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 di f erent risks

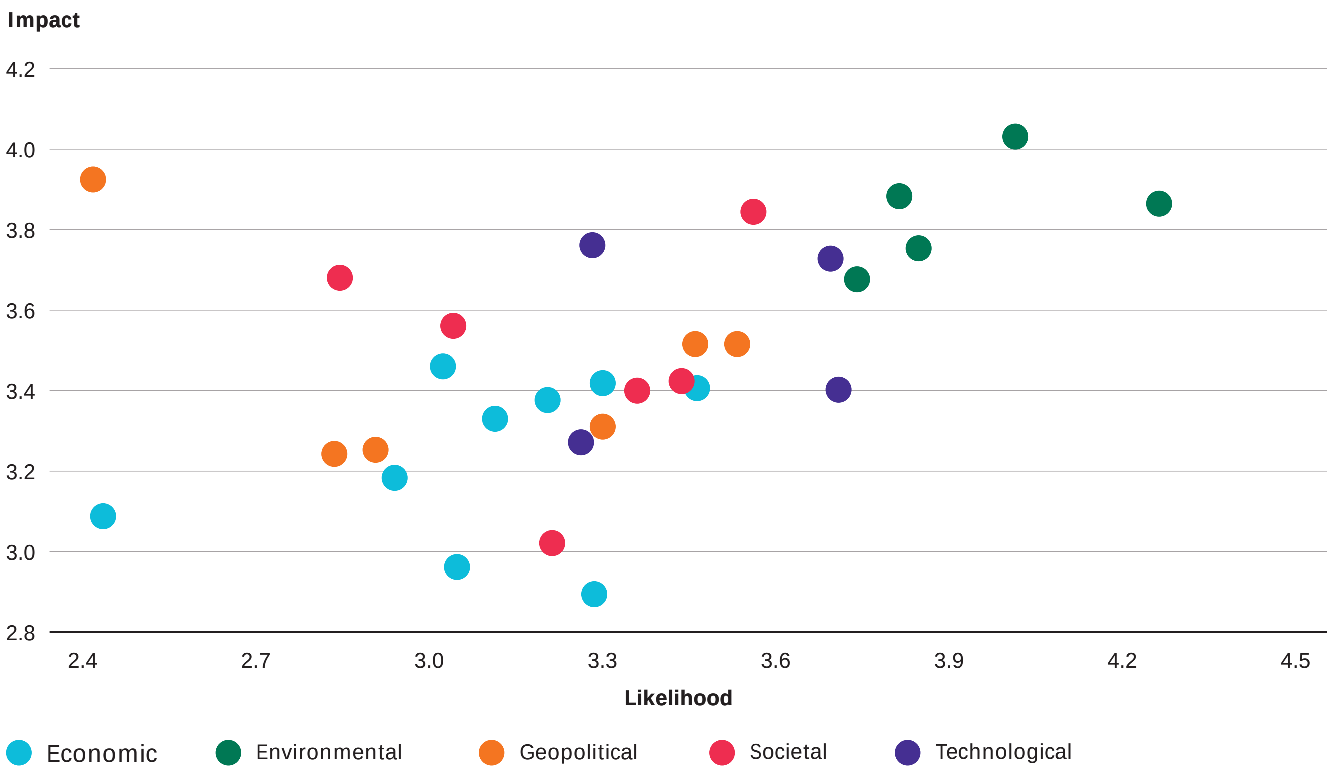
3. E f ective scenario planning links model outputs to business metrics to inform a f rm-wide response to climate reinuous rh0 12 342.8502 388.2181 Tm[r)20 (

INTRODUCTION

The stable and long-term returns o f ered by the infrastructure asset class are under increasing pressure. As the global economy adapts to both physical changes

1 An international working group of f nancial professionals providing recommendations on best practices in climate-related f nancial 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	a
Adaptation	Reducing the impact of a risk event
Climate resilience	The ability of a f rm 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 f rms
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 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 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
Policy	Government policies or financial programs linked to the energy transition that affect the competitiveness of infrastructure assets or longevity of their returns 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

UNDERSTANDING THE RISKS

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

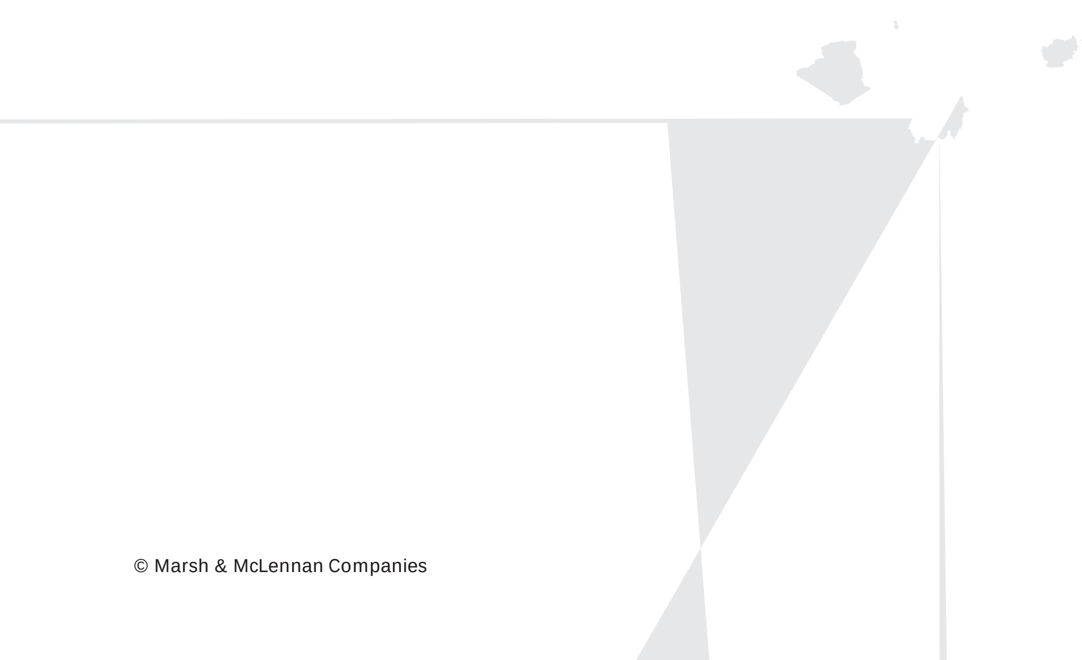


Exhibit 4. Selected physical climate risk impacts on core infrastructure sectors[1]

	Chronic risks		Acute risks		
	Sea level rise	Temperature rise	Drought**/Heatwave	Storm/Flood	Wildfire
Energy					
Telecoms					

Widespread portfolio impacts. Understanding the

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

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.

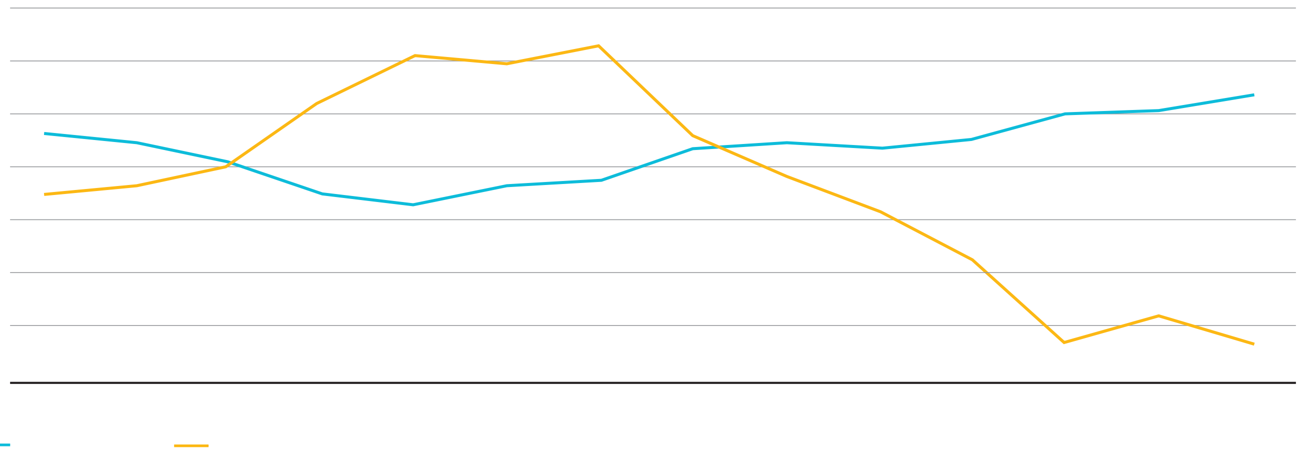
The pressure to minimize emissions and maximize resource efficiency will take shape through the interplay of a range of transition risks. Infrastructure investors will need to prepare for the complex, multidimensional risks these dynamics can produce in the long term, including far-reaching policy shocks,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

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 di f erent 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 f nancial 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- è = d ^

Investing in the Low-Carbon Transition After COVID-19

Government commitments internationally and locally are also likely to continue to drive policy and regulation in favor of the tra7to drive pol-60.2 (D)-921‹Lan (t)820I[c9.9 (a7to drivn‹La

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

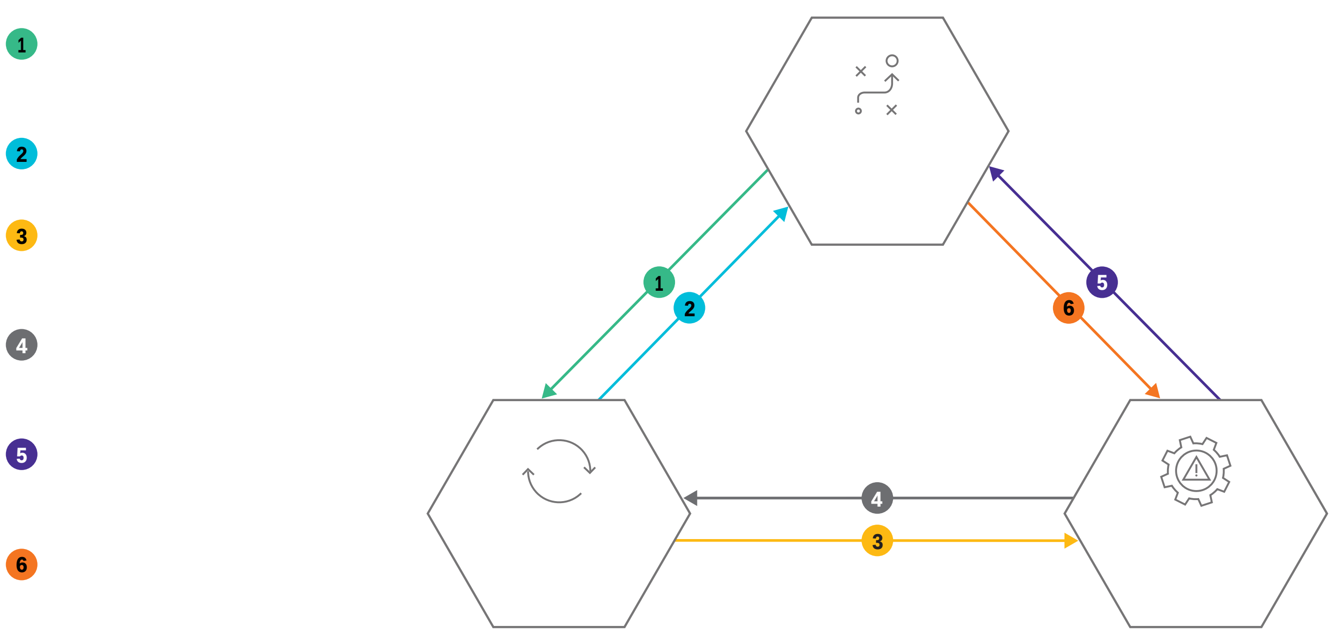
A FOUNDATION FOR RESILIENCE

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



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.

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

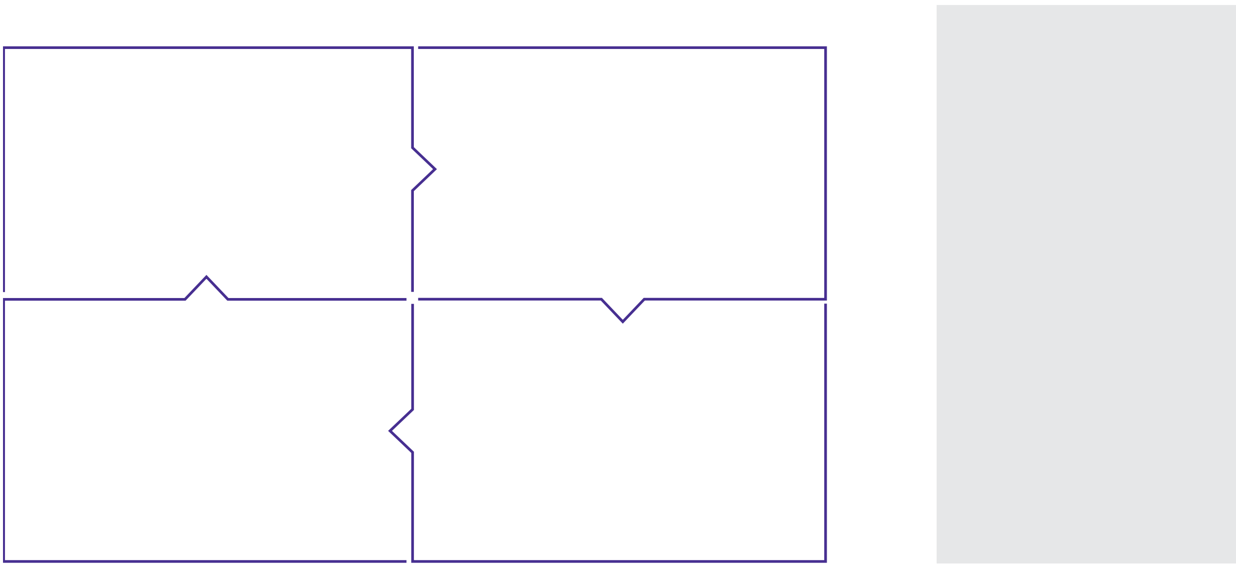
CO_2 emission trajectory for various temperature scenarios

$GTCO_2e$/year

Event-based scenarios

Carbon pricing	Transition (policy)	Carbon price	Fossil fuel energy production
			Renewable energy production
Drought	Physical	Duration and severity of reduced precipitation	Utilities

Exhibit 10. Representative scenario-based systematic model structure



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).

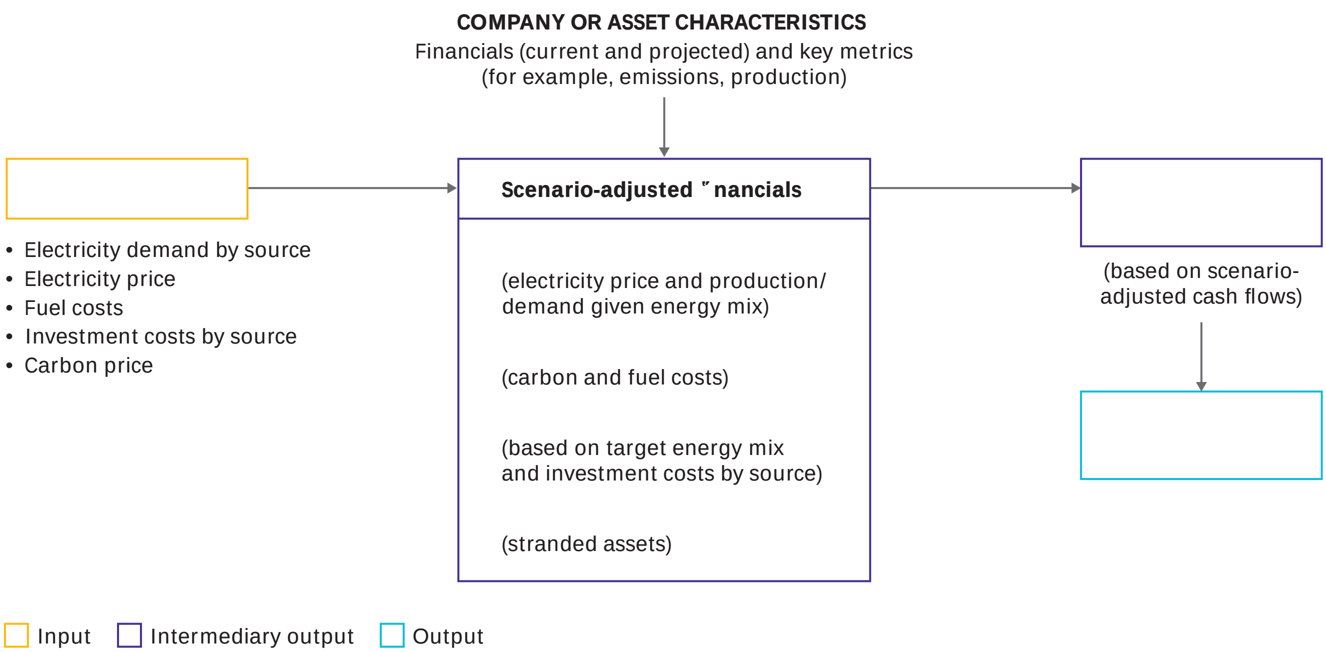
Scenario models (discussed under "Identify and select appropriate scenarios") provide variables that are relevant for a given sector's performance. For example, regional carbon prices, electricity demand, fuel costs, and investment costs are important drivers of unregulated power generation utilities. 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

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 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.

of early climate resilience beyond the private bene f ts to the asset, which include minimized business disruption, community safety, or job creation.) By ensuring that a long-term and multidimensional approach to cost-bene f t 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 di f erent genres of climate risks across a variety of stakeholders.

Two key clauses for addressing discrete and high-impact ("one-o f ") 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 de f ned 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 de f nitions 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 f xed 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 adjust46005200550053005

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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

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

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 a f ect 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 f rms to invest in hard physical risk resilience measures. Collaborating with private and public-sector infrastructure f rms facing similar physical climate risks can enable investment in much-needed multi-asset protective measures such as f ood 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 f ooding, 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 naturall@orce s ᴬ ng ╥hynaoenab╥orpr Ư

CONCLUSION

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