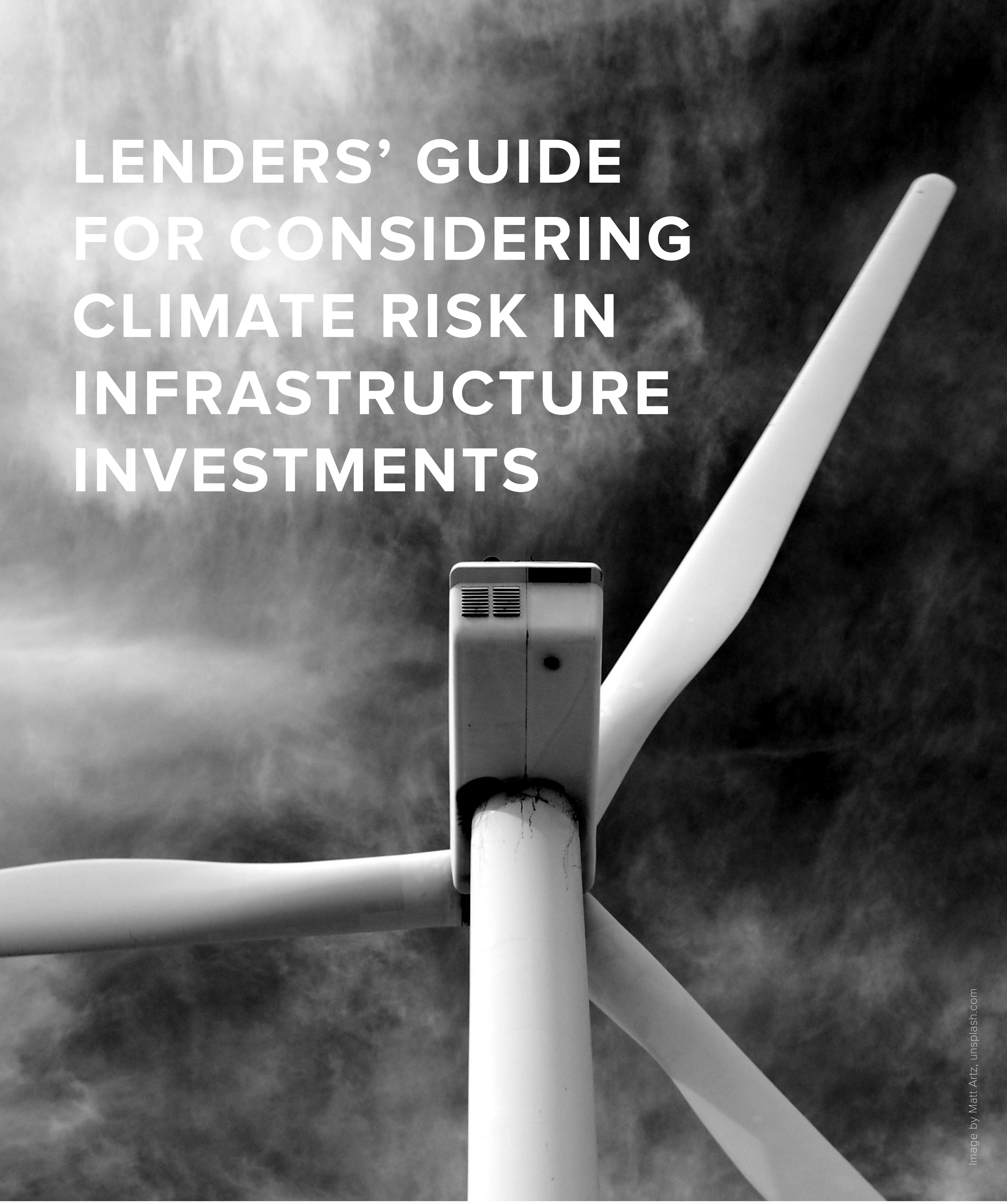
LENDERS' GUIDE FOR CONSIDERING CLIMATE RISK IN INFRASTRUCTURE INVESTMENTS



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ACKNOWLEDGEMENTS

This Guide is the result of a collaborative effort between Acclimatise, Climate Finance Advisors, and Four Twenty Seven and would not have been possible without contributions from the staff who helped to frame, research, draft, and design the document. They include:

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- Climate Finance Advisors – Yan Fan, Lori Kerr, Stacy Swann, Brandon Yeh
- Four Twenty Seven – Alejandra Calzada, Yoon Kim, Emilie Mazzacurati, Kendall Starkman.

We would like to extend our gratitude to Jay Koh and the Global Adaptation and Resilience Investment ("GARI") Working Group, which has provided a critical forum for discussing the needs of and opportunities for investors and lenders in the adaptation and resilience space and which seeded the idea for this Guide. We would also like to thank the numerous participants of the GARI group who have talked through these issues with us in-depth, and have provided specific guidance on this lender Guide. Further, we would like to thank early reviewers of this draft for detailed input and feedback, which was invaluable for refining the content better to meet the needs of infrastructure lenders, in particular: Joseph Chu, Lori Collins, and Vladimir Stenek.

INTRODUCTORY NOTE

This short Guide emerged from ongoing discussions among participants of GARI during 2017. GARI is a private sector, private investor-led initiative that was announced at Paris COP 21 in 2015. It is a partner of the UN Secretary General's A2R Climate Resilience Initiative. The working group has brought together over 150 private and public investors, bankers, leaders, and other stakeholders to discuss critical issues at the intersection of climate adaptation and resilience and investment with the objective of helping to assess, mobilize, and catalyze action and investment. GARI has convened more than eight times during 2016 and 2017, and has underscored the continuous interest of the private sector and specifically, private investors, in investment and climate adaptation and resilience.

This Guide is meant to respond to questions that have emerged in various fora – including within the GARI meetings – specifically from banking institutions and infrastructure investors. Many of these questions build off work by the Task Force on Climate-related Financial Disclosures (TCFD) and related efforts to understand and consider enhanced disclosure requirements. Such discussions within the GARI and elsewhere have highlighted the need to break down in a clear, tangible manner the ways in which physical climate risks might affect key financial aspects of prospective infrastructure investments that credit officers and investment decision-makers within a bank consider. This Guide is meant to be responsive to and provide a framework for questions about how to link revenues, assets, and costs with potential project vulnerability because of physical climate risks. Enhancing understanding of these risks is a necessary step for banks better to understand and manage these risks in their pipeline of investments, and may also provide important insights for managing such risks in their portfolio.

This Guide includes ten "snapshots" of infrastructure sub-sectors provided to illustrate how investment and credit officers might think about weather and climate-related risks and opportunities when appraising a new project or corporate loan, when evaluating an equity investment in infrastructure, and/or when managing a portfolio of infrastructure investments. These snapshots are not exhaustive and do not present all the ways climate risks may arise for an infrastructure project. Rather they are meant to be illustrative only, and to provide an approach for the lender/credit officer to think about how climate risk may manifest in key financial drivers of projects, which may in turn impact their investment.

We hope you find this Lender Guide useful, and would welcome any feedback, comments or additional information which can improve future publications. Please feel free to reach out to us at the following:

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ACCLIMATISE

Acclimatise Group Ltd (www.acclimatise.uk.com) is a world leader in best practice climate change risk assessment and adaptation. A specialist advisory and analytics company, Acclimatise advises public and private sector clients in over 70 countries on how to make policies, projects, investment portfolios and assets resilient to climate change risks and uncertainties today and over time. The company has an extensive project portfolio on climate vulnerability and risk assessments; policy, strategy and action plan development; the design of bankable projects; identification of sources of finance; the development of tools and risk management frameworks, and development and implementation of learning programs.

The company has undertaken numerous projects for development banks and the financial services sector including commercial banks, asset managers and owners and insurers. Acclimatise is currently working on other projects delivering guidance to corporates on implementing the recommendations of the Financial Stability Board's (FSB) Task Force on Climate-Related Financial Disclosures (TCFD), for the European Bank for Reconstruction and Development, the Global Centre of Excellence on Climate Adaptation and the United Nations Environment Programme – Finance Initiative (UNEP FI). Acclimatise was founded in 2004 and is registered in England and Wales with offices in the UK, USA, Barbados and India.

CLIMATE FINANCE ADVISORS

Climate Finance Advisors (CFA) (www.climatefinanceadvisors.com) is a consulting and advisory firm based in Washington, DC with extensive experience in development, finance, sustainability, and climate change. CFA's mission is to facilitate the acceleration of sustainable, climate-smart investments and to encourage the integration of climate considerations into investment decision-making and underlying investments. The CFA team is comprised of bankers and finance professionals with more than 75 years' collective expertise working at the intersection of finance, climate change, infrastructure and project development. The CFA Team has a deep understanding of the financial implications of climate risk for investments, and understands how risks are integrated into the investment decision making process. CFA works with private developers and investors, development finance institutions and governments, as well as non-profit organizations. The firm's work spans the public, private, multilateral, and non-profit sectors. CFA advises clients in three main areas: 1) project structuring, climate finance and blended finance, 2) national and local climate change strategy development, including and specifically how to mobilize finance for those strategies, and 3) helping clients understand and address climate risks as they relate to financing, investments, and returns, and providing strategies for mitigating those risks. The firm is a Benefit LLC with the explicit purpose of creating material positive impact for society and the environment, and is a women-owned business.

FOUR TWENTY SEVEN

Four Twenty Seven (www.427mt.com) is an award-winning market intelligence and research firm specialized in the economic risks of climate change. Four Twenty Seven's data analytics solutions bring climate intelligence to economic and financial decision-makers. Four Twenty Seven provides financial portfolio climate risk assessments, development of climate resilience strategies, quantification of metrics and indices for benchmarking, monitoring and evaluation, and training and stakeholder engagement to financial institutions, Fortune 500 corporations, and governments worldwide. The company was founded in 2012 and is headquartered in Berkeley, California with offices in Washington, DC and Paris, France.

This short Guide provides an introduction to weather- and climate-related risks and opportunities for loan and credit officers assessing potential lending for infrastructure. The goals are to enhance understanding of these risks so as to structure lending that maximizes performance and minimizes risks. This Guide is complemented by "snapshots" of ten infrastructure sub-sectors: airports, marine ports, gas and oil transport and storage, power transmission and distribution, wind-based power generation, data centers, telecommunications, commercial real estate, healthcare, and sports and entertainment. These snapshots illustrate how loan and credit officers might think about weather- and climate-related risks and opportunities when appraising new projects or corporate loans to companies in these sectors, when evaluating equity investments in infrastructure, or when managing infrastructure portfolios.

Weather- and climate-related risks and opportunities are emerging aspects that are important to understand, identify, and assess. How these risks and opportunities manifest for prospective and existing clients over the short-, medium-, and long-term, including their impact on key financial parameters, such as revenues, expenditures, assets, capital, and financing, can affect the overall credit quality of borrowers, which can affect structuring decisions, loan pricing, and returns.

WEATHER AND CLIMATE-RELATED RISKS AND OPPORTUNITIES: WHAT ARE THEY? WHY DO THEY MATTER FOR INFRASTRUCTURE LENDING?

Is climate change all risk and no opportunity? Climate-related risks may be more far-reaching than the physical impacts of specific weather events or even gradual changes in weather patterns. Indeed, the Taskforce on Climate-related Financial Disclosures (TCFD) characterizes climate-related risks across *physical risks* and *transition risks.*[1] **Physical climate risks are the focus of this brief Guide and are discussed below.**[2] However, climate change may also present opportunities in terms of intensifying resource efficiency, diversifying energy sources, enhancing resiliency, as well as development of new products, technologies and services, and opening of new markets, which all play into the financial durability, as well as the development of new products, technologies and services, and opening of new markets. All these factors contribute to the financial durability -as well as environmental sustainability- of infrastructure assets.

Extreme weather events and climate change pose both acute & chronic physical risks to infrastructure. Understanding both types of risk is important for infrastructure lending. For example, increased frequency and severity of extreme weather events may temporarily disrupt infrastructure service delivery more often, resulting in lower revenues and increased expenses. In the worst cases, increased intensity of extreme weather events may cause damage that results in catastrophic failures and reduces the lifespan of infrastructure assets. Less immediately perceptible, but equally important, are the impacts caused by gradual climatic shifts, such as increasing temperatures or changing precipitation patterns. For example, reduced river flow negatively

WHAT IS THE DIFFERENCE BETWEEN WEATHER AND CLIMATE?

Weather is the state of the atmosphere at a particular location over the short-term, while climate is the average of the weather conditions in a given location over a longer period of time, usually 30 years or more. In other words, climate is what one expects, and weather is what one gets.

Source: U.S. National Oceanic and Atmospheric Administration (NOAA) National Ocean Service

WHAT IS THE DIFFERENCE BETWEEN ACUTE AND CHRONIC PHYSICAL RISKS?

The TCFD defines acute physical risks as those that are event-driven, including increased severity of extreme weather events, such as cyclones, hurricanes, or floods. Chronic physical risks refer to longer-term shifts in climate patterns, such as changes in precipitation patterns and sustained higher temperatures, that may cause sea-level rise or chronic heat waves.

Source: Taskforce on Climate-related Financial Disclosures (TCFD)

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[1] Task Force on Climate-related Financial Disclosures (TCFD) website. (2017). Recommendations of the Task Force on Climate-related Financial Disclosures. [online] Available at: https://www.fsb-tcfd.org/publications/final-recommendations-report/ [Accessed 8 Dec. 2017].

[2] Transition risks—related to possible changes in policy and legal frameworks, evolving customer preferences and behaviors, as well as potential technology advances and substitution effects, among others—may also affect key financial parameters and ultimate credit quality of borrowers and investees. Although beyond the scope of the present Guide, transition risks also merit attention when considering investing in new infrastructure assets and for managing a portfolio of infrastructure investments.

impacts the operability of hydropower facilities. Some impacts, such as temperature, have the potential to manifest in both acute (heat waves) and chronic (average increases over time) ways.

On the negative side, these risks can lead to reduced operational and economic performance over time (reduced water availability for cooling power plants or data centers, for example) and increased operating costs. On the positive side, gradual climatic shifts may present opportunities through new markets. For example, progressively higher temperatures may make some existing or new tourist destinations served by transportation and sports and recreational infrastructure more attractive, offering increased revenue potential. In addition to new markets, there are significant opportunities in making infrastructure more resilient to physical climate impacts. For example, replacing copper wire telecommunications networks with fiber-optic cables, which are waterproof, can save operating costs by reducing network faults and repair costs and can improve network reliability. Moreover, minimizing resource intensity through, for example, replacing water cooling systems with technologies that reduce water use, can reduce electricity bills and cut emissions. (As temperatures rise, increasing the demand for cooling, water scarcity may also increase.) Diversifying energy sources and incorporating new technologies, such as low-carbon energy generation or distributed energy storage, may also offer opportunities for infrastructure investment now and in the future.

Weather and climate change are already having financial impacts on infrastructure. Climate change affects infrastructure in several ways. In the United States for example, hurricane damage in 2017 to infrastructure in key economic centers, such as Houston, Texas,[3] exceeded tens of billions of dollars (USD), not to mention losses to revenues and increased operating costs due to recovery efforts. In fact, 2017 was the most costly weather disaster year in the United States, with an estimated US $306 billion. Much of these costs result from impacts on critical infrastructure, including airports, energy, and real estate. Over the last decade alone, Texas has had 32 storms with economic losses exceeding US$1 billion—four times more than experienced during the decade of the 1990s.[4] Data from NOAA show that the frequency of extreme weather events globally causing US$1 billion or more in losses has risen sharply over the past decade, posing risks particularly to infrastructure on the coasts and in other geographically vulnerable areas.[5] In the Philippines, which faces recurring flooding during the typhoon season between June and October,[6] the past decade has seen several extreme weather events. Damages from each of these disasters have ranged from US$2.5 million to US$1 billion.[7] In the case of the 2009 tropical storm that hit Manila, damages were equivalent to 2.7% of the country's GDP or about US$4 billion.[8] Scientists warn that extreme weather events may become more frequent and intense as the planet warms. These risks warrant attention when considering loans for new infrastructure assets and managing a portfolio of infrastructure investments.

In terms of lending for new infrastructure—and for existing infrastructure—a lot of value is potentially at risk. From 2015 to 2030, global demand for new infrastructure could amount to more than US$90 trillion, according to the New Climate Economy report–a value greater than the world's existing infrastructure stock of US$50 trillion.[9] Even without considering climate-related risks, a range of barriers must be addressed to increase the quantity of new infrastructure, as well as improve the quality of both existing and new infrastructure globally.

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[3] AON Benefield. (2017). Global Catastrophe Recap – October 2017. [online] Available at: http://thoughtleadership.aonbenfield.com/sitepages/display.aspx?tl=724 [Accessed 8 Dec. 2017].

[4] Watson, R., McCarthy, J.S. and Hisas, L. (2017). The Economic Case for Climate Action in the United States. Universal Ecological Fund (FEU-US). [online] Available at: https://feu-us.org/case-for-climate-action-us2/[Accessed 8 Dec. 2017].

[5] BlackRock Investment Institute. (2016). Adapting portfolios to climate change: Implications and strategies for all investors. [online] Available at: https://www.blackrock.com/investing/literature/whitepaper/bii-climate-change-2016-us.pdf [Accessed 8 Dec. 2017].

[6] Wingard, J. and Brandlin, AS. (2013). Philippines: A country prone to natural disasters. Deutsche Welle. [online] Available at: http://www.dw.com/en/philippines-acountry-prone-to-natural-disasters/a-17217404 [Accessed 8 Dec. 2017].

[7] Wingard, J. and Brandlin, AS. (2013).

[8] The World Bank. (2012). Philippines: Integrating Flood Risk Management into Local Planning Saves People's Lives. [Press release]. [online] Available at: http://www.worldbank.org/en/news/press-release/2012/02/13/integrating-flood-risk-management-into-local-planning-saves-peoples-lives [Accessed 8 Dec. 2017].

[9] Global Commission on The Economy and Climate. (2014). Better Growth, Better Climate: The New Climate Economy Report. [online] Available at: http://newclimateeconomy.report/2014/wpcontent/uploads/sites/2/2014/08/NCE-Global-Report_web.pdf [Accessed 8 Dec. 2017].

Traditional tools to help banks assess credit risks—such as industry benchmarks on performance—may be only marginally useful for helping assess physical climate-related risks to an individual infrastructure projects, as climate risk manifests differently in different locations. Thus, generalized approaches to understanding performance may underestimate or overestimate the sensitivity of a particular asset to physical climate-related risks.

Changes in weather and climate may impact infrastructure design thresholds for safe and efficient operation. Design thresholds, which traditionally have been developed according to historical environmental conditions, vary and may be set by physical limitations, regulation, contract, or social acceptance. They may include, for example, specific flood risk standards, water requirements for cooling, or temperature ranges for efficient operation. Threshold failures that currently are considered exceptional but acceptable may become normal and unacceptable, such as tides overtopping a sea wall or thawing permafrost destabilizing buildings and roads in northern latitudes. This may lead to reduced asset life expectancy, higher operating costs, increased capital expenditures, and loss of revenues. At the same time, there is tremendous opportunity to incorporate climate risk into the design and construction of the estimated US$90 trillion worth of infrastructure yet to be built worldwide.[10]

TRANSLATING PHYSICAL CLIMATE-RELATED RISKS AND OPPORTUNITIES INTO FINANCIAL IMPACTS

As touched upon in various examples above, physical climate-related risks and opportunities may have numerous financial impacts on infrastructure with regard to revenues, expenditures, assets, capital, and financing. While one such risk may not be the sole driver of financial vulnerability, climate-related impacts may affect the financial viability of projects over loan tenors and may weaken the case for new lending in the future. The final section of this Guide includes a series of ten infrastructure sub-sector "snapshots" that illustrate with more concrete examples potential impacts of physical climate-related risks and opportunities on the following key financial parameters:

REVENUES

The income derived from normal business activities can be affected by climate-related operational disruptions. These may result from acute incidents - such as extreme weather; or these may be from climate-related changes which are chronic - such as an increased number of extreme heat days per year. For example, high temperatures on an aiport's tarmac can affect aerodynamic performance which may require airlines to limit passenger and cargo weight. That can result in operational disruption and revenue loss. For power generation facilities, revenue may increase or decrease due to temperature variability since demand for electricity for heating and cooling is highly correlated with temperature. Consideration of both acute and chronic climate risks on supply chains, especially for goods and services inputs during operations, may also impact revenues.

COSTS/EXPENDITURES

Restoring infrastructure to operating condition following damage from extreme weather events may increase unplanned maintenance expenditures. For example, downed power lines or flooded port patios may not only disrupt revenue generation; expenses to re-establish operations can also mount. In addition, adapting infrastructure assets to climate change may require unplanned operational and capital expenditures. For instance, power supply may be disrupted due to increased energy demand during heat waves or extreme weather events. These disruptions can increase operational expenditure for backup power generation, such as batteries or diesel. For ports, reinforcing breakwaters and elevating patios to adapt to climate change may increase capital expenditure budgets. Moreover, across different types of infrastructure, climate change risks may result in a greater need for and higher costs of insurance. For high-risk infrastructure (due to location or design), rising

[10] Global Commission on The Economy and Climate. (2016). The Sustainable Infrastructure Imperative: Financing for Better Growth and Development. [online] Available at: http://newclimateeconomy.report/2016/wp-content/uploads/sites/4/2016/08/NCE_2016_Exec_summary.pdf. [Accessed 8 Dec. 2017].

insurance premiums, as well as stricter exclusionary clauses, may make it increasingly difficult to obtain insurance at reasonable rates. Greater risk of interruptions may require additional insurance or increase the cost of maintaining existing levels of insurance.

ASSETS

Physical climate-related impacts may also affect tangible and intangible assets. Extreme weather events or temperature variability causing disruption to operations, service performance, and delivery of infrastructure may lead to a decrease in overall asset value, especially on land and leasing contracts. Furthermore, asset damage from extreme weather events may not only increase infrastructure maintenance costs, but also could result in shortened asset life and increased depreciation rates, thus negatively affecting asset value. In terms of impacts on intangible assets, extreme weather events leading to disruption of telecommunications service, for example, may undermine the brand and reputation of operators who cannot provide customers with uninterrupted service, while those providers that manage to maintain service could gain brand and reputational advantage.

LIABILITIES

Impacts related to physical climate risks may affect current and contingent liabilities. Extreme events may lead to higher costs due to expenses associated with repair and recovery and increased insurance fees, as well as lower revenues due to operations disruptions, leading to unexpected contingency costs. The evolution of regulations, technologies, and markets to better account for the impacts of physical climate risks may increase revenues, capital expenses, and the costs of supplies, materials, and production, with implications for current liabilities. As laws, regulations, and case law related to a company's preparedness for climate change evolves, the incident or probability of contingent liabilities arising may increase. Companies failing to make decisions on the best available information are likely to be vulnerable. Non-compliance with environmental regulations can also result in different forms of liability (contractual, civil, or penal) for the project owner, which may adversely affect cash flow (due to costs incurred), income (due to decreased sales), or market capitalization (due to loss of reputation).

CAPITAL AND FINANCING

Long-term debt and equity capital may also be affected by physical climate-related risks. As capital and operational expenditures increase to respond to weather events and adapt to climate change, this may require an increase in debt, given lower cash-flow resulting from higher expenses. At the same time, the ability to raise debt, refinance debt, or attain adequate tenors may be affected by these operational realities. In the case of equity investments, lower cash-flow impacts on valuation may decrease the attractiveness of the asset in raising capital. Profitability ratios estimating future return on equity may decline if decreases in interim payments received (dividends) and the company's long-term market value are attributable, in part, to enduring climate change-related impacts. For example, an airport experiencing lower traffic and thus lower revenues, as well as higher operational expenses due to severe weather, may see its debt and ability to raise capital adversely affected.

Certain types of infrastructure lending is more at risk from weather and climate change. Some types of infrastructure assets are more likely to be affected by physical impacts of weather and climate change, such as:

Investments and assets in weather- and climate sensitive locations: Some infrastructure assets are at greater risk given their locations. Assets located in low-lying coastal areas will, for instance, be increasingly exposed to and affected by sea-level rise. Similarly, for infrastructure in sectors where activity is strongly weather-dependent, increased intensity and occurrence of extreme weather events will have substantial impacts. For example, coastal ports are at risk from sea-level rise and storm surges. Airports are particularly sensitive, given that temperatures, storms, and flooding are likely to affect air traffic and cause operational disruptions.

Already stressed assets that are currently in weather- and climate-sensitive locations: Although weather and physical climate-related impacts alone may not have a decisive financial impact on a particular infrastructure asset, extreme weather events and a changing climate may add stress factors or compound other problems, especially for infrastructure assets that are already facing difficulties. Examples of how this may manifest include locations where climate-related risks impact tourism and thus infrastructure, such as transportation and energy, that serve tourist destinations.

Investments that rely on the long-lived nature of infrastructure assets: Infrastructure is characterized by fixed assets with significant lifespans. For example, water and transportation infrastructure have a useful life of 30-200 years, while power plants have lifespans of 20-60 years. This long-term nature exposes these assets to changing climate conditions over future decades, such as sea-level rise, shifts in temperature, and alterations in precipitation patterns. Investment time horizons for both debt and equity are typically shorter, usually less than 10 years (although they can be longer under certain types of project financing), than the useful life of an infrastructure asset. Nonetheless, it is important to consider longer time horizons when planning investments in infrastructure in order to consider and manage physical climate-related risks that may arise during the asset's lifespan. This is relevant for lenders that may want to pursue securitization or other financing approaches for mature loan portfolios, as climate risks may accumulate within infrastructure portfolios, as well as for equity holders planning exit strategies.

MANAGING PHYSICAL CLIMATE-RELATED RISKS

Identifying risks–including physical climate-related risks–is a critical part of the risk management process and is the focus of this Guide and the sub-sector snapshots. However, there are several important next steps, including:

- Assessing and quantifying the potential impacts of physical climate-related risks through sensitivity and scenario analyses to determine materiality and support the design of appropriate risk mitigation strategies. The use of data and tools to assess physical climate-related risks on specific assets in specific geographies is key to a comprehensive understanding of asset vulnerability and of the potential effects on revenues, expenditures, assets, capital, and financing.

- Minimizing or structuring around physical climate-related risks through structuring levers, including:

  Physical strategies: These may include design adjustments that enable infrastructure assets to be more resilient to increasingly frequent and severe weather events and/or built-in enhancements that adapt infrastructure assets to longer-term physical climate-related changes.

  Financial strategies: These may include higher debt service coverage ratios, larger debt service reserve accounts and maintenance reserves, lower leverage, shorter tenors, or higher pricing in the face of greater cash-flow variability from physical climate-related risks on revenues and costs. Insurance requirements also may be expanded to include different or higher coverage of physical climate-related risks.

SUB-SECTOR SNAPSHOTS: CLIMATE RISKS AND OPPORTUNITIES

The following section includes ten “snapshots” of infrastructure sub-sectors as examples of how loan and credit officers might think about physical climate-related risks when appraising a new project or corporate loan or when evaluating an equity investment. The sectors covered are transport, energy, telecommunications, data centers, real estate, and social infrastructure:

TRANSPORT-AIRPORTS

TRANSPORT-MARINE PORTS

ENERGY-GAS AND OIL TRANSPORT AND STORAGE

ENERGY-POWER TRANSMISSION AND DISTRIBUTION

ENERGY-WIND-BASED POWER GENERATION

TELECOMMUNICATIONS

DATA CENTERS

REAL ESTATE-COMMERCIAL REAL ESTATE

SOCIAL INFRASTRUCTURE-HEALTHCARE

SOCIAL INFRASTRUCTURE-SPORT AND ENTERTAINMENT

Each snapshot includes:

- A general description of what the sub-sector includes;
- Estimates of sub-sector potential globally, and in some cases by region;
- Summaries of potential financial impacts for revenues, costs, and assets; and
- Examples of observed financial impacts on specific assets from weather and physical climate risks or projections of how these risks will affect sector-specific assets.

Six climate-related hazards that may have operational and financial impacts on infrastructure are considered in the snapshots:

Temperature	**Sea-level Rise**
Precipitation & Flood	**Storms**
Drought	**Water Stress**

SECTORAL SNAPSHOTS

AIRPORTS

Airports are a sub-sector of the Transportation sector. This sub-sector includes:

- **Airport facilities:** infrastructure where the vehicles (airplanes) receive maintenance, restock, refuel, and load and unload crew, cargo, and passengers;
- **Airside infrastructure:** facilities associated with the movement of aircraft, including airfield, runways, taxiways, gates, air bridges, etc.;
- **Landside infrastructure:** facilities associated with the movement of passengers and baggage/cargo to and from aircraft, including terminals, airport car parking facilities, check-in and baggage claim/cargo facilities, airport connections, retail services, etc.;[13] and security and safety infrastructure, including facilities associated with the provision of police, security, customs, immigration, fire and rescue services.[14]

INVESTMENT POTENTIAL[11,12]:

Global project pipelines
US$721.7 billion (May 2017)

Estimated average global annual CAPEX:
US$120 billion (2015-2030)

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**Revenues to airports (airport facilities, airside infrastructure, landside infrastructure) can be impacted when weather and climate-related hazards occur. The following are examples of how these hazards might impact revenues:**
		Temperature (Acute): Extreme heat makes the air above runway tarmacs become less dense, which can impact the aerodynamic performance of airplanes and/or weight of passenger/cargo carried loads. Extreme temperatures can compromise the integrity of asphalt and may cause buckling and/or rutting, rendering runways and access roads impassable, which can disrupt airport operations and negatively impact revenues. Temporary impacts to aeronautical revenues (e.g., terminal rents, landing fees, passenger fees, fees for gate allocation, boarding bridges) could be experienced due to airline traffic disruptions.
		Temperature (Chronic): An increased number of extreme-heat days may lead to chronic heat-related disruptions if airport infrastructure is not designed to enable uninterrupted air traffic (e.g., investments in longer runways may mitigate incidents of heat-related disruptions, but costly (see below)). In addition to aeronautical revenue impacts, over time non-aeronautical revenues (e.g., rents and fees (and/or profit sharing) paid by gift shops, restaurants, rental car operations; fees for parking and airport access; land rents for hotels, office buildings) may also be impacted. Increasing temperatures may decrease the need for aircraft de-icing services thus decreasing associated revenue from de-icing services.
		Storms (Acute): Airport facilities and fixed infrastructure may be damaged by excessive precipitation and/or flooding during acute precipitation events impacting availability of infrastructure. Revenues may be temporarily affected until normal airport operations resume. Airports are also vulnerable to disruptions to water, electricity and fuel supplies that may affect the ability of airports to offer services.
		Precipitation & Flood (Chronic): In some locations, nuisance flooding – temporary inundation of low-lying areas during exceptionally high tide events or floods that result from storm surges – may cause chronic disruption to airport facilities and infrastructure thus affecting their availability and revenue generation.

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**Additional costs may be incurred for airport infrastructure (facilities, airside infrastructure, landside infrastructure) because of weather and climate-related hazards. These include, for example, increased energy and water costs, increased costs to address physical damages/recovery expenses, costs related to higher insurance premiums to protect against loss and damage, and/or penalties for violating concession operating standards along with increased capital expenditures to adapt to climate change. The following are examples of how these hazards might impact costs:** **Temperature (Acute):** Increases in operating expenditures to address occurrences of extreme temperature (e.g., extended operating hours during cooler late-night hours potentially resulting in curfew penalties, overtime paid, increased energy and water costs, runway asphalt repair) **Temperature (Chronic):** An increased number of extreme-heat days per year may impact overall cost and budgeting components of airport infrastructure (e.g., building-out/reconfiguring space for larger waiting areas for delayed passengers, extending runways, higher frequency of runway asphalt maintenance, greater cooling needs). Increasing temperatures may decrease the need for aircraft de-icing services thus decreasing incurred expenses. **Precipitation & Flood (Chronic):** Contingency and recovery costs may increase and/or become more frequent (e.g., costs of runway maintenance, frequency of runway resurfacing, equipment costs for pumping/clearing water, drainage system upgrades) and penalties may be payable if operating standards under concession are violated (if not a relief or force majeure event).
ASSETS		**Asset values of airport infrastructure (facilities, airside infrastructure, landside infrastructure) may be impacted by ongoing weather and climate-related hazards, particularly those that (i) wear on asset performance or (ii) require additional (possibly unplanned) investment. The following are examples of how weather and climate-related hazards might impact the asset value of airport infrastructure.** **Tangible (fixed assets, e.g., buildings, infrastructure):** Frequent disruption and damage to an airport could lead to a decrease in value of an airport's tangible assets (e.g., airside and landside infrastructure under operation). Conversely, airports with enhanced infrastructure adapted to climate change and that mitigates weather impacts (e.g., longer runways, better drainage systems, mitigation plans) may realise increased tangible asset value/valuation. **Intangible (e.g., goodwill, brand):** Frequent climate-related disruption of operations may affect an airport's brand and reputation, as well as service ratings by consumers and airlines.

EXAMPLES

Storms' impact on Gatwick Airport, London, UK

In 2013, multiple storms caused damage to electrical systems supplying the UK's Gatwick's North Terminal, resulting in the cancellation of 72 departing and 73 arriving flights. Impacts included:

- £250,000 in direct costs to Gatwick Airport as a result of disruption
- £3m in welfare costs to 16,000 Gatwick passengers affected by flight cancellation[15]

Flooding resulting from Sandy at LaGuardia Airport, New York, USA

Flooding from Superstorm Sandy inundated LaGuardia Airport, which is located on the banks of Flushing Bay in a low-lying area prone to minor flooding even during modest storms.[16] Impacts on the airport included:

- Decreased airport revenues with 893 flights cancelations and airport closure for seven days
- Significant costs for clean-up

Extreme heat disrupting traffic at Sky Harbor International Airport, Phoenix, USA

Temperatures reached 120°F for several days, causing disruptions to flights in and out of the airport. For example, certain planes in American Airlines' fleet were unable to take-off under extreme temperatures, as hotter, less-dense air prevents generation of adequate lift.[17] Impacts on the airport included:

- Decreased airport revenues
- Additional costs to operate airport facilities

[11] Organisation for Economic Co-operation and Development (OECD). (2012). Strategic Transport Infrastructure Needs to 2030. [online] Available at: http://espas.eu/orbis/sites/default/files/generated/document/en/strategic-transport-infrastructure-needs-to-2030.pdf [Accessed 8 Dec. 2017].

[12] Timetric's Construction Intelligence Center. (2017a). Project Insight - Airport Generation Construction Projects: Global. [online] Available at: https://www.construction-ic.com/pressrelease/ high-levels-of-investment-in-airport-construction-projects-in-the-us-and-china-5811160 [Accessed 8 Dec. 2017].

[13] Statistical Office of the European Union (Eurostat). (2017). Air transport infrastructure, transport equipment, enterprises, employment and accidents. Reference Metadata in Euro SDMX Metadata Structure. [online] Available at: http://ec.europa.eu/eurostat/cache/metadata/en/avia_if_esms.htm [Accessed 8 Dec. 2017]

[14] The World Bank. (2005). Air Transport Infrastructure: The Roles of the Public and Private Sectors. [online] Available at: http://pubdocs.worldbank.org en/317661434652909047/Air-Transport-infrastructure.pdf [Accessed 8 Dec. 2017].

[15] Hill, E. (2016). Flood Protection Options for Airports. Floodlist. [online] Available at: http://floodlist.com/protection/flood-protection-options-airports [Accessed 8 Dec. 2017].

[16] Freedman, A. (2013). U.S. Airports Face Increasing Threat from Rising Seas. Climate Central. [online] Available at: http://www.climatecentral.org/news/coastal-us-airports-faceincreasing-threat-from-sea-level-rise-16126 [Accessed 8 Dec. 2017].

[17] Hedding, J. (2017). Planes at Phoenix Sky Harbor Airport Grounded When It Gets Too Hot. Trip Savvy. [online] Available at: https://www.tripsavvy.com/planes-at-phoenix-sky-harborairport-2682513 [Accessed 8 Dec. 2017].

SECTORAL SNAPSHOTS

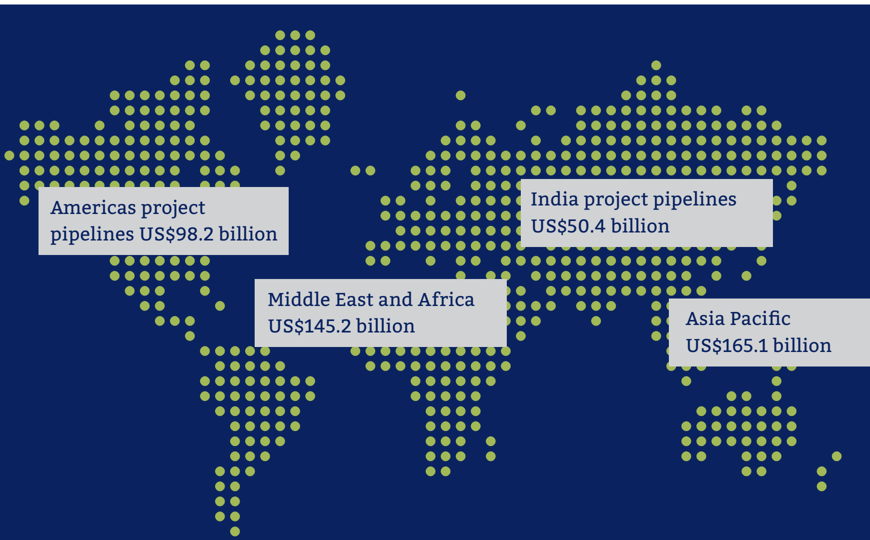
MARINE PORTS

Marine ports are a sub-sector of the Transportation Sector. This sub-sector includes:

- **Marine ports:** facilities located on a coast or shore that contain harbors where ships can dock and transfer people and cargo. Infrastructure usually includes piers, basins, stacking or storage areas, warehouses, and equipment such as cranes, all of which involve high levels of capital investment.[20]
- The main tool for global port operators to finance the construction and operation of port terminals has been through concession agreements, where commercial banks are often involved as creditors. Depending on the scale and location, ports are categorised as a **deep-water seaport, river port, harbour, pier/jetty/wharf, off-shore terminal, and port terminals.**[21]

INVESTMENT POTENTIAL[18,19]:

Global project pipelines: US$459 billion (May 2017)



CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**Revenues to marine ports can be impacted when weather and climate-related hazards occur. The following are examples of how these hazards might impact revenues:** **Temperature (Acute):** Extreme temperature events can cause disruptions to marine shipping and/or marine passenger traffic from which port revenues are derived. Extreme temperatures can compromise the integrity of asphalt and may cause buckling and/or rutting, rendering access roads impassable and affecting movement within the port complex, which can disrupt port operations and negatively impact revenues. **Temperature (Chronic):** Gradual temperature increases may melt ice along shipping routes, thus extending shipping/cruise ship seasons and/or eventually opening new routes, which may increase traffic and provide revenue opportunities for ports in certain locations. Gradual warming temperatures may impact agricultural production and trade flows, affecting port traffic to/from certain locations and thus port revenues. **Storms, Precipitation & Flooding (Acute):** Given locations in coastal zones and other low-lying areas, ports face increasing risk of regular inundation due to hurricanes, cyclones, and typhoons. Port facilities may be damaged by excessive precipitation and/or flooding during acute precipitation events impacting the availability of infrastructure. Anticipatory safety measures for equipment (e.g., cranes) from impending severe weather events impact port availability. Flooding may also close access roads and shipping channels, disrupting traffic to/from ports. Increased runoff from severe weather events may increase accumulation of debris and silt, making port access channels shallower and thus disrupting port traffic. Ports are also vulnerable to disruptions to water, electricity and fuel supplies due to severe weather and flooding that may affect ports' ability to offer services. Revenues may be temporarily affected until normal port operations resume. **Flooding & Sea-level Rise (Chronic):** In some locations, nuisance flooding—temporary inundation of low-lying areas during exceptionally high tide events or floods that result from storm surges—may cause chronic disruption to port facilities, affecting service availability and revenue generation. Specifically, access roads which are critical linkages for moving goods to/from port facilities may be vulnerable to both acute precipitation/flooding and (in some areas) chronic nuisance flooding which impact normal port operations. Sea-level rise may submerge patio and other infrastructure, rendering port facilities inoperable. To the extent that sea-level rise impacts inland waterways, bridge clearance may affect traffic and thus port revenues.

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
		Water stress (Chronic): To the extent inland waterways experience decline in water levels, transiting ships may face weight restrictions that may impact traffic to certain ports, thus negatively affecting revenues. Water stress may impact agricultural production and trade flows, affecting port traffic in certain locations and thus revenues.
COSTS		**Additional costs may be incurred by marine ports because of weather and climate-related hazards. These include, for example, increased energy and water costs, increased costs to address physical damages/recovery expenses, costs related to higher insurance premiums to protect against loss and damage, and/or penalties for violating concession operating standards, along with increased capital expenditures to adapt to climate change. The following are examples of how these hazards might impact costs:** **Temperature (Acute):** Maintenance expenses may increase due to needed asphalt repairs. **Temperature (Chronic):** Depending on the location and type of traffic/cargo, an increased number of extreme-heat days and gradual temperature rise may escalate ongoing costs for maintenance if port traffic increases due to extended shipping/cruise ship seasons and changed trade flows. **Storms (Acute):** Contingency and recovery costs may increase and/or become more frequent (e.g., costs of channel maintenance/dredging, implementing anticipatory safety measures for cranes and other equipment, expanding/reconfiguring container storage space, frequency of patio resurfacing, equipment costs for pumping/clearing water, drainage system upgrades, etc.) and penalties may be payable if operating standards under concession are violated (if not a relief or force majeure event). **Flooding & Sea-level Rise (Chronic):** Port infrastructure may have to be raised due to continuous flooding and sea-level rise.
ASSETS		**Asset values of ports can be impacted by ongoing weather and climate-related hazards, particularly those that (i) wear on asset performance or (ii) require additional (possibly unplanned) investment. The following are examples of how weather and climate-related hazards might impact the asset value of port infrastructure.** **Tangible (fixed assets, e.g., buildings, infrastructure):** Frequent disruption and damage to port infrastructure could lead to a decrease in tangible asset value. Conversely, ports with enhanced infrastructure adapted to climate change that mitigates weather impacts (e.g., raised patios, better drainage systems, mitigation plans) may realise increased tangible asset value/valuation. **Intangible (e.g., goodwill, brand, copyrights):** Frequent climate-related disruption of operations may affect a port's brand and reputation, as well as service ratings by vessel operators and other customers/clients.

EXAMPLES

Potential climate impacts on Port Muelles el Bosque (MEB), Cartagena, Colombia[22]

A climate change risk analysis undertaken by Port Muelles el Bosque found that a number of "port success criteria" could be significantly affected by climate change, including:

- The causeway linking the mainland to the port experiencing regular flooding (nuisance and storm surge);
- Potential costs of disruption estimated at approximately US$250,000/day (and potential to impact earnings of 3%-7%) if no adaptive measure were taken;
- Also, increased risk of damage to goods stored inside ports due to seawater flooding;

Post-script: Analysis estimated the cost of investment to be US$380,000. MEB moved forward with adaptive investments (est. $10-$20 million) to raise the causeway linking the port to the mainland.[23]

Vulnerability of Port of Los Angeles, California, USA[24]

The Port of Los Angeles/Port of Long Beach breakwater is vulnerable to sea-level risk and storm surge, leaving terminals and marinas exposed to disruptions.

- Impacts from these risks include damage to the port, impairment of shipping terminals making them unusable, and interruptions to the flow of cargo
- The cost of a shutdown of the Port of Los Angeles/Port of Long Beach would be US$1 billion/day.
- The breakwater has a US$500 million replacement value.

Port of Los Angeles, California, USA

[18] OECD (2012)

[19] Timetric's Construction Intelligence Center (2017a)

[20] Rodrigue, J.-P., Slack, B. and Notteboom, T. (2017). Port Terminals. In: The Geography of Transportation Systems. [online] Available at: https://people.hofstra.edu/geotrans/eng/ch4en/conc4en/ch4c3en.html [Accessed 8 Dec. 2017].

[21] Roa, I., Peña, Y., Amante B. and Goretti, M. (2013). Ports: definition and study of types, sizes and business models. Journal of Industrial Engineering and Management 6(4): 1055-1064. [online] Available at: http://www.jiem.org/index.php/jiem/article/view/770/523 [Accessed 8 Dec. 2017].

[22] Stenek, V., et al. (2011). Climate Risk and Business – Ports: Terminal Marítimo Muelles el Bosque, Cartagena, Colombia. International Finance Corporation. [online]. Available at: http://www.ifc.org/wps/wcm/connect/98f63a804a830f878649ff551f5e606b/ClimateRisk_Ports_Colombia_Full.pdf?MOD=AJPERES [Accessed 18 Dec. 2017].

[23] The World Bank. (2016). Emerging Trends in Mainstreaming Climate Resilience in Large Scale, Multi-sector Infrastructure PPPs. [online]. Available at: https://library.pppknowledgelab.org/PPIAF/documents/2874/download [Accessed 18 Dec. 2017]

[24] Grifman, P.M., J.F. Hart, J. Ladwig, A.G. Newton Mann, and M. Schulhof. (2013). Sea Level Rise Vulnerability Study for the City of Los Angeles. USCSG-TR-05-2013.[online] Available at: https://dornsife.usc.edu/assets/sites/291/docs/pdfs/City_of_LA_SLR_Vulnerability_Study_FINAL_Summary_Report_Online_Hyperlinks.pdf[Accessed 18 Dec. 2017]

SECTORAL SNAPSHOTS

GAS AND OIL TRANSPORT AND STORAGE

Gas and oil transport and storage are a sub-sector of the Energy Sector. This sub-sector pertains to the movement of crude oil from the oil fields (where oil has been discovered) to petroleum refineries (where the oil is further processed) to storage areas, where the petroleum products are stored for distribution and emergency reserves. **This subsector includes the infrastructure necessary for the transport of crude oil to market:**

- In its raw state, crude oil is transported by two primary modes: tankers, which travel interregional water routes, and pipelines where most of the oil moves through for at least part of the route.
- Once the oil has been refined and separated from natural gas: pipelines transport the oil to another carrier or directly to a refinery.
- Petroleum products then travel from the refinery to market: by tanker, truck, railroad car, or more pipelines.[27]

INVESTMENT POTENTIAL[25,26]:

Between 2014 and 2020, an average of greater than US$80 billion will be invested annually in the U.S. midstream and downstream petroleum infrastructure.

Global downstream oil and gas investment in 2016 represented US$215 billion.

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**Oil and gas transport and storage companies generate revenue through storage service fees, throughput fees and ancillary service fees (heating, mixing, blending products stored in tanks). The following are examples of how weather and climate related hazards might impact revenues:** **Temperature (Chronic):** Increasing temperatures can affect the storage of volatile oil and gas products in tanks and increase safety hazards. **Storms (Acute):** Flooding can dislodge and lift oil and gas storage tanks which can cause a loss of petroleum and piping breaks. High wind speeds can also lead to buckling of metal fuel storage tanks (particularly if they are not full). Flooding can also cause damage to underground storage tank systems, including the buoying up of tanks which are partially full or empty, water entering the tanks and displacing product, failure of underground piping from groundwater pressure or debris, and damage to electrical systems from extended contact with water.[28] Climate-induced land movements such as subsidence or heave (due to changes in soil moisture), as well as landslides triggered by heavy rain, can cause excessive strain on pipelines and failure in the form of cracking or buckling. Furthermore, oil and gas pipeline disruptions are often caused by power outages during extreme weather. **Precipitation and Water Stress (Chronic):** Fuel transport by rail and barge can be affected when water levels in rivers and ports drop too low, such as during a drought, or too high, such as during a storm surge.[29] **Combination of Hazards:** Flooding, wildfires and icy conditions affect roads, railroads and other fuel transportation networks that move oil, coal and liquefied gas.
COSTS		**Additional costs may be incurred by companies in gas and oil transport and storage due to climate-related hazards. These include, for example, additional operating expenses, such as increased energy and water costs, increased costs to address physical damages/recovery expenses, along with increased capital expenditures to adapt to climate change, and/or costs related to increased insurance premiums to protect against loss and damage, addressing regulatory requirements.**

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**Temperature (Acute):** Warmer temperatures can result in more icebergs and ice movement, which in turn can damage barges transporting natural gas and oil. At the same time, decreasing sea ice could also generate some benefits; warmer temperatures are expected to improve shipping accessibility in some areas of the Arctic Basin, including oil and gas transport by sea.[30] In Alaska, thawing permafrost has caused pipeline, rail, and pavement displacements, requiring reconstruction of key facilities and raising maintenance costs.[31] **Temperature (Chronic):** Thawing permafrost in Alaska, Canada, and Russia will reduce the availability of ice road transportation and require companies to invest in other forms of transport infrastructure, such as all-season roads. **Precipitation & Flood (Chronic):** These hazards could lead to increased remediation, recovery, and repair costs to address the loss/leakage of petroleum products (e.g., floods lifting storage tanks and causing loss of petroleum).
ASSETS		**Values of gas and oil transport and storage assets may be impacted by ongoing weather and climate-related hazards, particularly those that either (i) wear on asset performance, (ii) require additional (possibly unplanned) investment, and (iii) reduced asset life due to damage or a higher depreciation schedule. The following are examples of how weather and climate-related hazards might impact the asset value of this sector's infrastructure.** **Tangible (fixed assets, e.g., buildings, infrastructure):** Aging infrastructure is more susceptible than newer assets to the hurricane-related hazards of storm surge, flooding, and extreme winds, and retrofitting this existing infrastructure with more climate-resilient technologies is a long-term task which may require significant capital expenditures.[32] More importantly, capital invested today into future oil and gas production is at risk of being stranded or wasted, and shareholders may not get the returns they have modeled for.[33] Such changes may improve asset valuation on the Balance Sheet, but will in the first instance require capital expenditure (e.g., costs). There is also a risk of transportation systems (e.g., pipelines) becoming stranded assets with decreasing utilization rates due to decarbonization policies. **Intangible:** Frequent climate-related disruption of operations may impact companies' brand and reputation. Their social license to operate may also be challenged due to failure to respond adequately during extreme events, or to maintain levels of service set by regulatory requirements. In addition, rising consumer awareness of climate change-related issues may impair the reputation of the oil and gas industry, resulting in a change in behavior leading to reduced consumption.[34]

EXAMPLES

Flood impact on ExxonMobil Silvertip pipeline, Montana, USA

In July 2011, ExxonMobil's Silvertip pipeline in Montana, buried beneath the Yellowstone riverbed, was torn apart by flood-caused debris, spilling oil into the river and disrupting crude oil transport in the region, with damages estimated at US$135 million, according to the U.S. Department of Transportation.[35]

Disruptions caused by Hurricane Katrina, USA

Electric power outages from Hurricane Katrina caused three critical pipelines—which cumulatively transport 125 million gallons of fuel each day—to shut down for two full days and operate at reduced power for about two weeks, leading to fuel shortages and temporary price spikes. In addition to the power outage, approximately 457 pipelines were damaged during the hurricane, interrupting production for months.[36]

Decreased water levels and reduced fuel barge hauls, USA

Lower water levels can also affect the amount of fuel that barges are capable of hauling; according to a 2013 assessment by the U.S. Department of Energy, a one-inch drop in river level can reduce a barge's towing capacity by 255 tons.[37]

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25 IHS Global. (2013). Oil & Natural Gas Transportation & Storage Infrastructure: Status, Trends, & Economic Benefits. Report for the American Petroleum Institute (API). [online]. Available at: http://www.api.org/~/media/Files/Policy/SOAE-2014/API-Infrastructure-Investment-Study.pdf [Accessed 18 Dec. 2017].

26 International Energy Agency (IEA). (2017). "World Energy Investment 2017." [online] Available at : https://www.iea.org/publications/wei2017/ [Accessed 18 Dec. 2017].

27 U.S. Library of Congress. (2006). The Oil & Gas Industry: Transport and storage. Business & Economic Research Advisor 5/6: Winter 2005/Spring 2006. [online]. Available at: https://www.loc.gov/rr/business/BERA/issue5/transportation.html [Accessed 18 Dec. 2017].

28 Petroleum Tank Management Association of Alberta (PTAAM). (2017). "Flooding and Underground Storage Systems." February 15, 2017. [online] Available at: http://ptmaa.ab.ca/index.php/ptmaanews/16-flooding-and-underground-storage-systems [Accessed 18 Dec. 2017].

[29] Zamuda, C. (2016). "Climate Resilience and the Energy Sector." Presentation to the 6th Forum on the Climate-Energy Security Nexus. June 7, 2016. [online] Available at: https://www.iea.org/media/workshops/2016/6thnexusforum/CraigZamuda.pdf [Accessed 18 Dec. 2017].

[30] U.S. Government Accountability Office (GAO). (2014). Climate Change: Energy Infrastructure Risks and Adaptation Efforts. Report to Congressional Requesters. GAO-14-74. [online] Available at: http://www.gao.gov/assets/670/660558.pdf [Accessed 18 Dec. 2017].

[31] U.S. GAO (2014)

[32] U.S. GAO (2014)

[33] Allianz Global Investors. (2017). Climate Risk Investment Positioning. [online] Available at: http://www.allianzglobalinvestors.de/MDBWS/doc/16-2021+Climate+Risk+Investment+Positioning+SH2211.pdf?1bab3f89d4227f4fc20de05b197aa4cced8dd227 [Accessed 18 Dec. 2017].

[34] Rudloff, D., and M. Schultz. (2016). "Top risks in oil and gas: How oil and gas companies gauge the risks they face." Oil and Gas Financial Journal, September 11, 2016. [online]. Available at: http://www.ogfj.com/articles/print/volume-13/issue-9/features/top-risks-in-oil-and-gas.html [Accessed 18 Dec. 2017].

[35] U.S. GAO (2014)

[36] U.S. GAO (2014)

[37] U.S. GAO (2014)

SECTORAL SNAPSHOTS

POWER TRANSMISSION & DISTRIBUTION (T&D)

Power transmission and distribution is a sub-sector of the Energy Sector. This sub-sector includes establishments that:[40]

- **Operate transmission systems (including lines and transformer stations)** that convey the electricity from the generation facility to the distribution system, and
- **Operate distribution systems (consisting of lines, poles, meters, and wiring)** that convey electric power received from the generation facility or the transmission system to the final consumer.

INVESTMENT POTENTIAL[38,39]:

Between 2007-2012, total investment in T&D globally was US$102 billion.

Estimates of required global investment in T&D range from US$2-7 trillion through 2035.

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES	 	**Power T&D companies' revenue, generated through the sale of power to consumers, can be affected by weather and climate-related hazards which result in operational disruption. Furthermore, regulatory agreements covering revenue (e.g., Public Private Partnership (PPP) contracts and Power Purchase Agreements) are often inflexible and cannot be adjusted to take account of such changes.** **Temperature (Acute):** Extreme heat events may decrease the performance of substations and transmission equipment, for example by causing disconnections and reducing the level of performance in energy transformation in substations. Some components may not be operational when a high threshold temperature is reached. Moreover, as a result of increasing temperatures, wildfires could occur and damage transmission systems. **Temperature (Chronic):** An increased number of extreme-heat days may lead to chronic heat-related disruptions if T&D infrastructure is not designed to enable uninterrupted operation. Prolonged incidence of extreme heat can also result in increased demand for cooling and put further pressure on the efficiency of T&D systems, but can also create opportunities for better service provision. **Storms (Acute):** Extreme weather events (e.g., storms, high winds, falling trees, snow and ice accumulation, lightning strikes, landslides) can cause damage to transmission towers, substations and transmission lines. In addition, heavy rain and floods can lead to transmission towers collapsing, and floods and water stagnation can submerge substations. Such extreme events may also prevent staff from accessing equipment for maintenance or repair.
COSTS		**Additional costs may be incurred by companies in the power T&D sector due to climate-related hazards. These include, for example, additional operating expenses, such as increased energy and water costs, increased costs to address physical damages/recovery expenses, along with increased capital expenditures to adapt to climate change, and/or costs related to increased insurance premiums to protect against loss and damage, addressing regulatory requirements such as new design and safety standards, permitting, siting and zoning of T&D infrastructure.**

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**Temperature (Chronic):** Taking into account the effects of temperature changes on thermal power plant efficiency, transmission line capacity, substation capacity and peak demand, a higher temperature scenario requires additional peak generation capacity and additional transmission capacity, or a greater demand-side response at peak times. The efficiency of T&D networks is compromised by a rise in ambient temperature, which would translate into higher operating expenses to meet the challenges arising from necessary adaptation measures. **Storms and Precipitation & Flooding (Acute):** In order to manage extreme weather-related risks, increased operating expenses and capital expenses for adaptation measures may be required. This may include pruning and managing trees near T&D lines, installation and maintenance of underground power lines, which are more resilient to floods and storms but more expensive,[41] research and development of distribution loss reduction technologies, and infrastructure hardening measures (e.g., physically reinforcing overhead transmission lines).
ASSETS		**Values of power T&D infrastructure assets may be impacted by ongoing weather and climate-related hazards, particularly those that either (i) wear on asset performance, (ii) require additional (possibly unplanned) investment, and (iii) reduced asset life due to damage or a higher depreciation schedule. The following are examples of how weather and climate-related hazards might impact the asset value of power T&D infrastructure.** **Tangible (fixed assets, e.g., buildings, infrastructure):** Expanded generation and T&D infrastructure/ assets built to accommodate distributed energy resources from renewables can create new climate-related exposures that need to be evaluated. The assets' value could be impacted as changes in operation practices to meet levels of service, changing customer needs, or regulatory requirements reduce the asset's life. Regulatory schemes supporting renewables may also undermine investment in T&D capacity, which is required to be able to accommodate irregular changes in supply and reflect the value of the grid as a backup for distributed energy systems. **Intangible (e.g., goodwill, brand, copyrights):** A utility company's brand and reputation may be negatively impacted during long power outages caused by extreme weather, as customers face inconvenience, discomfort, anxiety, lost economic activity, food spoilage, etc. Social licence to operate could be challenged due to failure to respond adequately during extreme events, or to maintain levels of service set by regulatory requirements. In developing countries where there are existing T&D losses (as well as energy theft), load shedding (by distribution companies) and brown-outs because of increased peak loads can impact a company's reputation and market valuation.

EXAMPLES

Increased energy sector expenditures due to extreme events, global

The estimated capital expenditure for climate change adaptation since 2000 and planned to 2020s amounts to US$1.5 billion for six large global power utilities:

- China Light and Power (China)
- Electricité de France (France)
- E-ON (Germany)
- ESKOM (South Africa)
- Hydro-Québec (Canada)
- National Grid (United Kingdom)

Estimates of repair costs for Hurricane Isaac which hit United States energy sectors in four states (Arkansas, Louisiana, Mississippi, and New Orleans) totalled US$400 million. This means that impact to the energy infrastructure by a single regional-scale extreme event totals to a little over one fourth of total spending by utilities on climate risk management over a 20-year period.

Assessing flood impacts on transmission and distribution, UK

UK-based electricity transmission and distribution companies Western Power Distribution and National Grid have both assessed climate change impacts on weather-related faults and supply interruptions. In the case of National Grid, this has included assessing flood risk using climate change projections for all its substations.

Increased incidence of weather-related disruptions, USA

Weather-related disturbances to the electricity network in the United States have increased ten-fold since 1992 and, while weather events accounted for about 20% of all disruptions in the early 1990s, they now account for 65%.

[38] Critchlow, J. (2015). "Business and Investment Opportunities in a Changing Electricity Sector." Insights – Bain & Company, January 29, 2015. [online] Available at: http://www.bain.com/publications/articles/business-and-investment-opportunities-in-a-changing-electricity-sector.aspx [Accessed 18 Dec. 2017].

[39] International Energy Agency (IEA). (2014). "World needs $48 trillion in investment to meet its energy needs to 2035." IEA, June 3, 2014. [online]. Available at: https://www.iea.org/newsroom/news/2014/june/world-needs-48-trillion-in-investment-to-meet-its-energy-needs-to-2035.html [Accessed 18 Dec. 2017].

[40] Class Codes. (undated). "Definition of NAICS 5 Digit Industry 22112." [online]. Available at: https://classcodes.com/lookup/naics-5-digit-industry-22112/ [Accessed 18 Dec.2017].

[41] Alonso, F., and C. Greenwell. (2013). Underground vs. Overhead: Power Line Installation-Cost Comparison and Mitigation. Electric Light and Power 18(2). [online] Available at: http://www.elp.com/articles/powergrid_international/print/volume-18/issue-2/features/underground-vs-overhead-power-line-installation-cost-comparison-.html [Accessed 18 Dec. 2017].

[42] Audinet, P., J.-C. Amado, and B. Rabb. (2014). Climate Risk Management Approaches in the Electricity Sector: Lessons from Early Adapters. In: Weather Matters for Energy (Alberto Troccoli, Laurent Dubus and Sue Ellen Haput, eds). Springer, New York.

[43] Audinet et al. (2014)

[44] Karl, T., J. Melillo, and T. Peterson. (2009). Global Climate Change Impacts in the United States. Cambridge University Press.

SECTORAL SNAPSHOTS

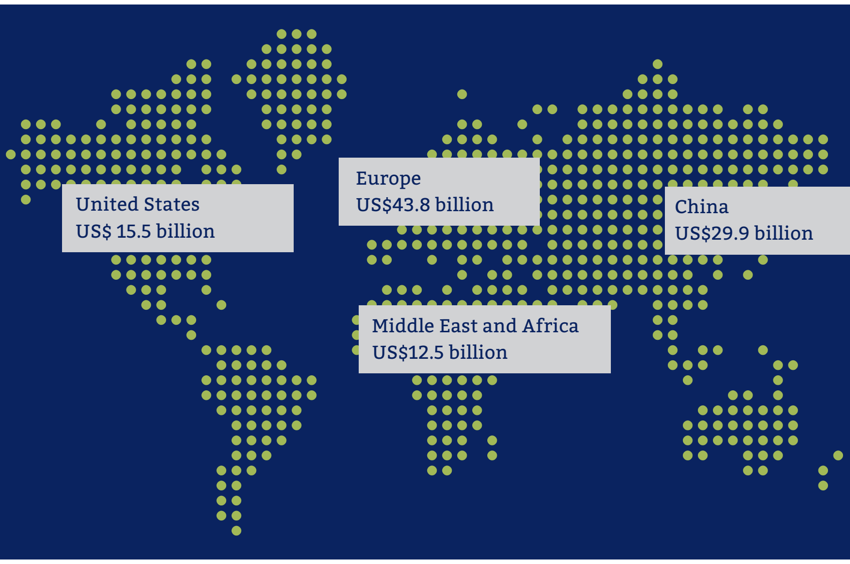
WIND-BASED POWER GENERATION

Wind-based power generation is a sub-sector of the Energy Sector and includes projects that encompass:

- **Wind power generation:** including turbines, gearboxes and towers, etc.
- **Associated cabling, ground support equipment, and other components** necessary to the point of interconnection with the grid, etc.

INVESTMENT POTENTIAL[45,46,47]:

Total value of global investment: US$112.5 billion (2016)



CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**The geographic distributions and/or the annual variability of the wind resource is subject to change as a result of global climate change (e.g. wind patterns change; with the frequency and intensity of storms; variations in inter-annual variability of wind). This has implications for both energy production and reliability of these investments, as well as project economics, particularly for revenues and possibly for operation and maintenance costs.[48]** **Furthermore, revenues to wind power generation facilities can be impacted when weather and climate-related events occur. The following are examples of how these hazards might impact revenues:** **Temperature (Acute):** Functioning and/or efficiency of certain equipment/components may be negatively affected by temperatures outside of rated conditions. Although wind turbines are typically designed for extreme temperatures, batteries used for storage can become less efficient, as extreme heat can affect battery chemistry causing degradation (e.g., excessively high temperatures can reduce battery life by as much as 90% for some batteries) while very low temperatures can slow chemical reactions and impair battery ability to deliver current.[49] Wind facilities counting on battery storage may experience negative impacts to revenue if batteries are unable to function as expected. **Temperature (Chronic):** Although inconclusive, evolving research suggests that wind power may decrease in some regions of the world as global temperatures rise. To the extent that wind resource decreases (both temporarily and long-term), revenue may be affected. **Storms, Precipitation & Flooding (Acute):** Depending on the location and nature of wind power infrastructure (e.g., onshore, offshore; utility-scale, small, distributed), increasing intensity and frequency of storm events, storm surge and flooding pose risks affecting availability and revenue generation. Turbines may be halted during storms with excessive winds (velocity/duration) beyond design conditions, and greater exposure to saltwater due to certain weather events can corrode parts; so as frequency and severity of storms increases, downtime may increase thus impacting revenues. Smaller-scale wind infrastructure may be more susceptible to disruption. Coastal wind infrastructure may experience flooded access. Disruption of power lines that connect to the grid or to customers in a distributed system may also be affected.
COSTS		**Additional costs may be incurred by wind power facilities attributable to weather and climate-related hazards. These include, for example, increased costs to address physical damages/recovery expenses,**

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**costs related to higher insurance premiums to protect against loss and damage, and/or penalties for violating concession operating standards along with increased capital expenditures to adapt to climate change. The following are examples of how these hazards might impact costs:** **Temperature (Acute and Chronic):** Costs may increase if higher-heat rated batteries are substituted for those that are unable to withstand extreme temperatures. **Storms, Precipitation & Flooding (Acute):** Recovery costs may increase and/or become more frequent due to damage from storms and flooding. Depending on the location and nature of wind power infrastructure (e.g., onshore, offshore; utility-scale, small, distributed), increasing intensity and frequency of storm events, storm surge and flooding can cause physical impacts, such as compromised integrity of pilings, both onshore and off, as well as corroded parts. Penalties may be payable if operating standards under concession are violated (if not a relief or force majeure event). Lightning, which can cause blade and turbine damage, poses a particular challenge for wind infrastructure; since lightning damage can be difficult to detect, changing weather patterns can lead to increased costs and downtime due to more frequent inspection.
ASSETS		**Asset values can be impacted by ongoing weather and climate-related hazards, particularly those that (i) wear on asset performance or (ii) require additional (possibly unplanned) investment. The following are examples of how weather and climate-related hazards might impact the asset value of wind power infrastructure.** **Tangible (fixed assets, e.g., buildings, infrastructure):** Wind turbine condition is a key factor affecting asset value. Degraded turbines can negatively impact asset value while installed assets that have more rigorous heat and weather ratings may have higher value. **Intangible (e.g., goodwill, brand, copyrights):** Frequent climate-related disruption of operations might change the wind energy's brand and reputation, as well as the rating of overall service by the clients.

EXAMPLES

Damage to infrastructure due to storm, Norfolk, UK

Scira Sheringham Shaol is a 316 MW windfarm located on the north Norfolk coast. Extreme weather and their accompanying extreme winds and waves have caused monopile turbines in the Scira Sherngham Shoal to experience bending movement between the monopile and the transition piece (an extension of the turbine's tower), causing some of these turbines to tip, no longer standing vertically, and impacting output and performance.[50]

Florida Power and Light (FPL) Energy National Wind OpCo/HoldCo Ratings Impact, USA

FPL is the third largest utility in the United States, whose assets include eight wind farms with aggregate capacity of 390 MW. In November 2015, Fitch Ratings Agency issued a negative outlook, in part as a result of weaker-than-expected revenues due to wind resource performance that was "persistently below the original P50 estimate... Low wind conditions and down-time at four of the eight wind farms resulted in a material erosion in cash flow with a 2015 annual DSCR at about 0.90X for the [operating company]". While FPL wind assets have geographic diversification, Fitch was concerned that it had not fully mitigated generation losses from reduced wind speeds overall. Revised projections expect on average 10% below the original P50 estimate(s) for assets in the wind portfolio through a stronger-than-expected El Nino cycle.[51]

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45 Bloomberg New Energy Finance. (2017). Global trends in clean energy investment. [online]. Available at: https://about.bnef.com/clean-energy-investment/ [Accessed 18 Dec. 2017].

46 Global Wind Energy Council. (2016). "Global Wind Energy Outlook 2016: Wind Power to dominate power sector growth." [online]. Available at: http://www.gwec.net/publications/global-wind-energyoutlook/global-wind-energy-outlook-2016/[Accessed 18 Dec. 2017].

47 Frankfurt School of Finance & Management. (2017). Global Trends in Renewable Energy Investment 2017. Frankfurt School-UNEP Centre/BNEF. [online]. Available at: http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf; Frankfurt School of Finance & Management. (2016). Global Trends in Renewable EnergyInvestment 2016. Frankfurt School-UNEP Centre/BNEF. https://www.actu-environnement.com/media/pdf/news-26477-rapport-pnue-enr.pdf [Accessed 18 Dec. 2017].

48 S.C. Pryor, R.J. Barthelmie (2010). "Climate Change Impacts on Wind Energy: A Review" Renewable and Sustainable Energy Reviews, ScienceDirect. [online]. Available at: https://www.sciencedirect.com/science/article/pii/S1364032109001713 [Accessed 18 Dec. 2017].

49 Stout, M. (2013). "Protecting Wind Turbines in Extreme Temperatures." Renewable Energy World, June 26, 2013. [online]. Available at: http://www.renewableenergyworld.com/articles/2013/06/protecting-wind-turbines-in-extreme-temperatures.html [Accessed 18 Dec. 2017].

50 Diamond, K. (2012)

51 Business Wire. (2015). Fitch Affirms FPL Energy National Wind Opco and Holdco; Outlook Remains Negative. [online]. Available at: https://www.businesswire.com/news/home/20151117007089/en/Fitch-Affirms-FPL-Energy-National-Wind-Opco. [Accessed 18 Dec. 2017].

SECTORAL SNAPSHOTS

TELECOMMUNICATIONS

Telecommunications are a sub-sector of the Information and Communication Technology (ICT) sector. This sub-sector includes:

- **Data/voice transmission infrastructure:** providers of communications and high-density data transmission services primarily through a high bandwidth/fiber-optic cable network;
- **Telecommunications operations:** operators of primarily fixed-line telecommunications networks and companies providing both wireless and fixed-line telecommunications services not classified elsewhere; and
- **Wireless infrastructure:** providers of primarily cellular or wireless telecommunication services, including paging services.

INVESTMENT POTENTIAL[52,53]:

Global telecommunications infrastructure demand requires US$9.5 trillion in investment by 2030

Global market size 2015: US$1.607 billion

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**Telecommunications generate revenues through the delivery of services such as traditional telephone calls, data and internet services. Revenues to telecommunication infrastructure (data/voice transmission, operations, and wireless infrastructure) can be impacted when weather and climate-related hazards occur. The following are examples of how these hazards might impact revenues:** **Temperature (Acute):** Increases in temperature and higher frequency, duration, and intensity of heat waves create an additional burden on keeping equipment cool in exchanges and base stations, resulting in increased failure rates and impacting service delivery. **Temperature (Chronic):** Increases in mean temperature increase the operating temperature of network equipment over a period of time, leading to malfunction or premature failure if it surpasses design limits, affecting service delivery. **Precipitation & Flooding (Acute):** Acute heavy precipitation can result in some transmitted signals not being received clearly or at all. Reduction in service delivery can also occur due to increased storm-related damage to above-ground transmission infrastructure (masts, antennae, switch boxes, aerials, overhead wires, and cables), which are often final access connections to homes and businesses. **Precipitation & Flooding (Chronic):** Increased precipitation and humidity can affect the radio spectrum on which wireless communications rely. Some services may also require increased transmission powers (and incur associated costs) in order to withstand poorer weather without experiencing an outage. As a result, this could limit the number of users supported in a given spectrum band. **Storms (Acute):** There is often increased demand for services during extreme weather events, such as for emergency communications and for teleworking. Service may also be reduced or disrupted due to flooding of central offices during extreme events.

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**Additional costs may be incurred by telecommunications due to weather and climate-related hazards. As weather patterns become increasingly variable, additional operating expenditures will incur, including increased energy/cooling costs to maintain the same level of service, expenses to address physical damages/recovery expenses, along with increased capital expenditure related to increasing insurance premiums to protect against loss and damage, faster infrastructure degradation, and fault rates. The following are examples of how these hazards might impact costs:** **Temperature (Chronic):** Increased temperatures in winter (e.g., in the US and Canada) may reduce the cost of space heating in assets such as exchanges, creating a cost-saving opportunity. Reduced snowfall lessens the impact on transmission infrastructures, such as masts and antennae, requiring less upkeep or maintenance and reduced operational expenditures. **Precipitation & Flood (Acute):** Decreased precipitation over time can lead to land subsidence and heave, which can reduce the stability of telecommunications infrastructure both above and below ground. **Precipitation & Water Stress (Chronic):** Decreased precipitation increases seasonal water scarcity, reducing the amount of water available for cooling of assets. Increased dry spells increase the risk of fire which can damage assets, particularly in rural locations. Changes in humidity lead to changes in patterns and rates of the corrosion of equipment (e.g., broadcasting towers), requiring more frequent maintenance or replacement, leading to new dehumidification requirements and incurring associated costs. There is also an increased cost of implementing climate-resilient solutions (e.g., laying cables that can better withstand water damage, switching from copper to fiber-optic cables). **Sea-Level Rise (Chronic):** Rising sea levels affect the operation of data centers and service centers upon which telecommunications rely, and is likely to increase the cost of maintaining levels of service and asset performance by investing to address physical risks (e.g., insurance premiums, recovery expenses). Rising sea levels and corresponding increases in storm surges increase the risk of saline corrosion of coastal telecommunications infrastructure as well as erosion or inundation of coastal and underground infrastructure. **Combination of hazards:** Telecommunications rely heavily on continuous power supply. Acute weather events can cause disruption of power supply, which would increase the cost of energy supply (e.g., by incurring additional costs for backup power generation such as battery and diesel). Increased frequency and intensity of extreme weather events make it difficult for employees to get to work or for maintenance employees to access infrastructure, particularly in remote transmission networks, increasing recovery costs and compromising service. In addition, increased frequency and intensity of extreme weather events around the world increase the risk of interrupting the supply of materials, such as chips or other ICT components (by disrupting air and sea transport), and manufacturing operations.
ASSETS		**Asset values of telecommunication infrastructure may be impacted by ongoing weather and climate-related hazards, particularly those that either (i) wear on asset performance, (ii) require additional (possibly unplanned) investment, and (iii) reduce asset life due to damage or a higher depreciation schedule. The following are examples of how climate-related hazards might impact the asset value of telecommunications infrastructure.** **Tangible (fixed assets, e.g., buildings, infrastructure):** Extreme events as outlined above may lead to a reduction in asset life (e.g., cables, masts, towers) as a result of increased maintenance costs and higher depreciation rates due to damage; a rise in asset renewal rates will increase capital expenditure budgets. On the other hand, operators that invest in climate proofing (e.g., in-house power generation, replacing copper cables with fiber-optic) may increase the value of their assets. It is worth noting that relatively shorter infrastructure lifespans in this subsector provide flexibility to respond quickly to changes in climate (high turnover), which lends itself well to building resilience. **Intangible (e.g., goodwill, brand, copyrights):** Frequent climate-related disruption of telecommunications service might negatively impact an operator's brand and reputation, causing customers to switch providers. On the other hand, operators who continue to provide excellent service during extreme weather events may gain reputational advantage.

[52] Dobbs, R., et al. (2013). Infrastructure Productivity: How to Save $1 Trillion a Year. McKinsey Global Institute, McKinsey & Company. [online] Available at: https://www.mckinsey.com/~/media/ McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Infrastructure%20productivity/MGI%20Infrastructure_Executive%20summary Jan%202013.ashx [Accessed 18 Dec. 2017].

[53] Boniecki, D., C. Marcati, W. Abou-Zahr, T. Alatovic, and O. El Hamamsy. (2016). Middle East and Africa – Telecommunications industry at cliff's edge: Time for bold decisions. McKinsey & Company. [online] Available at: https://www.mckinsey.com/~/media/McKinsey/Industries/Telecommunications/Our%20Insights/Winning%20the%20rush%20for%20data%20services%20in%20the%20Middle%20East%20and%20Africa/Telecommunications%20industry%20at%20cliffs%20edge%20Time%20for%20bold%20decisions_June2016 [Accessed 18 Dec. 2017].

EXAMPLES

Superstorm Sandy's impact on telecommunications companies, USA

Superstorm Sandy (2012) illustrated the impact of extreme events on the telecommunications sector in the U.S. Several New York City central offices belonging to telecoms operator Verizon experienced flooding as a result of storm surge, which led to power failures and rendered the back-up power systems at these sites inoperable. According to federal regulators, Sandy knocked out about 25% of cell towers belonging to all carriers in a coastal area spread over parts of 10 states. As a result, in the fourth quarter of FY 2012-2013, AT&T announced a US$175 million loss in its operating income due to storms including Superstorm Sandy.[54] Verizon reported a quarterly loss of US$4.23 billion, or $1.48 per share, in part because of losses and damages related to Sandy, even while adding wireless customers during that period.[55]

Widespread installation of fiber-optic cables after Sandy increased Verizon's growth, USA

By replacing old copper cables with fiber-optic ones after damage due to Superstorm Sandy, Verizon increased its ability to generate more customer revenue from FiOS, its super-speed Internet service, which it only offered in limited locations before the storm In 2013, this service generated two-thirds of customer revenue[56] and continues to drive Verizon's revenue growth.[57]

2010 flooding affected underground telecommunications networks, London, UK

In 2010, a major flood occurred at a British Telecom (BT) exchange in Paddington, London, which led to an electrical fire and ripple effects at exchanges around the UK, affecting broadband and telephone services for several hours. Four hundred and thirty-seven exchanges and up to 37,500 datastream circuits were affected. BT has since invested in making its underground network more resilient to flooding by switching from copper to fiber-optic cables.

[54] BBC News (2013). "AT&T takes $10bn pensions charge." BBC News, January 18, 2013. [online] Available at: http://www.bbc.co.uk/news/business-21071155. [Accessed 18 Dec. 2017].

[55] Greenfield, R. (2013). "Verizon's Massive Loss Reveals Scope of Damage from Hurricane Sandy." The Atlantic, January 22, 2013. [online] Available at: https://www.theatlantic.com/technology/archive/2013/01/verizon-massive-loss-reveals-scope-damage-hurricane-sandy/319223/[Accessed 18 Dec. 2017].

[56] Greenfield, R. (2013)

[57] Verizon. (2017). "Financial and operational highlights as of December 31, 2016." [online] Available at: https://www.verizon.com/about/sites/default/files/annual_reports/2016/financial-highlights.html [Accessed 18 Dec. 2017].

SECTORAL SNAPSHOTS

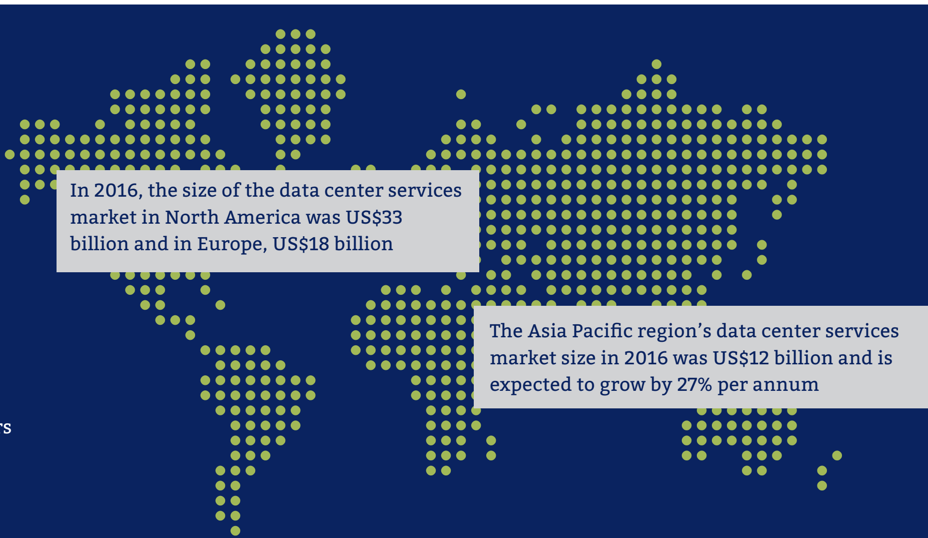
DATA CENTERS

Data centres are a sub-sector of the Information and Communication Technology (ICT) sector and includes:

- **Establishments that provide the infrastructure for hosting:** These establishments may provide specialized hosting activities, such as web hosting, streaming services or application hosting, provide application service provisioning, or may provide general time-share mainframe facilities to clients.
- **Establishments that provide data processing services,** including complete processing and specialized reports from data supplied by clients or automated data processing and data entry services.

INVESTMENT POTENTIAL[58,59]:

Data centers have one of the highest EBITDA margins in the infrastructure sector (approx. 43%). The growth in demand for data center capacity (primarily due to cloud services), combined with the high profitability and scope to reduce operating costs by reducing energy costs, make data centers an attractive opportunity for investors.



CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**Data centers generate revenue by providing data processing and hosting services including web hosting, streaming services, application hosting, and application service provisioning. The following are examples of how weather and climate related hazards might impact data center revenues:** **Temperature (Acute):** Extreme temperature events can lead to increased demand for cooling during heat waves, causing power failures in local transmission grids due to excessive loads, which can affect the delivery of data center services. **Temperature (Chronic):** Potential increased revenues for data centers located in cooler regions (such as Scandinavian countries) as some companies choose these locations to reduce the need for active cooling. **Combination of hazards:** Flooding of buildings can cause damage to operational equipment and potential loss of data, whether due to increased river flood risk, sea-level rise, groundwater or increased risk of flash flooding due to heavy precipitation. This leads to service disruption for customers. At the same time, as extreme weather events become more frequent, data centers can actively promote themselves as a vital part of any company's business continuity planning.
COSTS		**Additional costs may be incurred by data center companies due to weather variability and climate-related hazards. As weather patterns become increasingly variable, additional operating expenditures will incur, including increased energy/cooling costs to maintain the same level of service, expenses to address physical damages/recovery expenses, along with increased capital expenditure related to increasing insurance premiums to protect against loss and damage, faster infrastructure degradation, and higher default rates. The following are examples of how these hazards might impact costs:** **Temperature (Acute):** Increased average temperatures and the greater frequency of heat wave events put additional burdens on cooling equipment, leading to the deterioration or failure of equipment and more frequent maintenance/repair. Increased energy demand during heat waves can result in power outages, which can affect the delivery of data center services and increase the costs of energy supply. This can also lead to increased demand on backup power generators and batteries which are costly and have environmental impacts (e.g., greenhouse gas emissions, hazardous waste).

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**Temperature (Chronic):** Increases in average temperatures and associated humidity can affect baseline design parameters, for example, the loss of ambient cooling potential. On the plus side, companies can achieve cost savings from energy efficiency initiatives in data centers resulting in reduced operational efficiency and greater component failure rates. **Storms, Precipitation & Flooding (Chronic and Acute):** Flooding of buildings and assets can cause damage to operational equipment and increased maintenance costs. Increased frequency and intensity of extreme weather events around the world increase the risk of interrupting the supply of materials, such as chips or other ICT components (by disrupting air and sea transport), and manufacturing operations. **Water stress:** Data centers require enormous volumes of water to cool their high-server-density spaces, which is making water management a priority for operators. During periods of drought, water supply is restricted. On the plus side, companies can achieve cost savings from water efficiency initiatives in data centers such as free cooling.
ASSETS		**Asset values of data center infrastructure may be impacted by ongoing weather and climate-related hazards, particularly those that either (i) wear on asset performance or (ii) require additional (possibly unplanned) investment. The following are examples of how weather and climate-related hazards might impact the asset value of data center infrastructure.** **Tangible (fixed assets, e.g., buildings, infrastructure):** Extreme events as outlined above may lead to a reduction in asset life as a result of increased maintenance costs and higher depreciation rates due to damage; a rise in asset renewal rates will increase capital expenditure budgets. On the other hand, operators that invest (e.g., capital expenditures) in climate proofing (e.g., in-house power generation, replacing copper cables with fiber-optic) may increase the value of their assets. Such changes may improve asset valuation on the Balance Sheet, but will in the first instance require capital expenditure (e.g., costs). **Intangible (e.g., goodwill, brand, copyrights):** Frequent climate-related disruptions to data center service might negatively impact an operator's brand and reputation, causing customers to switch service providers. On the other hand, data centers which continue to provide excellent service during extreme weather events may gain reputational advantage.

EXAMPLES

Hurricane Katrina's impact on data center, New Orleans, USA

A data center serving 128 New Orleans public schools was located on the fourth floor of an administrative building when Hurricane Katrina hit. The hurricane blew the air conditioning system off the roof, allowing rain ingress. When power was restored, there was no air conditioning, and the rainwater and heat corroded contacts on switches. Other gear overheated and failed. Repairs to the data center cost in excess of US$3 million and took several months.[60]

Superstorm Sandy's damage to East Coast data centers, USA

When Superstorm Sandy hit the US East Coast in 2012, it left a number of data centers underwater, damaging equipment, putting critical data at risk and threatening to interrupt Internet service nationwide. Before the storm hit, data center operators in New York, Philadelphia, and Washington, D.C., tested emergency backup generators and prepared to maintain services during power outages caused by the hurricane. But generators began running out of fuel after several days, and data center companies told customers to shut down servers and move workloads elsewhere. In other cases, flooding submerged diesel pumps and prevented them from pumping fuel to generators.[61]

Alternative methods of cooling in data centers lead to substantial savings

There have been examples of alternatives to the use of large volumes of water for cooling data centers. Some data centers are beginning to use dry coolers (closed loops) to cool data centers in combination with operating equipment capable of operating at higher temperatures based upon revised guidelines. This is part of a trend toward increased acceptance for less stringent guidelines with respect to cooling hardware. For example, a water-cooled IT system was applied in a retrofit project at the Maui High Performance Computing Center data center. An evaluation of cooling and electrical system components during tests showed much less cooling power is required by the water-cooled IT system, compared to the cooling power required by the air-cooled system. It is estimated that the water cooling will save US$200,000 per year in operating costs.[62]

58 IHS Global (2013)

59 PricewaterhouseCoopers Advisory Services. (2017). Surfing the data wave: The surge in Asia Pacific's data centre market. [online] Available at: https://www.pwc.com/sg/en/publications/assets/surfing-the-data-wave.pdf [Accessed 18 Dec. 2017].

60 Acclimatise. (2014). Climate Risks Study for Telecommunications and Data Center Services. [online] Available at: https://sftool.gov/Content/attachments/GSA%20Climate%20Risks%20Study%20for%20Telecommunications%20and%20Data%20Center%20Services%20-%20FINAL%20October%202014.pdf [Accessed 18 Dec. 2017].

61 Brown, J. (2014). "Underwater: Data Centers Nationwide Must Prepare for Flooding." Government Technology, August 28, 2014. [online] Available at: http://www.govtech.com/local/Underwater-Data-Centers-Nationwide-Must-Prepare-for-Flooding.html [Accessed 18 Dec. 2017].

62 Mahdavi, R. (2014). Liquid Cooling v. Air Cooling Evaluation in the Maui High Performance Computing Center. Prepared for the U.S. Department of Energy Federal EnergyManagement Program by Lawrence Berkeley National Laboratory. [online] Available atL https://energy.gov/sites/prod/files/2014/08/f18/cs_maui_high_pcc.pdf [Accessed 18 Dec. 2017].

SECTORAL SNAPSHOTS

COMMERCIAL REAL ESTATE

Commercial real estate is a sub-sector of the Real Estate sector and includes properties intended for use solely to conduct business such as office space and retailers including restaurants, hotels, malls, stores, gas stations, and others.

INVESTMENT POTENTIAL[63]:

The direct commercial real estate transactional market is projected to exceed US $1 trillion per annum by 2030, compared with 2012 annual volumes of US$450 billion.

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**Revenues from commercial real estate can be impacted when weather and climate-related hazards occur. The following are examples of how these hazards may impact revenues:** **Temperature (Acute):** With projected increases in the frequency of heat waves, people are likely to visit public places with air conditioning, especially during the hottest hours of the day. The property value of places such as shopping malls and other commercial sites with air conditioning which are expected to be among the most popular places to which people escape the heat may see an increase. **Sea-level Rise (Chronic):** As sea levels rise, people may be forced to relocate away from the shore, driving down demand for coastal commercial real estate. **Combination of hazards:** Climate change is already driving people's migration to lower-risk areas, and this trend may increase in the coming decades, resulting in shifts in the supply and demand of real estate markets. Commercial activity tends to decline in the aftermath of extreme weather events due to employee inability to attend work and loss of business due to affected customers. Frequent extreme events may result in diminished property value over time. The loss of power supply following disasters may discourage customers from coming to businesses or force businesses to stop operations altogether.
COSTS		**Additional costs may be incurred by commercial real estate due to weather and climate-related hazards. A weather patterns become increasingly variable, additional operating expenditures may be incurred such as increased energy or water costs, maintenance costs, or costs related to rising insurance premiums to protect against loss and damage. The following are examples of how these hazards may impact revenues:** **Temperature (Chronic):** As temperatures rise, the need for cooling in order to maintain/increase the attractiveness of assets may increase, resulting in higher levels of energy use. **Water Stress (Chronic):** Water and energy efficiency requirements are becoming stricter in many regions of the world, and compliance with such requirements may lead to higher and/or additional expenses for asset owners. In regions where water availability is at risk, real estate managers may have to make significant investments in water efficiency systems to maintain the viability of their assets.

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**Storms (Acute):** The greater frequency and intensity of storms are likely to lead to higher insurance costs for assets, particularly those that are located in flood-prone areas. Storms and other extreme weather events are also likely to damage commercial infrastructure, and the costs of recovery may rise as storm severity and frequency increase.
ASSETS		**Asset values of commercial real estate may be impacted by ongoing weather and climate-related hazards, particularly those that either (i) wear on asset performance, (ii) require additional (possibly unplanned) investment, or (iii) reduce asset life due to damage or a higher depreciation schedule. The following are examples of how weather and climate-related hazards might impact the asset value of commercial real estate.** **Temperature (Chronic):** Rising temperatures are likely to increase the demand for air conditioning and other cooling systems or features such as cool roofs. Increased uptake of cooling features or systems that are also energy-efficient may result in higher levels of capital expenditures (e.g., costs on the balance sheet) for the owners and/or managers of commercial real estate such as health facilities. This may not impact asset valuation on the balance sheet per se, but may be an important consideration if/when assets are transferred/sold. **Water Stress (Chronic):** In regions where water availability or accessibility is projected to decrease, real estate managers may have to make significant investments in water treatment facilities in order to maintain the viability of their assets. This may not impact asset valuation on the balance sheet per se, but will be an important component if/when assets are transferred/sold. **Sea-level Rise (Chronic):** The managers and owners of coastal properties are expected to face increased risk of flooding as sea levels rise. Capital expenses for measures such as ecosystem restoration, floodwalls, and levees can help to reduce the risk of flooding, but may represent significant investments for asset owners and managers. **Storms (Acute):** Extreme weather is anticipated to become more severe and therefore more disruptive. Infrastructure located in high risk regions may be increasingly prone to physical damage and, potentially, complete loss, which can have dramatic effects on asset values held on the balance sheet. **Combination of hazards:** The attractiveness and valuation of assets in particularly vulnerable regions may be impacted, for example those in low-lying coastal areas that face high levels of risk from sea-level rise or flooding, or areas that are expected to see significant increases in temperatures and/or more frequent high heat events. Also, as governments and societies become increasingly aware of the gravity of climate change, governments may start requiring the real estate industry to disclose climate-related risks, making infrastructure that is designed to minimize its carbon footprint and enhance resilience more attractive.

EXAMPLES

Property losses due to severe floods Queensland, Australia

In December 2010 and January 2011, 78% of Queensland, Australia was declared a disaster zone due to multiple floods. The overall damage to infrastructure and property added up to US$10 billion.[64] One in five businesses were forced to close for an average of eight days due to inundation, loss of power, or inability to access their business. Average property loss was over US$580,000. A month after the event, businesses were expected to lose nearly US$895,000 on average (11% of their annual turnover). Median losses were expected to be closer to US$50,000 or 7% of annual turnover. [65]

Hurricane Harvey's impact on Houston commercial real estate, USA

In August 2017, Hurricane Harvey hit the coast of Texas as the most powerful hurricane in 50 years. The Governor of Texas stated the costs of recovery could amount to US$180 billion, greater than the costs associated with storms Katrina or Sandy.[66] In September 2017, a study that conducted an analysis of flood maps estimated that roughly 27% of Houston commercial real estate may have been impacted by the flood—12,000 properties worth an estimated US$55 billion.[67]

Increased demand for high-rise residential units after tropical storm, Manila, Philippines

A tropical storm that hit Manila in 2009 caused damage equivalent to 2.7% of the country's GDP or US$4 billion.[68] In 2012, a typhoon caused US$1 billion in damages after hitting the Compostela Valley region.[69] After these events caused widespread floods and affected a large fraction of the city's assets, the commercial real estate firm Jones Lang Lasalle announced that the demand for high-rise residential units had increased, and that 142,000 new units would be built in areas less prone to flooding.[70] This highlights the potential for market opportunities for commercial real estate located in areas at lower risk of flooding and/or designed to be flood-resilient.

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[63] Asia Investor Group on Climate Change, et al. (2015). Financial Institutions Taking Action on Climate Change. [online] Geneva, Switzerland: United Nations Environment Programme - Finance Initiative (UNEPFI). Available at: http://www.unepfi.org/fileadmin/documents/FinancialInstitutionsTakingActionOnClimateChange.pdf [Accessed 7 Dec. 2017].

[64] Lloyd's. (2015). Case Study: Flood. Lloyd's City Risk Index 2015-2025. [online] Available at: https://www.lloyds.com/cityriskindex/threats/flood/case-study [Accessed 7 Dec. 2017].

[65] Chamber of Commerce & Industry Queensland. (2011). Impact of the Queensland Floods on Business. CCIQ Survey. [online] Springhill, Queensland, Australia: Chamber of Commerce and Industry Queensland. Available at: https://www.cciq.com.au/assets/Documents/Advocacy/110204-CCIQ-report-on-the-Impact-of-the-Queensland-floods-on-business.pdf [Accessed 7 Dec. 2017].

[66] Reuters. (2017). "Hurricane Harvey Damages Could Cost up to $180 Billion." Fortune, [online] Available at: http://fortune.com/2017/09/03/hurricane-harvey-damages-cost/ [Accessed 7 Dec. 2017].

[67] Putzier, K. (2017). "Hurricane Harvey put as much as $55 billion worth of Houston's commercial real estate underwater." Business Insider, [online] Available at: http://www.businessinsider.com/hurricane-harvey-55-billion-houston-commercial-real-estate-underwater-2017-9 [Accessed 7 Dec. 2017].

[68] World Bank, (2012). PHILIPPINES: Integrating Flood Risk Management into Local Planning Saves People's Lives — WB. [online] Available at: http://www.worldbank.org/en/news/press-release/2012/02/13/integrating-flood-risk-management-into-local-planning-saves-peoples-lives [Accessed 7 Dec. 2017].

[69] Acosta, L., et al. (2016). Loss and damage from typhoon-induced floods and landslides in the Philippines: community perceptions on climate impacts and adaptation options. International Journal of Global Warming, [online] Volume 9(1): 2016. Available at: https://www.inderscienceonline.com/doi/pdf/10.1504/IJGW.2016.074307 [Accessed 7 Dec. 2017].

[70] Cordero, C. (2012). "The rise (of flood) in Metro Manila: lessons and opportunities." Blog Jones Lang LaSalle (JLL) Asia Pacific Research. Available at: http://www.jllapsites.com/research/the-rise-of-flood-in-metro-manila-lessons-and-opportunities/ [Accessed 7 Dec. 2017].

SECTORAL SNAPSHOTS

HEALTHCARE

The healthcare sector belongs to the Social Infrastructure sector and includes:

- **Hospitals:** large-scale public or private healthcare facilities with in- and out-patient treatment, typically including emergency rooms; and
- **Surgery centers and long-term care facilities:** facilities with a specific treatment or service focus that are physically separate from large-scale hospital operations.[72]

INVESTMENT POTENTIAL[71]:

Global project pipelines
US$406 billion (July 2017)

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**Revenues to healthcare facilities can be impacted when weather and climate-related hazards occur. The following are examples of how these hazards may impact revenues:** **Temperature (Acute):** As rising temperatures lead to more heat waves, poor air quality and heat stress may result in more emergency room visits and hospitalizations.[73] The influx of patients is more likely to result in additional revenue for non-hospital healthcare facilities, but could result in bad debt and failure of payment for hospitals with emergency room facilities. Regulatory agreements covering revenue (e.g., PPP contracts, Power Purchase Agreements) are inflexible and cannot be adjusted to take account of changes in revenues. **Storms (Chronic):** Hospitals located in low-lying areas and close to coastal bodies of water face increasing risk of regular and permanent inundation from hurricanes, cyclones, and typhoons. This may result in the disruption of business supplier services (e.g., emergency transport, medical supplies, and water, energy and other utilities), leading to loss of adequate patient services and care. Facilities could also face impacts on revenues from extreme events (e.g., lack of patient ability to pay) causing disruption to healthcare service performance and delivery. **Precipitation & Flooding (Acute):** With increasingly varying precipitation patterns, facilities and fixed infrastructure are more likely to be damaged and inundated by excessive precipitation and flooding. These can include nuisance flooding, where there is a temporary inundation of low-lying areas during exceptionally high tide events or floods that result from storm surges. The impacts on revenues from increased frequency and intensity of precipitation and possible flooding can disrupt healthcare service performance and delivery. In addition to impacts to the physical hospital infrastructure itself, damage to local roads could also limit access to the facility by both patients and employees and limit the ability to maintain adequate service delivery.
COSTS		**Additional costs may be incurred by healthcare facilities due to weather and climate-related hazards. As weather patterns become increasingly variable, additional operating expenditures are likely to incur, including increased electricity and water utility expenses, costs of supplies and medical equipment for hospitals and lab facilities, and other variable expenses. The following are some examples of how climate hazards may affect costs:**

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**Temperature (Chronic):** Hospitals may face an increase in operating expenditures to address extreme temperatures, regulatory requirements, changes in costs of supply/materials, disruptions to supply chains, and limitations in regulatory agreements and licenses to operate regarding their ability to pass costs on to customers. In terms of opportunities, certain facilities may see a decrease in operating costs resulting from increased energy or water efficiency in response to climate-related risks. **Combination of hazards:** More intense extreme weather events may result in increased operating expenditures, including prevention measures (e.g., more frequent maintenance to the drainage system), as well as contingency and recovery costs after events. In addition, facilities may be obliged to pay for higher insurance premiums due to the increased risk of flooding.
ASSETS		**Asset values of healthcare facilities may be impacted by ongoing weather and climate-related hazards, particularly those that either (i) wear on asset performance, (ii) require additional (possibly unplanned) investment, or (iii) reduce asset life due to damage or a higher depreciation schedule. The following are examples of how climate-related hazards might impact the asset value of healthcare facilities.** **Water Stress (Chronic):** Medical facilities often have a back-up water source to mitigate potential issues related to the supply, quality, or capacity of traditional sources. However, climate change and related impacts in water supply may influence the capacity of these secondary sources to provide for the needs of the healthcare facility. **Sea-Level Rise (Chronic):** Hospitals located in low-lying areas and close to bodies of water face increased risk of flood damage to physical assets and infrastructure, and regular or permanent inundation from nuisance flooding, storm surge, or seasonal inundations, leading to escalating damage costs. In some cases, this risk may be extreme and facilities may need to be relocated, while in other cases facilities may be forced to invest (e.g., capital expenditures/costs) in protecting infrastructure. Such changes may improve asset valuation on the balance sheet, but will in the first instance require capital expenditure. **Combination of hazards:** Extreme events may result in increased unplanned capital expenditures to address disruptions to operations and physical damage to infrastructure and equipment (e.g., relocating temperature control and electrical systems, relocating waiting and treatment areas for patients, repairing damage, replacing damaged equipment), regulatory requirements, changes in costs of supply/materials, and disruptions to supply chains. Such changes may improve asset valuation on the balance sheet, but will in the first instance require capital expenditure. **General:** Hospitals and other facilities could see changes in the value of an organization's assets, or the acquisition or sale of assets, as a result of temperature and climate-related risks and opportunities. Also, asset values could be impacted due to reduced asset life and changes in operational practices to meet levels of service, changing customer needs, and regulatory requirements.

EXAMPLES

Damage to and closure of New York City hospitals due to Superstorm Sandy Manhattan hospital, New York, USA

After Superstorm Sandy hit New York in 2012, Manhattan's Bellevue Hospital Center was forced to evacuate patients and shut down for months due to recovery efforts. The basement, where the electrical equipment and critical medical equipment were located, was flooded with millions of gallons of water.[74] The New York City Health and Hospitals Corporation estimated that the cost to reopen, repair, and prepare for future storms in the nine storm-damaged hospitals and facilities in the New York City public hospital system would total US$810 million. [75]

Climate-resilient hospital design, Florida, USA

Cleveland Clinic is investing US$300 million in new facilities in Florida, and is using the results of a climate hazard analysis to inform these investments and enable conversations about future risk. In one case, Cleveland Clinic decided to raise the floor of a new health center to mitigate the risk from future flooding caused by storm surge and sea-level rise. The analysis also informed Cleveland Clinic's decisions about how best to build resilience into their future energy use designs. Specifically, the Clinic decided to use four small chillers as opposed to one large chiller in their new Florida health center facility to better enable the Clinic to alter their energy use in relation to anticipated heat fluctuations. The Dashboard analysis has also influenced Cleveland Clinic's Asthma Care Path by spurring conversations about how the Clinic should change and expand their delivery of care for the populations most vulnerable to the health impacts of increased heat.

Healthcare system of Jammu and Kashmir state compromised by flooding, India

In 2014, Jammu and Kashmir, a state in northern India, experienced significant flooding which adversely affected the provision of care throughout the state's healthcare system. The damage affected public and private facilities, as well as primary, secondary, and tertiary services.[76] Four of the five major hospitals in the capital, Srinagar, were shut down due to the floods. The remaining functioning hospital was overwhelmed with patients and understaffed. Two of the affected hospitals remained closed for two to three weeks, but the others took much longer to be fully functional, requiring repeated cleaning and fumigation. Most of the diagnostic equipment and medical supplies were destroyed in the floodwaters and took months to replace and reinstall.[77]

[71] Timetric's Construction Intelligence Center, (2017b). Project Insight: Global Health Construction Projects. [online] Available at: https://www.timetricreports.com/report/cn0047pi--project-insight-global-health-construction-projects/ [Accessed 7 Dec. 2017].

[72] Zucchi, K. (2013). "Investing in Healthcare Facilities." Investopedia [online] Available at: https://www.forbes.com/sites/investopedia/2013/10/03/investing-in-healthcare-facilities/#12bbbd1b4cd5 [Accessed 7 Dec. 2017].

[73] Knowlton, K., et al. (2009). The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environ Health Perspect. [online] Volume 117(1): 61-67. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2627866/ [Accessed 7 Dec. 2017].

[74] Reuters, (2013). "New York's Bellevue Hospital resumes service after Sandy." Reuters. [online] Available at: http://www.reuters.com/article/us-storm-sandy-bellevue/new-yorks-bellevue-hospital-resumes-services-after-sandy-idUSBRE9160ZQ20130207 [Accessed 7 Dec. 2017].

[75] Evans, M. (2013). "NYC system pegs Sandy costs at $810 million." Modern Healthcare, [online]. Available at: http://www.modernhealthcare.com/article/20130108 NEWS/301089959 [Accessed 7 Dec. 2017].

[76] Sharma, D.C. (2014). Floodwaters cripple health facilities in Kashmir. The Lancet, [online] Volume 384. Available at: http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(14)61754-2.pdf [Accessed 7 Dec. 2017].

[77] Tabish, S.A., and Nabil, S. (2015). Epic Tragedy: Jammu & Kashmir Floods: A Clarion Call. Emerg Med, [online] Volume 4:233. Available at: https://www.omicsonline.org/open-access/epic-tragedy-jammu-and-kashmir-floods-a-clarion-call-2165-7548.1000233.php?aid=40910 [Accessed 7 Dec. 2017].

SECTORAL SNAPSHOTS

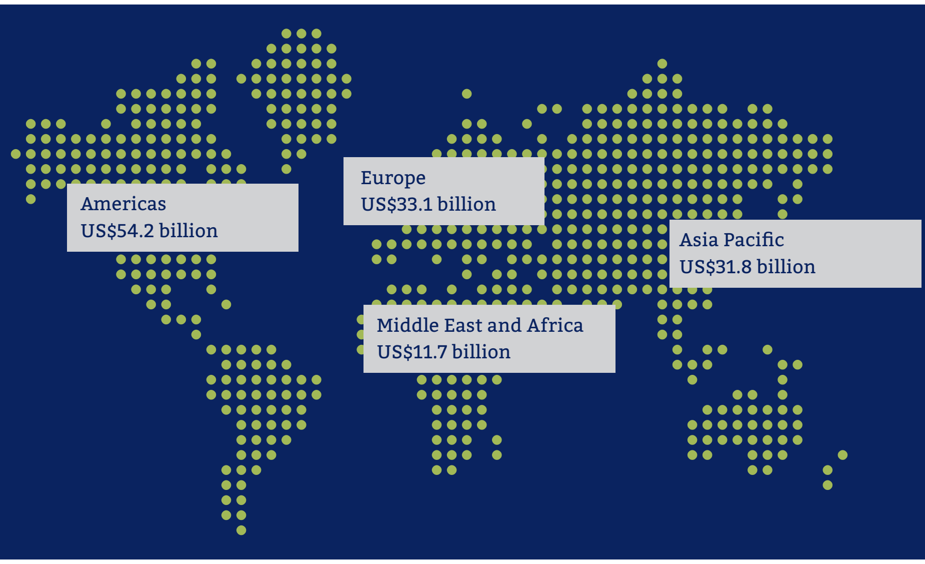
SPORT AND ENTERTAINMENT

The sport and entertainment sub-sector belongs to the Social Infrastructure sector and includes:

- **Public sports infrastructure:** Facilities that are open for use by individuals who are not professional athletes and includes swimming pools, velodromes, climbing centers, indoor courts, and playing fields.
- **Commercial sports infrastructure:** Major facilities that are reserved for exclusive use by professional athletes and includes sports arenas and stadiums.

INVESTMENT POTENTIAL[78]:

Global project pipelines
US$130.8 billion (June 2017)



CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
REVENUES		**Revenues to sports infrastructure can be impacted when weather and climate-related hazards occur. The following are examples of how these hazards may impact revenues:** **Temperature (Acute):** Athletes' performance and health are highly dependent on weather conditions. For instance, extreme temperatures hinder athletes' ability to perform and can even jeopardize their health. As temperatures rise, open-air stadiums may become less attractive than covered or retractable-roofed stadiums. **Temperature (Chronic):** Temperatures are expected to increase throughout the 21st century and this trend may have negative impacts, both on athletes' performance and health, and on associated sporting event profitability, as event attendees may not be willing to attend events in higher temperatures. As a result, some cities and venues may become less attractive locations to host events. However, market opportunities may arise for cities with more temperate weather as well as for air-conditioned sports facilities. **Sea-level Rise (Chronic):** Coastal sports venues are at risk of permanent flooding due to sea-level rise, especially in low-lying areas. **Water Stress (Chronic):** As water supply becomes increasingly scarce, support for water sports (or sports that are water-intensive, such as golf) may be affected as water use is prioritized for more critical uses (i.e., consumption and agriculture). Water shortages and drought may also result in an increased demand for synthetic surfaces. **Combination of hazards:** Increasingly severe weather events are likely to result in more frequent cancelation of sports events and structural damage to sports facilities, disrupting revenue generation. **General:** Climate hazards such as heat waves and extreme weather events are likely to increase the occurrence of sporting event cancelations, potentially leading to declining revenue streams. A study estimates that a venue with greater than a 10% possibility of event cancelation due to weather and climate hazards would make the venue an unviable choice, and that by 2085 the vast majority of 543 cities (outside of western Europe) will face a high risk of event cancelation, with only 1.5% of these cities at low risk of event cancelation due to weather events.

CATEGORY	HAZARDS	POTENTIAL FINANCIAL IMPACTS
COSTS		**Additional costs may be incurred by sports infrastructure because of weather and climate-related hazards. These include increased energy or water costs, maintenance costs, or costs related to higher insurance premiums to protect against loss and damage. The following are examples of how climate hazards may affect costs:** **Temperature (Acute):** Extreme temperatures are expected to affect the temperatures of outdoor pools, a critical element for athlete performance, requiring aquatic facility owners to invest in technologies such as pool blankets to help maintain water temperature at reasonable cost. **Temperature (Chronic):** Indoor venues will likely see a rise in electricity expenses, given that higher temperatures will increase the need for air conditioning to maintain environmental conditions that are conducive to athletes' performance and attractive for event attendees. In addition, the rising demand for air conditioning and increasingly strict regulations regarding energy use may require greater investments in clean (e.g., solar) energy and result in higher energy costs. Higher temperatures and varying precipitation patterns may result in the diminished reliability of snow availability for winter sports events. For sports that cannot be taken indoors, facility managers may be required to invest in artificial snow production systems and snow storage. **Combination of hazards:** Increasingly frequent and intense weather events may result in event delays and/or cancellations. Given that the organization of a major sporting event can cost millions of dollars, cancellations can represent enormous losses. Because of these impacts, it is likely that facility owners will see an increase in insurance costs. Furthermore, facility owners may be required to make capital investments to ensure the viability of their facilities, such as retractable roofs (which allow sports events to take place despite varying weather conditions), water recycling systems (which can help to ensure the continued operation of aquatic facilities even as water becomes scarcer), and flood protection (which protect facilities from inundation due to extreme precipitation and rising sea levels, particularly in low-lying areas).
ASSETS		**Asset values of sports infrastructure may be impacted by ongoing weather and climate-related hazards, particularly those that either (i) wear on asset performance, (ii) require additional (possibly unplanned) investment, or (iii) reduce asset life due to damage or a higher depreciation schedule. The following are examples of how weather and climate-related hazards may impact the asset value of sports and entertainment infrastructure:** **Temperature (Chronic):** Temperature can impact a number of sports infrastructure, including stadiums, sports arenas, and ski resorts. For example, snow availability for winter sports may no longer be sufficient in the future in many locations to support revenues or asset values of corporations that own ski resorts, as as snow levels decrease. Some winter sports events are likely to be relocated to indoor arenas, where conditions can be monitored and controlled more easily. The amount of investment (e.g., capital expenditures) needed for this infrastructure may be significant, but necessary for the longer-term viability of winter sports in locations expected to see reduced rain/snowfall and/or warmer temperatures. For summer sports, as temperatures rise, facility owners are likely to be required to invest in energy-efficient air conditioning systems to respond to the increased need to lower temperatures for athletes and event attendees. **General:** Because many cities around the world will not be suitable for hosting major sports events in the coming decades and beyond due to extreme heat, flooding, and other climate change-related impacts, sports venues that currently exist in such cities are at risk of losing value.

EXAMPLES

Sea-level rise and golf course inundation, USA

A study[80] conducted in 2008 noted that given sea-level rise projections, over 50% of the 1,168 coastal golf courses in the United States that are below two meters above sea-level rise may be partially or totally inundated before the end of the century. Courses that are completely inundated would no longer be viable, and courses that experience partial inundation are likely to see an increase in costs related to, for instance, insurance.

Viability of host cities for the Winter Olympics

Winter Olympic games rely heavily on weather conditions, and poor weather has been identified as one of the main challenges that organizing committees face. A study published in 2014 showed that of the 19 former Olympic Winter Games host cities, 100% were classified as favorable for hosting the winter event between 1981-2010. However, by 2050, only 10 of these cities will be considered "climate-reliable," and by 2080, only six cities will fall under this category.[81] Under these scenarios, the existing sports infrastructure in cities whose climates are no longer conducive to hosting the games would diminish in value and reduce the potential for further investments in sports infrastructure. In cities that are considered "climatically high risk," indoor sports venues will likely face significant increases in costs to maintain needed conditions.

Climate-resilient features of Singapore's Sports Hub

In Singapore, temperatures have risen by 1.1°C and rainfall has become more intense.[82] Singapore's Sports Hub, a US$1.3 billion multi-purpose sports complex includes an aquatic center, multi-purpose arena, museum, library, and mall that can host various types of events, such as concerts and community events. The Sports Hub was built through a public-private partnership between Sport Singapore and Sports Hub Pte. Ltd. and was designed to minimize the impacts of climate variability on sports events. Features include a retractable roof to protect athletes and event attendees from rainfall and intense heat, which enables the facility to continue to hold events despite of extreme conditions.[83] Measures that help to reduce the venues energy costs are: an energy-efficient bowl cooling system, which circulates cool air under seating, and 2,700 solar modules that surround the stadium and,[84] generate renewable energy for the venue as well as reduce heat due to sunlight reflection.

[78] Timetric's Construction Intelligence Center, (2017c). Project Insight: Global Stadium and Arena Construction Projects. [online] Available at: https://www.timetricreports.com/report/cm0042pi--project-insight-global-stadium-and-arena-construction-projects/ [Accessed 7 Dec. 2017].

[79] Smith, K.R., et al. (2016). The last summer Olympics? Climate change, health, and work outdoors. The Lancet, [online] Volume 388(10045): 642-644. Available at: http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(16)31335-6/abstract [Accessed 7 Dec. 2017].

[80] Weiss, J., J. Overpeck, and M. Stachura. (2008). "Global Warming: Our Coast is Under Attack." Golf Digest, [online]. Available at: https://www.golfdigest.com/story/environment_globalwarming [Accessed 7 Dec. 2017].

[81] Scott, D., Steiger, R., Rutty, M., and Johnson, P. (2014). The Future of the Winter Olympics in a Warmer World, [online] Waterloo, Canada: University of Waterloo, Management Centre Innsbruck, Interdisciplinary Centre on Climate Change. Available at: https://uwaterloo.ca/news/sites/ca.news/files/uploads/files/oly_winter_games_warmer_world_2014.pdf [Accessed 7 Dec. 2017].

[82] National Climate Change Secretariat, (2017). "Impact of Climate Change on Singapore." https://www.nccs.gov.sg/climate-change-and-singapore/national-circumstances/impact-climate-change-singapore.

[83] Skyscanner, (2017). "Must-know facts about Singapore Sports Hub´s National Stadium." Skyscanner, [online]. Available at: https://www.skyscanner.com.sg/news/5-must-know-facts-about-singapore-sport-hubs-national-stadium [Accessed 7 Dec. 2017].

[84] Shah, V. (2014). "Singapore's Sports Hub marks new dawn for solar industry." Eco-Business, [online]. Available at: http://www.eco-business.com/news/singapores-sports-hub-marks-new-dawn-for-solar-industry/ [Accessed 7 Dec. 2017].

REFERENCES

Acclimatise, (2014). *Climate Risks Study for Telecommunications and Data Center Services.* [online] Fort Collins, Colorado, US: Riverside. Available at: https://sftool.gov/Content/attachments/GSA%20Climate%20Risks%20Study%20for%20Telecommunications%20and%20Data%20Center%20Services%20-%20FINAL%20October%202014.pdf.

Acosta, L., et al. (2016). Loss and damage from typhoon-induced floods and landslides in the Philippines: community perceptions on climate impacts and adaptation options. *International Journal of Global Warming,* [online] Volume 9(1). Available at: https://www.inderscienceonline.com/doi/pdf/10.1504/IJGW.2016.074307 [Accessed 7 Dec. 2017].

Allianz Global Investors, (2017). *Climate Risk Investment Positioning.* [online] Available at: http://www.allianzglobalinvestors.de/MDBWS/doc/16-2021+Climate+Risk+Investment+Positioning+SH2211.pdf?1bab3f89d4227f4fc20de05b197aa4cced8dd227 [Accessed 7 Dec. 2017].

Alonso, F., and Greenwell, C. (2013). Underground vs. Overhead: Power Line Installation-Cost Comparison and Mitigation. *Electric Light and Power,* [online] Volume 18(2). Available at: http://www.elp.com/articles/powergrid_international/print/volume-18/issue-2/features/underground-vs-overhead-power-line-installation-cost-comparison-.html[Accessed 7 Dec. 2017].

AON Benefield, (2017). *Global Catastrophe Recap.* [online] Available at: http://thoughtleadership.aonbenfield.com/sitepages/display.aspx?tl=724 [Accessed 7 Dec. 2017].

Asia Investor Group on Climate Change, et al. (2015). *Financial Institutions Taking Action on Climate Change,* [online] Geneva, Switzerland: United Nations Environment Programme - Finance Initiative (UNEPFI). Available at: http://www.unepfi.org/fileadmin/documents/FinancialInstitutionsTakingActionOnClimateChange.pdf [Accessed 7 Dec. 2017].

Audinet, P., Amado, J.C., and Rabb, B. (2014). Climate Risk Management Approaches in the Electricity Sector: Lessons from Early Adapters. In: *Weather Matters for Energy* A. Troccoli, L. Dubus, and S.E. Haput, eds., New York, New York, USA: Springer.

BBC News, (2013). “AT&T takes $10bn pensions charge.” *BBC News,* [online]. Available at: http://www.bbc.co.uk/news/business-21071155 [Accessed 7 Dec. 2017].

BlackRock Investment Institute, (2016). *Adapting portfolios to climate change: Implications and strategies for all investors.* [online] Available at: https://www.blackrock.com/investing/literature/whitepaper/bii-climate-change-2016-us.pdf [Accessed 7 Dec. 2017].

Bloomberg New Energy Finance, (2017). *Global trends in clean energy investment.* [online] Available at: https://about.bnef.com/clean-energy-investment/ [Accessed 7 Dec. 2017].

Boniecki, D., et al. (2016). *Middle East and Africa – Telecommunications industry at cliff's edge: Time for bold decisions.* [online] McKinsey & Company. Available at: https://www.mckinsey.com/~/media/McKinsey/Industries/Telecommunications/Our%20Insights/Winning%20the%20rush%20for%20data%20services%20in%20the%20Middle%20East%20and%20Africa/Telecommunications%20industry%20at%20cliffs%20edge%20Time%20for%20bold%20decisions_June2016.ashx.

Brown, J. (2014). “Underwater: Data Centers Nationwide Must Prepare for Flooding.” *Government Technology,* [online]. Available at: http://www.govtech.com/local/Underwater-Data-Centers-Nationwide-Must-Prepare-for-Flooding.html [Accessed 7 Dec. 2017].

Chamber of Commerce & Industry Queensland, (2011). *Impact of the Queensland Floods on Business. CCIQ Survey.* [online] Springhill, Queensland, Australia: Chamber of Commerce and Industry Queensland. Available at: https://www.cciq.com.au/assets/Documents/Advocacy/110204-CCIQ-report-on-the-Impact-of-the-Queensland-floods-on-business.pdf [Accessed 7 Dec. 2017].

Class Codes, (undated). *Definition of NAICS 5 Digit Industry 22112.* [online] Available at: https://classcodes.com/lookup/naics-5-digit-industry-22112/ [Accessed 7 Dec. 2017].

Cordero, C. (2012). “The rise (of flood) in Metro Manila: lessons and opportunities.” Blog Jones Lang LaSalle (JLL) Asia Pacific Research, Available at: http://www.jllapsites.com/research/the-rise-of-flood-in-metro-manila-lessons-and-opportunities/ [Accessed 7 Dec. 2017].

Critchlow, J. (2015). *Business and Investment Opportunities in a Changing Electricity Sector. Insights - Bain.* [online] Available at: http://www.bain.com/publications/articles/business-and-investment-opportunities-in-a-changing-electricity-sector.aspx [Accessed 7 Dec. 2017].

Diamond, K. (2012). Extreme Weather Impacts on Offshore Wind Turbines: Lessons Learned. ***Natural Resources and Environment,*** [online] Volume 27(2). Available at: https://www.lowenstein.com/files/Publication/23b0d113-b158-4a06-a140-9c2e76fa6b25/Presentation/PublicationAttachment/a677f0c5-52bc-4af4-b09c-9d183737da5a/Extreme%20Weather%20Impacts%20on%20Offshore%20Wind%20Turbines.pdf [Accessed 7 Dec. 2017].

Dobbs, R., et al. (2013). ***Infrastructure Productivity: How to Save $1 Trillion a Year.*** [online] McKinsey Global Institute, McKinsey & Company. Available at: https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Infrastructure%20productivity/MGI%20Infrastructure_Executive%20summary_Jan%202013.ashx.

Evans, M. (2013). "NYC system pegs Sandy costs at $810 million." ***Modern Healthcare,*** [online]. Available at: http://www.modernhealthcare.com/article/20130108/NEWS/301089959 [Accessed 7 Dec. 2017].

Frankfurt School of Finance & Management, (2017). ***Global Trends in Renewable Energy Investment 2017.*** [online] Frankfurt, Germany: Frankfurt School-UNEP Centre/BNEF. Available at: http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf [Accessed 7 Dec. 2017].

Frankfurt School of Finance & Management. (2016). ***Global Trends in Renewable Energy Investment 2016.*** [online] Frankfurt, Germany: Frankfurt School-UNEP Centre/BNEF. Available at: https://www.actu-environnement.com/media/pdf/news-26477-rapport-pnue-enr.pdf [Accessed 7 Dec. 2017].

Freedman, A. (2013). "U.S. Airports Face Increasing Threat from Rising Seas." ***Climate Central,*** [online]. Available at: http://www.climatecentral.org/news/coastal-us-airports-face-increasing-threat-from-sea-level-rise-16126 [Accessed 7 Dec. 2017].

Global Commission on The Economy and Climate, (2016). The Sustainable Infrastructure Imperative: Financing for Better Growth and Development. [online] Washington, DC, US: The New Climate Economy. Available at: http://newclimateeconomy.report/2016/wp-content/uploads/sites/4/2016/08/NCE_2016_Exec_summary.pdf.

Global Commission on The Economy and Climate, (2014). Better Growth, Better Climate. [online] Washington, DC, US: The New Climate Economy. Available at: http://newclimateeconomy.report/2014/wp-content/uploads/sites/2/2014/08/NCE-Global-Report_web.pdf.

Global Wind Energy Council. (2016). "***Global Wind Energy Outlook 2016: Wind Power to dominate power sector growth."*** [online] Available at: http://www.gwec.net/publications/global-wind-energy-outlook/global-wind-energy-outlook-2016/ [Accessed 7 Dec. 2017].

Greenfield, R. (2013). "Verizon's Massive Loss Reveals Scope of Damage from Hurricane Sandy." ***The Atlantic,*** [online]. Available at: https://www.theatlantic.com/technology/archive/2013/01/verizon-massive-loss-reveals-scope-damage-hurricane-sandy/319223/ [Accessed 7 Dec. 2017].

Grifman, P.M., et al. (2013). ***Sea Level Rise Vulnerability Study for the City of Los Angeles.*** [online] Los Angeles: University of Southern California Sea Grant Program. Available at: https://dornsife.usc.edu/assets/sites/291/docs/pdfs/City_of_LA_SLR_Vulnerability_Study_FINAL_Summary_Report_Online_Hyperlinks.pdf [Accessed 7 Dec. 2017].

Hedding, J. (2017). "Planes at Phoenix Sky Harbor Airport Grounded When It Gets Too Hot." ***Trip Savvy,*** [online]. Available at: https://www.tripsavvy.com/planes-at-phoenix-sky-harbor-airport-2682513 [Accessed 7 Dec. 2017].

Hill, E. (2016). "Flood Protection Options for Airports." ***Floodlist,*** [online]. Available at: http://floodlist.com/protection/flood-protection-options-airports [Accessed 7 Dec. 2017].

IHS Global, (2013). ***Oil & Natural Gas Transportation & Storage Infrastructure: Status, Trends, & Economic Benefits. Report for the American Petroleum Institute (API).*** [online] Washington, DC, US: IHS Global, Inc.. Available at: http://www.api.org/~/media/Files/Policy/SOAE-2014/API-Infrastructure-Investment-Study.pdf [Accessed 7 Dec. 2017].

International Energy Agency, (2017). ***World Energy Investment 2017,*** [online]. Available at: https://www.iea.org/publications/wei2017/ [Accessed 7 Dec. 2017].

International Energy Agency, (2014). "World needs $48 trillion in investment to meet its energy needs to 2035." ***International Energy Agency,*** [online]. Available at: https://www.iea.org/newsroom/news/2014/june/world-needs-48-trillion-in-investment-to-meet-its-energy-needs-to-2035.html [Accessed 7 Dec. 2017].

Karl, T., Melillo, J. and Peterson, T. (2009). ***Global Climate Change Impacts in the United States.*** Cambridge, England Cambridge University Press.

Knowlton, K., et al. (2009). The 2006 California heat wave: impacts on hospitalizations and emergency department visits. ***Environ Health Perspect,*** [online] Volume 117(1): 61-67. Available at:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2627866/ [Accessed 7 Dec. 2017].

Lloyd's, (2015). ***Case Study: Flood. Lloyd's City Risk Index 2015-2025.*** [online] Available at: https://www.lloyds.com/cityriskindex/threats/flood/case-study [Accessed 7 Dec. 2017].

Mahdavi, R. (2014). Liquid Cooling v. Air Cooling Evaluation in the Maui High Performance Computing Center. Prepared for the U.S. Department of Energy Federal Energy Management Program by Lawrence Berkeley National Laboratory. [online] Available at: https://energy.gov/sites/prod/files/2014/08/f18/cs_maui_high_pcc.pdf [Accessed 7 Dec. 2017].

National Climate Change Secretariat, (2017). ***"Impact of Climate Change on Singapore."*** [online] Available at: https://www.nccs.gov.sg/climate-change-and-singapore/national-circumstances/impact-climate-change-singapore [Accessed 7 Dec. 2017].

Organisation for Economic Co-operation and Development, (2012). ***Strategic Transport Infrastructure Needs to 2030.*** [online] Available at: http://espas.eu/orbis/sites/default/files/generated/document/en/strategic-transport-infrastructure-needs-to-2030.pdf [Accessed 7 Dec. 2017].

Petroleum Tank Management Association of Alberta, (2017). ***Flooding and Underground Storage Systems.*** [online] Available at: http://ptmaa.ab.ca/index.php/ptmaa-news/16-flooding-and-underground-storage-systems [Accessed 7 Dec. 2017].

PricewaterhouseCoopers Advisory Services, (2017). ***Surfing the data wave: The surge in Asia Pacific's data centre market.*** Available at: https://www.pwc.com/sg/en/publications/assets/surfing-the-data-wave.pdf [Accessed 7 Dec. 2017].

Putzier, K. (2017). "Hurricane Harvey put as much as $55 billion worth of Houston's commercial real estate underwater." ***Business Insider,*** [online]. Available at:"http://www.businessinsider.com/hurricane-harvey-55-billion-houston-commercial-real-estate-underwater-2017-9 [Accessed 7 Dec. 2017].

Reuters, (2017). "Hurricane Harvey Damages Could Cost up to $180 Billion." ***Fortune,*** [online]. Available at: http://fortune.com/2017/09/03/hurricane-harvey-damages-cost/ [Accessed 7 Dec. 2017].

Reuters, (2013). "New York's Bellevue Hospital resumes service after Sandy." ***Reuters,*** [online]. Available at: http://www.reuters.com/article/us-storm-sandy-bellevue/new-yorks-bellevue-hospital-resumes-services-after-sandy-idUSBRE9160ZQ20130207 [Accessed 7 Dec. 2017].

Roa, I., Y. Peña, B. Amante, and M. Goretti. (2013). Ports: definition and study of types, sizes and business models. ***Journal of Industrial Engineering and Management,*** [online] Volume 6(4): 1055-1064. Available at: http://www.jiem.org/index.php/jiem/article/view/770/523 [Accessed 7 Dec. 2017].

Rodrigue, J.P., Slack, B., and Notteboom, T. (2017). ***The Geography of Transportation Systems.*** [online] New York, New York, USA: Routledge. Available at: https://people.hofstra.edu/geotrans/eng/ch4en/conc4en/ch4c3en.html [Accessed 7 Dec. 2017].

Rudloff, D., and Schultz, M. (2016). "Top risks in oil and gas: How oil and gas companies gauge the risks they face." ***Oil and Gas Financial Journal,*** [online]. Available at: http://www.ogfj.com/articles/print/volume-13/issue-9/features/top-risks-in-oil-and-gas.html [Accessed 7 Dec. 2017].

Scott, D., et al. (2014). ***The Future of the Winter Olympics in a Warmer World.*** "[online] Waterloo, Canada: University of Waterloo, Management Centre Innsbruck, Interdisciplinary Centre on Climate Change. Available at: https://uwaterloo.ca/news/sites/ca.news/files/uploads/files/oly_winter_games_warmer_world_2014.pdf [Accessed 7 Dec. 2017].

Shah, V. (2014). "Singapore's Sports Hub marks new dawn for solar industry." ***Eco-Business,*** [online]. Available at: http://www.eco-business.com/news/singapores-sports-hub-marks-new-dawn-for-solar-industry/ [Accessed 7 Dec. 2017].

Sharma, D.C. (2014). Flood waters cripple health facilities in Kashmir. ***The Lancet*** [online]. Available at: http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(14)61754-2.pdf [Accessed 7 Dec. 2017].

Skyscanner, (2017). "Must-know facts about Singapore Sports Hub´s National Stadium." ***Skyscanner,*** [online]. Available at: https://www.skyscanner.com.sg/news/5-must-know-facts-about-singapore-sport-hubs-national-stadium [Accessed 7 Dec. 2017].

Smith, K.R., et al. (2016). The last summer Olympics? Climate change, health, and work outdoors. ***The Lancet,*** [online] Volume 388(10045): 642-644. Available at: http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(16)31335-6/abstract [Accessed 7 Dec. 2017].

Statistical Office of the European Union, (Eurostat). (2017). *"Air transport infrastructure, transport equipment, enterprises, employment and accidents." Reference Metadata in Euro SDMX Metadata Structure.* [online] Available at: http://ec.europa.eu/eurostat/cache/metadata/en/avia_if_esms.htm [Accessed 7 Dec. 2017].

Stenek, V., et al. (2011). *Climate Risk and Business – Ports: Terminal Marítimo Muelles el Bosque, Cartagena, Colombia.* [online] Washington, DC: International Finance Corporation. Available at: http://www.ifc.org/wps/wcm/connect/98f63a804a830f878649ff551f5e606b/ClimateRisk_Ports_Colombia_Full.pdf?MOD=AJPERES [Accessed 7 Dec. 2017].

Stout, M. (2013). "Protecting Wind Turbines in Extreme Temperatures." *Renewable Energy World,* [online] Available at: http://www.renewableenergyworld.com/articles/2013/06/protecting-wind-turbines-in-extreme-temperatures.html [Accessed 7 Dec. 2017].

Tabish, S.A., and S. Nabil. (2015). Epic Tragedy: Jammu & Kashmir Floods: A Clarion Call. *Emerg Med,* [online] Volume 5(233). Available at: https://www.omicsonline.org/open-access/epic-tragedy-jammu-and-kashmir-floods-a-clarion-call-2165-7548.1000233.php?aid=40910 [Accessed 7 Dec. 2017].

Timetric's Construction Intelligence Center, (2017a) *Project Insight - Airport Generation Construction Projects: Global.* [online] Available at: https://www.construction-ic.com/pressrelease/high-levels-of-investment-in-airport-construction-projects-in-the-us-and-china-5811160 [online] [Accessed 7 Dec. 2017].

Timetric's Construction Intelligence Center, (2017b). *Project Insight: Global Health Construction Projects.* [online] Available at: https://www.timetricreports.com/report/cn0047pi--project-insight-global-health-construction-projects [Accessed 7 Dec. 2017].

Timetric's Construction Intelligence Center, (2017c). *Project Insight: Global Stadium and Arena Construction Projects.* [online] Available at: https://www.timetricreports.com/report/cm0042pi--project-insight-global-stadium-and-arena-construction-projects [Accessed 7 Dec. 2017].

U.S. Government Accountability Office (GAO). (2014). Climate Change: Energy Infrastructure Risks and Adaptation Efforts. Report to Congressional Requesters. GAO-14-74. [online] Washington, DC: GAO. Available at: http://www.gao.gov/assets/670/660558.pdf [Accessed 7 Dec. 2017].

U.S. Library of Congress, (2006). The Oil & Gas Industry: Transport and storage. *Business & Economic Research Advisor,* [online] Volume 5/6: Winter 2005/Spring 2006. Available at: https://www.loc.gov/rr/business/BERA/issue5/transportation.html [Accessed 7 Dec. 2017].

Verizon, (2017). *"Financial and operational highlights as of December 31, 2016."* [online] Available at: https://www.verizon.com/about/sites/default/files/annual_reports/2016/financial-highlights.html [Accessed 7 Dec. 2017].

Watson, R., McCarthy, J.S., and Hisas, L. (2017). *The Economic Case for Climate Action in the United States. FEU-US,* [online] Available at: https://feu-us.org/case-for-climate-action-us2/ [Accessed 7 Dec. 2017].

Weiss, J., Overpeck, J., and Stachura, M. (2008). "Global Warming: Our Coast is Under Attack." *Golf Digest,* Available at: https://www.golfdigest.com/story/environment_globalwarming [Accessed 7 Dec. 2017].

Wingard, J., and A.S Brandlin. (2013). "Philippines: A country prone to natural disasters." *Deutsche Welle,* Available at: http://www.dw.com/en/philippines-a-country-prone-to-natural-disasters/a-17217404 [Accessed 7 Dec. 2017].

The World Bank, (2016). *Emerging Trends in Mainstreaming Climate Resilience in Large Scale, Multi-sector Infrastructure PPPs.* [online] Available at: https://library.pppknowledgelab.org/PPIAF/documents/2874/download [Accessed 7 Dec. 2017].

The World Bank, (2012). *PHILIPPINES: Integrating Flood Risk Management into Local Planning Saves People's Lives — WB.* [online] Available at: http://www.worldbank.org/en/news/press-release/2012/02/13/integrating-flood-risk-management-into-local-planning-saves-peoples-lives [Accessed 7 Dec. 2017].

The World Bank. (2005), *Air Transport Infrastructure: The Roles of the Public and Private Sectors.* [online] Available at: http://pubdocs.worldbank.org/en/317661434652909047/Air-Transport-infrastructure.pdf [Accessed 7 Dec. 2017].

Zamuda, C. (2016). Climate Resilience and the Energy Sector. In: 6th Forum on the Climate-Energy Security Nexus. [online] Ottawa, Canada: IEA. Available at: https://www.iea.org/media/workshops/2016/6thnexusforum/CraigZamuda.pdf [Accessed 7 Dec. 2017].

Zucchi, K. (2013). "Investing in Healthcare Facilities." *Investopedia,* [online] Available at: https://www.forbes.com/sites/investopedia/2013/10/03/investing-in-healthcare-facilities/#12bbbd1b4cd5 [Accessed 7 Dec. 2017].