MARSH & McLENNAN ADVANTAGE | GIIA Global Infrastructure Investor Association

GLOBAL RISKS FOR INFRASTRUCTURE

The climate challenge

CONTENTS

KEY TAKEAWAYS

1. Navigating the climate risk landscape will require a keen understanding of both physical and transition risks

2. Resilience-building measures for climate risks must be subject to continuous review and improvement to keep pace with the evolution of different risks

3. Effective scenario planning links model outputs to business metrics to inform a firm-wide response to climate resilience

4. Taking a life-cycle approach to building climate resilience can ensure value for money is secured for investors and operators

5. True resilience to climate risks can only be achieved when investors understand asset interdependencies and proactively work with public authorities to build ecosystem-wide resilience for local communities and infrastructure peers

INTRODUCTION

The stable and long-term returns offered by the infrastructure asset class are under increasing pressure. As the global economy adapts to both physical changes in the earth's climate, as well as to the transition toward a low-carbon operating environment, infrastructure investments stand to face new levels of loss and disruption.

Entities across the infrastructure investment universe will need to take note of these dynamics and invest in strategies for 'climate resilience' to protect their assets: that is, the ability of a firm or asset to withstand and recover from a climate risk event. A truly future-proof approach to building climate resilience will need to not only allocate significant resources to this endeavor, but ensure that climate risk is embedded into investment strategy in a dynamic and highly responsive manner.

To establish a truly dynamic approach to climate resilience, infrastructure investors and operators will need to recognize and deploy three key 'levers'. These are:

- Climate-focused scenario planning
- Life cycle imperatives
- Managing interdependent risks across the infrastructure ecosystem

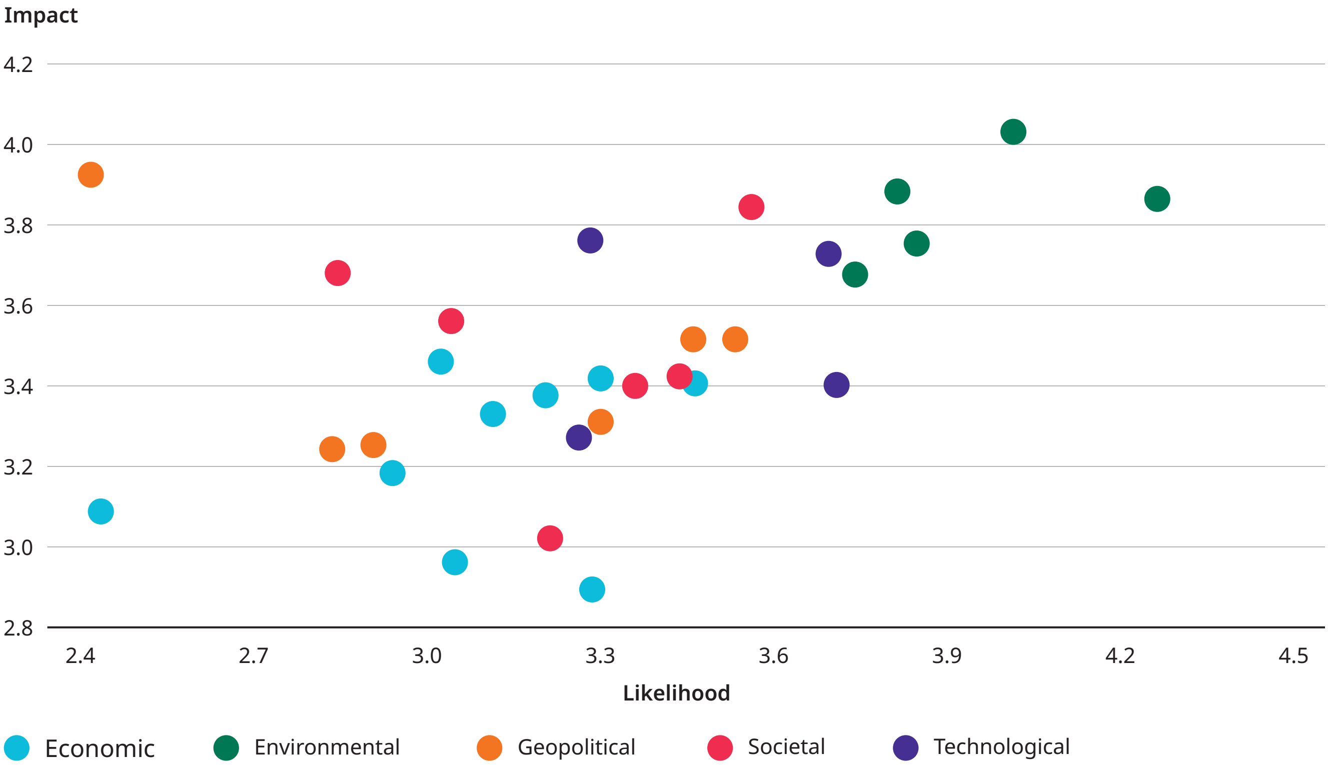
As the climate risk landscape becomes increasingly volatile, these levers will be central to ensuring that infrastructure investors are agile in their response to climate risks.

This report is the second in a three-part analysis of the global risks facing infrastructure investors, produced by Marsh & McLennan Advantage in collaboration with the Global Infrastructure Investor Association. The first installment outlined the overall risk landscape for infrastructure using the 2020 Global Risks for Infrastructure Map interactive online tool. The following installments take a closer look at two key high-impact and high-probability risk categories highlighted by the Global Risks Report: environmental risks and technological risks (see Exhibit 1 on the following page). This current installment serves as a focused overview of the varied risks the sector faces from climate change. The third report will explore technological risks: the impact of transformative and disruptive technological innovations on the infrastructure sector.

The Global Risks for Infrastructure: The Climate Challenge report discusses the specific risks to infrastructure investors under each of the key risk categories outlined by the Task Force on Climate-related Financial Disclosures (TCFD; see Exhibit 2),[1] as well as crucial levers for achieving climate resilience at both the portfolio and asset level for the infrastructure sector. Ultimately, infrastructure investors of all stripes will need to ensure that climate resilience is integral to both their firms' portfolio design and their asset-specific risk mitigation strategies. *Global Risks for Infrastructure: The Climate Challenge* provides investors with an outline of the climate risk landscape and offers them a framework for developing a strategy that suits their needs.

1 An international working group of financial professionals providing recommendations on best practices in climate-related financial disclosure.

Exhibit 1. The global risks landscape 2020



Note: Global Risks Perception Survey (718 responses worldwide): Respondents were asked to rate each risk based on its likelihood and impact on a scale from 1 to 5.

Source: World Economic Forum, Global Risks Report 2020

Key terms and concepts

Term	Definition
Adaptation	Reducing the impact of a risk event
Climate resilience	The ability of a firm or asset to withstand and recover from a climate risk event
Climate-resilient infrastructure	Infrastructure assets that can withstand and recover from climate risk events
Climate risks	A physical or transition risk
Ecosystem resilience	The extent to which an asset's stakeholder network can withstand and recover from a climate risk
Green or sustainable infrastructure	Low-carbon (that is, low-emissions) infrastructure, such as renewables and hydrogen-powered transportation
Infrastructure investor	An entity either directly or indirectly invested in infrastructure-focused companies or assets
Interdependent risks	Indirect exposure to climate risks impacting other assets, communities, or firms
Low-carbon economy	A decarbonized economy powered by low-carbon energy sources producing minimal emissions
Mitigation	Reducing the source of, or exposure to a risk

Exhibit 2. Task Force on Climate-related Financial Disclosures (TCFD) risk framework

Physical Risks and examples	
Acute	Risks driven by discrete extreme weather events, such as hurricanes, floods or heatwaves *In January 2019, Australia's hottest month on record, the state of New South Wales saw widespread disruption as roads began to melt under an unprecedented 48°C heatwave*
Chronic	Risks driven by longer-term shifts in climate patterns, such as an increase in temperature and rising sea levels *Low-lying coastal airport operators are projected to be highly vulnerable to long-term sea level rise in the coming decades without a reduction in global emissions*

Transition Risks and examples	
Market	Unpredictable shifts in the inputs for infrastructure development (financial and non-financial) and changes in the quantity and nature of infrastructure demanded by governments and users *A global survey for the World Economic Forum showed that more than half of all respondents globally on average limit their water and energy usage at home due to climate change concerns*
Policy	Government policies or financial programs linked to the energy transition that affect the competitiveness of infrastructure assets or longevity of their returns *Subsidy policy shifts for renewable energy contributed to at least five solar-sector bankruptcies in China and Taiwan in 2019*
Legal	Risks from climate-related litigation, such as injury claims from physical loss events, failure to disclose climate risks, or unjust enrichment from or impairment of public trust resources *Lawsuit and insurance-claim settlements arising from the 2018 North Bay and Camp wildfires led to the bankruptcy of a US utility in early 2019*
Technology	New climate-related technologies threaten to directly replace existing assets, indirectly endanger usership/revenue, create opportunity costs in efficiency losses, or leave new markets underutilized *The world's largest advanced indirect potable-water reuse system in California serves as a new and potentially disruptive form of water infrastructure*
Reputation	Risks from shareholders, government, consumers, or the public (such as through social organizations or grassroots movements) challenging corporations' or investors' social license to operate *More than 100 banks and insurance companies worldwide have announced restrictions on, or a complete exit from, thermal coal financing — due in part to perceived reputational risk*

Source: TCFD, Press and Marsh & McLennan Advantage

UNDERSTANDING THE RISKS

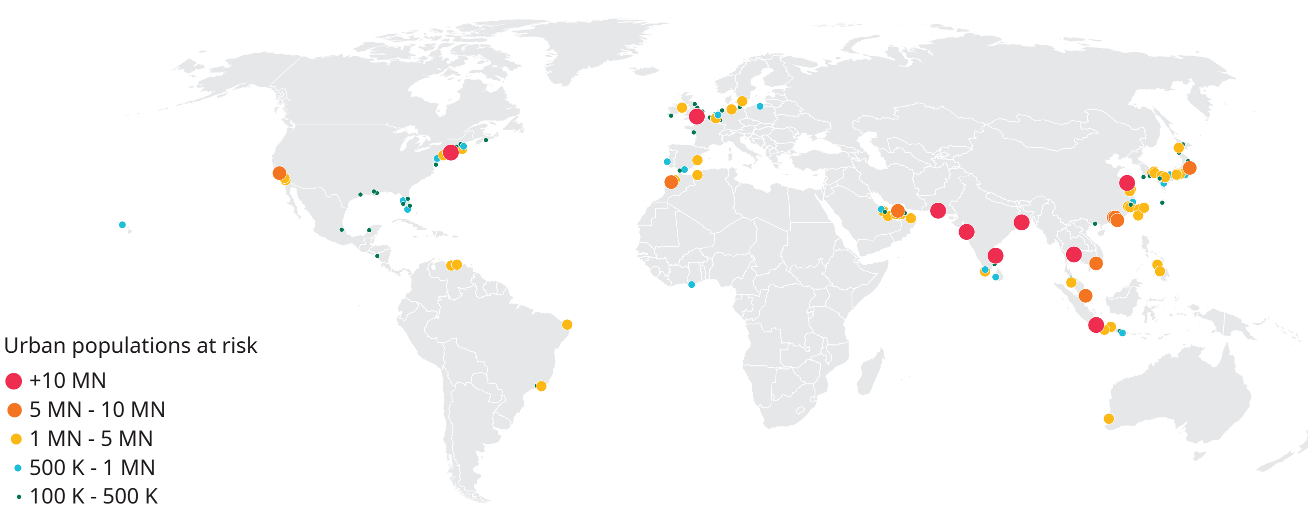
PHYSICAL RISKS

Physical risks related to climate change are becoming a crucial risk category for infrastructure owners and operators. Natural disasters are already a leading cause of infrastructure disruptions in high-income nations, and climate change is expected to exacerbate these disruptions. Over the past three decades, the number of climate-related natural catastrophe events has almost tripled,[2] and Morgan Stanley estimates that approximately two-thirds of all insured natural disaster losses in 2017 were incurred in the property and infrastructure sector.

The inherently large-scale, capex-heavy, and long-term characteristics of infrastructure assets mean they are uniquely exposed to physical risks and challenges. Uncertainty in climate change projections tends to increase in tandem with time (that is, the more years into the future a projection, the more uncertain it is likely to be). This poses a challenge for investors seeking to price physical climate risks into assets with decades-long lifespans. Assets built a generation ago already face unexpected climate impacts today: infrastructure assets in the Northern hemisphere (particularly those near the Arctic) are confronting permafrost melt, while coastal cities must cope with the threat of rising exposure to severe flood risks.

Increased urbanization will also heighten the concentration of infrastructure assets in high-risk areas, such as coastlines and low-lying land spaces, as well as in emerging markets that lack the infrastructure to protect new assets from physical climate risks. Almost 70 percent of the world's population is projected to live in urban areas by 2050, up from 55 percent today. Scenario projections by the C40, a network of the world's megacities, estimate that 270 power plants globally — which together generate enough power for 90 percent of all homes in the United States — face a rise in coastal sea levels of at least 0.5 meters by the 2050s (see Exhibit 3).

Exhibit 3. Sea level rise and power plants in the 2050s



Note: Map shows cities whose nearby power plants are vulnerable to coastal flooding as a result of 0.5 meters of sea level rise in the 2050s.

Source: C40 Cities Climate Leadership Group

2 According to data from MunichRE, climate-related events increased by 2.7 times from 1980 to 2019.

Interdependencies across infrastructure assets are also on the rise, increasing the sector's exposure to interdependent risks. Such risks emerge when a physical climate event does not impact an asset directly; rather, it impacts an adjacent community or linked infrastructure network, rippling into the asset in question. The intensification of interconnections between assets has the potential to magnify the effects of any single natural disaster, and generate risk multipliers across a wide range of interlinked assets.

With multiple risk vectors on the horizon, infrastructure owners and operators must invest in understanding the physical risk landscape to adequately prepare for the climate challenge ahead.

PHYSICAL CLIMATE RISK IMPACT TYPES

Physical climate risks can generate a wide range of losses for infrastructure assets. These risks can result in unexpected capital and operational expenditures across an asset's lifetime, cutting into returns and diminishing value. Assets without contractual protections (such as availability-based PPP contracts or comprehensive force majeure clauses), can also experience serious revenue losses as a result of physical risk events, and even assets armed with these protections may still find themselves forced into early decommissioning. Illustrations of how physical risks can generate these losses include:

Direct operational impacts. An asset's exposure to physical risks is contextual: its risk exposure depends on asset type, location, lifespan, vintage (with older assets less likely to be engineered for climate change resilience), and interdependencies. Exhibit 4 illustrates variations in the operational impacts of physical climate risks according to a selection of these contextual dimensions — infrastructure sector and risk type. Chief among these impacts are: an asset being rendered temporarily or permanently unusable due to damage, reduced efficiency or output, and increased maintenance costs. These impacts can have a severe impact on asset profitability.

Exhibit 4. Selected physical climate risk impacts on core infrastructure sectors[1]

	Chronic risks	Acute risks				
	Sea level rise	Temperature rise	Drought**/Heatwave	Storm/Flood		Wildfire
Energy	Inundation of assets	Coolant losses Hydropower output reduction Transmission and distribution efficiency loss Distribution network failure		Network outages or failure	Damage to assets (erosion or breakage)	Network outages or failure
Telecoms		Coolant losses				
Transport		Melting/buckling of roads/rail	Melting/buckling of roads/rail Water-based traffic disruptions	Traffic disruptions		Traffic disruptions
Water and sewage networks	Inundation of assets Increased desalination requirements Increased water storage requirements	Increased need for treatment Water source shortage		Increased need for treatment Liabilities or fines for overflows		Increased need for treatment Water source shortage

Impacts: ● Physical damage ● Efficiency/output loss ● Maintenance cost increase

1 This table focuses on the direct impacts of each risk type, and therefore do not include the indirect effects chronic risks can have on acute risks.
2 A drought can manifest as a chronic risk in the form of a multiple-season or multiple-year drought or a permanent change in water availability.
Source: OECD, IFC, World Bank, Marsh & McLennan Advantage

Widespread portfolio impacts. Understanding the risk landscape can help identify where — and how — multiple segments of a portfolio may be disrupted by a single physical climate risk. For example, water supply risks arising from droughts, heatwaves, or chronic temperature escalations can have widespread effects. Water and sewage infrastructure providers stand to face both reputational and revenue risks. Segments of the energy sector are also extremely vulnerable to water supply risk: water shortages from climate change have a direct impact on hydro and thermoelectric power output and on maintenance costs at power plants that rely on water reservoirs to serve as a coolant.

Additionally, falling water levels due to drought or changing precipitation patterns may lead to traffic disruptions at certain port assets. While ports tend to be coastal and therefore exposed to risks from sea level rises, inland ports require adequate water levels to sustain capacity — and suffer significant repercussions when water levels dip below minimum requirements. An intense drought combined with record heat in 2019, for example, lowered the level of Panama's Gatun Lake and led to shipping limits at the Panama Canal, reducing revenue from major market shipments. Portfolios with significant exposure to water and sewage systems, water-dependent energy assets, and inland ports will need to be sensitive to the risk of temperature rises, droughts, and heatwaves — and must be cognizant more broadly of structuring an infrastructure portfolio that reduces its exposure to common physical risk threats.

Creating your own risks. It is crucial for owners and operators to recognize an asset's capacity to generate its own physical climate risks. This can occur when faulty operations and a harsher climate come together. In recent years, flawed power transmission and distribution lines have been linked to severe wildfires, which ultimately damaged the lines themselves. Data from the California Department of Forestry and Fire Protection shows that at least nine percent of all wildfires caused between 2013-2017 were caused by the power

Multiple segments of a portfolio may be disrupted by a single physical risk

sector — making it the second-largest identifiable source of wildfires in that period. These damages have raised operational and maintenance costs for California's power operators, as brush management and undergrounding transmission lines are becoming crucial for mitigating wildfires. Understanding an asset's specific context can expose these hidden fault lines and prevent operational mishaps.

Immediate-term interdependent risk impacts on revenue. An acute natural disaster can mete out sudden damages and disruptions across interconnected infrastructure networks. This occurred in 2010, when floods in Australia's Queensland and New South Wales states caused severe disruptions to the country's coal mines and rail lines. Although direct damage to port facilities was minimal, the disruption to the coal industry seeped into the nation's port operations, with several facilities forced to shut down and one of the country's largest coal export terminals operating at just 60 percent capacity. As a result, the nation's ports lost an estimated AUD$37 million in revenue from 2010 to 2011.

Long-term interdependent risk impacts on revenue. Chronic physical risks from climate change present cascading and indirect effects on revenue from infrastructure assets. A rise in sea levels has begun to force coastal communities to relocate. According to one study, rising sea levels in the United States will contribute to the involuntary migration of up to 13 million residents by 2100. These dynamics could result in underutilized assets, hurting operators without revenue protections built into their contracts. Even assets armed with contractual protections may risk having to decommission early due to declining demand.

TRANSITION RISKS

Pressure on businesses to embrace the transition to low-carbon economic systems is rising. In a low-carbon economy, emissions are minimized through the use of low-carbon resources (both in the energy sector and elsewhere), while resource efficiency is maximized by the reduction of wasteful and high-emissions consumption. Infrastructure assets, which underpin global business operations, face unexpected dynamics from the regulatory, legal, market, technological, and reputational risks generated by the transition.

The global economy has already begun to shift away from fossil fuel-based energy generation. Approximately 20 percent of the world's total final energy consumption currently comes from renewable energy sources, and more than 200 companies have committed to sourcing 100 percent of their energy from renewables through the RE100 initiative. New national and multilateral government initiatives (such as fiscal support for green energy and commitments to "net-zero" emissions targets) will accelerate this transition and expose traditional energy infrastructure investors to multiple transition risks if they fail to adapt. Carbon Tracker, a think tank, estimates that 42 percent of today's global coal power plants already run at a loss, a number that could rise to 72 percent by 2040.

As governments and international organizations look to legislate reductions in carbon emissions and increased resource efficiency, infrastructure assets beyond the energy sector face challenges. Air travel, shipping, and water distribution will need to confront inevitable changes in both demand for their services and the cost structures underpinning them. This was made evident in February 2020, when the UK government's plans for a third runway at London's Heathrow airport were deemed unlawful on the basis of the Paris Agreement. As the first major ruling to be based on the agreement, the ruling has highlighted the growing centrality of emissions in determining new projects. Costs will also rise for projects as they adapt to meet new low-emissions rules: The International Maritime Organization has committed, for example, to reducing shipping emissions by 2050 by 50 percent from 2008 levels. This move will have important cost implications for port operators as they seek to minimize emissions from both idling and active vessels passing through their facilities.

Expectations around minimizing waste and consumption will also affect construction and procurement on projects. With urban infrastructure consuming 40 percent of the world's resources annually, scrutiny by governments and users over the use of resources will increase across a project's life cycle, from construction to maintenance. The UK's High Speed Rail 2 (HS2) project, for example, has committed to using "circular economy" principles to reduce waste and increase the whole-life value of the project.

The pressure to minimize emissions and maximize resource efficiency will take shape through the interplay of a range of transition risks. Infrastructure investors will need to prepare for the complex, multidimensional risks these dynamics can produce in the long term, including far-reaching policy shocks, stranded assets, and an uncertain subsidy landscape.

Far-reaching policy shocks. Policy adjustment will serve as a driver of many transition risks. Between 1997 and 2017, the number of global climate change laws increased twentyfold. Governments are legislating new initiatives and reforms favoring the green transition, a trend that is likely to trigger additional transition risks for infrastructure investors.

At the end of 2019, for example, the European Union released a roadmap for a sustainable green transition for all member nations in the form of the European Green Deal. It establishes a roadmap for making the European Union's economy sustainable, introducing new policy and regulatory shifts such as emission limits, an ambitious target of net-zero greenhouse gas emissions by 2050, a commitment to investing in new research and technologies, and a pledge to transition to a "circular economy." The Green Deal also includes new funding sources and targets that could generate new market and technological risks for incumbent infrastructure players across a range of sectors (see Exhibit 5).

Exhibit 5. Key aspects of the European Green Deal for the infrastructure sector

Goals

90% reduction in transport emissions needed by 2050 to reach climate neutrality

75% of inland freight carried by road will need to shift to rail and inland waterways

In 2021 a zero-pollution action plan will be adopted for air, water, and soil

Decarbonizing steel, chemicals, and cement industries

Broad commitment to transitioning to a "circular economy"

Financing/Support

Trans-European Energy Networks (TEN-E) regulation to be reviewed and used to deploy innovative green infrastructure (such as smart grids and hydrogen networks)

European Investment Bank and European Union budget-supported loan facility to be provided to the public sector for green investment projects

Horizon Europe program to contribute funds, particularly for batteries and clean hydrogen

Source: European Commission, Marsh & McLennan Advantage

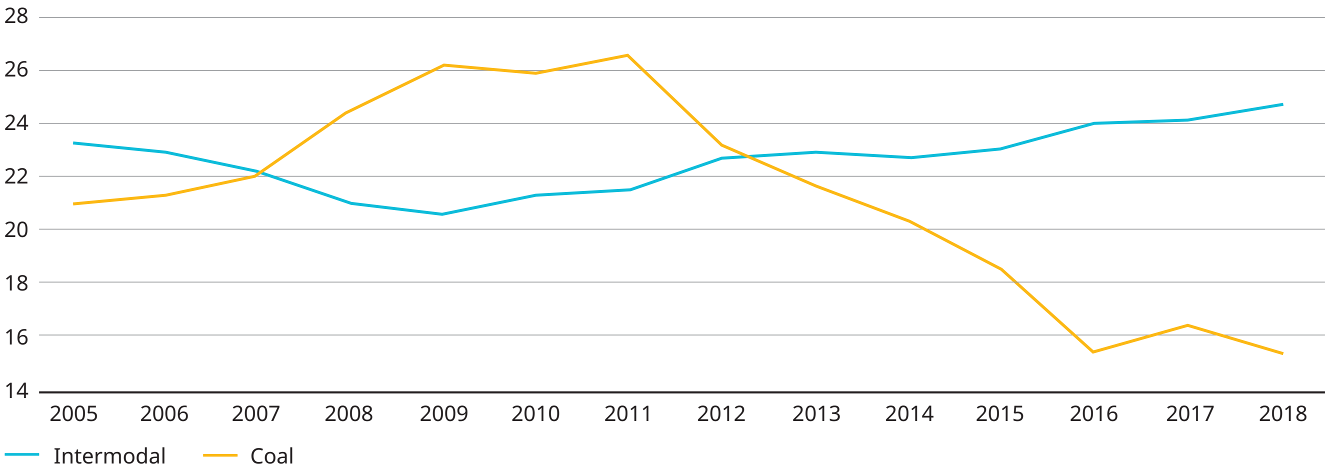
Infrastructure investors will also need to be cognizant of shocks that programs similar to those within the European Green Deal may pose in other economies. New initiatives beyond the EU or changes in government could result in unfavorable tax treatments or construction requirements, for example, undermining the underlying investment model of a project. Meanwhile, investors will need to remain mindful that the landscape of global environmental policy will remain uneven, as priorities in growth markets are likely to differ from those in mature markets.

Stranded assets. The transition to a low-carbon global economy poses serious "stranded asset" risk: the possibility that a portion of existing assets tied to long-term financial agreements may lose economic value well ahead of their anticipated useful lives. Policy shifts and market dynamics have intensified stranded asset risk by accelerating innovation and helping low-emissions technology become price-competitive. Climate-conscious consumers have also raised the specter of reputational risk for companies with exposure to high-emissions infrastructure. Reputational damage erodes companies' social license to operate, quickening the obsolescence of their assets as governments, consumers, and shareholders drive up business costs or close their wallets to their services.

As a result, major infrastructure assets stand to be left "stranded" in the coming decades. The intergovernmental organization IRENA estimates that up to US$700 billion in power asset value might be lost by 2050 due to asset stranding — 82 percent of which will be in coal assets. The ecosystem of assets surrounding coal mining and firing, including railways and important terminals dedicated to the industry, will also be at risk. As coal consumption in the US has declined sharply, coal freight — once the primary driver of railroad revenues — has now shrunk dramatically as a percentage of total US rail revenue (see Exhibit 6 on the following page).

Over the long term, gas-fired power plants and gas pipelines may also find themselves on the front line of stranded asset risk. Gas has long been referred to as an important "transition fuel" due to its low emissions relative to coal and oil, as well as its ease of distribution in emerging markets. However, climate scientists have noted that reliance on natural gas will prevent many nations from meeting their Paris Agreement targets, and it contributes to life-threatening levels of the greenhouse gas, methane. Nonetheless, the global system added an average of 25 new pipelines a year from 2009-2018 (up from seven a year between 1980 to 1995) — creating what some have begun to call a "pipeline bubble" that will be susceptible in the future to the losses the coal sector is seeing today.

Exhibit 6. Coal versus intermodal as a percentage of US rail revenue



Note: "Intermodal" refers to containers and trailers loaded with a wide variety of different products being carried by more than one mode of carrier (e.g. trains and trucks), excluding coal.

Source: The Association of American Railroads

Uncertain subsidy landscape. Public-sector financial support (referred to broadly as subsidies) has been a key driver of renewable energy growth; that, however, may be about to change. Government support for renewable energy takes a variety of forms around the world, from tax breaks, to Feed-in-Tariffs, to certificate programs (such as the Renewable Portfolio Standards program in the US). These programs offer financial relief and risk protection to renewable energy developers and investors seeking reliable returns in a new and unpredictable industry. Many programs have the potential to expire, be reduced, or be phased out altogether in mature renewable energy markets. While the post-COVID-19 landscape may incentivize governments to provide a short-term financial boost to the renewable energy sector, investors cannot count on long-term support mechanisms.

This major policy risk is rooted in technological advancement and market dynamics. Innovations including solar PV conversion efficiency, wind turbine improvements, and lithium-ion batteries, as well as the unexpected rush of new projects and competition in recent years, have allowed renewable prices to fall and compete with those of fossil fuels — leading several governments to re-evaluate the case for renewable subsidies.

However, the uncertainty surrounding subsidies has highlighted a key risk inherent to renewable energy — the problem of intermittency. The intermittency of wind and solar-based renewables means that they are likely to systematically receive a lower overall market price than the average generator. Although volume-based subsidies tend to smooth out this problem, returns will likely decline once operators in systems with large-scale dependence on renewable energy can no longer depend on them. No subsidies may mean that many renewable energy producers will no longer be financially viable, thus undermining the current effort toward a low-carbon transition.[3]

Developing a nuanced understanding of both the physical and transition risk landscape will be crucial for infrastructure investors. By translating these risks into balance sheet effects and, ultimately, strategic decisions, investors will be better able to select long-term investments that retain their value and yield stable returns.

3 For more information, see Oliver Wyman article in Forbes: Why It's Too Soon To Sunset Renewable Energy Subsidies.

Investing in the Low-Carbon Transition After COVID-19

The COVID-19 pandemic and its aftermath pose challenges as well as opportunities for the low-carbon transition agenda. Several governments have deprioritized climate commitments to boost their flagging economies, resulting in policy reversals and delays that threaten to slow the low-carbon transition. The United States saw the relaxation of several environmental regulations and fines during the height of the pandemic, as well as a shift in environmental review processes. In China, Beijing approved more coal-fired plants in the first three weeks of March 2020 than were approved in all of 2019.

At the same time, private firms advancing the green agenda have faced significant market shocks. The drop in demand for energy due to COVID-19-imposed economic lockdowns eroded already thin margins of renewable energy generators and additionally levied new pressures on liquidity-strapped renewables firms. Other market shocks, such as governments freezing budgets or delaying tenders, as well as supply chain disruptions for greenfield construction, also pose significant obstacles for investors in new green infrastructure.

Nonetheless, longer-term trends are pushing the climate agenda forward. Consumer preferences in the post-pandemic world are likely to be more climate-conscious and drive market momentum for the transition: in a Lippincott survey of more than 2,500 US consumers, approximately 70 percent indicated strong support for focusing on climate change as economies rebuild themselves in the post-pandemic world. Financial institutions globally have also invested heavily in the low-carbon transition both internally (through measures such as climate scenario planning and ESG product development) and externally (through long-term investments in “green” portfolio companies).

Government commitments internationally and locally are also likely to continue to drive policy and regulation in favor of the transition. In some cases, governments took action immediately: France imposed green conditions on its COVID-19 recovery package for Air France, for example, while Canada mandated that large companies file climate disclosures to qualify for emergency COVID-19 government loans.

Investors and operators will need to take note of the significant risks the pandemic poses to infrastructure investments linked to the green transition, but concurrently keep an eye on the longer-term horizon of the low-carbon transition to make well-informed investment decisions. To navigate this uncertainty, investors will need to be prepared for several key dynamics, including:

- An uneven stimulus package landscape
- Considerations for post-pandemic M&A
- Diversification opportunities

COVID-19-imposed economic lockdowns eroded already thin margins of renewable energy generators

AN UNEVEN STIMULUS PACKAGE LANDSCAPE

In a survey of 230 economists and policymakers on the pathways to economic and climate recovery following the pandemic, investments in infrastructure emerged as a highly ranked policy instrument with widespread potential benefits. The respondents said spending on physical infrastructure investment (in clean energy and connectivity)[4] could produce positive climate impacts and long-run multiplier effects. Stimulus packages for green infrastructure are increasingly identified as a potential recovery mechanism by academics and policymakers alike, and could provide investors with new opportunities.

Investors must appreciate, however, that not all stimulus packages are created equal. Although some programs may support private investment, investors must be prepared for packages that may "crowd out" or compete with private investments for green infrastructure projects.

CONSIDERATIONS FOR POST-PANDEMIC M&A

In the immediate wake of the COVID-19 outbreak, the US bond market found itself awash in new junk-rated companies. The growing volume of junk or low-rated assets indicates that the number of undervalued assets may also be rising — and investors with enough dry powder may be poised to invest in green infrastructur in the resulting buyer's market.

However, investors will need to be cautious of rising protectionism. Governments are beginning to tighten restrictions on foreign investment to protect critical infrastructure assets (including some green infrastructure projects) from opportunistic foreign buyouts: by June 2020, controls had already been imposed in Australia, Canada, and the EU. Although this trend began gathering pace before the COVID-19 outbreak, governments wary of the new spread of undervalued assets may impose additional scrutiny on foreign investments in critical green and sustainable infrastructure.

DIVERSIFICATION OPPORTUNITIES

The pandemic has reminded investors of the importance of diversification in mitigating risk. Decarbonized energy sources and other green assets can provide attractive means of diversification — particularly those assets that have the potential to see structural and long-term gains from the pandemic. The grounding of planes during the pandemic raised prices for cargo flights, for example, causing companies to turn to lower-emission alternatives such as rail. Trans-Eurasian freight rail saw volumes rise to record levels during the height of the pandemic as a result. In the energy sector, significant declines in power demand due to COVID-19-related lockdowns are accelerating coal shutdowns while supporting renewable growth in certain markets. The US government has projected that US energy consumption will rely more on renewables than on coal in 2020 for the first time.

4 Note that while the overall survey results showed that respondents found "clean energy infrastructure investment" to have long-run multiplier effects, survey responses from lower and middle-income country (LMIC) members did not rank this policy highly in terms of its potential for multiplier effects for their countries.

A FOUNDATION FOR RESILIENCE

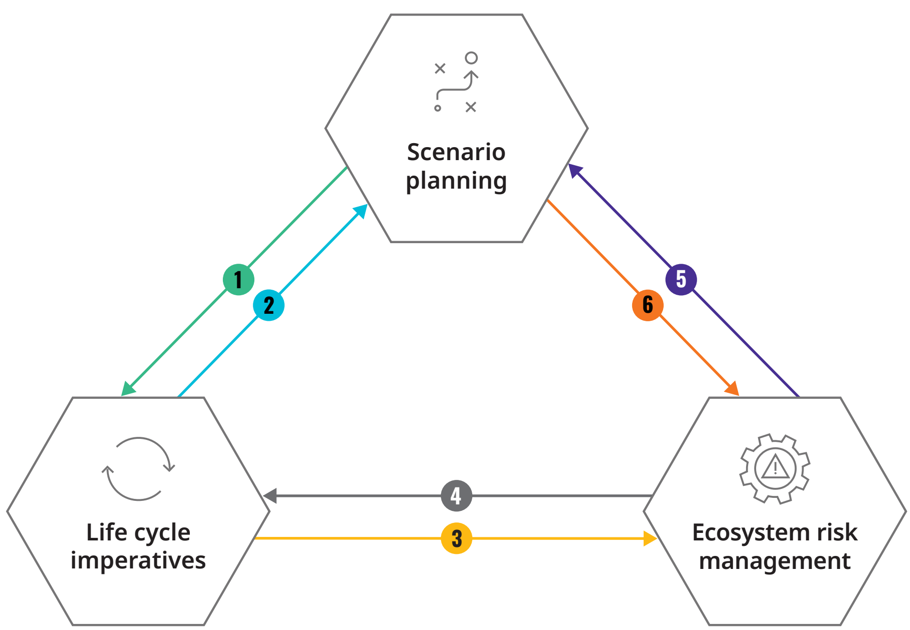
Understanding the range of and interconnections between climate risks is only the first step in building resilience. Infrastructure investors and operators will also need to establish targeted mechanisms and protocols for responding to those risks dynamically as they arise. Risks will need to be translated into financial implications across the short, medium, and long term; the complexity of the infrastructure life cycle will need to be addressed; and owner-operators will need to proactively engage with members across the stakeholder base of an infrastructure asset. Building resilience, therefore, cannot be undertaken as a static activity.

Instead, investors and operators need to apply three mutually reinforcing levers to defend their assets against climate risks (see Exhibit 7). When dynamically adapted in response to the evolving risk landscape, these three levers can build a broad and robust base of climate risk protection:

- **Climate-focused scenario planning**
  Using modern modeling techniques to project multiple potential futures based on potential climate scenario pathways
- **Life cycle imperatives**
  Considering the key decision checkpoints in an infrastructure asset's life cycle; timing and structuring climate resilience interventions to ensure value for money
- **Managing interdependent risks across the infrastructure ecosystem**
  Using stakeholder engagement and collaboration across an asset's ecosystem to build resilience against interdependent climate risks

Exhibit 7. Selected interlinkages between climate resilience levers

1. Physical model outputs can inform early resilience investment decisions
2. New investment due diligence can inform future scenario inputs
3. Risks diagnosed across the life cycle can be addressed through stakeholder engagement
4. Interdependency mapping outputs can inform adaptation decisions
5. Insights from ecosystem management measures can shape future pathway assumptions
6. Scenario inputs can inform dialogue with ecosystem stakeholders



Source: Marsh & McLennan Advantage

DYNAMIC SCENARIO PLANNING

Scenario planning (or scenario analysis) serves as an agile tool for understanding the physical and transition risks from climate change, and for improving decision-making. It tests portfolio and asset resilience under multiple, and sometimes interlinked, potential future outcomes — eventualities that are often hidden behind the top-line results of stochastic modeling exercises. Successful implementation helps investors accommodate the high levels of uncertainty surrounding climate risks, and support investment and capital-expenditure decisions without triggering analytical or model breakdown.

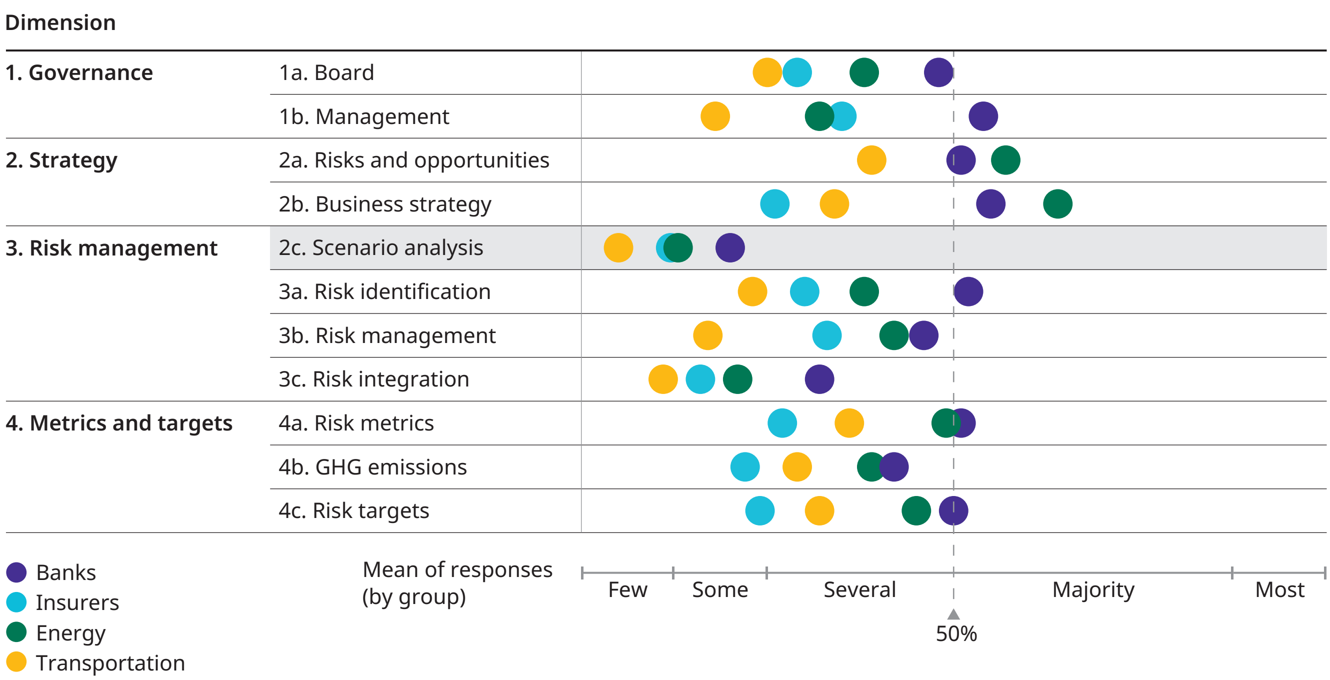
Additionally, developing effective scenario planning exercises satisfies growing calls for infrastructure investors and industry players to underpin their climate disclosure filings with scenario-based risk assessments. As governments intensify efforts to protect their economies from cascading climate risk shocks, disclosure obligations are being extended broadly across industries. Owners and operators of infrastructure face rising pressure for scenario-based disclosure, not just from regulators but also from end investors and project stakeholders.

However, while investors in infrastructure are more familiar with evaluating investments on a multidecade time horizon (as compared to other financial institutions), running climate-driven scenario analyses for infrastructure investments presents challenges. Results from a 2019 survey by the Task Force on Climate-related Financial Disclosures (TCFD) indicate that this is an area where many sectors relevant to the infrastructure investment community are still at the early stages of adoption (see Exhibit 8).

To embed a scenario analysis process effectively and maximize its value, infrastructure investors and operators must invest in high-impact approaches to structuring the exercise. To do so, they must execute three key actions: identify and select appropriate scenarios, deploy the right analytical tools, and be prepared to act effectively on the outputs.

Exhibit 8. Alignment with recommended TCFD disclosures

Percentage of companies from each group



Source: Task Force on Climate-Related Financial Disclosures: 2019 Status Report

IDENTIFY AND SELECT APPROPRIATE SCENARIOS

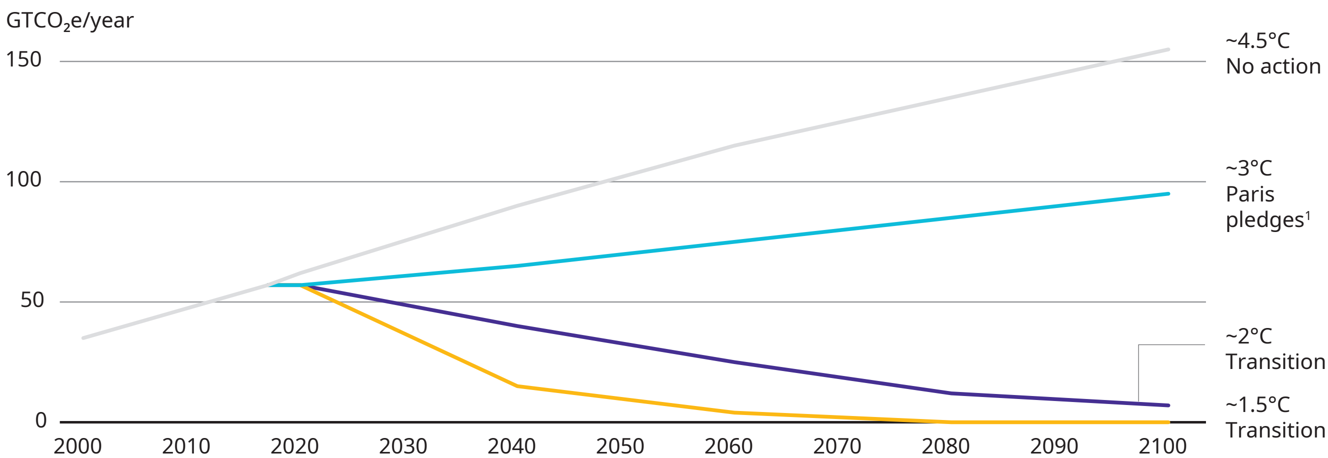
Climate scenario analysis helps to quantify the potential exposures of an institution to transition and physical risks. This analysis serves as a useful "what-if" analysis of a potential future state under a specific climate scenario. Best-practice approaches to scenario planning often leverage both temperature-based and event-based scenarios (see Exhibit 9).

Temperature-based scenarios set out headline futures such as 2°C, 3°C, or 4°C worlds, which may come to pass due to a combination of government policies, technology development and business actions that result in critical consequences over a particular time period. These consequences can include both physical outcomes (such as declining water availability or sea level rise) or broader industry-based outcomes (such as a higher share of power generation sourced from renewables).

Exhibit 9. Scenario types for climate risk analysis

Temperature-based scenario models

CO_2 emission trajectory for various temperature scenarios

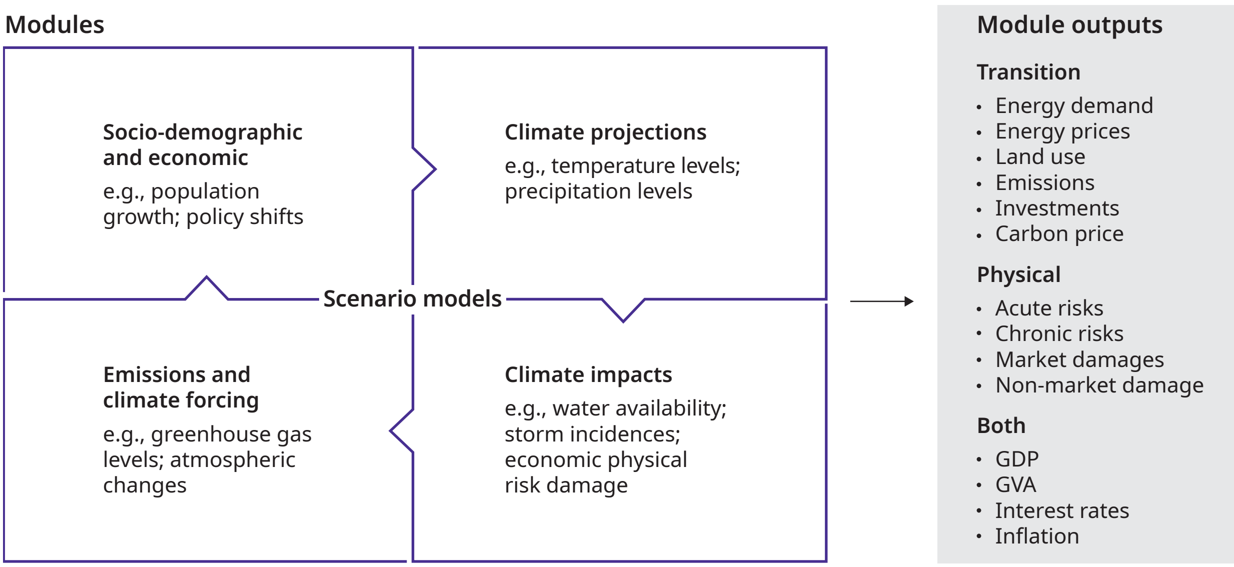


Event-based scenarios

Triggering event	Risk type	Key metric	Sample sector applications
Carbon pricing	Transition (policy)	Carbon price	Fossil fuel energy production
Breakthrough in energy storage	Transition (technology)	Battery capacity	Renewable energy production
Storms and hurricanes	Physical	Probability/severity of weather events	Cross-sector (location specific)
Drought	Physical	Duration and severity of reduced precipitation	Utilities

1 Scenario based on latest UN projections.
Source: Oliver Wyman

Exhibit 10. Representative scenario-based systematic model structure



Source: Oliver Wyman; adapted from Potsdam Institute for Climate Impact Research (PIK)

Temperature-based scenarios have already been developed by the scientific community for use in academic research and policymaking, but financial institutions and corporations are increasingly using advanced temperature-based climate models to analyze their assets and portfolios as well (see Exhibit 10). Infrastructure investors looking to do so must ensure that the modeling assumptions employed in externally prepared scenarios are contextually appropriate or adaptable, and be prepared to develop additional variables to ensure the outputs are industry-relevant.

Conversely, *event-based scenarios* focus on a singular plausible triggering event that may have direct impacts on a particular sector or geography as well as broad impacts across selected sectors, markets, and localities. Examples of such events include a change in carbon pricing or a persistent drought. This scenario type is appropriate for modeling abrupt shocks or a disorderly transition to a low-carbon economy, which can be instrumental for climate stress testing (an increasingly high-order agenda item for regulators) as well as for informing near-term and high-capex decision-making for infrastructure assets.

DEPLOY THE RIGHT ANALYTICAL TOOLS

Once climate scenarios are selected, institutions need to link them to financial performance through the targeted deployment of analytical tools. For instance, Oliver Wyman and Mercer, originally commissioned by the UN Environment Program Finance Initiative (UNEP FI), have developed a methodology for translating climate scenarios into a risk profile calculation that can be applied to a variety of asset classes, scenarios, and risk types (physical or transition). The methodology emphasizes the importance of tailored assessments to evaluate the risks of each investment or individual company (see Exhibit 11).

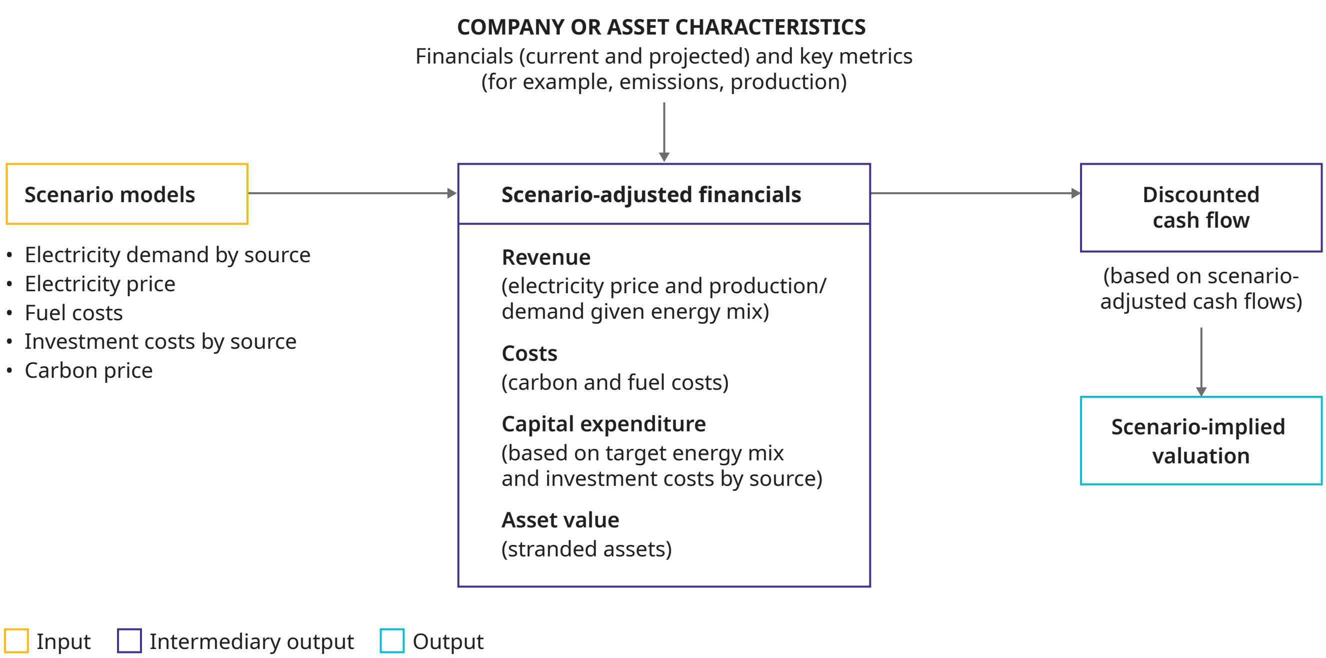
Scenario models (discussed under "Identify and select appropriate scenarios") provide variables that are relevant for a given sector's performance. For example, regional carbon prices, electricity demand, fuel costs, and investment costs are important drivers of unregulated power generation utilities. These variables are then linked to the financial performance of the company to estimate the scenario-adjusted financials of the specific asset or investee company and, ultimately, project a scenario-implied valuation.

Those estimates will need to be substantiated with expert judgment and qualitative investigation, which can inform the assumptions necessary for a successful scenario planning exercise. For example, a high-carbon tax scenario's impact on a gas-fired power plant in a deregulated electricity market (an asset type relevant to the sector illustrated in Exhibit 11) will depend on various assumptions, such as the future energy mix relevant to the asset's geography (which can aid in determining the cost-competitiveness of the newly taxed asset) or the adaptive capacity of the asset's owner/operator (that is, the owner/operator's capacity to invest in low-carbon alternatives). Being cognizant of these contextual dynamics for individual assets and companies will be crucial for qualitatively establishing effective links between investment financials and transition scenarios.

Separately, a highly localized understanding of a company or asset's **physical risk** exposure will also be crucial for ensuring that financial impacts are sensibly projected in the face of a changing natural environment. Tools for evaluating site-specific risk exposures include geospatial mapping and modeling resources such as catastrophe models, as well as site-level environmental engineering reviews. Outputs from these tools typically take the form of physical variables (such as centimeters of sea level rise or number of days above a defined temperature level), although some tools (for example, catastrophe models) support a deterministic or stochastic financialization of these risks as well. These outputs are instrumental in informing the "company or asset characteristics" inputs necessary for an effective scenario planning exercise.

This approach allows investors to overcome the lack of historical data around today's unique landscape of physical climate risks and low-carbon transition dynamics, and fulfills an increasingly important recommendation from regulators. Tailored or "bottom-up" analyses such as these are therefore the preferred approach. When the necessary resources and data are not available, "top-down" analyses serve as a helpful complement to a bottom-up approach by extrapolating the results to a broader sector-level. An elaboration on this approach can be found in the *Extending Our Horizons* report by Oliver Wyman, Mercer, and UNEP FI.

Exhibit 11. Framework for an unregulated power generation utilities asset using scenario variables
(Simplified, illustrative)



Source: Oliver Wyman

ACT ON THE OUTPUTS

Risk assessment integration across organization

Climate risks and climate scenario planning cannot be treated as merely "tick-box" exercises, and the outputs of climate scenario analysis must be integrated into a firm's risk management practices and climate risk response. The board of directors and senior management must, therefore, consider climate risks an important factor in long-term decision-making. Climate risk awareness at the top of the organization enables and accelerates the embedding of climate-related considerations into a company's risk management framework. In this way, climate risks must be considered in a similar manner to other strategic risks a company might face.

This integration will also require firmwide buy-in into the climate resilience agenda. Climate-related targets — such as a reduction in total portfolio emissions or risk appetite statements and tolerance levels — will need firmwide support to ensure they are fulfilled in an accelerated time frame and comprehensively across all functions. Giving primary responsibility for managing climate risks based on scenario outputs to a central risk function, which is then supported by sustainability or environmental and social risk teams, can increase the chance of developing and implementing risk mitigation mechanisms in collaboration with functions across a firm.

As an example of how the operator-level response to a risk would benefit from ownership by a core risk team, consider the challenge a physical climate peril (such as a rise in sea levels or increases in tropical storm intensity) poses to a specific asset. After conducting a risk exposure analysis using a catastrophe model or site-level engineering review, there are three high-level actions that need to be carried out, touching upon a wide range of business functions. First, appropriate engineering enhancements should be assessed in light of the potential peril to increase resiliency — for example, reinforcing perimeter walls or strengthening asset foundations to address changing flood risk. Second, avenues for risk transfer should be explored — which will likely include insurance solutions (further detailed in the following section of this report).

Last, it is important that appropriate crisis management protocols and business-continuity management plans are instituted, which should include stakeholder management guidance covering customers, impacted residents, regulators, and local authorities, among others. The implementation of these steps is often enhanced by centralized ownership over the climate agenda, which can ensure that climate risks are viewed as a core imperative for a company to address.

Portfolio management: investment and divestment

Investors must be equipped to review and revise investment strategies on the basis of scenario planning outputs. Building these outputs into the portfolio construction and reconstruction process can be done in a variety of ways. Two options are set out below.

Mercer's report series *Investing in a Time of Climate Change* models the impact of climate change scenarios on investment return expectations. The model results found that, in a 2°C scenario, investments in infrastructure generally and in sustainable infrastructure (and renewables) specifically would likely deliver some of the largest returns across a range of asset classes through to 2030 (see Exhibit 12 on the following page). Conversely, the same report also found that the infrastructure asset class was one of the most sensitive to the increase in physical risks expected in a 4°C world — offering insights for investors looking to incorporate a climate scenario-based lens into their investment evaluations on a portfolio level.

Alternatively, for deal-specific decisions, investors can integrate scenario-level outputs into additional analyses as part of the due diligence process. In the report commissioned by the UNEP FI, Oliver Wyman and Mercer developed a scorecard for banks to rank investment opportunity attractiveness, using the outputs of climate transition risk modeling as well as a framework for evaluating the internal investment capabilities and expertise of the bank. Infrastructure investors can adapt this approach to the infrastructure context to inform climate-resilient investment decisions for both physical and transition scenarios.

Exhibit 12. Return projections under a 2°C scenario

Example industry sectors and asset classes	Percent p.a. to 2030 in 2°C scenario	Percent p.a. to 2050 in 2°C scenario	Percent cumulative impact to 2030 in 2° C scenario	Percent cumulative impact to 2050 in 2° C scenario
Coal	-7.1	-8.9	-58.9	-100[1]
Oil and gas	-4.5	-8.9	-42.1	-95.1
Renewables	6.2	3.3	105.9	177.9
Electric utilities	-4.1	-3.3	-39.2	-65.7
Developed market equities	—	-0.2	-0.5	-5.6
Emerging market equities	0.2	-0.1	1.8	-4.0
All world equities — sustainability themed	1.6	0.9	21.2	32.0
Infrastructure	2.0	1.0	26.4	39.4
Infrastructure — sustainability themed	3.0	1.6	42.3	67.1
All world real estate	—	-0.2	-0.1	-4.7

1 Effective absolute loss of value is expected to occur in 2041 under a scenario in which global warming is limited to 2°C by 2100.

Source: Mercer

Disclosure and engagement

Including the outputs of scenario planning exercises in annual reports or disclosure documents also addresses the increasing pressure on infrastructure investors and industry players to report scenario-based climate risk assessments. In early 2020, for example, the UK's Financial Conduct Authority proposed "comply or explain" requirements for TCFD-based climate disclosures, including a scenario analysis component. Separately, the European Central Bank (ECB) conducted public consultations throughout the first half of 2020 on climate disclosure requirements and scenario analysis/stress testing that will be finalized into a guide for banks. The early public disclosure of the outputs of scenario-planning exercises can ensure firms are prepared for the regulatory shifts on the horizon — and even help build systemwide resilience against interdependent climate risks.

Reference TCFD Scenario-based disclosure is additionally becoming a growing requirement for establishing the trust of investors and stakeholders. The inclusion of scenario-based climate risk mapping in investor relations communications or in engagement documentation can secure the confidence of shareholders and prevent censure (such as voting action being taken against board members). Scenario-based risk assessments in disclosure documentation can additionally act as a signaling mechanism for financial institutions and public-sector contracting bodies that are looking to develop or maintain climate-resilient fixed assets, and open up new avenues of access to project funding.

LIFE CYCLE IMPERATIVES

The nature of infrastructure investments is such that decisions made early on in a project life cycle can result in higher overall project costs and lasting climate resilience deficiencies. To prevent such outcomes, investors and operators should carefully consider four key imperatives in the life cycle of an asset:

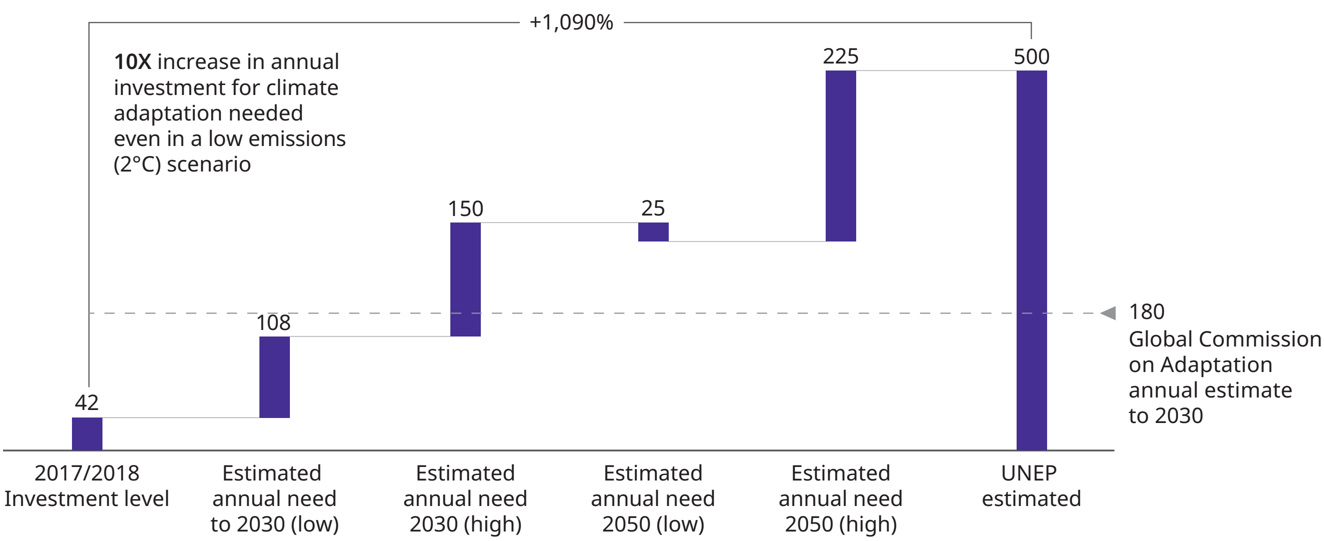
- Obtain financing for climate-resilient infrastructure development
- Ensure climate resilience matters in tender design and scoring
- Negotiate appropriate risk-sharing terms
- Determine modes of climate adaptation for existing assets

OBTAIN FINANCING FOR CLIMATE-RESILIENT INFRASTRUCTURE

The Global Commission on Adaptation estimates that between today and 2050, approximately US$180 billion in "climate adaptation finance" will be required annually to combat the physical risks of climate change. The United Nations Environment Program (UNEP) sets the cost higher, estimating up to US$500 billion per year will be needed. The construction of new climate-resilient infrastructure, as well as the adaptation and upgrading of existing infrastructure, will be central to this effort — for which a combination of private and public financing will be crucial.

The volume of private investment available for climate-resilient infrastructure is limited, however. Uncertainty around investment returns means that private investors tend to offer largely equity or short-term bank loans for resilience projects — and even these forms of financing may be insufficient. While large volumes of public-sector capital have been allocated to climate adaptation finance (between 2015 and 2018, public investment in climate adaptation grew by approximately 30 percent) the gap between actual capital in-flows and estimated needs remains significant (see Exhibit 13). While the private sector works on increasing its capacity for financing climate resilience, sourcing capital for mitigating climate risk or adapting infrastructure assets will require creative approaches. A number of financing

Exhibit 13. Climate adaptation funding requirements for developing countries (2° scenario)
US$ billions



Source: CPI; UNEP; Global Commission on Adaptation structures, while nascent, are growing in volume to serve this need (see Exhibit 14). "Green bonds" (sometimes called "climate bonds"), initially devised to finance investments to mitigate greenhouse-gas emissions, are increasingly being targeted toward climate resilience investments. Other potential instruments include insurance-linked securities (such as catastrophe bonds) and environmental impact bonds.

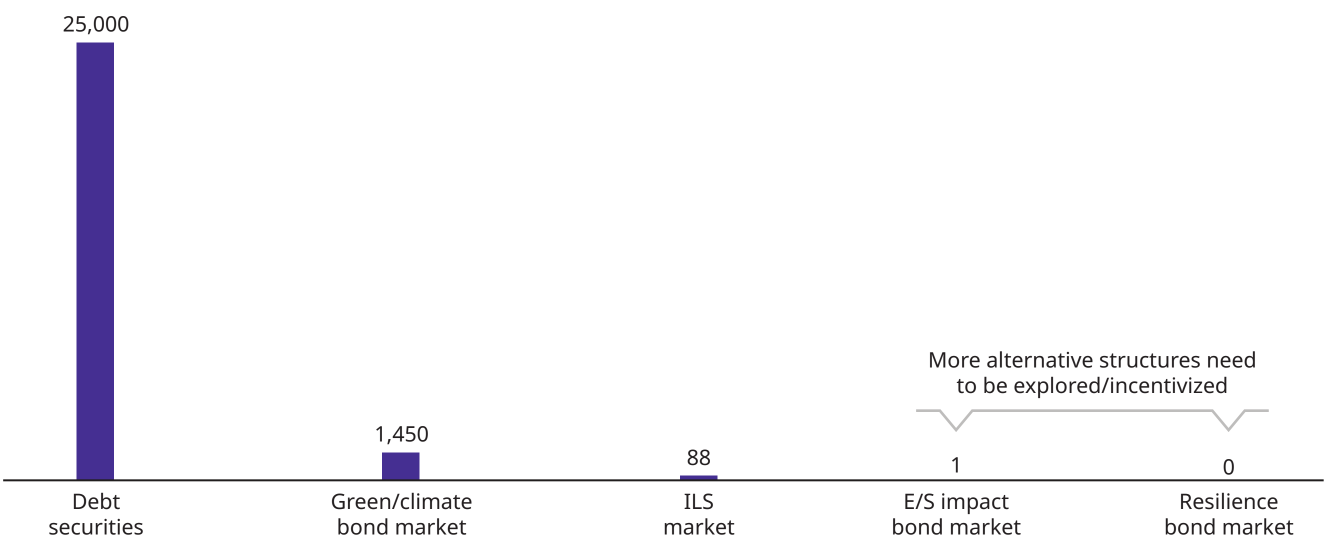
ENSURE CLIMATE RESILIENCE MATTERS IN TENDER DESIGN AND SCORING

Competitive public procurement or bidding processes sometimes fail to provide bidders with incentives to invest early in climate resilience. Early and proactive deployment of capex for physical climate risk protection adds a significant price tag to overall project costs and can render a bid unattractive. If cost is the chief selection criterion, then a more climate-resilient bid can become less competitive.

Investors and international organizations, however, have begun to appreciate that early climate resilience investment pays dividends. A World Bank analysis found that in 96 percent of potential socioeconomic and climate trend scenarios, the benefit-to-cost ratio of early climate resilience investment is greater than one. High initial costs can often be recouped from substantial future savings in maintenance and rehabilitation costs, lower insurance premiums, and from the revenue ensured by the asset's greater lifespan and longevity — meaning that the overall life cycle costs of a project are minimized. However, although many public-sector procurement processes in developed markets recognize the importance of Life Cycle Cost Analysis (LCCA), not all procurement processes employ LCCA as a requirement for bids.

It is therefore essential that investors and operators take a proactive approach to working with authorities to ensure that early climate resilience is incorporated into the decision-making criteria for procurement and bidding. This will mean encouraging governments to recognize the lower overall life cycle costs to be gained from upfront resilience spending and the positive externalities that resilience can generate. (By "positive externalities" we refer to the broader economic benefits

Exhibit 14. Selected global financing sources for climate-resilient infrastructure



Sources: BIS; CBI; Guy Carpenter; Social Finance UK of early climate resilience beyond the private benefits to the asset, which include minimized business disruption, community safety, or job creation.) By ensuring that a long-term and multidimensional approach to cost-benefit analysis and accounting is used in tender scoring, infrastructure investors can secure crucial protections against physical climate events.

NEGOTIATE APPROPRIATE RISK-SHARING TERMS

In an era of climate change, the success of an infrastructure asset will depend on the ability of the asset's contractual structure to distribute the burden of different genres of climate risks across a variety of stakeholders.

Two key clauses for addressing discrete and high-impact ("one-off") climate risk events include the "force majeure" and "change in law" clauses. These clauses can be triggered in the event of an acute climate risk or sudden policy change, so long as these provisions are carefully drafted and defined in the contracts and subcontracts of a project early on. As climate risk data becomes more readily available, and as communication around climate policy becomes normalized, these clauses and the definitions within them will likely be revisited and tightened. Project owners will need to prepare for additional scrutiny around these clauses in the coming years.

It will also be crucial to ensure contractual mechanisms are used to share the burden of transition or chronic physical risks that may gradually increase operational costs or hurt revenues. For example, investors negotiating long-term fixed contracts, such as corporate Power Purchase Agreements (PPAs) and availability-based contracts, would do well to include provisions for revised pricing schemes in the event of higher carbon pricing, the loss of incentives or subsidies, or resource shortages that may squeeze margins. For assets tied to demand-based contracts, ensuring provisions negotiated early on that allow for alternative recourses for recouping revenue losses from diminishing demand — such as adjusted ownership timelines — can provide much-needed relief.

Where an investor must take on the burden of a particular risk type, tailored risk solutions may be required. There are evolving risk management and financing solutions that investors should consider in the project-planning phase for this purpose. These options include:

Cliff insurance. Norton Rose Fulbright LLP and Marsh have jointly developed a "cliff insurance" policy that can protect developers and financiers from the risk of the loss of statutory renewable energy incentives. This product can serve as a vital risk mitigation tool for projects that find themselves "going over the policy cliff" (for example, narrowly missing a deadline or prerequisite due to a policy change) to qualify for a certain incentive or support program from a government. This solution can provide much-needed coverage in today's uncertain regulatory landscape.

Parametric insurance. Parametric insurance products are designed such that once a defined threshold for a specific physical or meteorological parameter is hit, claim payments are triggered and distributed rapidly with little interference from the loss adjustment process (see Exhibit 15 on the following page). Key to being able to structure an effective parametric insurance contract is the ability to access relevant historic, objective, and accurate weather data over a reasonably long period, and then creating an index with a high correlation with the financial exposure.

Marsh works with a variety of infrastructure sectors to deploy parametric insurance solutions as protection against physical climate risks. This includes solutions for transmission and distribution assets belonging to utilities or communications networks that may be damaged by windstorms, for example, as well as power stations that may be required to shut down for environmental protection if water temperatures are too high at their point of outflow.

Exhibit 15. How does parametric insurance work?

Assessment
Analysis of available and measurable data (i.e., amount of precipitation, duration) to create a reliable and credible index on which to trigger the policy

→

Policy cover
Design of an insurance adapted to the needs of the client and mutually structuring a bespoke policy (including wordings, definitions, payout, and price)

→

Recovery
Pre-agreed payment structure triggered based on event parameter (i.e., amount of precipitation and duration) exceeding threshold

Source: Marsh & McLennan, Parametric Insurance: A Tool to Increase Climate Resilience

DETERMINE MODES OF CLIMATE ADAPTATION FOR EXISTING ASSETS

Many existing assets — particularly ones that are decades old — do not benefit from the resilience measures that are being engineered into equivalent assets today. However, retrofitting existing assets with infrastructural resilience solutions is usually more costly than integrating them into new greenfield projects, making investments into late-stage resilience building more challenging to structure and justify.

In cases where both the price tag and uncertainty around physical risk exposure are prohibitively high, capex-heavy pre-event resilience for existing assets may not be financially prudent. The OECD has highlighted that because hydroelectric dam design lives extend between 70-100 years, for example, conducting cost-benefit analyses for early resilience investment in those assets is highly challenging. Similarly, a World Bank study shows that while physically raising water and wastewater treatment plants could increase upfront costs by a very small fraction and reduce flood risks by approximately 60 percent, elevating a railway would incur additional costs of up to 50 percent of the project's original costs — but still only reduce flood risks by 60 percent. In such cases, it could be excessively expensive to prepare for all potential outcomes at the design, planning, and construction stages.

In these cases, investors should remember that resilience measures do not necessarily need to be capital intensive. Instead, equipping an asset with adaptive management processes and protocols in anticipation of a climate risk event (be it a physical or transition one) can be instrumental in building climate resilience. Adaptive infrastructure asset management involves nimble processes and operations, informed by climate data and supported by scenario-based risk event mitigation and recovery plans. These processes and plans can include:

- Stress testing/shock analysis
- Business continuity measures (BCM)
- Diversification across assets, supply chains, and lenders
- Regular communication channels with governments on policies (such as building codes or subsidies/taxes)
- Contingencies in cost estimations for potential capital costs

Resilience measures do not necessarily need to be capital intensive

ENSURING ECOSYSTEM-WIDE RESILIENCE

Interdependent risks are a crucial dimension of the challenge facing infrastructure owners and operators. Interdependent risks arise from investments in new infrastructure, the spread of globalized supply and value chains, and technological developments (such as increased use of data sharing and the Internet of Things). In some cases, these connections also emerge from cost-cutting initiatives by governments seeking to minimize redundancies across infrastructure networks. For example, decommissioning underutilized energy pipelines with spare capacity can reduce costs — but can concurrently remove backup capacity that would serve well in the event of a storm or flood disrupting other pipelines, and increase interdependent risk exposure.

Therefore, lasting asset resilience can only be achieved when both the asset and the broader ecosystem around it are equipped to withstand and recover from climate risk events. Preparing for these risks will require a detailed understanding of an asset's interdependent risks: a comprehensive view of the networked assets, communities, supply chains, or companies that could create material damage for said infrastructure asset if faced with climate risks. A survey of several OECD nations showed that only 36 percent of central governments had identified key interdependent risks for critical infrastructure assets — highlighting the urgent need for private players to be proactive agents in diagnosing these vulnerabilities.

Ultimately, asset owners must take an ecosystem-wide approach toward building resilience against interdependent climate risks. This will mean engaging with a diverse range of stakeholders to establish new climate resilience initiatives based on coordination and collaboration. In this way, the infrastructure sector can shift its focus from "asset resilience" to "system resilience," adopting a holistic approach for ensuring the continuity and safety of critical infrastructure networks.

UNDERSTANDING CLIMATE-DRIVEN INTERDEPENDENCIES

Interdependent climate risk events arise when a physical or transition risk triggers a series of effects that cause indirect — but material — damage to an infrastructure asset. These risks can take different forms in the context of the climate challenge:

- **Geographical or physical:** Closely situated assets can cause physical damage or disruption to one another
- **Digital:** Digitally connected assets can be disrupted by a central node affected by a climate-related risk
- **Operational:** Suppliers, staff, insurance firms, and other entities providing goods and services to an asset can experience a disruptive climate event that raises operational costs for that asset
- **Strategic:** Climate risk events affecting connections to other assets, networks, or communities can cause disruptions to the revenue, usership, and/or availability of an infrastructure asset

MAPPING INTERDEPENDENT RISKS

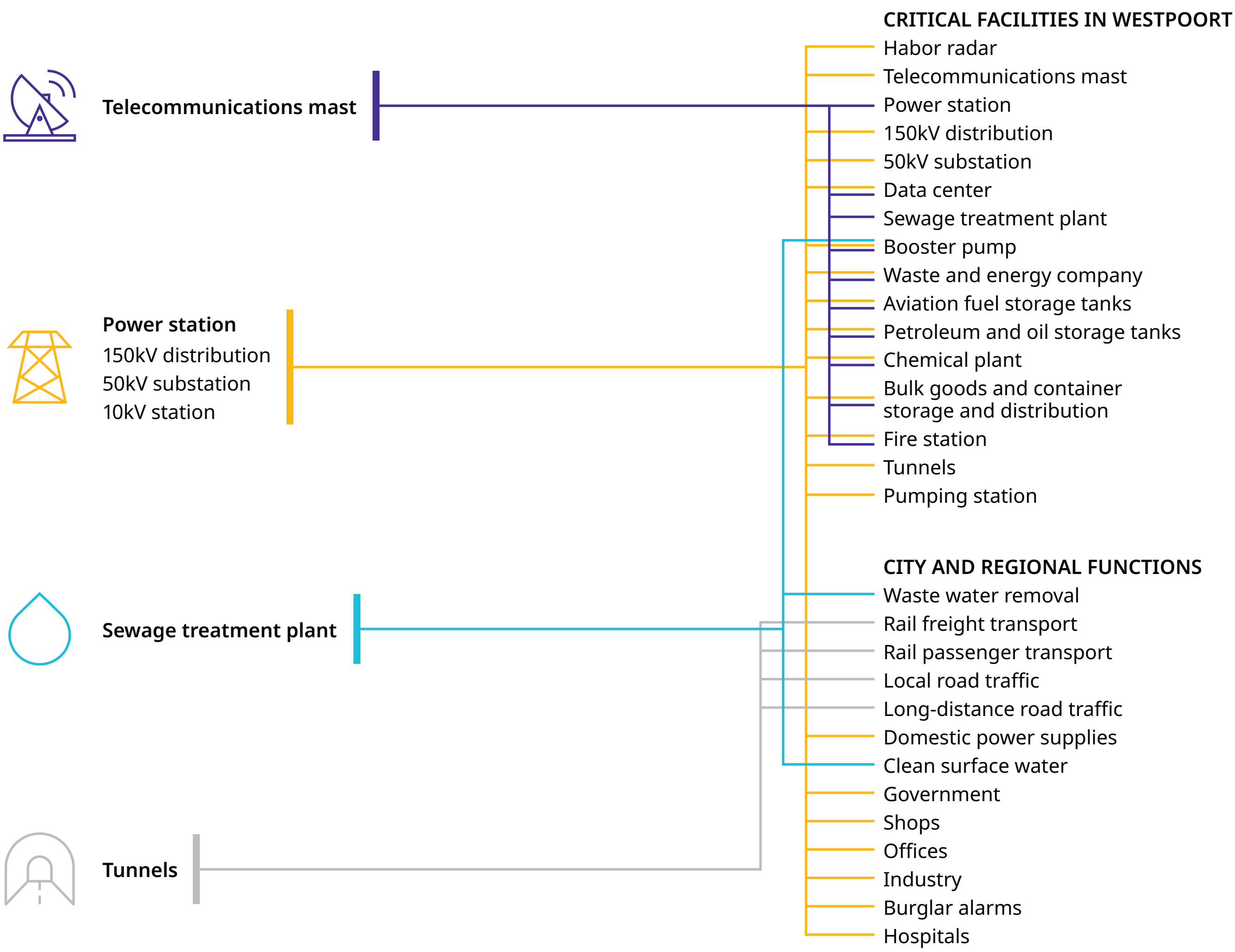
Infrastructure owners will need to contribute to, facilitate, and encourage "interdependency mapping" exercises in collaboration with external organizations and stakeholders. This will involve identifying and illustrating the key entities that an asset (or a collection of assets) relies on to function.

One example of mapping interdependencies is highlighted in a case study by the C40 organization. The City of Amsterdam undertook a comprehensive information-sharing exercise in 2013 between 15 publicly and privately owned companies to map the interdependent risks relevant for the Westpoort harbor — home to the Port of Amsterdam, the Netherland's second-largest port (see Exhibit 16 on the following page). The result was a detailed interdependency map, demonstrating the complex and multi-faceted knock-on effects that could be triggered by the flooding of a critical facility or asset in Westpoort.

As Amsterdam's mapping exercise demonstrates, success in identifying interdependent risks will rely on private players engaging collaboratively as part of diverse stakeholder groups. Each entity can play a crucial role in mapping interdependent climate risks:

Exhibit 16. Westpoort Harbor District interdependency map

Interdependent risk impacts on critical facilities and relevant functions shown for flood impacts on selected assets



Source: C40 Cities Climate Leadership Group. Note that the image above reflects a limited selection of interdependencies. A comprehensive illustration of these interdependencies can be found in the *C40 Infrastructure Interdependencies and Climate Risks Report*

Municipal governments/governmental bodies. Governments can serve as unbiased collectors of sensitive information from within the infrastructure community, creating channels for synthesizing information that would otherwise have been impossible. Additionally, they can provide perspectives from across subnational or national boundaries and from outside the infrastructure sector. By hosting knowledge-sharing events, public-sector bodies can help synthesize information collected from diverse sources into maps reflecting key vulnerabilities across infrastructure assets.

Infrastructure peers. Absent public-sector support, infrastructure investors and owners may benefit from sharing information with one another. While this will require building trust and establishing security protocols, intra-sector information sharing between infrastructure owners can be instrumental in building resilience for a larger system of assets.

Local community leaders and groups. Local communities will be on the front lines of certain physical and transition risks that may arise from operating an asset or from the physical risks that the asset may be exposed to. Additionally, these communities may represent a meaningful percentage of an asset's users and employees. Early engagement with local communities can reveal localized risk exposures that could affect certain subgroups in a community — such as racial or low-income groups — or market trends relating to climate transition that could impact revenue.

RESILIENCE THROUGH STAKEHOLDER ENGAGEMENT

After building a comprehensive understanding of an asset's ecosystem and interdependent risks, infrastructure operators can begin to engage with key stakeholders to build new avenues of resilience. These avenues can take several forms, including:

Collaborating with private- and public-sector firms to invest in hard physical risk resilience measures. Collaborating with private and public-sector infrastructure firms facing similar physical climate risks can enable investment in much-needed multi-asset protective measures such as flood barriers/levees, or pooled access to cooling facilities and agents. The United Kingdom's major High Speed 2 (HS2) railway, for example, plans to use collaborative working arrangements with local infrastructure operators along the railway's network to ensure protection from a variety of interdependency-based climate risks (including flooding, overheating, and ICT or electricity failures from climate events).[5]

Working with private, public, and local community organizations to plan and invest in natural infrastructure measures. Natural infrastructure projects involve the organization and management of naturally occurring phenomena to provide benefits to nature, local communities, and nearby hard ("built") infrastructure assets: for example, mangrove or wetland management can provide impactful forms of flood protection. Collaboration between international organizations, as well as local NGOs and environmental groups, will be crucial for securing financing and acquiring the expertise to execute these projects successfully.

Building a private-sector alliance or network to engage and negotiate with governments. By banding together, infrastructure firms can provide "crowd-sourced" feedback to government stakeholders and influence climate resilience strategies. These channels can give infrastructure firms opportunities to highlight instances where resilience measures that would be difficult to justify under existing contracts or regulatory regimes could benefit the wider community or infrastructure network. Network- or alliance-based communication with the public sector can become a mechanism for justifying changes in contracts, exceptions, or obtaining financing for climate resilience measures.

Data sharing and early-warning signal collaboration. The more data that is shared between interconnected assets and facilities, the more prepared the system will be for climate risks — particularly physical risks. As physical assets become increasingly connected to the Internet of Things — and thus become generators and repositories of valuable information — data sharing between the public sector and their private-sector peers could enable infrastructure systems to build early-warning signals based on information drawn from diverse sources.

Negotiating resource sharing and environmental protections with local community groups. Environmental impact assessments, as well as workshops and engagements with local communities, can highlight opportunities for private infrastructure owners to coordinate with local groups to protect the environment. This collaboration can aid in environmental reporting, reduce climate damage, and protect against reputational risks. This is happening in Australia, where water infrastructure managers and local aboriginal and other community organizations are working to improve the quality of wetlands by negotiating agreements for shared water use.

5 Explicit plans for this collaboration are forthcoming from the UK Government.

CONCLUSION

The global climate challenge is shifting the risk profile of infrastructure investments. The threat of asset damage and operational disruption from physical risk is on the rise, while the transition to a low-carbon economy is likely to trigger policy, reputational, market, and technological risks. This report has outlined the importance of three key levers in addressing these risks and building resilience: scenario-planning capabilities, life cycle-based imperatives, and ecosystem-wide risk management.

Investors will need to build a culture of collective responsibility and dynamic responsiveness for the successful implementation of each of these climate resilience levers. All functions in investor firms will have to be primed for new risks and opportunities, and strengthen their capacity to adapt to their evolving potential futures. As such, firms will need to be prepared to regularly refresh risk management and strategic decisions, including scenario planning, disclosure commitments, engineering measures for physical resilience, risk transfer structuring and portfolio restructuring actions.

However, private-sector infrastructure stakeholders will not be able to deploy this dynamic response to the climate challenge alone. As governments navigate the post-pandemic world, infrastructure development and enhancement will become increasingly central to national recovery plans — and infrastructure investors will need to lean on their collaborators to ensure that new investments result in climate-resilient assets and business models. Regular dialogue with public-sector stakeholders will be crucial for ensuring the delivery of climate-resilient infrastructure, and collaboration with industry peers and local communities will provide new avenues from protecting those assets from climate risks.

Ultimately, infrastructure investors and operators of all stripes will need to ensure that climate resilience is part and parcel of both their firms' portfolio design and their asset-specific risk mitigation strategies to address the climate challenge ahead. Applying the three mutually reinforcing levers discussed in this report can provide infrastructure investors with a launchpad for developing a dynamic and future-ready climate resilience strategy.

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