



**PGIM**  
India Mutual Fund



**MEGATRENDS**

# **WEATHERING CLIMATE CHANGE**

Opportunities and risks in an  
altered investment landscape





## CHAPTER 4

# INVESTMENT IMPLICATIONS BY ASSET CLASS

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*Markets are inconsistent in accounting for many climate risks, and this mispricing creates opportunities for active investors.*

# CHAPTER 4

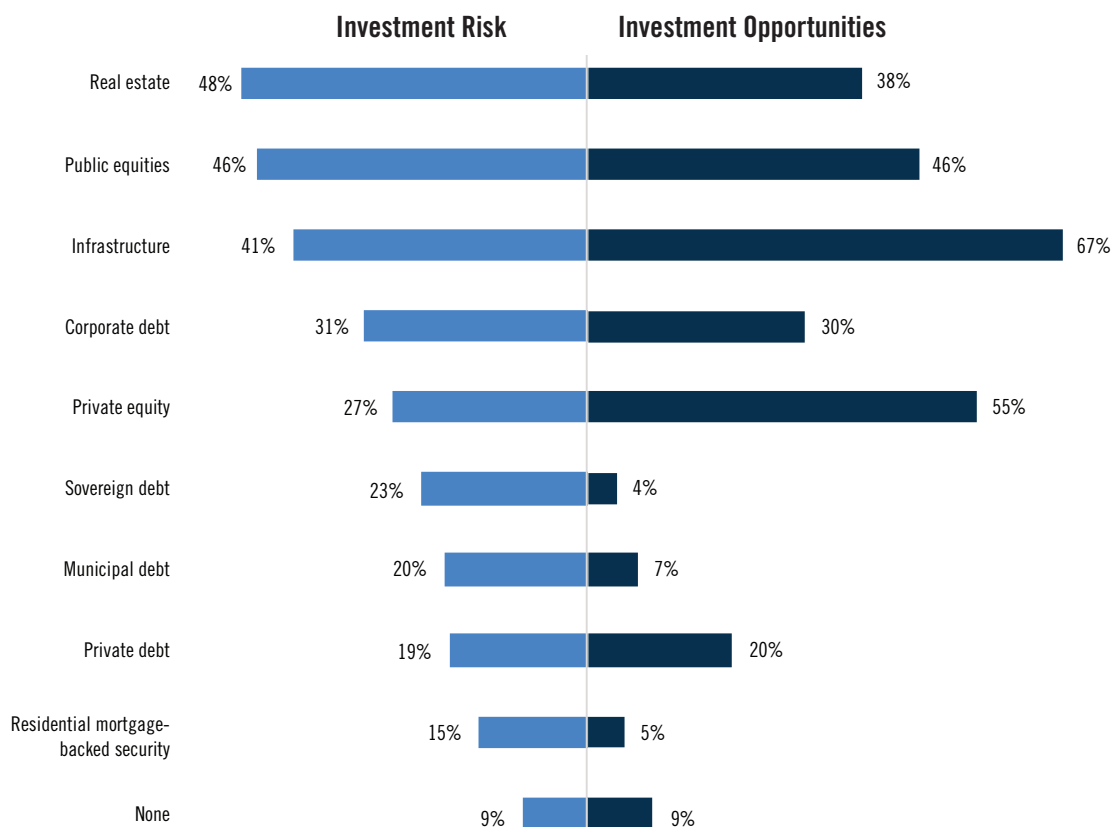
## INVESTMENT IMPLICATIONS BY ASSET CLASS

Climate change is no longer a hypothetical risk and is impacting economies and markets today. As such, it is a major material consideration for all investors – regardless of whether or not they tilt towards sustainability objectives. The time has come for long-term investors to view climate change not just as a risk factor in their investment framework but as an opportunity for active alpha<sup>iv</sup> generation along the path to a greener economy.

According to PGIM’s proprietary survey on climate change, many investors are not yet at this stage (Exhibit 14). Many opportunities lie in facilitating the transition to a lower-carbon world through innovative and transformative technology. These range from

identifying technology-forward companies adept at transitioning to the new “low-carbon economy,” to incorporating physical and transition climate risk in analyzing real assets, all the way to providing seed capital to start-ups pioneering technologies

Exhibit 14: Which of the following asset classes will have substantial investment risks and investment opportunities associated with climate change in the long term?



Source: PGIM 2020 Climate Change Investor Survey

Note: This survey was conducted along with Greenwich Associates and included 101 participants from across North America, EMEA and APAC. Participants were chief investment officers or senior decision makers at institutional investor organizations including pension plans, insurance companies, endowments, foundations, sovereign wealth funds and central banks.

<sup>iv</sup> Alpha indicates the performance, positive or negative, of an investment when compared against an appropriate standard, typically a group of investments known as a market index.

to reduce carbon emissions. Another aspect of potential opportunity for investors is around markets inconsistently accounting for many climate risks. The resulting mispricing can create opportunities for active investors in public and private markets. Here we lay out the key implications by asset class: public and private fixed income, public and private equity, venture capital and real assets – including real estate, infrastructure and agriculture.

## Public and Private Debt

### Sovereign Debt: Actively discern between winners and losers where markets do not

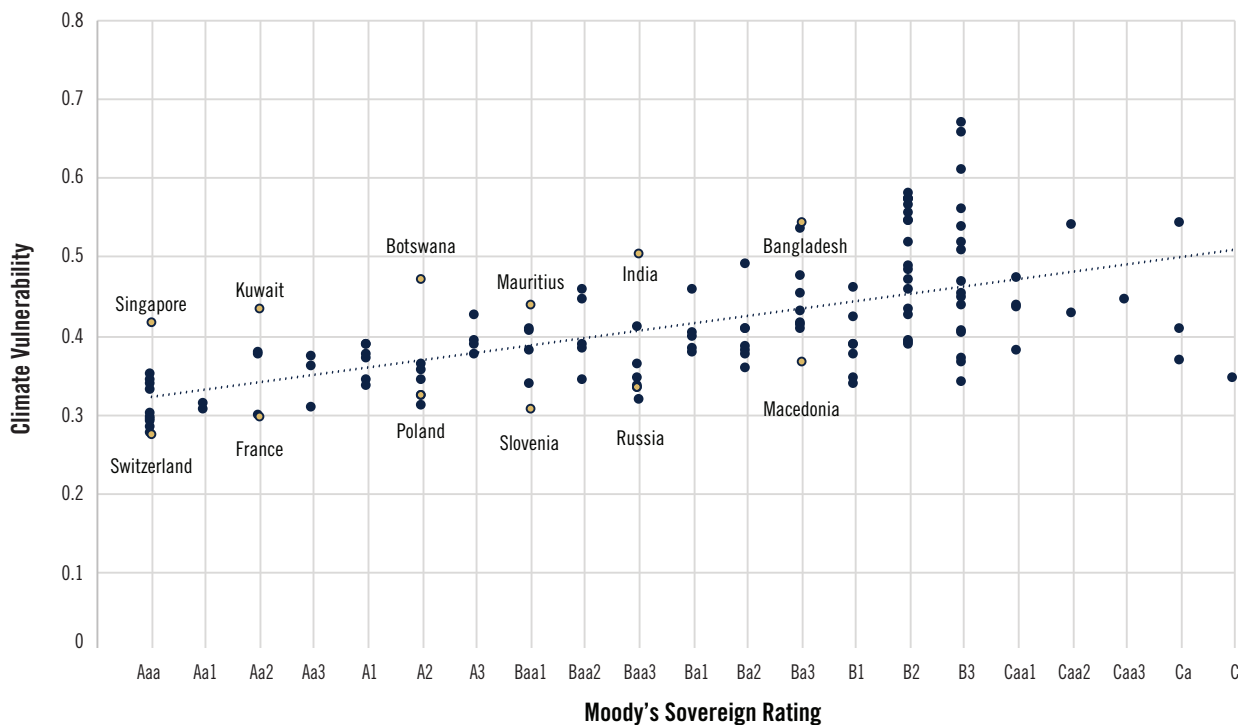
PGIM’s proprietary survey on climate change indicates that nearly 25% of investors view climate as a risk for sovereign debt, while only 4% view it as an opportunity. This downplays the opportunities arising from the mispricing of climate risk in sovereign debt. That is, countries with similar credit ratings exhibit wide variations in both climate change vulnerability and resilience, allowing investors to take advantage of

the eventual repricing of sovereign debt around climate risk (Exhibit 15).

Take Russia and India, for example. As of November 2020, both were rated Baa3 by Moody’s – one notch above junk status – with similar default spreads. Of course, climate change is not the sole factor in assessing sovereign credit worthiness, but with regard to physical risk Russia’s economy is less vulnerable to climate change.

Understanding the impact of climate change for a country or region comes down to assessing two dimensions: vulnerability and readiness. Vulnerability measures a country’s exposure, sensitivity, and capacity to absorb the negative effects of climate change, while readiness measures a country’s ability to leverage investment and technology and convert them to adaptation or resilience actions.<sup>82</sup> Investors need to adopt a framework that accounts for both climate vulnerability and readiness – and by analyzing countries using this framework, some meaningful differences emerge.

Exhibit 15: Sovereign Credit Ratings Don’t Capture Climate Vulnerability



Source: Aswath Damodaran, “Country Default Spreads and Risk Premiums,” updated July 1, 2020, accessed July 29, 2020 and [Notre Dame Global Adaptation Initiative Country Index](#), data released July 2020  
 Note: Climate vulnerability rating is for 2017, Moody’s sovereign ratings as of December 2020.

As a stark example, take Bangladesh and the Netherlands. Both face similar risks from rising sea levels – yet the Netherlands has the financial resources and political will to deploy sophisticated technology and urban planning techniques to preserve its territorial integrity even in a scenario with up to a five-meter rise in sea level.<sup>83</sup> By comparison, Bangladesh is projected to lose approximately 11% of its land with a 50-centimeter (or roughly 20 inches) rise in sea level.<sup>84</sup>

For long-term, active investors, the implication is clear: until debt markets begin to fully and efficiently price climate risk, there may be opportunities in the sovereign debt of climate-vulnerable countries that are better prepared – like Singapore and Thailand, whose economies are likely to be less adversely impacted than some of their neighbors. Since spreads don't fully reflect these differences in climate change readiness, active investors should be able to find attractively priced debt opportunities.

The logic of analyzing readiness in tandem with vulnerabilities extends to transition risks as well. Some fossil fuel-exporting countries have more diversified economies and are less dependent on extraction and drilling. When considering transition risk in sovereign debt, investors may want to focus on countries like Mexico and Brazil with economies that are broadly diverse and likely to withstand the decline of fossil fuels better than, say, Angola, Venezuela or Nigeria.

### **Municipal Bonds: Investors can get climate resilience without foregoing returns**

US municipal bonds are an example of a market where climate risks are overlooked. As noted in Chapter 3, one reason for this is climate risk is not a primary consideration for US retail investors – who make up well over half of the market.<sup>85</sup> They are attracted to municipal bonds primarily because of their tax-advantaged status.

For institutional investors with active strategies, this indifference creates opportunities. With little differentiation in pricing, more resilient credits can be available without sacrificing yield. Investors employing a framework that incorporates both risk and readiness can take advantage of this. For example, California faces numerous perils from climate change

– from water scarcity to wildfires to agricultural damage. Recent wildfires have crystalized these risks for investors. However, the state government has recently adopted several policies specifically aimed at mitigating fire risk in the future and courts have upheld holding utilities legally liable for wildfires sparked by their power lines.<sup>86</sup> With muni bond markets seemingly more focused on the ongoing fires, long-term investors may benefit from California's ongoing mitigation and resilience efforts without foregoing return.

*When considering transition risk in sovereign debt, investors may want to focus on countries with economies that are broadly diverse and likely to withstand the decline of fossil fuels.*

### **Energy Infrastructure: Attractive debt opportunities over the prolonged sunset**

For all the attention given to renewable energy (Chapter 2), fossil fuels will continue to play a prominent role in the global energy landscape for decades. Midstream energy infrastructure provides a good example. Not only will it continue to be essential for decades, it will be extremely difficult to replace. In fact, the growing opposition to new pipelines in the US may create a significant barrier to entry, making select pipeline infrastructure more critical and enhancing incumbent pricing power going forward. For debt investors, pipelines offer a stable source of cash flows. Additionally, pipeline companies are relatively insensitive to the price of fossil fuels. Refineries are another example of midstream energy infrastructure that is often overlooked and can provide compelling debt opportunities. Savvy, active debt investors should seek out refineries that are at scale, have the ability to process a range of sweet and sour crude oil and have easy access to natural gas, pipelines and ports.

## Property and Casualty Insurance: Innovations in risk-sharing offset higher risks from climate change

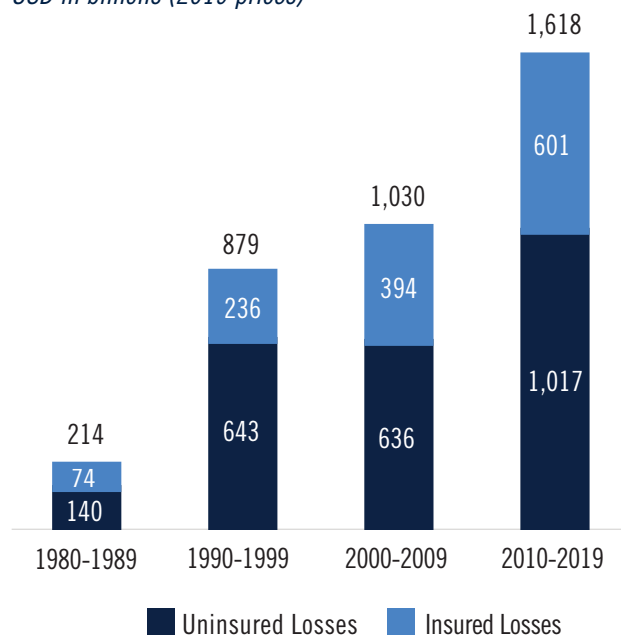
Conventional wisdom suggests that as extreme climate events increase in intensity and frequency, property and casualty (P&C) insurers will be left holding the bag for surging insured losses.

In reality, climate change has made it easier to discern winners and losers within the industry. Several innovations have bolstered the position of the strongest P&C players. First, new capital sources have expanded the loss-absorbing capacity of the industry. For example, innovative risk-sharing structures known as “sidecars” have enabled US insurers to disperse risk by syndicating it to institutional investors globally.<sup>87</sup> Second, top-tier P&C insurers have benefited greatly from advances in climate forecasting and analytics. The combination of enhanced modeling and computing power with granular data has led to a more nuanced understanding of some potential climate change tail risks.

Since many of the weaker players had already exited the market over the past decade, the remaining P&C players are well capitalized and have robust loss absorbing capacity. This was demonstrated in the epic 2017 US hurricane season. Three large hurricanes ravaged major metropolitan areas and unleashed nearly \$280 billion in estimated damages.<sup>88</sup> Yet, P&C insurers’ diversified earnings largely absorbed the record losses, and the US industry avoided the need to raise meaningful amounts of new capital.<sup>89</sup>

What is often overlooked is that climate change may also create an opportunity for P&C insurers. The portion of the market that is uninsured is several times larger than the insured segment. As changes in the climate become more apparent, it only follows there will be greater US demand for P&C insurance (Exhibit 16). The strongest P&C players like Chubb and Liberty Mutual will leverage the innovations in risk-sharing and capture more of these new opportunities as an increasing number of businesses seek protection from rising climate volatility.

Exhibit 16: A Widening Protection Gap From Rising Uninsured Losses Creates Opportunity for P&C Insurers  
USD in billions (2019 prices)



Source: Pinto Suri, “[On the Front Lines of Climate Change: The Opportunity in P&C Insurers](#),” PGIM Fixed Income, 2020

## Structured Finance: Multiple mechanisms to insulate investors from climate

The risk to physical assets like homes, autos and boats from climate change is evident. However, senior tranches of securitized products backed by these physical assets face low levels of risk as investors are insulated in several ways. First, extreme weather events like hurricanes in the US can create “payment holidays” for mortgages and auto loans and these forbearance measures can disrupt cash flows. However, the cash flow structure of securitizations has specific mechanisms designed to be resilient and insulate senior tranche investors from temporary disruptions.

Second, with physical risk to the underlying assets, location matters. Automobiles in California are more prone to fire and flood risk than those in Montana, for example. The pool of collateral that supports asset-backed securities (ABS) are deliberately designed to diversify such regionally concentrated risks.

Finally, aside from the resilient cash flow structure and the geographic distribution of collateral pools, investors in agency mortgage-backed securities (MBS) have additional protection from climate risk. All the mortgages within an agency MBS are guaranteed by government-sponsored entities like Fannie Mae and Freddie Mac – whose policies prevent them from considering regional factors such as climate change. The net effect is, mortgage investors are insured against climate risk by the federal government.

## Public and Private Equity

### Disaggregating common categories can sharpen insight into climate risk – and opportunity

One consequence of the widely uneven impact of climate across regions and sectors is that aggregated views can really distort perceptions of climate risk. Disaggregating commonly used equity categories can help identify winners and losers. For example, large emerging markets such as China, Brazil and India share long-term growth potential. Yet, even within this grouping of countries, climate change will have drastically different impacts. While the aggregated impact across these large emerging markets is projected by many to be modest, recent research by QMA suggests that climate change will impact the economic

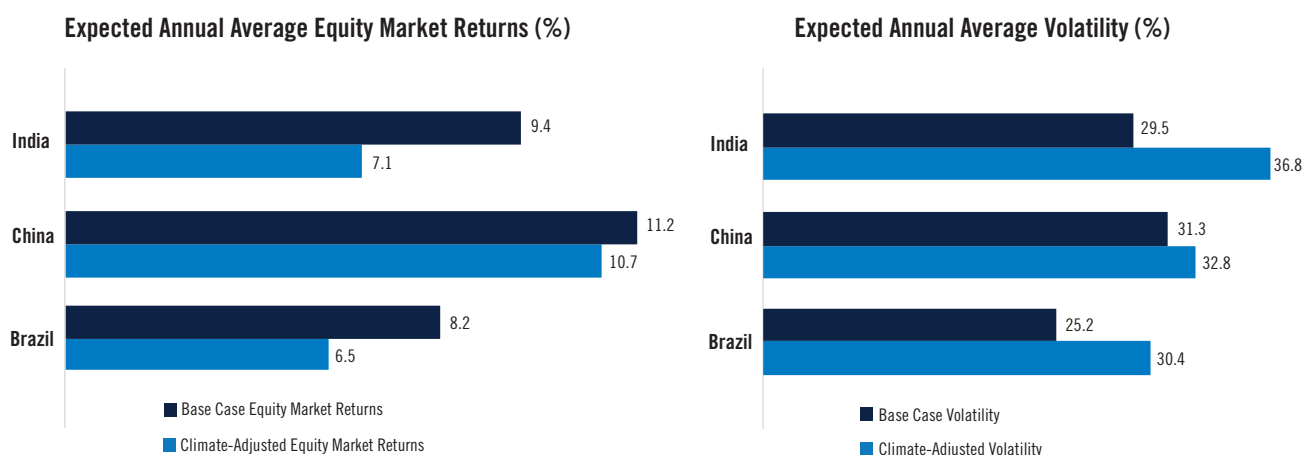
growth of these countries and their equity returns in strikingly divergent ways. Climate, for instance, is expected to curtail annual economic growth by almost 3% in India and long-term equity market returns by more than 2% annually. By contrast, the hit to growth and equity returns in China from climate change is much more muted (Exhibit 17).

### Evaluate the optimal approach to advance ESG objectives

Excluding “dirty” industries, like fossil fuel extraction, from portfolios has been a tenet of ESG investing for many institutional investors. For early ESG adopters, this method made sense – especially given the scarcity of data at the individual company level, the ease of implementation across their portfolio and the clarity of the approach in communications with stakeholders.

While pure exclusion may certainly be the appropriate way to meet portfolio and beneficiary objectives for many investors even today, some ESG-focused investors may also want to evaluate alternative approaches to achieve climate-related goals and fiduciary objectives. Put simply, fossil fuels, as Chapter 2 explained, will remain a major source of global energy supply for decades – despite the ongoing and necessary transition to a low-carbon economy.<sup>90</sup> The reality of this protracted sunset might prompt some investors to reconsider banishing fossil fuels altogether from their portfolios for three reasons.

Exhibit 17: Climate Change Impact on Select EM Equity Returns and Volatility



Source: QMA analysis

Note: Negative GDP growth impact from climate change also increases expected volatility in equity markets.

First, it is now easier to identify the greenest firms within an industry. Greater availability of climate analytics – based on an expanding array of firm-level carbon emission and other metrics – make it possible to differentiate and go beyond a “one size fits all” characterization of all firms within an excluded sector. One benefit of better corporate climate disclosures (however imperfect they may be) is they enable investors to have a more nuanced, data-driven view of the good and bad players within an industry.

Second, given how much of the fossil fuel sector is priced for imminent obsolescence, there are compelling reasons to expect the greenest firms to outperform. Leaning into greener technologies and fuel sources will enable forward-looking fossil fuel companies to navigate the long, slow transition to a low-carbon world. It may even be an enduring source of competitive advantage for these firms – many of which have the scale to fund, develop and deploy innovative new green technologies and processes. For example, oil majors like Total and Shell that are more willing to embrace the transition to a low-carbon world will face a materially lower risk of obsolescence than their peers. As oil producers unable to adjust begin to shutter, the “last firms standing” will be able to capture a larger portion of the remaining market.

Investors will need to recognize no single approach is suitable for all oil majors here. They will want to focus on firms that leverage their existing strengths while shifting to green activities. For instance, oil majors with expertise in offshore oil and gas exploration are better placed to transition to offshore wind power. And oil companies with strength in deep mining or fracking may be better suited to explore carbon storage techniques – essentially the reverse process of drilling.

Last, even for ESG-focused investors, differentiating between good and bad players in the industry can have a significant constructive impact during this lengthy sunset. Public and private equity owners can actively influence fossil fuel users and extractors to employ more sustainable practices. Since fossil fuels will be essential for decades under almost all energy use scenarios, a pragmatic approach for some ESG investors may be to encourage use of the cleanest fossil fuels (e.g., LNG and natural gas) and eschew dirtier options like coal. By actively engaging with these

companies – rather than excluding them – a group of like-minded shareholders can positively impact carbon emission outcomes over the decadeslong wind-down period for fossil fuels. Indeed, groups of investors are already influencing major oil players.<sup>91</sup>

*Investors can influence fossil fuel users and extractors to fund, develop and deploy greener technology and practices.*

## Greener power generation

Public and private equity investors may also find attractive opportunities in energy-efficient utilities. High-carbon assets like coal-powered generators will continue to be displaced by cleaner alternatives like natural gas and eventually renewable power sources. Electricity-generating firms that lean on cleaner energy sources today are attractive investments even at current valuations.

In Europe, for example, carbon trading has accelerated this transition and made utilities more mindful of their carbon emissions, pushing them to move away from the dirtiest fossil fuels towards cleaner ones. EU officials have proposed a European Green Deal to make the union climate neutral by 2050.<sup>92</sup> A major component of this is transforming the power industry, which emits 75% of the EU’s greenhouse gas emissions.<sup>93</sup>

While the capacity of renewables is growing along with demand for green energy, the need for smart transmissions networks that integrate renewable and fossil fuel sources is immense. Wind and solar projects often generate power in remote areas. Transmitting this power to urban population centers and integrating fossil fuel sources as well is a vital part of the energy landscape.

On the demand side, companies that boost efficient consumption by households and businesses can provide good opportunities for public and private equity investors such as smart meters that allow industrial and individual consumers to better understand and manage their electricity consumption.



## Venture Capital

The transition to a low-carbon world can be accelerated with innovative technologies, many of which are materializing in venture capital markets:

### New analytics and alternative data sources

The climate data revolution plays an important role in resilience and adaptation technologies. This includes advanced agriculture and microclimate analytics to help the food production industry anticipate and respond to weather variability. Additionally, advances in catastrophe risk modeling and digital mapping help manage and reduce risk for reinsurers, financial companies and owners of physical assets and infrastructure.

*The need for smart transmission networks that integrate renewable and fossil fuel sources is immense.*

### Next-generation construction

Innovative materials for construction are another area for resilience investing. For example, novel coatings and additives for paint have been developed that reduce heat absorption for buildings and transportation equipment. This has very practical and immediate uses as these coatings can reduce cooling costs by as much as 20%.<sup>94</sup>

### Enabling renewable energy

One of the biggest hurdles for renewable energy is its intermittency. Storing energy in batteries is the most obvious answer and capacity of utility-scale batteries quadrupled between 2014 and 2019.<sup>95</sup> Other means of energy storage for utilities and power-generating plants are key areas for innovation.<sup>96</sup> Pumped storage hydropower – where volumes of water are pumped to various elevations by excess power and then allowed to flow downward to generate power when it is needed – is not new technology, but remains one efficient way to store energy at scale. Additionally, smart grids and more-efficient transmission networks can help to integrate renewable sources more broadly than they are currently. Innovations around superconductive alloys

could also help reduce waste in long-distance high-voltage transmission lines, with waste running from 6% of power transmitted in the US to almost 20% in Brazil and India.<sup>97</sup> Looking ahead, so-called “room-temperature superconductors,” such as ceramics and metallic alloys, hold the promise of eliminating much of the waste from power transmission today.<sup>98</sup>

### Ground transportation

Scaling down the carbon footprint of cars, trucks and buses provides an opportunity for reducing global carbon emissions substantially. Manufacturers of key components for electric vehicles (EV) are a natural area for investors to explore. For example, continued innovations in battery storage, recharging efficiency and cost of production are essential for widespread use of EV in ground transport. Currently, more than three-quarters of charging is conducted at home by US owners and operators of EV.<sup>99</sup> As a result, their use is limited primarily to short trips – like city buses and local deliveries.

### Hydrogen

One potentially transformative innovation is hydrogen-powered cells, which can generate immense energy yet recharge within minutes. Their only byproduct is water. This might be useful in sectors that have been resistant to decarbonizing, for example in steel and cement production where they can generate the intensity of heat required for those manufacturing processes. Over time, hydrogen cells could power long-distance trucks, high-speed trains, tanker ships or even airplanes.<sup>100</sup>

One challenge for hydrogen is that the most common way to produce it requires fossil fuels. However, a greener hydrogen-based energy source has been a central component of green fiscal stimulus plans in Europe and Asia.<sup>101</sup> For example, the North Sea is emerging as a hub for production of “green hydrogen” with numerous projects underway using offshore wind power.<sup>102</sup> Furthermore, infrastructure to support storage and distribution as well as a pipeline for tankers will be coming online.<sup>103</sup>

In the US, there are also efforts underway to use excess power from nuclear plants to create green hydrogen. For example, this is currently being explored at the Palo Verde Nuclear Generating Station in Arizona. Nuclear plants not only view this as an environmental

solution, but also an economic way to manage the negative pricing that occurs when other electricity sources such as solar dominate the grid.<sup>104</sup>

Governments are eager to push hydrogen power forward for several reasons: it helps them meet decarbonization commitments, address energy independence vulnerabilities and is an effective response to mounting pressure for climate action. The billions of dollars committed to the space could potentially help accelerate industrialization and scalability of hydrogen fuel cell technology, reduce costs and encourage adoption.

## Carbon capture and storage

Carbon capture and storage (CCS) is perhaps the most speculative category, but also holds the most upside for transformative change. The International Energy Agency has called for a 20-fold increase in carbon capture capacity over the next decade in order to meet climate goals. For industries that face difficulties in slashing carbon emissions (like airlines) or that are concerned the carbon offset market may not scale up fast enough for them, carbon capture and storage can be especially attractive.<sup>105</sup> Yet, investment in this space over the last decade is less than 1% of the investment in renewable power.<sup>106</sup>

This is partly because current approaches to CCS are quite limited and not very cost-effective. However, there are several reasons to monitor the space. First, there is real promise in increasing the efficiency of carbon capture; innovative techniques around capture and storage are already emerging in research labs. Second, there has been progress in redeploying the collected carbon for industrial uses like curing concrete, creating industrial lubricants, or even as an input into synthetic jet fuel.<sup>107</sup> Creating some industrial demand for the captured carbon could meaningfully improve the cost efficiency of CCS.

Of course, the holy grail is direct air carbon capture and storage. That is, plucking carbon dioxide directly from the air (powered by renewable energy, of course) and storing it deep underground in a solid state. The technologies to achieve this immense undertaking are nascent and scattered across the startup landscape. One Swiss firm has taken meaningful strides in this area, partnering with similar firms in Iceland and Canada to consolidate complementary technology and offer

an integrated solution. However, it comes at the hefty price of \$250 per metric ton of carbon – or roughly 10 times the going rate for carbon offsets on the European ETS.<sup>108</sup>

*Hydrogen powered cells can generate immense energy yet fully recharge within minutes.*

## Real Assets

### Real Estate: Integrating climate change into the investment process

Incorporating climate change risks and mitigation costs into the heart of the real estate investment process can not only help manage physical risks but can also generate additional investment opportunities.

First, capital investments to bolster climate resilience can be attractive for equity owners. The adage “an ounce of prevention is often worth more than a pound of cure” certainly applies here. Capital projects will detract from cash flows and operating incomes in the near term and may not be sensible for real estate debt providers. But direct real estate equity owners are more likely to see the payback when such projects prevent large losses and preserve cash flows later. Simple renovations like elevating the electricals a foot or two off the ground may make sense for properties in vulnerable areas. In fact, such resilience projects have shown to not only keep the lights on but, more importantly, keep tenants in place during extreme events and maintain steady lease payment cash flows. Additionally, while assets with a strong resilience strategy don't currently see any beneficial pricing in the insurance markets, it's likely this will change in the coming years. This would further decrease operating expenses for asset owners.

Second, by employing cutting-edge data and leveraging their own climate analytics, data-conscious real estate investors can be thoughtful in uncovering situations where the broader market sees limited value. For example, investors can consider high-risk locations by factoring in resilience-boosting capex into their models

for capitalization rates and cash flows (Exhibit 18). By integrating these improvements into their investment process, investors can tap into attractive opportunities where markets may overshoot.

Third, with more high-end office and retail space customers demanding certified “green” properties, the additional cost of energy efficient renovations or construction can be offset by attracting and retaining tenants seeking climate-differentiated properties and willing to pay a premium for it.

## Infrastructure: Desalination, renewables and charging stations

### Solar and wind projects in Latin America

With many investors eager to support wind and solar projects, the US and Europe are relatively saturated markets. Investors should find higher returns for solar and wind projects in South American countries such as Chile and Uruguay. With an aging network of hydroelectric power suffering from declines in river flow and unable to cope with rising demand for power, South America is full of opportunity for renewable energy generation. Wind and solar projects are in demand there to replace vast hydroelectric networks.

### Charging stations

There are opportunities to enhance cash flow of private toll roads and other road-related infrastructure such as the motorway services and plaza businesses by adding electric charging stations. As EV transport becomes more popular for long-haul trips, there will

be growing demand for on-route charging. With so few charging stations on most US highways and related infrastructure, this can be an opportunity for road infrastructure owners to generate a new revenue stream and increase their assets’ usage.

### Water infrastructure

Less predictable rainfall due to weather variability creates opportunities for water desalination plants, water transport and water storage. As water is highly regulated in most jurisdictions, investors should mainly focus on markets with a straightforward regulatory landscape and strong property rights. Australia, which has historically relied on rainfall for much of its clean water, is a favorable market for water desalination given its projected rain shortages and supportive regulatory environment. Other opportunities are arising in water filtration (turning brown water into white water) in the US and Latin America.

### Agriculture: Ag tech drives a range of new investment opportunities

Inconsistent and unpredictable temperatures, precipitation and aridity is a serious threat to crop yields. Investors may want to evaluate the significant business opportunities in the next generation of agrarian business models and the associated technologies.

### Precision agriculture

Investors in farmland should look to partner with farming operators that leverage precision

Exhibit 18: Integrating Climate Change Into the Real Estate Investment Process Requires Innovative Data and Analytics

Site	State/Province	Primary Type	Average Risk	Earthquakes	Floods	Heat Stress	Hurricanes & Typhoons	Sea Level Rise	Water Stress
11 Filmore Street	NY	Office	36	83	52	41	0	0	84
7825 W Ash	NY	Healthcare	25	0	7	45	25	0	46
4th Cell Ave	NY	Retail	62	0	7	39	46	40	58
15 Valley Park	WA	Warehouse/Storage	35	0	5	66	62	0	44
5th & Broadway	CA	Office	21	83	7	37	0	0	61
2400 Park Ave	CA	Office	31	83	75	44	0	0	35
440 Elmo Road	NY	Office	40	85	61	42	0	0	94
St. Allen	IL	Healthcare	25	0	7	45	25	0	46
La Vie on 5th	FL	Residential	46	0	46	60	64	0	44
Park Cir #2	WA	Warehouse/Storage	25	0	8	51	0	0	64

Source: Measurabl and Four Twenty Seven, accessed 2020

agriculture techniques to manage rising weather variability. These technologies now go well beyond drip irrigation systems and subterranean drainage systems.<sup>109</sup> Many employ real-time farm monitoring and advanced weather forecasting, for example, to trigger underground root warmers to spare crops from unexpected frosts and help guard against unseasonal drops in temperature. Sensors, GPS and variable rate technologies can also adjust crop inputs like water, fertilizer and pesticides based on current and expected soil conditions. Similarly, the market for agricultural drones and robotics is growing rapidly. Collectively, it is estimated that the next generation of ag tech could be a \$250 billion annual business by 2030.<sup>110</sup>

### **Smaller and more resilient farms**

Smaller scale farms present another investable application of ag tech to help ensure food systems remain resilient to climate change. As weather patterns shift and food production seasons in some areas become shorter, small-scale farmers can leverage new tactics and seize opportunities for production in areas beyond current fertile zones. Protected crop cultivation techniques can shield crops from adverse climate and weather. Greenhouse horticulture, for example, can still thrive in warming regions like the Middle East and Africa, even as crop yields from large-scale farming are adversely impacted by climate change. Vertical farming in warehouses also presents some opportunities for investors, as these small-scale farms located closer to urban markets can be more resilient to weather variability.

### **Alternative protein**

Livestock production accounts for 15% of global greenhouse gases and has led to the potential for significant growth in alternative proteins for consumers conscious about their health or the climate.<sup>111</sup> It may be hard to replace a ribeye steak, but there has been significant success with plant-based burgers, sausages and ground beef – now even sold in Burger King and McDonald's.<sup>112</sup> Similarly, there are opportunities in plant-based dairy options like soy, oat and almond milk, that may offer higher returns than conventional dairy. Although some of these crops are water-intensive.

### **Solar farm land leasing**

Farmland investors may be able to enhance yields by leasing land to solar farm developers. Solar panels are

most productive in areas with high sun exposure, light wind, moderate temperatures and low humidity – the same conditions required for growing most agricultural crops.<sup>113</sup> As a result, solar developers have been paying farmland owners favorable lease terms to convert their agricultural land into solar farms. This is most profitable for farmland investors that own plots close to urban centers where electricity demand is highest.

### **Renewable natural gas rises**

Agricultural waste is the largest contributor of methane gas, accounting for about 20% of global emissions.<sup>114</sup> Driven by pressure from consumer preferences for sustainability, more innovative techniques are emerging to make farming greener. For example, agricultural waste is typically stored in vast open lagoons where it emits methane – a GHG 25 times as potent as carbon dioxide – for decades. However, new innovations have emerged that can transform organic waste product into biomethane, or renewable natural gas (RNG).<sup>115</sup> Companies are working with dairy farms to install biodigesters, which use specialized bacteria to convert their organic waste into biogas which can be purified into RNG.

### **Tapping into a growing market for carbon offsets**

Looking ahead, reforestation projects may see new opportunities for growth in corporate carbon offsetting. A growing number of companies have pledged carbon neutral footprints. As more companies take these pledges, many will fall short of carbon neutrality in their internal operations and will seek external carbon offsets. Reforestation projects, or even young timberland, can be a source of verifiable carbon offsetting for corporations.

Chapter 4 examined the significant investment opportunities and risks for individual asset classes (Table 2). However, the sweeping changes resulting from climate change also have profound implications for chief investment officers across the entire portfolio. We turn to these implications in Chapter 5, where we propose a portfolio-wide climate change action plan for institutional investors.

Table 2: Asset Class Implications Summary

<b>Fixed Income: Mispricing Creates Long-term Opportunities for Active Investors</b>	
<b>Sovereign Debt</b>	<ul style="list-style-type: none"> <li>■ Adopt a framework that considers both climate vulnerability and readiness.</li> <li>■ Opportunities for active investors to discern between winners and losers where markets do not.</li> </ul>
<b>US Municipal Bonds</b>	<ul style="list-style-type: none"> <li>■ With most muni investors motivated by favorable US tax treatment, climate risk is largely overlooked.</li> <li>■ Long-term active investors can find climate-resilient municipal debt without foregoing yield.</li> </ul>
<b>Energy Infrastructure</b>	<ul style="list-style-type: none"> <li>■ The long sunset for fossil fuels creates opportunities in midstream energy infrastructure (e.g., pipelines and refineries).</li> </ul>
<b>US Property and Casualty Insurance</b>	<ul style="list-style-type: none"> <li>■ New sources of capital and advances in underwriting have enabled top P&amp;C insurers to better manage exposures.</li> <li>■ Climate events are likely to drive US demand for P&amp;C coverage and expand the market for the top players.</li> </ul>
<b>Structured Finance</b>	<ul style="list-style-type: none"> <li>■ Investors are structurally insulated from physical risks to underlying collateral in ABS.</li> <li>■ In the agency MBS market, government-sponsored entities absorb much of the climate risk around the underlying properties, not investors.</li> </ul>
<b>Public / Private Equity and Venture Capital: Navigating the Green Transition and Game-changing Technologies</b>	
<b>Public and Private Equity</b>	<ul style="list-style-type: none"> <li>■ Significant divergence in climate sensitivity across sectors and countries creates opportunities for discerning, active equity investors.</li> <li>■ Capture opportunities for long-term outperformance with the “greenest” firms within brown industries.</li> <li>■ For ESG-focused investors, evaluate the benefits of pure exclusionary approaches vs. selective engagement with fossil fuel companies given their long sunset and improved data disclosures.</li> </ul>
<b>Venture Capital</b>	<ul style="list-style-type: none"> <li>■ Evaluate potentially transformative early-stage technologies: hydrogen power and carbon capture and storage.</li> <li>■ Integration of renewable energy with better power storage, smart grids and superconductive transmission networks.</li> <li>■ Electric vehicles: Seek technological innovations in key components like improved battery storage and recharging efficiency.</li> <li>■ Cutting-edge climate forecasting, analytics and modeling tools to help manage and reduce risk for the financial, agriculture and infrastructure sectors.</li> <li>■ Next-generation construction materials like exterior paint that reduces heat absorption and cooling costs.</li> </ul>
<b>Real Assets: Deploying Technology to Protect Assets and Uncover Opportunities</b>	
<b>Real Estate</b>	<ul style="list-style-type: none"> <li>■ Leverage next-generation climate analytics to capture opportunities where the broad market sees mostly risk.</li> <li>■ Consider capital projects to enhance climate resilience of high-risk properties that make lease payments more durable.</li> </ul>
<b>Infrastructure</b>	<ul style="list-style-type: none"> <li>■ Aging energy infrastructure creates new opportunities in solar and wind projects in Latin America.</li> <li>■ Less predictable rainfall creates new investment opportunities in water desalination, transport and filtration.</li> <li>■ Enhance cash flows and increase usage of toll roads by installing electric vehicle charging stations and plazas.</li> </ul>
<b>Agriculture</b>	<ul style="list-style-type: none"> <li>■ Ag tech innovations: Deploy advanced root sensors, vertical farming, drip irrigation and variable rate technology to adapt to changing weather patterns.</li> <li>■ Generate renewable natural gas from livestock production.</li> <li>■ Shifting consumer preferences for alternative protein creates opportunities.</li> <li>■ Reforestation and timberland: Capture growing corporate demand for verifiable carbon offsets to fulfill climate pledges.</li> </ul>

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