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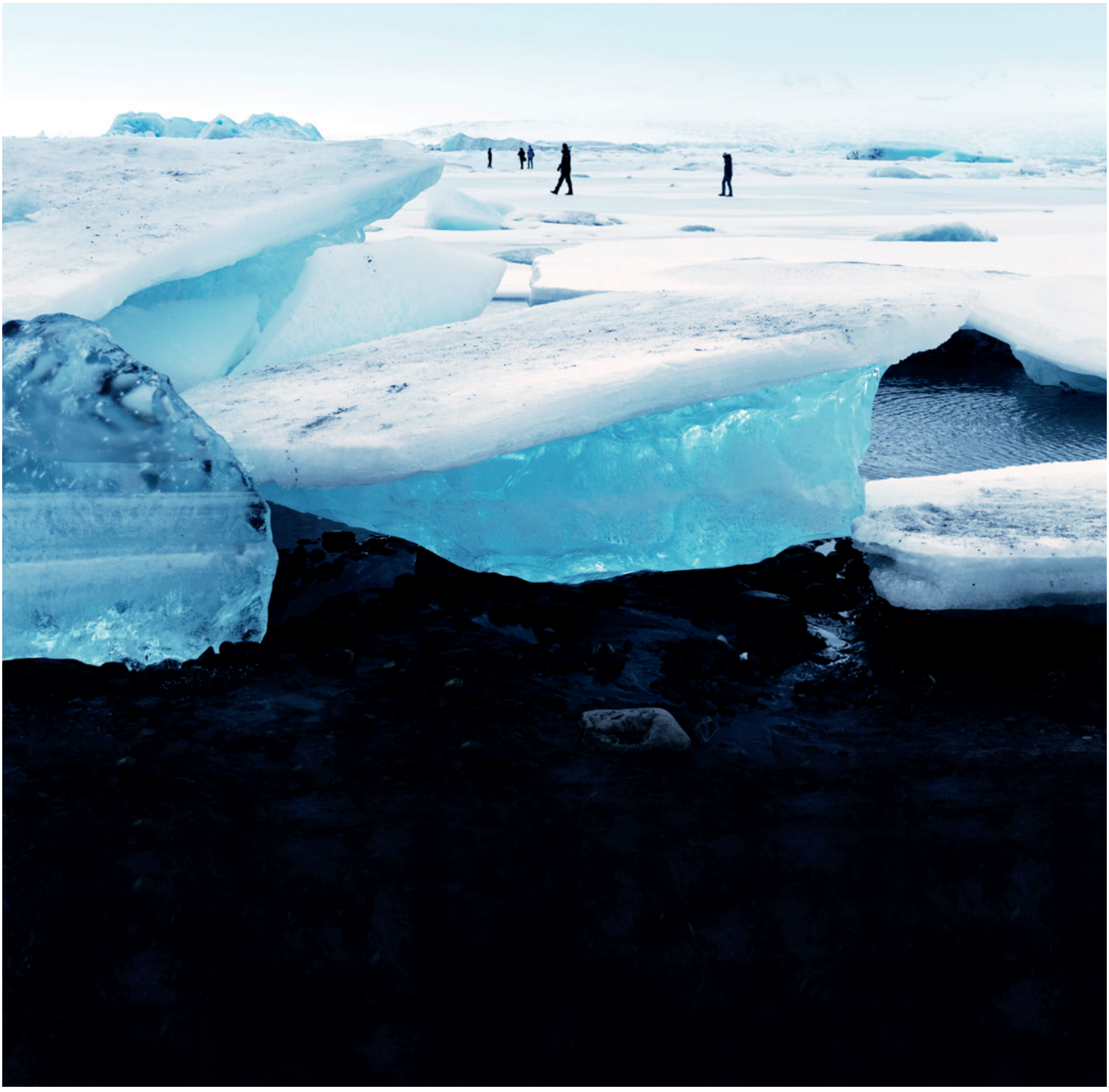
Managing the impacts of climate change: risk management responses – second edition



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Acronyms

2 C	2 degrees Celsius
B2B	business to business
BCP	business continuity plan
CCS technology	carbon, capture and storage technology
CCUS	carbon capture, utilization and storage
COP	conference of parties
ERP	emergency response plan
ESG	environmental, social and governance
ETS	emission trading systems
EV	electric vehicles
FSB	Financial Stability Board
GHG	greenhouse gas
HLEG	high-level expert group
HSE	health, safety and environment
IAE	International Energy Agency
INDCs	independent nationally determined reduction commitments
IPCC	Intergovernmental Panel on Climate Change
PV	photovoltaic
RCP	representative concentration pathways
TCFD	Taskforce on Climate-related Financial Disclosures
TRP	total risk profiling
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

A defining feature of climate change-related risks is the dynamic nature of the landscape in which they occur.

Over the past year, many aspects of this landscape have shifted rapidly, particularly in the areas of policymaking and public sentiment. This means climate change-related risks are a more critical and urgent challenge than ever for businesses. Companies must analyze scenarios and develop holistic strategies that adapt and build resilience – both to the de-carbonization of the services they deliver and the physical risks of climate change.

This is why Zurich has updated its highly successful 2018 climate change white paper. The updated paper will help businesses better understand the evolution and status of climate change-related risks. It will serve as a guide for businesses in developing an informed view of their exposures, vulnerabilities and hazards. And it will support them on managing and addressing risks through advice and the latest developments on tools and risk management practices.

Chapter 1 sets the context – using developments in the areas of policy, technology and emissions and sentiment and behavior to update Zurich's Climate Change scorecard. Despite some encouraging progress, this maintains our view that actions to date are insufficient to meet the Paris Agreement's target of limiting global warming to 2°C. In this Chapter, we also give examples of how physical and transition risks related to climate change are already being felt in the global economy and society. Lastly, we envisage both the challenges and opportunities of a sudden acceleration in low carbon transition.

Chapter 2 provides an update on risk management responses. We have restated Zurich's three step guide for companies to develop a climate resilience adaptation strategy and updated our commentary and guidance on the external environment in which these strategies must take place. The immediate challenge – especially carbon intensive sectors – is aligning investment, adaptation, transition and resilience strategies. This Chapter also highlights the current impediments to achieving a 'tipping point' in climate change adaptation strategies that would push us towards a 2°C scenario. The lack of analytic tools to model and quantify climate change effects is cited as one of the key barriers to a meaningful dialogue that could see such a change.

The chapter ends by noting the increasing demand for risk management tools that measure the impact of climate change. This demand is driven by the impact of severe weather on businesses and infrastructure, increased understanding that insurance alone is not a sound risk management strategy, the influence of external factors on losses and uncertainty in short and long-term investment strategies due to climate change.

Chapter 3 focuses on some of the latest developments on the tools and practices which can help to model climate change risk and develop options for strategic responses to climate change-related risks. It also provides a selection of Zurich-developed methodologies already in place such as Total Risk Profiling (TRP). Importantly, the chapter tracks the emergence of ecosystem solutions – provided by academic, business and government organizations – in a similar approach to that taken for cyber risk. This section further stresses the importance of working collaboratively on climate change challenges, to avoid unintended consequences from isolated stakeholder actions.

Zurich implements the multi-stakeholder ecosystem approach in refining its analytical and risk management tools both for understanding our own risk as an insurer and in the context of services we can offer to companies. Recognizing this growing customer demand, Zurich will be launching during its next strategic cycle a new Climate Advisory Service offering. This service will help those customers seeking a deeper understanding of the physical impact of natural hazards and climate change effects on their operations. It will be offered through Zurich's global commercial insurance team.

The chapter concludes with three options of how physical climate change-related risk can be integrated into insurance modelling tools. It also provides a case study of how natural hazard scenario planning can be used in practice – through Zurich's support to our customer, Konecranes.

This white paper also includes an Afterword of Zurich's own position on climate change. We are helping our customers and communities become more resilient to natural disasters and extreme weather; we make a difference through our responsible investment approach; and we are swiftly reducing our own carbon footprint. As part of this, we have become the first insurer to commit to the UN Global Compact's Business Ambition for 1.5°C.

Zurich is a company with sustainability at the heart of its business. By helping business to address and adapt to climate change-related risks, we are confident that this updated white paper can make a positive difference.

Introduction

The clock is ticking to avoid the likely irreversible and catastrophic effects of exceeding the Paris Agreement's 2°C target.

Like other global risks, climate-change related risks are highly interconnected and complex. However, a defining feature is the dynamic nature of the landscape in which these climate change-related risks occur.

Over the past year, many aspects in this climate change risk landscape have shifted rapidly. Policymaking has moved in favor of tackling climate change – our own analysis via the Zurich Climate Change scorecard shows that legislation and regulation has reaccelerated. The number of initiatives in the first half of 2019 (either introduced or commenced, already active or expected) has increased markedly compared to the same time last year. Moreover, it exceeds the number of initiatives that were enacted in 2015. Public sentiment is moving in the same direction – symbolized by the activism of millennials and Generation Z'ers like Greta Thunberg and the Youth Climate Movement. And attention on climate change-related risks has been further sharpened by extreme weather events – new heat records have been reached and natural disasters have brought severe economic and human consequences.

This fast-evolving landscape is making climate change-related risk a more critical and urgent challenge than ever for businesses to address. Companies must analyze scenarios and develop strategies that adapt and build resilience – both in the de-carbonization of the services they deliver and to the physical risks of climate change. Given the scale and nature of the risks involved, this strategy needs to be holistic. Actions are required at company level, alongside peers and with Governments in public-private collaboration.

This is why Zurich has updated its highly successful 2018 climate change white paper. The updated paper will help businesses better understand the evolution and status of climate change-related risks. It will serve as a guide for businesses in developing an informed view of their exposures, vulnerabilities and hazards. And it will support them on managing and addressing risks through advice and the latest developments on tools and risk management practices.

The clock is ticking to avoid the likely irreversible and catastrophic effects of exceeding the Paris Agreement's 2°C target. Whist Zurich's own estimates – informed by our Climate Change scorecard – maintain the view that actions remain insufficient to avoid this scenario, there are positive signs. We are particularly encouraged by the wave of new commitments over the past twelve months on adaptation and pre-event resilience.

Such progress can set the stage for an acceleration of action. We hope this will lead to a *"decade of resilience"* – that truly prepares individuals, communities and nations for the increased physical and economic risks we expect from climate change.

> *To do this, all stakeholders must up their game, both individually and collectively. It is not just about avoiding disaster but also grasping opportunities – including an $18 trn low-carbon economy global infrastructure gap across segments such as energy, transport, and digital technology.*

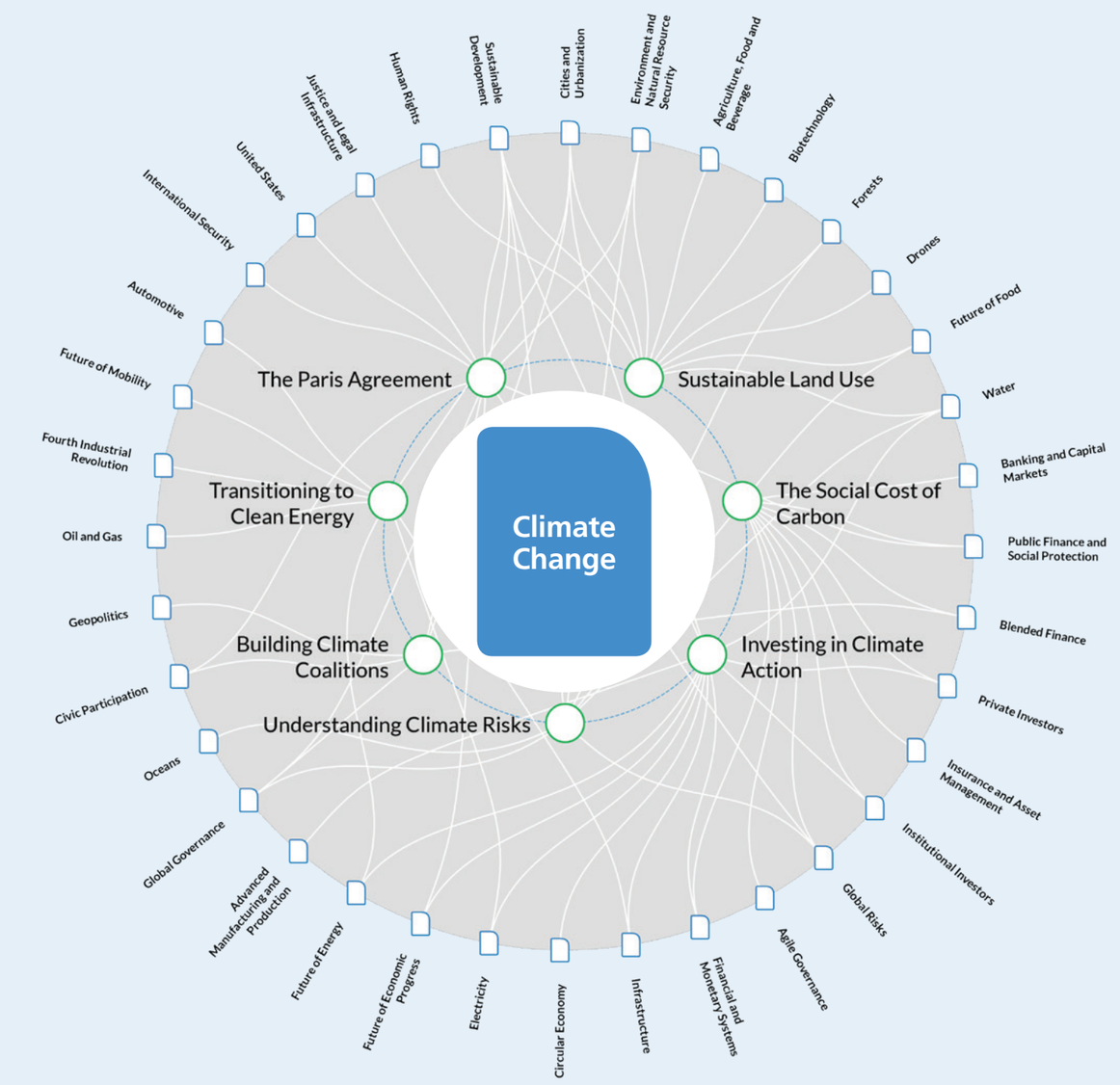
In short, acting on climate change-related risks makes sense economically, strategically and, above all, it is simply the right thing to do.

Definition of physical and transition risks:

Physical risk
adaptation to the largely physical consequences of climate change.

Transition risk
mitigation of greenhouse gas (GHG) emissions and its associated transition risks, including revaluation of assets.

Climate risk interconnectivity



CHAPTER 1

Zurich's Climate Change scorecard and narrative – progress, but not enough

Fueled by the Youth Climate Movement, high-profile warnings from the scientific community and an increased occurrence of extreme weather events, climate change-related topics have become more prominent in the media and political discussion over the last year.

Yet emissions of greenhouse gases (GHG) have continued to increase – with CO_2 emissions now rising at the fastest pace since 2013 – making the burden of climate change yet heavier for future generations.

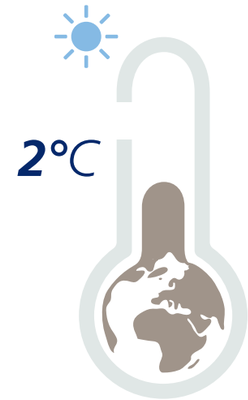
Also in the past year, other global risks in the areas of geopolitics, economic, societal and technology have continued to act as distractions – deflecting focus from longer-term issues such as climate change. At the same time, extreme weather events have been frequent, with heat records set in almost all regions, and devastating wildfires, droughts, rainfalls, typhoons and mudslides have brought with them human tragedies and disruption to economic activity.

It is currently difficult to say for sure if a specific weather-related event is either more severe or likely as a consequence of climate change. However, it is clear that – in a warming world – the patterns of severe weather are changing. The effects of these patterns are exacerbated by the more obvious impacts of climate change: including melting land ice, sea level rise and changes to ocean temperatures and circulation. They serve as a warning that urgent change is now required in order to shift the trajectory for greenhouse gas emissions and limit the rise in global temperature.

With these conflicting forces at play, it is not easy to assess the overall progress and direction of change. This is why Zurich developed the climate change scorecard, which aims to measure developments in a range of climate change-related areas. It uses quantitative data and draws on various climate change scenarios constructed by the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA), among others.[1] This is by no means an easy task, and data uncertainty and measurement issues are large. But, by tracking developments over time, it is easier to detect if progress has picked up, or where efforts and ambitions are lagging behind (more details on **Navigating Climate Change** and **Two Degree Target for Global Warming** is Melting).

Our initial scorecard analysis indicated that the likelihood of missing the Paris Agreement's target of limiting global warming to 2°C or below was higher than achieving it.

Now, almost three years after our original scorecard, we have updated it once again.



*Our initial scorecard analysis indicated that the **likelihood of missing** the Paris Agreement's target of limiting global warming to 2°C or below **was higher than achieving it**.*

[1] See appendix for definitions of the data.

1.1. Zurich scorecard update

1. Carbon pricing
2. Corporate action
3. CCUS
4. Energy systems
5. Social trends
6. Energy storage
7. Energy demand and efficiency
8. CO_2 emissions
9. Investment
10. Legislation
11. Fossil fuel subsidies
12. Electrical vehicles

1. Carbon pricing
2. Corporate action
3. CCUS
4. Social trends
5. Energy supply
6. Legislation
7. Energy demand and efficiency
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10. Energy integration and storage
11. Fossil fuel subsidies
12. Electrical vehicles

Not on track for 2°C scenario | Improving but more is needed | On track if pace is maintained

Source: Datamaran, World Bank Group, IEA (International Energy Agency), BP, IMF, MSCI, Bloomberg NEF (New Energy Finance), ZIG (Zurich Insurance Group)

The overall takeaway from the most recent score card is that, while legislation, sentiment and social trends have shifted in favor of tackling climate change, actions are still falling short of what is needed to sustainably transition the global economy and societies to a 2°C scenario.

The scorecard takes the view that far-reaching change to the global energy system is needed to achieve a 'two-degree compliant world'. To accomplish this, fundamental changes to policy and technology are required; sentiment and behaviors have to move strongly in favor of tackling climate change. To achieve the 2°C scenario, sufficient progress needs to be made in three key areas:

– Policy measures

– Technology and emissions

– Sentiment and behavior

Policy measures

Key targets: *A global price on carbon; national and regional legislation to enforce binding climate change commitments; a phasing-out of fossil fuels, including subsidies.*

Zurich advocates for a global price on carbon, established at a level that over time becomes consistent with transitioning to a 2°C trajectory. Such a price would mean that negative externalities of fossil fuels and other sources of GHG emissions are properly accounted for and reflected in the price. This would help ensure that a proper assessment of risks and opportunities is reflected in investment and business decisions. It is therefore one of the key categories of the score card.

Over the past year, developments around carbon pricing schemes have been limited. Carbon pricing remains patchy – only around 16 per cent of global greenhouse gas (GHG) emissions are covered by a pricing scheme – and the average price in existing schemes remains around USD 20 per ton of carbon dioxide. This compares to the World Bank Group's indication that a price of USD 80-120 per ton of carbon dioxide equivalent emissions is required to transition to the 2°C path.

On the critical aspect of a carbon price, too little progress is therefore being recorded to be on track for the 2°C scenario.

We are encouraged by the latest indicators which show a re-acceleration in new climate change-related legislative and regulatory initiatives. This includes in fields such as air emissions, alternative fuels, energy efficiency and use, greenhouse gases and renewables. The number of initiatives in the first half of 2019 (either introduced or commenced, already active or expected) has increased markedly compared to the same time last year. Moreover, it exceeds the number of initiatives that were enacted in 2015 – when the Paris Agreement caused a spike in legal activity that then slowed sharply. While this is a positive development, the pickup in legislative activity in 2015 was a false dawn, and it will be critical that current improvements are sustained.

However, in other policy areas, developments have been outright negative. Fossil fuel subsidies – which were reduced at a rapid pace over the past few years – have reversed, with a large increase in overall subsidies in 2018. This partly reflects rising subsidies to the natural gas sector, but traditional fossil fuels have also seen subsidies increasing.

Technology and emissions

Key targets: *Achievements of near-term targets for CO_2 emissions, global energy demand and energy efficiency; a rapid rise in the share of renewable energy in the energy mix; progress on energy integration and storage technologies to support large-scale use of renewable energy; rapid penetration of electrical vehicles; positive developments on carbon-capture technology.*

Carbon dioxide emissions have risen over the past two years, up by close to 2 per cent in 2018, following an increase of 1per cent in 2017. This is the largest annual increase since 2013 and not consistent with a sustainable transition to a 2°C scenario – which requires CO_2 emissions to start plateauing by 2030. Some of this additional carbon dioxide will remain trapped in the atmosphere for thousands of years, raising the burden for future generations.

The acceleration in emissions partly reflects stronger economic activity. This shows that energy efficiency gains are not yet large enough to decouple emissions from global economic activity. The pattern is also clear at a country level. In any given year, countries that achieve a higher growth rate are, on average, also associated with a larger increase in CO_2 emissions.

This highlights the complexity of the challenge. The global economy and individual countries need growth to create wealth and opportunities. However, with carbon emissions still on a rising trajectory, governments and businesses need to raise their ambitions and do more to reposition their countries for a cleaner, more productive and ultimately sustainable future.

In the case of clean technologies, we draw on the IEA's technology tracker for many indicators.

There is good progress in some fields, including the penetration of electrical vehicles and around renewable electricity generation – which rose solidly in 2018. Wind and solar accounts for the bulk of the increase. Energy integration and storage technologies are additionally needed to make energy systems more flexible and allow for the large-scale use of renewable energy. While progress is picking up, this appears to be an area where more innovations – and investment – are needed.

We are less encouraged by the lack of progress around coal-fired power generation, which rose further in 2018, mainly reflecting growth in Asia. To leave the door open for a 2°C scenario, we have to take advantage of low hanging fruit – such as the substitution of natural gas for oil and coal, as well as reducing GHG emissions from oil and gas production refining and transport, including methane emissions and flaring. There is also insufficient progress on carbon capture utilization and storage technology (CCUS), with only a handful of projects in place globally.

Sentiment and behavior

Key targets: *Decisive corporate action and positioning; increased public and private investment in climate change research and clean energy; social trends driving actions to tackle climate change.*

The last components of the scorecard capture bottom-up action and trends.

The business sector will be critical in driving developments towards a 2°C scenario. We use indicators to track corporate actions – as well as positioning – on climate change-related topics. Morgan Stanley Capital International (MSCI) company scores on management actions on climate change and environmental, social and governance (ESG) related topics show a modest improvement in the global ranking over the past year, but it is not yet sufficient to bring it into a more sustainable category. These scores also confirm that, although a large group of companies are making excellent progress, too many are still lagging behind. Corporate reporting data, used to detect changes in the emphasis that businesses place on climate change-related topics, show a similar picture.

Taken together, the indication is that the business sector as a whole still appears to be lacking in ambition on climate change. Companies are vulnerable to climate change-related risk, and their consumers are becoming increasingly aware of climate change, demanding firms take more action. Climate change-related risk will moreover affect all companies' stakeholders and action is being demanded from investors, employees and communities alike. This therefore reflects a missed opportunity, as it is clearly in the interest of businesses to act on this topic.

On a positive note, our scorecard picks up that news flow on climate change-related topics has become more marked. The number of articles published on related topics in major international media has picked up significantly compared to previous years. Effort to put climate change on the agenda appear to have achieved some success. This will be important in shaping politics and climate change actions over the coming years.

To conclude, the scorecard shows that there have been encouraging improvements in some fields over the past year. However, the overall likelihood of transitioning the global economy to a 2°C trajectory still appears to be lower than that of failing to do so.

The business sector will be critical in driving developments towards a 2°C scenario.

1.2. Impact of present physical and transition-related climate change risks on the economy

Climate change has famously been dubbed a tragedy of the horizon – where its catastrophic impacts are only likely to be felt beyond the time horizon of most actors, imposing a cost on future generations that the current generations have no incentive to fix. If, as our score card currently suggests, too little is done to tackle climate change, we would expect transition risks to remain limited, and physical risk would only become more material over the coming decades – as temperature gradually rises.

However, last year saw a number of events and actions that appear to challenge this assumption. While uncertainty is large, it appears that climate change risk may already be impacting on businesses and the broader economy. This trend is only likely to increase in the years ahead.

A series of wildfires in the State of California in 2017 and 2018 showed how climate change can incur very specific near term costs – as well as long term hypothetical ones. The wildfires led to the California-based utility company PG&E filing for bankruptcy after facing liability for the damages. This was one of the first bankruptcies that was tied to climate change, where extensive damage was amplified by extremely hot and dry weather conditions.[2]

The automotive industry has additionally struggled with transition risk – in the form of regulatory changes around the testing process for the EU's fuel efficiency ratings that have caused ripple effects across the global supply chain. Considerable uncertainty around future technology and regulation on CO_2 emissions appear to have had a longer-lasting effect on auto demand, as consumers await more clarity around future regulation. Elsewhere, several manufacturers recently agreed to an emission cut target with the state of California, showing that the sector is still committed to meaningful progress, and suggesting that change is coming.[3]

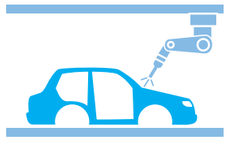
The market value of businesses exposed to thermal coal has also continued to drop as investors look towards the future. While this is not new, divestment appears to be accelerating. For example, major mining groups -alongside investors more broadly – are choosing to disinvest from thermal coal assets.[4]

Major central banks have also begun to question whether climate change may already be having an impact on economic activity. In 2018, for example, the European Central Bank noted a puzzling persistence in petroleum prices in Germany despite falling oil prices.[5] It also saw slowing activity in the chemical, steel and pharmaceutical sectors. One reason for both of these observations appears to have been the hot summer, which caused the water levels in German rivers to fall to levels that only allow petrol tankers to carry half their capacity.[6] This created unexpected supply bottlenecks, impacting across the economy. This illustrates that all societies are vulnerable when the weather changes, and the impact can be both unexpected and material.

More broadly, politicians and financial regulators are beginning to respond quickly. Since the development of the Taskforce for Climate related Financial Disclosure (TCFD framework), over 800 companies have now done the analysis, scenario work and strategy development to begin disclosing climate change impacts. This is being further amplified and codified by the European Commission's Sustainable Finance Action Plan. The plan starts with a sustainable finance taxonomy to help investors understand broadly the *"green"* versus *"brown"* aspects of different sectors and businesses, as well as the other ESG impacts of decisions to invest or disinvest in these sectors.

A number of financial regulators around the world are mulling whether or not to introduce specific climate change risk assessment as part of capital or solvency metrics for regulated firms. The Bank of England/Prudential regulation Authority (PRA) released in April of 2019 a new supervisory statement that aims to enhance banks' and insurers' approaches to managing the financial risks from climate change.[7] This requires regulated entities to calculate the capital and solvency impact of climate change risk on both short and long-term time scales. Whilst acknowledging the challenges in doing this, it is the start of a movement that will change the financial services attitude towards investing in the risks associated with climate change.

Finally, the Youth Climate Movement is important because it is driven by a generation that will be more exposed to the costs of climate change. It could break the tragedy of the horizon – eventually forcing policy makers, business leaders and individuals to take critical action. If successful, this would lead to rising transition risk over the coming years.



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[2] https://energypolicy.columbia.edu/sites/default/files/file-uploads/PG&E-CGEP_Report_081519-2.pdf
[3] https://ww2.arb.ca.gov/news/california-and-major-automakers-reach-groundbreaking-framework-agreement-clean-emission
[4] https://www.bloomberg.com/opinion/articles/2019-07-12/bhp-s-thermal-coal-unit-may-fetch-less-than-rio-tinto-s
[5] https://www.ecb.europa.eu/press/key/date/2018/html/ecb.sp181108.en.html
[6] https://www.bloomberg.com/news/articles/2019-07-23/the-rhine-river-risks-a-repeat-of-last-year-s-historic-shutdown
[7] https://www.bankofengland.co.uk/prudential-regulation/publication/2019/enhancing-banks-and-insurers-approaches-to-managing-the-financial-risks-from-climate-change-ss

1.3. Accelerated transition – a risk scenario

As the frequency of extreme weather events is expected to rise further, and as costs associated with climate change become more visible, there is the hope and possibility that actions to tackle climate change will accelerate. While our climate change scorecard shows that this is not yet happening at a sufficient level, it is nonetheless useful to look closer at what a sudden, and potentially disruptive, transition scenario may look like. There is, however, still a lack of models that quantify such a scenario, and this is one area where more targeted work needs to be done by academics, businesses and central banks.

The box below gives more details on a **transition risk scenario** gives more details on a transition risk scenario which includes a global price of carbon and stricter regulation for the auto and aviation sectors. The starting point for this analysis is that the global economy is already vulnerable, with high debt levels, weak growth dynamics, and negative interest rates. Sudden action to tackle climate change would, in such environment, likely trigger a growth slowdown – and potentially a global recession.

Precisely because a transition risk scenario will be disruptive, one conclusion from our scenario analysis is that policy makers and businesses should aim to take action on climate change sooner rather than later. Only then will they be able to phase in action and take gradual steps, limiting disruptions to individual sectors and the broader economy.

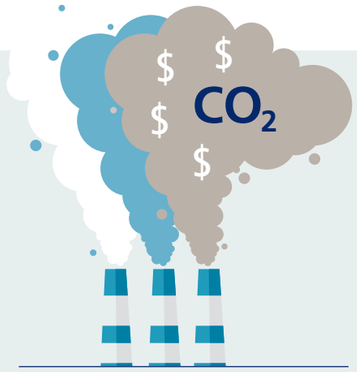
A fortunate combination of circumstances is currently presenting governments with an opportunity to stimulate their slowing economies while repositioning their countries for a cleaner and more productive future. This includes a return to historically low – and in many cases deeply negative – interest rates and an inflection point in sentiment towards climate change. Now is the time to act.

A major energy transition would create huge opportunities as well as risk. Within each sector, there would likely be a large variation between businesses that stand to gain from the transition, and those that fall behind. This is why companies must focus on developing strategies that build resilience, both to the de-carbonization of the services they deliver, and the physical risks of climate change.

A sudden, and disruptive, transition scenario

This scenario is based on a sudden, and coordinated, announcement by OECD countries to impose a price of carbon, initially set at USD 30 per ton of CO_2 emissions, but with a credible plan to raise it to USD 100 over the coming decade. This could be implemented either as a carbon tax or a quota (cap and trade), with a top-up tariff whenever the quota undershoots the target price. Stricter regulation for the auto sector is also announced, together with increased duties for air transport. While unlikely to occur over the next few years, this scenario is not unthinkable. In particular, there is broad agreement that a carbon price at this level is required to tackle climate change. Governments could partly offset the overall impact on the economy by redistributing or the tax revenues, in which case the tax would come with a carbon dividend.

To put this into perspective, a tax of ***USD 100 per ton of CO_2 implies a tax of USD 43 per barrel of oil****. Given current oil prices at around* ***USD 60/bbl, a global tax of this size would lead to a material – but not unprecedented – rise in oil prices****. Another way to quantify the shock is to consider that global CO_2 emissions were 34bn tons in 2018, so* ***taxes of around USD 3.4trn would be needed to be raised. This is equivalent to around 4per cent of global GDP.***



There is surprisingly little work that tries to assess the impact on the global economy of a sudden and disruptive increase in the carbon price of this magnitude. Most studies look at the long run impact of a gradual and well-behaved transition, where the impact on financial markets and GDP are typically found to be limited. Here, new technology allows a relatively smooth transition to happen, and households and businesses are able to fairly seamlessly substitute away from fossil fuels.

If one looks at a shorter time span, however, energy demand is likely to be inflexible, with substitutes to fossil fuels still lacking in many sectors and regions. A carbon tax is therefore an additional cost that energy users – households and businesses – would need to pay. Households would be faced with a real income squeeze and reduced non-energy spending. Businesses would be forced to take a hit on their profits or pass on the higher energy costs to output prices, which would put further downward pressure on household demand. Households and businesses would also be likely to delay purchases of some items, such as cars, until there is more certainty around future technology and regulation. This would lead to underutilization of resources in more exposed sectors.

There is large uncertainty regarding the precise impact on economic activity, given the unprecedented nature of the event. Historically, however, large increases in energy prices have often coincided with US and global recessions. This suggests that a carbon tax of this scale may well tip the global economy into a recession. This is particularly likely given broader vulnerabilities in the global economy; such as high debt, negative interest rates, and elevated geopolitical and political risk.

Global financial markets would be impacted. Risk assets would be expected to respond negatively, with a sharp decline in equity prices. The impact would be differentiated depending not only on CO_2 emissions, but also perceived vulnerability to the emergence of new technology and linkages to the fossil fuel sector. Industries that would likely see higher than average declines in equity prices would include those that are directly linked to fossil fuel extraction and refining, energy utilities, heavy manufacturing, and transportation. A major energy transition would also create huge opportunities as well as risk. Within each sector, there would likely be a large variation between businesses that stand to gain from the transition, and those that fall behind.

CHAPTER 2

Risk management responses to climate change

Climate change is similar to many other global risks, in that it is interconnected with other global risks (e.g., the 'water-food-energy' risk nexus) and is therefore a multi-stakeholder challenge.

How it differs is in its long-term nature, which makes it difficult for companies to take immediate and urgent risk management actions. Risk management responses to climate change risks fall into two categories; those addressing physical climate risks and those addressing transition risks. (see page 8 for full definitions).

While the most severe physical changes of climate change are likely to take decades to manifest (although, as per section 1.2, some are already being felt), they are largely irreversible in the long term. So, the challenge is to act now, to transform the global economy and largely decouple global economic growth from GHG emissions. At the same time, due to the lag effects of GHGs in the atmosphere, the world will need to continue to adapt to the physical effects of climate change for decades to come. The challenge, then, is to drive risk-informed climate-sensitive decision-making across all sectors.

In contrast, transition risks are driven largely by changes in societal perception of carbon intensive industries, new public policy, new technologies and changing consumer sentiment. This will potentially lead to economic and societal impacts on a much shorter time frame. A clear understanding of the goals of transition and the unintended consequences of even the most well-meaning policies will help focus and mitigate transition risks.

2.1. Adopting and acting upon a climate resilience adaptation strategy

As climate change and its associated risks continue to evolve rapidly – assessing resilience and responding accordingly remains essential for communities and corporations. For businesses leaders, this process may yield benefits beyond investment in improving the physical resilience of assets and developing alternatives to existing supply chains, utilities, and so on. A truly holistic review of environmental risks will reveal opportunities as well (USD 2 trillion according to the CDP).

Given this, it is useful to restate the three key steps that are crucial for companies to develop a climate resilience adaptation strategy:

1. **Identify the broad business and strategic risks** – including exposures your businesses have, understanding where your vulnerabilities are and to what kind of hazards, or risk triggers to which you are exposed.

2. **Develop a granular view of the risks involved,** typically involving the modelling of both physical and transition risk impacts – including, for example, individual locations, or specific business activities, including products and services.

3. **Develop a mitigation strategy involving insurance** and developing resilience strategies, either through physical risk adaptation, or perhaps changing business models and activities to address transition risks.

Step 1: Identify the broad business and strategic risks

Scenario-based approach
1. Governance
2. Strategy
3. Risk management
4. Metrics and targets

For this we recommend using a scenario-based approach and a structured analysis such as the one developed by the TCFD:

1) **Governance:** Define the company's governance around climate change-related risks and opportunities including:
   - i) The Board's oversight of climate change-related risks and opportunities
   - ii) Management's role in assessing and managing risks and opportunities

2) **Strategy:** Identify actual and potential impacts of climate change-related risks and opportunities on the company's businesses, strategy and financial planning
   - i) Describe the climate change-related risks and opportunities the company has identified over the short, medium, and long term
   - ii) Assess the impact of climate change-related risks and opportunities on the company's businesses, strategy, and financial planning
   - iii) Assess the resilience of the company's strategy, taking into consideration different climate change-related scenarios, including a 2°C or lower scenario

3) **Risk management:** Define how the company identifies, assesses and manages climate change-related risks
   - i) Develop processes for identifying and assessing climate change-related risks
   - ii) Develop the company's processes for managing climate change-related risks
   - iii) Integrate the processes for identifying, assessing and managing climate change-related risks into the company's overall risk management

4) **Metrics and targets:** Implement metrics and targets used to assess and manage relevant climate change-related risks and opportunities
   - i) Disclose the metrics used by the company to assess climate change-related risks and opportunities in line with its strategy and risk management process
   - ii) Disclose GHG emissions and the related risks
   - iii) Describe the targets used by the company to manage climate change-related risks and opportunities and performance against targets

Step 2: Develop a granular view of the risks involved – including, for example, individual locations, or specific business activities, including products and services

Use scenarios developed in step 1 and gather appropriate data to model the magnitude of risk, prioritizing according to the company's particular circumstances (industry, products and services, supply-chain, physical locations/assets, business model maturity and risk appetite).

For transition risks, there are evolving socio-economic transition pathways being developed (see example here: https://www.ipcc.ch/sr15/chapter/spm/spm-c/spm3b/) but in some sectors there are some very precise regulatory or technology pathways that need to be built-in to models that analyze the impact on products & services, or even entire business models. The challenge is that, in some sectors, data and scenarios are well understood, but in others they are not, or are poorly provided for.

Nevertheless, it is important for businesses to start the analysis of how they could be affected by climate change risks and opportunities. Developing scenarios that are plausible, relevant, distinctive, consistent and challenging and which span both transition and physical risks is an important first step. This needs to identify the main challenges facing an industry, the companies within it, as well as individual products and services and their associated business plans. There then needs to be an analysis of which key risk categories to model and how to embed climate risk considerations in business-as-usual risk processes.

For each industry, there are different quantitative and qualitative tools, data and metrics used to monitor and assess exposure to the transition risks. There are also the challenges of determining the depth of any analysis across the dimensions of different portfolios and the depth of supply chain analysis. The key is to avoid models that are either founded on multiple layers of assumptions, are overly-complex, or that do not produce credible outputs that can be used by the business as the foundation of business decisions.

In the physical risk domain, the impact of climate change risks on physical locations or assets is somewhat clearer. Over the last 30 years, catastrophe models have evolved as innovative tools to identify, assess and manage natural catastrophe risks for seismic and climate change-related hazards. Today, sophisticated catastrophe models exist for several perils and covering many regions and lines of business.

Today's models are generally designed to reflect current climate conditions. So while catastrophe models can play an important role in capturing physical risks of climate change, it is important to recognize their limitations and the complexity of conditioning them to a different future climate. In section 3.2, we provide the latest on the evolution of modeling capabilities to better quantify the impact of climate change on physical risks.

Lastly, as catastrophe models do not cover all perils and countries, other tools, such as global (or where available local) peril-specific hazard maps are necessary to assess these 'non-modelled' perils and regions to develop loss estimates. These tools do not price the risk in the same manner as catastrophe modelling tools, which are traditionally used in the insurance industry. However, they are an essential tool for performing a preliminary analysis of multiple locations with a global footprint to identify the natural hazard exposure level.

Experience and judgment – of local topographic conditions, construction practices or local protection mechanisms – play an important role in analyzing the output of the conventional tools used for multilocation hazard identification and assessment, as the severity of the event could dramatically change within a short distance. An example is the effects of soil properties on earthquake shaking levels, or the impact of changes of topography within a short distance on flood depths.

Besides yielding information relating to accumulated annual loss, 'exceedance' occurrence probability and other parameters used by insurers in the design of policies, catastrophe modelling tools may also help identify high-risk single locations, as well as concentrations of locations that could potentially be affected by a single event.

We recommend that prioritizing locations for the second step of the resilience strategy is based on the definition of 'critical' in the company. For example, this may be a location or region that meets one or more of the following criteria:

- High concentration of value at one location
- Long replacement time for equipment or stock at a location
- The location is a significant contributor to the group value chain or revenue
- Large concentration of occupants or population in the immediate vicinity
- Large area around the site that could be impacted environmentally
- Multiple locations that could be affected by a single event
- Location relies on workers living in highly exposed and vulnerable neighborhoods
- Location relies on public utility and infrastructure services that are highly exposed and vulnerable

This review and analysis relates to operations or locations within the stakeholder's own responsibility. Ideally, suppliers and critical infrastructure would also be included in the analysis.

Improving the impact measurement of physical risks: a key enabler of climate resilience adaptation strategies

Assessment of the physical impacts of climate change starts with determining the evolution of hazard levels, i.e. effect of climate change on intensity and frequency of natural hazard phenomenon (wildfire, water shocks, flooding, windstorms, etc.).

There is an increasing demand for tools that measure the impact of climate change. This is driven by:

- The severity of impact on businesses and infrastructure (especially business interruption) from increased frequency of events. Although it is worth pointing out that the latest (IPCC reports and climate science often paints a confusing picture of different peril/regions having unexpected decreases in frequency. For example, tropical storms seem to have increasing intensity (impact/severity) but reducing frequency. Regions are experiencing events to which they have historically been immune (e.g., wildfires in the northern polar region, migration of typhoons northwards towards Shanghai.
- Increasing realization that relying on insurance alone is not a sound risk management strategy for physical events. This is especially true of the consequences of severe weather events. Increased resilience involves a range of measures – physical, organizational and insurance.
- The severity of extreme natural hazard events is often influenced by factors outside the control of the organization, for example the performance of key infrastructure, utilities and public control measures (e.g., levees, pump systems for flood)
- Limitations exposed in traditional tools used in the insurance industry – through changes in frequency, intensity, and severity of events. This is also true of other industries (e.g., building design codes, infrastructure management, etc). These tools have been developed based on historical data. The influence of climate change effects on hazard level evolution is still highly uncertain and complex.
- Uncertainty in short and long-term investment strategies, due to impact of climate change on physical and transition risks.

It is important to understand that the current state-of-knowledge precludes development of very precise tools. Some actions can nevertheless be taken for improvement in risk management of natural catastrophes, in particular severe weather using the available science. For example, traditional building design codes need to consider the reduction of (content of buildings) and not only focus on human safety. They must also define the hazard levels (e.g., snow loads, wind forces, flooding characteristics) based on evolution due to climate change – in addition to historical events which are currently the basis of such documents.

As mentioned previously, the insurance industry also needs to look beyond catastrophe models to account for climate change effects. Traditional natural catastrophe models are essential tools to design the insurance policy (e.g., price the risk). However they cannot consider all factors that influence severity (e.g., hazard level evolution due to climate change, deterioration of physical assets (aging) and infrastructure, duration of events as well as their limitation in terms of global coverage of the various perils).

Step 3: Develop a mitigation strategy involving insurance and developing resilience strategies, either through physical risk adaptation, or perhaps changing business models and activities to address transition risks

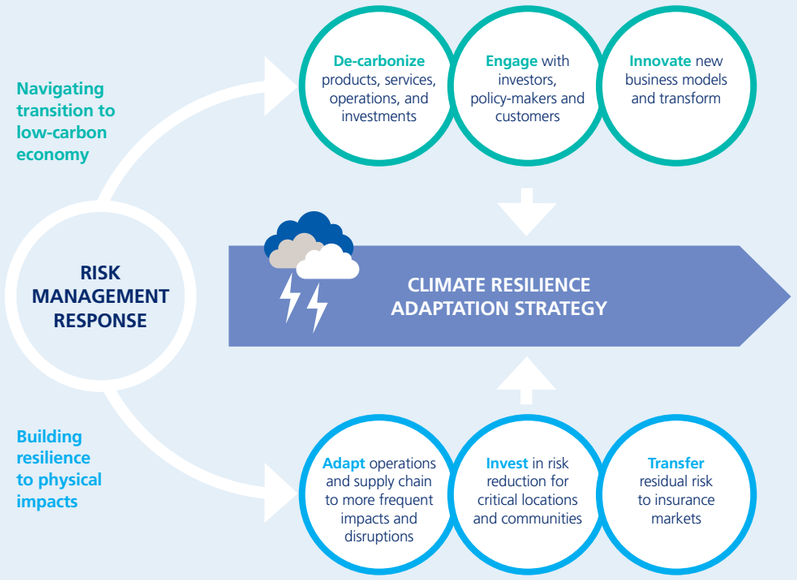
On the transition risks side, for carbon-intensive sectors a meaningful GHG emissions reduction strategy should consider product and service innovation – as well as potential needs for business transformation. Typically, lifecycle carbon intensity measures and targets should be set that match – or exceed – those expected as society more broadly reduces overall emissions. The Science Based Targets initiative (https://sciencebasedtargets.org/) provides a simple framework to set targets for carbon emission reduction that match the Paris Agreement goals of keeping global warming substantially lower than 2 degrees. This makes good business sense as *"Setting greenhouse gas emission reduction targets in line with climate science is a great way to future-proof growth"*.

On the physical risks side, for those locations defined in the second step as 'at risk', scenario-based loss estimates should be developed, based on detailed information regarding site vulnerabilities (physical and organizational) and potential events which could impact the locations.

Local hazard maps, where available, are used and assumptions applied regarding climate change effects in the scenario process. Such an analysis is an essential component of the resilience strategy. It would include an on-site assessment of the reliability and effectiveness of emergency response and business continuity plans, any peril-specific protection measures (e.g., mobile flood protection elements, etc.), quality of structures, infrastructure and utilities. With this information in hand, a medium- to long-term resilience strategy can be developed. Within this, budget for capital expenditure projects, as well as reallocation of existing budget toward resilience measures, can be defined.

This type of integrated approach involves not only insurance – which supports the site in restoring operations after the event – but also prevention measures (physical and organizational) that reduce the impact and severity of an event on the locations.

Companies must decarbonize and innovate to address transition risks while at the same time building resilience to physical risk



2.2. Progress on climate resilience adaptation and GHG emissions mitigation strategies

The challenge for business leaders and policymakers is to create strategies that optimize the opportunities associated with adaptation to the physical risks of climate change and GHG emissions mitigation. In some cases, this will be done by individual initiatives carried out by the private or public sectors. In most cases, it will require multi-stakeholder action. In a few cases, it will require new technologies, new industries and new business models to be developed with new approaches to managing risk, including changes to legislation and regulation.

In Europe, the EU has developed the EC Action Plan on Sustainable Finance. In June 2019, the Technical Expert Group on Sustainable Finance published the first classification system, or taxonomy, for environmentally sustainable economic activities. This aims to provide guidance for policy makers, industry and investors on how best to support and invest in economic activities that contribute to achieving a climate neutral economy.

In addition, regulators in the Financial Services sector are beginning to mandate quantification of climate change risks. This will,in-turn, impact all sectors – as banks, asset managers and insurers begin to understand climate change risks in more detail and start applying the learnings to risk-adjusted returns on capital. In April 2019 the Bank of England published Supervisory Statement 3/19 and Policy Statement 11/19, which codified their consultation paper 23/18 on climate change risks. Broadly the Bank of England / Prudential Regulation Authority (BoE/PRA) aligned their supervisory requirements with the TCFD framework.

As already pointed out in section 2.1 the TCFD is a useful starting point for companies to address the corporate governance, strategic and risk management implications of climate change on the financial performance or value of a company. The expectation is that this will then form the basis of information for investors and other stakeholders to target 'green' investment and policies to enable a transition to the low-carbon economy. This task is of course challenged by the definition of what is 'green' and what needs to be prioritized to deliver sustainable finance.

However, in contrast with the TCFD framework – which is currently only a recommended approach – the Bank of England / Prudential Regulation Authority now mandates the following for regulated firms:

1. **Governance:** *"Firms will need to identify and allocate responsibility for identifying and managing financial risks from climate change to the relevant existing Senior Management Function(s) (SMF(s)) most appropriate within the firm's organisational structure and risk profile."*
2. **Strategy:** *"the PRA expects firms to conduct scenario analysis to inform their strategic planning and determine the impact of the financial risks from climate change on their overall risk profile and business strategy. This includes both short-term assessment and quantification where appropriate of climate change risks within the planning horizon and a long-term assessment based on a range of scenarios.*
3. **Risk Management:** *"As part of the Own Risk and Solvency Assessment (ORSA), firms should include at a minimum:*
   a. *all material exposures relating to the financial risks from climate change; and*
   b. *an assessment of how firms have determined the material exposure(s) in the context of their business."*
4. **Disclosure:** *"Firms should recognise the increasing possibility that disclosure will be mandated in more jurisdictions, and prepare accordingly".*

Disclosure of climate change impacts on a business seems likely to be increasingly mandated by regulators, at least in the financial services industry and in time, perhaps in other industry sectors too. By implication, this will increase pressure on other industry sectors to disclose their financial impacts from climate change and strategies to adapt. The advantage of this approach by financial services regulators is that it will drive a step-change in the strategic analysis of climate change-related risk. The Bank of England / Prudential Regulation Authority have established a Climate Financial Risk Forum (CFRF) to build intellectual capacity and establish best practice in how to manage the financial risks from climate change. The goal of the four working groups set up by the CFRF is to deliver draft handbooks on the key areas of scenario analysis, risk management, disclosure and innovation.

The nature of the challenge and implementation of potential solutions requires more than a single stakeholder. Public-private partnerships on initiatives like open-source data platforms are vital for success. The wide range of relevant organizations that need to be involved includes Governments, national weather and climate organizations, central banks and regulators, academic institutions, climate scientists, natural catastrophe modelers, the insurance industry, banks and asset managers.

On top of this, key *"real economy"* sectors and industries need to play their part. They must analyze scenarios and develop strategies that adapt and build resilience – both to the de-carbonization of the services they deliver and the physical risks of climate change. Federal, National and Local government will also need to work with these sectors and develop their own adaptation plans. It is in this area that the insurance industry can play a vital role informing risk management actions, in particular with various regulatory bodies and engineering organizations (building code development, testing labs and agencies, etc.)

The wide range of relevant organizations that need to be involved includes Governments, national weather and climate organizations, central banks and regulators, academic institutions, climate scientists, natural catastrophe modelers, the insurance industry, banks and asset managers.

The immediate challenge for both financial services and industry – especially carbon intensive sectors – is aligning investment, adaptation, transition and resilience strategies. There is often a clear and reasonably well-informed understanding of climate change-related financial risk in carbon intensive industries. In some sectors, there are very precise regulatory or technology pathways. But there is tension between the analysis, conclusions and strategies that these industries are developing and the ability to disclose them to investors without provoking an unsophisticated set of responses, such as divestment or downgrades.

In contrast, within financial institutions, the complex portfolio exposures (by product, tenor, sector, geography etc.) make it very difficult to analyze and understand climate change-related financial risk. Material gaps in scenario data combined with complex value chain dimensions contribute to this. There are many solution providers offering apparently 'simple' solutions. But these involve models built on layers of assumptions which produce climate change risk results that are not credible to the front line. This creates a tension between *"compliance"* and good risk management. There are also significant business process integration challenges of fitting *"climate change risk"* into existing risk taxonomies and models.

Impediment	Potential solution
High level of investment required for transition (replacement of equipment, alternative, potentially higher-cost suppliers, carbon tax, etc.)	Scenario-based approach to highlight not only physical but also liability, transition (loss of market, etc.), reputational risks AND opportunities associated with climate change, e.g., increased consumer awareness of low-carbon products and services.
Organizational complexity and lack of a single point of reference to make strategic decisions (e.g., supply chains are managed by procurement or finance specialists, but should be a risk management discussion as well)	Focus responsibility in a single decision-making unit. With regards to supply chains, highlight that a resilient supply chain is less sensitive to short-term (current risk) and long-term shocks (climate change). Effective supply chain modelling will achieve this.

Achieving a 'tipping point' in climate change adaptation strategies

Businesses have always had to change their strategies to respond to market conditions. Lots of studies have shown that major corporations experience significant *"reversals of fortune"* about every seven years on average. Climate change is different in that the timescales of the most severe impacts are far beyond most strategic plans. In these circumstances, scenario planning as recommended by the TCFD is an appropriate way to deal with such future uncertainty.

Achieving a 'tipping point' in transition strategies that would push us towards a 2°C scenario would require several 'triggers' or 'incentives'. These triggers are covered by our scorecard and include public pressure, political action, market forces, price changes for 'externalities' and consumer behavior. In fact, it appears a series of events over the course of the next year may serve as such a catalyst, including the anticipated Global Adaptation Summit hosted by the Dutch Government in October 2020.

The lack of analytic tools to model and quantify climate change effects (not only physical, but also economic) is one of the main impediments to a meaningful discussion with involved stakeholders towards a sea-change in adaptation strategies. Losses triggered by current events only marginally affect the risk perception. This has to do partly with how these events are communicated to the public (i.e. a 100 year event has happened this year so the perception is that it won't for another 100 years), and partly to do with over-reliance on existing tools (natural hazard maps, catastrophe models, etc.). Here too, a scenario-based approach is recommended – as Zurich does with customers for current risks.

Other impediments to the *"tipping point"* and potential solutions are listed above.

Role of boards

Boards play a pivotal role in overseeing the company's risk appetite and in identifying major global risks.

To achieve their strategic objectives, companies must decide what risks they are willing to take to drive their agenda forward. But it does not stop there. In order to best respond to the impact of GHG emissions mitigation on their business, companies should consider a strategic risk analysis on the type and scale of impact climate change will have in the mid to long term:

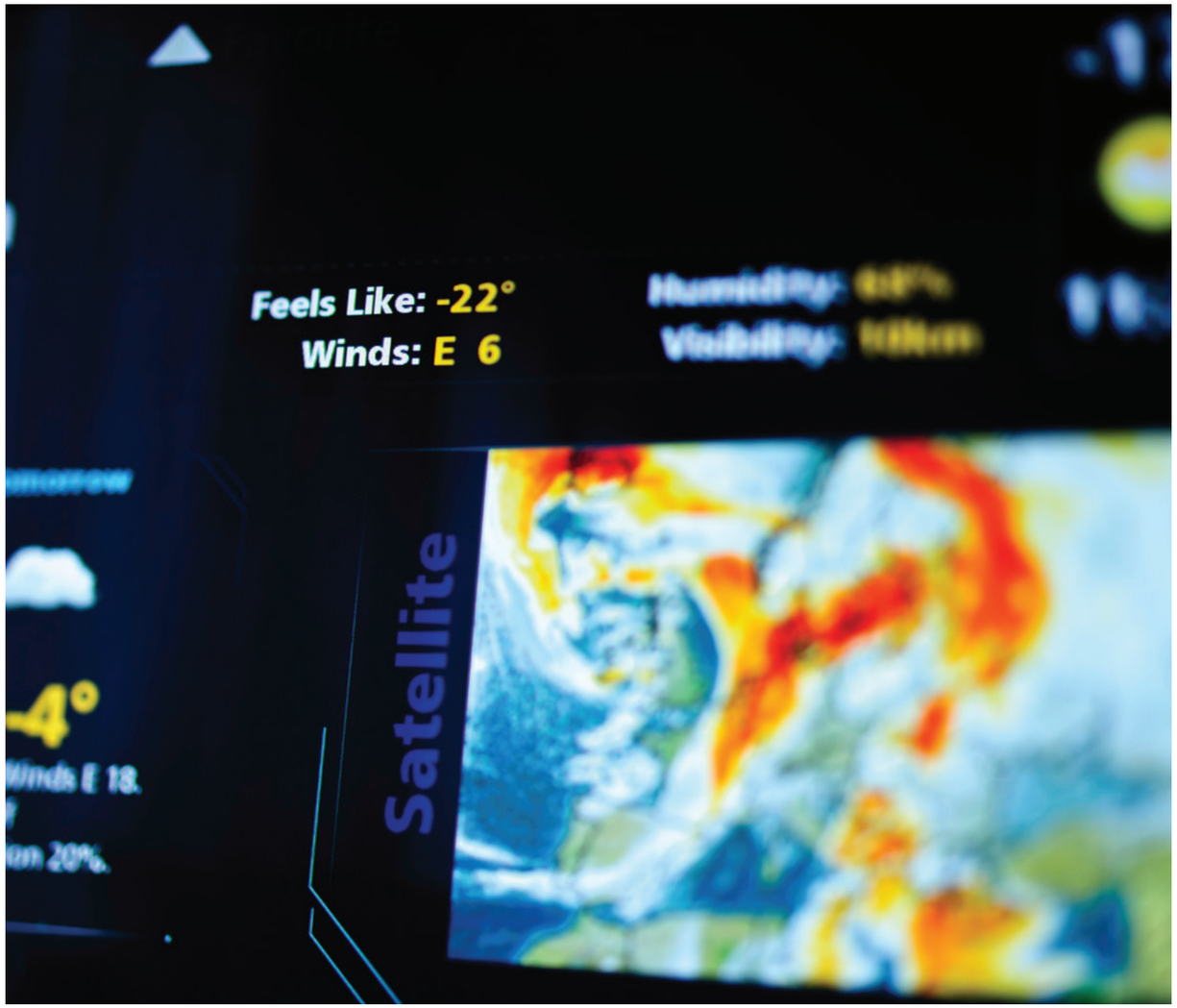
We recommend for such strategic risk analyses to answer the following 10 key questions as a baseline:

1. What is the likely impact of climate change on our business, now and in the future?
2. Have we followed the FSB's TCFD framework and what are the conclusions of that analysis? What are the impacts on the key drivers of performance now and in the future?
3. Is our business model still viable? If yes, for how long?
4. Should we focus on core areas of the business, even if they are carbon intensive, but add value in other ways to society, the economy and to investors?
5. Are there opportunities for us to create new products, to join new business ecosystems?
6. Which aspects of our climate change response do we need to advocate for to best protect shareholder value and best capitalize on climate change-related opportunities or threats?
7. Do we need to make big technological shifts in order to cope and successfully compete with the new environment?
8. Which growth strategy we should aim for in light of the changes that climate change brings (e.g., organic, new products/services, strategic partnerships, or mergers and acquisitions)?
9. Should we change our product mix? Should we create entirely new supply chains?
10. What and how should we disclose?

CHAPTER 3

Updates on risk management solutions to climate change

In addition to scenario planning, there are a number of risk management tools and practices at companies' disposal which can help to model climate change risk and help develop options for strategic responses to climate change-related risks. In this section, you will find some of the latest developments on these tools and practices since we produced our initial report a year ago, and a selection of Zurich-developed methodologies already in place such as Total Risk Profiling (TRP).



3.1. Solution ecosystems are emerging

Given the complex, interconnected, multi-stakeholder nature of managing the risks related to climate change, it is not surprising that individual companies do not have all the capabilities to hand to either identify, analyze, or manage these risks. It is a situation similar to cyber risk – another global challenge. Here, groups of companies operating in a service ecosystem provide analytical services, informing strategy development and mitigation that is performed by yet other organizations, all working across business, government and wider civil society.

In the case of climate change, there are many academic, business and government organizations developing different approaches to analyzing the major bodies of work. These are highly inter-related and inter-dependent, but also markedly different. Climate science generates vast volumes of data. An example is measuring the impact of aerosols in the atmosphere over multiple decades – through simulations of climates based on scientific equations. This needs to be downscaled and – where possible through advances in the science of climate change attribution – linked to the entirely different approach of empirical natural catastrophe modelling. Such a linkage would help in understanding and interpreting the physical consequences of climate change on extreme weather patterns. At the same time, transition risks are being modelled in empirical models using socio-economic pathways, which commonly have multiple layers of assumptions – with material gaps in scenario data sources. This often produces erroneous results, that when applied in business are not credible in the short-term.

It is likely that businesses that want to understand this complexity will need to work with multiple providers who can be coordinated to deliver useable insights to develop strategies to manage climate change risks. When it comes to implementing the actions of these strategies, yet another group of service providers needs to be engaged to help deliver these actions.

This will be true for creating solutions in the investment space, academia, or the real economy. The most obvious examples will be where there is a need to deliver entirely new technologies in short time-scales.

In other areas, such as adaptation and resilience to physical risks, government, academia and the private sector will need to work together to deliver solutions at both local regional and federal levels. Great examples exist in managing water either in times of flood or in times of drought. Climate change is changing the frequency and impact of perils associated with water; flood (fluvial, pluvial and storm surge) drought and frost. Human impact is also changing demand and supply (urban development, land use, industrial requirements, clean water, the role of natural infrastructure, planning, flood management). To solve this, we need to work across all aspects of the water supply chain. It is a truly multi-stakeholder, systems challenge.

Examples of how different stakeholder actions can cause unintended consequences when taken in isolation include: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1 **Upland management (e.g., tree felling)** can create increased erosion and silt run-off, which clogs up rivers and causes flooding.

2 **Urban development can cause rapid water run-off** during thunderstorms (pluvial flooding) if large areas of concrete are not built with sustainable urban drainage systems. Increased area of concrete also increase temperatures in urban areas, affecting water and power consumption (e.g., increased use of air conditioning).

3 **Taller buildings** affect the micro-climate in the surrounding neighborhoods through (e.g., increased temperatures, wind vortexes at street level.)

4 Planners allowing **new houses to be built in flood prone areas** e.g., water meadows that for centuries have been nature's natural flood containment zones. This is a political and socio-economic necessity in light of increasing population, need for job creation, etc.

5 **Flood management in towns** (e.g., river walls) channeling flood waters to other areas downstream that have never been flooded before.

6 **Dam operators failing to operate dam overspill gates** in a timely manner, allowing flood water to build up and which is then released in a catastrophic way. This highlights the uncertainty of short-term forecasting as such decisions rely on weather forecasts over 2 to 5 days, as well as deteriorating quality of infrastructure due to lack of public investment and increasing population.

7 **Tourism over development** and **general increase of population**, especially in urban areas, affecting the ability of marshland or wetland areas to naturally clean and manage polluted water supplies.

It is important that risk management actions, whether improving adaptation and resilience to the physical consequences of climate change or the transition risks associated with decarbonizing the delivery of carbon-intensive services, need to be coordinated across business, government and civil society.

It is important that risk management actions, whether improving adaptation and resilience to the physical consequences of climate change (as in the example above) or the transition risks associated with decarbonizing the delivery of carbon-intensive services, need to be coordinated across business, government and civil society.

Clearly, more disclosure of climate change risks could improve the public dialogue on climate change and our responses to it, spurring better informed decision-making. Furthermore, it will likely improve the strategic positioning of individual firms as they internalize both the full extent of their longer-term exposures and the risk mitigation strategies they could employ to manage those exposures. This public dialogue will lead to not only more sophisticated investors and consumers, who are questioning the ecological viability of products and services, but could also increase pressure for more definitive political (and hence regulatory, legislative and fiscal) action. Zurich implements the multi-stakeholder ecosystem approach in refining its analytical and risk management tools both for understanding our own risk as an insurer and in the context of services we can offer to companies.

Recognizing this growing customer demand, Zurich will be launching during its next strategic cycle a new Climate Advisory Service offering. This service will help those customers seeking a deeper understanding of the physical impact of natural hazards and climate change effects on their operations. It will be offered through Zurich's global commercial insurance team.

In addition, Zurich is partnering with the World Economic Forum, the Adrienne Arscht/ Rockefeller Foundation Resilience Center and other leading institutions to develop clear guidelines on disclosure best practices, thereby facilitating the broader societal use of analytics to inform and accelerate the climate resilience and low-carbon transition.

Zurich implements the multi-stakeholder ecosystem approach in refining its analytical and risk management tools both for understanding our own risk as an insurer and in the context of services we can offer to companies. Recognizing this growing customer demand, Zurich will be launching during its next strategic cycle a new Climate Advisory Service offering.

3.2. Evolution of modeling capabilities – quantification of climate change's physical risks

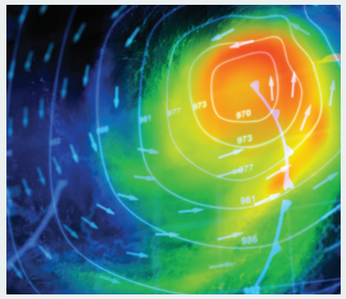
In addition to the multi-stakeholder approaches discussed above, the insurance industry has a very specific set of capabilities that are used to understand and model natural catastrophes such as earthquakes, windstorms and floods. These models help insurers manage accumulation risk (the risk of concentrating insurance capital in only a few, natural catastrophe-prone regions) and to price related insurance products. This area of work melds academic research with empirical modelling and is driven by a commercial natural catastrophe modelling industry supporting insurers.

Historically, this analysis has been proprietary for insurers – who have used the outputs of these models to manage their own natural catastrophe risks. Increasingly, other industry sectors are beginning to look towards the insurance industry to apply this expertise beyond the understanding of current climate risks and to apply it in a forward-looking manner to climate change risk. This is to help develop adaptation strategies to the physical risks of climate change, and even to help understand the physical impacts of climate change on supply chain risks.

There are currently three options (described here) which link climate change models to natural catastrophe models, each offering a different level of sophistication and application suitable for different industries and companies.

Three options

1. Scenario Mock-Up
2. Coupling climate models with existing natural catastrophe models
3. Development of in-house natural catastrophe models incorporating climate change



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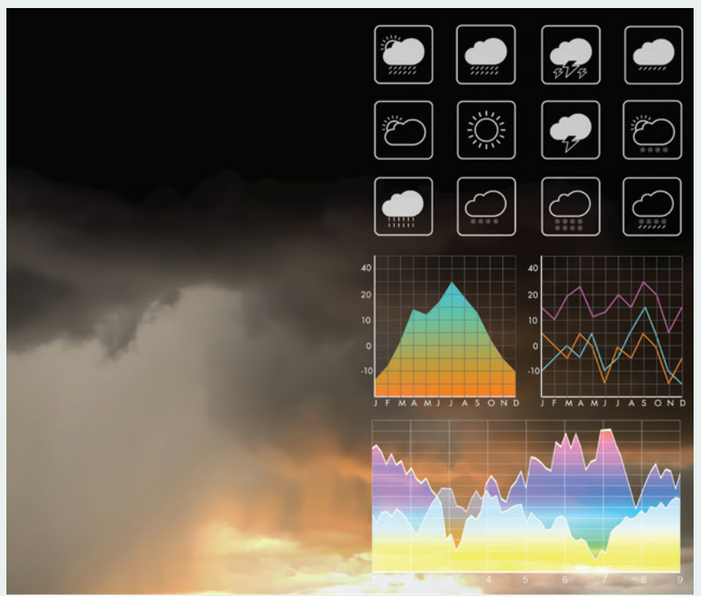

Option 1
Scenario Mock-Up

In this first approach, the natural catastrophe model output is modified by **including the summary of climate change effects**, as outlined in recent IPCC reports. This is achieved by **adapting the natural catastrophe model outputs, known as *"event sets"* to reflect the *"average"* climate change effects.**

This approach is quite straightforward, **quick to implement** and can give a qualitative indication of how the physical climate risk could change for different climate change scenarios. The down-side is that it might not be detailed enough to model the physical risks of a company's global portfolio of physical assets, or locations, either geographically, or over time. Nevertheless, this approach is best used in a strategic scenario planning exercise to gain a broad overview of climate change effects, and to determine if a more sophisticated approach is required.

Option 2
Coupling climate models with existing natural catastrophe models

The second option modifies the hazard module in the natural catastrophe models to include **climate change effects by incorporating the research-based climate change global circulation model (GCM) output.** This science-based approach is much more resource-intensive to develop, but creates a more detailed model of climate change risks for a company's physical assets.

This approach is suitable to quantify the impact of climate change on companies' physical assets – over different time scales and in different geographic regions. Different climate change scenarios, reflected in the Greenhouse Gas concentration pathways (RCP) climate scenarios, allow the identification of the most affected regions, 'critical' perils & impact on specific portfolios of physical assets. The results of such a scenario-based analysis can support companies in the planning of future physical infrastructure expansion (e.g., factories, offices and their associated supply chains). It can also go beyond the current physical climate risks to include climate change effects, as part of a wider strategic planning exercise that includes consideration of physical and transition risks.

This approach can support companies in their investment strategies for climate change-related risk reduction and adaptation measures ranging from building protection measures to optimizing insurance policies for existing assets, assessment of potential future sites for new facilities, and assessing the impact on value chains (supply chains, infrastructure and utilities).

Option 3
Development of in-house natural catastrophe models incorporating climate change

This is the most sophisticated (but also most resource-intensive) methodology and **involves building an in-house, proprietary natural catastrophe model, faithfully reflecting all aspects of climate change.**

This approach can overcome the limitations of existing commercially-available models, especially regarding the inclusion of climate change effects. Using the tropical cyclone model as an example, studies have shown that climate change will have several effects on storms, e.g., reduced rate of movement, more precipitation, changes in storm surge flooding due to associated rise in sea levels, the influence of temperature difference between the upper atmosphere and the sea surface on storm intensity.

Building a bespoke in-house natural catastrophe model incorporating all climate-relevant parameters would allow a company to reflect all aspects of the physical consequences of climate change on their business model. **The drawback of this approach is the time taken and expense of developing a proprietary model and would only benefit those companies and industry sectors most exposed to physical climate change risks.**

3.3. Case study: Working with customers to manage climate risks:

How natural hazard scenarios help Konecranes

Zurich Risk Engineering applies a holistic view of risk that includes natural hazards which is the first step in any climate change-related study. This approach starts at the global multi-location level and aims to identify the locations or regions that are critical to the customer's operations. Besides the impact of natural hazards on physical assets, the impact on suppliers, value chains, infrastructure and utilities are also considered.

Konecranes, a Helsinki-based manufacturer of cranes and other lifting equipment, provides sustainable products and services in a society that aims to move ever closer to a low-carbon way of life.

And while the 16,000-employee company works to minimize the environmental footprint of its operations in 50 countries, Konecranes also considers it a primary aim to help its customers operate in a sustainable manner. *"With safe and ecoefficient products and services, we can answer changing customer needs and help develop the sustainability of our customers,"* said Nathalie Clément, the company's Director of Corporate Responsibility.

Not surprisingly, Konecranes takes its climate change exposures seriously. As such, it works with Zurich to identify and mitigate climate change-related risks that possibly could, in the long run, have an impact on the company's operations.

Konecranes takes a three-pronged approach to managing climate risks. In collaboration with Zurich, the company conducts natural hazard risk evaluations, holds a company-wide risk assessment and performs climate risk evaluations through local environmental management systems.

"Zurich has helped us better understand our natural hazard and climate-change-related risks on a local level," Ms. Clément said. *"Their reports are also part of the material used to build scenarios that show how climate change could affect our business going forward."*

"Not a day passes without the mention of climate change in global media outlets," said Amar Rahman, Zurich Insurance Group's Risk Engineering Global Practice Leader for Natural Hazard Resilience. *"So it's very rewarding to support a customer who is aware of the urgency of the problem and to actively work with them to develop viable solutions."*

Zurich's assessment of Konecranes' Jingjiang location in China is typical of the work the insurer does to examine different natural hazard scenarios, the impact they would have on Konecranes' operations and ways to mitigate such potential losses. From a climate change perspective, adaptation strategies to the *"future state"* are also developed.

Mr. Rahman led the analysis at the Jingjiang location that also involved Ms. Clément and Konecranes' Head of Risk Management Atso Mattila.

At the 14-year-old Jingjiang location, which produces components for other Konecranes units from its site in the Yangtze River watershed, 100-year flood and wind scenarios were played out to determine the potential impact on property and business interruption exposures. Such scenarios are based on expert analysis of hazard maps, local conditions, historical events and vulnerabilities assessed onsite. Site management experts are involved to determine the potential loss values associated with these scenarios.

These are valuable tools for customers, as they highlight the potential benefits of implementing risk mitigation measures identified during the assessment. They provide deeper insights than could be obtained from conventional insurance tools such as cat modeling and hazard mapping. In addition, they provide information that benefits several stakeholders in the customer's organization, not just those that are insurance-related.

"Zurich's team of experts provided Konecranes with valuable insight on core locations and their natural hazard risk exposures," Ms. Clement emphasized. Zurich's work is performed by experts with *"comprehensive skills and tools,"* she said. *"It not only helps us highlight relevant risks, but also supports our internal sustainability and environmental risk assessments from a fresh perspective and with a sharp focus."*

Zurich has helped us better understand our natural hazard and climate-change-related risks on a local level. Their reports are also part of the material used to build scenarios that show how climate change could affect our business going forward."

Nathalie Clément, Director of Corporate Responsibility, Konecranes

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These (scenarios) are valuable tools for customers, as they highlight the potential benefits of implementing risk mitigation measures identified during the assessment. They provide deeper insights than could be obtained from conventional insurance tools such as cat modeling and hazard mapping.

Conduct a Total Risk Profiling on climate change

Apply a structured risk assessment process such as Zurich's **Total Risk Profiling (TRP) approach**. The table below shows how companies can apply Zurich's TRP approach from a climate change perspective to better assess hazard level, exposure and controls.

Risk factors	Issues	Comments
Exposures	How well do you know the value chain of your operations?	This includes not only suppliers, but also utilities and infrastructure as well as customer locations
	What is the definition of 'critical' for your company (including suppliers and customers)?	For example, are these locations with the highest value concentrations, containing equipment/stock with long replacement times, producing critical components for other locations or products/services that are profitable or have a high contribution to group revenue or where hazardous processes occur? Or is critical defined as locations with a high concentration of employees, or are situated in areas that can impact a large population if an accident occurs? From the perspective of a single location the above definitions of 'critical' apply to individual structure(s) or building(s).
	Have you identified your critical locations, your critical suppliers and the critical utilities and infrastructure at these critical locations?	Have you identified redundancies? How easily can these components of your operations be replaced? Is it possible to organize contractual arrangements to ensure priority of supply?
Hazards	Which natural hazards do you consider might have an impact on your global supply chain? Again, the scope is also in question: Does it involve suppliers and customers?	• Flood • Wind (hurricanes, typhoons, European winter storms, etc.) • Storm surge • Hail • Lightning • Heavy rainfall • Drought / water shortage • Tornado
Controls	For your critical locations: What is the level of urban development in the area of your critical operations?	High level of development, without corresponding upgrade of infrastructure to accommodate this development, means the capacity of the infrastructure is probability inadequate for climate change.
	What is the age of the buildings, especially the critical ones at those critical sites (owned ones, as well suppliers' ones)?	Not only buildings themselves but also contents and equipment should be designed to state-of-the-art structural design codes. These codes are regularly revised to reflect technological advances in construction methods, building materials as well as hazard maps, i.e., force levels to which the buildings and contents are designed, etc. When undertaking expansions or adding new equipment, a review of the existing buildings and equipment/contents should be performed by a qualified structural engineer to ensure compliance with the requirements of the latest code version.
	Has your business continuity plan (BCP) been developed based on risk scenarios?	BCP is an important organizational natural hazards control system. A BCP which only mentions the hazards is ineffective. An effective BCP should be based on a Business Impact Analysis (BIA) and should cover all hazards to which the region is exposed and the scenarios to ensure operations continue at the affected location. The scenario should consider the fact that a natural hazard event, in contrast to an on-site fire event, impacts an entire region. As such, not only loss of utilities and infrastructure, but also access and business will be severely impacted. In addition, issues such as duration until the restoration of services (which includes the duration of the event itself) should be considered. Try to achieve an understanding about the level of planning by your local authorities and especially their foreseen priorities for reconstruction. Consider a balance between community and business needs.
	How effective and reliable is your emergency response plan (ERP)?	As with BCP, the site ERP should be scenario based. The ERP should be realistic with respect to resources, especially (but not only) manpower. For each of the hazards identified to which the site is potentially exposed consider the time between receipt of the warning and the event impacting the site. Resources and actions should be planned accordingly.

APPENDIX 1

Zurich's position on climate change

At Zurich, being a responsible and sustainable company is at the foundation of our business. We help our customers and communities become more resilient to natural disasters and extreme weather; we make a difference through our responsible investment approach; and we are swiftly reducing our own carbon footprint.

We are working closely with communities and policy-makers to place more emphasis on risk reduction, preparedness and resilience rather than purely focusing on recovery and rebuilding. We are also sharing with our customers the best practices and other risk-related insights developed during our 140-year history.

Using our core insurance skills to respond to some of the most significant long-term societal and environmental trends, we identified climate change as perhaps the most complex risk facing society today. It is inter-generational, it is international and it is interdependent. Representing the consensus of the international scientific community, the Intergovernmental Panel on Climate Change (IPCC) finds strong evidence that climate change is occurring, that it is influenced by human action, and that it is leading to changes in extreme weather and climate events.

Our own analysis suggests that the likelihood of missing the Paris Agreement's target of limiting global warming to 2°C or below is higher than achieving it. That is why we are accelerating action to reduce climate risks by driving changes in how companies and people behave and support those most impacted. For us, it is simply the right thing to do.

Francis Bouchard giving testimony to the U.S. House Select Committee on the Climate Crisis

We will:

1. **Work with clients** as well as public and private partners to enhance resilience and advocate for solutions to prevent, or minimize, damage and harm from weather and climate change-related perils for our customers and communities.
2. **Develop insurance and risk management solutions** for the new technologies, business models and approaches that will be required to achieve this unprecedented transition to a low-carbon economy.
3. **Integrate assessments of both physical and transition risks** into our investment strategies and contribute to avoiding 5 million tons of CO_2 emissions annually through our dedicated impact investments.
4. **Minimize the environmental impact** of our own operations.
5. **Disengage and divest** from those whose activities are predominantly focused on thermal coal, oil sands and oil shale if these companies have no plan to realign their business over time towards a low-carbon future. See our detailed position here.
6. **Play an active role in developing science-based targets** for the insurance industry by joining the Business Ambition for 1.5°C. Zurich recognizes the role the science-based targets plays in highlighting the decarbonization pathways necessary to meet the Paris Agreement per sector and translating these into useful tools for companies. Currently, in the insurance sector, science-based targets do not exist for either insurance or investment portfolios. As part of the Business Ambition for 1.5°C, we have committed to play an active role in changing that and to set our own targets.
7. **Publicly advocate** for policies that encourage the private sector to fully leverage capabilities and resources in support of the transition to a global low-carbon economy, including:
   - A global price on carbon, established at a level sufficiently high over time to incentivize action aligned with below -2°C warming.
   - A clear roadmap for the progressive phasing out of fossil fuel subsidies.
   - Credible policy roadmaps for internationally integrated energy policies, systems, markets and electricity grids capable of handling large scale use of renewable energies.
   - Policies in support of both public and private research and development of critical technologies such as energy storage, electric mobility, renewable power and carbon capture and storage (CCS).
   - Integrating key aspects of climate change, alongside other ESG issues, in public and private education and curricula.
   - Enhanced transparency by mandating better disclosure of climate risks, alongside other ESG issues.
8. **Adopt the recommendations of the Financial Stability Board's Task force** on Climate Change-related Financial Disclosure (FSB-TCFD) and report on progress made in implementing the above commitments.

We acknowledge that our actions must be compatible with Zurich's broader strategic and financial objectives and reflect the real-world operating environment driven by client demand and bound by public policy. We will continue working with customers to better manage climate risks; providing coverage for new technologies and infrastructure, such as electric vehicles, renewable energy or carbon capture and storage; investing in companies and assets that support the transition to a low-carbon economy; and – if and when possible – putting a price on climate risks when making investment or underwriting decisions.

APPENDIX 2

Zurich Climate Change Scorecard terminology

Score card on climate change

Progress is judged vs the IEA Bridge scenario when relevant scenario data are available. This applies to: carbon pricing; CO_2 emissions; energy use; energy efficiency. For other indicators, we make an assessment based on the change in the indicator and, when appropriate, the level vs target.

Carbon pricing: Equal weighted score of (1) the direction and change in the share of emissions covered by carbon pricing scheme; (2) average price vs target price, target price = 100USD / tCO_2. Source: World Bank Group

Corporate action and positioning: Average score for corporate action and corporate positioning

Corporate action: MSCI scores for management practices related to climate change relevant dimensions, current ranking vs maximum ranking of 10. Source MSCI

Corporate positioning: Level of emphasis on climate change related topics in corporate reporting, medium to high emphasis relative to low emphasis or no mentioning.
Source: Datamaran

CCS technology: External tracker of progress in CCS technology and number of projects deployed. Source: IEA

Social trends: Size and direction of change in the number of articles published on climate change related topics. Source: Datamaran

Energy supply: External tracker of progress on gas, nuclear, renewable power, coal and renewable power, equal weighted score.
Source: IEA

Legislation: Number of global regulatory initiatives that impact corporate transparency on climate change issues, annual change vs historical average. Source: Datamaran

Energy demand and efficiency: Equal weighted average of scores for energy demand and energy efficiency:

Energy demand: World primary energy consumption (mln tons of oil equivalent). Direction and size of change.
Source: BP Statistical Review

Energy efficiency: Energy usage per global GDP. Direction and size of change.
Source: BP Statistical Review, IMF

CO_2 emissions: Direction and size of change. Source: BP Statistical Review

Investment: Direction and size of change in investment into clean energy, vs estimated target level. Source: Bloomberg BNEF clean energy trends, World Bank

Energy integration and storage: External tracker on progress in energy storage, smart grids, demand response, digitalisation, hydrogen, cogeneration of heating/cooling, equal weighted score.
Source: IEA

Fossil fuel subsidies: Global fossil fuel subsidies, direction and size of change.
Source: IEA

Electrical vehicles: External tracker of technological progress in the sector.
Source: IEA

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Contributors from Zurich Insurance Group

Justin D'Atri
Sustainability Change Manager, Group Risk Management

Francis Bouchard
Group Head of Public Affairs & Sustainability, Group Risk Management

Michael Bradford
Senior Writer and Editor, Group Communications

Laura Castellano
Strategic Partnerships' Lead and Integrated Campaign Manager, Group Communications

Linda Freiner
Group Head of Sustainability, Group Risk Management

Mathias Graf
Head of Cat Research & Development, Group Operations

Charlotta Groth
Global Macroeconomist, Group Investment Management

Jean-Pierre Krause
Global Head of Risk Engineering, Commercial Insurance

Eugenie Molyneux
Chief Risks Officer, Commercial Insurance

Amar RAHMAN
Global RE Practice Leader Natural Hazards Resilience, Commercial Insurance

Gregory Renand
Head of Strategic Partnerships and Integrated Campaigns, Group Communications

John Scott
Head of Sustainability Risks, Group Risk Management

Iwan Stalder
Head of Group Accumulation Management, Group Operations

David Swaden
Senior Speech and Content Writer, Group Communications

Contributors from Konecranes

Nathalie Clément
Director of Corporate Responsibility

Atso Mattila
Head of Risk Management

Contributors from The Creative Lab (Tag agency)

Elaine Gander
Project Manager

Peter Walker
Design

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Zurich Insurance Company Ltd
Austrasse 46
8045 Zürich
Switzerland

173006049 (09/19) TCL

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