGY ADOPTION NEEDED BY 2030 FOR HARD-TO-ABATE SECTORS

Aviation	Trucking	Shipping	Steel	Aluminium	Concrete	Chemicals
What is needed by 2030?						
300 Sustainable Aviation Fuel (SAF) plants	**7** million zero-emissions trucks (there are currently debates about hydrogen-powered trucks)	**200** ships using zero-emissions fuel	**70** (near) zero-emissions steel plants	**90** new low-carbon smelting and refinery plants	**20+** commercial-scale carbon capture, usage and storage plants	**60** green and blue ammonia plants
40 Mt of SAF (for 10–15% of SAF in aviation supply globally)	**1.6** million overnight depot chargers	**5%** zero-emissions fuel in international shipping	**170** Mt of near-zero-emissions primary steel produced	**43%** of aluminium production from recycling by 2030	These would need to deliver **160** million m^3 concrete	**50** Mt of near-zero-emissions ammonia produced
	600,000 public high-speed chargers for battery electric trucks					
Situation as of September 2022						
70 operational and in pipeline	4,000 electric trucks	0 operational[12]	1 demo plant[13]	50 operational plants	0 operational	2 operational plants

10 MPP 2021, 2022a,b,c,d,e,f,g.
11 Ibid.
12 Laura Maersk was the first methanol fuel-enabled feeder container ship to be launched in 2023.
13 Vogl et al. 2023.

This transition also requires a number of cross-cutting technologies for energy production and carbon removal to be scaled		
Cross-cutting technologies	**What is needed to support these sectors by 2030?**	
Hydrogen	100 Mt H_2 (hydrogen) produced (all production routes – with at least 6.5% green production)	600 GW electrolysers producing green hydrogen
Renewable electricity	2 TW – installed wind and solar (excludes cement and non-H_2 chemical power consumption)	20,000 new renewable development projects
Carbon capture and removal	700 Mt CO_2 – global carbon captured and stored or utilised	200 large-scale carbon capture and removal and storage projects (assumes project size of 3.5 Mt CO_2 based on Northern Lights and Gorgon Project size)
Sustainable biomass	~50 Mt biofuel consumed (across aviation and trucking)	500 biofuel production facilities

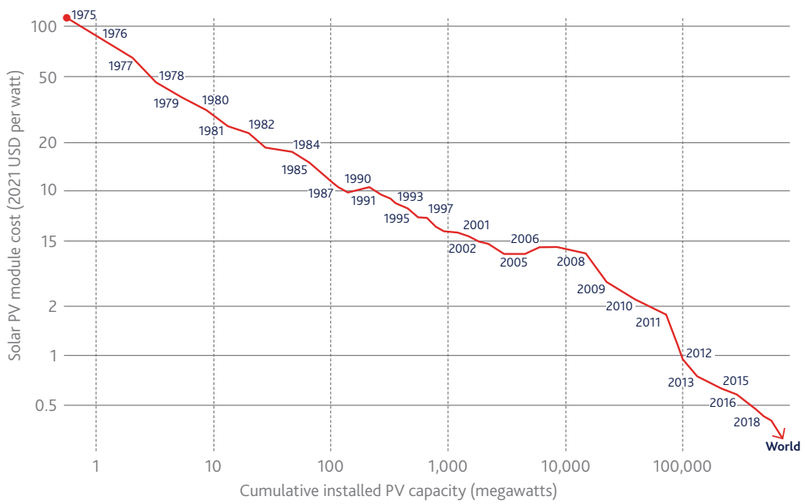
Source: Mission Possible Partnership[14]

1.2 Urgent need for the deployment of new climate technologies

It has taken many decades for renewable energy sources such as solar and wind to become cost competitive with their fossil fuel counterparts. Figure 2 demonstrates the cost of solar photovoltaic (PV) module prices against cumulative installation capacity from 1975–2018. However, despite competitive costs, these technologies have not realised their full deployment potential. This is due to various reasons, such as the credit risk of the project developer or the off-taker(s) as well as issues with the manufacturing and supply chain of new modules.

Reducing GHG emissions across industrial sectors will require much more agility during the development, commercialisation and deployment phases of new climate technologies and infrastructure systems.[15] New policies and regulatory frameworks as well as government subsidies will also be critical to incentivising action on the supply and demand sides.[16] Institutional transformations and cross-sectoral partnerships will be needed to break through silos and overcome barriers, including those related to cost, regulation, finance, market factors, supply chains and other logistics, to reduce the high risk premiums of new climate technologies.

FIGURE 2: SOLAR PV MODULE PRICES VS. CUMULATIVE INSTALLED CAPACITY



1975 ⟶ 2021
World

1975
115.28 USD per watt; 0.54 megawatts

2021
0.27 USD per watt; 848,404.56 megawatts

Source: Our World in Data[17]

14 MPP (n.d.)
15 The Geneva Association and OECD 2021; The Geneva Association 2022; WEF 2021.
16 The Economist 2023b. According to The Economist, war and subsidies have turbocharged the green transition.
17 Ritchie et al. 2020.

1.3. The investment gap

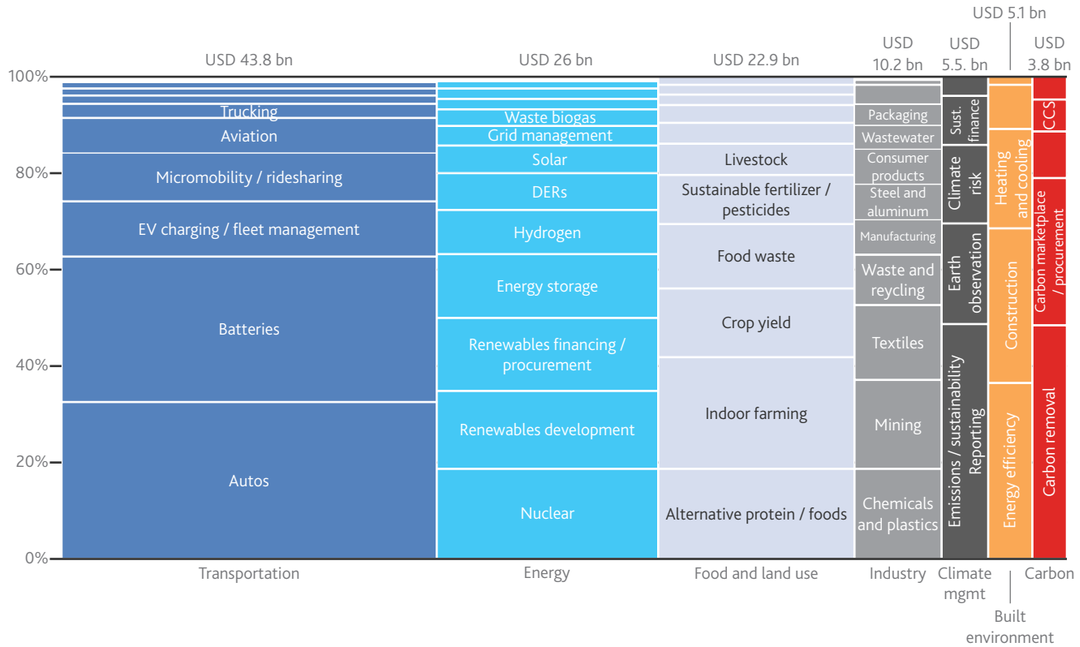
Over the last few years, there has been a steady rise in venture capital funding for climate technologies, from the innovation to the growth stages, around the world. In 2022, for example, total funds in this space were estimated at USD 70.1 billion.[18, 19] Additionally, funding has expanded beyond traditional spending on renewable energy. Figure 3 illustrates the order of investments by sector since 2020 in technologies for transportation, energy, food and land use, industry, climate risk management, the built environment and carbon.

Despite this, the annual estimated total investment gap to fund the transition of the global economy stands at USD 7–9.2 trillion until 2050.[20] A significant portion of transition funding needs to be deployed towards financing climate tech innovation, commercialisation and wide-scale deployment – for example, financing pilot projects currently in the pre-commercialisation stages right through to industrial-scale plants and infrastructure systems.

The annual investment gap to fund the transition to a decarbonised economy is USD 7–9.2 trillion. Closing this will require massive amounts of private capital.

Given the scale of this gap, it is clear that no single entity can address this challenge alone. Relying solely on public capital will not be sufficient – massive amounts of private capital will also need to be mobilised. The public and private sectors need to align on priorities and work together to find solutions, and leverage capacities and resources with a long-term investment and planning mindset.[21]

FIGURE 3: EXPANSION OF VENTURE CAPITAL FUNDING FOR CLIMATE TECHNOLOGIES SINCE 2022



Source: Climate Tech VC[22]

18 HolonIQ 2023.
19 According to PwC (2023), while equity investing in climate tech in many areas declined amid tough conditions in the private markets in 2023, investments in climate technologies for industrial decarbonisation experienced a steady rise.
20 BloombergNEF 2022; McKinsey & Company 2022a.
21 WEF 2022. Much of the emissions abatement post-2030 will rely on breakthrough technologies such as hydrogen-based fuels, bioenergy and carbon capture, utilisation and storage solutions. Successful expansion of these will require significant scale-up and capital. This report by WEF highlights that critical decarbonisation technologies will need at least '10x' investment to hit zero-emissions targets. Experts from over 50 financial institutions, including banks, insurers and asset managers, as well as the public sector, were brought together to develop financing blueprints and policies to mobilise investment in these technologies. Furthermore, the report outlines how to address the supply- and demand-side gaps to achieve significant scale-up of these technologies.
22 Climate Tech VC 2023.

Many breakthrough climate technologies for industrial decarbonisation remain in the pre-commercialisation stages and come with a range of new risks. Demonstrating, deploying and operationalising these technologies in the coming decade will require significant private capital.[23] WEF has further stressed that unlocking private capital will require innovative risk management solutions and blending of public and private capital, which will necessitate collaboration among many stakeholders.[24]

Many climate technologies are in the pre-commercialisation stages and come with a range of new risks.

The ecosystem of stakeholders engaged in climate tech commercialisation is complex, with different entities involved in different stages of the process, each with varying roles and priorities. Re/insurers, as risk management experts and institutional investors, have played an essential role in enabling the entrepreneurial pathways and deployment of many technologies in the past.[25] WEF has emphasised the need for collaboration among stakeholders in the climate tech commercialisation ecosystem and highlighted the important role re/insurers could play in supporting the transition.[26] Further investigation is required to explore this issue. A recent report by the London Market Group has also put focus on insurance as an essential tool to unlock the growth of green projects, in particular as an enabler to secure financing and offer protection against construction delays and overruns.[27] However, the question remains: how and when should re/insurers engage? Re/insurers also motivate and engage with standard-setting and certification institutions to develop risk management frameworks, codes of practice, guidelines and standards for emerging technologies with a risk reduction and prevention lens. This facilitates industry adoption of new technologies as well as project replication.[28]

To explore these questions in more detail, The Geneva Association launched the research project, *Accelerating Climate Technologies for Industrial Decarbonisation and the Insurance Industry*, designed and implemented with the support of The Geneva Association's Climate Tech Advisory Committee and partner organisations.[29] This report, which summarises the first part of the project, describes the climate technology commercialisation landscape, as well as the challenges and opportunities associated with expedition and what re/insurers can offer if they are brought into the process earlier.[30, 31] It also offers perspectives from key stakeholders and insurance C-level executives on the benefits of and challenges with engaging re/insurers with the climate tech commercialisation ecosystem from the pilot and early demonstration stages. It involved:

- An in-depth literature review complemented by workshops and roundtable discussions with the Climate Tech Advisory Committee and the aforementioned partners.
- A qualitative survey of insurance C-level executives, specifically:[32]
  - Group Chief Executive Officers (CEOs) (life and P&C)
  - Group Chief Investment Officers (CIOs) (life and P&C)
  - Group Chief Underwriting Officers (CUOs) (P&C only)
  - Heads of Risk Engineering (P&C only)

Section 2 describes the climate technology commercialisation landscape and highlights critical developments driving change in this space. Section 3 offers views from stakeholders that are shaping the climate tech landscape on the role re/insurers can play and the benefits of their early engagement for expediting climate tech commercialisation and deployment. The results of the Geneva Association Climate Tech Survey are provided in section 4, and section 5 offers conclusions and recommendations for the way forward.

23 WEF 2021.
24 Ibid.
25 The Geneva Association 2018. Author: Maryam Golnaraghi; The Geneva Association 2019. Author: Maryam Golnaraghi; Golnaraghi 2022; WEF 2021.
26 WEF 2021.
27 London Market Group 2023.
28 For a comparable scenario from the past, see VdS 2014. In this case, a large group of re/insurers, brokers, engineers and technical organisations worked together to develop codes of practice for managing risks of offshore wind farms. These were published in 2014 and were further revised in 2017.
29 The Geneva Association's Climate Tech Advisory Committee comprises senior experts from 12 re/insurers (AIG, Allianz, AXA, AXIS Capital, Intact Financial Corporation, Liberty Mutual, Lloyd's, Manulife, Munich Re, SCOR, Swiss Re, Tokio Marine); risk engineering, investment, and commercial and speciality business line experts; and company CEOs. The project also involved executives and staff from a number of partner organisations, including three leading Managing General Agents (MGAs) (New Energy Risk, Energetic Capital and kWh Analytics), the U.S. Department of Energy, Breakthrough Energy, Worley, the banking sector (including HSBC and Citibank) and WEF's Net Zero Financing Working Group.
30 For a review of the insurance industry value chain and business model, see The Geneva Association 2018.
31 For this report, we worked with primary insurance companies, which offer financial protection through risk transfer solutions to individuals, businesses and collectives; reinsurance companies, which act as insurers for insurance companies; and highly specialised MGAs, which are a specialised type of insurance agent/broker that, unlike traditional agents/brokers, is vested with underwriting authority from an insurer. We also make brief comments about traditional brokers, which are transactional and serve as sales agents between policyholders and insurers, and between primary insurers and reinsurers.
32 P&C re/insurers generally cover property losses, liability losses and, in some countries, workers' compensation and health insurance. Life re/insurers pay benefits upon death, disability or injury. The investment (asset management) function of re/insurance companies is linked to their liabilities. P&C re/insurers' investment categories are geared towards more liquid investments. Life re/insurers are typically 'buy-and-hold', long-term investors.

2 The climate tech commercialisation landscape

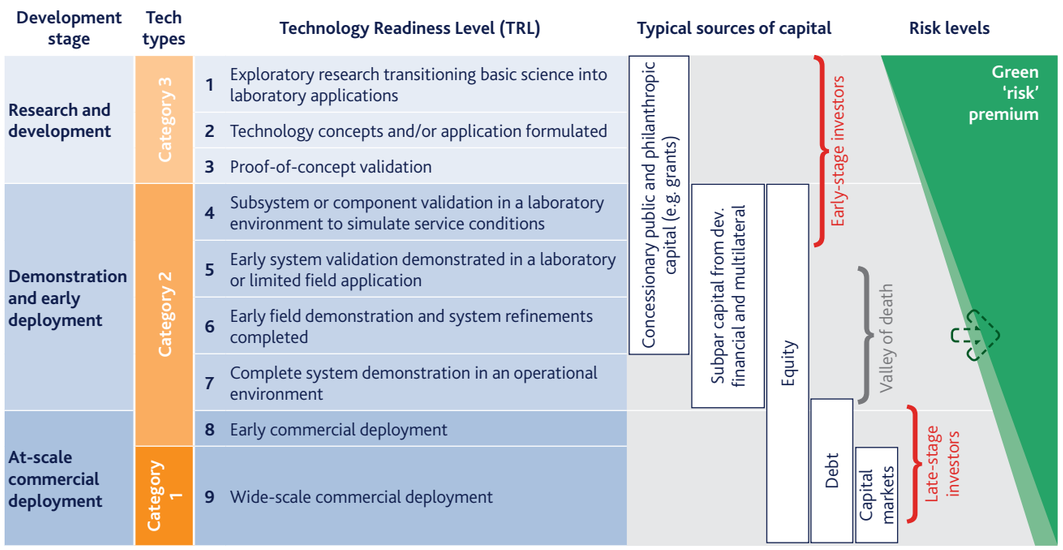
The climate tech commercialisation landscape

Developments such as transformative public policy, increasing availability of government subsidies and the emergence of climate tech hubs are helping to expedite the commercialisation and deployment of climate technologies.

2.1 The traditional pathway to technology commercialisation

The commercialisation pathway of a technology is its advancement from an innovative idea in a lab to market adoption and full-scale deployment. This entails several stages: research and development, demonstration (pilot projects) and early deployment, and at-scale commercial deployment (Figure 4).

FIGURE 4: TECHNOLOGY READINESS LEVEL IN RELATION TO TECHNOLOGY MATURITY LEVELS AND SOURCES OF CAPITAL



Source: The Geneva Association (revised from WEF[33])

Technology Readiness Level: A framework for measuring technological maturity along the commercialisation pathway

Traditionally, a 'Technology Readiness Level' (TRL) framework is used to assess the maturity of a technology along the different stages of the commercialisation pathway. The TRL was originally developed by the U.S. National Aeronautics and Space Administration (NASA) in 1974 and was formally defined in 1989. Over the years, modified versions of the TRL have been adopted by stakeholders involved in the technology commercialisation process in different sectors.[34, 35]

Figure 4 illustrates the nine typical levels of technology maturity along the technology commercialisation pathway.

The TRL framework does not address the maturity of the company or the industry that is behind the technology. In addition, it does not explicitly consider many other factors that could hinder a technology's market readiness, for example, risks associated with a lack of demand, market size, the downstream value chain, the manufacturing process and supply chain, material sourcing or the policy and regulatory environment. These factors, if not dealt with concurrently as the technology reaches the early commercialisation stages, could significantly delay its deployment increase the risk premium.

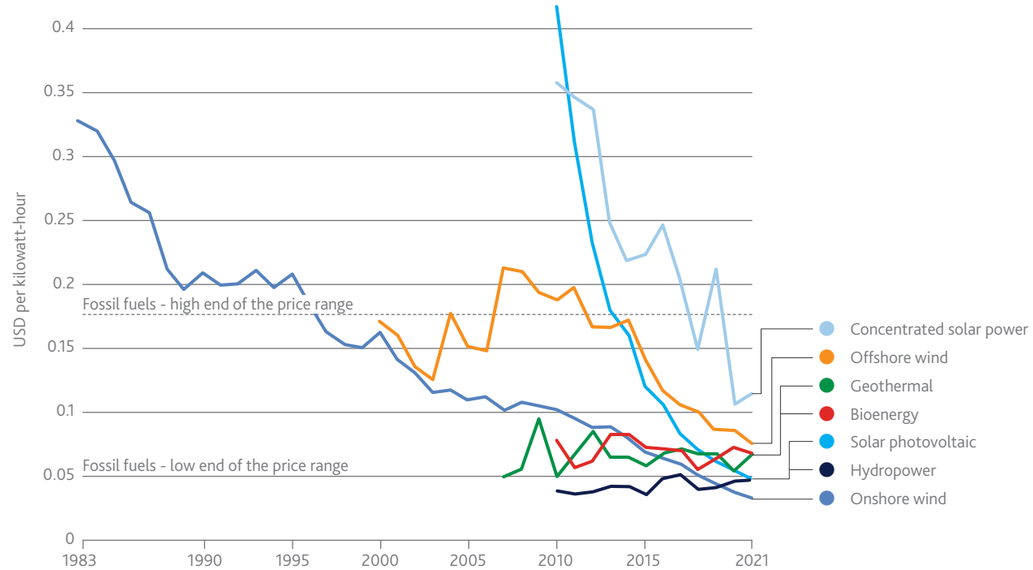
Categorisation of climate technologies based on the Technology Readiness Level framework

Climate technologies that are essential for industrial decarbonisation can be split into three categories according to their technological maturity (Figure 4).

Category 1: Climate technologies that are already commercialised (TRL 9) and are cost competitive with their high-GHG-emitting counterpart but may not have realised their full market-deployment potential.

For example, solar and wind power (onshore and offshore) have been commercialised and their costs have fallen over the last decades (Figure 5). However, they continue to face a number of risks that hinder their widespread deployment, such as manufacturing and supply chain risks associated with new modules that may not have been tested sufficiently before being used in new projects, or the credit risk of project developers or off-takers.[36]

FIGURE 5: LEVELISED COSTS OF RENEWABLE ENERGY SOURCES BY TECHNOLOGY IN RECENT DECADES



Note: Levelised cost of energy estimates the average cost per unit of energy generated across the lifetime of a new power plant.
Source: Our World in Data, based on data from the International Renewable Energy Agency (IRENA)[37]

33 WEF 2021, Figure 6.

34 The original definition included seven levels but in the 1990s, NASA adopted the nine-level scale that subsequently gained widespread acceptance.
35 NASA 2023.
36 The cost of solar photovoltaic electricity has fallen by 85% between 2010 and 2020, and the costs of onshore and offshore wind have dropped by half, making them cost competitive with fossil fuels. In 2015, when the Paris Agreement was signed, wind and solar accounted for only 4.6% of global electricity; by October 2022 they accounted for 12.39%, rising from 10.3% in 2021 and 9.3% in 2020.
37 Our World in Data (n.d.)

Category 2: These climate technologies are understood, yet all or some aspects remain in the pre-commercialisation stages and need to be technologically demonstrated and refined in an operational environment.

Most technologies needed for industrial decarbonisation fall into this category (TRL 5–7). The aim is to become cost competitive for scaling and replication. Examples include carbon removal (point source and direct air capture and storage), green hydrogen (see Box 1), long-term energy storage, sustainable aviation fuel (SAF) and small modular nuclear reactors, to name a few.

Box 1: Commercialisation challenges of carbon storage and green hydrogen

The primary methods of **carbon storage** are geological sequestration in reservoirs like depleted oil and gas fields or saline formations, and mineralisation (or mineral carbonation). While geological sequestration has seen some commercial implementation globally, the wider adoption of carbon storage faces various challenges. These include concerns about induced seismicity, potential CO_2 leakage, water contamination, environmental impacts and long-term liabilities associated with storing CO_2, which have slowed the pace of wider commercial deployment.

Challenges associated with the commercialisation of **green hydrogen** include the need for large areas of land for solar and wind infrastructure, lack of available transportation and storage infrastructure, significant energy losses during the production and conversion processes, and the need for high-temperature hydrogen heating processes for hard-to-abate sectors like steel production.

Source: The Geneva Association, based on Boussidan, Capgemini, Swiss Re, IEA and IRENA[38]

Category 3: Promising technologies that are in the research and development stages (TRL 3–5), with potential for commercialisation in the next 10–20 years, for example, nuclear fusion.[39] This category is not within the scope of this study.

Financing and the 'Valley of Death' in the demonstration and early-deployment stages

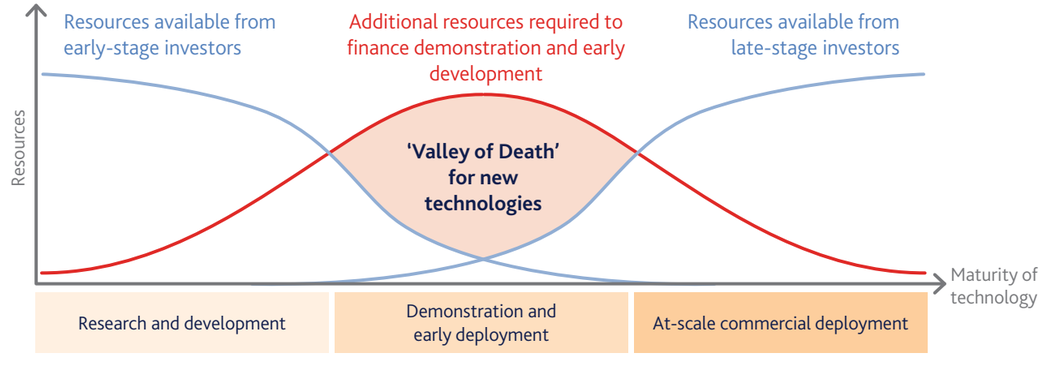
The technology commercialisation pathway is financed by various stakeholders such as wealthy individuals, philanthropic organisations, governments and the private sector (e.g. venture capital firms, corporations, institutional lenders and investors). Typically, the early phases (TRL 1–4) are financed by 'early-stage investments' such as concessionary public and philanthropic capital (mainly in the form of grants) and equity investments[40] (mainly friends, angel investors and early venture capital).[41] 'Late-stage investors' generally include industry and institutional investors, who prefer to invest when the technology has been demonstrated and technological risks related to operationalisation at scale have been addressed (TRL 7–9). Late-stage investments are in the form of equity, debt and capital market-financing tools (e.g. green bonds, indexed based funds).

A major funding gap – known as the 'Valley of Death' – exists for technologies in the demonstration and early-deployment stages.

Traditional resources available from the government and private sector fall significantly short in the demonstration and early-deployment stage, where significantly more resources are required for the financing of pilot projects in which critical risks such as functional performance, ease of use and operational safety issues for scaling of the technology are addressed. This funding gap is referred to as the 'Valley of Death', where many 'potentially viable' technologies 'die' and never make it to the market (Figure 6).

38 Boussidan 2023; Capgemini 2023, Swiss Re 2021, 2022; IEA 2022, 2023a,b; IRENA 2022.
39 U.S. DoE 2022.
40 Equity refers to ownership of any asset after all debts associated with that asset are paid off. For a company, equity represents the amount of money that would be returned to a company's shareholders if all of the assets were liquidated and all of the company's debt was paid off in the case of liquidation. In the case of acquisition, it is the value of company sales minus any liabilities owed by the company not transferred with the sale. See Investopedia 2023.
41 Angel investors are wealthy private investors focused on financing small business ventures in exchange for equity.

FIGURE 6: THE VALLEY OF DEATH – THE MAJOR INVESTMENT GAP IN THE COMMERCIALISATION PATHWAY OF NEW TECHNOLOGIES

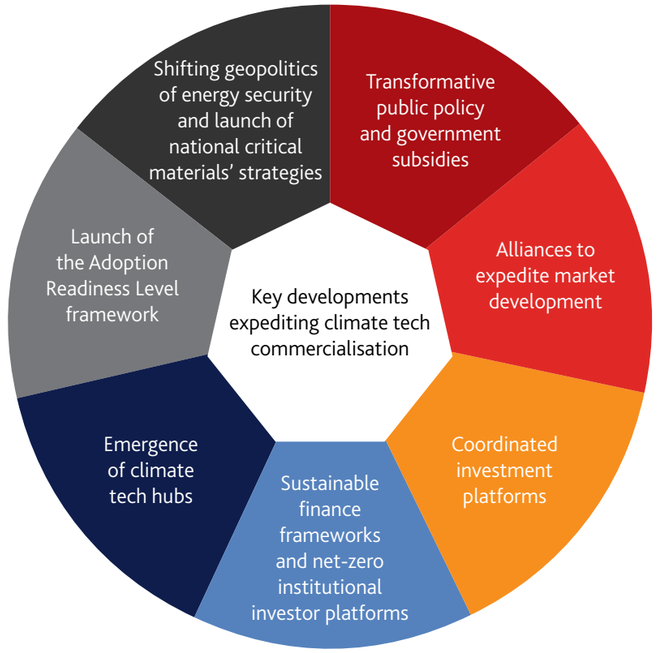


Source: The Geneva Association (revised from WEF)

2.2 Developments shaping the climate tech commercialisation risk landscape

Over the last two years, seven developments have significantly impacted the climate technology risk landscape, paving the way for expediting commercialisation and deployment. These are highlighted in Figure 7 and further described in this section.

FIGURE 7: SEVEN DEVELOPMENTS CHANGING THE CLIMATE TECH RISK LANDSCAPE



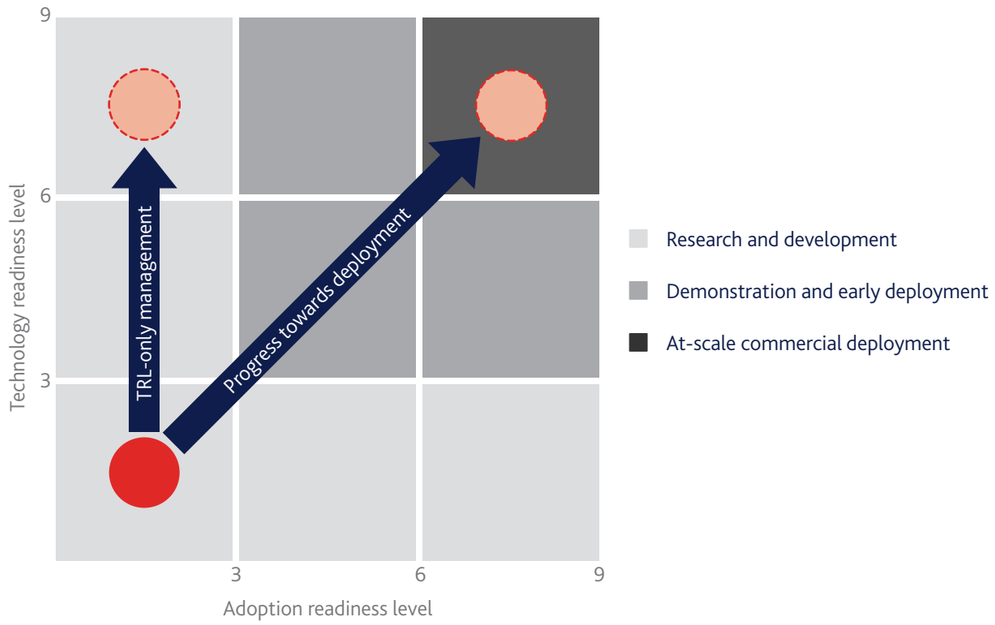
Source: The Geneva Association

Launch of the Adoption Readiness Level framework

In 2022, the 'Adoption Readiness Level' (ARL) framework was launched to enable project developers, investors and other key stakeholders to assess and address a wide range of risks hindering climate technology market readiness.[42] Led by the U.S. Department of Energy (DoE),[43] this framework was developed to supplement the traditional TRL framework. Commercialisation often fails or is significantly delayed, or full market potential is not realised because the economic aspects of the ecosystem needed for scaled deployment have not been addressed. Critical requirements, such as the manufacturing and supply chains of the technology or regulatory and permitting processes, may also not be ready. The ARL framework has been developed to assess the risks that hinder market adoption and translate this into a readiness score (Figure 8).

The ARL framework includes four risk categories, namely 'Value Proposition', 'Market Acceptance', 'Resource Maturity' and 'License to Operate', and 17 corresponding risk types, which are explained in Table 2. Different risks within the ARL are relevant at different stages of the commercialisation pathway. The market readiness score shines light on areas that need to be addressed to enable market adoption and robust market deployment. This framework is currently under consultation with various stakeholders. Discussions with the U.S. DoE have raised the question about the insurability of these risks and the role of the insurance industry. The second phase of this project will include a review of the ARL with the goal to enhance and further supplement the framework from an insurability and risk transfer perspective.[44]

FIGURE 8: ADOPTION READINESS LEVEL



Source: U.S. DoE[45]

Designed to complement the Technology Readiness Level framework to enable climate tech market readiness

42 U.S. DoE 2023a.
43 The ARL was developed based on extensive industry consultations.
44 The results of this initiative will be published in a forthcoming Geneva Association report in 2024.
45 U.S. DoE 2023a.

Launch of national critical materials strategies

Growing concerns around energy insecurity have led several governments to update or launch new national critical materials strategies, indicating growing interest in investing in the energy transition.[46, 47] These strategies aim to build a competitive advantage in material sourcing to secure access to critical materials such as lithium, nickel, cobalt, manganese and graphite that are needed for the manufacturing of new climate technologies for domestic use and international trade purposes (risk 11 in Table 2). In December 2022, the Canadian government convened the governments of Australia, France, Germany, Japan, the U.K. and the U.S., leading to the 'Sustainable Critical Minerals Alliance,' to promote the global adoption of environmentally conscious, socially inclusive and responsible practices in the mining, processing and recycling of rare earth and critical metals (risks 13 and 16 in Table 2).[48]

Through national critical materials strategies, countries aim to gain a competitive advantage in sourcing materials for the manufacturing of climate technologies.

Emergence of transformative public policy and government subsidies

Since 2022, transformative public policy and regulatory frameworks, along with substantial government subsidies, have been emerging, which create a more favourable and enabling environment for the development of climate technologies. The availability of government subsidies in particular is changing the economics and commercial profile of climate tech commercialisation. For example, there has been major legislative movement in the U.S. with the passage of the Bi-partisan Infrastructure Act, the Inflation Reduction Act and a series of executive orders issued by the U.S. Government, which provide nearly USD 1 trillion in government grants and subsidies.[49] This led the EU parliament to expedite the passage of the New Green Industrial Deal on 1 February 2023, with over EUR 500 billion in financing to create a level playing field with the U.S.[50] A number of other countries have followed suit, including Australia, Canada, Japan and the U.K.[51] This avails capital to high-risk pilot projects during the demonstration and early-deployment stages to help expedite the assessment of functional performance and other technological risks associated with high-priority technologies (risks 1 and 2 in Table 2).

Regulatory frameworks and government subsidies are creating a more enabling environment for the commercialisation of climate technologies.

Among other important public policy and regulatory developments is the launch of carbon border adjustment mechanisms (CBAM) to promote greener manufacturing by imposing import fees on foreign products that cause more pollution during manufacturing than similar domestic products, to help shift market size (risk 5 in Table 2).[52] However, there are concerns that border carbon taxes could potentially impact low- and medium-income economies that were not primarily responsible for anthropogenic climate change in the first place, and may not guarantee a fair transition for all nations.[53]

Finally, government programmes aim to mitigate market-related risks for specific technologies, such as the recent U.S. DoE initiative of USD 1 billion to boost demand for clean hydrogen. This initiative is designed to provide initial revenue for the first large-scale producers and provide certainty for potential buyers, helping to mitigate market-related risks for specific technologies (risks 4 and 5 in Table 2).[54]

Alliances to expedite market development and identify early adopters

Since 2021, there have been proactive efforts by governments, companies in the industrial and financial sectors and multi-lateral organisations to expedite market development and the emergence of early market adopters (particularly addressing risks 4 and 5 in Table 2). Examples include the First Mover Coalition (FMC), a collaboration between the U.S. State Department and WEF, which was launched at Glasgow Climate Change negotiations in

46 IEA 2023c; IRENA 2023.
47 Government of Australia 2023; Government of Canada 2023a; Government of Brazil 2021; European Commission 2023a; Government of India 2019; Government of Japan 2020; Government of South Africa 2022; U.K. Government 2022; U.S. DOE 2021; The White House 2022a,b.
48 Government of Canada 2022.
49 The White House 2022c,d, 2023a.
50 European Commission 2022a,b, 2023b,c.
51 Government of Australia 2022; Government of Canada 2023b,c; Government of Japan 2023; U.K. Government 2020, 2023.
52 European Commission 2023d,e; Cohen 2023.
53 Saiyid 2023.
54 Moore 2023; U.S. DoE 2023b.

TABLE 2: RISK CATEGORIES OF THE ADOPTION READINESS LEVEL FRAMEWORK

Value proposition	Market acceptance	Resource maturity		License to operate	
1. Delivered cost Risks associated with achieving cost competitiveness when produced at full scale, including amortisation of incurred development and capital costs and accounting for switching costs (if any). **2. Functional performance** Risks associated with the ability of the technology solution to meet or exceed the performance and feature-set of incumbent solutions or create new end-use markets. **3. Ease of use/complexity** Risks associated with operational switching costs; the ability of a new user (individual, company, system integrator) to adopt and operationalise the technology solution with limited training, few new requirements, or special resources (e.g. tools, workforce, contract structures).	**4. Demand maturity/market openness** Risks associated with demand certainty and access to standardised sales & contracting mechanisms (if required), as well as with natural (e.g. network effects, first-mover-advantages) and/or structural (e.g. existing monopolies/oligopolies) barriers to entry in the market(s) to which the technology solution can be applied. **5. Market size** Risks associated with the overall size of the market that can be served by the technology, and the level of uncertainty with which it will materialise. **6. Downstream value chain** Risks associated with the projected path to get the product from a producer to a customer along the value chain (considering, e.g. split incentives, technology acceptance, business model changes).	**7. Capital flow and availability** Risks associated with the availability of capital needed to move the technology solution from its current state to production at scale, including total investment required, availability of willing investors, availability of associated financial and insurance products, and the speed of capital flow. **8. Project development, integration and management** Risks associated with the existence of processes and capabilities to successfully and repeatedly execute projects using the technology solution. **9. Infrastructure** Risks associated with the physical and digital large-scale systems that need to be in place to support, enable, or facilitate deployment at full scale (e.g. pipelines, transmission lines, roads and bridges, etc.)	**10. Manufacturing & supply chain** Risks associated with all the entities & processes that will produce the end product, including integrators and component and sub-component manufacturers & providers. **11. Materials sourcing** Risks associated with the availability of critical materials required by the technology (e.g. rare earth and other limited-availability materials). **12. Workforce** Risks associated with the human capital and capabilities required to design, produce, install, maintain and operate the technology solution at scale.	**13. Regulatory environment** Risks associated with local, state and federal regulations or other requirements/standards that must be met to deploy the technology at scale. **14. Policy environment** Risks associated with local, state and federal government policy actions that support or hinder the adoption of the technology at scale. **15. Permitting & siting** Risks associated with the process to secure approvals to site and build equipment and infrastructure associated with deploying the technology at scale.	**16. Environmental & safety** Risks associated with the potential for hazardous side effects or adverse events inherent to the production, transport or use of the technology solution or end product in the absence of sufficient controls. **17. Community perception** Risks associated with the general perception by global and local communities of the technology solution and its risks or impacts, whether founded or unfounded.

Source: U.S. DoE[55]

2021;[56] the U.S., Canada and Mexico North American Hydrogen partnership established at the 2023 Three Amigos Conference held in Mexico;[57] the U.S.–Japan Hydrogen Strategy;[58] and the EU Clean Hydrogen Partnership.[59]

Coordinated investment platforms with philanthropic-private-public funding

Since 2017, there have been targeted efforts to coordinate philanthropic-private-public funding to scale up and offer more cohesive financing across the climate tech supply chain, particularly in the demonstration and early-deployment stages to help get viable technologies over the 'Valley of Death' (risks 2 and 7 in Table 2). For example:

- Breakthrough Energy[60] is the largest network of ultra-net-worth investors, philanthropic sources, corporations, governments and banks. It is structured around three main programmes: Breakthrough Energy Fellows (BEF), which funds early-stage start-ups;[61] Breakthrough Energy Ventures (BEV), which invests in growth-stage ventures;[62] and Breakthrough Energy Catalyst (BEC),[63] which is financing the first demonstration projects for promising technologies such as sustainable aviation fuel.[64] This platform has raised an estimated USD 3.8 billion as of November 2023.[65] Breakthrough Energy is also working to help expedite market development and promoting the need for public policy and government funding and subsidies.[66]

55 U.S. DoE 2023a.
56 Launched by U.S. President Biden at the 2021 United Nations Climate Change Conference in Glasgow, FMC is a global initiative harnessing the purchasing power of companies (with support from governments) to decarbonise hard to abate industrial sectors that currently account for 30% of global emissions. As of December 2022, 71 companies have joined the FMC.
57 At the North American Leaders' Summit (NALS), Canada, Mexico and the U.S. committed to working together to develop the North American clean hydrogen market. Bnamericas 2023.
58 U.S. to invest USD 7 billion in hydrogen hubs with eye on export to Japan.
59 For more information, see: https://www.clean-hydrogen.europa.eu/get-involved/regions-hub_en
60 Information on the organisation's board and investors is available at: https://breakthroughenergy.org/our-work/breakthrough-energy-ventures/bev-board-and-investors/
61 Breakthrough Energy 2023.
62 For more information, see: https://breakthroughenergy.org/our-work/breakthrough-energy-ventures/
63 Hook 2022.
64 Breakthrough Energy 2022.
65 According to public reports.
66 For more information, see: https://breakthroughenergy.org/

- Mission Innovation, a coalition of 23 governments and the European Commission (on behalf of the EU) working together to coordinate funding to support the deployment of climate technologies for a just energy transition.[67]

Sustainable finance frameworks and alliances of net-zero institutional investors

The development of sustainable finance frameworks along with taxonomies and regulations for disclosure and reporting[68] are critical for institutional investors such as life re/insurers and pension funds to make informed investment decisions, particularly at the full commercialisation stages (addressing risk 7 in Table 2).[69, 70, 71] Over the last few years, coalitions of institutional investors, such as the Net-Zero Asset Owner Alliance (NZAOA)[72] and the Glasgow Financial Alliance for Net Zero (GFANZ),[73] have been formed.

Climate-tech-specific hubs

Emerging climate-tech-specific regional hubs are bringing together producers and customers (public and private alike) to leverage existing infrastructure systems, provide a business marketplace, develop safety standards and promote the technology to expedite scaled deployment (risks 6, 9 and 10 in Table 2).[74] Some examples are provided in Table 3.

67 For more information, see: http://mission-innovation.net/about-mi/overview/
68 IFRS 2023.
69 European Commission 2019, 2020, 2021a,b; Canadian Climate Institute 2022; Monetary Authority of Singapore 2023; Australian Sustainable Finance Initiative 2020.
70 European Commission 2023f. The IPSF was launched in October 2019. Its members are public authorities in charge of developing environmentally sustainable finance policies in Argentina, Canada, Chile, China, Hong Kong, India, Indonesia, Japan, Kenya, Malaysia, Morocco, New Zealand, Norway, Senegal, Singapore, Switzerland, the U.K. and the EU.
71 ASEAN Taxonomy Board 2023. This association comprises 10 member states in Southeast Asia. In November 2021, ASEAN introduced the *ASEAN Taxonomy for Sustainable Finance*. It was developed to facilitate an orderly and just transition, promoting the adoption of sustainable finance across ASEAN member states.
72 NZAOA was convened by the UN in 2019. It is a member-led international initiative including institutional investors such as pension funds and insurance companies, who commit to transition their investment portfolios to achieve net-zero GHG emissions by 2050.
73 GFANZ was announced in April 2021 ahead of COP26 in Glasgow, as a coalition of financial institutions from around the world aiming to accelerate the transition to a net-zero economy by 2050 at the latest. This coalition brings together various financial actors from different sectors such as banks, asset managers, asset owners and other financial institutions.
74 U.S. DoE definition: https://www.energy.gov/oced/regional-clean-hydrogen-hubs

TABLE 3: EXAMPLES OF CLIMATE-TECH-SPECIFIC HUBS

Technology	Hubs
Hydrogen	- Seven Regional U.S. Department of Energy Hydrogen Hubs (H2Hubs), recently announced by the Biden-Harris Administration[75] - Monaco Hydrogen Alliance (https://monacoh2.org/) - Hydrogen Council (https://hydrogencouncil.com/en/)
Carbon management	- Aramco Jubail (https://www.aramco.com/en/sustainability/climate-change/managing-our-footprint/carbon-capture-utilization-and-storage) - Carbon Development Council (https://www.carbondevelopmentcouncil.org/) - CCS+ Initiative (https://ccsplus.org/) - Northern Lights (https://norlights.com/) - Port of Rotterdam (https://www.porthosco2.nl/en/) - Ravenna CCS (https://www.eni.com/en-IT/net-zero/ravenna-energy-transition.html)
Offshore wind	- North Sea Wind Power Hub (https://northseawindpowerhub.eu/)

Source: The Geneva Association

75 U.S. DoE 2023c. The seven regional hydrogen hubs are: California; Ohio-Pennsylvania-West Virginia; Minnesota-North Dakota-South Dakota; Texas; Pennsylvania-Delaware-New Jersey; Illinois-Indiana-Michigan; Washington-Oregon-Montana.

3 Market perspectives on the role of re/insurers

Market perspectives on the role of re/insurers

There is rising recognition of the critical role re/insurers can play in expediting the deployment of climate technologies and the benefits of engaging them in projects from the pre-commercialisation stages.

3.1 Need for new ways to manage risks and finance climate tech projects

According to WEF, expediting the commercial deployment of climate technologies over the next decade will require new ways of doing business. There is a need to bring together relevant stakeholders across different sectors to work collaboratively to co-develop transformative risk management measures and innovative financing approaches to address the investment gap for climate technologies.[76]

The ecosystem of public and private stakeholders engaged in climate tech commercialisation and deployment is complex, with different touchpoints, roles and priorities for various parties at different phases of project development and financing (Box 2).[77]

Box 2: Stakeholders involved in various climate tech project stages

Technology, industry and related supply chains:
- Technology providers (may also be the project owner)
- Project owners (small to medium-sized ventures and corporates)
- Engineering, procurement and construction (EPC) companies
- Customers
- Suppliers (material providers, equipment manufacturers, etc.)
- Infrastructure owners (private)
- Standard setters/certification agencies
- Legal firms (project structuring)

Financial institutions and re/insurance companies
- Banks
- P&C re/insurers (risk engineering and underwriting, generally in later commercialisation stages except for new emerging MGAs)
- Asset owners/institutional investors (including re/insurers and pension funds, generally in later commercialisation stages except for new emerging MGAs)
- Other types of investors (growth venture capital, corporate venture capital and investment funds)
- Multilateral development banks

Public sector
- Governments/policymakers
- State financiers
- Export credit agencies (ECAs)
- Infrastructure owners

Source: The Geneva Association

76 WEF 2021.
77 Ibid.

This is particularly relevant for the demonstration and early-deployment stages (TRL 6–7), when there is a significant rise in resource needs for pilot projects, which come with untested risks (Figure 4). While some project owners may be large corporations with substantial balance sheets and extensive in-house risk management expertise, our consultations reveal that over 80% of projects are expected to be developed by small to mid-sized companies that do not have the same capacities or any previous demonstrated project success. The high risk/return profiles of pilot projects therefore neither meet the requirements of early- or late-stage investors, and thus are at risk of falling into the 'Valley of Death.'

If the technology successfully moves to early commercialisation stages (TRL 8–9), there are other technology-specific risks, for example related to manufacturing and the supply chain, underlying infrastructure, and permitting and siting, which need to be addressed. Furthermore, risk management frameworks, standards and codes of practice for project replication are needed for industry adoption, resulting in lower risk premiums (Figure 4). To this end, collective action is needed to:

- Enable innovative, structured risk management to allocate risks based on appetite and use blended finance, where public and private sources of capital are brought together in technology-specific project financing.
- Leverage targeted public-sector interventions to incentivise both innovation and market development through carefully designed government programmes, which can change the economics of deals to make them more attractive for private-sector investors.

3.2 Growing need for re/insurers' early engagement

There is rising recognition among stakeholders shaping the climate tech commercialisation landscape of the critical role re/insurers can play and the benefits of engaging them in projects from the pre-commercialisation stages.[78, 79] Traditionally, P&C re/insurance companies are approached during the final financing and construction phases of projects. More recently, however, highly specialised MGAs have been engaging in the demonstration and early development stages by offering technology performance guarantees for pilot projects.[80]

Our consultations with representatives from various stakeholder groups have indicated significant benefits for project developers, EPC companies and investors if re/insurers get involved as early as the demonstration and early-deployment stage by offering risk engineering services (Figure 4). In this capacity, re/insurers can:

- Help frame risks, define insurance needs and outline insurability conditions for technology-specific risks.
- Aid in co-designing innovative, multi-stakeholder risk management solutions, based on risk appetite and risk mitigation ability, in order to reduce the green risk premiums of projects (Figure 4).
- Contribute to attracting more private capital by enhancing risk-adjusted returns, and help secure equity and reduce the costs of debt financing by underwriting, for example, credit risks for renewable energy projects at the later stages when the technology has been demonstrated.[81]

This could also benefit re/insurers, by exposing them to new technologies and helping them gain experience and expertise, which could be particularly useful given the current lack of data on new risks. However, mechanisms to bring re/insurers and other stakeholders together in the early phases of projects do not presently exist.

Early engagement in projects can help re/insurers gain expertise on challenges and risks, but mechanisms to bring stakeholders together are lacking.

Feedback from stakeholders also suggests that as new climate technologies reach the early commercialisation stages, robust mechanisms are required to engage re/insurers with various technical, standard-setting bodies and certification entities for the co-development of risk management standards, guidelines and codes of practices for project replication and scaling.

78 WEF 2021; Insurance News 2023.
79 Discussions during the following meetings: 'How Climate Change is Reshaping the Insurance Business', hosted by New York State Energy Research and Development Authority in February 2022; meetings hosted by the WEF Net-Zero Financing Working Group in autumn 2022; meeting hosted by the US Department of Energy and WEF in December 2022; podcast hosted by Norton Fullbright Rose in November 2023.
80 For example, New Energy Risk.
81 Stakeholder consultations with the Geneva Association Climate Tech Advisory Committee, engaging the U.S. DoE, Worley, Breakthrough Energy, HSBC, Citi Group and WEF in December 2022, and February, March, April, May and September 2023.

4 Perspectives of re/insurance C-level executives

Perspectives of re/insurance C-level executives

Climate technologies are already being considered in re/insurers' decarbonisation strategies and informing their risk appetite.

In light of the feedback received from those shaping the climate tech commercialisation landscape (see section 3.2), The Geneva Association conducted a survey of insurance C-level executives to gain insight on the industry's interest in and capacity to engage in climate tech projects from an early stage, as well as related barriers and drivers. The results shed light on companies' strategies in this space and how to increase industry engagement in the pre-commercialisation stages of projects.

4.1 Overview of survey respondents

Eighty-eight C-level executives from 26 re/insurance companies responded to the GA Climate Tech Survey. Their companies collectively manage over USD 7 trillion in assets.[82] Further details are provided in Box 3.

Box 3: Respondents to the GA Climate Tech Survey

Company type	22 primary insurers 3 reinsurers 1 re/insurance market place
Line of business	5 P&C only 8 life only 13 P&C and life
Regional coverage	20 global 1 Europe, Middle East and Africa (EMEA only) 2 U.S., Canada, Latin America and the Caribbean (Americas only) 3 Asia-Pacific (APAC only)

Source: The Geneva Association

4.2 CEO perspectives

All companies that responded to the survey are actively working on their decarbonisation strategy, targets and plans; of the 26 responding companies, 24 have already developed their strategy. Half of these entities are committed to addressing scope 1, 2 and 3 emissions over the next five years, while the remaining half is aiming to achieve these targets within the next five to 10 years.

More than 80% of CEOs (P&C and life) acknowledge that the development and wide-scale deployment of climate technologies are key to achieving the energy transition and industrial decarbonisation. Consequently, climate technologies are already being considered in companies' decarbonisation strategies and informing their risk appetite. Furthermore, respondents indicated early signs of interest from clients, investors, governments and brokers, who are approaching

82 Companies that submitted responses: Aegon, AIA, Allianz, Aviva, AXA, AXIS Capital, China Pacific Property Insurance Company, Dai-ichi Life, Fidelidade, Fubon Financial, Generali, Global Atlantic Financial Company, Intact Financial Corporation, Liberty Mutual, Lloyd's, Manulife, MetLife, Mitsui Sumitomo Insurance, Munich Re, Nippon Life, Swiss Re, Talanx, The Hartford, Toa Re, Tokio Marine and VidaCaixa.

their companies about risk engineering services and risk transfer solutions and investing in demonstrated climate technologies (category 1, e.g. solar or wind power) as well as some that are in the pre-commercialisation stage (category 2). The remaining 20%, primarily life re/insurance CEOs, cite the high risk/return ratio of investing in the pre-commercialisation stages as the primary reason for not considering category 2 technologies in their strategy.

Ninety-five percent of CEOs of P&C companies believe that re/insurers can play a strategic role by engaging in projects from the pre-commercialisation stages. Furthermore, nearly 70% recognise the benefits of getting involved as early as the pilot and early-deployment stages (Figure 4). Engaging early with risk engineering and consulting functions allows companies to build expertise in identifying, understanding and pricing untested risks and estimating potential loss impacts, given that historical loss information does not exist. It also offers first-mover advantages, such as the opportunity to build relationships with other stakeholders, gain a competitive edge through market access, take on a leadership position and improve understanding of the scaling approach through involvement in hands-on projects. As the technology moves on to early commercialisation, re/insurers engaged from earlier stages would have a head start with, for example, working with standard-setting bodies to develop technology-specific risk management frameworks, codes of practice and safety standards. Early engagement could facilitate congruent understanding of brokers of the appropriate risk-sharing balance for such projects, which could avoid unrealistic expectations around coverage and pricing.

However, CEOs also highlighted a number of factors that hinder re/insurers from engaging in the pre-commercialisation stages, including the lack of data on untested technological risks, profitability concerns and insufficient decarbonisation planning of companies in industrial sectors, which could impact clients' demand for these technologies and the speed of their adoption.

Factors such as lack of data and profitability concerns can hinder re/insurers' engagement in the pre-commercialisation stages of climate technologies.

As this area gains in importance, discussions about strategic engagement and investments in building internal capacity are taking place at different levels within companies, taking into account the status of the climate technology, and the company's size, line of business and risk appetite. For example, for category 2 technologies, 80% of the 18 companies with P&C business lines are actively discussing these issues on a technical level within business units and executive committees, with 60% also having brought these matters to the Board of Directors, and nearly 30% describing their engagement in their shareholder meetings and documentation.

More than 75% of CEOs (particularly those with life business lines) indicated that the insurance industry could play a role by investing in the commercial deployment stages of climate technologies, for example through investing in industrial-scale projects and infrastructure systems. Seventy percent of respondents also indicated that investments in the early-deployment stages could lead to long-term benefits and opportunities for their companies, for example by helping shape their future climate investment strategies by giving them a view of the pipeline for the next five to 10 years, identifying high-opportunity areas in the energy and industrial sectors, enhancing internal expertise within their investment teams and achieving the company's own decarbonisation goals. Ten percent of respondents state that investing in emerging technologies is a high priority, 20% indicate that this is becoming a priority area, and 26% indicate that they are considering investments on a case-by-case basis.

4.3 Perspectives of CUOs and Heads of Risk Engineering

Responses from CUOs and heads of risk engineering provided more details on the benefits and challenges of expanding services to the pre-commercialisation stages. Benefits include the opportunity to gain valuable insight into the operations of pilot projects through access to risk surveys, better understanding of client needs and strengthened collaboration with academic institutions and technologists. The challenges associated with category 1 and category 2 climate technologies are outlined in Box 4.

Expansion of risk engineering and underwriting capacities

Larger re/insurers are investing to expand their risk engineering services, data and analytics services and underwriting solutions for category 1 and a growing list of category 2 technologies such as green hydrogen. They are also engaged in a wide range of research and development initiatives, for example through internal innovation hubs, centres of excellence and partnerships, to further understand and model the risks of new climate technologies, develop risk mitigation solutions, advance scientific and engineering research, and fund early-stage ventures that are developing innovative solutions.

Box 4: Factors hindering re/insurers' engagement through risk engineering and risk transfer services

Category 1 technologies	• Innovative modules are being developed continuously (e.g. new and bigger turbines, floating turbines, new type of PV modules) and many lack the appropriate pilot testing. As a consequence, re/insurers consider many category 1 technology projects through a prototype lens, as past experiences cannot be used to predict performance • For solar and wind: excessive permitting timelines, the policy and regulatory environment, supply chain issues, grid integration, siting, aesthetics • Rising demand for the large-scale deployment of these technologies in countries with high political, credit and currency risks • Difficulties with directly accessing clients from the early design stage, which would give re/insurers a holistic view of the risks and insurance needs through the project life cycle
Category 2 technologies	• New, untested risks associated with these technologies (mainly prototype projects), and the failure of clients to address the unique safety risks • Access to pilot projects, clients and other stakeholders engaged in the development and financing of the technology • High costs and uncertainties associated with new client uptake, noting that project owners in the demonstration and early-deployment stages may be small to mid-sized technology companies with limited or no previous experience with re/insurers

Source: The Geneva Association

Factors hindering re/insurers' direct engagement in the pre-commercialisation stages

Regarding the role of insurance industry intermediaries (brokers and MGAs), re/insurers highlight the importance of better understanding market needs for risk engineering services, data and analytics services and insurance products and services on a tech-by-tech basis.

There is clear agreement among respondents that intermediaries can offer benefits in the at-scale commercialisation stages, when technology-specific risks are understood and insurance products and services have been developed. Specifically, intermediaries play a key role in convening clients and re/insurers, educating clients, getting on-the-shelf products into the market and helping re/insurers expand their new products and services.

The survey results indicate that the emergence of innovative MGAs with extensive expertise in modelling certain risks associated with new climate technologies is improving the understanding of insurance needs for these technologies. Examples of such MGAs include New Energy Risk, Energetic Capital, kWh Analytics and Kita.

The survey responses also revealed several factors that may hinder the effectiveness of industry brokers in the demonstration and early-deployment stages of new climate technologies. Respondents stressed the need for direct engagement of re/insurers with customers for the development of innovative risk management and risk transfer products.[83] However, the transactional approach of brokers and the need for technical expertise with new climate tech as well as research and development capabilities to identify clients' needs and accurately capture their data, hinder such innovation.

Insurance brokers can offer benefits in the at-scale commercialisation stages. However, several factors may hinder their effectiveness in facilitating the direct engagement of re/insurers in the demonstration and early-deployment stages.

Collaboration and partnerships to step up re/insurers' engagement

The survey results revealed six ways industry-level collaboration and cross-sectoral partnerships can help step up the insurance industry's contributions:

83 Traditional approaches to project development and financing do not engage re/insurers until the construction phase of the project.

1. Raising awareness of insurance among stakeholders in the pre-commercialisation stages, including insurability conditions and data needs for risk assessment. It was noted that many stakeholders in the climate tech pre-commercialisation stages are smaller entrepreneurial companies that may be unaware of what the insurance industry can offer.

2. Addressing data needs and risk analytics challenges for untested technologies. There are a number of novel risks associated with new technologies and the data is insufficient to assess them through an insurance lens. Data requirements therefore need to be defined during pilot projects.

3. Co-designing innovative risk management solutions, such as risk pooling or public-private partnerships, to address extreme risks that no insurer could underwrite alone. Such was the case with a number of technologies, e.g. nuclear power, in the past.

4. Working with supply-chain stakeholders (e.g. equipment manufacturers, contractors, customers) to develop risk prevention and risk reduction solutions, through innovation in equipment and process design. Solar panels that can withstand hail storms are one example.[84]

5. Collaborating with the investment community to identify insurance needs to enable debt and capital market financing. As technologies move towards early commercial deployment, debt and capital market financing become critical for raising the scale of funds needed for industrial-scale projects and infrastructure systems, though risks vary by technology. The availability of insurance is essential to unlocking capital.

6. Proactively engaging with standard-setting and certification bodies to develop risk management frameworks, standards, guidelines and codes of practice. Robust processes to develop such standards are required as new technologies approach early commercial deployment, to enable project replication.[85]

4.4 CIO perspectives

Re/insurers invest in a wide range of equity, debt and capital market financing tools for their long-term investments (particularly life re/insurers). With respect to climate technologies, current investments are primarily directed towards the wide-scale commercial deployment of category 1 technologies and related infrastructure systems. This includes as solar power, onshore and offshore wind energy, hydropower, green buildings and electric vehicle infrastructure.

In general, large-scale investment in the pre-commercialisation stages for category 2 technologies are currently very limited. Reasons for this include the risk profiles of these technologies; companies' risk appetite, resources and expertise; regulatory constraints such as cost of capital for investing in risky projects; the need for clear and stable public policies; accessibility to investable-grade projects; and commitment to fiduciary responsibility.

Re/insurers' investments in pre-commercialisation stages are limited due to the risk profiles of the technologies, low risk appetite, lack of resources and expertise, and regulatory constraints.

Some companies have expanded their investments in areas such as long-duration energy storage, sustainable biomass and geothermal energy, and are considering expanding their investment in carbon removal and storage,[86] green hydrogen and eventually sustainable trucking, shipping and aviation. In general, respondents indicated lower appetite for investing in modular nuclear.

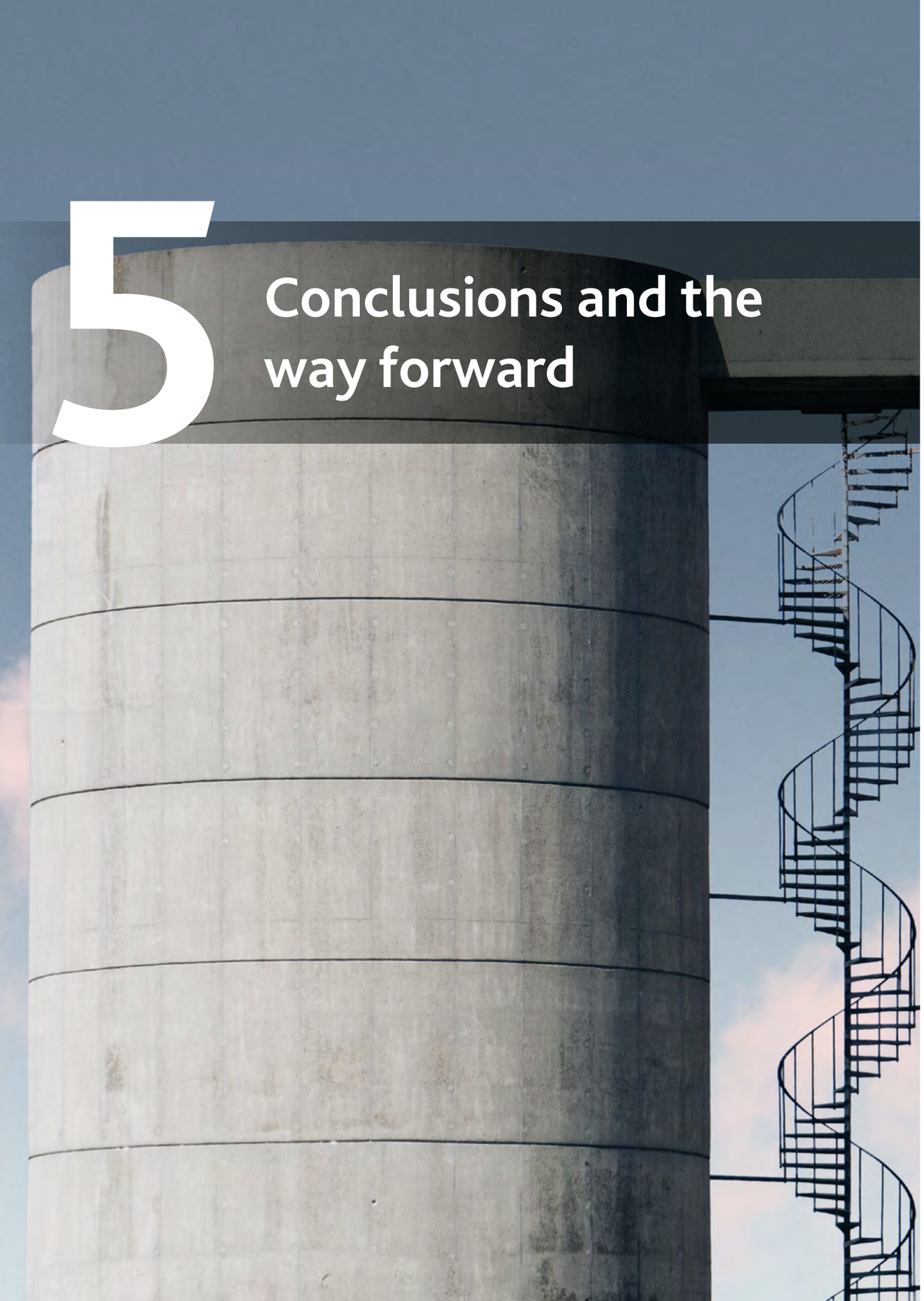
As assessing the feasibility of new climate tech is complex, re/insurers primarily invest in active partnerships with third-party venture capital firms (VCs) or in climate tech funds with diversified portfolios. Some re/insurers are also using their philanthropic funding to finance academic research to help expand innovations in this space.

CIOs have suggested that innovative financing approaches for new climate tech projects could help mobilise private capital investment. For example, the use of blended finance, government provision of umbrella protection and guarantees, and structured risk management solutions to allocate the risk to enhance risk-adjusted returns could be instrumental in attracting private capital into the pre-commercialisation stages.

84 U.S. DoE (n.d.)
85 VdS 2014.
86 With carbon removal and storage being one of the main areas for investment expansion among survey respondents. Almost half of the respondents noted that a robust, voluntary carbon market could potentially impact their investment decisions. Yet, for several of them, carbon credit markets do not hold a central place in their current investment strategies. Some further highlighted the importance of carbon credits in developing technological solutions, especially in areas like geological carbon storage and mineralisation.

Seventy percent of the CIOs surveyed highlighted the fundamental role that MDBs play in enabling institutional investors' engagement in climate tech projects within middle- and low-income economies. MDBs help to source and structure investable-grade projects; can enhance projects through public-private partnerships and blended finance structures; issue guaranteed bonds to attract investments; back the credit worthiness of the project counterparts; offer investment platforms; and help identify and mitigate uncertainties associated with on-the-ground project management. In addition, MDBs could eliminate or minimise downgrade and foreign exchange risk, and offer expertise in conducting due diligence, further supporting the successful deployment of climate tech projects.

Multilateral development banks can enable institutional investors' engagement in climate tech projects in middle- and low-income economies.



5 Conclusions and the way forward

Conclusions and the way forward

Re/insurers can help frame risks, design innovative risk management solutions, define insurability conditions and identify insurance needs to mobilise capital for new climate technologies.

The time window to decarbonise the global economy is narrow and closing rapidly. Transformative action across all sectors, particularly hard-to-abate, high-emitting industrial sectors, is needed. The current annual investment gap to fund the transition to a net-zero economy by 2050 stands at USD 7–9.2 trillion. A significant portion of this funding needs to be deployed to expedite the wide-scale commercial deployment of a range of new climate technologies.

Many of these technologies are in the pre-commercialisation stages and come with a wide range of new risks that need to be tested. A number of factors also hinder their market readiness. However, major efforts are underway to address the risks that obstruct market adoption and deployment.

The commercialisation and deployment of new climate technologies over the next decade will require new ways of doing business. Stakeholders from across different sectors will need to come together to develop risk management measures and innovative financing approaches to address the aforementioned investment gap and other barriers.

The research conducted for this report has revealed that, on one hand, there is clear evidence that recognition of the important role re/insurers can play in this space is increasing. The survey results confirmed interest and receptivity, particularly from larger P&C re/insurers, to engage in projects from an early stage, initially through their risk engineering services. Re/insurers can help to frame risks; aid in co-designing innovative, multi-stakeholder risk management solutions; define insurability conditions for technology-specific risks; and identify insurance needs to mobilise capital. The survey responses also highlighted the need to develop mechanisms that enable re/insurers to engage directly with key stakeholders at the project level. Exactly how and when re/insurers should engage in this context needs to be more clearly defined. Furthermore, as technologies reach the early commercialisation stages, re/insurers will need to cooperate with technical, standard-setting and certification entities to develop risk management frameworks, codes of practice, guidelines and standards with a focus on risk prevention for industry adoption. These processes will be foundational for expediting deployment and project replication but, again, still need to be outlined.

Re/insurers also contribute to the development of climate technologies by investing in the commercial deployment stages. The survey results shed light on the factors that limit large-scale investment in the pre-commercialisation stages but also reveal that some companies are expanding their investments in category 2 technologies through active-partnerships with third-party VCs or investments in climate tech funds with diversified portfolios. Some re/insurers are also using their philanthropic funding to finance academic research to help expand innovations in this space. The CIOs surveyed for this report also confirmed the need for innovative financing approaches for new climate tech projects to help mobilise private capital investment.

Industry-level collaboration and cross-sectoral partnerships will ultimately be essential for addressing the challenges associated with accelerating the commercialisation and wide-scale deployment of climate technologies outlined in this report.

The second report of this two-part series will focus on how to achieve some of these solutions. It will:

- Propose an enhanced ARL framework that includes additional risk categories that may hinder market readiness but are not included in current frameworks.

- Present a novel 'Insurability Readiness Framework' that enables ARL risks to be viewed through an insurance lens and mapped onto different phases of project development and financing to help frame and assess risks and related data needs from an early stage.

- Demonstrate the use of this new framework by applying it to two category 2 technologies, namely green hydrogen and carbon removal and storage to identify major hurdles from insurance lens.

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The Geneva Association
Talstrasse 70
Zurich, Switzerland

www.genevaassociation.org