Urban Land Institute

COLD SNAP

Extreme Cold and Real Estate

COVER PHOTO: Winter Storm Uri covering the eastern third of the United States on February 15, 2021. (NOAA)

2001 L Street, NW | Suite 200 | Washington, DC 20036-4948

Recommended bibliographic listing: Urban Land Institute. *Cold Snap: Extreme Cold and Real Estate*. Washington, DC: Urban Land Institute, 2024.

ABOUT THE URBAN LAND INSTITUTE

The Urban Land Institute is a global, member-driven organization comprising more than 48,000 real estate and urban development professionals dedicated to advancing the Institute's mission to shape the future of the built environment for transformative impact in communities worldwide.

ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and Asia Pacific regions, with members in 84 countries.

More information is available at uli.org. Follow ULI on X (formerly known as Twitter), Facebook, LinkedIn, and Instagram.

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ULI Randall Lewis Center for Sustainability in Real Estate leads the real estate industry in creating places and buildings where people and the environment thrive. In collaboration with ULI members and partners, the Randall Lewis Center drives industry transformation, cultivates leaders and champions, and helps foster solutions for sustainable, resilient, healthy, and equitable cities and communities. The center pursues these goals via cutting-edge research, global convenings, community technical assistance, and other strategies. The center's main programs are Decarbonization, Urban Resilience, and Healthy Places.

Discover transformative practices for real estate and land use at uli.org/sustainability. Connect with the center at sustainability@ uli.org.

ABOUT THIS REPORT

This report introduces real estate owners, developers, and investors to the risks posed to real estate by extreme cold and other hazards typically associated with winter. While many prominent climate hazards take place in other seasons—hurricanes, wildfires, and heat waves—extreme cold can pose substantial risks to property, infrastructure, and health, and awareness of the risks and resilience measures available to mitigate these hazards is a key aspect of any climate and sustainability strategy. This report presents the business case for cold-resilient buildings and the potential impacts and mitigation measures real estate can consider as part of a fully resilient portfolio.


SHUTTERSTOCK

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INTRODUCTION

As global temperatures rise from accelerating climate change, extreme temperature swings—both cold snaps and heat waves—are causing increasing damage and disruption. However, extreme cold and storms that bring snow, ice, and freezing rain can receive less focus than warm-weather hazards such as blistering heat and powerful hurricanes.

Nonetheless, cold waves and winter storms can be just as destructive, forming storm fronts hundreds of miles long and bringing plunging temperatures that infrastructure cannot withstand, all causing tremendous damage, disruption, and loss of life. Damages from the five costliest winter storms from 2013 to 2022 totaled nearly $50 billion.

Storm Filomena in 2021 dropped more snow on Madrid than had been seen since 1971, leading to five deaths and causing an estimated US$2.2 billion in damages.

A foot of fresh snow covers the landscape in Round Rock, Texas, during Winter Storm Uri in 2021.

The risk from these hazards, long confined to northern regions in North America and Europe, has begun to reach more southerly locales that have not designed their built environments with extreme cold and winter storms in mind.

Winter storm Uri, which brought devastation to Texas in 2021, was a stark lesson in this new reality. Thus far the world's costliest winter storm on record, Uri created over $30 billion in damage, knocked out the power grid for millions of people for days, and led to 246 deaths—more than Hurricane Sandy in 2012—and caused water pipes to freeze and burst in many buildings. Over 500,000 insurance claims were filed. Additionally, winter storm Eunice, which hit Ireland and Belgium in 2022, caused more than $5.6 billion in damage, while severe hail events in France in 2022 caused in excess of $3 billion in property losses (though hail is typically associated with summer thunderstorms, it can form at any time of year).

Warming overall may also increase the occurrence of wetter, and therefore heavier, snow. "Building code uses historical models. It says, 'this is the kind of snow and these are the weights we've had for the last 100 years.' What we're seeing with climate change is that those backward-looking models are not necessarily telling us everything we need to know moving forward as the climate is changing."

ROSE GRANT
Former program director, State Farm Insurance

JBG SMITH Assesses New Risks in New Places

Firms savvy at assessing climate risk, such as JBG SMITH, a real estate investment trust with office and multifamily holdings primarily in the Washington, D.C., metro area, are using detailed risk assessments to look comprehensively at asset- and market-level risk and resilience factors before investing (see ULI's research on climate risk and real estate investment for more on this process).

JBG SMITH had developed a robust physical risk assessment and management strategy, which includes financial modeling, as Kim Pexton, senior vice president of sustainability, describes. When the firm was looking at markets around the country for expansion of its workforce housing investment management platform, LEO Impact Capital, red-flag risks from extreme cold in traditionally warm markets came as a surprise. "One of the things that jumped out to us in the analysis was that some warmer markets where we didn't expect it had significant climate risk—both from heat and from cold," according to A.J. Jackson, president of LEO Impact Capital.

What stood out most of all, Jackson notes, was the "vulnerability of infrastructure. Coupled with the increasing frequency of extreme cold events, and flash freezes, it created a situation where there was much more climate risk in some warm markets than we had anticipated."

After reviewing the analysis, "the upshot was that it informed how we think about whether or not we're going to enter a market and if so, the types of assets that we want to acquire, and what the resilience is at the asset level to extreme cold."

To that end, JBG is examining whether assets have strong backup power sources and what building construction and energy systems look like to determine whether the properties can be comfortably inhabited "whether it's 25 degrees or 105 degrees outside," as Jackson says. Risk is particularly high in older assets, which often have what LEO calls "light systems or no systems" for heating, ventilation, and air conditioning (HVAC) or insulation.

These assets pose both livability and insurance concerns that affect decision-making. "There's a significant issue going on right now in the multifamily space around rapidly escalating insurance costs," Jackson points out. These properties would be more difficult to insure and more likely to have large claims in case of damages—both of which would affect their marketability and value. Along with factoring in the cost of upgrades the properties would need to operate safely, these findings are becoming part of the investment decision process.

How is climate change affecting extreme cold events?

Surprisingly, climate change—which leads to warmer temperatures overall—is also making extreme cold events like this more common. Though still a matter of debate, some research suggests that this could be due to the rapid warming of the Arctic changing the dynamics of the jet stream, a current of winds high in the atmosphere that affect the movement of cold and warm air around the globe.

As Munich Re puts it, "Climate change studies offer contrasting projections regarding the number of winter storms. These scientific studies indicate that the risk of severe winter storms, and possibly also autumn storms, from the North Atlantic to central Europe could increase in the 21st century, while the overall number of storms is likely to decrease."


SHUTTERSTOCK

Cold and the Future Climate

A changing climate has impacts in store for extreme cold and cold-weather storms.

Anne Waple, president and founder of Studio30k and former director of technical support for the U.S. National Climate Assessment at the National Oceanic and Atmospheric Administration, notes that although temperatures are getting warmer, "the current thinking is that warming in the Arctic is potentially destabilizing the jet stream there to the extent that we could see more incursions of extreme cold and polar vortexes. They are warmer than they used to be, and winter will be warmer overall, but we could still have more of those extreme cold events."

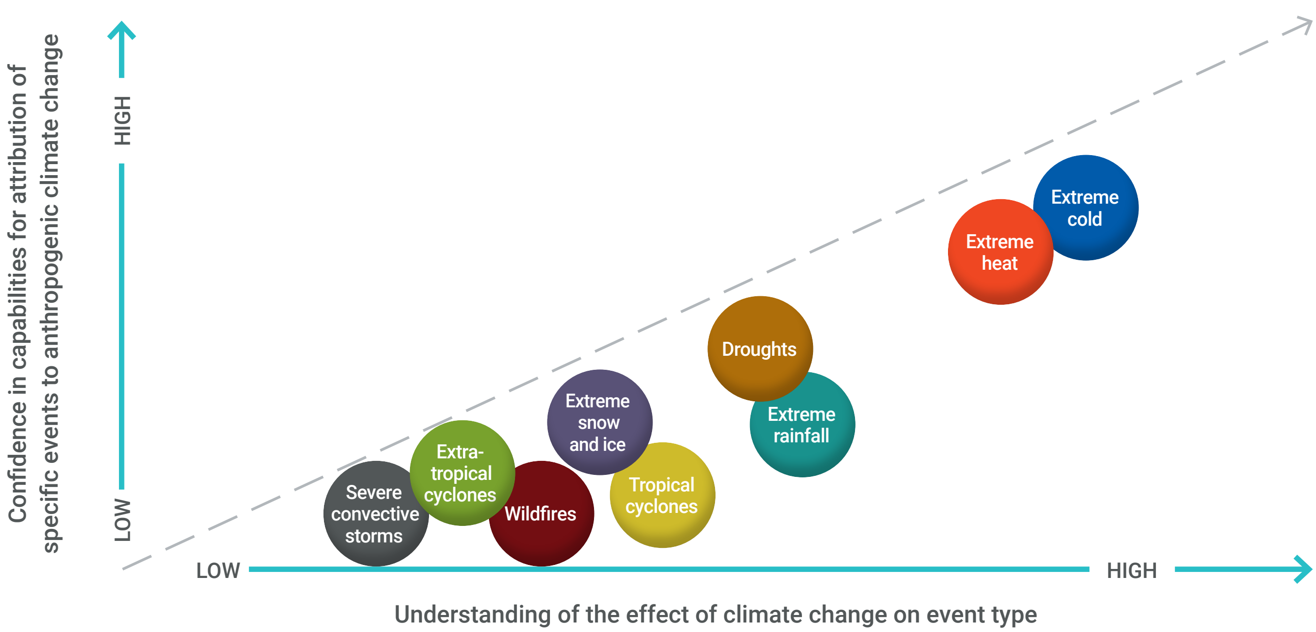
Such events are likely to be concentrated geographically. According to Waple, "in the Midwest, in particular, and the Great Plains in general, I would definitely expect to see cold outbreaks as part of the routine extremes."

However, what these storms might look like could change. If emissions continue as usual, we are likely to see "less snow, and more ice; then less ice, and more rain," long term, as Waple explains. "In general, though, the challenge is not so much what the mix of precipitation will be on average, but what will be unusual in the context of that average. For example, right now in Atlanta, when it gets an ice storm, it's pretty much crippled, because we don't see it in the Southeast. Not so much in the Northeast."

Seasons are also changing: spring is starting earlier, and winter is starting later. These shifts can cause broader changes in the risk profile of other hazards as well, says Waple. For example, "Another question is the timing of melt. If you have a particularly snowy winter, for example, that melts all at once, instead of over time throughout the spring, that's a flooding risk."

In fact, among natural hazards affected by climate change, scientific certainty in attributing the likelihood of hazard events to human-caused climate change is highest for extreme cold and higher for extreme snow and ice than for wildfires, cyclones, and other severe storms, as shown in the figure below.

CONFIDENCE IN LINKING CLIMATE CHANGE AND EXTREME COLD EVENTS



Scientific certainty in understanding the impact of climate change on extreme cold events is greater than for any other hazard.

Source: Adapted from National Academies of Sciences, Engineering, and Medicine, *Attribution of Extreme Weather Events in the Context of Climate Change* (2016).

Extreme cold, snow, and ice can impact places both familiar (like Chicago, above) and unfamiliar with their impacts.

The threat is real, and real estate needs to prepare.

Extreme cold and winter storm events threaten assets and portfolios directly, through property damage and occupant safety, but also indirectly: large winter storms and extreme cold that shut down power and access to buildings for days will cause huge disruptions and loss of income. As events become more extreme, building to local code may be insufficient to protect properties.

Insurance is also not enough to protect owners from this exposure. Rapidly accelerating climate risk and development in risk-prone areas is driving an insurance crisis, leading to rising premiums and private insurers pulling out of certain markets. Even if it can be secured, insurance is unable to prevent a disaster from occurring and may not fully cover repair or replacement costs, losses from business disruption, or the reputational damage that can arise when an asset experiences heavy damage or temporary closure.

Preparing for hazards in advance by physically adapting buildings and sites, however, can fill many of those gaps. Real estate developers, owners, and investors who take proactive steps to ready their properties will thus gain a competitive advantage.

"We're seeing a hard market in the insurance industry. The underwriting criteria is tougher and the prices have gone up. Which means if you have a marginal building, it's going to be really hard to get insurance. And if you have a very expensive building, one insurance company may not want to take on the entire risk themselves, and you may actually need two or three insurance companies that each take a portion of the risk. It's getting tougher for folks on the temperature extremes."

ROSE GRANT
Former program director, State Farm Insurance

Heavy snow and ice can impact energy sources including renewable energy, though renewable energy networks can be easier to bring back online.

THE BUSINESS CASE FOR ADAPTING TO EXTREME COLD

Resilient buildings, whether prepared for extreme cold and winter storms or other climate hazards, are quickly becoming a necessity to protect investments from physical climate risk. However, they also create benefits year-round and are a no-regrets strategy for real estate to enhance asset and portfolio value. The following are several ways resilient buildings create stronger returns.

"Over the last decade, commercial losses from winter weather in the U.S. have averaged about **$4 billion dollars per year**. It can be one of the highest-risk seasons for businesses. . . . Of the nine most recent catastrophic freeze events, eight of them occurred in California, Florida, or other southern climates, mostly in areas south of the 32-degree frost line in the International Building Code."

CHUCK MICCOLIS
Insurance Institute for Business and Home Safety

Maintaining business continuity. Extreme cold events and winter storms cause widespread disruption and closures that can create huge revenue losses. Properties that can remain operational during these events will avoid this disruption. For example, during winter storm Uri, the University of Texas at Austin was one of the city's few areas that experienced no power outages and was able to provide continuous heat and shelter because of its large, award-winning on-site power plant and microgrid, which can operate independently from the state power grid. This capability kept the campus's research facilities running and allowed the campus to open warming shelters.

Reputational benefits. Assets and developments that can withstand, or quickly resume operations after, hazard events can attract significant attention and build brand value. For example, Babcock Ranch outside Fort Myers, Florida, gained national prominence for its extensive resilience features after weathering the intensely destructive Hurricane Ian with minimal damage and never losing power thanks to its extensive solar array. The property became a recovery hub after the storm for nearby areas that were harder hit.

Multinational Investment Manager Responds to Winter Storm Uri

Winter storm Uri, which struck Texas in 2021, and another extreme cold event the following year caused significant damage to a large multifamily property in Dallas owned by a leading multinational investment manager. Much like many other properties in the state during the storm, pipes for both the potable water and the fire protection systems froze and burst, causing flooding throughout the property, common areas, and living spaces.

The second cold snap on Christmas Day in 2022 was worse: "We had massive disruption and a million dollars of damages," notes a vice president for asset management at the firm. Insurance covered repairs and lost revenues, but the disruption to property operations and overall business continuity was massive, given that the clubhouse was affected and amenities were down for almost nine months, with tenant retention plummeting to record lows. "Despite having insurance, we couldn't let this happen again, and we knew it would unless we took action," says the vice president.

The firm realized that cold snaps were becoming more and more extreme, even in Texas, and took steps to make the property more resilient. The property, a garden-style, wood-framed multifamily building, lacked significant insulation in walls and around pipes, similar to many multifamily assets of that vintage in the region. "It was not built to withstand deep freezes for long periods of time, and due to climate change, we're now seeing multiple days of subfreezing temperatures occur annually," adds the vice president.

The company upgraded insulation in every building, mapping out the locations of exposed pipes that are vulnerable (usually in attics, or those facing exterior walls). These mitigation measures were relatively low-cost for a property of its size—a no-brainer, given the huge impact of possible recurring freeze damage. While there are no guarantees that the insulation will completely prevent issues from occurring in the future, it is expected to minimize potential damage and operational impact.

There are benefits that can apply year-round as well. "There's also an added benefit for tenant comfort," the vice president found. "In these older buildings, the top units are always the hottest. When you have better insulation, the air-conditioning systems work better. The tenants are expected to have lower energy bills and the landlord should benefit from lower repairs and maintenance costs."

Reduced insurance premiums and preserving access to insurance. As losses from climate events mount, the insurance industry is reacting by raising premiums and reducing coverage in the highest-risk areas. Though this is occurring principally in areas hit by repetitive wildfire and coastal storms, other hazard events can also incite price hikes. Winter storm Uri caused significant increases in insurance premiums in Texas.

Insurers are beginning to offer discounts for more-resilient properties. Some do so proactively—FM Global recently began offering a 5 percent resilience credit to all policyholders for adding features that reduce risk—and some are mandated by law, as in California and several other states that require insurers to reduce premiums for owners who take steps to reduce risk from wildfire and wind damage, respectively. Protecting properties from worsening climate risk is often the best way to help secure coverage and more affordable premiums.

Avoided losses from damage. Climate impacts cause property damages and raise capital expenses for repairs. However, proactive resilience investments, especially in new construction, typically cost far less than damages from hazards. Though benefit-cost analysis varies by hazard type, and research on specifically extreme cold and winter storms is limited, the National Institute of Building Sciences has found that the return on resilient building investments can reach 13:1. For example, a large, multinational investment manager interviewed for this report has found that upgrading insulation is a relatively low-cost project that's expected to have a high impact on mitigating future damages.

Reduced operating costs. Many strategies for reducing risk from extreme cold and winter storms involve improving the efficiency of building envelopes and energy systems to maintain internal temperatures. These steps reduce energy use year-round, reducing operating costs and improving net operating income while providing better thermal comfort for residents.

Extreme cold, snow, and ice can cause widespread disruption beyond property lines, particularly to transportation networks.

THE IMPACTS OF EXTREME COLD AND WINTER STORMS

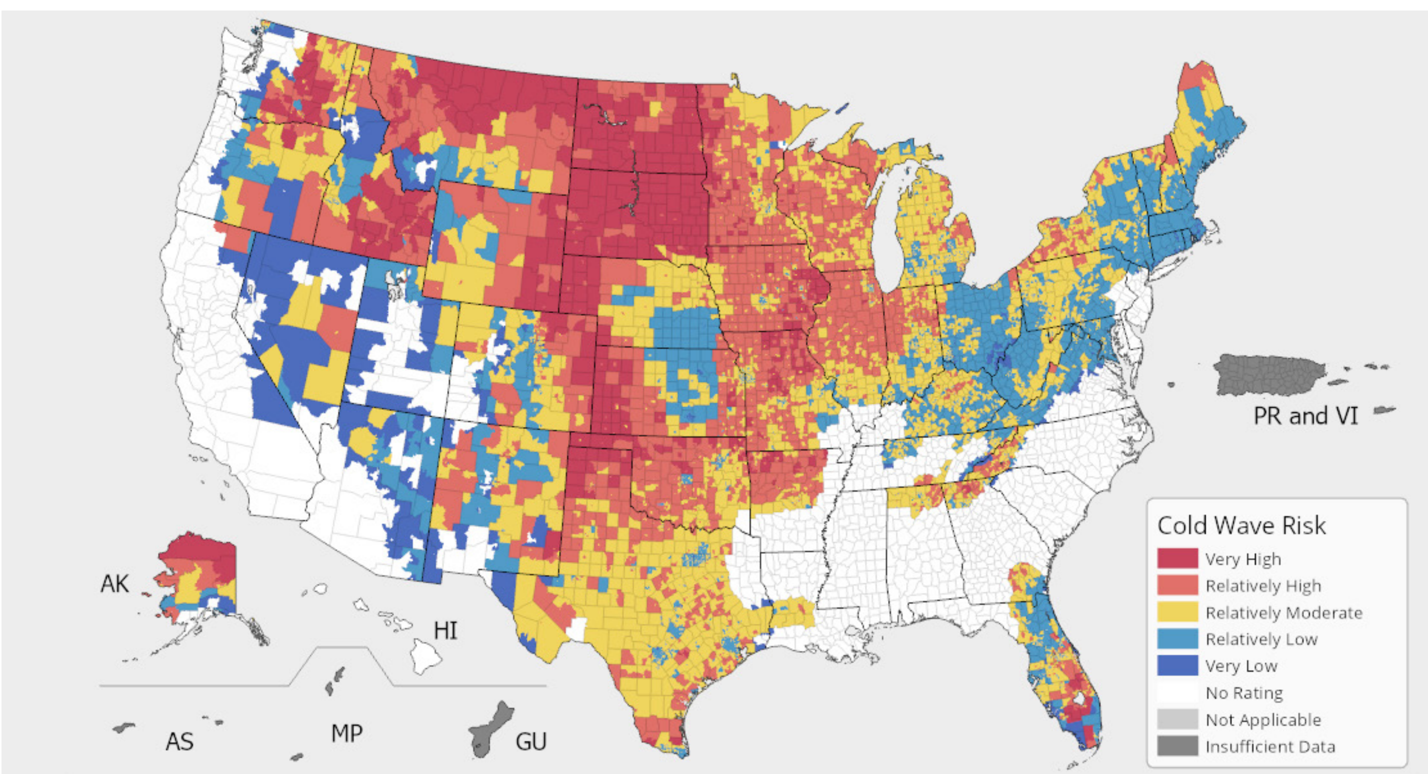
Extreme cold and winter storms that bring high winds and intense snow and ice can cause physical damage to buildings, critical infrastructure, and health and safety and disrupt access to the buildings and services communities rely on to function. These damages can be extensive and community-wide, even in places accustomed to cold-weather storms: for example, a blizzard that dumped record snowfall in Buffalo, New York, in 2022 caused $46 million in damages and cleanup costs. There are also cascading effects that can exacerbate risks from other climate-related hazards.

Long lines for supplies at a grocery store after a winter storm. Extreme cold and cold-weather storms can cause major, community-level disruptions to business operations, and commercial establishments can prepare ahead of storms to operate safely for employees and customers.

RISKS OF COLD WAVES, ICE STORMS, AND WINTER STORMS IN THE UNITED STATES

Real estate faces risks from a variety of cold-weather hazards. Risk levels from each hazard differ across geographies, as shown in these maps from the Federal Emergency Management Agency (FEMA) National Risk Index, and mitigation strategies should reflect the risks each asset will face. Note that these maps show historical patterns and do not include forward-looking projections for how risk distribution might shift because of climate change.

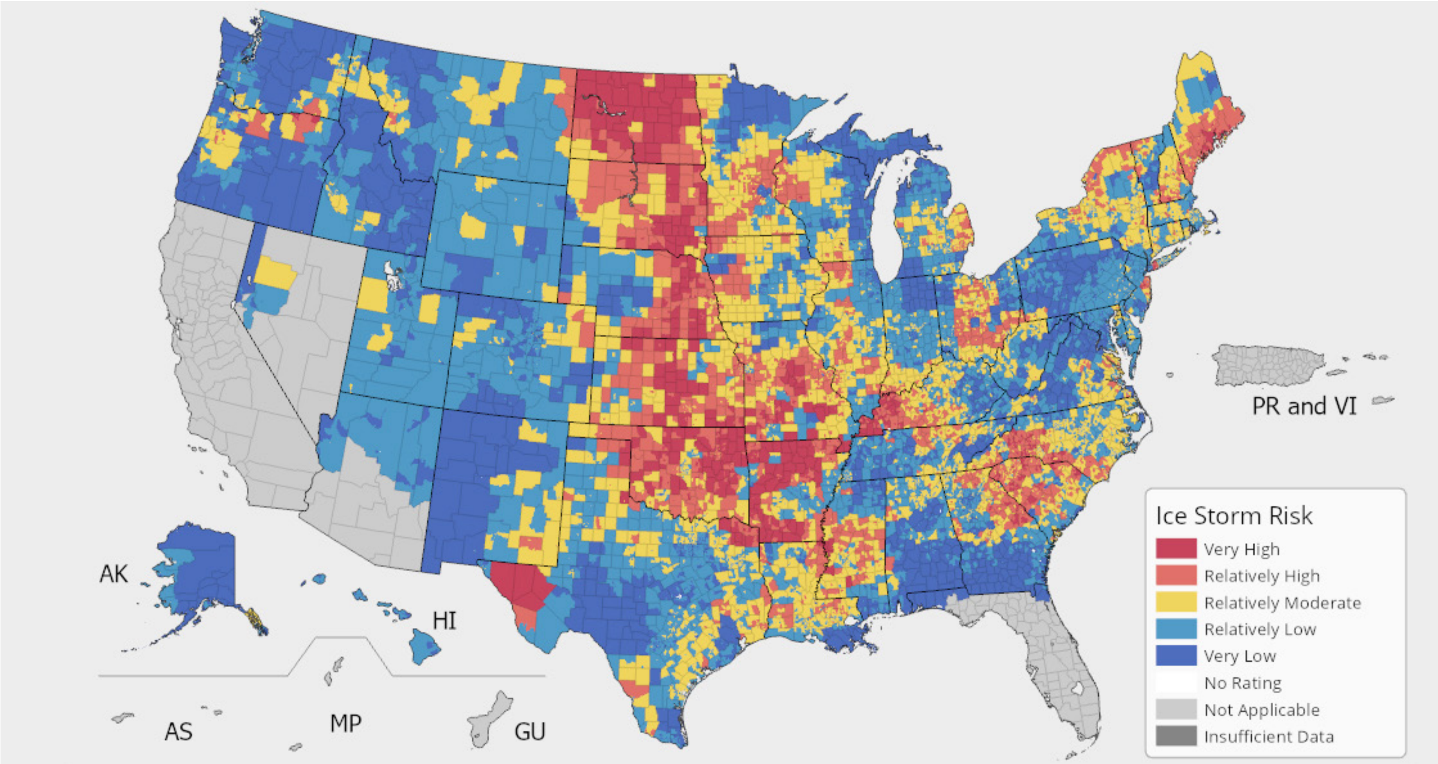
COLD WAVES



A cold wave is a rapid fall in temperature within 24 hours and extreme low temperatures for an extended period. The temperatures classified as a cold wave are dependent on location and defined by the local National Weather Service forecast office.

Source: FEMA National Risk Index. AK: Alaska; AS: American Samoa; GU: Guam; HI: Hawaii; MP: Northern Mariana Islands; PR: Puerto Rico; VI: Virgin Islands.

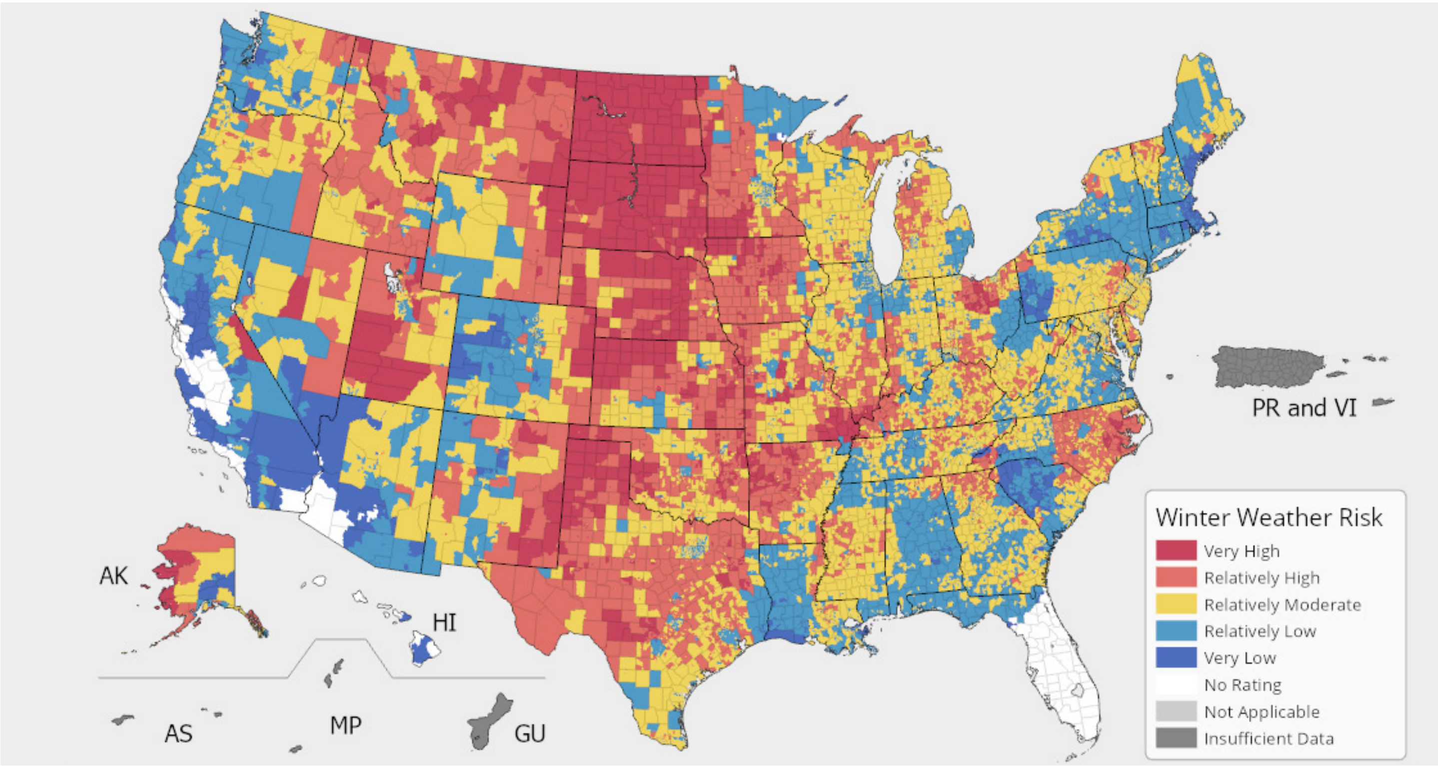
ICE STORMS



An ice storm is a freezing-rain event (rain that freezes on surface contact) with significant ice accumulations (0.25 inches or greater).

Source: FEMA National Risk Index. AK: Alaska; AS: American Samoa; GU: Guam; HI: Hawaii; MP: Northern Mariana Islands; PR: Puerto Rico; VI: Virgin Islands.

WINTER STORMS



A winter storm is one in which the main types of precipitation are snow, sleet, or freezing rain.

Source: FEMA National Risk Index. AK: Alaska; AS: American Samoa; GU: Guam; HI: Hawaii; MP: Northern Mariana Islands; PR: Puerto Rico; VI: Virgin Islands.

The following major risks to buildings are posed by intense cold and winter storms:

- **Roofs or buildings collapsing from heavy snow and ice.** Risk is highest for older buildings and buildings built to older codes, those with flat roofs, and those with preexisting damage (e.g., leaks). See resilience strategies for this risk.
- **Water leaks from ice dams.** Ice dams are built-up ice on the edges of pitched roofs that forms when precipitation melts from below because of heat escaping from uninsulated upper floors, whose heating system then cannot drain off, so the water refreezes and backs up, causing water to enter the building. See resilience strategies for this risk.
- **Damage to buildings from high winds and wind-driven ice, snow, or freezing rain.** Wind speeds are generally lower in winter storms than during hurricanes or tornadoes but can still reach dangerous levels, create gaps in building envelopes, and drive precipitation into the building. See resilience strategies for this risk.

Hail, though not restricted to episodes of extreme cold, can cause millions of dollars of damage to roofs and facades.

Damage from frozen water after burst pipes can be significant.

- **Water pipes freezing and bursting.** Experts note that this is a leading cause of damage that can cause significant losses and can damage pipes for water systems and fire protection systems. Often occurs because of loss of power. See resilience strategies for this risk.
- **Loss of power.** Lost power can cause significant risks to health, safety, and operations. See resilience strategies for this risk.
- **Damage to landscapes.** Extreme temperatures, wind, and precipitation can damage vegetation and landscaping, incurring replacement costs and reducing the ecosystem services landscapes provide. For example, damaged tree canopy will provide less shade and cooling later in the year. See resilience strategies for this risk.

Although real estate is often focused on risks to buildings, the risks posed to market-level infrastructure by extreme cold and winter storms are just as vital to consider. Regions that are not adequately prepared for extended freezing temperatures or precipitation will face significantly greater likelihood of loss of power and other community-level disruptions, as shown in the following table.

Though some of these risks require broader coordination among local governments, businesses, and other stakeholders to address, many of them—particularly risks to buildings and occupants' health and safety—can be mitigated at the property level by real estate owners, developers, and investors who take proactive steps to reduce risk, as explained in the next section.

TYPES OF IMPACTS OF EXTREME COLD AND WINTER STORMS

BUILDING DAMAGE

- Damage or collapse, for example, roof failure under weight of ice/snow, roofs or other attached structures torn off by high winds, roofing or windows damaged by hail/ice
- Damage to foundations or supports or other building materials as temperatures cause material expansion and contraction or as soil shifts at base of buildings
- Damage caused by water and/or fire protection pipes freezing and bursting
- Damage caused by falling tree branches to buildings, equipment, power lines, occupants

DISRUPTION TO BUSINESS CONTINUITY

- Shortages of fuel, food, or other supplies as communities prepare for extreme weather
- Hazardous travel conditions, including road closures or slowdowns, reduced public transportation service, and reduced flight service, and disrupted operations and supply chains
- Closures of businesses, government offices, and public facilities during hazard events, affecting business continuity, income, and service provision

HEALTH AND SAFETY RISKS

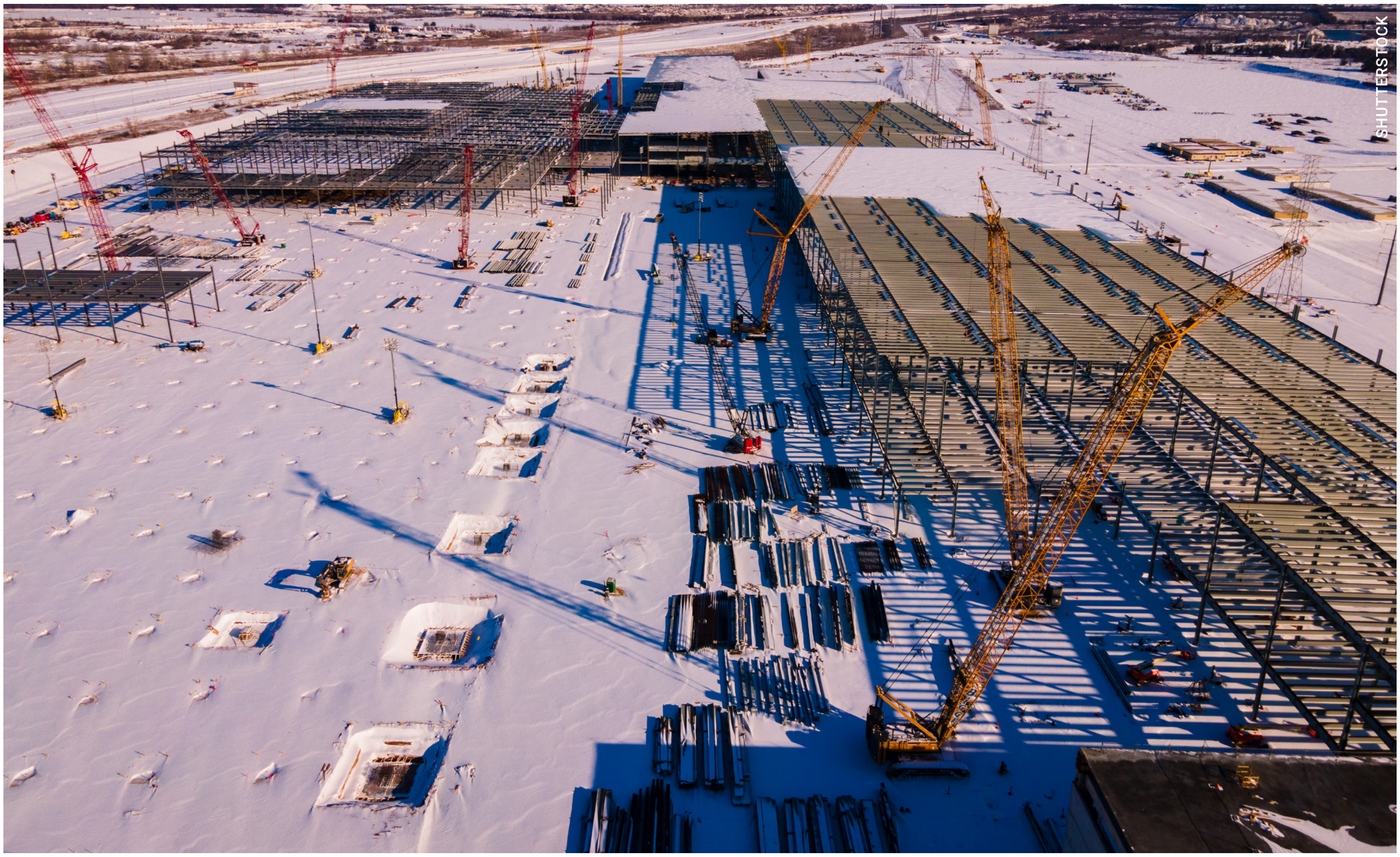
- Indoor exposure to extreme cold for individuals in buildings without heat or electricity, particularly in low-income communities with higher concentrations of inadequate/inefficient housing stock
- Use of backup power or secondary heating systems without proper ventilation, such as generators or wood stoves, which can cause carbon monoxide poisoning and air quality issues or cause fires if not used and maintained properly
- Decreases in indoor air quality due to blocked or damaged ventilation systems
- Outdoor exposure to extreme cold, especially for outdoor laborers and unhoused individuals
- Heightened likelihood of vehicle accidents
- Reduced access to health care and emergency services
- Reduced employee/tenant well-being (e.g., stress on working parents when schools close, fear for well-being of community or family members, stress on employees from potential lost income)

CRITICAL INFRASTRUCTURE AND TRANSPORTATION IMPACTS

- Loss of power due to surging demand for electricity for heating, damaged or poorly winterized power grids, and lack of fuel (e.g., coal and gas) supply for electricity production during freezing conditions
    - Note: electrical equipment, such as transformers, solar panels, and wind turbines can also freeze during extreme cold, but renewable energy systems are generally better prepared for extreme weather than fossil fuel-based systems. For example, though all types of energy systems were affected, power outages in Texas during winter storm Uri were due primarily to failures in the natural gas-based energy system.
- Damage to bridges or waterfront infrastructure from ice dams
- Damage to roads from freeze-thaw cycles
- Damage to transportation infrastructure, such as public transit

CASCADING IMPACTS

- Fluctuating temperature cycles (premature freezes and shifts in warming) can lead to double blooms, premature budding, and early snowmelt that can increase scraggly brush growth and worsen wildfire risks
- Heavy snow or ice storms that melt suddenly can cause flooding
- Loss of tree canopy and vegetation from cold exposure, high wind, or snow/ice damage can damage amenity value of landscaping and reduce trees' ability to moderate extreme heat, absorb stormwater, sequester carbon, reduce air pollution, and provide mental health benefits



Snow covers a manufacturing facility after an unexpected storm. Resilience strategies for extreme cold, snow, and ice are critical to protect real estate of all kinds, including those that impact the supply chain.

RESILIENCE STRATEGIES FOR EXTREME COLD

Many design and operational strategies for improving the resilience of buildings for extreme cold and winter storms are available and have benefits for decarbonization, utility costs, health and wellness, and reduction of risk from other hazards.

These strategies will differ by assets' locations and climate zones, which determine the relevant risks and whether common building practices—such as heavy snow loads or enhanced insulation—that may increase resilience to aspects of extreme cold or winter storms are already in use. Adapting to climate risk should always begin with assessment of specific risks and vulnerabilities and designing or retrofitting accordingly, as laid out in the *ULI Developing Resilience Toolkit: Protecting Buildings and Sites*.

The ULI Developing Resilience Toolkit provides an introduction to risk assessment and a resilient design process, along with a Risk Reduction Matrix with more than 140 strategies that can help protect buildings and sites from nine major climate hazards. Learn more.

The table on the following page presents a selection of critical strategies for protecting buildings and occupants from extreme cold and cold-weather storms and the cobenefits these strategies provide. Additional information on each (including the other hazards the strategies may help protect against; their applicability to new construction, retrofits, and/or landscapes; asset type–specific considerations; and relevant operations and maintenance considerations), as well as additional strategies not presented here, can be found in the Developing Resilience Toolkit's Risk Reduction Matrix. Information in this section is drawn from that matrix, as well as resources from the Insurance Institute for Business and Home Safety's checklist guides for extreme cold and winter storms for commercial and residential properties and the U.S. Department of Energy's Building America Solution Center.

Downed power lines from winter storms can cause outages and disruption to electrical grids.

Broadly, strategies can be grouped into five categories. Select a category below to jump to the start of that category.

1. Enhancing envelope performance and structural strength
2. Creating energy resilience and improving HVAC systems for building habitability
3. Utilizing green infrastructure
4. Developing and executing operational and preparedness plans and measures
5. Protecting water systems

The Insurance Institute for Business and Home Safety has developed comprehensive checklist guides for extreme cold and winter storms for commercial and residential properties, which inform many of the resilience strategies recommended here. Additionally, their FORTIFIED design standard and designation program helps protect commercial, multifamily, and residential properties from high-wind damages that can occur during winter storms, as well as hurricanes, tornadoes, hail events, and more.

"One of the easier things to do is to make sure that your electrical connection is coming in underground. We've seen in the past, in communities where there's a new subdivision, all the utilities are brought in underground, and they're fine [after a storm]; and then you get into an older part of town, and all the power lines are above ground, and ice builds up on the lines and takes them down. From a resilience standpoint, having your own on-site power generation if the grid goes down is a measure that will allow you to do everything from keeping the heat on to keeping your pipes from freezing."

ROSE GRANT
Former program director, State Farm Insurance

RESILIENCE STRATEGIES

STRATEGY	DESCRIPTION
ENVELOPE AND STRUCTURE	
Anchor or engineer attached structures (e.g., porches, balconies, decks, overhangs)	Heavy snow and ice loads that pile on top of these structures can cause damage or collapse if structures are not designed correctly. Strong anchors and connections can reduce this risk.
Assess and improve snow load (clear safely during hazard events)	Heavy snow and ice loads can cause older roofs, roofs built to older code, or roofs in poor condition to collapse if not cleared. If snow load is unknown, it can be verified by a structural engineer. For roofs expected to be chronically overloaded, work with an engineer to explore retrofitting of connection details or structural strengthening. During winter storms, snow, ice, or ice dams exceeding snow load should be carefully cleared, potentially by a snow removal team, and roofs should be monitored for signs of overload (e.g., bowing or sagging; creaking sounds; cracks in finishes, framing, or masonry). Explore building to higher snow loads than required by local code.
Brace or engineer parapets and false fronts	Parapets can provide shelter for the accumulation of snow drifts that add weight to the roof/wall intersection, and connections here should be adequately detailed to resist this load.
Build in chimney crickets *Primarily for small residential buildings*	Chimney crickets will direct meltwater from snow and ice around the chimney, avoiding drifting and water leakage that could otherwise cause interior damage to the building.
Construct high-performance building envelopes (enhanced insulation, continuous air barrier, high-performance glazing)	High-performance envelopes increase protection from numerous hazards. Tightly sealed and insulated envelopes provide a continuous barrier between indoor and outdoor space, helping regulate indoor temperatures, air quality, and energy use in all conditions and improve passive survivability, keeping buildings habitable longer during blackouts and power outages. During winter storms and high-wind/rain events, these envelopes (especially paired with flood- and impact-resistant materials) reduce debris damage, extreme cold impacts, intrusion by wind-driven snow, and ice and ice dam formation.
Engineer continuous load paths	Continuous load paths securely connect foundations, walls, floors, and roofs so that snow and ice loads can be transferred safely through the structure, reducing damage. Connecting the roof system to upper-floor walls, to lower-floor walls, to the foundation creates a continuous load path that transfers weight safely into the foundation. A verified load path may be required by building code.
Prevent formation of ice dams	Ice dams form when snow is present on a roof but the roof deck underneath reaches above-freezing temperatures (due to escaping heat from building interiors; warmer temperatures can also occur in roof valleys or near chimneys). Snow in contact with the warmer roof melts, runs down roof slopes until reaching eaves at cooler temperatures, and refreezes, causing a buildup of ice that prevents proper drainage of meltwater, which can leak and cause structural damage. Simple roof designs, continuous air and thermal barriers, ventilation of roof deck, and sealing roofs with self-adhering waterproof membranes to protect them will reduce ice dam formation.
Protect solar photovoltaic systems from heavy snow and ice loads	During severe snow and ice events, the added weight of snow and ice can strain, warp, or break components of a solar photovoltaic module. Systems should be designed to resist these loads, including module selection, racking parameters, attachments of modules to the racking or roof, system layout, and foundation design, as well as anti-snow or anti-ice coating, depending on local climate and whether heavy snow or heavy ice events are more likely.
Steep and simple roof design	Roof design with steeper slope and fewer angles/corners (e.g., those created by dormer windows or other protrusions) can improve roof snow load and reduce ice dam formation. However, in high-wind regions, tradeoffs between roof slope and wind resistance exist, as steeper slopes may increase wind loads on structure. Load paths should be checked for the selected roof slope to ensure consistency with design wind speeds, and roof system should be compatible with selected slope.
Storm shutters and panels	Storm shutters for windows can protect from snow, ice, and hail, while reducing heat loss and energy needed for heating.
Use rainscreen cladding	A construction detail in which air space between exterior cladding and the structural wall system is provided. This allows cladding (or siding) to dry out between precipitation and storm events, blocks the vapor drive of moisture through cladding materials, and allows water vapor from inside the building to escape without degrading walls or growing mold.
Wind- and impact-rated roofing material	Roofing is vulnerable to ice/hail impacts that can cause significant damage. Roofing materials should be rated for impact resistance, whether asphalt shingle, metal, or an alternative.

Designing and Retrofitting Roofs for Heavy Snow and Ice

“Ten to 12 inches of new snow is going to weigh about 5 pounds per square foot. Three to five inches of packed snow is also going to weigh about 5 pounds per square foot, and so will one inch of ice. So, if you calculate your roof loads at about 20 to 25 pounds per square foot, you need to be a little concerned about collapse, especially if you’re in a milder climate.”

CHUCK MICCOLIS
Insurance Institute for Business and Home Safety

“During initial design, if I were designing somewhere where there might be heavy snow, I would do what’s called ‘code plus.’ Say my snow load by code is 50 pounds per square foot, and this building is going to last 50 years. I might bump that up to 75 pounds, and err on the side of caution, since it doesn’t cost a lot to beef up the structure a little more now.

And for an existing building, one that’s 20–25 years or older, built under an older code, it might be inadequate even for what we’re seeing today. It never hurts to have an engineer come in and do an analysis, based on what conditions the building will face over the next 25–50 years, and including any new structures built around it that could affect snow drifts, and see what strengthening might need to be done.”

ROSE GRANT
Former program director
State Farm Insurance

ENERGY RESILIENCE AND HVAC PERFORMANCE	
Electrify building systems	Buildings that are designed or retrofitted to eliminate all fossil fuel-based building systems (e.g., HVAC, hot water, cooking, etc.). All-electric buildings are better prepared for on-site or grid-delivered renewable energy and, if connected to on-site renewables, are more prepared to remain operating during power outages caused by snow and ice storms, extreme cold events, and other hazards.
Enhance filtration and ventilation systems	Indoor air quality can be affected by winter storms, which may increase use of fuel-based heating systems on site or nearby. Filtration and ventilation strategies can protect indoor air quality, such as higher-performance air filters (MERV-13 or above); ventilation systems sized to accommodate high-performance filters; central ventilation systems, with fewer filter banks to maintain; passive house design and air tightness to reduce infiltration of outdoor air; design or reprogramming of indoor spaces to accommodate activities typically conducted outdoors; regular maintenance of ventilation/HVAC systems; use of air quality sensors (including smoke/carbon monoxide detectors); use of air purifiers; keeping windows and doors shut and installing vestibules or rotating front doors or air curtains at entrances; and use of scrubbers in ducts.
Implement energy efficiency measures (e.g., efficient appliances, HVAC, light-emitting diode [LED] lighting)	Energy efficiency reduces grid strain and/or energy needed from on-site renewables or backup power, helping buildings and grids remain operational during snow and ice storms, extreme cold events, and other hazards. Modern HVAC systems such as heat pumps and energy recovery ventilators provide efficient heating during extreme cold events, especially when cold-climate heat pumps are used. Some of these measures or performance standards may be required by building/energy code.
Install backup on-site power (e.g., solar plus battery storage or generator)	A backup power supply to ensure that the building (or critical systems) can remain operational in case of power outage during snow and ice storms, extreme cold events, and other hazards.
Install microgrids	Microgrids are small, localized energy grids of connected, distributed energy sources and loads that can act as a single controllable entity. Microgrids increase reliability and resilience to power outages caused by snow and ice storms, extreme cold events, and other hazards if the microgrid can be disconnected from the larger grid (island mode).
Utilize secondary heat sources	Depending on the building's climate zone, secondary heat sources may range from being used only during emergencies to being a necessity for winter safety. Secondary heat sources should not use the same fuel type as primary heat sources and, depending on development context, can include non–electricity-based options such as sealed wood-burning appliances, nonelectric pellet stoves, and direct-vent nonelectric gas heaters for smaller residential buildings or natural gas– or fuel oil–based heating systems for larger commercial buildings. Proper ventilation during use of these systems is critical to ensure that they do not create dangerous indoor air quality.

GREEN INFRASTRUCTURE	
Construct windbreaks	Vegetation such as trees and hedges can redirect drifting snow away from buildings, roads, and other areas, preserving safe access to businesses and services. Walls and other nonvegetated structures can also serve as windbreaks, though vegetated versions can provide biodiversity and aesthetic value.
Monitor tree canopy health	Heavier snow and ice loads may affect tree canopy health in urban forests. Ongoing inventories to assess and prepare for shifting canopy conditions can guide changing landscape maintenance needs and ensure that trees continue to provide multiple benefits to properties and building occupants.
Protect or restore soil health	Soil health is foundational to ecosystem well-being. Healthy soil retains moisture and structure for absorption of meltwater after heavy snow or ice storms to prevent flooding. Use of soil amendments (e.g., compost) and mulch, restoration techniques such as subsoiling, and minimizing disturbance/compaction during development/operations can all preserve or enhance soil health.
Select native and resilient species for landscaping	Native plant species require less maintenance and inputs than nonnative species, and native species that are more resilient to extreme cold and heavy snow and ice loads will be less likely to fall or break and damage buildings, power lines, or vehicles (may need to be drawn from nearby regions reflective of future conditions).
Trim trees and vegetation	Remove or trim weak trees and other vegetation near buildings or power lines that could cause damage during storms. Vegetation should be monitored to balance damage reduction goals with heat and flood management goals (reduced vegetation may decrease landscape ability to provide natural cooling and flood reduction).

OPERATIONAL AND PREPAREDNESS MEASURES	
Conduct pre-hazard preparation	Put out a deicer on walkways and entrances. Ensure adequate supply of fuel for generators.
Develop a business continuity plan	Create a plan for communicating with employees using multiple channels (email, phone, text). Develop an emergency and recovery plan that can be communicated to all stakeholders. Create a snow and ice removal plan for roofs and grounds, and plan for emergency snow removal if needed. Purchase and be ready to use nonslip water absorption mats in front of entrances. Test and practice the plan in advance.
Maintain HVAC system	Schedule preventative maintenance to ensure that the system is operating efficiently. Change filters and check that exhaust is being ventilated properly. Contract a service provider to inspect the system quickly during or after a hazard event (when safe).
Maintain roofs and gutters	Inspect roof and repair any leaks before winter. On flat roofs, check that all flashing and seals are flush and secure. On steep roofs, secure loose shingles and check roof-edge waterproofing and seal to prevent drafts. Debris that collects in gutters and on roofs can block flow of water after snow and ice melt. Regular clearing will reduce blockages that can cause damage to buildings. Ensure that gutters are securely fastened, run tests of gutters and downspouts to be sure water does not back up, and check that downspouts divert water away from foundation.

WATER SYSTEMS	
Detect and repair leaks	Use a combination of devices and practices to quickly identify and fix water leaks, improving water efficiency. This includes setting water budgets, conducting water audits, using water leak detection devices and smart meters, and repairing/replacing plumbing, fixtures, and appliances. Proactive maintenance can help protect pipes from bursting in extreme cold.
Install freeze protection for plumbing and other systems	Frozen pipes can burst during winter storms and extreme cold, causing significant interior damage and disruption. Design and retrofit measures include the following: ensuring that shutoff valves to outdoor faucets and the main shutoff valve for the home or the power shutoff for the pump are installed to be accessible from indoors; installing bleeder caps on shutoff valves; installing frost-free sill cocks, with the pipe to the sill cock sloped at a slight downward pitch; applying insulating hose bib covers during the winter; where possible, not placing drains back to the main on exterior walls; using cross-linked polyethylene piping, which has proven to be more robust to freeze-thaw cycling than traditional copper piping; inspecting and sealing all cracks, holes, and leaks in roofs and exterior walls, as well as windows, doors, and other openings; insulating and sealing attic penetrations such as partition walls, vents, plumbing stacks, and electric and mechanical chases; insulating pipes in attics and crawl spaces or along outside walls, as well as pipes/faucets in unheated or minimally heated areas or areas that may experience freezing temperatures (or wrap in heat trace tape); also wrapping pipes leading to exterior in insulation or heat trace tape, or shutting off/draining if possible; conducting routine maintenance on fire sprinkler system and exploring system exposure to winter weather with fire protection specialist; and shutting off and draining irrigation systems and outdoor hoses. Temperature sensors that create alerts if pipes are in danger of freezing can also be applied. Small commercial and residential properties should let all faucets drip during extreme cold. Heat trace tape can also be applied to outdoor units of heat pumps. Keep internal thermostats set to at least 55°F (12.8°C).
Provide secondary access to potable water	Have a backup water supply (e.g., roof tank or other containers) or pressure booster to maintain water supply during emergencies. A backup supply is helpful for buildings over six stories.

SHUTTERSTOCK

CONCLUSION

Risks to real estate from extreme cold and winter storms are on the rise and spreading to new places that are frequently underprepared.

Real estate owners, developers, and investors can turn to time-tested strategies for increasing resilience to these hazards and use design and operational approaches that will not only protect buildings and occupants, but also make the assets more comfortable, healthy, efficient, and cost-effective to operate, adding value year-round.

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Cold Snap: Extreme Cold and Real Estate This report introduces real estate owners, developers, and investors to the risks posed to real estate by extreme cold and other hazards typically associated with winter. While many prominent climate hazards take place in other seasons—hurricanes, wildfires, and heat waves—extreme cold can pose substantial risks to property, infrastructure, and health, and awareness of the risks and resilience measures available to mitigate these hazards is a key aspect of any climate and sustainability strategy. This report presents the business case for cold-resilient buildings and the potential impacts and mitigation measures real estate can consider as part of a fully resilient portfolio.