

Our Transition

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ADAPTING TO CLIMATE CHANGE: A BUSINESS APPROACH

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PEW CENTER
ON
Global CLIMATE
CHANGE

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Introduction

In 2007, the Intergovernmental Panel on Climate Change (IPCC) affirmed that warming of the climate system is unequivocal, with effects such as increasing land and ocean temperatures, rising global average sea level, and reduced snow and ice already being observed. These changes—which are linked directly to human activities producing greenhouse gases—are already causing changes in ecosystems, water supply and availability, and patterns of extreme events, with (in many but not all cases) consequent damages to human health, buildings, livelihoods, and infrastructure. The question is no longer, “Is there human-caused climate change?” but “What can be done to react and adapt to it?” Adaptation does not preclude steps to reduce greenhouse gas emissions, but recognizes that we are unavoidably committed to some amount of climate change, and that changes are already occurring.

The business community has for some time been aware of the risks and opportunities associated with greenhouse gas mitigation and current and future climate change policies. Many businesses have taken steps to reduce greenhouse gas emissions voluntarily. Many are taking into account some of the impacts of climate change—potential state and federal regulations, shareholder perceptions, and changes in consumer and supplier markets, for example—on the cost of doing business now and in the future. Fewer businesses, however, are incorporating the risks and opportunities associated with the *physical* effects of climate change in their business planning. As trends in climate become clearer and the uncertainty surrounding future changes is reduced, more businesses will want to consider whether to adapt to projected changes by taking action now. This, in turn, involves reacting to and managing risks as well as taking advantage of opportunities.

Climate change represents a new and somewhat daunting topic for many businesses. The challenge is compounded by the diverse and uncertain projections of changes in temperature, precipitation patterns, extreme events, and other effects. This paper outlines a sensible business approach to analyzing and adapting to the physical risks of climate change. It focuses on a critical first step in assessing these climate impacts: understanding the potential risks to business and the importance of taking action to mitigate those risks. Not all businesses need to take action now; this paper develops a qualitative screening process to assess whether a business is likely to be vulnerable to the physical risks associated with climate change, and whether a more detailed risk assessment is warranted.

Section I of this paper offers context on the broader risks and opportunities presented by climate change. Sections II and III summarize the case for business action to adapt to the physical effects of climate change, and the pathways by which climate can affect business. Section IV describes a screening process that

businesses can use to assess whether they are likely to be vulnerable to the physical risks associated with climate change. If the screening indicates that climate change may pose a significant risk, a business can decide whether to undertake a more detailed financial risk assessment, and then, if indicated, take action. Section V presents case studies of three companies that have begun to look at climate risks. These case studies highlight the very different circumstances that motivated each company, and how the companies may be moving towards different conclusions about the appropriate response to the changing climate. Section VI concludes with a summary of key points.

I. Climate Change: A Range of Risks and Opportunities

It is widely recognized that climate change poses potential risks and opportunities to business in the form of current and possible future greenhouse gas regulations and emissions trading systems, changing attitudes of shareholders and consumers, evolving product markets, and actions taken by competitors.¹ Equally, the physical effects of climate change—changes in temperature and weather, water availability, and other changes—can affect business processes, fixed assets like buildings, and resource availability. However, relatively few businesses have climate impacts on their “radar screens.”

Climate change is projected to result in a variety of physical effects, including sea level rise and changes in patterns of temperature, precipitation, and extreme weather events (see text box on *Projected Effects of Climate Change*). These effects will in turn have implications for both managed and unmanaged ecosystems, human health, and other human systems, such as buildings, industrial processes, transportation, energy supply and demand, and infrastructure. Current economic structures, production processes, and supporting systems have all developed over time under relatively stable climate conditions. Taking steps to understand how these conditions are changing, and what the implications might be for different sectors and industries, is an important first step for business to take in deciding whether, and how, to adapt to climate change.

For many businesses, at least some of the physical changes associated with climate change may present opportunities as well as risks.² The construction industry in some locations may face disruptions to construction sites and the delivery of materials as a result of extreme events or damage to transportation infrastructure. Higher temperatures may restrict the amount of time that workers can safely engage in some tasks, such as roofing. Conversely, climate change may provide opportunities for this industry by reducing work stoppages caused by frost, thereby extending the portion of the year during which construction is possible. Adaptation may also create new product markets, such as climate proofing materials and building designs, or result in market shifts, by making locally sourced materials more attractive in order to reduce travel miles, for instance.

Similar examples can be constructed for many other businesses, suggesting that climate change will produce both winners and losers, risks and opportunities. For agriculture, changes in temperature and precipitation patterns will change the crops that are viable in different locations and create an incentive for the development of new crop strains and the adoption of farming techniques suited to the changing climate. Tourism will also face a mixed picture, with opportunities for winter tourism and some ecosystem uses declining, but being replaced in some cases by extended spring and summer recreation opportunities.

The insurance industry also faces a number of risks arising from the physical effects of climate change, including high volumes of claims and the reduced reliability of underwriting based on historical losses. However, opportunities also exist for this industry to adapt by developing and marketing new products, assisting homeowners and business in reducing losses by taking appropriate adaptive action, and enhancing business reputation by taking a proactive stance. Similarly, the higher temperatures associated with climate change can pose risks to some of the laboratory processes associated with biotechnology and chemicals producers. But climate change also poses an opportunity for these industries to deliver new products for agriculture, health, and other sectors to respond to the changing climate.

Business opportunities may also arise from superior management of the risks associated with climate change. Companies that identify and analyze emerging risks earlier than their peers will be better positioned to avoid or mitigate potential damages. They will, for example, be less likely to make investment decisions that lock high-value assets into areas vulnerable to rising sea levels, extreme drought, severe weather events, or other projected climate change impacts, relative to companies that have not yet begun to consider these impacts.

While adaptation by business, government, and households can reduce the impacts of climate change, for the most part it will not eliminate them. Globally, the IPCC reports with high confidence that (1) hundreds of millions of people will be exposed to increased water stress; (2) many species are at increased risk of extinction from rising temperatures; (3) millions of people could experience more coastal flooding; and (4) the health status of millions of people will be affected through increases in malnutrition, death and injury due to extreme weather events and altered spatial distribution of some infectious diseases.³ Countries with fewer resources (many of which are also facing the harmful effects of sea level rise, water shortages, temperature rise, and increased exposure to diseases) will be hard hit by climate change. Even in more developed countries with adequate resources, effects on water supplies, ecosystem health, species diversity, and the effects of extreme weather events can pose significant risks to business and even households. Taking the first step of recognizing these potential risks, and asking the question: “How and to what extent are these risks relevant to decisions I am making today, tomorrow, and in the near future?” is an important action for government at all levels, large and small businesses, and even households to take.

Projected Effects of Climate Change

Changes in the global climate system during the 21st century are projected to include increased average global temperatures and changes in precipitation, sea level rise, extreme events such as hurricanes, droughts, and wildfires, and other effects. Changes projected by the IPCC include:

Temperature increase

- Global average warming of approximately 0.2°C per decade is projected for the next two decades
- Projected longer-term warming (associated with doubled CO₂ concentrations) is likely to lie in the range of 2°C to 4.5°C
- The amount of warming generally increases from the tropics to the poles in the Northern Hemisphere
- Warming will result in fewer cold days and nights, and warmer and more frequent hot days and nights
- Increased frequency, intensity, and duration of heat waves is very likely in central Europe, western United States, East Asia, and Korea

Sea level rise

- Sea level will continue to rise in coming decades due to thermal expansion and loss of land ice at greater rates
- Sea level rise of 18 to 59 centimeters is projected by the close of the 21st century
- Projected warming will continue to contribute to sea level rise for many centuries after greenhouse gas concentrations are stabilized

Precipitation and humidity

- High latitudes will generally see increases in wet days and precipitation, and subtropical areas will generally see increases in dry spells
- Increases in annual precipitation are expected in most of northern Europe, Canada, the northeast United States and the Arctic
- Winter precipitation is expected to increase in northern Asia and the Tibetan Plateau
- The length and frequency of dry spells over the Mediterranean, Australia, and New Zealand is expected to increase, with increased seasonable droughts over many mid-latitude continental interiors

continued on next page...

Projected Effects of Climate Change—continued

Extreme wind and rain storms and other events

- Increased intense tropical cyclone activity
- Increased frequency of flash floods and large-area floods in many regions
- Increased risk of drought in Australia, eastern New Zealand, and the Mediterranean, with seasonal droughts in central Europe and Central America
- Increased wildfires in arid and semi-arid areas such as Australia and the western United States

Other related effects

- Decrease in snow season length and snow depth over most of Europe and North America
- Fewer cold days and nights leading to decreased frosts
- Accelerated glacier loss likely over the next few decades
- Expected reduction in and warming of permafrost

Sources: IPCC 2007a and 2007b; Solomon, Qin, and Manning 2007.

II. The Case for Business Adaptation: What is at Risk?

Business efforts to address the potential risks posed by the physical effects of climate change have in general lagged behind consideration of the financial risks associated with mitigation. Moreover, although the hurricanes, cyclones, heat waves, and other extreme events of recent years alerted many to the potential direct impacts of extreme events, there is generally less appreciation of the effects of changes in longer term average conditions and seasonal variation in temperature and precipitation.⁴

Susceptibility to the physical effects of climate change varies considerably across sectors of the economy. A number of studies identify the types of risks that the physical effects of climate change impose on different sectors, as illustrated in Table 1. While some sectors are particularly at risk, all businesses face the possibility of property damage, business interruption, and changes or delays in services provided by public and private electricity and water utilities, and transport infrastructure.

Many businesses already take weather into account in planning, or are located in areas where changes are occurring in the intensity or frequency of extreme events, such as storms, droughts, or flooding. These businesses are more likely to have concerns about the physical effects of climate change, and in some cases are already responding. The insurance industry has for a number of years been a leader in identifying climate-related risks to property, health, crops, business interruption, and other activities subject to insurance (see the case study on Travelers, presented in Section V, for examples of actions a leading insurer has taken on the issue). The case study on Entergy (also in Section V) illustrates how one business has reacted to extreme events not only by adjusting in the short term, but also by incorporating climate change into longer term planning.

Some businesses that have begun to experience the effects of climate change are taking action to adapt. While warmer winters may be a boon for bikers and hikers, businesses that rely on snow and cold temperatures—including winter tourism and some diamond mines—are beginning to feel the bite of warmer winters. Ski resorts in Western Montana—near Glacier National Park where the area covered by glaciers has dropped by nearly three quarters since 1850—have in recent years suffered from lack of snow. *The Washington Post* in 2006 reported that the owner of a ski resort in Montana was trying to persuade the United States Forest Service to lease him 12,000 acres of land adjoining his resort that were at a higher elevation. At the same time, he was negotiating with snowmaking manufacturers, who were asking for tens of millions of dollars for their services.⁵ Meanwhile, according to *The New York Times*, resorts in the Swiss Alps are investing in new spas and other non-ski attractions in order to continue to lure tourists as projections call for diminished snowpack due to climate change.⁶

Table 1. Potential Effects of Climate Change on Selected Sectors

Sector	Example Risks Resulting from Physical Effects of Climate Change
Electric Utilities	<p>Peak electricity demand due to warmer and more frequent hot days could in some regions exceed the maximum capacity of current transmission systems and will be combined with system stresses due to heat</p> <p>Increased risk of damage to facilities and infrastructure from extreme and unpredictable weather conditions</p> <p>Uncertainty over energy output from hydroelectric plants due to potential water shortages</p> <p>Uncertainty over water supplies for cooling power plants</p>
Mining	<p>Extreme weather events increase physical risk to business operations, for example due to flooding</p>
Integrated Oil & Gas	<p>Negative business impacts due to weather changes and natural disasters</p>
Food, Tobacco, & Beverages	<p>Risk of food supply and operations interruptions due to extreme weather events</p> <p>Longer term weather trends may affect reliability (and quality) of supply of fresh produce</p> <p>Physical risk to water supply and raw materials</p> <p>Greater risk of animal infections (e.g., avian flu), insect infestation, plant disease, wildlife damage, etc.</p>
Building Design & Construction	<p>Extreme weather events may disrupt transport for site deliveries and affect site work (e.g., muddy site conditions), restricting work-days</p> <p>Infrastructure (e.g., drainage) affected by extreme weather events</p> <p>Excessive heat in summer will affect some construction processes and onsite workforce</p> <p>Design standards may need to be clarified or upgraded in response to changing climate</p> <p>Insurance may be more expensive or difficult to obtain for existing buildings, new buildings, and during the construction process</p>
Insurance	<p>Increased need to develop catastrophe models to evaluate capital adequacy and overall natural catastrophe exposure</p> <p>Disruptions to business operations become unpredictable and more financially relevant</p> <p>Competition for water resources between agricultural and urban developments increases commercial risks with impacts on crop insurers</p> <p>Increased risks to human health (thermal stress, vector-borne diseases, natural disasters)</p> <p>Prolonged periods of poor weather or extreme events increase costs of claims and make it more difficult to deal with high volumes of claims</p>
Agriculture	<p>More refrigerated distribution and storage required and problems with livestock transportation in summer heat</p> <p>Damage to transportation infrastructure or disruptions in services due to floods, etc. creating problems with transporting raw materials</p> <p>Limited availability of water and potential interruption of supply to irrigation systems</p> <p>Equipment and other investments, as well as expertise of farmers and workforce, are linked to specific crops, which may become unprofitable or may no longer be viable</p> <p>Quality issues: overheating of grain, or availability of water for pre-washed products</p> <p>Access to land during flood or extreme rain conditions</p> <p>Less frequent frosts will affect quality of certain crops and reduce kill-off of pests/disease</p> <p>Exposure of workforce to increased heat</p> <p>Farm buildings affected by extremes of wind, heat, rain (animal welfare issue)</p>
Motor Manufacturing	<p>Supply chain interruptions and vulnerable transport systems carrying high value products around the world (e.g., one ship carries over \$60 million of product)</p> <p>May need vehicles that tolerate new extremes of climate, including greater intensity of rainfall (affecting seals, wipers, tires) and increased need for cooling</p> <p>Process environment will become hotter with increased need for cooling—particularly important for comfort/health of workforce and performance of production processes</p> <p>Increased drying time for painted products as a result of increased humidity</p>

Sources: CDP 2007, UKCIP 2005, Risk Solutions 2005, IPCC 2007b, Overbye et al. 2007.

Diavik Diamond Mines Inc. in Canada provides another example. Diavik hauls thousands of tons of equipment, fuel, and supplies for its mining operation on an “ice highway” built over frozen rivers, lakes, and tundra. *Business Week* reported that, due to higher temperatures in 2006, the road was shut down early, and that the ice never was thick enough to support the weight of big trucks. Faced with the choice of slowing operations, executives opted to haul the mine’s diamond output using an expensive airlift.⁷

While some businesses are being forced to recognize the need for immediate adaptation, few are contemplating *proactively* adapting to expected future changes. A report recently released by the Carbon Disclosure Project (CDP)⁸ indicates that nearly 80 percent of the 500 corporate respondents (representing the largest publicly traded companies in the world and covering a range of industries) considered climate change to present some sort of commercial risk.⁹ However, most respondents were much less concerned with physical effects than with other risks, particularly the risks associated with regulations and higher energy prices resulting from mitigation efforts. Only sectors with significant operations in areas subject to extreme weather events (either due to the nature of operations or location in an area prone to extreme events, such as the Gulf Coast of the United States) consistently listed physical risks as a concern of climate change.

In the CDP report, four sectors—Insurance, Oil and Gas, Electric Utilities, and Beverages, Tobacco, and Food Products—expressed the most concern about climate change and, in some cases, reported adaptive actions and/or analyses that had been taken (see Table 2). In some cases (also described in Table 2), respondents in a given sector were split, with one or more recognizing potential physical risks from climate change, but others reporting no risks. While extreme events were of most concern, businesses in some sectors have also begun to consider other risks of climate change, such as water availability.

Some businesses have begun to take steps to evaluate and potentially respond to the physical effects of climate change,¹⁰ but for many, the perception remains that these effects—temperature rise, hydrology changes, storms, and sea level rise—are either irrelevant to business decisions or too uncertain. In the next section, we begin to break down the problem of assessing climate impacts into more tractable components.

**Table 2. Results from the Carbon Disclosure Project:
Examples of Business Action to Address Physical Effects of Climate Change**

BUSINESSES THAT HAVE ACTIVELY TAKEN STEPS TO ADAPT TO CLIMATE CHANGE		
Sector	Type of Adaptive Action	Company Examples
Beverages & Tobacco, Food Products, and Food & Drug Retailing	Increased frequency and intensity of extreme weather events has generated significant concern through these sectors, with particular attention given to the availability of future water resources.	Anheuser-Busch is active in seed research design to develop crops that are resistant to extreme weather events, and its Water Council manages water-related issues related to its supply chain, products, and local communities. Heineken developed an Aware of Water program to establish water usage targets for its facilities. Unilever has partnered with several stakeholder groups to develop sustainable agriculture programs that focus on ways to improve farming efficiency and minimize water use.
Insurance	Insurance companies are actively taking steps to develop strategies to manage the risks associated with climate change.	Travelers is working to develop more accurate underwriting tools, such as catastrophe models, to establish appropriate exposure-based rates for insurance. Munich Re has formed a global weather risk business that offers capital market solutions, such as catastrophe bonds (that transfer risk) and weather derivatives.
Electric Utilities	Long-term increases in energy demand and water shortages are compelling companies to invest more heavily in increased capacity and improved transmission and distribution networks.	Fortum launched a program in 2005 to increase the reliability of its distribution network and halve average yearly outage time by 2011. Chubu is expanding fuel-related infrastructure and taking other actions. Iberdrola and E On AG made commitments to improve grid management and power station usage.
DIFFERENCES IN APPROACH TO PHYSICAL EFFECTS WITHIN A SECTOR		
Sector	Physical Risks Not Identified	Physical Risks Presented by Climate Change Acknowledged
Aerospace and Defense	Boeing stated that “no specific physical risks have been identified.”	Northrop Grumman, after experiencing significant impacts due to Hurricane Katrina, recognizes that “any severe weather conditions could have an impact on the business due to property structure damage, temporary shut down of production, or inability of employees to reach the worksite.”
Computers and Peripherals	Toshiba responded, “Our operations are not affected by climate changes at this moment.”	Hewlett Packard replied, “Our worldwide operations could be subject to natural disasters and other business disruptions, which could seriously harm our revenue and financial condition and increase our costs and expenses” and has developed a risk-based business continuity program to protect people, property, the environment, and continuity of operations.
Food and Drug Retailing	Seven & I Holdings, in response to the question about physical risks of climate change, replied “none.”	Tesco divided physical risks into three categories: risks to store operations, risks to supply chain, and risks to customers. The company stated that “Tesco currently has store operations in a number of developing countries which may be more exposed to climate change,” and that “physical changes to our environment may also put existing sources of products, or the companies that supply us, at risk.”
Investment Banks and Brokerages	Charles Schwab replied “N/A” to the question about physical risk of climate change.	Lehman Brothers stated, “Physical risks pose a threat to the operations of all financial services firms and therefore to the financial markets overall.”

Source: CDP 2007

III. The Risk Disk and The Adaptation Challenge

Both the need for—and the complexity of—adaptation hinges on the fact that the future climate will not be like the past. Because of the buildup of carbon dioxide in the atmosphere from human activities, patterns of climate change in the 21st century will differ from those in the 20th century. As a result, past trends cannot be used reliably to predict future changes.¹¹ A 100-year-flood, for example, may in some locations occur more frequently, posing problems for water resource managers, land use planners, and others. Many of the recent trends in climate change—such as rates of sea level rise, temperature increase, and reduction of glacier mass—are accelerating.^{12,13} Moreover, climate change includes the potential for “surprises.” Because climate is highly complex, sudden or discontinuous change is possible, or it might evolve quite differently from what is expected.¹⁴ There is also a risk that certain tipping points for climate impacts may be crossed, such as the disappearance of the Greenland ice sheet.¹⁵ Surprises challenge humans’ ability to adapt, because of how quickly and unexpectedly they occur.

The key to successful adaptation is determining the magnitude of the risk, and identifying what actions are available and should be taken to respond to the risk. It will be prudent to take climate change into account if it materially affects a company’s operations, its value chain, or its broader commercial environment. Consequently, understanding whether adaptation is necessary—and what adaptation can accomplish—requires taking a closer look at the dimensions of possible impacts on business.

Climate change may result in adverse business outcomes, including business interruptions, increased investment or insurance costs, or declining financial measures such as value, return, and growth, or other measures of business success. These outcomes (i.e., impacts) will be determined by the types of climate effects the business is exposed to and the likely effects of exposure on the business. As illustrated in Figure 1,¹⁶ the risk of adverse impacts of climate change is a function of probability and outcome; in this case, the probability of business exposure to climate change and the potential outcomes of that exposure. In turn, the risk of adverse outcomes can be addressed by adaptive actions, ranging from acceptance to management of the risk. Risk combined with actions taken (or not taken) to adapt yields a net vulnerability of the business to the physical effects of climate change.

Figure 2 illustrates the pathways by which the physical risks of climate change can affect business.¹⁷ This figure—entitled the “Risk Disk”—illustrates three types of risks. Risks to core operations, such as physical plants, are indicated in the innermost circle. Risks to the value chain are listed in the medium blue ring. The outermost ring displays risks that arise because of broader changes in the economy and infrastructure.

Core operations. Climate change may have direct effects on business production facilities, buildings, and sites.

- Physical structures and assets of the business may be at direct risk from weather extremes, requiring design and/or location changes, affecting asset values, or causing physical damage.
- Climate may directly influence the effectiveness or efficiency of production processes, the cost of operations and maintenance activities, or the quality of a product. For example, a production process—whether construction or industrial—may be dependent on ambient temperatures.

The value chain. Climate change may also influence the quality or quantity of inputs into production, or the demand for product. Climate will have impacts on natural resources, such as agricultural and forestry products. Water availability or quality—for some production processes or irrigation for agriculture—may be affected. If effects of climate on water resources include quality—through salt water intrusion or higher dissolved oxygen levels, for example—more stringent effluent and pollution regulations may be forthcoming to maintain quality. Impacts of climate on health and safety of the workforce may necessitate taking precautions for workers, e.g., construction workers during heat waves. Increased illness in the population more broadly may affect work attendance or health care costs. Demand for products may also be affected by climate impacts. For example, demand for cooling in summer months is likely to rise, whereas demand for products related to winter tourism may fall in some locations.

The broader supply and demand network. Publicly- and privately-owned utilities, services, and related infrastructure provide support to business operations and production processes, and to supply chains and distribution networks. Disruption to utilities, especially electricity generation, water supply, and sewerage can affect the supply chain. In addition, extreme weather events associated with climate change, such as flooding or high winds, may damage transport infrastructure or slow delivery of inputs and supplies via road or rail. A general increase in temperature and a higher frequency of hot summers are likely to result in an increase in buckled rails and rutted roads, which involve substantial disruption and repair costs.¹⁸ Structural failures in

Figure 1. Determining Vulnerability

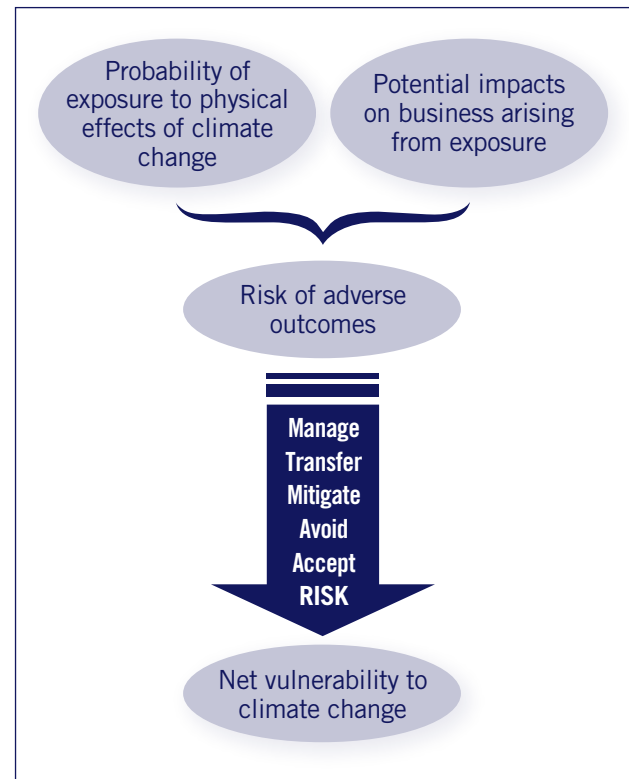
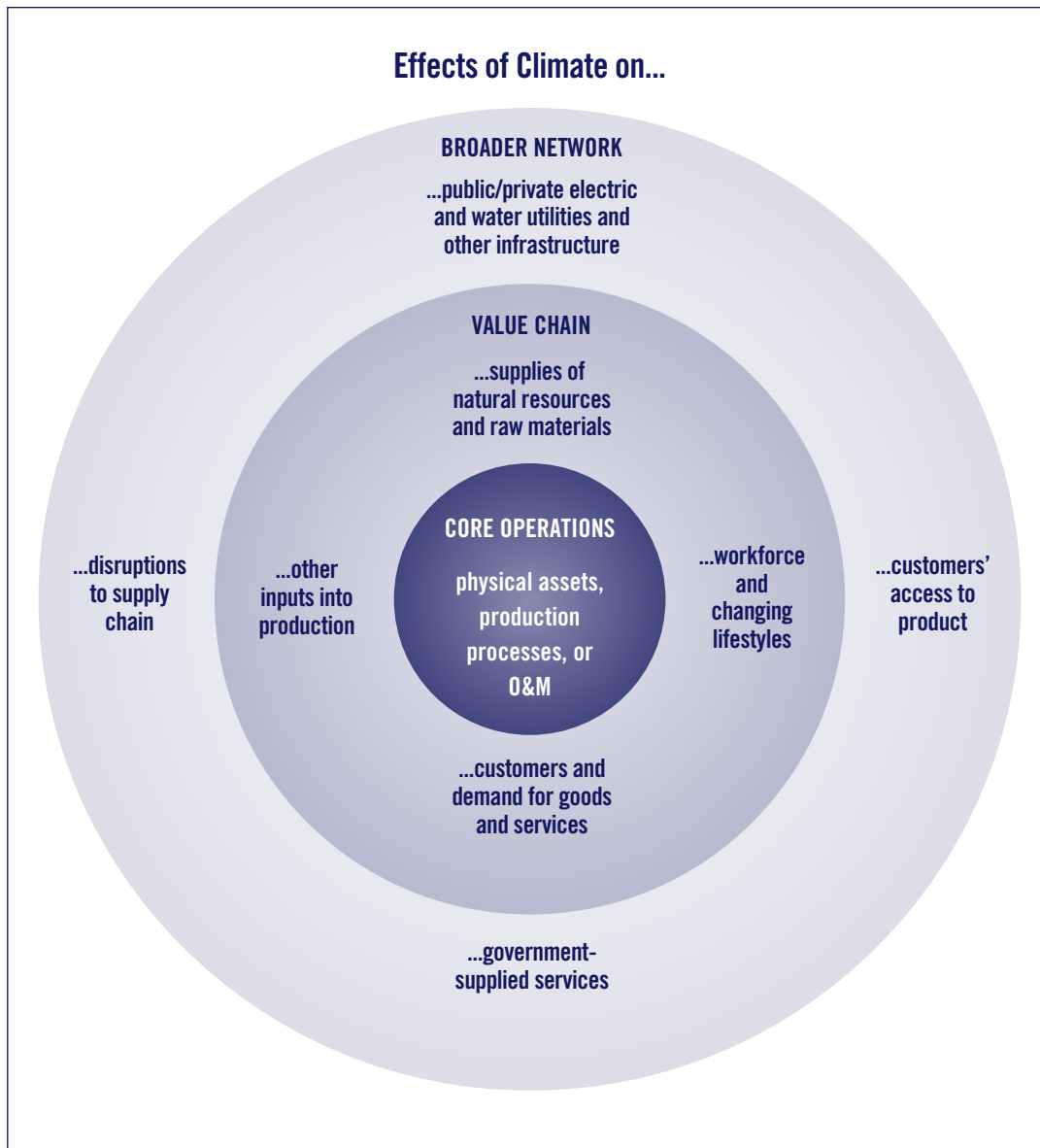


Figure 2. The Risk Disk



transportation and industrial infrastructure are becoming more common as a result of permafrost melting in northern Russia.¹⁹ These services and infrastructure also provide customers with access to the goods and services of the business. During extreme events, such as hurricanes, disruptions in access may affect not only the supply of inputs and product deliveries, but also the ability of workers to reach the workplace, or customers to access the business. Adapting to these types of effects may require working with government and utilities to ensure that adaptive actions—which may be outside the direct control of the business—are taken.²⁰

IV. Meeting the Challenge: Screening for Climate Impacts and Adaptation

With impacts already being observed, it is no surprise that some businesses have begun taking steps to adapt to climate change. Many of these actions are *reactive*—i.e., businesses are responding to climate change and impacts that have already occurred, or to observed trends in climate.²¹ Most obviously, some businesses have begun to move headquarters or operations out of harm's way, as in the case of Entergy (see case study in Section V). Other businesses are beginning to make—or consider—process changes in response to changing climate. For example, some farmers have expressed interest in purchasing drought and flood resistant seeds in response to increased weather extremes.²² Insurance companies are beginning to take steps to reduce losses—both by encouraging loss mitigation by customers and by changing underwriting procedures—as in the case of Travelers and others.²³

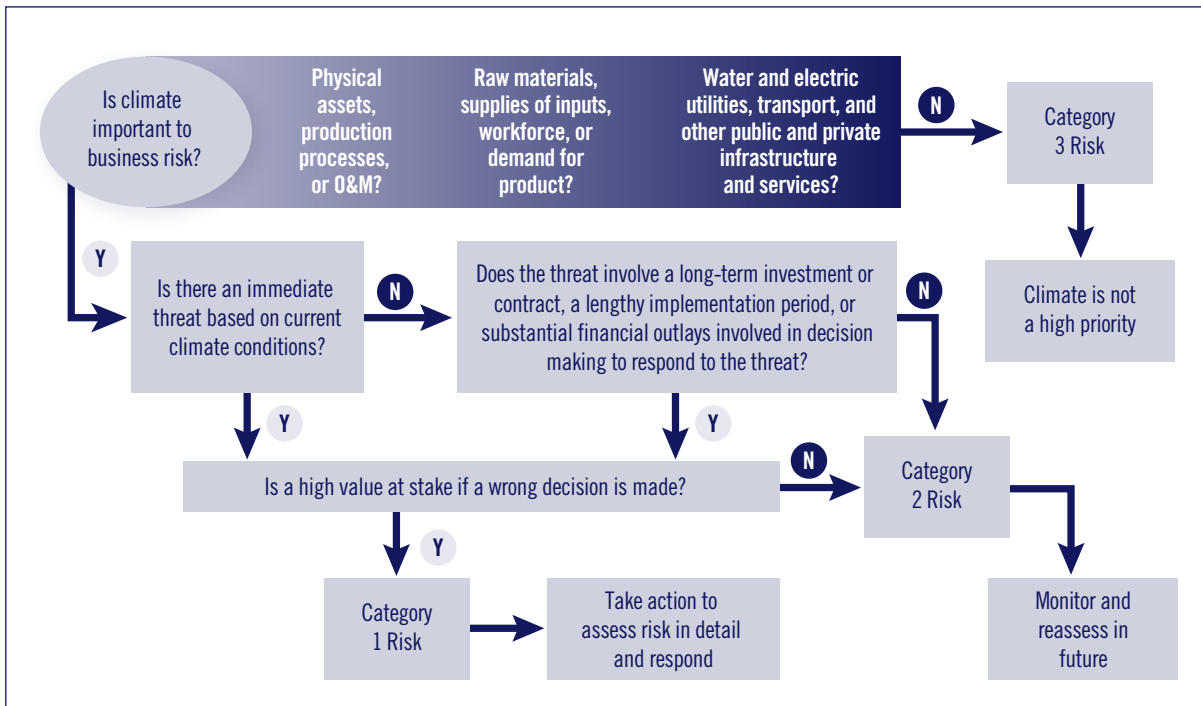
Successful adaptation over the long term, however, requires recognizing and acting on threats from an early stage—often before they occur—and identifying appropriate proportionate responses.²⁴ Moreover, tackling climate change effectively may require companies to challenge their embedded routines for dealing with weather—requiring a shift in thinking away from reliance on historical trends and decisions, to one that assesses projected climate changes and the likelihood of those changes. Thus, *proactive* adaptation options that consciously anticipate future climate change and incorporate these options into decision making will be less obvious and more difficult to identify and evaluate.

For example, climate change may be an important factor in the siting of a new production facility or electricity generation plant. Many electric power plants rely on nearby rivers and lakes to draw in water for cooling purposes. Reduced water levels could limit the amount of water available for these purposes, and rising water temperatures could reduce the cooling efficiency of the water.²⁵ New power plants may be designed with recirculating or even dry cooling systems to reduce their need for water, or choose to locate where water supplies will be more reliable under climate change. Similarly, facilities that discharge into streams may have to treat discharge water to meet more stringent water quality standards in streams that have lower water levels under climate change. A risk assessment that evaluates decision making in the context of long term climate trends can identify and evaluate these alternative options. Screening to identify the potential risks of near-term and long-term climate change is the first step in determining whether or not a risk assessment is necessary to identify further actions.

The purpose of the screening is to determine whether the business might be at risk, what aspects are at risk and from what, and whether a more complete risk assessment is needed to determine exactly what, if any, actions are needed. The goal of the screening is to classify/screen risks into one of three categories: assess now,

wait and study, and take no action. Screening (as illustrated in Figure 3) to identify whether climate change is a potentially important factor in current decision making involves several steps: identifying sensitivities, identifying the types of decisions susceptible to climate change, and evaluating the magnitude of what is at risk.

Figure 3. Screening for Climate Risks



Question 1. Is climate important to business risk?

Answering this question entails identifying aspects of the business that are sensitive to weather and climate and could be at risk from climate change. This requires, first, identifying projected climate and physical effects of climate change in regions/areas where business operations, supplies, or customers are located, or where supply and/or distribution networks are located. These effects can then be compared with an inventory of key operations and assets in these locations to identify possible threats to the business “risk disk,” i.e., to determine which aspects of business are sensitive to weather or climate. For example, operations that can be disrupted by flooding, or that are dependent on seasonal temperatures or weather may be sensitive to climate. Businesses that have design standards keyed to weather/hydrologic extremes—such as a 100-year flood, a 2-year 24-hour rainfall event, a 100 kilometer/hour wind, or a category 3 hurricane—will be susceptible to possible changes in the frequency or intensity of such events. Businesses with a history of weather-related damages will also likely be sensitive to the types of changes projected for climate change.

Rio Tinto (see the case study in Section V) conducted a screening much like this at the start of their climate change investigation. They relied on the climate data contained in the IPCC’s Third Assessment, and they are

now revisiting that screening using newer information from the Fourth Assessment.²⁶ The results of their initial screening suggested that they look into climate effects more carefully, and so they have conducted additional studies and, as a result, updated engineering standards in a number of locations.

Quantifying uncertainty of climate effects is not critical in this stage of the screening (as it would be in a risk assessment), although uncertainty may be a factor in identifying the types of climate effects evaluated. Not all climate effects (or magnitudes of those effects) are considered equally likely by scientists; a more cautious (or risk-averse) approach to screening might also include climate effects or magnitudes of some effects that scientists consider less likely to occur, but could be potentially damaging to the business. For example, the risk of additional contribution to sea level rise from both the Greenland and possibly the Antarctic ice sheets may be larger than projected by ice sheet models,²⁷ suggesting that the current range of projections for sea level rise do not reflect one tail of the distribution—i.e., the non-zero probability of much greater increases in sea level.

Question 2. Is there an immediate threat? Or are long-term assets, investments, or decisions being locked into place?

Answering this question entails evaluating the immediacy and nature of the potential threat. Not all climate sensitive assets or operations need to be protected in the short term. Clearly, if there are immediate threats, they should be dealt with. But some adaptive decisions can wait for more information or until the threat of damages is more immediate.

In some cases, however, it will be prudent to begin to evaluate adaptation options now even if no threat is evident. This will be the case for assets that are long-lived and where decisions are being made currently about where to site and what design standards to build to, or even whether to build. Decisions made today of where to site a hotel for winter tourism, what type of power plant to build and how to protect distribution and transmission lines, or what orchards to plant, will all have implications decades down the road, and so continuing trends in climate change as far away as the next twenty to thirty years will be relevant to choices made today. Similarly, the design of long-term contracts for supplies of natural resources or food products may need to consider the implications of changing climate over the next few years. Methods of transport that have been used in the past may not be available or cost-effective in the future, and so locating closer to suppliers or customers may make sense. The idea is that decisions made now will determine vulnerability in the future; it is desirable to avoid regret and not to undertake investments or make decisions that may prove irreversible or costly in the face of likely future climate scenarios.

The siting of buildings located in areas susceptible to sea level rise and storm surges is a case in which long-term climate considerations may deviate from current conditions, necessitating relocation. Not only might some areas be submerged, but areas not previously at risk could become so. Further, short-term adaptations may turn out to be unprofitable in the longer-term, unless not only observed trends, but climate projections

that include both averages and variability, are taken into account. For example, more than half a decade ago an unusually long period of dryness led farmers in western Iowa to switch from corn to a more drought-resistant sorghum, only to find themselves struggling with unseasonably cool and wet weather.²⁸

The potential for extreme events—such as hurricanes—to increase in severity or frequency has implications for long-lived assets that require proactive, rather than reactive adaptation. For example, a company that built its facilities to withstand a category 3 hurricane may need to consider strengthening to withstand a category 4 or 5. Companies farther inland may be forced to rethink normal operations and emergency response plans, as well, if business depends on certain ports being open in order to ship products or receive supplies.²⁹ By identifying ways in which climate may change, and mapping these to climate sensitive business considerations, the screening process can help to identify circumstances in which climate sensitive decisions are likely to be influenced by these and other longer term trends and projections.

Question 3. Is a high value at stake if a wrong decision is made?

The final step in the screening is to estimate how large the cost of a wrong decision is—what is the magnitude at stake—and is it large enough to necessitate additional research and evaluation? This step may involve looking at the rough size of an investment, the likely change in cash flow, impacts on firm value or reputation, the importance of a particular market or growth goals, or other measures of business success. If it is large—in the context of other business planning—then a more comprehensive risk assessment that looks in more detail at climate projections, operations, supply and demand chains, and business decisions may be in order.

The screening cannot indicate where adaptation to long-term climate change is needed, but only where risk assessment and risk management might be appropriate. Three possible outcomes are indicated in Figure 3:

- Category 1—potential significant climate risk that may need to be managed in the short term.
- Category 2—potential climate threats that need to be monitored and reassessed over time.
- Category 3—climate risks do not appear significant, no further analysis is required.

In turn, Category 1 risks may require in-depth assessment and development of risk management strategies to adapt to climate change over the next few decades. In some cases, subsequent risk assessment may suggest a rapid and comprehensive response. While Entergy is still evaluating long-term solutions, steps have been taken to relocate and protect long-lived assets, including transmission and distribution centers. In contrast, Rio Tinto's evaluations have led to less dramatic steps. An initial screening suggested to Rio Tinto that there were potential climate risks. A more detailed risk assessment concluded that design standards should be improved to withstand increased frequency and intensity of extreme events. However, although risk assessment is continuing, Rio Tinto's initial conclusion is that while mines and other assets are long-lived, they are constantly evolving and so it should be possible to adapt over time as evidence accumulates of additional climate change impacts.

V. Case Studies: Three Business Responses to Climate Risks

It may be prudent to take climate change into account if it materially affects a company's operations, its value chain, or its broader commercial environment. Businesses that are most likely to be at risk from climate change are in those sectors that are currently affected by weather events, those that make long-term investments, and those that are global in nature and so may be adversely affected by events in developing countries where impacts are more likely to be felt.³⁰ Not all businesses need to take action now to adapt to climate change, or even undertake a complete risk assessment; an initial screening can help determine whether business is likely to be at risk, and whether a full risk assessment makes business sense.

Three companies—Entergy (engaged primarily in electric power generation and distribution), The Travelers Companies, Inc. (provider of personal and commercial property and casualty insurance), and Rio Tinto (an international mining group)—have each taken projections of changes in temperature, precipitation, and other variables seriously. The case studies for these companies, presented below, illustrate how each company screened for climate risk, and the further assessments and steps that each has taken. The case studies were developed through telephone interviews and e-mail exchanges with key company officials. All three companies are members of the Pew Center's Business Environmental Leadership Council (BELC).

The potential for—and actual—damage from extreme events was a key motivation in the decision of the companies to examine climate risks more closely. In the case of Entergy, it was the very real effects of Katrina and other hurricanes that first spurred the company to move the location of key business centers out of harm's way, and subsequently to look more carefully at location decisions and business contingency plans. Travelers, like other insurers and reinsurers,³¹ was concerned about observed trends in insurance losses, and ways to mitigate those losses, due primarily to the effects of extreme events on household and commercial customers. Adaptation, in this case, refers both to changes in insurance practices, such as pricing and underwriting, and to changes in behavior by the insured. For Rio Tinto, the events were less extreme, but the potential damages no less troubling: both extreme flooding and prolonged drought can pose problems for their mining activities, raising questions of whether changes in engineering standards or practices in different locations might be warranted.

Each of the companies initially conducted a risk screening, followed by more detailed risk assessments. While the broad screenings were concluded relatively quickly, conducting detailed risk assessments and making decisions about longer-term responses to climate change has been a more protracted process, involving not only commitment at the executive level, but also interdisciplinary groups and, in most cases, the use of outside experts to supplement in-house expertise. The three companies have used different sources of data—

ranging from trend analysis, to IPCC projections, to detailed climate projections—depending on the level of detail needed. They have also come to different conclusions about the need for immediate action to protect long-term interests.

The three companies are evaluating the range of climate risks—from risks to core business operations, to their value chains (including supply and demand chains and effects on the workforce), and more broadly to the network of supporting infrastructure that is supplied and maintained by government and other private sector companies. Travelers, in particular, has not only made internal changes, but has also worked with other organizations to achieve broader adaptive changes by, for example, encouraging hurricane preparedness by homeowners and communities. Entergy has also recognized the broader implications of extreme events in developing its contingency plans; while the headquarters building (located next to the New Orleans Superdome) itself was relatively unaffected by Katrina, the devastation in the surrounding area made it impossible for employees to get to work, highlighting for them the importance of adaptive planning. Entergy is working with governments and environmental organizations to preserve Louisiana’s coastal wetlands, which help to blunt the impact of major storms along the state’s coastline.

Entergy Corporation: A Climate Wakeup Call—The First Step Was Admitting There Was a Problem

Entergy Corporation is an integrated energy company engaged primarily in electric power production and retail distribution operations. Entergy owns and operates power plants with approximately 30,000 megawatts of electric generating capacity, and is the second-largest nuclear generator in the United States. Entergy delivers electricity to 2.6 million utility customers in Arkansas, Louisiana, Mississippi, and Texas. It has annual revenues of more than \$10 billion and approximately 14,500 employees. In 2001, Entergy set a voluntary goal of stabilizing emissions at 2000 levels through 2005, becoming the first electric utility in the country to announce such a target. After meeting that goal, it set a new target in 2006 to reduce greenhouse gas emissions from its operating plants and stabilize those emissions at a level 20 percent below year 2000 levels from 2006-2010.

Visit <http://www.entergy.com/>

After suffering \$2 billion in losses from Hurricanes Katrina and Rita, Entergy considers itself the “prime example of the potential negative physical effects of climate change,” says Brent Dorsey, Entergy’s Director of Corporate Environmental Programs. While Entergy points out that the 2005 hurricanes cannot be clearly linked to climate change, the New Orleans-based energy company believes the storms can be viewed as a sign of things to come if greenhouse gas emissions are not brought under control. Facing significant infrastructure damages and forced relocations of several offices located in New Orleans, the hurricanes prompted CEO Wayne Leonard and other senior managers to begin preparing for potential future climate impacts and adapting to observed changes in climate. Climate change considerations became one of the pillars in a broader business continuity planning exercise that Entergy put into motion in the aftermath of 9/11. The company has already taken important steps to adapt to the changing climate, but knows it will likely have to do more in the future.

“We’re still trying to take the next steps,” says Dorsey. “But it’s like alcoholism—admitting there’s a problem is the first step.”

Following Hurricane Katrina, Entergy took immediate action to relocate important business centers, including moving a data center to Little Rock, Arkansas, creating redundancy in data storage throughout the service area, and moving its transmission center to Jackson, Mississippi. Entergy made decisions about where to locate these important business centers based in part on information about the climate-related risks in different geographic regions within the service area, and in order to locate centers and buildings in different parts of the service area. In addition, Entergy put together a business continuity group specifically to look at broader implications of climate in the context of other serious business threats, including terrorist acts and a potential flu pandemic. The group, which included both in-house experts and consultants in the fields of security and medicine as well as energy, undertook a three-phase analysis.

The first phase was a scoping study identifying climate and related risk drivers. This study identified likely changes in a number of key climatic and related physical effects over the near term (20 years), medium term (20 to 50 years), and long term (end of the 21st century). Trend analysis and observed historical probability distributions were used to develop scenarios for a number of key variables, including heating and cooling degree-days, drought, earthquakes, episodic flooding, hurricanes, ice storms, lower river levels, sea level rise, abrupt temperature change, tornadoes, plant and animal shifts, wetland loss, and wildfire. Using GIS (geographic information system) techniques, consultants mapped potential changes in these climate and physical effects to Entergy’s service area and to other areas where Entergy has large-scale investments.

The second phase, which is ongoing as of March 2008, looks at the correlation of each identified risk with Entergy assets or operations, in order to identify candidate threats for response and adaptation. The third phase has not yet begun, and will assess existing risk mitigation plans and seek alternatives to reduce impacts.

In the near term, Entergy recognizes that unchecked climate change poses potential long-term risks to the economic viability of Entergy’s franchise and asset base, both of which are located in an area that is vulnerable to flooding and hurricanes. The recent intense hurricanes that ravaged the Gulf Coast have put Entergy’s business continuity planning to the test and provided valuable lessons on how to manage near term physical risks, restore systems, and recover from devastation. Entergy has put these lessons to use improving and strengthening emergency response performance. For example, Entergy has begun to relocate certain key functions—transmission, the corporate data center, revenue processing, and accounts payable—to areas not as susceptible to flooding and storms. Dorsey characterizes these early actions as “no brainers,” or immediate, obvious steps the company felt compelled to take. The next steps will require more careful deliberation as they are likely to be more expensive and taken in anticipation of events expected to occur over a longer time horizon. Another issue Entergy has to contend with is that, as a regulated utility, its investment decisions must be cost effective, in order to keep the price of electricity reasonable.

Table 3. Identified Climate Risks to Entergy and its Service Area

Entergy has identified a number of risks arising from climate change that could collectively affect the sustainability of their regulated service area. These impacts could threaten not only its direct business operations, but the culture and economy of business and households within the Gulf Coast area.

Sectors	Risks
Electric Power	<ul style="list-style-type: none"> • Damage to power plants, T&D (transmission and distribution) system & operation centers from more frequent, intense storms & flooding • Disruptions in supply chain from storm events • Increased insurance costs • Loss of customer base and employees from fear of future storm damage • Reduced economic well being of the area from increased taxes and investments needed to adapt to climate change
Building Construction & Real Estate	<ul style="list-style-type: none"> • Certain property types in high-risk locations may become extremely expensive to insure, subject to more stringent risk management mechanisms, or even uninsurable because coverage is too risky • Loss of property value due to unavailability of insurance
Forest & Pulp	<ul style="list-style-type: none"> • Damage to forests from storms
Tourism	<ul style="list-style-type: none"> • Increased damage to hotels and resort properties in coastal areas
Agriculture	<ul style="list-style-type: none"> • Decreased production for rain fed crops • Increased risk of crop loss due to weather cycle extremes • Disruptions to transportation systems from storms
Transportation	<ul style="list-style-type: none"> • Storm damage to bridges & rail systems disrupting companies' ability to ship product and/or receive supplies
Insurance	<ul style="list-style-type: none"> • Weather-related losses could stress property and casualty (P&C) insurers to the point of impaired profitability, consumer price increases, withdrawal of coverage, and elevated demand for publicly funded compensation and relief • Potential climate-related impairment of the value of securities into which insurance firms invest as part of their asset management activities could leave companies unable to cover future losses
Petroleum	<ul style="list-style-type: none"> • Oil and gas infrastructure in coastal areas at risk from storms & flooding • Interruption of feedstock flows to onshore refineries and production plants

Source: Entergy

The Travelers Companies, Inc.: An Ounce of Prevention—Linking the Interests of Homeowners, Business, and Insurance Providers

The Travelers Companies, Inc. is one of the largest providers of personal and commercial property and casualty insurance products in the United States, with headquarters in St. Paul, Minnesota, and representatives in every U.S. state, Canada, Ireland, and the U.K. Travelers provides a range of personal insurance products, including automobile, homeowners, renters and condominium policies, and coverage for boats and yachts, floods, identity theft protection and valuable items. Travelers also provides a wide array of business insurance services to clients that range from small “main street” businesses to Fortune 100 corporations. The service array includes property and liability coverage, as well as surety and fiduciary products and products tailored to the unique needs of individual industries such as oil and gas, construction, and transportation. Travelers has for years been proactively looking at options for adaptation to climate change and recently joined the Pew Center’s Business Environmental Leadership Council (BELC) and its efforts to address global climate change. Visit <http://www.travelers.com>

As a major property and casualty insurer, Travelers has consistently focused on the impact of changing climatic conditions in order to provide insurance protection that both addresses customer needs and achieves internal financial objectives. However, following the severe 2004 and 2005 Atlantic hurricane seasons, the company determined that a more cohesive and integrated approach to climate risk was needed. Travelers formed a number of new internal working groups and expanded the roles of existing groups to address exposure and risk associated with climate change.

Travelers continues to be engaged in initiatives designed to reduce exposures to extreme weather events for itself and its customers. These actions include providing information and price incentives for insured parties to help mitigate personal and commercial losses due to extreme weather events, reassessing its exposure to risk because of changes in climate, and modifying pricing strategies and policy terms and conditions to reflect updated assessments of current and future risks.

Specific actions that Travelers has taken to adapt to climate change include:

- **Reassessing coastal underwriting practices.** Travelers has reexamined how it approaches and underwrites property exposures in coastal locations. The definition of coastal areas has been expanded to include counties farther inland than previously considered and contractual terms of coverage now include more sharing of responsibility for both households and businesses. In general, coastal customers now assume a greater share of risk than before, providing greater incentives for them to engage in loss control and adaptation activities.
- **Updating catastrophe modeling.** Travelers and other insurance companies utilize current modeling techniques to help predict and manage potential catastrophic losses. Estimates of losses in severe weather scenarios are rising due to the anticipation of more frequent and severe hurricanes, growth in coastal development, and rising costs to repair damaged property after a severe event. Travelers recently joined an effort initiated by the Center for Health and the Global Environment at Harvard

Medical School that is drawing together a number of business and academic stakeholders to focus on how catastrophe modelers can better integrate climate change science into their models and estimates of potential loss.

- **Offering “Risk Control” services.** Travelers Risk Control Services Group provides assistance with a range of loss mitigation and adaptation techniques. These include monitoring building code standards and regulations in support of building resiliency, providing assistance in disaster preparedness planning, and delivering business continuity training. About 800 consultants work around the country to provide advice in person, while information and guidance are also provided to businesses via safety academy classes, “webinars,” and online tools. The Risk Control group utilizes numerous delivery formats in order to reach a wide spectrum of customers.
- **Redesigning pricing.** Pricing strategies for commercial and personal customers take into account differences such as building age, construction, and loss mitigation efforts, which affect likely losses during extreme weather events due to changes in building codes over time (see text box below). Travelers continues to evaluate and enhance its products through the development of incentives to homeowners who install storm resistant building components such as shutters or fortified roofs that are better able to withstand severe weather events. Commercial customers are also offered incentives to build to the latest catastrophe-resistant building codes.
- **Engaging in community and government outreach.** Travelers engages in industry and broad-based efforts to encourage disaster awareness and preparedness among homeowners and commercial customers. These efforts also focus on providing information to governmental organizations about the benefits of long-term loss mitigation strategies. These include the adoption and enforcement of more robust building codes, and enhanced land-use planning. Travelers also seeks to raise awareness of climate change and thereby mitigate the effects by providing strong support to the Institute of Business and Home Safety to promote property damage mitigation strategies and by sponsoring the National Hurricane Survival Initiative to promote hurricane preparedness.

Making Buildings More Resilient

A 2004 report from the Institute for Business and Home Safety (IBHS) examined the difference modern building codes made on the frequency and severity of claims filed after Hurricane Charlie, which was the first of four major hurricanes to make landfall in Florida in the fall of 2004.

Results from this study indicate that the enforcement of modern engineering design-based building codes had a positive impact on the performance of residential homes during the hurricane. The frequency of claims was reduced by 60 percent, and the claim was 42 percent less severe when a loss did occur, for homes built after the adoption of modern building codes (IBHS January, 2008).

Travelers has also introduced pricing strategies to encourage environmentally responsible behavior. This includes providing discounts on car insurance for drivers of hybrid-electric automobiles and enhanced coverage for owners of “green” commercial buildings. These products are designed to respond to the evolving needs of customers and also recognize the potential “halo effect” in which adopters of climate-change mitigation technologies are viewed as low-risk customers.³² While there is not yet enough data for clear actuarial support, Travelers’ internal market data indicates that there is a correlation between risk-averse and environmentally responsible behaviors. Thus, those who purchase a hybrid-electric car are also likely to be safer drivers. Similarly, owners or builders of energy-efficient or “green” buildings may be more likely to detect and remedy risk-related issues, such as the overall integrity of the building or the safety and maintenance of equipment and systems. Green buildings are also typically newer and less prone to the risks presented by older buildings.

Providing Leadership On Critical Industry Issues

Travelers prides itself on providing industry leadership on critical climate-related issues, advancing awareness among its customers, employees, and society at large. For example, Travelers CEO Jay Fishman called for the creation of a “Hurricane Wind Zone” to help ensure affordable property insurance to residents along the Atlantic and Gulf coasts. In this zone, the federal government would regulate most aspects of wind underwriting by private insurers, including pricing, but have no direct financial role. Fishman also called for a greater focus on adaptation in an August 2007 article in *The Wall Street Journal*. “To reduce losses from inevitable hurricanes, federal, state and local governments have another critical role to play in promoting risk-mitigation programs,” Fishman wrote. “Federal incentives to state and local governments to adopt and enforce modern building codes would be one key component. Other loss-mitigation plans include prudent land use management, such as acknowledging the importance of coastal wetlands in minimizing a hurricane’s impact upon landfall.”

Travelers has worked with other organizations to achieve broader adaptive changes. For example, Travelers provides financial support to the Institute for Business and Home Safety (IBHS)[®] for building code enforcement training of local and state building inspectors and private contractors in Louisiana in connection with the state’s recent adoption of the International Building Code Series. The St. Paul Travelers’ Foundation has made contributions to Habitat for Humanity[®] for fortification of Habitat homes in catastrophe-prone regions. Travelers was also the insurance sponsor of the “National Hurricane Survival Initiative,” a partnership of the National Hurricane Center, the Federal Emergency Management Agency, the Salvation Army, the National Emergency Management Association, and others, which focuses on building hurricane preparedness by educating homeowners and communities (www.hurricanesafety.org).

Underlining all of Travelers' actions on climate change is the notion that an ounce of prevention is worth a pound of cure. The company would much rather help its customers be prepared for events, thereby minimizing or avoiding potential losses, than have them suffer the monetary and non-monetary impact of a severe loss. Travelers recognizes that climate risks are evolving and the company is continuing to monitor and investigate these risks in order to proactively and appropriately adapt its products and services strategies to help its customers.

Rio Tinto: Reappraising “Normal”—Designing to Weather, Climate, and Climate Change

Rio Tinto is a leading international mining group, combining Rio Tinto plc, a London listed public company headquartered in the U.K., and Rio Tinto Limited, which is listed on the Australian Stock Exchange, with executive offices in London. The Group's major products include iron ore, aluminum, copper, diamonds, energy products, gold, and industrial minerals (borates, titanium dioxide, salt and talc). Its activities span the world but are strongly represented in Australia, North America and Europe. The company also has significant businesses in South America, Asia, and southern Africa. Rio Tinto is a member of the U.S. Climate Action Partnership, a coalition of 27 major corporations and six leading nongovernmental organizations calling on the U.S. Congress to pass legislation establishing mandatory limits on greenhouse gas emissions at the earliest possible date.

Visit <http://www.riotinto.com/>

Rio Tinto's interest in adaptation was first motivated by an internal climate change risk assessment undertaken in 2002, which prompted the company's management to ask, “If the climate is going to change, what does that mean for our operations?” Rio Tinto was already engaged in climate change policy and emissions abatement work, and an evaluation of potential climate impacts seemed a natural extension. The company's first adaptation study was a desk-top review using the IPCC's Third Assessment Report (TAR), knowledge of Rio Tinto operations, and phone interviews with site managers to identify the types of climatic variables that would be important to Rio Tinto's diverse businesses. The study looked at actual impacts of weather events and predicted climate changes described by the TAR. The order of magnitude scoping study concluded that—broadly defined—changes in climate could be important and should be considered more deeply.

Rio Tinto followed up with a second study that focused on the implications of climatic changes at a finer spatial detail. For this study, the company asked the Hadley Center for Climate Change in the U.K. to provide a summary of how climate variables might change over the next 25 to 50 years to assist in understanding the geographic regions where Rio Tinto has mining interests, or relies on supporting infrastructure and services, such as electricity supply, water, shipping lanes, and roads. Included in this study was an examination of weather insurance and Rio Tinto's actual exposure to weather-related events. As part of this study Rio Tinto also commissioned external engineering consultants to undertake a review of how potential climate change had been incorporated into engineering design standards and what the greatest vulnerabilities were. This study was completed in 2005. Rio Tinto plans to update it to include more recent insurance data.

Rio Tinto concluded from these studies that regions in which it operates will experience changed climate regimes. In the near term the changes are minimal, but are expected to increase over the longer term. Consequent impacts to its businesses are likely to occur gradually, allowing time for operations to learn and adapt. The work also indicated that building and engineering codes and standards have been slow to incorporate climate change risks. The studies indicated that, properly applied, current standards would provide adequate protection to weather events and so major upgrades of existing structures would not be required in the short to medium term. Over the longer term, Rio Tinto's exposure to climate risk is likely to vary by location. North American assets, for example, appear less vulnerable than those in the southern Hemisphere, where increased intensity of cyclones and drier conditions are both predicted.

This work is now being followed up with very detailed site assessments for many of Rio Tinto's higher priority sites. The sites have been selected based on their remaining life, prospective developments and expansions, and their location in climate sensitive parts of the world. The assessments are underpinned by high resolution climate modeling (down to 20 kilometer by 20 kilometer grids), which are able to provide some indication of changes in cyclonic activity and topographic effects.

Rio Tinto has learned much about climate-related impacts. The chief issues are about water: either having too much (floods) or too little (drought). While Rio Tinto does not ascribe any individual weather event to climate change, it believes the more extreme events it experiences could occur more frequently. In addition, Rio Tinto is concerned with reports that climate change will induce deeper and/or more frequent droughts. Partly as a result, it has developed a strong water strategy to respond to various aspects of droughts and floods.

Rio Tinto has experienced three headline weather events over the past few years that have reinforced the need for the company's adaptation work. These events are:

Cyclone activity in the Pilbara of Western Australia, which led to flooding and disrupted iron ore shipments from mines to customers.

Several high rainfall events in Australia's Northern Territory, which caused a uranium mine pit to flood, leading to the declaration of a force majeure event. Rio Tinto is on track to dewater the pit, however, strict environmental requirements prohibit the water from being released into the environment.

Drought events in southern Queensland, which caused a power plant to reduce output due to a lack of cooling water. As a consequence, Rio Tinto's Tarong coal mine, which supplies the plant with coal, had lower sales.

VI. Conclusions

Climate change has implications beyond the direct effects of weather on buildings and operations, and should be an integral component of long-term planning for many businesses. Leading companies are already beginning to consider the risks of climate impacts as part of evaluations of other climate risks, such as those associated with compliance with potential climate regulations, shareholder and customer perceptions, or the impacts of greenhouse gas controls on fuel supplies and prices.

Despite this, the physical risks of climate change are often overlooked by business. The reasons for this are several: the uncertainty of future projections and the long-term nature of the change make it easy for businesses to set aside current climate risk, and concerns about greenhouse gas emissions and mitigation are more pressing to corporate leaders and shareholders. Moreover, many decision-makers have yet to recognize that the past is not the best predictor of the future—whether for climate averages or climate variability. At the same time, however, there is also pressure for increased climate-related risk disclosure (from shareholders and regulators), which makes it increasingly important not to overlook sources of risk.

The reality is that not all companies need to incorporate information on the physical effects of climate change into planning decisions today. Those most at risk are companies facing decisions about long-term capital investments (infrastructure, equipment), those in sectors where weather and climate is an integral part of production (such as agriculture or construction), industries that rely heavily on transport and other infrastructure in their supply and demand chains, or those facing reflected risks, such as the insurance industry. Risks will not be evenly spread geographically, and will depend on the incidence of extreme events—such as storms, drought, flooding, or wildfire—in the locations where core processes, supplies of inputs, customers, or other components of the value chain are located.

While not all businesses need to take action now, some do, and all need to be aware of the potential threats of climate change. This paper has described a *climate risk screening framework* for identifying the circumstances in which a company may be at risk from climate change. Assessing susceptibility to climate change requires looking at risks across a company's operations, value chain, and broader commercial environment and dependencies on public and private infrastructure. An initial screening can, in many cases, be conducted relatively easily, using readily available information on climate trends and projections. Breaking down the process of evaluating climate change into manageable chunks—with the first step being a high level screening—makes sense from a business perspective. The screening can identify important risks, and provide

insight into whether detailed risk assessment and management—a process that places climate-related impacts and uncertainties in a common framework with other long-term risks—is warranted.

While the risks of negative impacts from climate change will be paramount for some businesses, others may be interested in the opportunities that climate change will provide. Melting ice opens waterways that can be used for transport, new cultivars may be needed in areas that become drier or warmer, or indoor recreation may substitute more frequently for outdoor recreation in areas that become uncomfortably hot. Proactive adaptation may also provide reputational benefits similar to those associated with mitigation; companies that currently publicize their “carbon neutrality” may in the future advertise how the adaptive actions they take benefit both their customer base and their profitability, by reducing the impacts of climate change on reliability, prices, product quality, and accessibility. Particularly for those sectors where the business risks of climate are not expected to be significant, a process similar to the screening described here can be used to identify not only the risks, but also the potential opportunities, associated with climate change.

Endnotes

1. See, for example, Firth and Colley 2006, Mills and Lecomte 2006, and Cogan 2006.
2. World Economic Forum (2008) divides the opportunities for the private sector associated with the potential losses associated with natural disasters into four categories: monitoring hazards and communicating risk, socio-physical strengthening, sharing financial risk, and disaster preparedness.
3. Meyer 2008.
4. Firth and Colley 2006.
5. Harden and Eilperin 2006.
6. Williams 2007.
7. Carey 2006.
8. CDP 2007. The CDP goal is to increase awareness and provide investor-relevant information about climate change to enable informed action.
9. Commercial risks could result from physical effects, uncertainty about future regulations, impacts on competitiveness, or damage to reputation.
10. For a discussion of the institutional process for managing mitigation risks, see CERES 2006.
11. U.S. Climate Change Science Program/Global Change Research Program 2003b.
12. IPCC 2007a.
13. See, for example, Shepherd and Wingham 2007 (regarding rapid polar ice sheet loss) and Rahmstorf 2007 (regarding sea level rise).
14. U.S. Climate Change Science Program/Global Change Research Program 2000.
15. See Lenton, et al. 2008.
16. Many of these terms—particularly risk and vulnerability—are used in very different ways in different contexts and there is by no means agreement on their definitions. For this paper, we have tried to reduce the amount of literature-specific jargon and so use only a few, hopefully simple, concepts, as indicated in Figure 1. See, for example, IPCC (2007b) and EPA (2004) for usage in climate change analysis and environmental risk assessment, respectively.
17. The literature contains a number of different categorizations of business impacts for purposes of risk assessment. See, for example, any of a number of texts on financial management, such as Brigham and Ehrhardt 2008. The United Kingdom Climate Impacts Programme uses the categorization of logistics, finance, markets, process, people, premises, and management. See UKCIP (2005) and materials available on their website: <http://www.ukcip.org.uk/>. The Australian government has also developed a workshop-based strategic assessment process for business and climate change (DEH 2006).
18. London Climate Change Partnership 2004.
19. ACIA 2004.
20. A number of reports deal with the issues facing municipalities and other levels of government. See, for example, Acclimatise 2007 and Allen 2005.

21. Easterling, Hurd, and Smith 2004.
22. Easterling, Hurd, and Smith 2004.
23. For more information on the perspective and actions of the insurance industry, visit the websites of AXA (<http://www.axa.com/en/responsibility/protection/property/environment/>), CERES (<http://www.ceres.org/pub/>), Swiss Re (<http://www.swissre.com/>), and Munich Re (<http://www.munichre.com/en/homepage/default.aspx>), which have numerous publications related to business and climate change. See also Center for Health and the Global Environment (2005) and Lloyds of London (2006).
24. Risk Solutions Consulting, Ltd 2005.
25. U.S. Climate Change Science Program/Global Change Research Program 2003a.
26. IPCC 2007a.
27. Rosenzweig 2008.
28. Schneider 2001.
29. Such a company might need to provide for alternative means of shipping, or stockpile a 2 or 3 week supply of needed components during hurricane season (Walsh 2006).
30. UKCIP 2005.
31. See also the case study on Swiss Re, "Staying One Step Ahead of Climate Change, Not Two", in Hoffman et al. 2006.
32. Mills and Lecomte 2006.

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This report presents a business approach to adapting to the physical effects of climate change. It adds to the Pew Center's expanding body of work on adaptation, an issue that has grown in importance as governments and businesses around the world recognize that a certain amount of climate change is unavoidable and that impacts are already being observed. The Pew Center was established by the Pew Charitable Trusts to bring a new cooperative approach and critical scientific, economic, and technological expertise to the global climate change debate. We inform this debate through wide-ranging analyses in four areas: policy (domestic and international), economics, environment, and solutions.

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