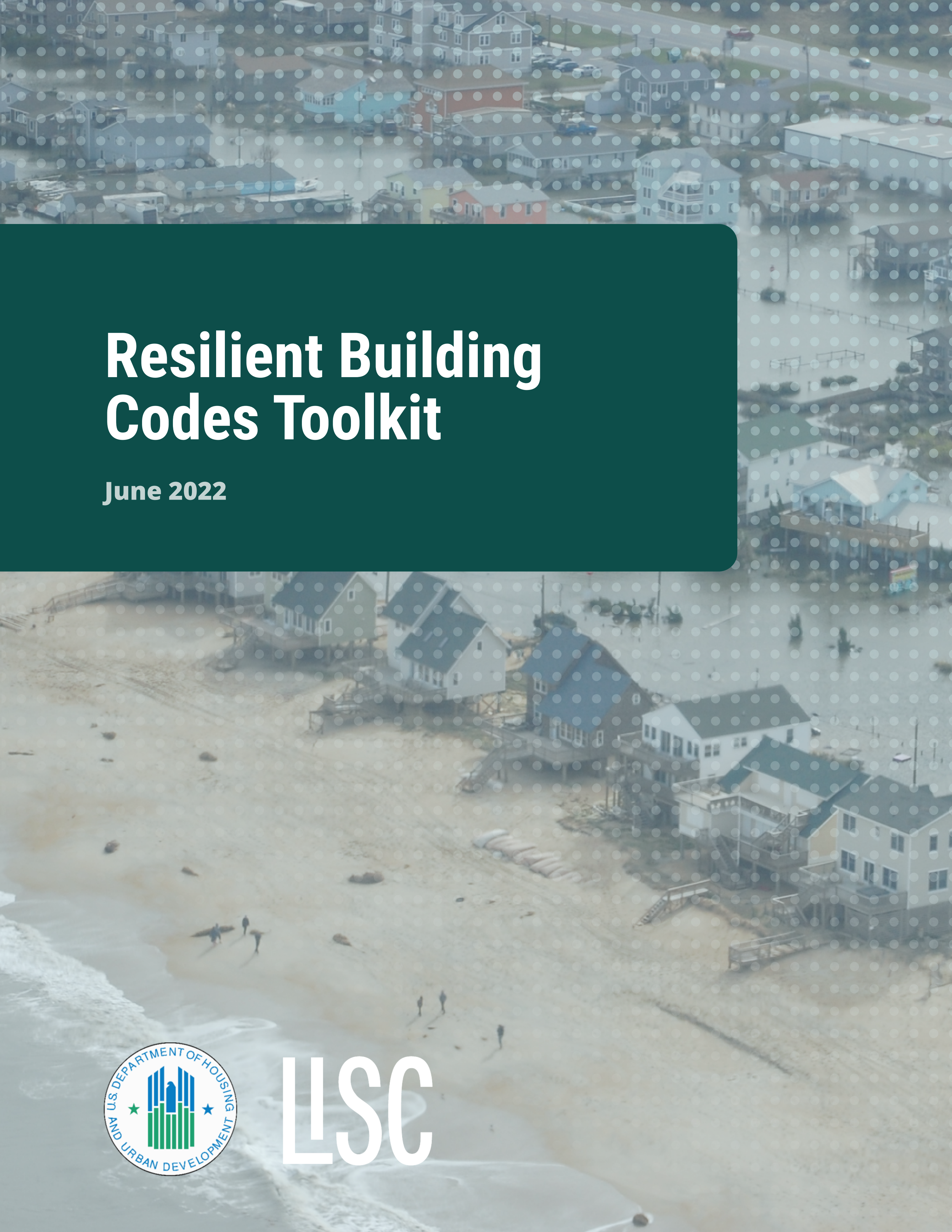

Resilient Building Codes Toolkit

June 2022

WHAT THIS TOOLKIT CONTAINS AND ITS INTENDED AUDIENCE

1

BUSINESS CASE OVERVIEW (4 PAGES)

Gets to the "why" and the relevance

Target audience: *Elected officials*

2

NARRATIVE (~30 PAGES)

Easily searchable document that describes the context of building codes, governance, challenges, and solutions

Target audience: *Practitioners (code officials, architects, engineers, home builders, realtors, contractors, developers, building code committee members, regulators, policy makers)*

3

CHECKLIST (1 PAGE)

How do you learn about building codes in your state?
What can you do to make changes locally?

Target audience: *Communities, municipalities*

4

CODE REQUIREMENTS BY STATE (4 PAGES)

Summary table showing adopted codes, and indicating state mandates as of March 2022

Target audience: *All audiences*

5

STATE-BY-STATE AMENDMENT PROCEDURES (30 PAGES)

Target audience: *Mostly communities and municipalities but anyone interested in how to change the code at a local level*

6

TECHNICAL APPENDIX FOR HAZARD-SPECIFIC INTERVENTIONS (35 PAGES)

Easily searchable document providing a deep, detailed dive on various codes and best practices arranged by hazard

Target audience: *Practitioners*

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EXHIBITS

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INTRODUCTION

The intent of this work

Building codes are regulations used to establish minimal life safety requirements for the construction of new buildings and retrofits to existing buildings. They underpin how we design and construct housing and other building types. While ubiquitous, the details of their requirements, governance, and overall application may vary from state to state and, within states, from locality to locality.

While the intent of building codes originally focused on life safety, there has been a shift to think more broadly, incorporating aspects of both sustainability and resilience. The recent increase in the frequency and intensity of extreme weather events has made these concepts even more relevant.

The intent of this guide is to bring transparency and clarity to building codes, especially with respect to resilience. Its target audience includes elected officials and communities seeking to leverage building codes to further enhance their own resilience. The information presented here also has value for practitioners and other industry stakeholders including code officials, architects, engineers, home builders, realtors, contractors, developers, building code committee members, regulators, and policy makers. The main objective of this work is to create a centralized repository and platform that allows the building community to navigate an otherwise challenging environment. Ultimately, the goal is to enhance resilience in the built environment, specifically with respect to housing and other critical building assets.

What are building codes and standards?

Building codes are regulations used to establish minimal life safety requirements for the construction of new buildings and retrofits to existing buildings. They are derived through a negotiated process which involves input from both public and private sector entities. The model codes — those codes that form the basis of state- and community-adopted codes — are updated on a three-year basis. Building standards are the translation of code requirements into more specific design criteria.

The International Building Code (IBC) and the International Residential Code (IRC) are the base model codes used in the U.S. for the housing market. They reference and draw upon other codes and standards. Each jurisdiction is responsible for determining which codes to adopt (if any) and what types of construction these codes will cover. In addition to regulatory standards, there are also voluntary standards, including but not limited to **FORTIFIED Homes** offered by IBHS, which can be used to design more resilient structures, as well as the National Green Building Standard ICC-700 (NGBS, which while part of the ICC suite of I-codes is more typically administered as a voluntary, above-code program. **NGBS Green** certification administered by Home Innovation Research Labs has an option for NGBS Green + Resilience, combining environmental high performance with resilient construction.

Coverage of the IBC and IRC

The IRC provides a complete set of code requirements for one- and two-family detached residences and townhouses three stories or less. The IBC covers all other buildings including multifamily. The IBC references multiple other codes that cover specific building attributes and systems.

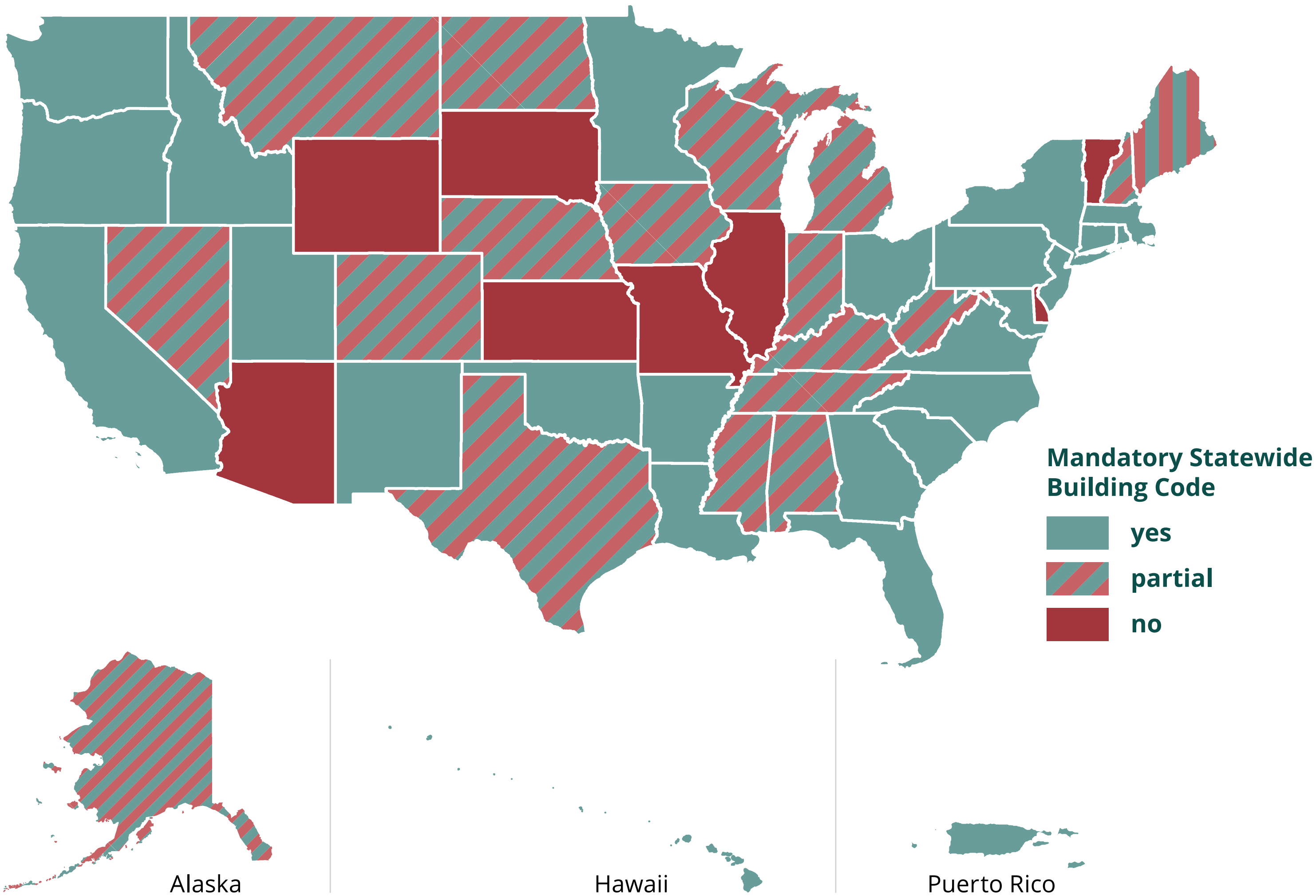
Why focus on building codes?

- Building codes underpin the key health and safety aspects of our built environment.
- They are a combination of operational expectations and physical requirements, with variations in interpretation and applications based on geography and building type.
- They are governed at the state and/or local level but nearly always reference international and national model codes and standards.
- Climate change is a new risk that is not commonly addressed in existing codes and standards.
- Updates to codes can take years because of a need to reach agreement across public and private sectors and within the technical and regulatory arenas.
- The pace of code adoption may not meet the urgency required by climate change.
- This guide provides a roadmap of how municipalities, homeowners and renters, businesses, developers and designers alike can achieve greater resilience within housing within the current system of building codes.
- Three main themes will be explored:
  1. The business case for improved building codes
  2. The governance of building codes
  3. A technical continuum of interventions (minimum code requirements to best-in-class)

- The work will focus on improving resilience in the face of flooding (sea level rise, storm surge and inland flooding), extreme temperatures (heat and cold), wildfires, and wind.
- The guide is written to be accessible by all and supported by more technical and detailed information in appendices.
- The goal of this guide is to provide a view into how codes work, what they currently protect and how they can be leveraged to improve resilience of buildings to climate change.

Exhibit 1 Which states have mandatory statewide building codes?

Yes, partial, and no refer to whether statewide code mandates apply for all building types; some mandates for some building types (partial); or no state-level code requirements. See Appendix A for detailed listing.



See **Appendix A** for a detailed summary of code requirements by state, include what criteria are used to determine "partial."

How building codes differ from land use and zoning ordinances

Land use refers to how land is used and occupied. For example, a lot could be used for housing, open space, farmland, commercial space, or industrial activity. In many jurisdictions, zoning ordinances determine the appropriate uses for that land and establish guidelines for how the land can be developed. These ordinances commonly cover types of uses allowed in particular areas (e.g., commercial versus residential) and the overall size, general dimensions, and density of development.

Building codes focus on the performance of the building itself, often with little reference to the immediate or surrounding land uses (although Wildfire–Urban Interface (WUI) code includes a stated awareness of the need for defensible space directly adjacent to the building).

There is also a difference in governance between the two that varies by state and even across municipalities within each state. While this adds to the complexity, it also provides opportunities for local communities to build more resiliently than what is in the current base code. Since codes (and many standards) are adopted through a multi-year, negotiated process, they can be several years out-of-date by the time they are adopted and may not necessarily represent newer industry practices. This is especially true for climate change influenced designs and construction.

While building code adoption is usually controlled at the state level, zoning practices are almost always controlled at the local level. This lets municipalities integrate more stringent resilience requirements as well as performance-based standards that may exceed the minimal criteria of the formally adopted state building codes.

What is the difference between prescriptive standards and performance-based standards in building codes?

Prescriptive standards require that construction be built according to a prescribed set of measurements and inputs. For example, the first-floor elevation must be located 2 feet above grade. Performance-based standards are based on an expected outcome and allow for creativity in how that outcome is achieved. For example: the building must be designed to allow for continued access and operation during a two-foot flooding event. In this case, there are other options to achieving that goal besides just raising the first-floor elevation by two feet.

CONTENTS

MAKING THE BUSINESS CASE

Building codes are a way to promote minimal life safety standards and, through that, afford a level of protection for the occupants, as well as imparting aspects of durability to the buildings themselves. Recent enhancements to the code, including energy efficiency considerations and the ability to withstand additional hazard types and intensities, have shifted the focus from strictly life safety aspects to broader resilience considerations. A truly resilient building is one that allows occupants to remain safely in place or to return to a safe and functioning environment immediately following an event. It also includes buildings whose overall operations and systems can withstand increasing climate change pressures from both acute shocks and longer-term stressors.

Municipalities depend on a healthy building stock to ensure a viable tax base, which allows local governments to be able to provide critical services. Buildings that deteriorate, are heavily damaged, or become expensive to operate can all lead to devaluation of assets and erosion of the tax base. A reduced tax base could lead to a reduction in city services, difficulty securing adequate capital, and challenges attracting or retaining business and other investments. There are already cited instances where the inability to keep pace with climate changes has impacted local economies and, in extreme cases, led to entire towns being abandoned.[1]

Developers and investors are actively tracking just how prepared cities and towns are for climate change. A recent **report** from the Urban Land Institute proposed a suite of indicators to assess that level of preparedness, many of which have direct application to the resilience of the overall building stock, as well as the supporting infrastructure and municipal services.[2] The work focused primarily on predicting areas prone to climate migration risk.

1 Flavelle, C., 2021. **Climate change is bankrupting America's Small Towns**. *New York Times*, September 15, 2021.

Cusick, D., 2020. **Climate Helped Turn These 5 Places into Ghost Towns**. Scientific American. October 30, 2020.

2 Urban Land Institute. **Climate Migration and Real Estate Investment Decision-Making**. Washington, DC: Urban Land Institute, 2022.

Exhibit 2 **Preliminary market assessment criteria and indicators to assess climate migration risk**

Criteria	Indicators
Economic fundamentals	• Levels of protection offered by existing infrastructure • Area median income; disposable income • GDP sectoral composition • Corporate and/or anchor institution presence • Inequality • Housing affordability
Physical risk exposure	• Exposure of assets and market, including value at risk
Transition risk exposure*	• Assets and primary tenants • Key economic sectors
Market-level adaptive capacity	• Credibility of resilience plans • Fiscal capacity of relevant public-sector agencies • Track record of local institutions addressing resilience

* Includes potential shifts in underwriting practices related to insurance and credit ratings, as well as energy burden considerations.
Table based on ULI's Initial Market Screening tool for climate migration risk.

Other disincentives include changes in the availability and affordability of insurance, potential credit rating downgrades and even the potential for mortgage defaults (discussed in more detail below). However, building codes present an opportunity for a proactive approach, one that can increase the adaptive capacity of the building stock. Enhancing the resilience of the building stock plays an important role in maintaining a vibrant community and healthy business sector. These factors help to stabilize the local economy, which enables a municipality to continue providing critical services. Community-wide resilience can be achieved only if there is sufficient adaptive capacity within the built environment. This is where building codes can play an important role.

The return on investment for resilience

It can be challenging to capture the actual return on investment with respect to resilience. It requires capturing and quantifying avoided losses and costs, thinking across the life expectancy of the asset, and considering both the operational and the physical impacts. The National Institute of Building Sciences (NIBS) **published a study** that quantified the value of resilience in a way that brought greater transparency to its economic value. In short, the study showed a positive return on investment for every hazard and building type — including both new and existing building stock. Just adopting the base code resulted in a $6-10 savings (inland flooding and wind, respectively) for every dollar invested.

National Institute of BUILDING SCIENCES	Adopt Code	Above Code	Building Retrofit	Lifeline Retrofit	Federal Grants
Overall Benefit-Cost Ratio	11:1	4:1	4:1	4:1	6:1
Cost ($ billion)	$1/year	$4/year	$520	$0.6	$27
Benefit ($ billion)	$13/year	$16/year	$2200	$2.5	$160
Riverine Flood	6:1	5:1	6:1	8:1	7:1
Hurricane Surge	not applicable	7:1	not applicable	not applicable	not applicable
Wind	10:1	5:1	6:1	7:1	5:1
Earthquake	12:1	4:1	13:1	3:1	3:1
Wildland-Urban Interface Fire	not applicable	4:1	2:1	not applicable	3:1

Source: National Institute of Building Sciences

FEMA conducted a similar study but with a stronger focus on codes. The focus was on estimating the avoided number of losses by hazard types based on the adoption of model I-Codes. The avoided costs ranged from $484 million to $60 million for flooding and hurricane winds alone.

Exhibit 3 National findings of modeled I-Code savings

	NUMBER OF POST-2000 STRUCTURES	MONEY SAVED (ANNUAL AVERAGE)
Flood	786,000	$484 million
Hurricane wind	2.4 million	$60 million
Earthquake	9.2 million	$1.1 billion

Source: Building Codes Save: A Nationwide Study of Loss Prevention, FEMA

Business case aspects at the community level

A non-resilient housing stock can create significant financial stresses for individuals as well as larger economic impacts at the municipal and regional levels. The fiscal health of a municipality is directly dependent on the health of its residents and businesses. Safe, reliable buildings are an essential determinant of the overall health of those two sectors. Climate change has the potential to increase both the frequency and intensity of short-term damages as well as the longer-term degradation of those buildings. In doing so, it can impact both the financial and economic stability of the larger community. The potential for mortgage defaults, loss of and/or an increase in the cost of insurance, credit rating downgrades, climate migration and decreasing disaster relief funding have all been implicated as potential ways in which climate change could fuel a devaluation in property and economic standing at local levels. Below is a brief summary of each of those topics.

Mortgage defaults

The relationship between mortgage defaults and climate change has received significant attention in recent years. Housing is often the largest source of household wealth and a wide-spread devaluation within the housing stock could also lead to significant economic losses at the local level.[3] A recent study looking at post-Harvey recovery efforts noted that payments of mortgages on damaged homes were more likely to become delinquent than those on homes which did not suffer damage[4] and that the greater the damage, especially for those homes without insurance, the greater the likelihood of prolonged delinquency (180 days or more) and eventual default. Another study has estimated that 80% of Houston homeowners who experienced the most damage did not have flood insurance.[5]

There has been growing concern regarding the level of climate risk sitting within the U.S. housing portfolio. A recent study estimated that homes at risk for flooding are overvalued by $34 billion.[6] Another study estimated the “unpriced flood costs” are already at $520 billion today and could reach $643 billion by 2050.[7]

Other indicators of climate pricing have been captured including the observation of sea level rise being priced into house transactions. The impact was estimated to be as much as $3.71 per square foot year on year compared

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3 U.S. Commodity Futures Trading Commission, 2020. **Managing Climate Risk in the U.S. Financial System: Report of the Climate-Related Market Risk Subcommittee**, Market Risk Advisory Committee; 196 pages

4 Kousky, C. et al, 2020. **Flood Damage and Mortgage Credit Risk: A Case Study of Hurricane Harvey.** *Journal of Housing Research*, vol. 29, # S1, S86-S120.

5 Long, H., 2017. **Where Harvey is hitting hardest, 80 percent lack flood insurance**. *Washington Post* (August 29, 2017).

6 Hino, M. and Burke, M., 2021. **Does Information about Climate Risk Affect Property Values?**, NBER Working Paper 26807.

7 Evans, D. et al, 2022. **Unpriced costs of flooding: An emerging risk for homeowners and lenders**. Milliman white paper.

with properties not at risk.[8] Another study noted that homes exposed to sea level rise were selling at a seven percent discount in some areas of Florida, although the discount appeared mostly in second homes, not primary residential homes.[9]

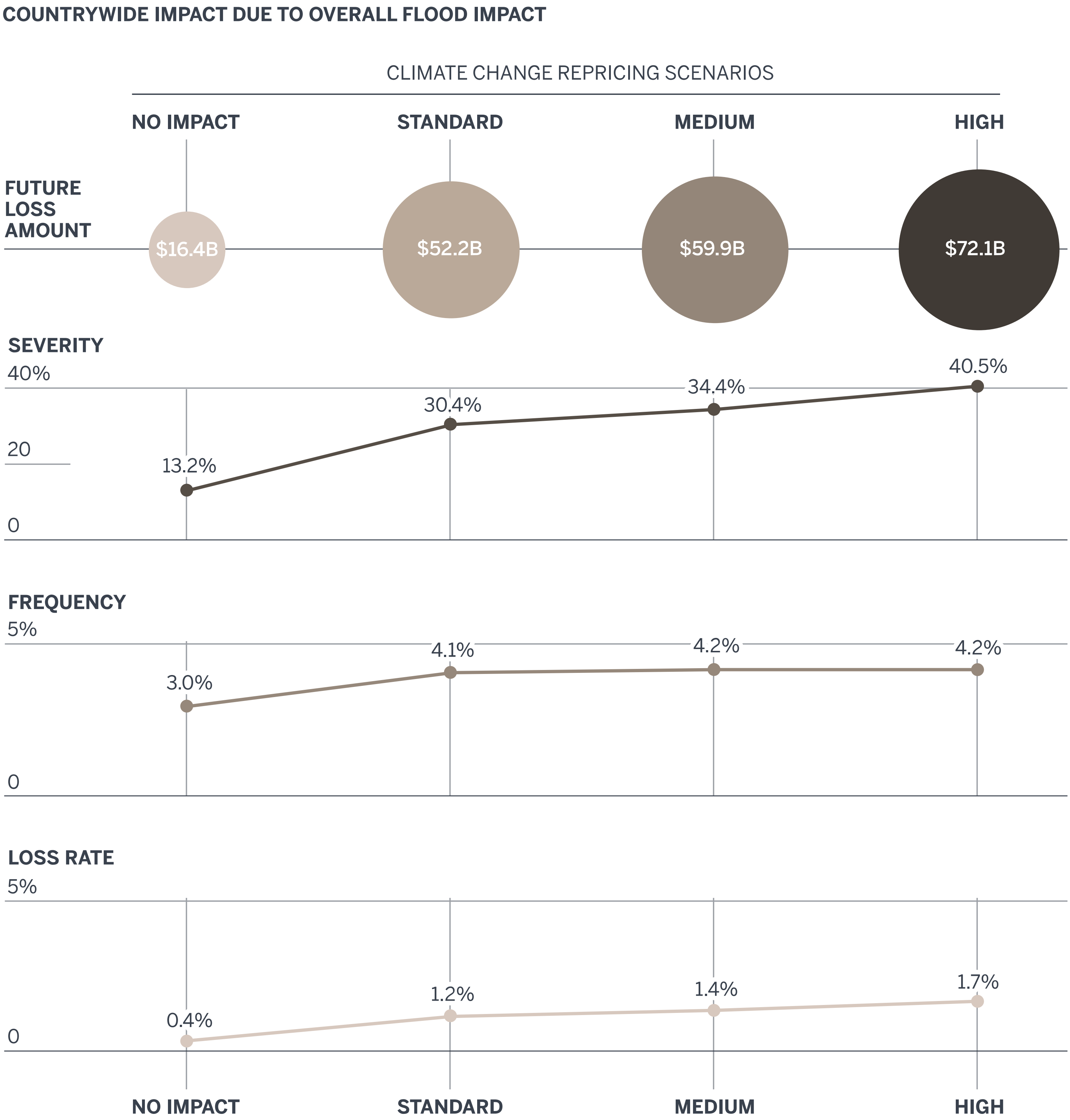
Jill Carlson flickr.com/photos/jill_carlson/37074280945

8 McAlpine, S.A., & Porter, J.R., 2018. **Estimating Recent Local Impacts of Sea-Level Rise on Current Real-Estate Losses: A Housing Market Case Study in Miami-Dade, Florida**. *Population Research and Policy Review*, Volume 37, pages 871-895.

9 Bernstein, A., Gustafson, M., & Lewis, R. **Disaster on the horizon: The price effect of sea level rise**, *Journal of Financial Economics*, Volume 134, Issue 2, November 2019, pages 253-272.

Exhibit 4 Future mortgage loss dollars by scenario

This figure outlines the potential future mortgage losses (in dollars) based on the following scenario considerations: overall severity of impact, frequency of impact and the rate of loss.



Source: Evans, D.D., et al, 2022. **Unpriced costs of flooding: An emerging risk for homeowners and lenders**.

Insurability considerations

Insurance is often viewed as a key mitigation solution for climate impacts. However, there are important nuances that need to be considered when relying on insurance as a way to hedge against climate risk: **(1)** it has a short-term focus; **(2)** eligible buyers may be unaware of extent of risk; **(3)** the focus of insurance coverage is more on direct physical damage versus operational continuity, and **(4)** an increasing likelihood of inadequate and/or unaffordable coverage as climate change intensifies.

1 SHORT-TERM FOCUS

Insurance offers year to year protection and can be modified, repriced and withdrawn at the end of that year's offering. It is a not a guaranteed option for the life of the asset and the time horizons of its business model (risk is assessed and re-priced on a yearly basis) do not align with the long-term interests of homeowners, communities or local governments.

As an example, insurance prices risks based on the likelihood of an event happening in that particular year. In other words, the underwriting is based on what a one percent chance of flooding (a one-in-a-100 year) event might look like based on historic observations. That risk is reset each year, failing to capture the cumulative risk to a property. If we were to forecast that risk over the life expectancy of a mortgage (30 years) or even further out to 50 years, the cumulative risk of flooding would actually be 26 percent or 39 percent, respectively. To state it another way, there is a 26 percent chance that the property would be flooded at least once during those 30 years. That is a much more relevant statistic to a homeowner than the year-to-year calculation. By understating the hazard, we understate the risk and thereby underestimate the value of resilient interventions, such as more resilient building codes.

2 ELIGIBLE HOMEOWNERS UNAWARE OF EXTENT OF RISK

FEMA has **mapped** the extent of potential flood risk based on historic data and with respect to annual occurrence. These maps are used to determine which mortgaged properties are required to have flood insurance. These areas are referred to as special flood hazard areas (SFHA). Flooding may occur outside of these zones but since mortgage institutions do not require homeowners to carry insurance for those areas, most people are often unaware of that risk. It has been estimated that at least 5.9 million properties sit outside of the SFHA but still face a significant risk of flooding.[10] Similar challenges have been noted with wildfire risk where it has been noted that most homebuyers are unaware of the actual risks when purchasing their home.[11]

In addition to understanding the current risk, there are also challenges in understanding how that risk may be shifting. For example, a recent report projects that sea level elevations are expected to rise an average of eight to ten inches over the next thirty years (2020-2050 timeframe) along US shores.[12] Similar shifts have been projected for wildfire, drought, temperature, and precipitation,[13] as well as the severity of storm events.[14] Housing stock once located in relatively "safe" areas may have already become more exposed and less resilient with projected shifts in climate change.

3 FOCUS ON PHYSICAL IMPACTS, NOT OPERATIONAL CONTINUITY

Designing to a more resilient standard means that the overall physical damage and interruption of services to a particular building will be less severe in the midst of both short-term and longer-term disruptions. Focusing on resilience requires that the design incorporates more than just life safety considerations (e.g., ensuring people can evacuate safely without being injured by a failing building). It requires designers and contractors to develop and construct a "hardier" structure — one that is able to withstand greater impacts and remain operational during the event as well as continuous occupancy during or directly after an event. The main function of a home — whether a single or multi-family residence — is to ensure a healthy and safe place to live. A truly resilient home is one that provides for that environment during and directly after a major event.

Studies have shown that these impacts are even greater for vulnerable populations (including people of color, low income and the elderly) Recent work by the EPA showed a higher risk within vulnerable pop-

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10 First Street Foundation, 2020. **First National Flood Risk Assessment**.

11 Champ. P.A. et al, 2010. **Homebuyers and Wildfire Risk: A Colorado Springs Case Study**, *Society and Natural Resources*, Volume 23; pages 58-70.

12 Sweet, W.V. et al, 2022: **Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines**. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pages.

13 Climate Toolbox: **Future Climate Dashboard**. Created by University of California Merced.

14 Pidcock, R. et al, 2021. **Attributing extreme weather to climate change**. Carbon Brief white paper.

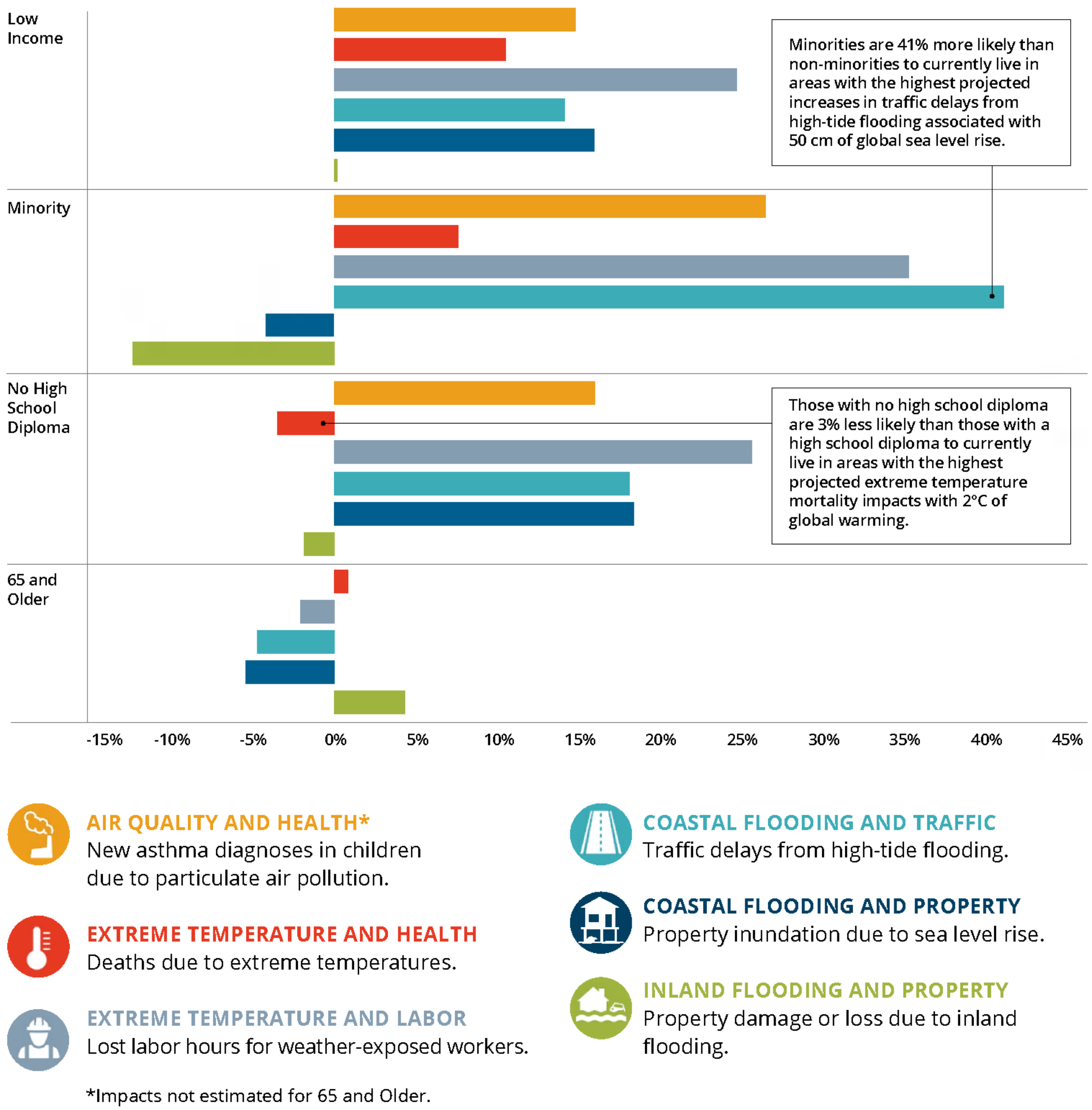
ulations for both flooding and extreme temperatures than what was reported for reference populations.[15]

Some of the greatest impacts to individuals and communities are tied to the inability to resume what were once daily activities. These include loss time from work, the inability to attend school, maintain employment, often brought about from both short-term or longer-term impacts of being temporarily dislocated or permanently relocated after these events. Several studies of school disruptions following major events have illustrated the significant negative academic and mental health impacts that leave long-lasting impacts on the students.[16] Since schools often provide additional social services to people in need, those impacts often extend to the students' families as well. Schools should be treated as critical assets to aid in both the sheltering and recovery aspects of extreme events. Resilient building codes would go far in providing that continuity of service.

16 Dolch, N.A. et al., 2008. **Hurricane Disaster Response by School-Based Health Centers**. *Children, Youth and Environments* Volume 18(1), pages 422-434.
Segarra-Almestica, E. V. et al., 2021. **The Effect of School Services Disruptions on Educational Outcomes after Consecutive Disasters in Puerto Rico**. Natural Hazards Center Public Health Report Series, 2. Boulder, CO: Natural Hazards Center, University of Colorado Boulder.
Goldstein, D., 2017. **School Closings from Harvey Threaten Disruption Across Texas**. *The New York Times*, August 29, 2017.

Exhibit 5 **Differences in risks to socially vulnerable groups relative to reference populations with 2°C of global warming or 50 cm of global sea level rise**

The estimated risks for each socially vulnerable group are relative to each group's "reference" population, defined as all individuals other than those in the group being analyzed. The estimated risks presented in the chart are for scenarios with 2°C of global warming (relative to the 1986-2005 average) or 50 cm of global sea level rise (relative to 2000). For the inland flooding analysis, the baseline is 2001-2020.



Source: EPA, 2021. **Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts**. U.S. Environmental Protection Agency, EPA 430-R-21-003.

4 INADEQUATE AND/OR UNAFFORDABLE COVERAGE

Even if the weaknesses of the NFIP are repaired, insurance alone may not be enough to sustain the complex system of risk allocation that underlies the housing system. The magnitude and persistence of climate change, particularly in the latter part of the 21st century may overwhelm the ability of insurance to spread and manage risk.

Source: Becketti, S. 2021. The Impact of Climate Change on Housing and Housing Finance. Research Institute for Housing America Special Report, in collaboration with the Mortgage Bankers Association, 41 pages.

The National Flood Insurance Program (NFIP) is federally-backed and funded, and requires that flood insurance be offered to any home identified with the current special hazard flood areas (SHFA). These areas are based on historic climate data and do not account for climate change. The program is currently $20 billion in debt even before taking additional climate burdens into account.[17]

First Street Foundation conducted a study which looked at the disconnect between insurance coverage and actual costs incurred from flooding and found that more than 4 million homes would face losses equal to 4.5 times the cost of the estimated NFIP premiums.[18] The cumulative average annual loss (AAL) for residential properties alone was estimated to be $20 billion this year with an expected loss of more than 32 billion in 30 years, directly attributable to climate change impacts.[19]

In recent testimony to the United States Senate Special Committee on the Climate Crisis, David Burt of DeltaTerra Capital stated that insufficient funds are being collected by insurers to cover the risk of climate risk. Specifically, "annual damages to residential real estate will be roughly 0.85 percent per year, 58 percent higher than the amount collected by insurers to cover it. The disconnect is larger in high-risk places like Florida, where risQ[20] predicts residential losses that are 87 percent higher than the insurance premiums collected there, despite those premiums being the highest in the country."[21]

His testimony continues, stating that "in 2007, investors made the irrational assumption that real estate demand would keep increasing indefinitely as more mortgages were given to less and less qualified borrowers. This kept inflating home values until it became obvious to all that many of these borrowers had no real hope of paying off their mortgages once their income potential was accurately considered. Today, investors are making an equally irrational assumption that the cost of ownership will stay constant even as catastrophe costs increase. This is flawed reasoning and ultimately insurance premiums, taxes, and uninsured losses will increase in risky regions."

17 Congressional Research Service, 2021. **A Brief Introduction to the National Flood Insurance Program**.

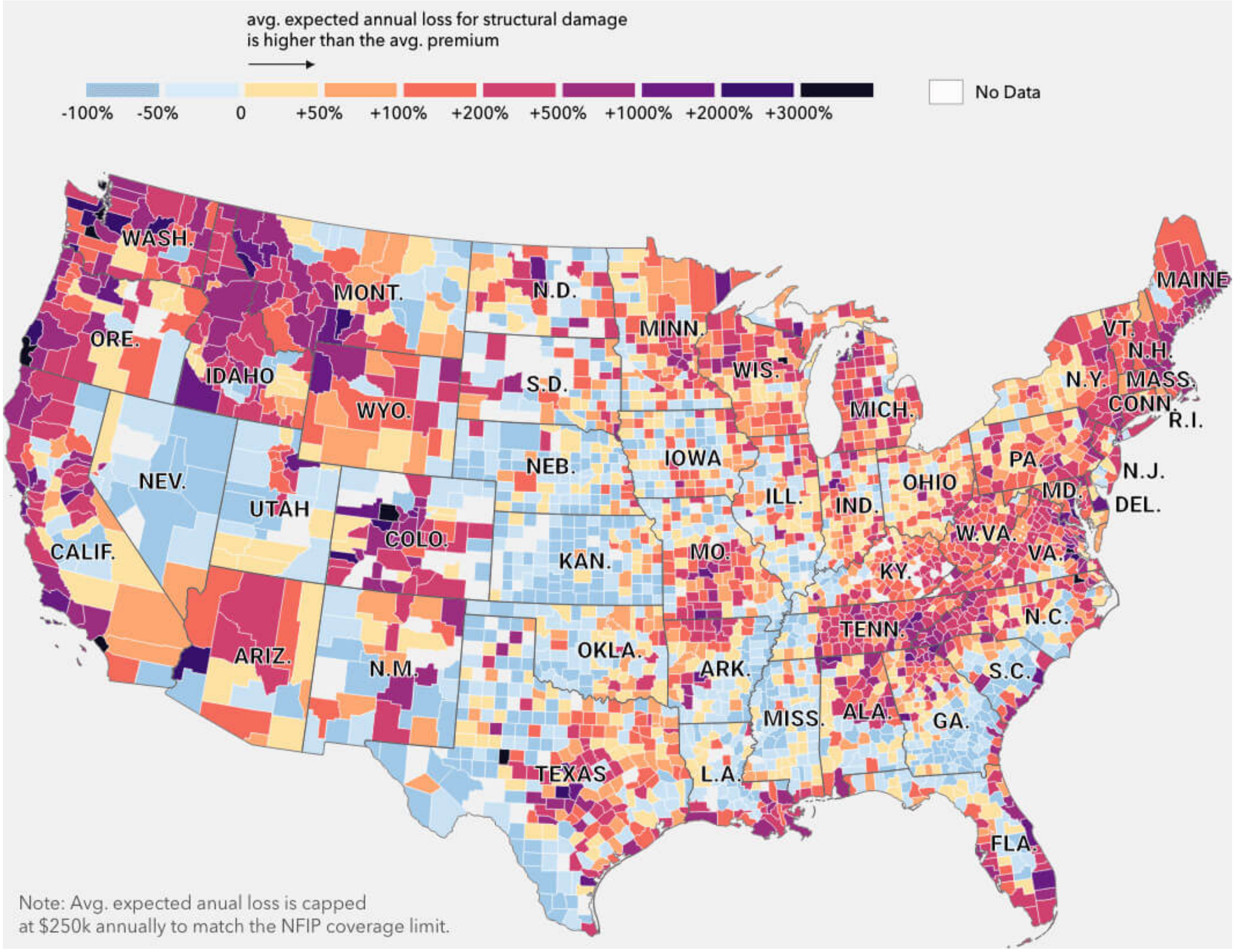
18 First Street Foundation, 2021. **Over 4 Million Homes Face Annual Financial Losses 4.5 Times the Cost of Their Estimated NFIP Premiums**. Press Release, February 22, 2021.

19 Ibid.

20 risQ is a climate data analytics company.

21 **Special Committee on the Climate Crisis Hearing: The Economic Risks of Climate Change**, Thursday, March 12, 2020.

Exhibit 6 **NFIP insurance premiums compared to economic risk for residential properties with substantial flood risk, 2021**



Source: **Over 4 Million Homes Face Annual Financial Losses 4.5 Times the Cost of Their Estimated NFIP Premiums**. February 22, 2021. First Street Foundation.

Governor Raskin of the Federal Reserve also testified that "banks and other lenders and investors are exposed to losses in their collateral or the assets underlying their investments, an exposure that is not understood by bank regulators and is not measured through current examination practices. This material omission may be more troublesome than the failure to appreciate the nature and scope of the risk inherent in derivative banking products in 2008…"[22]

22 Ibid.

She referenced a study outlining how the insurance industry was recalculating its underwriting practices to account for these foreseeable changes and warned that "[a]nother financial cost that will likely be borne by households is the cost associated with more expensive and/or more curtailed insurance policies."[23]

Frédéric Samama, Head of Responsible Investment, Amundi, and co-author of "Green Swan: Central Banking and Financial Stability in the Age of Climate Change" referenced a MunichRe study reporting that "insurance companies cover only 44 percent of the damages in the US (and 8 percent in Asia)" and that "households and banks are increasingly exposed."[24]

Private insurance companies have the option to leave markets where the probability of a disaster is greater than the risk tolerance of their business models.[25] The remaining companies may modify their coverage criteria to include higher prices, or more restricted eligibility criteria. In some cases, when private insurers completely exit a particular market, the state creates its own underwriting entity (e.g., California for wildfire risk and North Carolina for wind) to cover those risks.[26] This means that all residents of the state cover the risk of the most vulnerable properties. As a risk becomes more prevalent, the cost and availability of coverage will also become more challenging.

Other options are being explored, including a push for all-hazard insurance products[27] and long-term insurance products that incentivize investments in resilience,[28] but both are still under development.

Credit rating implications

A municipality's or company's credit ratings are tied to their ability to repay debt. Acute and chronic climate impacts could impact a municipality's fiscal health, and there have been instances where credit rating agencies have

23 Bradley Hope and Nicole Friedman, **Climate Change is Forcing the Insurance Industry to Recalculate**. *Wall Street Journal* (Oct. 2, 2018) (last visited March 2, 2020).

24 MunichRe, 2018. **The Natural Disasters of 2018 in Figures**.

25 Born, P. & Viscusi, W.K., 2006, **The catastrophic effects of natural disasters on insurance markets**. *Springer Science & Business Media*.

26 Hartwig, R.P. and C. Wilkinson, 2016. **Residual Market Property Plans: From Markets of Last Resort to Markets of First Choice**. Insurance Information Institute, 48 pages.

27 Kousky, C., Kunreuther, H. Wachter, S. and LaCour-Little, M. **Flood Risk and the U.S. Housing Market**.

28 See: **Climate Insurance Linked Resilient Infrastructure Finance working group**.

temporarily downgraded credit worthiness based on extreme events (e.g., following Hurricane Harvey, Standard and Poors readjusted its assessment of five utility districts in Texas and Moody's downgraded obligation bonds in Puerto Rico following Hurricane Maria).[29] A reduction in business and tax receipts can affect the cost of borrowing due to the more limited ability to service the obligations associated with the loans. Like insurance underwriting practices, credit rating agencies assess the ability to pay back on a yearly basis. However, some investors are using the climate impact data at a city level to determine whether to shorten their investments to a 10-year rather than a 30-year period as a hedge against climate change.[30]

When buildings are destroyed or damaged during an event, many homeowners and businesses choose not to rebuild or cannot afford to rebuild. This can result in significant reductions in the tax base. As an example, of the 14,000 homes in Paradise, CA, as of November of 2021 less than 1,100 of the homes have been rebuilt. It is estimated the number of homes will be under 10,000 until after 2045. The drop in population associated with the fire has devastated businesses where the reduction in customers has exceeded 50 percent.[31]

29 Kelly, S. 2017 **U.S. municipal disaster plans seen more vital for ratings: report**. Reuters, October 17, 2017.

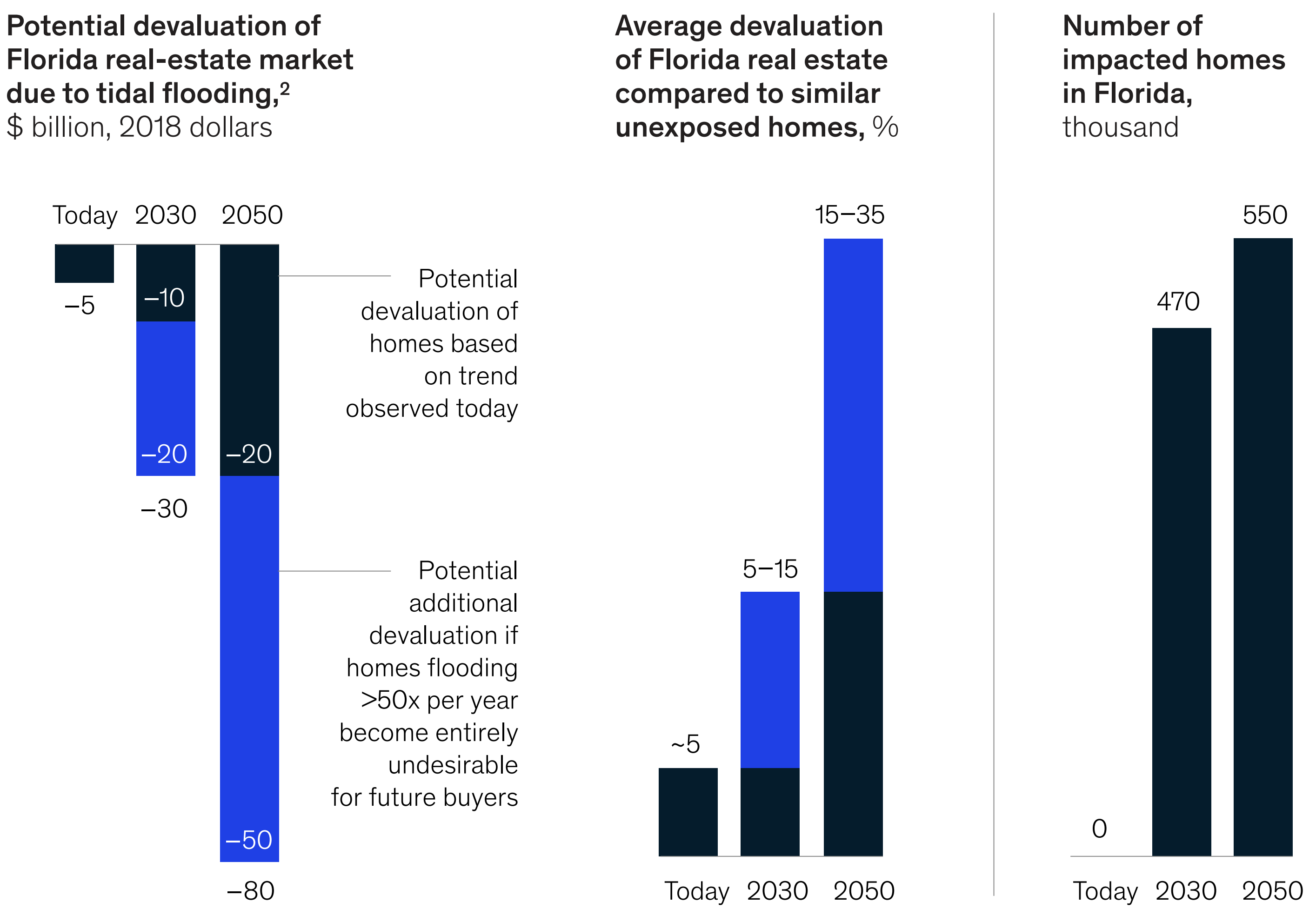
30 Whieldon, E. & Charbonneau, M. 2019, "**Climate change poses new threat to US cities' long-term creditworthiness**," S&P Global.

31 Blevins, J et al. 2021. **On the rise — three years after the fire, the rebuild continues | Camp Fire**, *Chico Enterprise-Record*, November 8, 2021.

Devaluation of property can significantly impact local economies that are heavily depending on the real estate market. Exhibit 7 illustrates the potential devaluation of properties in Florida due to tidal flooding.[32]

Exhibit 7 **Tidal flooding has caused an estimated $5 billion devaluation in real estate, which could grow to between $30 billion and $80 billion by 2050**

Florida real-estate market changes due to tidal flooding, based on USACE[1] high scenario



Note: Sea-level rise based on USACE high curve. High curve results in 1.5 meter eustatic sea-level rise by 2100 (within range of representative concentration pathway 8.5 scenario; see, for example, Jevrejeva et al., 2014). Based on current exposure. See Technical Appendix of the full report for why this climate scenario was chosen. Dollar figures rounded to nearest 5, % figures rounded to nearest 5%.

[1]US Army Corps of Engineers.

[2]Based on First Street Foundation's property-level analysis of relationship between real-estate trends and local experience of tidal-flooding events. Analysis identifies differential appreciation rates for properties that experience tidal flooding in comparison to those that do not, with the former seeing a slower rate of appreciation over study period (2005–17). Analysis relies on assumption that future relationship between flooding impact and home value devaluation equals historical relationship. Low end of range based on historical devaluation; high end assumes homes flooded >50x per year see 100% devaluation.

Source: First Street Foundation, 2019; McKinsey Global Institute analysis

Source: Woetzel et al, 2020. **Will mortgages and markets stay afloat in Florida?** McKinsey Global Institute. Climate risk and response: Physical hazards and socioeconomic impacts — Case Study.

32 Woetzel et al, 2020. **Will mortgages and markets stay afloat in Florida?** McKinsey Global Institute. Climate risk and response: Physical hazards and socioeconomic impacts — Case Study.

Climate migration

People may be forced to leave areas because of the effects of a warming climate. Some of those departures may be related to a single event (e.g., the outmigration following Katrina), others may occur more slowly in response to a variety of stressors (e.g., recurrent events, loss of jobs, reduction in tax base, etc.). Small towns are particularly vulnerable to these shifts[33] and some towns have already become ghost towns because of these climate shifts.[34] There is also a growing awareness of the impacts to the housing market itself (see discussion above) as well as the potential for disappearing local tax bases as a result of climate migration.[35]

Climate impacts can be even more challenging for under-resourced communities that are often dealing with limited resources, economic shortfalls, and an eroding tax base, particularly following disasters.

This lack of capacity at the local level compounds the ability to develop strategies and pursue funding to prepare for climate change. Rural communities face particular challenges. Of the 5,511 communities defined as having very limited capacity (the lowest ranked 25 percent of communities in the U.S.):

- 1,306 (24 percent) have high flood risk,
- 1,518 (28 percent) have high wildfire risk, and
- 446 (8 percent) have both high flood risk and high wildfire risk.[36]

"Repeated shocks from hurricanes, fires and floods are pushing some rural communities, already struggling economically, to the brink of financial collapse."[37] The lack of capacity to pre-position for climate preparedness investments, including building and/or retrofitting structures to be more climate resilient, could result in devaluation at both the individual and community level. **The Rural Capacity Index** highlights these most vulnerable communities and should be used as a way to prioritize where building code improvements (including associated funding) may be needed most.

33 Hersher, R., 2019. **Small Towns Fear They Are Unprepared for Future Climate-Driven Flooding**. NPR. July 25, 2019.

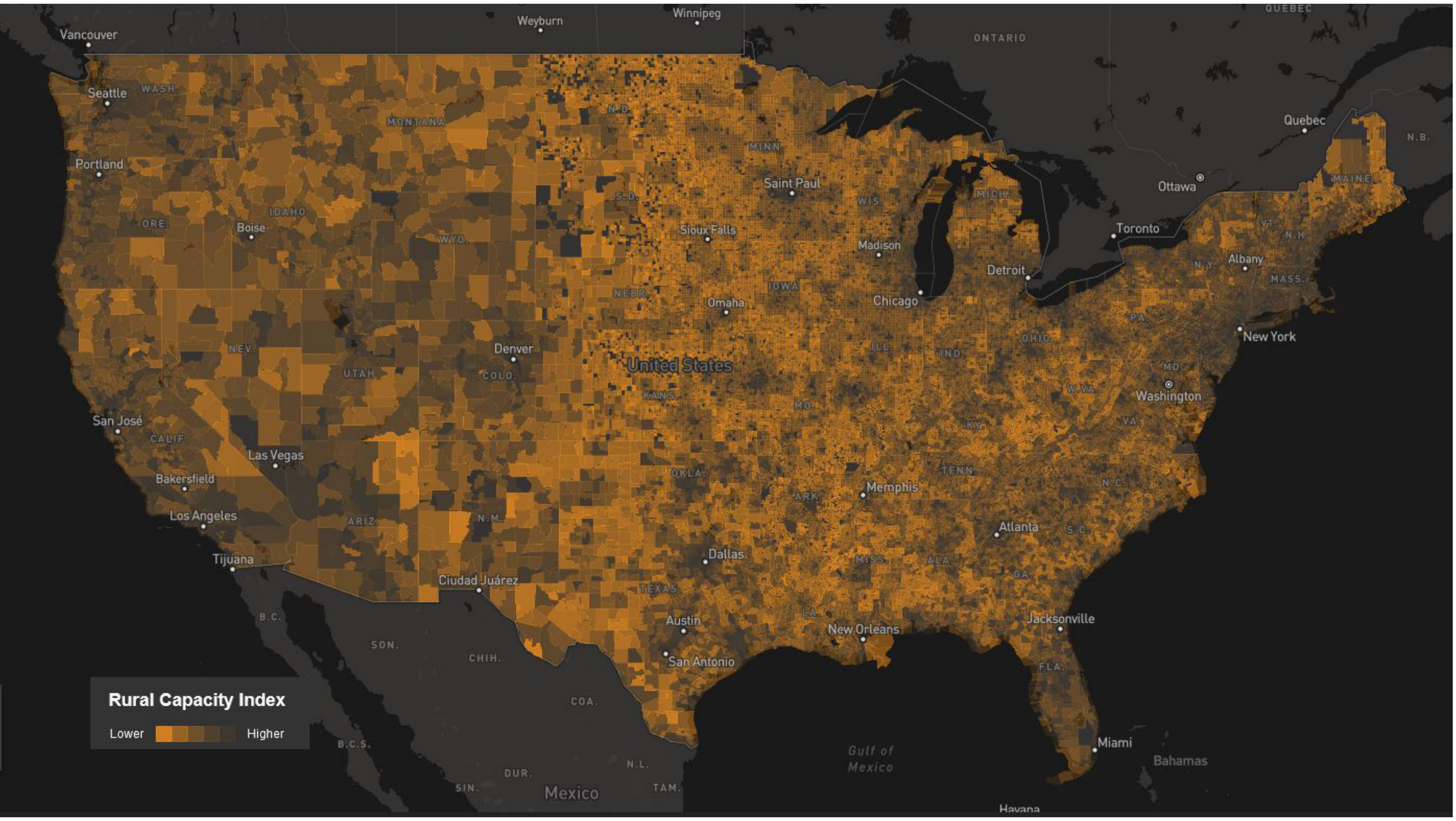
34 Cusick, D., 2020. **Climate Helped Turn These 5 Places into Ghost Towns**. *Scientific American*. October 30, 2020.

35 Marandi, A. and K. L. Main, 2021. "Vulnerable City, recipient city or climate destination? Towards a typology of domestic climate migration impacts in US Cities." *Journal of Environmental Studies and Sciences,* August 2021, pages 1-16.

36 Headwater Economics, 2022. **Rural Capacity Index**.

37 Flavelle, C., 2021. **Climate change is bankrupting America's Small Towns**. *New York Times,* September 15, 2021.

Exhibit 8 Rural Capacity Index



Source: Headwater Economics, 2022. **Rural Capacity Index**.

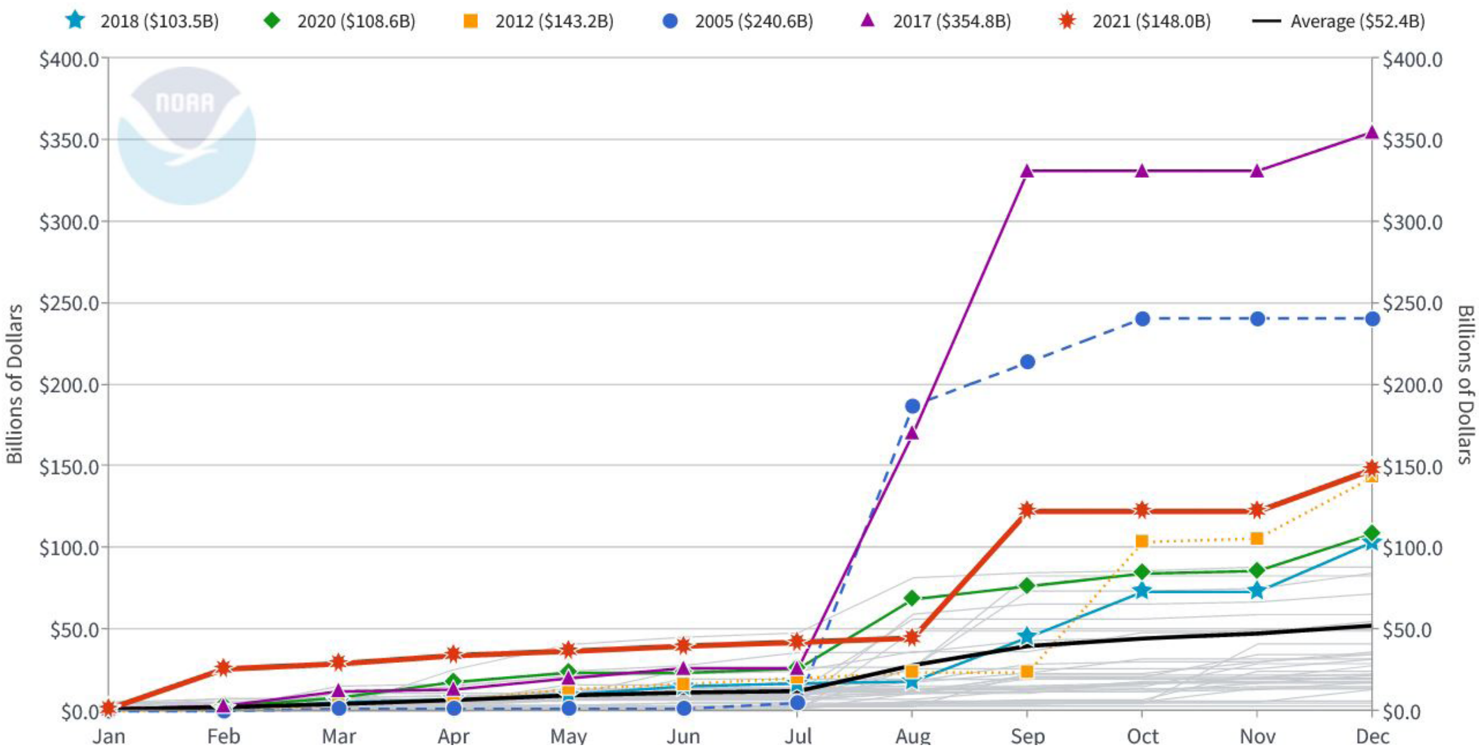
The table below shows, by region, communities, county subdivisions, and counties with Index scores below the national median:

	Communities with low capacity	County subdivisions with low capacity	Counties with low capacity
Midwest	75% (3,245)	76% (7,531)	65% (463)
Gulf Coast	59% (1,860)	58% (1,471)	61% (324)
West	53% (893)	41% (414)	52% (146)
Southeast	51% (1,425)	47% (1,905)	48% (337)
Great Lakes	43% (1,982)	44% (4,584)	41% (214)
Pacific Coast	36% (766)	20% (182)	31% (49)
Northeast	22% (807)	22% (1,352)	13% (33)

Disaster funding availability

Since 1980, 310 natural disaster events have occurred in the U.S., costing more than $2.155 trillion.[38] From 1980 to 2021, the average number of billion-dollar events was 7.4 per year. The average number of events in the last five years (2017-2021) is 17.2 events.[39]

Exhibit 9 1980-2021 U.S. billion-dollar disaster event cost (CPI-adjusted)



Source: NOAA National Centers for Environmental Information (NCEI) **U.S. Billion-Dollar Weather and Climate Disasters** (2022).:

As the quantity of disasters increase due to a warming climate, those funds will need to be either increased or spread over more events. Increases are subject to the political climate at the time and may not be forthcoming when needed. It cannot be assumed there is an unlimited amount of funds available to address the probable increase in climate related events. The availability of disaster funding and the amount can have a considerable effect on the ability of a community to recover from disaster.

38 NOAA National Centers for Environmental Information (NCEI), 2022. **U.S. Billion-Dollar Weather and Climate Disasters**.

39 Ibid.

HAZARD-SPECIFIC BUSINESS CASE CONSIDERATIONS

The previous section outlined general trends of how climate change impacts to the built environment could impact financial and economic considerations at a local level. The following section introduces hazard-specific building codes and standards that can be leveraged to make buildings more resilient. A more detailed and technical treatment of hazard-specific interventions can be found in **Appendix C**.

Wind

FORTIFIED Wind standards require roofs to be structurally tied to the building in ways that minimize their likelihood of being lifted off and damaged during significant wind events. Taken post-Hurricane Sally in Alabama, Exhibit 10 illustrates the difference in resilience between the FORTIFIED roof and traditional builds. At that time, Alabama had 16,000 IBHS FORTIFIED roofs, all of which withstood the winds of Hurricane Sally. Some roofs experienced shingle loss but remained intact and waterproof.

Exhibit 10 FORTIFIED Home

Source: "**Alabama's nation-leading 16,000 Fortified roofs held up well to Hurricane Sally**." September 27, 2020.

Flood

Hurricane Michael struck Florida as a Category 5 hurricane, resulting in significant flood and wind damage to existing buildings. While FEMA has designated certain areas as Special Flood Hazard Areas (SFHA) based on their likelihood of flooding, the flooding associated with Hurricane Michael extended beyond those zones and inundated areas that had a much lower level of flooding probability — some less than 0.2 percent of annual flooding (Zone X).

The buildings in Exhibit 11 are located outside of the SFHA, but all experienced significant flooding during Hurricane Michael. Since the buildings' main floors were elevated on pilings the building remained structurally intact and overall water damage to the structures was less severe than that experienced by on-slab structures.

Exhibit 11 Representative adjacent single-family dwellings elevated on concrete piles that survived the hurricane (Mexico Beach; unshaded Zone X)

Source: FEMA, 2020. **Mitigation Assess Team Report. Hurricane Michael in Florida: Building Performance Observations, Recommendations, and Technical Guidance**. February 2020.

Wildfire

A recent study of housing stock in California revealed a significant correlation between the adoption of new wildfire building standards and the likelihood that a home would be able to withstand a wildfire event.[40] It also highlighted the fact that the resistance of the more resilient home would also influence the resilience of neighboring homes since the more fire resistant home could act as a "break" of sorts with respect to the wildfire spread.

"We find remarkable vintage effects for California homes subject to the state's wildfire standards. A 2008 or newer home is about 16 percentage points (40 percent) less likely to be destroyed than a 1990 home experiencing an identical wildfire exposure. There is strong evidence that these effects are due to state and local building code changes - first after the deadly 1991 Oakland Firestorm, and again with the strengthening of wildfire codes in 2008. The observed vintage effects are highly nonlinear, appearing immediately for homes built after building code changes. There are no similar effects in areas of California not subject to these codes or in other states that lack wildfire codes.

"We also find that code-induced mitigation benefits neighboring homes, consistent with reduced structure-to-structure spread. These neighbor effects are in keeping with anecdotal reports of home-to-home spread as a factor in urban conflagrations (Cohen 2000; Cohen and Stratton 2008; Cohen 2010). Our results imply that, all else equal, code-induced mitigation by a neighbor located less than 10 meters away (within the distance fire experts refer to as the home ignition zone) reduces a home's likelihood of destruction during a wildfire by about 2.5 percentage points (6 percent). This benefit is even larger when homes have multiple close neighbors."[41]

"We are also aware of at least one insurance company which will not sell homeowners insurance to homes located next to a home with a wood roof in high-risk areas (Allstate Indemnity Company 2018)"

Source: Baylis and Boomhower, 2021. **Mandated vs. Voluntary Adaptation to Natural Disasters: The Case of US Wildfires**.

40 Baylis and Boomhower, 2021. **Mandated vs. Voluntary Adaptation to Natural Disasters: The Case of US Wildfires**.

41 Ibid.

Exhibit 12 House in Elkorn, Oregon

Representative example of fire-hardened home that survived the Beachie Creek Fire in Oregon. The home was built with concrete siding, a cement porch, metal roof with no gutter and air vents and vegetation had been cleared nearby the home.

Source: NPR, 2021. **Oregon has a new plan to protect homes from wildfire. Homeowners are pushing back**.

Extreme temperatures

Extreme temperatures can impact the building stock in different ways. The level of insulation, the ability to ventilate, the capacity and sizing of heating and cooling units, even the color of the roof and location relative to adjacent buildings and/or vegetation all affect a building's performance. National climate maps, based on historic averages, are used to determine how the building should be designed, including the supporting electrical and mechanical systems for these heating and cooling loads. The design of these buildings reflects historical averages and rarely accounts for extreme temperature events, let alone the projected shifts associated with climate change. This means that as the building ages, the average weather patterns are also changing. Assuming that the building's design was optimized based on historical climate data, the overall resilience of that building to temperature variations could also be changing. In other words, the “habitat” of the building may shift in significant ways over its lifetime.

The extreme cold snap that impacted Texas in February 2021 is a recent example of unusual weather and its impact to the larger region. The average housing stock in Texas was not built with these sorts of extremes in mind. The cold snap was also accompanied by extensive power outages forcing many residents to use their cars, shelters and other heated venues (such as stores) to stay warm.[42]

Another example is the heat dome that settled over the Pacific Northwest in June 2021. A long-duration, intense heat wave described as a one-in-1,000-year event that resulted in temperatures as high as 120 degrees F in areas known for much more moderate weather.[43] The lack of adequate cooling infrastructure in buildings exacerbated the overall situation and forced many to find shelter.

Immediate relief from these events include increased heating and cooling demands. However, those actions can result in greater carbon emissions and increase the growing energy burden low- and moderate-income families experience. While some challenges could be proactively addressed with new construction, using building codes as a lever, current building codes will have less relevance and influence with existing building stock.

42 **The devastating cold's impact on Texas, in photos**. *Vox*, February 18, 2021.

43 **3 things to know about the record-smashing heat wave baking the Pacific Northwest**. *Science News*. June 29, 2021.
Washington officially has a new all-time maximum temperature record: 120 degrees. *Yakima Herald-Republic*. February 10, 2022.

HOW BUILDING CODES INFLUENCE RESILIENCE

CONTENTS

The International Code Council, the entity responsible for overseeing the development of the International Codes (I-Codes) including the International Building Code (IBC) and International Residential Code (IRC), recently held a forum to determine how climate resilience should be incorporated into building codes. The work focused on defining the boundaries and areas of focus for the work, as reflected in Exhibit 13 below.

Exhibit 13 **Resilience applied to buildings**

Resilience...	Applied to buildings
...of what	Buildings or parts of buildings and the contribution this makes to the broader community.
...to what	Future extreme weather events, which are anticipated to change in frequency, duration, intensity, and/or distribution.
....when	Before (i.e., adapt), during (i.e., durability), and after (i.e., recovery), short- and longer-term.
Purpose	Health and safety of: **1** intended occupants of the building; and **2** those who rely on essential systems, services, or infrastructure provided by and from the building.

Source: **Delivering Climate Responsive Resilient Building Codes and Standards: Findings from the Global Resiliency Dialogue Survey of Building Code Stakeholders in Canada, Australia, New Zealand, and the United States**. November 2021.

Both operational and physical impacts were considered, as well as the recognition that the intensity and frequency of climate events will change in future years.

"Climate Resilience of Buildings is the ability of a building, structure and its component parts to minimize loss of functionality and recovery time without being damaged to an extent that is disproportionate to the intensity of a number of current and scientifically predicted future extreme climatic conditions (e.g., wildfires/bushfires, storms, hurricanes/cyclones, flooding, and heat)."[44]

However, the overall resilience of the site in which that building sits and its dependency on supporting systems (e.g., transportation, energy, water,

44 **Delivering Climate Responsive Resilient Building Codes and Standards: Findings from the Global Resiliency Dialogue Survey of Building Code Stakeholders in Canada, Australia, New Zealand, and the United States**. November 2021.

waste, communications) are also key determinants in a successful adaptation. In most instances, these considerations extend beyond the focus of the building code, and even when there may be a link, there may be separate regulations and governing entities.

As an example, it is well known that wildfire resilience not only depends on the building design and construction but is also determined by the amount of defensible space that surrounds the asset.[45] In California, different chapters of the law speak to each of those pieces separately. Chapter 7A covers the building itself, whereas Chapter 49 covers defensible space. In addition, there are various applicability requirements based on construction dates, locations within types of hazard zones and other jurisdictional considerations which can make it a difficult process to navigate. The International Wildland Urban Interface Code (IWUIC) addresses the building, defensible space, and community-level actions.

Finally, there is more to be done to determine minimal criteria for resilience, as well as validating some of the current practices. For example, the effectiveness of exterior sprinkler systems with respect to wildfire have not been validated, nor has the appropriateness of spacing requirements of at least thirty feet within defensible space zones or even the placement of sprinklers within residential homes.[46] And while codes and structures focus on individual structures, wildfire presents a unique problem in that the extent of wildfire resilience in your neighbor's property and building will directly impact your own resilience.[47, 48]

Codes and standards can and do play important roles in ensuring overall life safety considerations at the building level. There is an increasing awareness of needing to do more both in the face of increasing impacts from extreme weather events, as well as the need to focus more on operational considerations and performance-based standards, rather than strictly prescriptive measures.

However, the larger theme is the recognition that buildings themselves do not operate independently. Their overall resilience (and that of their occupants) is a direct result of the resilience of the land use systems, eco-

45 Defensible space is the area directly adjacent to the building and extending some distance out, in which easily combustible material is removed and/or replaced with less combustible alternatives — for example, replacing wood-based mulch with gravel. See wildfire section for more discussion.

46 Michael Gollner, Assistant Professor and Deb Faculty Fellow, Dept of Mechanical Engineering, University of California at Berkeley; email correspondence, January 10, 2022.

47 Ibid.

48 For a more in-depth and nuanced look into these issues, see "**Preparing for Disaster: Workshop on Advancing WUI Resilience**."

nomic incentives and the underlying infrastructure that connect them to the community. A truly resilient solution is one that takes this more holistic approach (as an example, see the work that the **Alliance for National and Community Resilience** is doing to link those various aspects). While the focus of this toolkit is on building codes and standards — specifically as they relate to housing — we have attempted to highlight issues that could be addressed within the codes, and those which may be better addressed by other processes.

How performance expectations are translated into codes and standards

Modern building codes can be traced back as early as 1897 with the publication of the National Electrical Code and with the model codes (the International Codes or I-Codes) appearing in 1994. The I-Codes form the basis of model building codes in the United States. The International Code Council (ICC) is the governing body who oversees these modern codes and was founded through the merger of regional code groups, The Building Officials and Code Administrators International (BOCA), the International Conference of Building Officials (ICBO) and the Southern Building Code Congress International (SBCCI).[49]

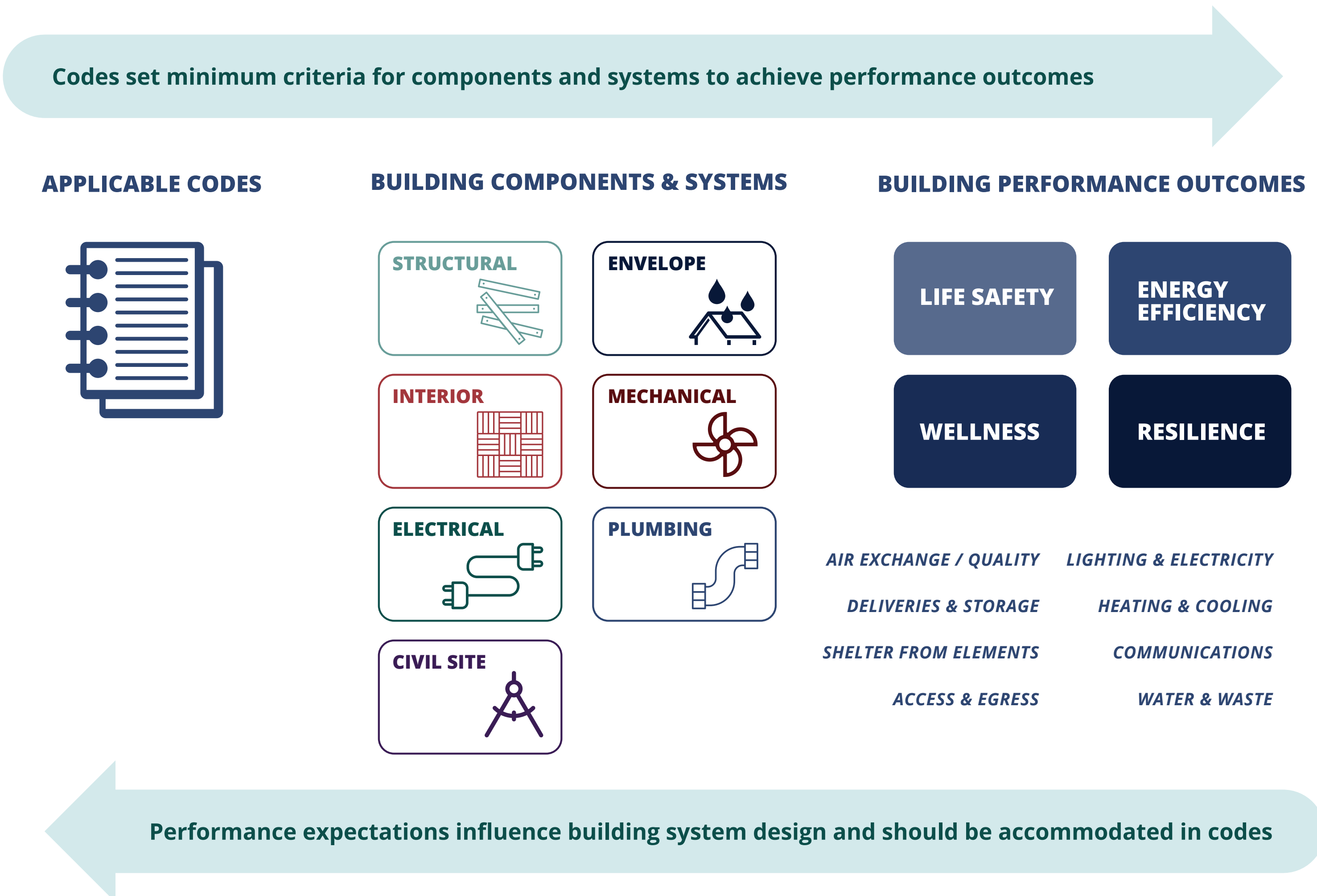
Model codes are developed through a consensus-based process across various stakeholders and are intended to serve as both a reference and minimal guideline within design and construction. The actual adoption of these codes, and turning them into regulatory requirements, happens at the state and local levels. Therefore, building design and construction types can vary considerably based not on what may be readily available through the codes (or even best practices) but on what states and local jurisdictions have decided to include as regulatory requirements. (See **Appendix A** for a summary of building code adoption per state.)

In this section, we focus more on the technical piece, specifically how performance expectations can become specific design and construction criteria that guide the building process. In the past, codes have focused more narrowly on life-safety aspects — will occupants be able to either safely shelter-in-place or exit if the building were to fail? In recent years, that focus has broadened to include other considerations such as energy efficiency, wellness, and resilience.

49 Vaughan, E., & Turner, J. (2013) "**The Value and Impact of Building Codes**." Environmental and Energy Study Institute.

Particular operational aspects must be optimized for the building to meet these performance standards. Key aspects are highlighted in the graphic below, but the list is definitely longer. There various building components and systems must be configured in such a way that they act in unison to support these building expectations. The major systems are highlighted below in Exhibit 14. The codes provide the translation of these base performance expectations to the various building systems and offer guidance on how to achieve those results. Building standards take that higher-level guidance offered within the model codes and provides detailed design and construction methodologies for use by the professional engineer, architect, and builder.

Exhibit 14 The relationship among codes, building design and performance outcomes



As shown in Exhibit 15, the ICC model codes often reference other codes and standards with respect to design and construction requirements. This helps in streamlining the various requirements across a variety of disciplines and ensuring alignment with standard practices. Again, there is flexibility at the state level and in home-rule jurisdictions to adopt some (or none) of the codes, as well as which standards they will include as part of those incorporations. The graphic below represents how individual standards align with different building systems, but it should not be read as what is adopted within each jurisdiction.

Exhibit 15 **A crosswalk showing the relationship across hazard types, building components, and relevant codes and standards**

REFERENCED CODES AND STANDARDS							
FLOOD	ASCE 24			IMC, UMC	NEC	IPC, UPC	ASCE 24
FIRE	Int. WUIC, NFPA 1140	Int. WUIC, NFPA 1140	NFPA 1140	Int. WUIC, NFPA 1140	NEC, NFPA 1140		Int. WUIC, NFPA 1140, IFC
TEMP		ASHRAE 90.1, IECC	ASHRAE 90.1, IECC	ASHRAE 90.1, IECC	ASHRAE 90.1, IECC	ASHRAE 90.1, IECC	
WIND	ASCE 7	ASCE 7					
	STRUCTURAL	ENVELOPE	INTERIOR	MECHANICAL	ELECTRICAL	PLUMBING	CIVIL SITE

Note: NFPA 1141 and NFPA 1144 have been incorporated into NFPA 1140, Standard for Wildland Fire Protection.

There have been changes in what the codes cover with respect to climate-related hazards. A summary of some of the most significant changes for each hazard is available in **Appendix C**.

How building codes are adopted at the state and local levels

Building codes are governed at the state level, each state having its own set of detailed rules. The following represents the continuum of possible governance structures and extent of legal authority that local jurisdictions have in adopting and/or mandating code requirements that differ from their state.

Exhibit 16 **Options for local jurisdictions depending on state code requirements**

STATE REQUIREMENT	WHAT CAN LOCAL JURISDICTIONS DO?
State-mandated minimal code for all jurisdictions	*Petition State Building Committee or introduce State-level legislation to adopt or amend other codes* AND *Implement changes through zoning and land use policies*
State-mandated code for certain building types and/or state-adopted minimal code with ability for local jurisdictions to adopt stricter codes	*Do not adopt / mandate any additional codes* OR *Adopt / mandate code for other building types* OR *Adopt / mandate stricter building codes than state minimum*
No state-mandated or -adopted code	*Choose to adopt / mandate their own building codes (or not)*

General challenges and potential solutions

Challenge: There is a general perception that building to a more resilient standard will involve more costly solutions. This is a particularly difficult assertion to test since the data are hard to collect (no centralized or standardized reporting platform exists for this information), there are few resources that have been invested in underwriting these types of studies, and those studies that have been conducted may not be well-socialized across the larger industry and/or within the public realm. With a readily available source of peer-reviewed work, volunteer-led planning boards do not have the capacity to challenge this perception. Likewise, without a readily available set of design and construction codes (or guidance), developers and contractors are not likely to take the risk of doing things differently.

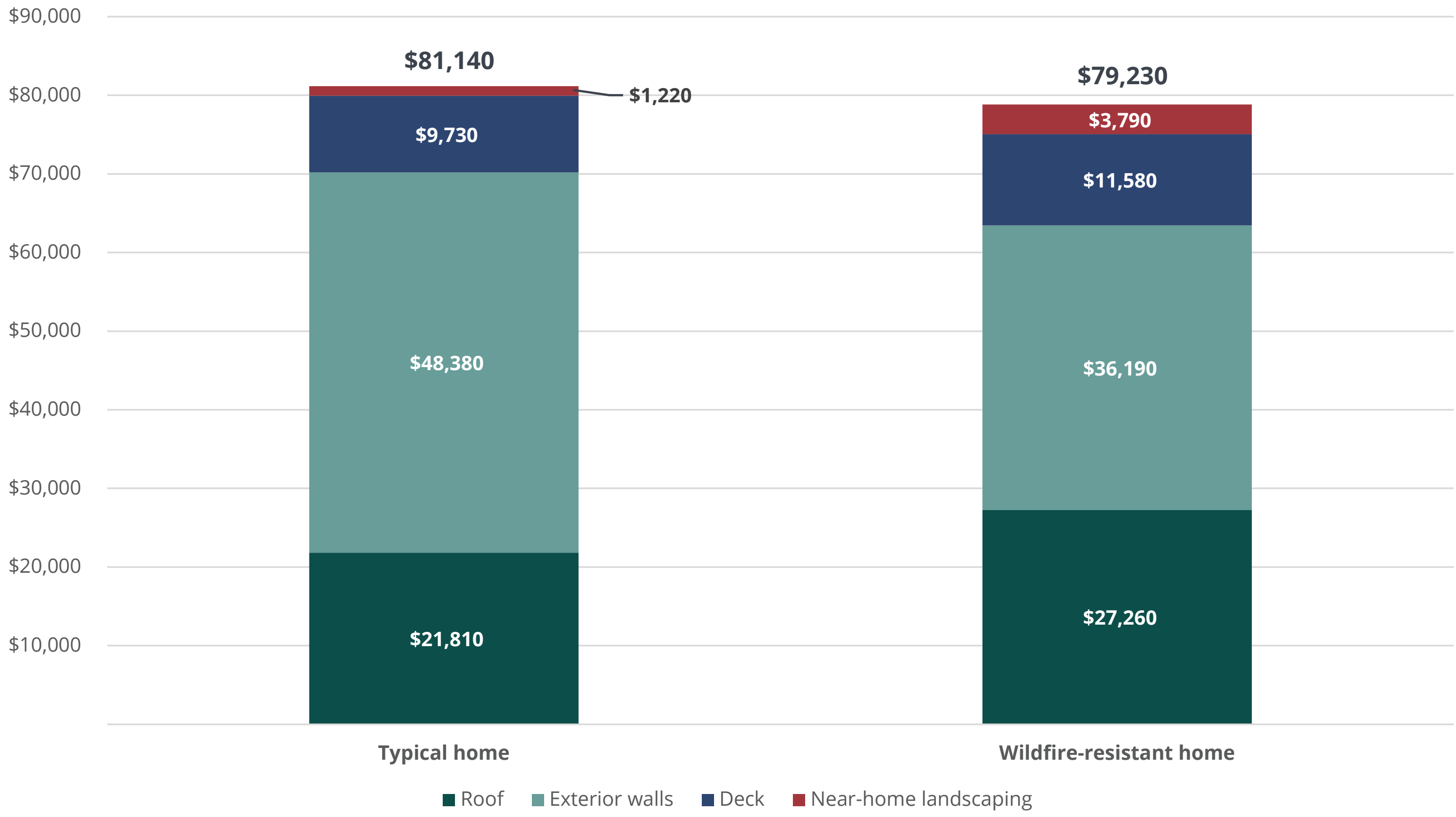
At the national level, building codes are enacted through a committee-based forum where changes are proposed by groups representing a variety of interest, ranging from safety and insurance representatives to engineers to professional organizations representing home builders and manufacturers of building supplies or individuals and then voted on by individuals representing jurisdictions throughout the country.

In general, homebuilders and developers can be reluctant to adopt additional codes because of the fear that they may add additional complexity and cost to the building process which could make the price of homes more expensive and less affordable. This is often the key area of conflict in proposing new changes to the code.

Solution: There needs to be a concerted effort to test the validity of this perception and to provide **cost–benefit analysis of more resilient building codes.** A recent **research effort** between Headwaters Economics and IBHS revealed that with wildfire construction, it can actually be *less* expensive to build to resilient standards than traditional builds.[50] The results of that work have been summarized in a readily accessible format and with adequate detail to support decision-makers as they consider whether or not to adopt more stringent standards than what may be available in the base model codes. The **NIBS study** found that updated codes added just one to two percent to the construction costs while capturing benefits for all stakeholders (builders, owners, tenants, financiers, and the community). A **study in Moore, OK,** following a code update after a string of tornadoes found no impact on price per square foot or home sales. This is representative of the type of work that needs to be done more widely throughout the industry, across the various hazards.

50 Headwaters Economics, 2018. **Building a Wildfire-Resistant Home: Codes and Costs**.

Exhibit 17 New construction costs by component in typical home and wildfire-resistant home



Source: Headwaters Economics. Building a Wildfire-Resistant Home: Codes and Costs.

Challenge: The criteria used to conduct fiscal impacts of new building codes may not include appropriate metrics and/or may result in unintended consequences. This is especially true with equity considerations and the ability to pay.

EXAMPLE OF UNINTENDED CONSEQUENCES AND EQUITY CONSIDERATIONS

St. John's County in Florida recognized the need to amend the current Florida Building Code to allow for residents to address storm-related damages without having to necessarily build to newer code requirements. The existing code required that the owner build to current-day codes if there were improvements that resulted in greater than 50 percent of the value of the resource over five years. Eligible upgrades included any type of improvements– not only those associated with storm damage. These originally well-intention actions created situations where less-resourced households could not afford to repair their homes following a storm event. The proposed reduction in standards would remove the requirement to enforce cumulative substantial improvement requirements. It also pointed to the need of solving more creatively for sea level rise and other types of resilience so that low- to moderate-income individuals have the same access to resilience interventions as others.

Some people interviewed as part of this work also highlighted how the current BRIC rating system used to rank the overall desirability of a proposal, awards as many as 20 points to jurisdictions that already have advanced building codes in place. This is meant to incentivize resilience but can also create the unintended consequence of making it more difficult for those municipalities with fewer resources to compete for funding. It has the potential to create a competitive advantage for those communities which may have the means to pursue more progressive codes instead of having the BRIC program invest more heavily in those that are interested but may not necessarily have the capacity to make the change on their own.

Solution: It is important to be **well-versed in the metrics used to underpin these calculations associated with affordability and equity,** where those data are sourced, and if any unintended consequences of the current ranking system would necessarily preclude the same outcomes each time. Several examples across the resilience field show where traditional cost–benefit analyses unfairly weight certain aspects more heavily than others. In many cases, these weightings could both limit the range of potential solutions and/or discount what should be significant considerations. An example of the latter includes basing the benefits heavily on the value of property at risk which often results in minimizing the impacts to low-moderate income populations and/or people who do not own property. Ideally, the entire community should be involved in code and policy related to development. This requires providing resources and accommodations (such as food, transportation, and childcare) to participants to ensure as many people as possible can be engaged.

Challenge: The overall structure of the governance and approval process will necessarily influence what gets introduced for consideration, how it is framed, and who has final say on what passes and what does not. Model and adopted codes are products of negotiations where a variety of stakeholders and perspectives can influence the outcome. The underlying governance associated with those negotiations, including how the discussions are held, who can participate, and how the approval process is determined, including who can votes and how votes are weighed, all influence the dynamics and eventual outcomes of these process.

Increasing attention has been paid to these processes, especially with respect to resilience. More specifically, when local entities are looking to create a higher standard of resilience than what currently exists in base codes. Examples of that include controversy around the ICC's recent changes in governance systems related to energy efficiency code approvals. The concern was that the change resulted in a process that will hinder a local governments' ability to adopt more progressive codes with respect to energy use and mitigation.[51]

Solution: Resilience enhancements can be further leveraged within the current system in parallel with the types of efforts described above. Examples of working within the current system include the work that ICC is doing in partnership with ANCR to create community-wide benchmarks for resilience working through a codes **framework**, as well as its recent publications around the types of resilience measures that currently exist within the codes.[52]

51 Chrobak, U., 2021. **Making buildings energy efficient just got harder**. *Popular Science*, March 21, 2021.

52 International Code Council, 2019. **Resilience Contributions of the International Building Code**. See also: how some aspects of the energy code also support resilience in **The Important Role of Energy Codes in Achieving Resilience**.

Exhibit 18 Aspects of resilience already captured in IBC

Selected code topic	Relevant sections (2018 IBC)	Supported resilience strategy	Relevant hazards
Critical facilities identification	307	• Emergency planning • Community operations • Response and recovery	• Flooding • Hurricanes • Tornadoes • Blizzards • Terrorism • Wildfire
Hazardous or combustible materials	413, 414	• Isolating risks	• Terrorism • Fire • Flooding • Hurricanes • Tornadoes
Storm shelters / areas of refuge	423, 1009, 1026	• Shelter in place / refuge • Robustness • Community protection	• Tornado • Terrorism • Fire
Flammability of materials	Chapters 6, 7, 8	• Fire resistance • Egress • Indoor air quality • Smoke exposure	• Fire • Secondary to other hazards
Protection of openings	Chapter 7, 1069.2	• Structural integrity • Debris impacts	• Hurricanes • Tornadoes
Fire suppression / protection, smoke control	Chapter 9	• Fire resistance • Egress • Property protection	• Fire • Secondary to other hazards
Communication	907, 908, 917	• Public safety • Evacuation	• Fire • Terrorism • Earthquake • Tsunami • Tornadoes
Means of egress	Chapter 10	• Evacuation • Fire protection • Accessibility	• Flooding • Hurricanes • Tornadoes • Blizzards • Terrorism
Accessibility	Chapter 11	• Inclusive communities • Community cohesion • Evacuation	• Public welfare • Secondary to other hazards
Occupant health	Chapter 12	• Indoor environmental quality • Indoor air quality • Access to sanitation	• Public health • Fire • Extreme heat / cold
Exterior envelope protection	Chapter 14	• Property protection • Debris impacts • Hazard spreading	• Fire • Flooding • Hurricanes • Tornadoes

Selected code topic	Relevant sections (2018 IBC)	Supported resilience strategy	Relevant hazards
Roof assembles	Chapter 15	• Fire resistance • Debris impacts • Sealing	• Fire • Hurricanes • Tornadoes • Extreme heat/ cold
Moisture protection	1209, 1402, 1503	• Durability • Mold, mildew, rot • Property protection	• Blizzards • Hurricanes • Flooding • Thunderstorms
Hazard maps	1608, 1609, 1611, 1613, 2603	• Identifying risk	• Tornado • Hurricane • Seismic • Pests • Snow • Rain
Continuous load paths	Chapter 16	• Structural integrity • Anchorage and bracing	• Earthquake • Tornadoes • Hurricanes
Identification of risk	1604.5	• Public safety • Emergency Planning	• Earthquake • Tornadoes • Hurricanes • Blizzards
Elevation of structure	1612	• Flood mitigation • Property protection	• Flooding • Hurricanes • Sea level rise
Tsunami	1615, Appendix M	• Identifying risk • Elevation above inundation • Minimum design loads • Evacuation / refuge	• Tsunami
Special inspections	Chapter 17	• Verification of performance • Structural integrity	• Earthquake • Fire
Soils and foundations	Chapter 18	• Load support • Subsidence	• Earthquake • Sea level rise • Drought • Flooding
Materials performance	Chapter 19-26	• Fire resistance • Structural integrity • Product safety	• Flooding • Hurricanes • Tornadoes • Blizzards • Terrorism • Wildfire
Safety during construction	Chapter 33	• Public safety • Fire safety • Means of egress	• Fire • Civil unrest
Fire Districts	Appendix D	• Fire safety	• Fire

Selected code topic	Relevant sections (2018 IBC)	Supported resilience strategy	Relevant hazards
Flood resistance	Appendix G	• Flood mitigation • Property protection	• Flooding • Hurricanes • Sea level rise

Source: **https://www.iccsafe.org/wp-content/uploads/19-17804_IBC_Resilience_WhitePaper_FINAL_HIRES.pdf**

Exhibit 19 Aspects of resilience captured in energy efficiency portions of the International Energy Conservation Code

Selected code topic	Relevant sections (2018 IECC)	Supported resilience strategy	Relevant hazards
Insulation	C402.2, R402.2	• Passive survivability • Reduced energy burden • Reduced grid impact • Reduced ice-dams • Reduced condensation, limiting mold and mildew	• Extreme heat / cold • Snow storms • Social resilience • Secondary impacts to all hazards
Walk-in coolers and freezers	C403.10	• Food safety / preservation	• Extreme heat • Secondary impacts to all hazards
Daylighting	C402.4.1	• Passive survivability • Reduced grid impact	• Extreme heat • Second impacts to all hazards
Window-to-wall ratios	C402.4.1, R402.3	• Passive survivability • Impact vulnerabilities	• Extreme heat / cold • Hurricanes • Tornadoes
Solar heat gain coefficient	C402.4.3, R402.3.2	• Passive survivability • Reduced grid impacts	• Extreme heat • Secondary impacts to all hazards
Solar reflectance of roof	C402.3	• Urban heat island • Passive survivability	• Extreme heat • Secondary impacts to all hazards
Air leakage	C402.5, R402.4	• Contaminants (secondary to wildfire, earthquake, etc.) • Mold and mildew (secondary to flooding, hurricane, extreme cold, etc.)	• Secondary impacts to all hazards
Pipe insulation	C404.4, R403.4	• Passive survivability • Reduced energy burden	• Extreme cold • Drought • Social resilience
On-site renewable energy	C406.5, Appendix CA, Appendix RA	• Contribute to distributed generation • Facilities islandability	• Secondary impacts to all hazards

For those entities looking to build beyond minimal code requirements, voluntary-based programs can be used to inform design and construction criteria. One example is the **FORTIFIED Home** program led by the IBHS and developed in partnership with leading industry experts. The construction method was developed to address key vulnerabilities that made buildings less able to withstand wind damage from hurricanes, tornadoes and other severe storm events. The standard includes "beyond-code" interventions that enhance a structure's overall resilience to these events, with a focus on minimizing overall damage in order to reduce (or avoid) post-event repairs, relocations or interruptions to daily living. An easy-to-use **website** allows interested parties to learn more about the program, find qualified contractors in their area and a roadmap for installing FORTIFIED products following an event. Several states have programs to incentivize the up take of these types of interventions, including providing grants as well as tax and insurance incentives (see "**Wind - Extreme Events**" on page C23 for more details).


Chris Sutton flickr.com/photos/xpinger/24003223577

Another benefit of **FORTIFIED Home** is that it offers standards to address hail damage. Hail is a big source of damage to structures but is not seen as a widespread health and safety issue because people can seek shelter so it is not specifically included in building codes.

Exhibit 20 FORTIFIED Home

The National Standard for Resilience	FORTIFIED Roof	FORTIFIED Silver	FORTIFIED Gold
Enhanced roof deck attachment			
Sealed roof deck			
Locked down roof edges			
Impact-resistant Shingles Rated by IBHS			
Wind- and rain-resistant attic vents			
Impact protection for windows and doors*			
Impact* and pressure-rated garage doors			
Chimney bracing			
Reinforced soffits			
Anchored attached structures			
Gable end bracing			
Pressure-rated windows and doors			
Stronger exterior sheathing			
Engineered roof-to-wall connections			
Engineered story-to-story connections			
Engineered wall-to-foundation connections			

Source: FORTIFIED Home

Challenge: It can take as many as three years (sometimes more) for changes in model building codes to be incorporated at the state or local level. It is necessary for the jurisdictions to amend and adopt the new editions before the changes are applicable. This process can take several years.

Solution: States and municipalities can shorten that time by **enacting a process by which a new code is adopted within a set timeframe after publication of a model code within 18 months.** The update process typically includes procedures for amending content in the model code to meet state or local requirements. Additionally, in states where local governments can adopt their own codes, municipalities can amend the codes according to their own schedules and/or needs (see **Appendix A** and **Appendix B** to learn more about code governance structures in each state).

Challenge: Having adequate capacity to ensure enforcement of building codes is a challenge for many states and municipalities. It can be a tedious and overwhelming proposition to ensure compliance for all new developments, even in states where the code only applies to certain structure types. Some municipalities have adequate capacity. In other cases, county, state and/or council of governments may have "circuit-riding" inspectors to carry out local inspections. The enforcement process ensures what was designed actually gets built.

Solution: The enforcement of building codes during design and construction requires adequate technical expertise, capacity, and budgets to allow for inspections during and post-construction. Assuming budget constraints will drive the capacity of local and state jurisdictions to properly inspect new and renovated facilities, there are options available that can be introduced into the codes at the local or state level. These options include using the affidavit process to assure conformance or allowing inspection by third party organizations.

In the affidavit process the designers of the facilities are responsible for assuring the structures are designed and constructed in accordance with the applicable codes. Members of the design team provide affidavits when the construction documents are submitted for permit. The affidavit indicates the design documents are in conformance with the applicable codes.

The challenge with the affidavit process is that it relies on the technical expertise of the designers or other parties and their knowledge of the applicable codes. Compliance needs to be tied to the professional license with sufficient mechanisms for monitoring compliance and penalties for non-compliance.

One example of this is GOVmotus, a program developed by the Institute for Building Technology and Safety (IBTS). This program allows for remote inspectional services via a hosted software platform and can be used to provide building department services, inspections and quality assurances to jurisdictions that may otherwise not have the capacity to perform these on their own.

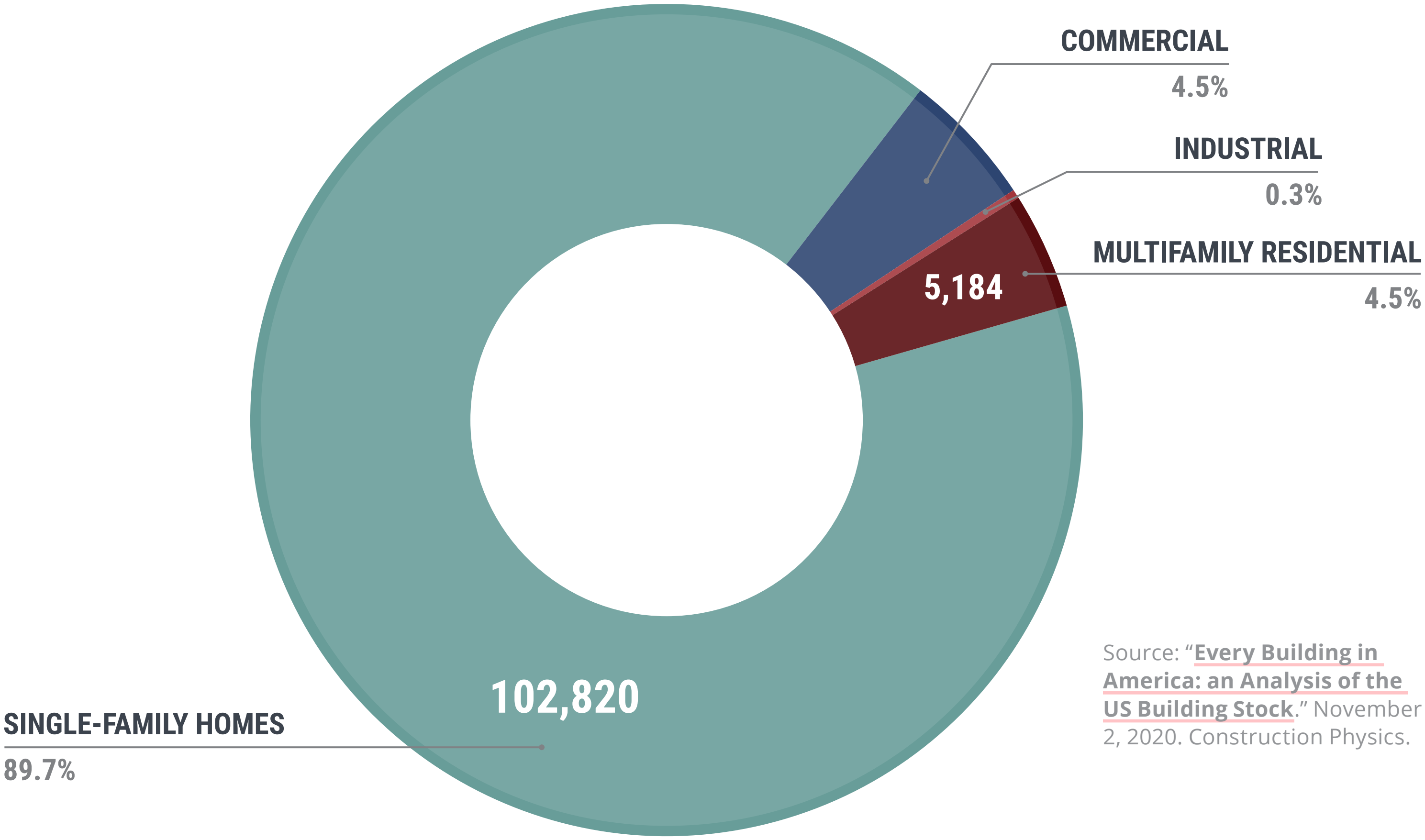
Source: **GOVmotus**

Third-party organizations can be used to supplement the capacity or expertise of the building officials. If the officials don't have the capacity or the expertise to review plans or construction, a third-party review and inspection organization can be an alternative. The cost is normally borne by the applicant. The official either has approval authority over the proposed organization or has a list of approved organizations from which the applicant can choose. The advantage of this approach is that the official can have more confidence that the organization conducting the reviews and inspecting the construction has the necessary expertise with regard to the applicable codes. The third-party organization(s) technically work for the jurisdiction, even though the cost is borne by the applicant.

Some communities have banded together to provide joint services where a single community cannot support its own building department.

Challenge: It can be difficult to address resilience in existing buildings. Approximately 111 million buildings exist in the United States, of which nearly 90 percent are single-family homes.

Exhibit 21 Number of buildings in the U.S. (thousands)



Source: "**Every Building in America: an Analysis of the US Building Stock**." November 2, 2020. Construction Physics.

For the most part, building codes focus almost exclusively on new construction (and or significant rehabilitations) which represent a very small percentage of the overall building stock. So, what can states and local governments do to address resilience in the existing building stock?

Solution: Municipalities have been quite creative in solving for this need using existing programs, regulatory frameworks and funding sources in slightly different ways. Below are some representative examples of how municipalities have enhanced resilience within existing building stock:

LEVERAGING CDBG-DR FUNDING TO ADDRESS RESILIENCE NEEDS IN ST. AUGUSTINE'S EXISTING BUILDING STOCK

St. Augustine, Florida, is the oldest city in America and almost at capacity as far as development is concerned. Many residents live in homes needing resilience to flooding impacts, but traditional revenue sources are insufficient to address this need.[53] Although homes built to the most recent editions of the Florida Building Code have been noted to better withstand impacts from flooding and storm damage, building code requirements do not necessarily have relevance here unless their homes experience significant damage.

The municipality used CDBG-DR funding to invest in resilience retrofits for those low- to moderate-income households that experienced repetitive losses from flooding. Possible actions included the option to demolish and rebuild, to elevate the structure or to move. Floodproofing is not recognized as eligible mitigation under FEMA programs, so this creative application of CDBG-DR funding allowed the city to address much needed resilience interventions for residents who may not have otherwise been able to access them.

MAKING THE MOST OF A NATURAL DISASTER

It is often difficult to think about long-term resilience in the immediate aftermath of a major weather event or natural disaster. However, these events can also present an opportunity to build back better *and* differently. The Federal funding that accompanies these events can be leveraged to relocate housing away from vulnerable areas and provide the required infrastructure (e.g., transportation, utilities) to keep them connected with the core community. The first reaction to a major flooding disaster may be to simply elevate the structure on the existing footprint. However, there

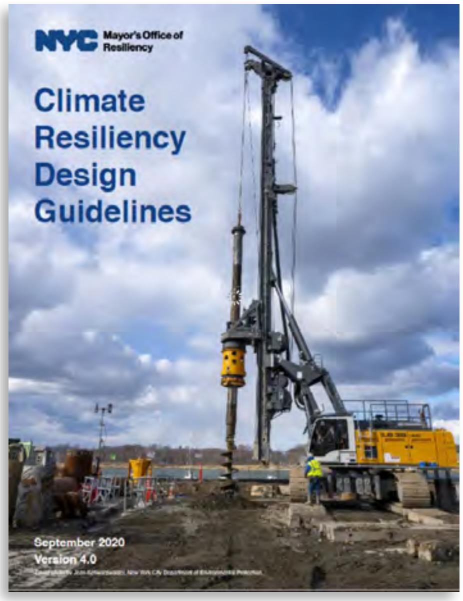
53 Personal communication, Westly Woodward, January 7, 2022

may be better solutions that involve relocating those homes to a slightly more inland area while still preserving the important community and cultural aspects of the neighborhood. When rebuilding, it will also be easier to incorporate more resilient building codes, standards and practices. While a relocation and rebuilding such as this can be challenging in dense, urban areas, less densely populated areas may offer more opportunities.

As an example, EPA has partnered with Smart Homes America and the Gulf of Mexico Alliance to proactively identify these opportunities and make the process less cumbersome for location communities. The goal is to "create community-wide ownership of a new post-disaster housing recovery plan by enabling local communities to incorporate and implement best practices in pre-disaster mitigation, policy, and planning by bridging the gap between the public and private sectors. The project will also identify missing knowledge or tools communities need to undertake disaster recovery efficiently and shorten the consistent lag time of federal aid."[54]

54 Project description from grant application, US EPA Gulf of Mexico Program, cooperative agreement #00D86619

LOCAL INITIATIVES THAT USE A COMBINED APPROACH OF LAND USE, ZONING, AND LOCAL CODE DEVELOPMENT AND ENFORCEMENT TO INCENTIVIZE THE ADOPTION OF RESILIENT BUILDING PRACTICES – IN BOTH NEW AND EXISTING STRUCTURES



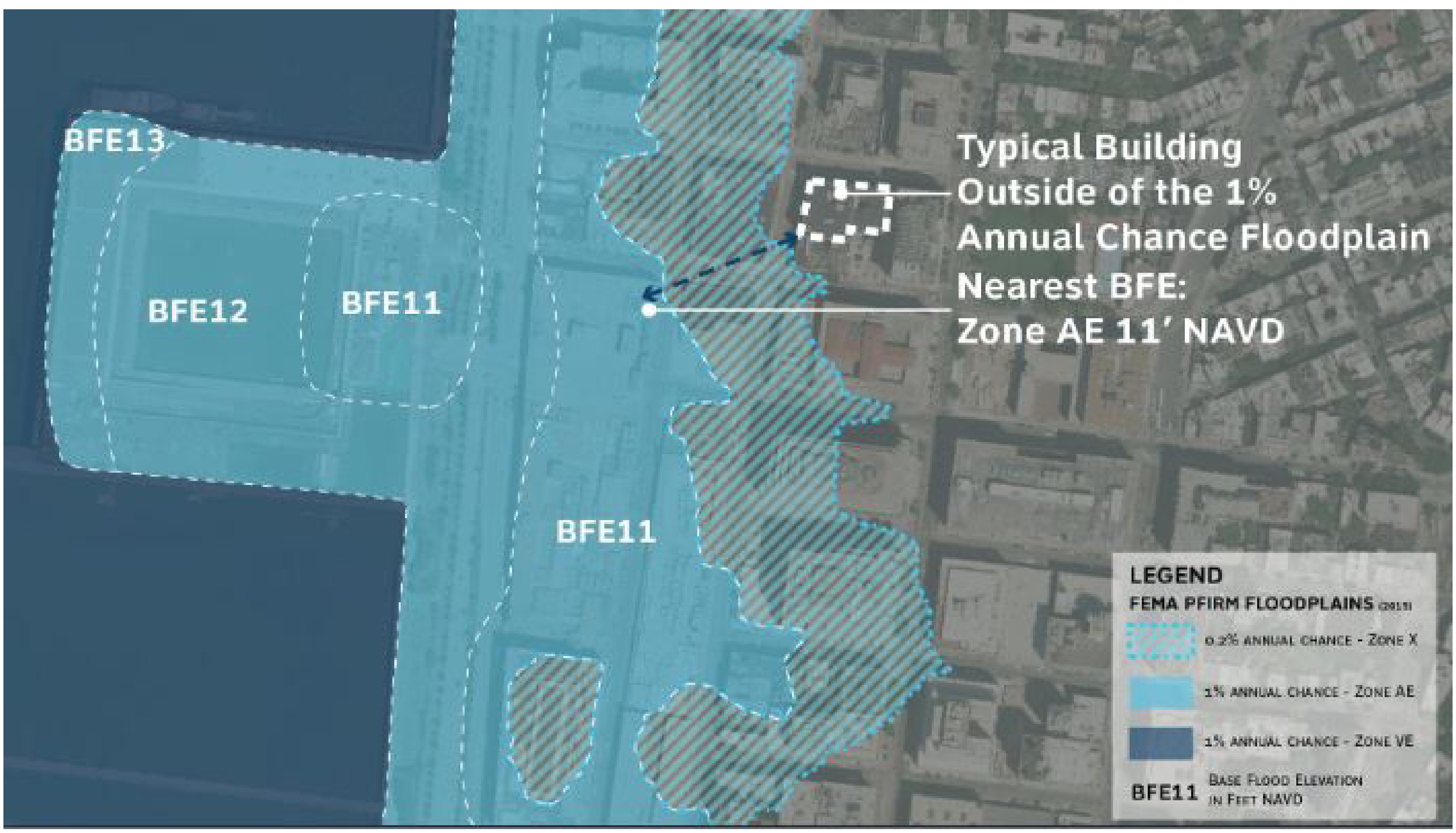
NYC'S RESILIENCE PROGRAM

New York City has taken a comprehensive approach to tackling climate change, leveraging both the existing codes structure as well as planning and land-use related interventions.

These **Climate Resilience Design Guidelines** dictate how climate change will be incorporated into city-funded capital projects. It requires that resiliency report cards be issued for all city projects and that those projects be designed to meet the design criteria outlined in the standards.

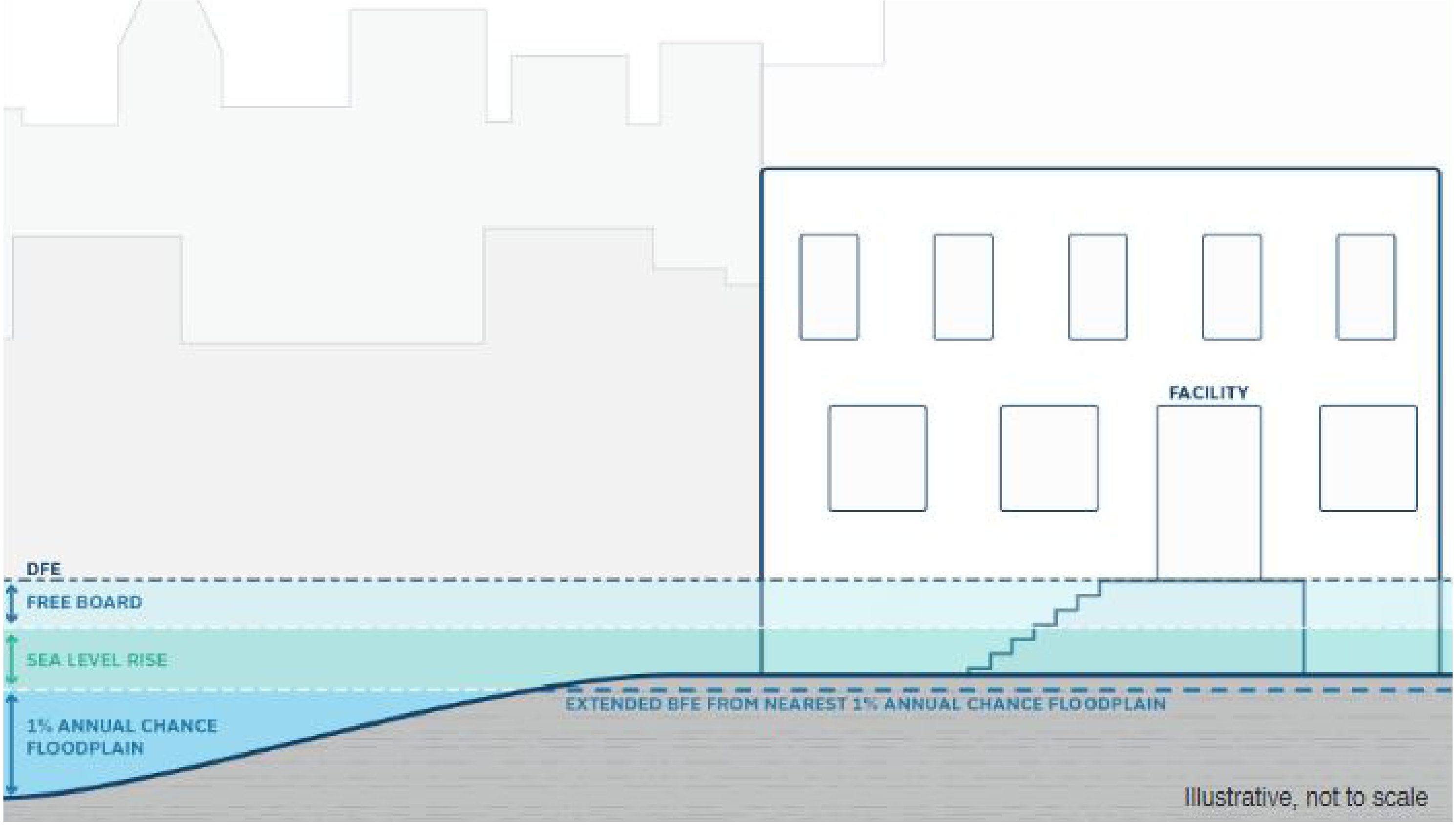
The companion piece, **Zoning for Coastal Flood Resiliency,** examines the role that land use and planning can achieve in meeting resilience objectives and proposes complementary solutions to those proposed at the building level.

Exhibit 22 **How to locate the nearest adjacent 1% floodplain elevation from a given project site**

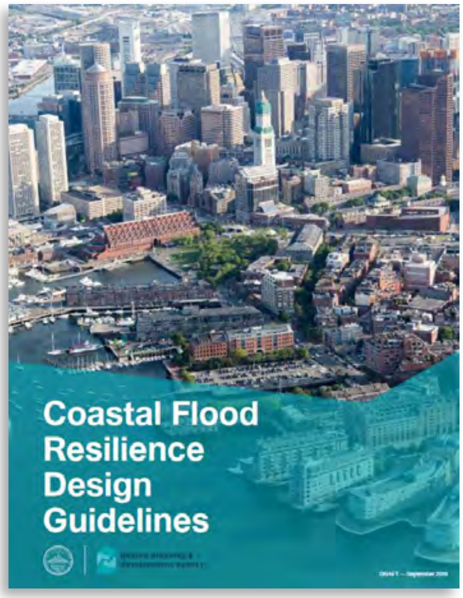


Source: NYC Climate Resiliency Design Guidelines

Exhibit 23 **How to use a base flood elevation in the current floodplain to determine a design flood elevation in the future floodplain**



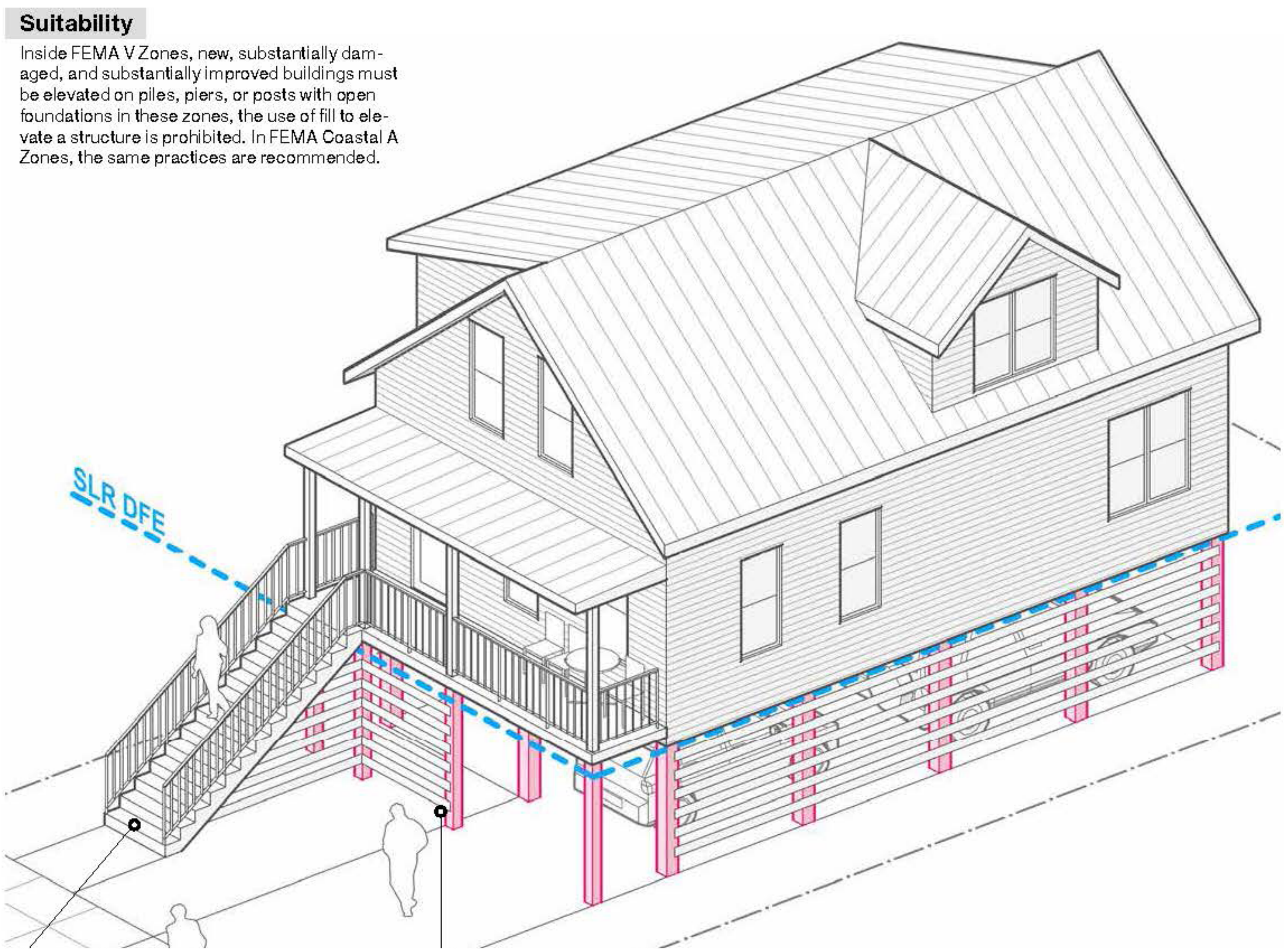
Source: NYC Climate Resiliency Design Guidelines



BOSTON'S COASTAL FLOOD RESILIENCE DESIGN GUIDELINES AND FLOOD RESILIENCE OVERLAY DISTRICT

Boston has adopted a similar approach to NYC in adopting both building-**specific guidance** for new construction and building within areas of the city which will be impacted by sea level rise and coastal storms, and combining those efforts with the recently adopted **Coastal Flood Resilience Overlay District** that uses climate projections to inform zoning decisions related to proposed use and dimensional aspects of buildings.

Exhibit 24 City of Boston Flood Resilience Design Guidelines

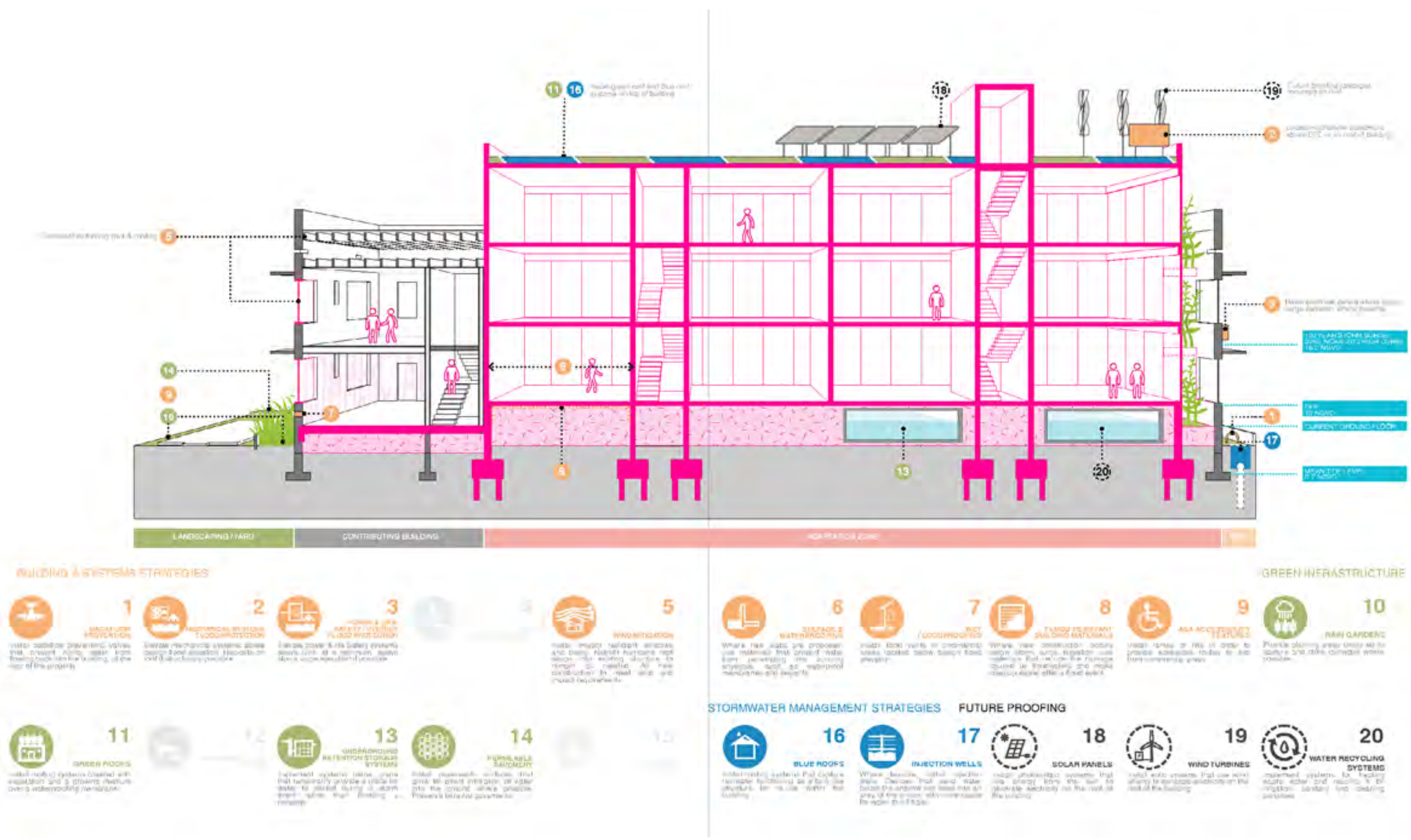


Source: **Coastal Flood Resilience Design Guidelines**

MIAMI BEACH — BUOYANT CITY

Buoyant City provides a comprehensive look, combining both land use and building code criteria, to address resilience across a variety of lenses, including within building typologies, at the level of landscapes and streetscapes, accounting for historic preservation needs and providing guidance by type and strategy.

Exhibit 25 City of Miami Beach — Buoyant City



Source: Buoyant City: Historic District Resiliency & Adaptation Guidelines

Challenge: Funding and technical assistance can be an issue when moving forward with building code initiatives. States and/or communities might not have sufficient resources to take the next steps.

Solution: While building code adoption occurs at the state level, the federal government can provide additional incentives — in the form of technical support, technical capacity and funding — to help with the development and implementation of code requirements. Exhibit 26 and Exhibit 27 capture two representative resources that provide additional direction, as well as potential funding and programmatic support.

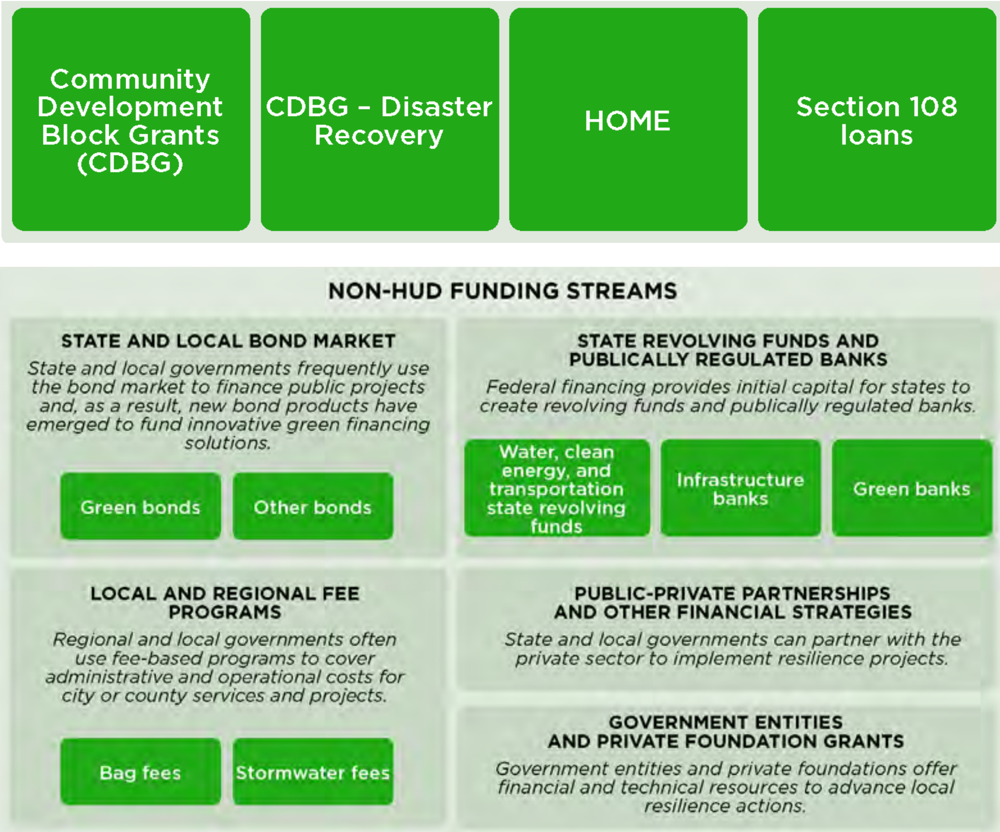
The Department of Energy **Building Energy Codes Program** (BECP) provides technical assistance and grant funding to support code adoptions and implementation. Sources include the state energy programs (SEP), energy efficiency and conservation block grants (EECBG), and the newly established energy code implementation program (EICP)."

Exhibit 26 FEMA Program Reference Matrix

Program	Flood	Fire	All hazard	Annual programming	Post-disaster	Mitigation project grants	Capability / capacity building, building code administration, & technical assistance grants	Nature-based solutions projects	Training, preparedness, technical assistance from FEMA
Sea level rise & flood maps	✓			✓					✓
Mitigation planning			✓	✓					✓
Building resilient infrastructure & communities			✓	✓		✓	✓	✓	✓
National flood insurance program	✓			✓			✓		
Flood mitigation assistance	✓			✓		✓	✓	✓	
National exercise program			✓	✓					✓
Fire-adapted communities		✓		✓					✓
Public assistance			✓		✓	✓	✓	✓	
Hazard mitigation grant program			✓		✓	✓	✓	✓	
Hazard mitigation grant program post-fire		✓			✓	✓		✓	

Source: FEMA, 2021. **FEMA Resources for Climate Resilience**.

Exhibit 27 HUD Community Resilience Toolkit



OTHER FUNDING OPPORTUNITIES

DOE Building Energy Codes Program – technical assistance

- Energy codes, stretch codes, workforce development

Funding Streams

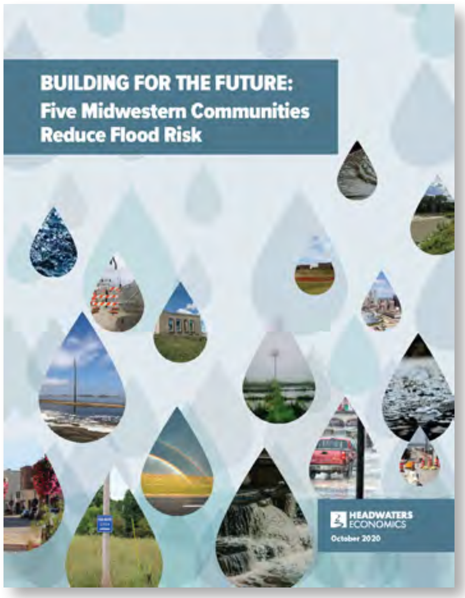
- State Energy Program (SEP)
- Energy Efficiency and Conservation Block Grants (EECBG)
- Energy Code Implementation Grants (in development)

Regional Energy Efficiency Organizations (REEOs)

Source: HUD Community Resilience Toolkit

Building for the Future: Five Midwestern Communities Reduce Flood Risk

This **study** is a good resource of case studies from five different municipalities that were able to leverage various sources of funding to progress flood mitigation programs within their jurisdictions.



RESILIENT BUILDING CODES CHECKLIST

1 What are the building code regulations in my state?

Where to look:

- Outputs from this project (**Appendix A: Code Requirements by State**)
- **NFPA CodeFinder**
- **ICC Code Adoption Database**

2 What are the hazards that my community is most concerned about? What strategies are available in the existing model codes that I could use to address these?

See **Appendix C: Technical Appendix for Hazard-Specific Interventions**.

3 Does my community have the ability to further amend the state's adopted codes?

See **Appendix B: State-by-State Amendment Procedures**.

4 What is the process for adopting a model code or ordinance for my community?

- See **Appendix B: State-by-State Amendment Procedures**.
- Contact the State (often the State Building Code Commission and/or Fire Marshal's Office) to determine if the municipality has legal authority to develop a code which exceeds the state's adopted standards.
- If a change in code is not allowable, work with local officials to determine how an ordinance could be developed to address similar concerns.
- Build from the success of others — start from a base code or ordinance developed by another municipality and build from there.

5 Who needs to be involved in the stakeholder process? Have I...

- coordinated with the State Building Code Commission and/or Fire Marshals Office to understand how codes might be amended at the local level;
- established partners in municipal and/or county government that will advocate for the proposed change;
- met with representatives from homebuilders and real estate industries to understand their viewpoints;
- recruited subject matter experts to vet the technical aspects of the revised code or ordinance;
- created a convincing case for why this is needed, including financial implications;
- assembled a diverse group of allies that can speak to technical aspects, health and safety considerations, community needs, business implications, economic and equity considerations?

ACKNOWLEDGMENTS

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

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* These experts contributed insights on one or more specific topics within the toolkit.

Appendix A
Code Requirements by State

State	Building Code	Residential Code	Existing Building	Plumbing code	Electrical Code (NEC)	Mechanical Code	Energy Code — Residential	Energy Code — Commercial (ASHRAE 90.1 or IECC)	Fire Code	Wildfire Code	Mandatory Statewide Building Code Asssessed from this research and unpublished IBHS data: *Yes*	*Partial*	*No*
Alabama	2015 IBC	2015 IRC	2015 IEBC	2015 IPC	2014 NEC	2015 IMC	2015 IECC	2013 90.1	2015 IFC			X	
Alaska	2012 IBC	No statewide code	No statewide code	2018 UPC	2017 NEC	2012 IMC	2018 IECC	No statewide code	2012 IFC			X	
Arizona	2018 IBC	2018 IRC	No statewide code	2018 IPC	No statewide code	2018 IMC	No state mandate	2004 90.1	2018 IFC	No codes at state level; several counties have adopted the model IWUI			X
Arkansas	2012 IBC	2012 IRC	No statewide code	2018 IPC	2017 NEC	2009 IMC	2009 IECC	2013 90.1	2012 IFC		X		
California	2018 IBC	2018 IBC	No statewide code	2018 IBC	2017 NEC	2018 UMC	2019 California Energy Code	2019 90.1	IFC 2018	Statewide WUI (Chapter 7A & Title 14)	X		
Colorado	2021 IBC	2021 IRC	2021 IEBC	2021 IPC	2020 NEC	2021 IMC	2015 IECC	2015 IECC	2021 IFC	2021 IWUI		X	
Connecticut	2015 IBC	2015 IRC	No statewide code	2015 IPC	2017 NEC	2015 IMC	2021 IECC***	2021 IECC***	2015 IFC; 2015 NFPA 1		X		
Delaware	2015 IBC	No statewide code	2015 IEBC	2018 IPC	2014 NEC	2018 IMC	2018 IECC	2016 90.1	2021 NFPA 1				X
District of Columbia	2015 IBC	2015 IRC	2015 IEBC	2015 IPC	2014 NEC	2015 IMC	2015 IECC	2013 90.1	2015 IFC		X		
Florida	2018 IBC	2018 IRC	No statewide code	2018 IPC	2017 NEC	2018 IMC	2018 IECC	2016 90.1	2018 NFPA 1		X		
Georgia	2018 IBC	2018 IRC	No statewide code	2018 IPC	2017 NEC	2018 IMC	2016 IECC	2015 IECC	2018 IFC	12 jurisdictions have adopted the model IWUI	X		
Hawaii	2018 IBC	2018 IRC	No statewide code	2018 UPC	2017 NEC	Admin Rules Title 11, Chapter 39 - Air Conditioning and Ventilating	2018 IECC	2018 IECC	2018 NFPA 1		X		
Idaho	2018 IBC	2018 IRC	No statewide code	2015 UPC	2017 NEC	2018 IMC	2018 IECC	2018 IECC	2018 IFC	No state level code but seven counties have adopted the NFPA 1144 as their WUI code	X		
Illinois	2015 IBC	No statewide code	No statewide code	Illinois Plumbing Code	No statewide code	2015 IMC	2018 IECC	2016 90.1	2015 IFC				X
Indiana	2012 IBC	2018 IBC	No statewide code	2006 IPC	2008 NEC	2012 IMC	2018 IECC	2007 90.1	2012 IFC			X	

Current as of February 2022

State	Building Code	Residential Code	Existing Building	Plumbing code	Electrical Code (NEC)	Mechanical Code	Energy Code — Residential	Energy Code — Commercial (ASHRAE 90.1 or IECC)	Fire Code	Wildfire Code	Mandatory Statewide Building Code Asssessed from this research and unpublished IBHS data: Yes	Partial	No
Iowa	2015 IBC	2015 IRC	No statewide code	2021 UPC	2020 NEC	2021 IMC	2012 IECC	2010 90.1	2015 IFC			X	
Kansas	n/a	No statewide code	No statewide code	2006 IPC	No statewide code		No state mandate	2006 90.1	2006 IFC				X
Kentucky	2015 IBC	2015 IRC	No statewide code	2012 IPC	2017 NEC	2015 IMC	2009 IECC	2010 90.1	2012 IFC			X	
Louisiana	2015 IBC	2015 IRC	2015 IEBC	2015 IPC	2014 NEC	2015 IMC	2009 IECC	2007 90.1	2015 NFPA 1		X		
Maine	2015 IBC	2015 IRC	2015 IEBC	2015 UPC	2020 NEC	2015 IMC	2015 IECC	2015 IECC	2018 NFPA 1			X	
Maryland	2018 IBC	2018 IRC	No statewide code	2018 IPC	2017 NEC	2018 IMC	2018 IECC	2018 IECC	2018 NFPA 1; 2018 IFC		X		
Massachusetts	2015 IBC	2015 IRC	No statewide code	2015 IMC	2020 NEC	2015 IMC	2018 IECC	2016 90.1	2015 NFPA 1; 2009 IFC		X		
Michigan	2015 IBC	2015 IRC	2015 IEBC	2018 IPC	2017 NEC	2015 IMC	2015 IECC	2013 90.1	2012 NFPA 1			X	
Minnesota	2018 IBC	2018 IRC	No statewide code	2012 UPC	2020 NEC	2018 IMC	2012 IECC	2018 IECC	2018 IFC		X		
Mississippi	2018 IBC	2018 IRC	2018 IEBC	2018 IPC	No statewide code	2018 IMC	No state mandate	2010 90.1	2018 IFC			X	
Missouri	2021 IBC	No statewide code	No statewide code	2021 IPC	No statewide code	2018 IMC	No state mandate	2015 IECC	No statewide code				X
Montana	2018 IBC	2018 IBC	No statewide code	2018 UPC	2017 NEC	2018 IMC	2018 IECC	2016 90.1	2012 IFC	2018 IWUI - No code but state written guidelines for developments within the WUIs		X	
Nebraska	2018 IBC	2018 IRC	No statewide code	2018 UPC	2017 NEC	No statewide code	2018 IECC	2016 90.1	2012 NFPA 1			X	
Nevada	2018 IBC	2018 IRC	2018 IEBC	2018 UPC	2017 NEC	2018 UMC	2021 IECC	2016 90.1	2018 IFC	2018 IWUIC		X	
New Hampshire	2015 IBC	2015 IRC	No statewide code	2015 IPC	2017 NEC	2015 IMC	2015 IECC	2015 IECC	2015 NFPA 1			X	

Current as of February 2022

State	Building Code	Residential Code	Existing Building	Plumbing code	Electrical Code (NEC)	Mechanical Code	Energy Code — Residential	Energy Code — Commercial (ASHRAE 90.1 or IECC)	Fire Code	Wildfire Code	Mandatory Statewide Building Code Assessed from this research and unpublished IBHS data: Yes	Partial	No
New Jersey	2018 IBC	2018 IRC	No statewide code	2018 National Standard Plumbing Code	2017 NEC	2018 IMC	2018 IECC	2016 90.1	2018 IFC		X		
New Mexico	2015 IBC	2015 IRC	2015 IEBCC	2015 UPC	2017 NEC	2015 UMC	2018 IECC	2018 IECC	2015 IFC		X		
New York	2018 IBC	2018 IRC	2018 IEBC	2018 IPC	2017 NEC	2018 IMC	2018 IECC	2016 90.1	2018 IFC		X		
North Carolina	2015 IBC	2015 IRC	2018 IEBC	2015 IPC	2020 NEC	2015 IMC	2015 IECC	2015 IECC	2015 IFC		X		
North Dakota	2018 IBC	2018 IRC	2018 IEBC	2018 UPC	2020 NEC	2018 IMC	No state mandate	2018 IECC voluntary	2018 IFC			X	
Ohio	2015 IBC	2018 IBC	No statewide code	2015 IPC	2017 NEC	2015 IMC	2018 IECC	2010 90.1	2015 IFC		X		
Oklahoma	2018 IBC	2015 IRC	2015 IEBC	2018 IPC	2017 NEC	2018 IMC	2009 IECC	2006 IECC	2018 IFC		X		
Oregon	2018 IBC	2018 IRC	No statewide code	2021 UPC	2020 NEC	2018 IMC	2018 IECC	2019 90.1	2018 IFC	Amendment to the 2017 Oregon Residential Code Section R327 (Wild-fire Hazard Mitigation)	X		
Pennsylvania	IBC 2018	IRC 2018	No statewide code	IPC 2018	2017 NEC*	IRC 2018	2015 IECC	2015 IECC	2015 IFC	2015 IUWIC	X		
Rhode Island	2018 IBC	2018 IRC	No statewide code	Based on 2018 IPC	2020 NEC	2018 IMC	2015 IECC	2010 90.1	2018 NFPA 1		X		
South Carolina	2018 IBC	2018 IRC	2018 IEBC	2018 IPC	2017	2018 IMC	2009 IECC	2007 90.1	2018 IFC		X		
South Dakota	2021 IBC	No statewide mandate	No statewide code	2015 UPC	2020 NEC	2015 IMC	No mandatory state code	No statewide code	2021 IFC				X
Tennessee	2012 IBC	2018 IRC	No statewide code	2012 IPC	2017 NEC	2012 IMC	No statewide mandate	2006 IECC or 2012 IECC for certain types of commercial buildings and state-owned buildings	2012 IFC			X	
Texas	2012 IBC	2018 IRC*	No statewide code	2018 UPC or 2018 IPC	2020 NEC	2018 UMC or 2018 IMC	2015 IECC	2013 90.1	2015 NFPA 1; 2006 IFC - counties			X	

Current as of February 2022

State	Building Code	Residential Code	Existing Building	Plumbing code	Electrical Code (NEC)	Mechanical Code	Energy Code — Residential	Energy Code — Commercial (ASHRAE 90.1 or IECC)	Fire Code	Wildfire Code	Mandatory Statewide Building Code Asssessed from this research and unpublished IBHS data		
											Yes	*Partial*	*No*
Utah	2018 IBC	2015 IRC	2018 IEBC	2018 IPC	2020 NEC	2018 IMC	2018 IECC	2018 IECC	2018 IFC; 2018 NFPA 1	State designated code based on 2006 IWUIC	X		
Vermont	2015 IBC	No statewide code	2015 IEBC	IPC 2018	2017 NEC	No statewide code	2018 IECC	2016 90.1	2015 NFPA 1				X
Virginia	2018 IBC	2018 IRC	2018 IEBC	2018 IPC	2017 NEC	2018 IMC	2018 IECC	2016 90.1	2018 IFC		X		
Washington	2018 IBC	2018 IRC	No statewide code	2018 UPC	2020 NEC	2018 IMC	2018 IECC	2016 90.1	2018 IFC	DNR has Wildfire liaison; community wildfire Protection Planning highly emphasized	X		
West Virginia	2015 IBC	2015 IRC	2015 IEBC	2015 IPC	2017 NEC	2015 IMC	2009 IECC	2010 90.1	2018 NFPA 1			X	
Wisconsin	2015 IBC	Wisconsin Uniform Dwelling Code - state written (2015)	2015 IEBC	Wisconsin Uniform Plumbing Code - state written (2015)	2017 NEC	2015 IMC	2009 IECC	2013 90.1	2012 NFPA 1			X	
Wyoming	2021 IBC	n/a	2021 IEBC	2018 IPC	2020 NEC	2021 IMC	no state mandate	no statewide code	2021 IFC	Several communities in Wyoming have adopted the IWUIC			X

* PA will be moving to 2017 in 2022

** for TX: 2018 IRC (State); 2012 IRC (muni) 2006 IRC (counties)

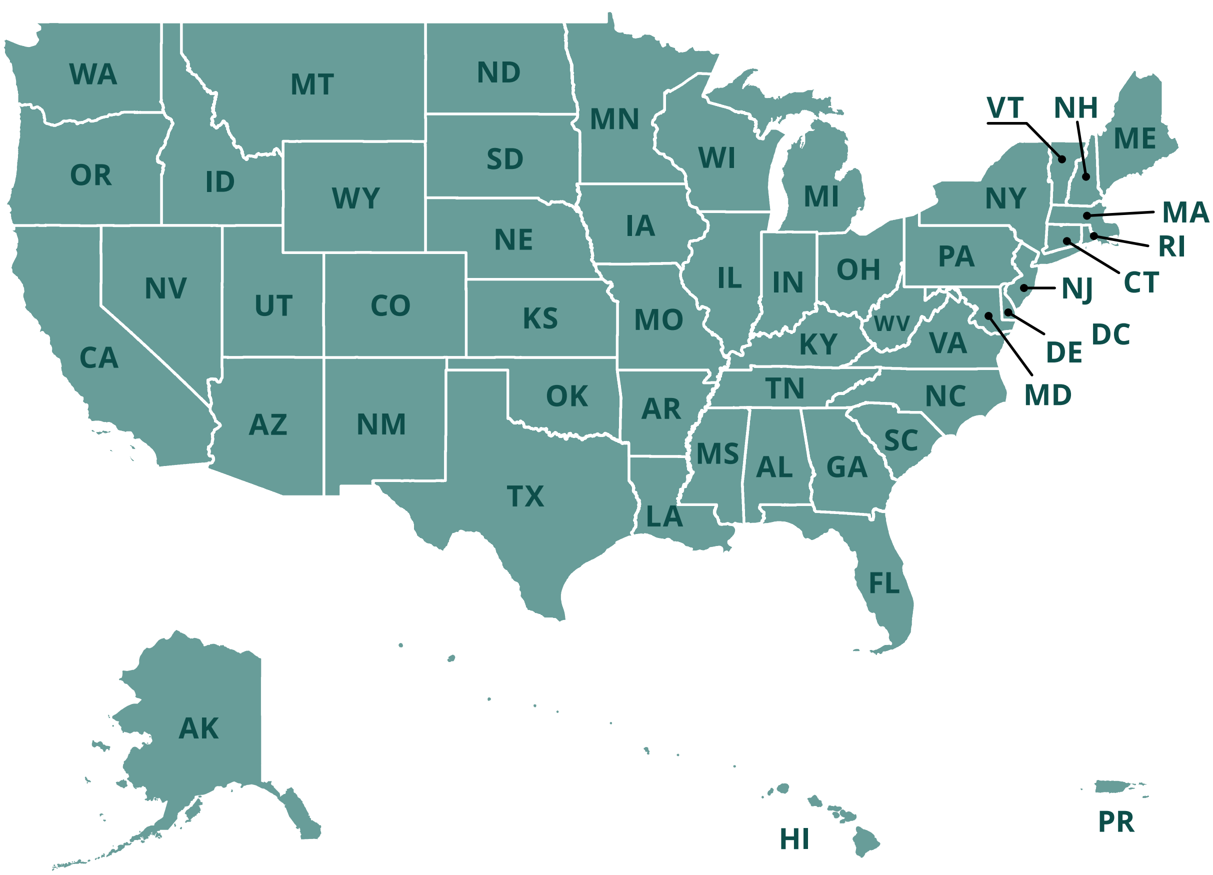
***goal of adopting 2021 IECC in October 2022 for both commercial and residential

Current as of February 2022

Appendix B
State-by-State Amendment Procedures

State-by-state amendment procedures

Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
Florida
Georgia
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan
Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Vermont
Virginia
Washington
West Virginia
Wisconsin
Wyoming
Puerto Rico
Washington D.C.



EXAMPLE

Telephone: number to call to learn more about code requirements in your state
Website: online information about code requirements in your state
Adopting entity: entity responsible for overseeing adoption of new codes
Full/Partial/None: refers to whether there are statewide code mandates for all building types; some mandates for some building types (partial); or no state-level code requirements
State Amendments allowed: indicates whether the state level codes can be adopted
Local Amendments allowed: indicates if the code can be amended at the local level
Form: Is there a required form that needs to be submitted as part of the amendment application
Link: What is the online link for the form
Topography, Geology, Weather, Temperature: do these variables needs to be addressed in the proposed amendment
Language: Is there specific language that needs to be cited and/or proposed as part of the amendment
Reason: Does the applicant need to provide a reason for the proposed code amendment?
Cost: Does the applicant need to provide a cost impact statement as part of the amendment?
Stakeholders: Does the amendment process require certain stakeholders to be consulted as part of this amendment
Filed with/approved by state: What filing requirements and approval processes are mandated at the state level

ALABAMA

Tel: (334) 242-5330
Website: **https://adeca.alabama.gov/energycodes**
Adopting entity: Alabama Residential and Energy Code Board for residential and energy code
Full/Partial/None: Partial, local jurisdictions adopt commercial building code
State Amendments allowed: Yes, for residential and energy code
Local Amendments allowed: Yes, for commercial building code
Form: Yes
Link: Contact board clerk at number above for copy of form.
Topography, Geology, Weather, Temperature: Yes
Language: As indicated on form
Reason: Yes
Cost: Yes
Stakeholders: No
Filed with/approved by state: Recommended to file with state. No state approval required.

Local jurisdictions can modify the state residential code and energy code as long as it is more restrictive. There is no statewide commercial building code and local jurisdictions can adopt the commercial building code. There are no limitations on adoption of the commercial code.

ALASKA

Tel: 907-269-5491
Website: **https://dps.alaska.gov/Fire/Home**
Adopting entity: State Fire Marshal's Office recommends to Lt Governor
Full/Partial/None: Full (No residential 4 or less units)
State Amendments allowed: Anybody
Local Amendments allowed: Stricter only
Code Change Submittal Form: Yes
Link: **dps.alaska.gov/getmedia/4a8d4159-c424-41ee-997e-4c220bc86f85/Code-Change-Request-Form.docx**
Based on Topography, Geology, Weather, Temperature: No restrictions
Language: Legislative
Reason: Yes
Cost: Not required
Stakeholders: No required
Filed with/approved by state: not required

Alaska has a process to review and adopt changes to the base building code:

1. Must state proposed wording for the change to wording in the base code.
2. Statement related to the need and reasons for change

ARIZONA

Tel: 602-771-1400 (SFM for fire code only)
Website: **https://dffm.az.gov/fire-marshals-office**
Adopting entity: Local jurisdiction adopt their own building code. State Fire Marshall adopts the State Fire Code
Full/Partial/None: NA
State Amendments allowed: NA, there is no statewide building code
Local Amendments allowed: Yes
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: NA

No statewide building codes. Local jurisdictions can adopt whatever edition of the building code desired. There is no state review or approval.

ARKANSAS

Tel: 501-618-8601
Website: **https://www.dps.arkansas.gov/law-enforcement/arkansas-state-police/divisions/regulatory-building/**
Adopting entity: State Fire Marshal with recommendations from appointed council and review by legislature
Full/Partial/None: Full
State Amendments allowed: Yes, anyone during public comment period
Local Amendments allowed: Yes, if they are more restrictive
Form: No
Link: NA
Topography, Geology, Weather, Temperature: No
Language: Yes
Reason: Yes
Cost: No
Stakeholders: No
Filed with/approved by state: Filing and approval required

CALIFORNIA

https://www.dgs.ca.gov/BSC/Codes

California has a well-documented process for local amendments to Title 24, the California Building Standards Code. The procedures are in the "Guide for Local Amendments of Building Standards."

COLORADO

Tel: 303-866-3079
Website: **https://osa.colorado.gov/**
Adopting entity: No statewide code
Full/Partial/None: None, state buildings only adopted by State Architect and Fire Marshal
State Amendments allowed: NA
Local Amendments allowed: Codes adopted locally
Form: NA
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: NA

No statewide building codes except for public buildings. Local jurisdiction can adopt their own code. They must adopt one of last three editions of IECC when adopting codes locally.

CONNECTICUT

Tel: 860-713-5900
Website: **https://portal.ct.gov/DAS/Office-of-State-Building-Inspector/Building-and-Fire-Code-Adoption-Process**
Adopting entity: Legislature, based on Codes & Standards Committee recommendations
Full/Partial/None: Full (min/max)
State Amendments allowed: Yes
Local Amendments allowed: No
Form: Yes
Link: **https://portal.ct.gov/-/media/DAS/Office-of-State-Building-Inspector/CAS_change_proposal.pdf**
Topography, Geology, Weather, Temperature: NA
Language: Legislative
Reason: Yes, with supporting data and documents
Cost: Recommended
Stakeholders: Recommended
Filed with/approved by state: NA

DELAWARE

Tel: 302-856-5496 (plumbing) 302-735-3480 (energy)
Website: **https://www.energycodes.gov/status/states/delaware** (energy)
Adopting entity: Individual boards
Full/Partial/None: Building codes adopted locally; mech., energy and plumbing are adopted statewide
State Amendments allowed: through public hearing process only
Local Amendments allowed: More restrictive amendments only to state adopted codes.
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: No

Contact local municipality authorities for amending locally adopted commercial and residential building codes. Energy, plumbing and mechanical code input is only allowed during the public hearing process in response to proposed adopted codes.

FLORIDA

Tel: 850-487-1824
Website: **https://floridabuilding.org/cm/cm_default.aspx**
Adopting entity: Commission
Full/Partial/None: Full
State Amendments allowed: Yes, anybody
Local Amendments allowed: Allowed if more restrictive
Form: Yes
Link:
Topography, Geology, Weather, Temperature: No, but normally are
Language: Yes
Reason: Yes
Cost: Yes
Stakeholders: Yes
Filed with/approved by state: Must be filed only

Proposed modifications are submitted online at **https://floridabuilding.org/cm/cm_default.aspx**. Submitters must be registered, logged-in users to access the form. See also Florida Statute 553.73 for detailed information on proposed code amendments.

GEORGIA

Tel: 800-436-7442
Website: **https://www.dca.ga.gov/local-government-assistance/construction-codes-industrialized-buildings/construction-codes**
Adopting entity: Board
Full/Partial/None: Full, local municipalities can adopt several permissive codes.
State Amendments allowed: Yes
Local Amendments allowed: More restrictive only
Form: Yes, state and local
Link: **https://www.dca.ga.gov/node/4963** (state) **https://www.dca.ga.gov/node/4962** (local)
Topography, Geology, Weather, Temperature: Topographic, geologic, or public safety only. (local only)
Language: Legislative language (state & local)
Reason: Yes (state & local)
Cost: Yes (state) No (local)
Stakeholders: No (state & local)
Filed with/approved by state: Must be filed, state may make recommendations

Department of Community Affairs does not approve or disapprove any local amendment. The department provides a recommendation only. However, in order to enforce any local amendment, the local government must submit the proposed amendment to DCA for review and file the amendment once is it adopted.

Permissive codes are:

- Disaster Resilient Building Code IBC Appendix
- Disaster Resilient Building Code IRC Appendix
- International Property Maintenance Code
- International Existing Building Code
- National Green Building Standard

HAWAII

Tel: 808-590-9555
Website: **state.bcc@hawaii.gov**
Adopting entity: State Building Code Council
Full/Partial/None: Full within two years of adoption of state code
State Amendments allowed: yes
Local Amendments allowed: yes
Form: Yes
Link: **https://calendar.ehawaii.gov/calendar/attachment/111274621/Wind%20Code%20Proposal.pdf**
Topography, Geology, Weather, Temperature: No restrictions
Language: Yes
Reason: Yes
Cost: Amendment will increase cost or not
Stakeholders: Not required to contact
Filed with/approved by state: Yes/No
Hawaii requires proposed state modifications to be submitted online or by mail with legislative language for proposed changes to the code. Supporting information for the proposed change is not required. However, proposals are rarely successful without supporting information.

Counties are required to adopt the state code with local amendments within two years of state adoption or the state code applies by default. Counties have their own rules for submitting proposed local amendments.

IDAHO

Tel: 208-332-7137
Website: **https://dbs.idaho.gov/boards/idaho-building-code-board/**
Adopting entity: Idaho Building Code Board then approved by Legislature
Full/Partial/None: Full
State Amendments allowed: Yes, spelled out in Title 67, Chpt 52, and Title 39, Chpt 41
Local Amendments allowed: More restrictive only
Form: Yes

Link: **https://dbs.idaho.gov/wp-content/uploads/sites/105/2021/04/rulemaking_BUILDING_comment_submittal_form_04052021.pdf**
Topography, Geology, Weather, Temperature: life/safety, unique condition in state only
Language: Yes
Reason: Yes
Cost: Yes, detailed cost benefit analysis
Stakeholders: Yes, effect on business/industry
Filed with/approved by state: No

Idaho requires modifications to be submitted online with legislative language for proposed changes to the code. Supporting information for the proposed change may be attached, but there is no indication it is required. Required information includes problem addressed, reason for amendment, benefits, and detailed cost/benefit analysis.

ILLINOIS

Tel: 217-782-2864
Website: **https://www2.illinois.gov/cdb/Pages/default.aspx**
Adopting entity: Legislature with recommendations from Capital Development Board
Full/Partial/None: Default for municipalities that have not adopted a code
State Amendments allowed: Yes in legislative public hearing process
Local Amendments allowed: Yes, no limits
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: Filed with Capital Development Board, no review or approval

No statewide building codes. There are statewide energy, accessibility, and plumbing codes.

INDIANA

Tel: None, email commission staff at **buildingcommission@dhs.in.gov**
Website: **https://www.in.gov/dhs/fire-and-building-safety/**
Adopting entity: Fire Prevention and Building Safety Commission
Full/Partial/None: Full
State Amendments allowed: Yes, during adoption process only

Local Amendments allowed: Yes, more restrictive only and not in conflict
Form: Yes
Link: Only available through commission when adopting code
Topography, Geology, Weather, Temperature: No
Language: Yes
Reason: Yes
Cost: Yes
Stakeholders: No
Filed with/approved by state: Yes, filed and approved

IOWA

Tel: (515) 725-6145
Website: **bcinfo@dps.state.ia.us**
https://dps.iowa.gov/divisions/state-fire-marshal/building-code-advisory-council
Adopting entity:
Full/Partial/None: Partial
State Amendments allowed: Yes
Local Amendments allowed: Building code adopted locally
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: No / No

The state adopts several codes and the building, residential and existing building codes areadopted at the local level. When the codes are being adopted the Iowa Department of Public Safety holds workshops where proposed amendments are presented and vetted.

Iowa adopts the building code at the state level for state buildings, state financed buildings and healthcare facilities.

Jurisdictions less than 15,000 do not need to adopt building codes.

KANSAS

Tel: NA
Website: NA

Adopting entity: Local jurisdictions only
Full/Partial/None: None
State Amendments allowed: NA
Local Amendments allowed: Yes, contact local jurisdiction
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: NA

No statewide building codes, no state information online. Contact each jurisdiction to determine adopted codes and amendment process. Fire, plumbing, and energy codes adopted for state buildings only.

KENTUCKY

Tel: 502-573-0365
Website: **https://dhbc.ky.gov/newstatic_info.aspx?static_id=297**
Adopting entity: Legislature with recommendation from Advisory Committee
Full/Partial/None: Full
State Amendments allowed: Yes, during adoption process
Local Amendments allowed: Yes
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: No

LOUISIANA

Tel: 225-922-0817
Website: **http://lsuccc.dps.louisiana.gov/index.html**
Adopting entity: Code Council
Full/Partial/None: Full
State Amendments allowed: Yes, for any reason
Local Amendments allowed: No
Form: No

Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: NA

If the council determines that an amendment is justified, it may enact such an amendment after a finding on the record that the modification provides a reasonable degree of public health, safety, affordability, and welfare.

MAINE

Tel: 207-441-0996
Website: **https://www.maine.gov/dps/fmo/building-codes**
Adopting entity: Technical Building Codes and Standards Board
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: Energy stretch code only, some allowed through zoning
Form: Yes
Link: **https://www.maine.gov/dps/bbcs/Applications%20and%20Forms/Applications%20and%20Forms.html**
Topography, Geology, Weather, Temperature: No
Language: Yes
Reason: Yes
Cost: Yes
Stakeholders: Yes
Filed with/approved by state: Energy – Yes, Zoning - No

Maine has rules for the review and adoption of amendments to the Maine Uniform Building and Energy Code, including:

1. A process for consideration of amendment proposals submitted by municipalities, county, regional or state governmental units, professional trade organizations and the public
2. A requirement that amendments that are more restrictive than the national minimum standard be accompanied by an economic impact statement that includes:
    a. An identification of the types and an estimate of the number of the small businesses subject to the proposed amendment
    b. The projected reporting, record-keeping and other administrative costs required for compliance with the proposed amendment, including the type of professional skills necessary for preparation of the report or record

c A brief statement of the probable impact on affected small businesses; and

d A description of any less intrusive or less costly, reasonable alternative methods of achieving the purposes of the proposed amendment

MARYLAND

Tel: 410-767-2000
Website: **https://www.dllr.state.md.us/labor/build/buildcodes.shtml**
Adopting entity: Legislature with recommendations from Building Codes Administration
Full/Partial/None: Full if not adopted locally within six months
State Amendments allowed: Yes, anyone can submit amendment during state code adoption process
Local Amendments allowed: Yes, counties have 6 months to adopt for local condition, no energy or accessibility codes amendments allowed
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: Cost/Benefit: NA
Stakeholders: NA
Filed with/approved by state: Filed with Building Codes Administration, No approval required

The International Energy Conservation Code (IECC — the Energy Code) and Maryland Accessibility Code (MAC — the Accessibility Code) may not be amended

MASSACHUSETTS

Tel: 617-727-3200
Website: **https://www.mass.gov/orgs/board-of-building-regulation-and-standards**
Adopting entity: Board of Building Regulations and Standards
Full/Partial/None: Full
State Amendments allowed: Yes, submit at or before public hearing
Local Amendments allowed: Yes, more restrictive only
Form: Yes
Link: **https://www.mass.gov/doc/code-change-proposal-form/download**
Topography, Geology, Weather, Temperature: Yes
Language: Yes
Reason: Yes
Cost: Yes
Stakeholders: No

Filed with/approved by state: Approval required by Secretary of State

The BBRS requires the form indicate whether there are any life safety benefits to the proposed change.

MICHIGAN

Tel: 517-241-9303
Website: **https://www.michigan.gov/lara/bureau-list/bcc/rules-acts/codes/code-books**
Adopting entity: Bureau of Code Council with review by legislature
Full/Partial/None: Partial
State Amendments allowed: Yes
Local Amendments allowed: No
Form: Yes
Link: call number above
Topography, Geology, Weather, Temperature: NA
Language: Yes
Reason: Yes
Cost: Yes, detailed
Stakeholders: not required, but recommended
Filed with/approved by state: NA

Michigan is a Min/Max state. Amendments are not allowed at the local level. However, several opportunities exist to submit amendments during the adoption process.

MINNESOTA

Tel: 651-284-5912
Website: **http://www.dli.mn.gov/about-department/boards-and-councils/construction-codes-advisory-council**
Adopting entity: legislature with input from the Construction Code Advisory Council
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: No, code is min/max
Form: Only able to be submitted during code adoption process (every 6 years)
Link: **http://dli.mn.gov/sites/default/files/pdf/com-tag-change030221.pdf**
Topography, Geology, Weather, Temperature: No
Language: Yes
Reason: Yes
Cost: Yes, cost/benefit analysis
Stakeholders: No

Filed with/approved by state: NA

Minnesota adopts ICC codes every six years. There is no process for submitting amendments outside the adoption process. No local amendments are allowed as the code is minimum/maximum code.

MISSISSIPPI

Tel: 601-467-3457
Website: **https://www.mid.ms.gov/ubc/ubc.aspx**
Adopting entity: Mississippi Building Code Council
Full/Partial/None: Partial, requires local adoption or opt-out
State Amendments allowed: during adoption process at public hearings
Local Amendments allowed: Yes
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: File information on adopted code with state, no approval required

Local jurisdiction must adopt any one of the latest three ICC codes or have opted out by 2014.

MISSOURI

Tel: None
Website: **https://data.mo.gov/browse?tags=building%20codes**
Adopting entity: Local municipalities only
Full/Partial/None: Partial IBC 2012 Section 107 for Office of the State Architect (Public Buildings)
State Amendments allowed: NA
Local Amendments allowed: Yes, check with local municipalities
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: NA

All local jurisdictions can make any amendments they deem necessary in their jurisdictions.

MONTANA

Tel: 406-841-2056
Website: **https://bsd.dli.mt.gov/building-codes-permits/**
Adopting entity: Montana Department of Labor and Industries with input from Building Codes Council
Full/Partial/None: Full
State Amendments allowed: Yes, during adoption process. Contact Building Codes Council
Local Amendments allowed: Yes
Form: Yes
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: Yes
Reason: Yes
Cost: Yes
Stakeholders: No
Filed with/approved by state: Filing and approval required

NEBRASKA

Tel: 402-471-2683
Website: **https://nebraskalegislature.gov/laws/statutes.php?statute=71-6403**
Adopting entity: Legislature
Full/Partial/None: Full after 2 years have passed unless a local municipality has adopted the code earlier
State Amendments allowed: Present at public hearing
Local Amendments allowed: Yes, unlimited
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: Not required

The Nebraska legislature adopts building codes to be enforced statewide. Local jurisdictions are able to amend the codes as long as they are not less restrictive than the adopted codes. If the local jurisdiction does not adopt a code, the state adopted code applies.

There is no process other than the public hearings to submit changes to the codes at the state level. Individual jurisdictions should be contacted about proposing local amendments to the codes.

NEVADA

Tel: 775-684-7525
Website: **https://publicworks.nv.gov/Contact/Contact/**
Adopting entity: Public Works Division for state buildings and State Fire Marshal
Full/Partial/None: Only apply to state buildings
State Amendments allowed: No
Local Amendments allowed: Codes locally adopted
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: No

(775) 684-4141

https://publicworks.nv.gov/Services/Permitting_Code_Enforcement/Permitting___Code_Enforcement/

Nevada adopts codes for state buildings. City and county jurisdictions within the state may adopt codes for enforcement within their jurisdiction. They are not required to adopt the same code edition as the state has adopted. Individual jurisdictions should be contacted about proposing local amendments to the codes.

Some codes are enforced statewide (plumbing code, energy code, and fire code)

NEW HAMPSHIRE

Tel: 603-223-4315
Website: **https://www.nh.gov/safety/boardsandcommissions/bldgcode/bcrb-procedure.html**
Adopting entity: Legislature with Building Code Review Board recommendation
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: Yes, as long as more restrictive
Form: Yes
Link: **https://www.nh.gov/safety/boardsandcommissions/bldgcode/documents/amendment-form.pdf**
Topography, Geology, Weather, Temperature: No
Language: Legislative
Reason: Yes
Cost: Yes
Stakeholders: Yes

Filed with/approved by state: File with state, approval by state

Any person, organization, or state agency can submit a code change proposal to the NH Building Code Review Board. The proposal shall be submitted on the Board's form (link to form above)

The BCRB then acts on the proposal, by approving it, approving an amended version of it, table it for further consideration or deny it. If approved, the BCRB then asks a legislator to sponsor a bill to ratify the amendment. If not ratified, the rule expires at the end of a two-year period.

New or renovated single family homes are not required to be inspected.

NEW JERSEY

Tel: 609-984-7609
Website: **https://www.state.nj.us/dca/divisions/codes/**
Adopting entity: Commissioner of the Department of Community Affairs after staff review
Full/Partial/None: Full
State Amendments allowed: Yes, but adoption unlikely due to state law
Local Amendments allowed: No
Form: Yes
Link: **https://www.state.nj.us/dca/divisions/codes/codreg/pdf_regs/njac_5_23_3.pdf** (Appendix 3-A)
Topography, Geology, Weather, Temperature: No
Language: As directed on form
Reason: Yes
Cost: No
Stakeholders: No
Filed with/approved by state: NA

Interested parties may submit comments or information related to code change proposals before the Commissioner of the Department of Community Affairs and the associated advisory board. The department can only make changes that are in state law or were in previous editions of the code. Therefore, amendments are technically not allowed.

NEW MEXICO

Tel: 505-476-4500
Website: **https://www.rld.nm.gov/construction-industries/about-us/**
Adopting entity: Construction Industries Commission
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: More stringent only

Form: Yes
Link: Form and location currently being revised
Topography, Geology, Weather, Temperature: Yes
Language: Yes
Reason: Yes
Cost: Yes
Stakeholders: Yes
Filed with/approved by state: No need to be filed, only reviewed if a complaint is filed

NEW YORK

Tel: (518) 474-4073, Option #3
Website: **https://dos.ny.gov/code/code-development**
Adopting entity: State Fire Prevention and Building Code Council (Code Council)
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: Yes
Form: No, requirements listed at link below
Link: **https://dos.ny.gov/code/code-development** (code change proposals)
Topography, Geology, Weather, Temperature: No
Language: Yes
Reason: Yes
Cost: Yes
Stakeholders: No
Filed with/approved by state: Required to be filed, must be approved by Code Council

NORTH CAROLINA

Tel: 919-647-0095
Website: **https://www.ncosfm.gov/codes/building-code-council-bcc**
Adopting entity: NC Building Code Council
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: Yes
Form:
Link: **https://www.ncosfm.gov/media/494/open**
Topography, Geology, Weather, Temperature:
Language: Yes
Reason: Yes
Cost: Yes, unless state agency
Stakeholders: Not required but recommended to work with stakeholders
Filed with/approved by state: Approval by Building Code Council required

Cost of proposed change and economic impact is required. If substantial (economic impact greater than $1 million), must include two alternatives, time value of money and risk analysis.

Cost benefit analysis is required for proposed energy and residential code changes.

NORTH DAKOTA

Tel: 701-390-4806
Website: **https://www.communityservices.nd.gov/buildingcode/**
Adopting entity: North Dakota Division of Community Services
Full/Partial/None: Full, local jurisdictions are to adopt state code
State Amendments allowed: Yes
Local Amendments allowed: Yes
Form: Yes
Link: **https://www.communityservices.nd.gov/uploads/28/SFN50180CodeAmendmentSubmittal102221.pdf**
Topography, Geology, Weather, Temperature: Not limited
Language: Yes
Reason: Yes
Cost: No
Stakeholders: No
Filed with/approved by state:

The Code Amendment Submittal is required to be filled out and submitted to the ND Division of Community Services. No cost information or economic analysis is required.

OHIO

Tel: 614-644-2613
Website: **https://com.ohio.gov/divisions-and-programs/industrial-compliance/boards/** board-of-building-standards
Adopting entity: Ohio Board of Building Standards after legislative review
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: Yes, as long as it does not conflict with state. Not recommended
Form: Yes
Link: **https://com.ohio.gov/divisions-and-programs/industrial-compliance/boards/board-of-building-standards/building-codes-and-interpretations/application-to-change-the-building-code**
Topography, Geology, Weather, Temperature: No

Language: Legislative language
Reason: Yes
Cost: Yes
Stakeholders: No
Filed with/approved by state: No filing required, Yes, must be approved for residential codes only

Submit code change in legislative text to the Ohio Board of Building Standards on provided form. The reason and technical justification for the proposed change is required. An estimate of the increase or decrease in cost is required to be submitted with the proposed code change.

OKLAHOMA

Tel: 405-521-6501
Website: **https://www.ok.gov/oubcc/**
Adopting entity: Uniform Building Code Commission with approval by the governor
Full/Partial/None:
State Amendments allowed: Yes
Local Amendments allowed: Yes, as long as more restrictive
Form: Yes
Links:

- **https://www.ok.gov/oubcc/documents/PCF%20for%20Proposed%20Rules%20fillable%201.pdf** (building)
- **https://www.ok.gov/oubcc/documents/2015%20IECC%20Comment%20Form.pdf** (energy)

Topography, Geology, Weather, Temperature: not required
Language: Legislative text
Reason: Yes, with substantiation
Cost: Yes, increase or not, no detailed cost analysis
Stakeholders: No
Filed with/approved by state: filing and approval by the commission required

Technical committees are normally tasked by the Oklahoma Uniform Building Code Commission with reviewing codes for adoption. The technical committees are required to provide for public comment and suggestions related to the task assignments of the committee.

OREGON

Tel: (503) 378-4133
Website: **https://www.oregon.gov/bcd/Pages/index.aspx**
Adopting entity: Specific boards per code, Board recommends to administrator
Full/Partial/None: Full

State Amendments allowed:
Local Amendments allowed: yes, stricter only
Form: yes
Link: **https://www.oregon.gov/bcd/Formslibrary/2652.pdf**
Topography, Geology, Weather, Temperature: issue applicable only to jurisdiction
Language:
Reason:
Cost:
Stakeholders:
Filed with/approved by state: local amendment approval necessary

Submit code change in legislative text to the Department of Consumer & Business Services Building Codes Division.

Provide information on how the proposal addresses an issue. Address issues of safety if applicable. Additional information is required if the proposal involves new technology, energy conservation or indoor air quality, or products requiring approval by other boards.

A cost–benefit analysis is required with backup related to methods and resources associated with how it was calculated.

The petitioner is required to contact other stakeholders that will be impacted by the proposed change or explain why they were not contacted.

PENNSYLVANIA

Tel: (717) 787-3806
Website: **https://www.dli.pa.gov/ucc/Pages/default.aspx**
Adopting entity: Legislature with recommendations from UCC Review and Advisory Council
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: Yes, more restrictive only
Form: Yes for state
Link: **https://www.dli.pa.gov/ucc/Pages/UCC-Review-and-Advisory-Council.aspx**
Topography, Geology, Weather, Temperature: No
Language: After consideration by UCC Review and Advisory Council
Reason: Yes
Cost: No
Stakeholders: No
Filed with/approved by state: Review and approval required for local amendments

Municipalities (only for local amendments) **http://www.pacodeandbulletin.gov/Display/pacode?file=/secure/pacode/data/034/chapter403/s403.102.html&d=**

Individuals and municipalities that want to amend the triennial state Uniform Construction Code, UCC): **https://www.dli.pa.gov/ucc/Pages/UCC-Review-and-Advisory-Council.aspx**

The UCC Review and Advisory Council first asks for public submissions related to proposals to be added to the UCC. The Council does not ask for specific wording at this time. Once the proposed changes have been posted, the Council asks for comments with the specific wording proposed. Applicable comment forms are posted to the website when the particular comment periods are open.

The Council does not require cost information, but many of the submittals for the previous cycles have contained some basic cost comments with only minor backup or no backup.

RHODE ISLAND

Tel: 401-921-1590
Website: **http://www.ribcc.ri.gov/committee/**
Adopting entity: Building Codes Standard Committee with legislative oversight
Full/Partial/None: Full
State Amendments allowed: Yes, anyone can submit proposal
Local Amendments allowed: No
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: NA

SOUTH CAROLINA

Tel: 803-896-4688
Website: **https://llr.sc.gov/bcc/**
Adopting entity: SC Building Codes Council
Full/Partial/None: Full
State Amendments allowed: Yes, by representative of a local jurisdiction or professional association
Local Amendments allowed: Yes, by representative of a local jurisdiction or professional association
Form: Yes
Link: **https://www.llr.sc.gov/bcc/Forms/Code-Modification-Form.pdf**
Topography, Geology, Weather, Temperature: based on local physical or climatological conditions
Language: Yes, as directed on form
Reason: Yes

Cost: No
Stakeholders: No
Filed with/approved by state: Must be filed and approved by SC Building Codes Council

Proposed modifications to the building code must be submitted by a local jurisdiction or a professional organization to the South Carolina Building Codes Council. The modifications may only be based on physical or climatological conditions. (See 8-240 to 8-250 of the Building Code Council regulations)

Local modifications to the state building code are allowed. The BCC will determine if a proposed amendment should apply only locally or statewide. Energy Standards amendments may only be requested by local jurisdictions.

SOUTH DAKOTA

Tel: (605) 773-3417 or (800) 658-3633
Website: None
Adopting entity: Legislature
Full/Partial/None: Full
State Amendments allowed: Only at public or administrative rules hearings
Local Amendments allowed: Yes, as long as more restrictive when adopting the designated code locally
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: No

The legislature designates a building code edition that the local jurisdiction can then choose to adopt or not. If not adopted by the local jurisdiction, the code still applies. Amendments to the state code can only be presented at legislative hearings. The energy code is adopted for new residential occupancies, but it is a voluntary standard.

A local jurisdiction that adopts the code may modify it if it is more restrictive and as long as it is filed with the municipal finance officer. There are no state provisions related to the process to be followed for amending the code. Contact the local jurisdiction to propose amendments at the local level.

TENNESSEE

Tel: (615) 741-7190

Website: **https://www.tn.gov/commerce/fire/codes-enforcement.html**
Adopting entity: State Fire Marshal
Full/Partial/None: Full
State Amendments allowed: Yes, in public hearings
Local Amendments allowed: Yes, more restrictive allowed
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: No

No local ordinances may be less restrictive than the adopted building code. A jurisdiction that has adopted a code that is within seven years of the legislative adopted edition (2012) is considered in compliance.

There are no restrictions in the law that prevent local jurisdictions from adopting more stringent standards than the legislative adopted edition. There are no approvals necessary from the state or necessary reporting requirements to the state.

TEXAS

Tel: 512-676-6800
Website: **https://www.sll.texas.gov/law-legislation/texas/building-codes/**
Adopting entity: Legislature
Full/Partial/None: Full
State Amendments allowed: Yes, through legislature public hearing process
Local Amendments allowed: Yes, local jurisdictions adopt their own building codes with no restrictions.
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: No

The state adopts editions of the codes via legislation that applies throughout the state. Local municipalities may modify the adopted code as they see fit. It can be more or less restrictive than the adopted code as long as it is adopted by ordinance at the local level. At the state level proposals for amendments can be introduced during the public hearing process associated with the legislature adopting the code.

An edition of the International Energy Conservation Code is adopted statewide for single family dwellings by legislation. Local municipalities may adopt a more recent edition of the code. An edition of the International Energy Conservation Code is adopted statewide for multi-family dwellings and commercial buildings by legislation. The State Energy Conservation Office may adopt a more recent edition of the code.

Local municipalities should be contacted to determine the process for proposing local code amendments.

UTAH

Tel: 801-530-6628
Website: **https://dopl.utah.gov/ubc/index.html**
Adopting entity: Legislature adopts based on recommendation by Uniform Building Code Commission
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: Yes, less or more restrictive
Form available: Yes
Link: **https://dopl.utah.gov/ubc/ubc_request_for_code_amendment.pdf**
Amendments must be based on local conditions: Yes
Legislative language: Yes
Reason provided: Yes
Cost: Yes
Stakeholders: Considered in cost
Filed with/approved by state: Yes

The state adopts editions of the codes via legislation that applies throughout the state. Local municipalities may modify the adopted code by proposing amendments to the Uniform Building Code Commission through a local or state regulator.

Submit code change form to the Division of Occupational and Professional Licensing. The proposed change shall be in legislative text. Provide information on how the proposal addresses an issue.

A cost analysis is required with information on how and who it would affect. There is a list of stakeholders that need to be considered when addressing cost implications.

VERMONT

Tel: 802-479-7561
Website: **https://firesafety.vermont.gov/buildingcode/codes**
Adopting entity: Division of Fire Safety with legislative committee review,

Full/Partial/None: Full
State Amendments allowed: Yes, during rulemaking and review process
Local Amendments allowed: Yes, as long as more restrictive
Form: Yes
Link: No, contact Division of Fire Safety
Topography, Geology, Weather, Temperature: No
Language: Yes
Reason: Yes
Cost: Yes
Stakeholders: No
Filed with/approved by state: No

Local jurisdictions adopt residential code.

VIRGINIA

Tel: 804-371-7150
Website: **https://www.dhcd.virginia.gov/code-development**
Adopting entity: Board of Housing and Community Development
Full/Partial/None: Full
State Amendments allowed: Yes, any member of the public
Local Amendments allowed: No
Form: Online submittal
Link: **https://va.cdpaccess.com/login/**
Topography, Geology, Weather, Temperature: NA
Language: Yes
Reason: Yes
Cost: NA
Stakeholders: NA
Filed with/approved by state: NA
The Board of Housing and Community Development has a new online process for code development, including proposals to change the existing and future codes. You need to register for the website in order to participate in the process and submit amendments.

Amendments are allowed only at the state level. Some jurisdictions make amendments using zoning codes.

WASHINGTON

Tel: 360-407-9277
Website: **https://sbcc.wa.gov/about-sbcc**
Adopting entity: State Building Code Council adopts codes

Full/Partial/None: Full
State Amendments allowed: Anybody can propose
Local Amendments allowed: Must be more restrictive
Form:
Link: **https://sbcc.wa.gov/state-codes-regulations-guidelines/forms**
Topography, Geology, Weather, Temperature: Yes
Language: Legislative text
Reason: Yes
Cost: Yes, lifecycle and construction
Stakeholders: Yes, impact on small business, housing, code officials, and others
Filed with/approved by state: Residential occupancies only require state approval

360-407-8768

https://sbcc.wa.gov/state-codes-regulations-guidelines/forms

The State Building Code Council adopts editions of national codes. Both state and local amendments are allowed. Locally, the accessibility and energy codes cannot be amended. Amendments cannot be less restrictive than the state adopted code.

Local amendments that address single family or multifamily buildings (up to four units) must be submitted on the state form to the State Building Code Council for review and approval. The amendments must be based on climatic, geologic, seismic, life, safety, or health conditions, environmental impacts, or other special conditions unique to the jurisdiction.

Amendments addressing other buildings are not restricted in any way.

For proposed changes to the code at the state level, submit the state code change form to the State Building Code Council. The proposed change shall be in legislative text. Provide information on how the proposal addresses an issue. A cost analysis is required with information on who it would affect and how.

WEST VIRGINIA

Tel: 304-558-2191 Ext. 20739
Website: **https://firemarshal.wv.gov/about/Pages/StateFireMarshal.aspx**
Adopting entity: Legislature with recommendations from West Virginia Fire Commission
Full/Partial/None: Partial, local jurisdictions need to adopt the state adopted code
State Amendments allowed: Yes, through legislature public hearing process
Local Amendments allowed: Yes, local jurisdictions may adopt appendices if desired.
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA

Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: Yes, must file ordinance adopting code with state

The state adopts editions of the codes via legislation that applies throughout the state. Local municipalities must adopt the edition of the code adopted in the law. The only ability to amend the code in the law is for sections of the code indicating the local jurisdiction should amend the section to fit the local conditions within the jurisdiction. The local jurisdiction may adopt appendices not adopted as part of the legislation. The legislation does not adopt any of the appendices.

The State Fire Commission shall be notified in writing when a local jurisdiction adopts the codes. A copy of the ordinance or order shall be sent to the State Fire Marshal within 30 days of adoption.

There is no process spelled out in the law or regulations relating to amendments to the technical aspects of the codes other than the ability to adopt appendices.

WISCONSIN

Tel: (608) 266-2112
Website: See below also
https://docs.legis.wisconsin.gov/code/admin_code/sps/safety_and_buildings_and_environment

Adopting entity: Legislature with recommendations from Commercial Building Code Council
Full/Partial/None: Full
State Amendments allowed: Yes
Local Amendments allowed: Yes, local jurisdictions are allowed to amend code
Form: Yes, only a public agenda request form during state adoption
Link: https://dsps.wi.gov/Documents/BoardCouncils/PublicAgendaRequestForm.docx
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: Approval required

Commercial: **https://dsps.wi.gov/Pages/BoardsCouncils/CommercialBuilding/Default.aspx**

Dwellings: **https://dsps.wi.gov/Pages/BoardsCouncils/UniformDwelling/Default.aspx**

WYOMING

Tel: (307) 777-7288
Website: **http://wsfm.wyo.gov**
Adopting entity: Legislature with recommendations from the State Fire Council
Full/Partial/None: Full
State Amendments allowed: Yes, but normally adopt without amendments
Local Amendments allowed: More restrictive only
Form: No
Link: NA
Topography, Geology, Weather, Temperature: NA
Language: NA
Reason: NA
Cost: NA
Stakeholders: NA
Filed with/approved by state: Filed with state but no approval necessary

Wyoming adopts national codes and standards on a three-year cycle. Local jurisdictions can adopt the state adopted codes or more restrictive codes or amendments. Each jurisdiction has its own process for proposed changes submittals.

Proposed changes to the energy code can be submitted to the Wyoming Dept of Fire Prevention and Electrical Safety who will review the proposed change and send their recommendation to the State Fire Council.

PUERTO RICO

Tel: (787) 721-8282
Website:
https://sbp.ogpe.pr.gov

https://up.codes/codes/puerto_rico

https://up.codes/viewer/puerto_rico/ibc-2018

Adopting entity: Oficina de Gerencia de Permisos (OGPe) (Local offices of OGPe)
Full/Partial/None: Full adoption of code island-wide

Latest code was adopted in 2019. It is based on the IBC Adoption of the new code is usually phased in at the local level. For the latest round of adoption of the 2018 Puerto Rico building code, there was a requirement that the new codes be immediately adopted for federally funded projects and a three month phase in for all other types of projects.

WASHINGTON D.C.

Tel: 202-442-4400
Website: **https://dcra.dc.gov/node/1409496**
Adopting entity: DC City Council with advice from Construction Codes Coordinating Board
Full/Partial/None: Full
State Amendments allowed: NA
Local Amendments allowed: Yes
Form: Yes
Link: **https://eservices.dcra.dc.gov/DocumentManagementSystem/Home/retrieve?id=2021%20ICC%20CCCB%202023%20Code%20Change%20Form.pdf**
Topography, Geology, Weather, Temperature: No
Language: Yes, legislative text
Reason: Yes
Cost: Yes, increase or decrease only
Stakeholders: No
Filed with/approved by district: NA

Any person or group may submit a petition to the Construction Codes Coordinating Board (CCCB) to amend the DC codes. The form requires the proposed wording, any increase of decrease in cost associated with the proposed change and justification for the change.

The change is submitted to the mayor by the CCCB and after review the mayor submits it to the city council for review and vote to adopt.

Appendix C
Technical Appendix for Hazard-Specific Interventions

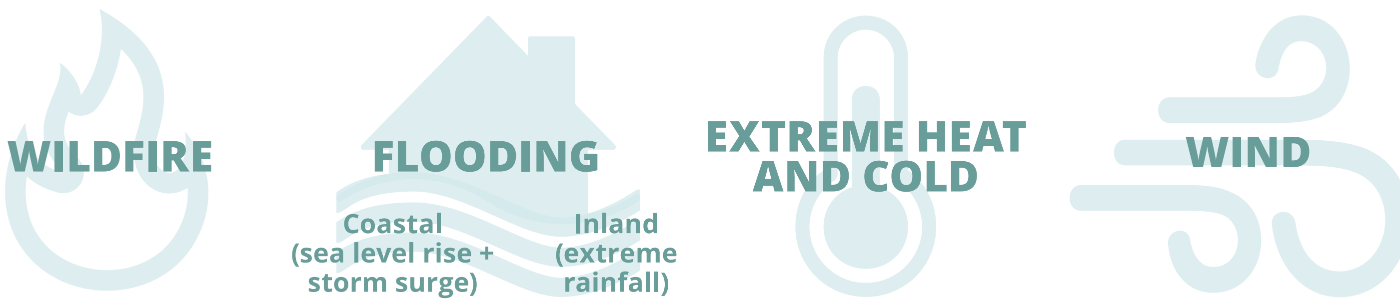
About this appendix

This section is arranged by hazard and focuses on the more technical aspects of the building code. The narratives are organized with housing in mind and according to individual hazards. That said, while the authors recognize many hazards may occur at the same time, that level of complexity is not addressed here.

Building types

- Housing — both single- and multifamily dwellings
- Existing housing stock and new construction

Hazard considerations



Key model codes referenced
International Building Code
International Residential Code
International Fire Code
International Mechanical Code (HVAC — heating, ventilation, air conditioning)
International Plumbing Code (water and wastewater)
International Wildfire Urban Interface Code
International Existing Building Code
International Energy Conservation Code
Uniform Mechanical Code
Uniform Plumbing Code
National Electric Code

Key standards referenced
ACEC 7 (wind)
ACEC 24 (flooding)
ASHRAE 90.1 (heating and cooling considerations)
NFPA (fire safety)

Exhibit 28 Modifications to code requirements for commercial buildings (IBC)

Subject	Code Section	2012	2015	2018	2021
Flood					
Mechanical equipment in manufactured homes	Appendix G	No requirement	Required to be above design flood elevation	No change	No change
Use of alternate flood data	Appendix G	No requirement	No requirement	No requirement	Only if data has been submitted to FEMA and received approval
Floodplain administrator	Appendix G	No definition	No definition	No definition	Defines designated floodplain administrator
Water courses	Appendix G	No requirement	No requirement	Documentation maintenance requirements for officials increased	Change to floodplain administrator responsible for maintaining records
Wind / Hurricane / Tornado					
Storm shelters	423	No change	Adds buildings/ occupancies where required	Adds occupant load provisions	Updates occupancy and occupant load provisions
Building wind resistance	1600	No change	Updated wind speed maps	Additional wind speed maps provided	Updated and simplified wind speed maps
Wind load calculations	1600	No change	Updated calculation methods	No change	Updated calculation methods
Storm shelters	1604	Adds section indicating seismic loads are used regardless of wind loads in some cases	No change	Added detail on shelter design loads	No change
Roofing materials attachment	1500	No change	More stringent requirements	Addresses metal roof shingles	No change
Roofing accessory attachment	1500	Attachment requirements for metal edges	No change	No change	Attachment requirements for gutter systems
Aggregate and ballast	1500	Aggregate/ballast not allowed in some conditions	No change	No change	Aggregate allowed in all conditions with parapets as indicated
Wildland Urban Interface					
Roof covering	1500	Reference to IWUIC with regard to Class of roofing	No change	No change	No change

There are no references to wildfire building code provisions in the IRC and only a minimal reference (see above) in the IBC.

Adoption of additional wildfire resilience considerations happens at the state, county, municipal, or individual levels.

Subject	Code Section	2012	2015	2018	2021
Extreme Temperatures					
Climate zones	301	No change	Tropical zones added	Revised climate zone naming	Adds significant detail for international climate zone determination
Insulation marking	303	No requirement	No requirement	No requirement	Detailed marking requirements or certification required
Building enclosure	402	No change	Significant changes to requirements for walls and openings	Increased insulation for heated slabs, clarifies insulation requirements for various components	Clarifies prescriptive versus performance requirements
Performance testing	402	No requirement	No requirement	No requirement	Building envelope testing requirement added
Equipment sizing	403	No change	No change	More detailed equipment sizing requirements added	No change
Controls	403	Minor changes to mechanical system controls added	Changes to mechanical system controls added	Significant changes to mechanical system controls added	No change
Economizers	403	Requirements for economizers added	Requirements clarified	No change	No change

Exhibit 29 Modifications to code requirements for residential buildings (IRC)

Subject	Code Section	2012	2015	2018	2021
Flood					
Concrete slabs	322	No requirement	No requirement	New requirements for slabs subject to scouring/erosion	No change
Stairs and ramps	322	No requirement	No requirement	New requirements and options to resist or avoid flood loads	No change
Tanks	322	No requirement	New requirements for tank anchoring	No change	No change
Structure	322	No requirement	New requirement in Coastal Zone A for first floor horizontal structure to be 1 foot above the base flood or design flood elevation	No change	No change
Openings	322	No change	Additional details with regard to openings serving areas below design flood elevation	No change	No change

Subject	Code Section	2012	2015	2018	2021
Wind / Hurricane / Tornado					
Windows and sliding doors	609	No change	Allows comparative analysis for different sizes than those tested	No change	No change
Exterior openings with glazing	609	No change	No change	Testing requirements for impact protection	No change
Garage doors	609	No change	No change	No change	Testing requirements for wind pressure
Soffits	704	No change	No change	No change	Requirements for soffit uplift and nailing
Photovoltaic shingles	905	No change	Additional requirements for high wind and wind resistance	No change	No change
Photovoltaic systems	907	No change	New requirements for roof-mounted systems	No change	Consolidated with 609
Photovoltaic panel systems	909	No change	New requirements for roof-mounted systems	No change	Consolidated into 607
Energy Efficiency					
Ducts	1103	No requirement	No requirement	Requirements for ducts buried in ceiling insulation added	No change
Heat recovery	1103	No requirement	No requirement	No requirement	Heat recovery ventilation required in some zones
Reports	1106	No requirement	Compliance reports required for permits and C of O	No change	Added detail to compliance reports requirements
Required energy efficiency options	1108	No change	No change	No change	Additional energy efficiency package options
Solar	Appendix T	No requirement	No requirement	Requirement for solar ready zone added	No change
Extreme Temperatures					
Heat recovery	1103	No requirement	No requirement	No requirement	Heat recovery ventilation required in some zones
Required energy efficiency options	1108	No change	No change	No change	Additional energy efficiency package options

Exhibit 30 Modifications to code requirements for commercial buildings (IECC)

Subject	Code Section	2012	2015	2018	2021
Climate zones	301	No change	Tropical zones added	Revised climate zone naming	Adds significant detail for international climate zone determination
Insulation marking	303	No requirement	No requirement	No requirement	Detailed marking requirements or certification required
Skylights and garage doors	303	No requirements	Separated garage door requirements	Refined tables with increased items	No change
Building enclosure	402	No change	Significant changes to requirements for walls and openings.	Increased insulation for heated slabs, clarifies insulation requirements for various components	Clarifies prescriptive versus performance requirements
Combustion air	402	No requirement	Added provisions related to appliance combustion air	Clarified requirements	No change
Performance testing	402	No requirement	No requirement	No requirement	Building envelope testing requirement added
Equipment sizing	403	No change	No change	More detailed equipment sizing requirements added	No change
Equipment fault detection	403	No requirement	No requirement	No requirement	Fault detection requirements added
Controls	403	Minor changes to mechanical system controls added	Changes to mechanical system controls added	Significant changes to mechanical system controls added	No change
Economizers	403	Requirements for economizers added	Requirements clarified	No change	No change
Kitchen exhaust air	403	No requirement	Added requirements for kitchen exhaust	No change	No change
Coolers and freezers	403	No requirement	Requirements for freezers and coolers added	No change	More detailed requirements added
Lighting	405	No change	Significant change to lighting power and lighting control requirements	Added changes to lighting controls and reductions in lighting power allowances	Added changes to lighting controls and reductions in numerous lighting power allowances
Parking garage lighting	405	No requirement	No requirement	No requirement	Added parking garage lighting controls requirements
Exterior lighting	405	No change	No change	Reduction in exterior lighting power allowances and exceptions added	Changes to lighting power calculations

Wildfire

Wildfire risk has been increasing steadily over the past few decades. Since 1991, 19 billion-dollar disasters have been directly tied to wildfires.[55] More land is burned by wildfires in the west and southeastern U.S. than in other parts of the country and the states with the highest number of property impacts are shown below in Exhibit 31.[56] The increase in fire risk has been tied to changes in climate, including a shift in the onset of peak wildfire season.[57]

Wildfire impacts also include indirect and cumulative effects. For example, smoke generated by wildfire impacts areas hundreds to thousands of miles away from the site of combustion. Decimated forests cause the underlying land to be more vulnerable to erosion and water quality concerns. Former burn scars can become areas of slope failure. Ash can pollute nearby water sources. These very significant concerns all have implications for buildings and the health and welfare of their occupants. However, building codes focus more narrowly on the direct physical impacts of fires, so our discussions will follow suit.

55 NOAA National Centers for Environmental Information (NCEI), 2022. **U.S. Billion-Dollar Weather and Climate Disasters**.

56 EPA. **Climate Change Indicators: Wildfires**.

57 Ibid.

Exhibit 31 Wildfire Risk Analysis

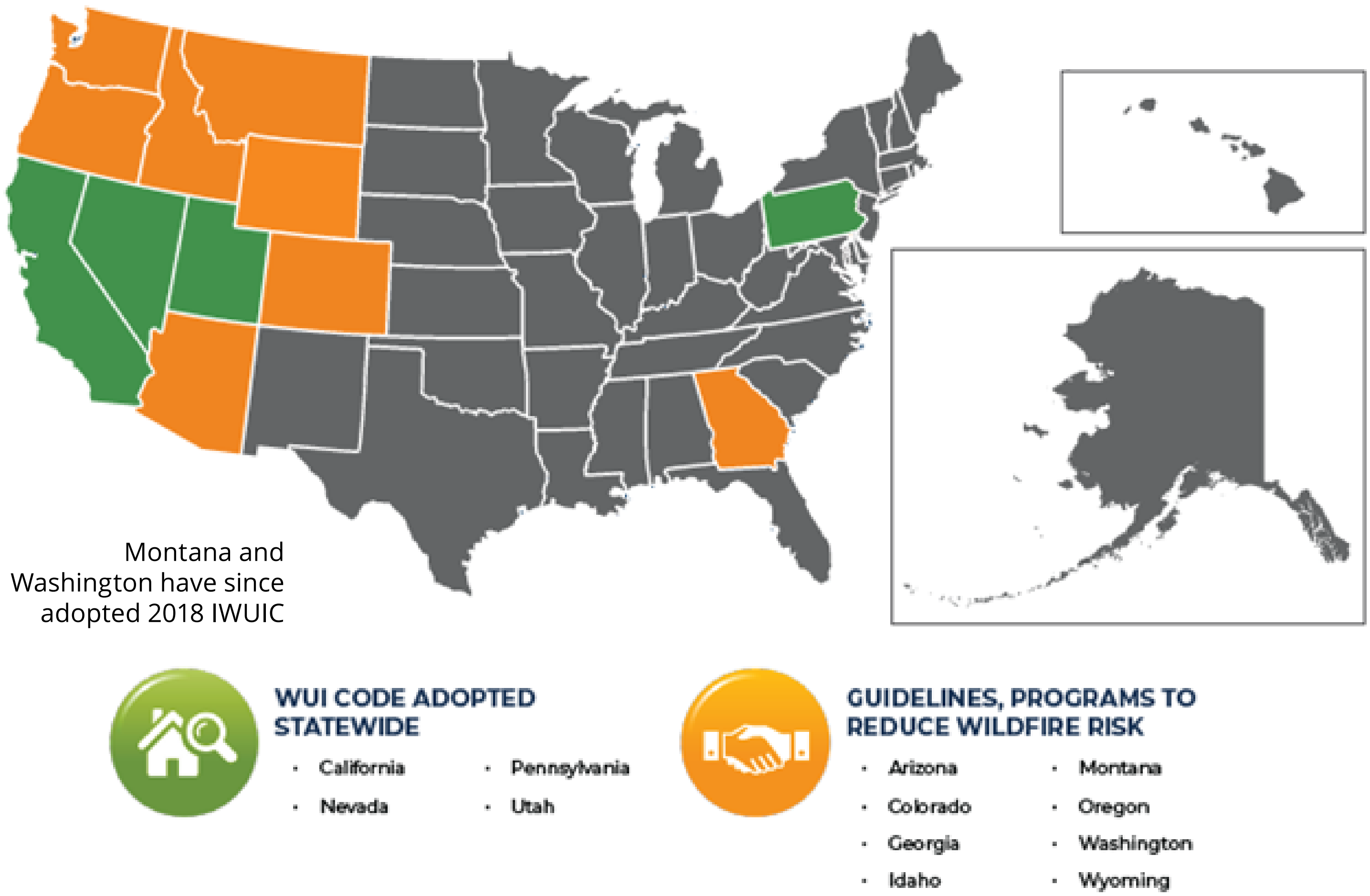
State	Number of properties at risk
California	2,040,600
Texas	717,850
Colorado	373,900
Arizona	242,200
Idaho	175,000
Washington	155,500
Oklahoma	153,400
Oregon	147,500
Montana	137,800
Utah	136,000
New Mexico	131,600
Nevada	67,100
Wyoming	36,800

Source: Verisk. **Wildfire Risk Analysis**.

Current State of Practice for Building Codes and Wildfire

Challenge: Very few states have adopted codes related to wildfire risk. Only 12 states have guidance related to wildfire risk, and of those only four have adopted the WUI code. Traditional IBC and IRC guidance do not adequately address the health and safety implications of wildfire, especially in the face of increasing intensity and spread of that danger.

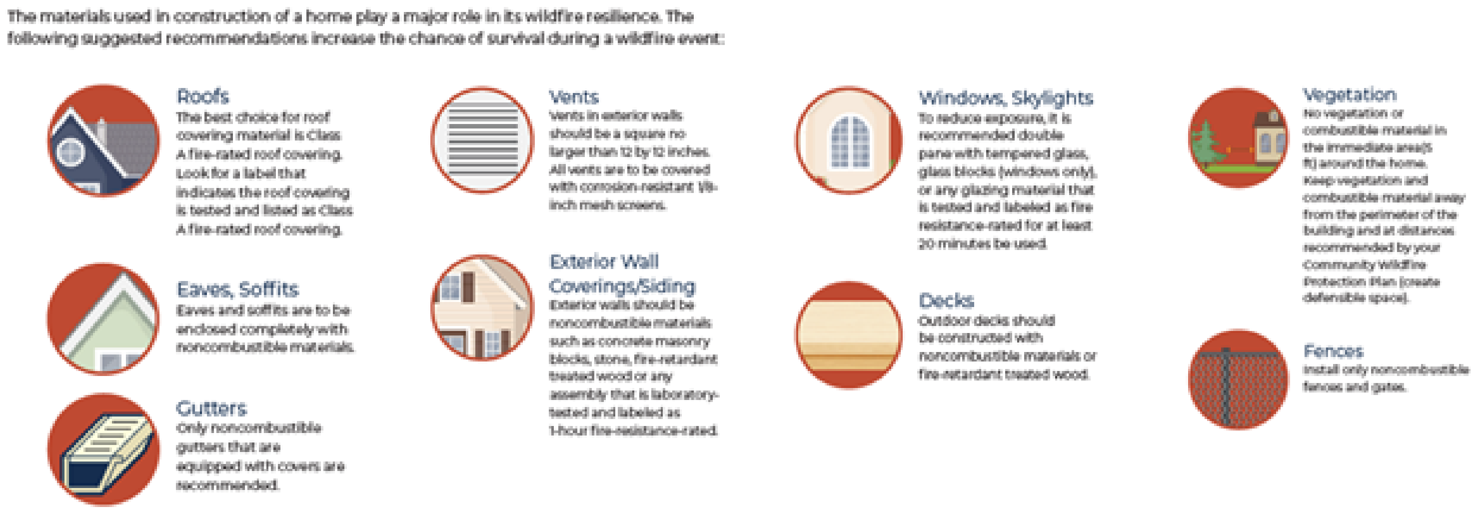
Exhibit 32 Wildfire codes and programs by state



Source: Wildfire Codes & Standards — State-by-State Reference Guide

Solution: It can be challenging to know where to start with respect to wildfire. Luckily, there is a significant body of readily available information that can be tapped. **The work on building design criteria and retrofits is perhaps best known but there are emerging sources of information on land-based interventions such as defensible space and community-based planning** (explained more below). In addition to what is offered in the model code, several individual municipalities have drafted their own standards and ordinances to support wildfire-resistant development that could be leveraged here, as well as more recent work on the cost-benefits of building for wildfire resilience (see Headwater Economics–IBHS study below).

Exhibit 33 Wildfire-resistant building construction



Source: Wildfire Codes & Standards — State-by-State Reference Guide

Challenge: Existing codes may focus more on the building and less on land-based considerations. Resilience to wildfires involves more than just building enhancements; it is also very dependent on the surrounding environment. This includes considering potential fuel sources (e.g., vegetation, other outbuildings) within the building's immediate perimeter, as well as the overall resilience of neighboring structures. Traditionally, codes have largely focused on the building itself. However, with wildfire (and other types of hazards), a community-based approach may be more effective in addressing the risk.

Solution: There has been significant attention paid to **defensible space requirements** in recent years, especially with the increase in intensity and geographic spread of wildfires. Defensible space requirements focus on minimizing the potential fuel sources within the immediate perimeter of a building. It is about creating a buffer around the building to make it less prone to wildfire impacts. California has been a leader in standardizing how these requirements are incorporated into both site development and code requirements, and provides a good starting place for those interested in learning more.

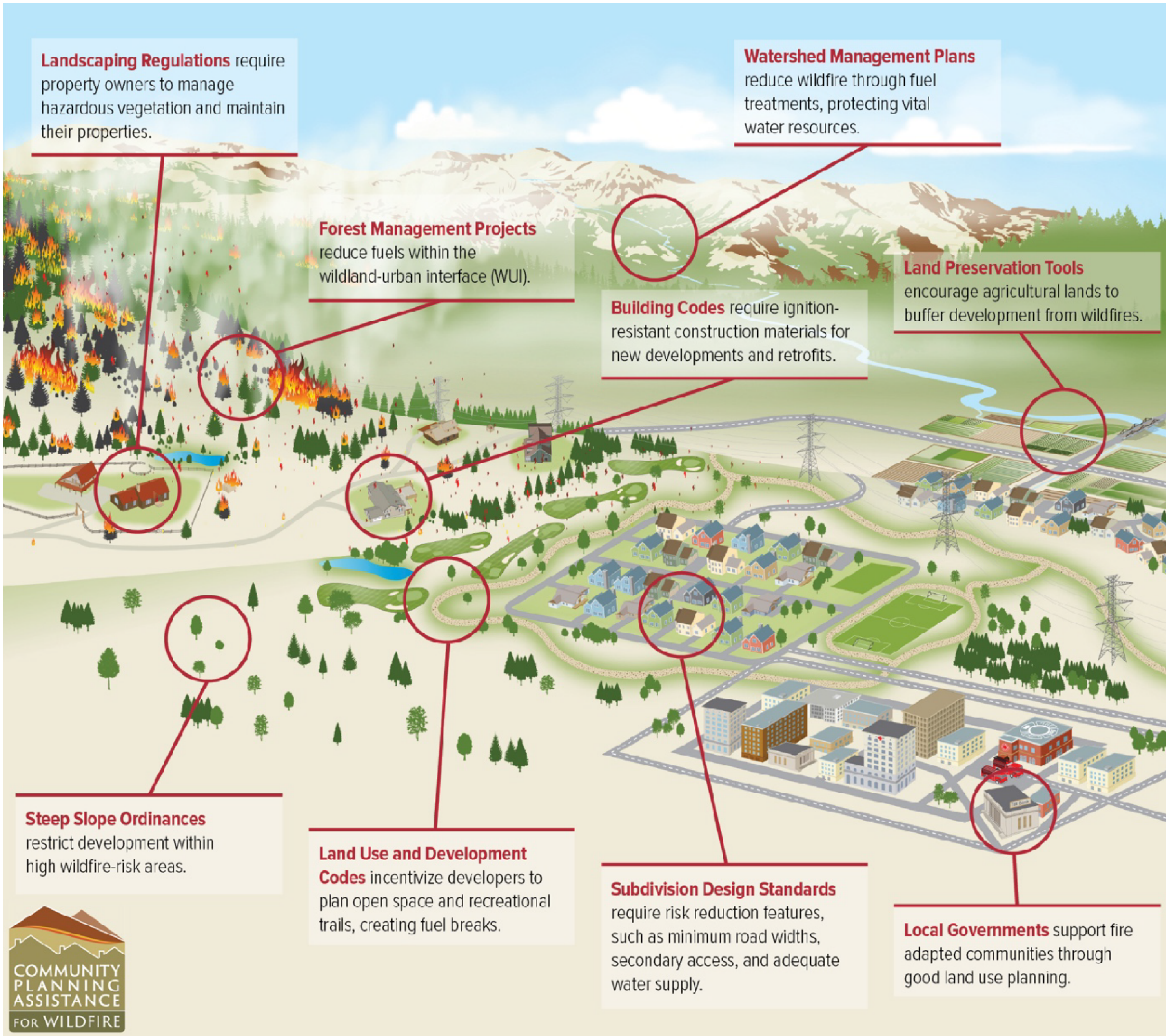
Cal Fire Defensible Space

Zones 1 and 2 currently make up to 100 feet of defensible space required by California law. Assembly Bill 3074, passed into law in 2020, requires a third zone for defensible space. This law requires the Board of Forestry and Fire Protection to develop the regulation for a new ember-resistant zone (Zone 0) within 0-5 feet of the home by January 1, 2023. The intensity of wildfire fuel management varies within the 100-foot perimeter of the home, with more intense fuels' reduction occurring closer to your home. Start at the home and work your way out to 100 feet or to your property line, whichever is closer.

The development of defensible zones has been found to be a useful intervention to slow the spread of wildfire. However, it is important to note that wildfires are not necessarily limited to wildlands and homes tucked into the mountains. The Marshal Fire in Colorado is an example where the fire impacted a traditional suburban neighborhood and was not necessarily the result of inadequate defensible space.

For **community-based wildfire planning** approaches, it may be beneficial to work with the local planning board to create zoning ordinances and overlays (similar to those proposed for flooding) to address the land use and modification opportunities that fall more within the planning realm than the code realm.

Exhibit 34 Land use planning tools to reduce wildfire risk



Source: Community Planning Assistance for Wildfire: Final Recommendations for Gunnison County, CO 2019

Depending on state and local governance structures around building codes (see **Appendix A** for a state-by-state summary), there may be the opportunity to develop **local building codes and/or ordinances that adopt more resilient building standards** with respect to wildfire risk. Chelan, Washington, is an example of a municipality that used this program to build out wildfire protection planning criteria, including a town-based WUI code that includes special building construction regulations, WUI interface requirements and fire protections requirements

Exhibit 35 Ignition-resistant construction from Chelan, Washington, Municipal-level WUI Code

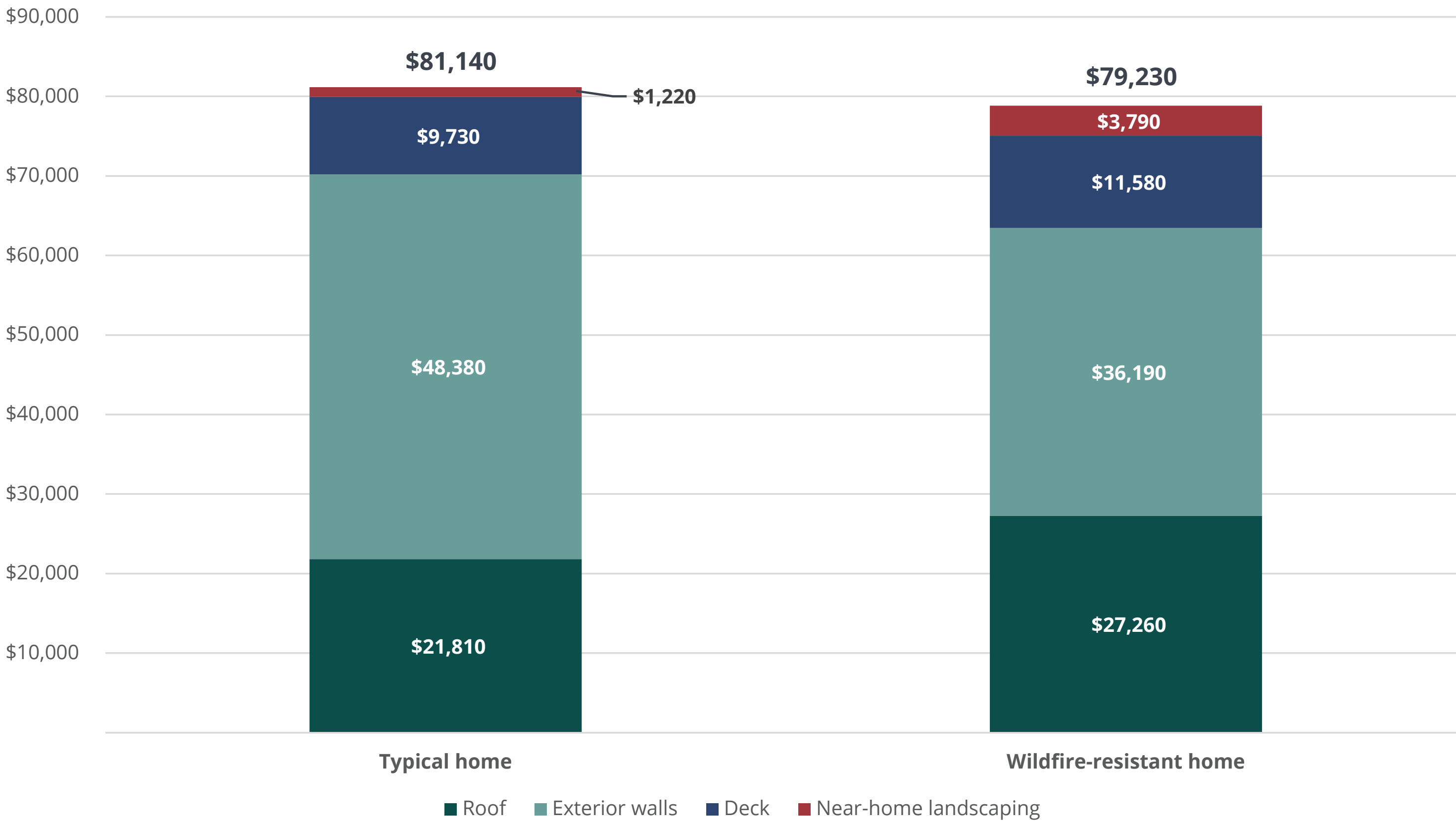
	Fire Hazard Severity					
	Moderate Hazard		**High Hazard**		**Extreme Hazard**	
	Water Supply		**Water Supply**		**Water Supply**	
Defensible Space	Conforming	Nonconforming	Conforming	Nonconforming	Conforming	Nonconforming
Nonconforming	IR 2	IR 1	IR 1	IR 1 N.C.	IR 1 N.C.	Not permitted
Conforming	IR 3	IR 2	IR 2	IR 1	IR 1	IR 1 N.C.
1.5 x Conforming	Not required	IR 3	IR 3	IR 2	IR 2	IR 1

Source: City of Chelan. **Chelan Municipal Code**.

Challenge: There is a general perception that building to a more resilient standard will involve more costly solutions. This is a particularly difficult assertion to test since the data are hard to collect (there is no centralized or standardized reporting platform for this information), there are few resources that have been invested in underwriting these types of studies, and those studies that have been conducted may not be well-socialized across the larger industry and/or within the public realm. With a readily available source of peer-reviewed work, volunteer-led planning boards do not have the capacity to challenge this perception. Likewise, without at readily-available set of design and construction codes (or guidance), developers and contractors are not likely to take the risk of doing things differently.

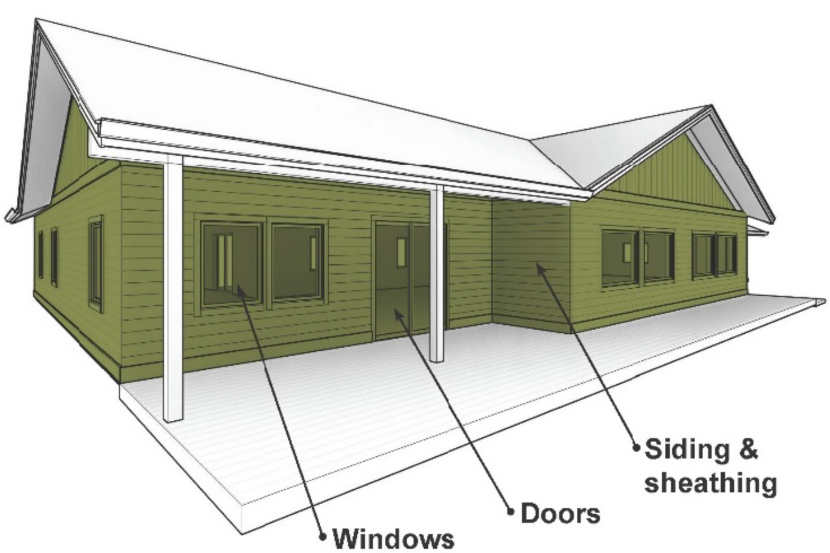
Solution: There needs to be a concerted effort to test the validity of this perception and to provide **cost–benefit analysis of more resilient building codes**. A recent **research effort** between Headwater Economics and IBHS revealed that with wildfire construction, it can actually be *less* expensive to build to resilient standards than traditional builds. The results of that work are summarized in a readily accessible format and with adequate detail to support decision-makers as they consider whether or not to adopt more stringent standards than what may be available in the base model codes. This represents the type of work needed more widely throughout the industry, across the various hazards.

Exhibit 36 New construction costs by component in typical home and wildfire-resistant home



Source: Headwaters Economics. **Building a Wildfire-Resistant Home: Codes and Costs**.

Exhibit 37 Exterior walls subcomponents and new construction cost



Source: Headwaters Economics. **Building a Wildfire-Resistant Home: Codes and Costs**.

Detailed code considerations

In states or municipalities that have adopted the International Fire Code (IFC 2021) and the International Building Code (IBC 2021) but not the International Wildland Urban Interface Code (IWUIC 2021), the jurisdictions may have inadequate protection from wildland fire impacts. In the few jurisdictions that have adopted the International Wildland Urban Interface Code (IWUIC 2021) the options available to the authorities are much greater.

ITEMS ADDRESSED BY THE IFC AND IBC:

- Combustibility of materials used for roof covering (IBC)
- Vegetative fuels adjacent to the structure (IFC)

ITEMS ADDRESSED BY THE IWUIC:

- Classification of wildland/urban interface areas within jurisdiction boundaries
- Requirement for a Fire Protection Plan
- Firefighting water supply
- Emergency services access to the site
- Structure construction materials and arrangement based on fire hazard severity
- Automatic sprinkler requirements based on fire hazard severity
- Control of nearby combustible materials and vegetation
- Maintenance schedule for continued mitigation
- Allowable roofing materials for roofing replacement

Appendices (if adopted) contain detailed requirements related to several of the items listed above.

MITIGATION MEASURES IN IBC, IFC, AND IWUIC INCLUDE THE FOLLOWING ITEMS:

1. Driveways are required where the distance from a fire apparatus access road is greater than 150 feet to an exterior wall of the building. The driveway is required to have a minimum unobstructed height of 13 feet, be a minimum of 12 feet wide and have a turnaround if it is greater than 150 feet long. Turnouts are required if it is longer than 200 feet and less than 20 feet in width. The turnaround shall have a minimum outside turning radii of 45 feet and a minimum inside turning radii of 30 feet.
2. To qualify as an apparatus access road, it must be a minimum of 20 feet wide, have 13 feet 6 inches of clear height, be designed to accommodate the loads, slopes and turning radii for the apparatus used by the jurisdiction in which it is located.
3. An approved water source capable of supplying the required fire flow for fire protection shall be provided within 1,000 feet of all buildings, or portions of buildings. Accessory buildings less than 600 square feet are exempted. The volume requirement is based on building size, construction type, separation, and the presence of automatic sprinkler protection throughout. For example, fully sprinklered, one- and two-family dwellings under 3,600 square feet in total area are required to provide 15,000 gallons of stored water available at 500 gpm. There are numerous means to provide the storage subject to the approval of the authorities (reservoirs, pressure tanks, elevated tanks, man-made ponds, etc.).
4. Ignition resistant construction is required based on the fire hazard severity, the defensible space, and the water supply to the site. There are three levels of fire hazard severity and defensible space and water

supply are either conforming or nonconforming. Different levels of ignition resistant construction include items such as specific classes of roofing material, fire-treated and non-combustible material requirements, and fire rated construction among others.

5 Replacement roofing is required to meet current requirements when 25% or more of the roof covering is replaced in a 12-month period. This requirement only applies to the area of roofing being replaced.

6 An automatic sprinkler system is required in all occupancies in new buildings required to meet the Class 1 ignition-resistant construction provisions.

7 A defensible space from 30 to 100 feet from buildings shall be provided based on the hazard rating of the wildland-urban interface area. Trees are allowed within the defensible space as long as they are 10 feet from buildings, other trees, overhead electrical facilities, chimneys, and unmodified fuels and maintained at that distance. Non-fire-resistant vegetation in the defensible space shall be significantly reduced or replaced with vegetation of a more fire-resistant variety.

8 Chimneys serving fireplaces, barbecues, incinerators, or decorative heating appliances shall be provided with spark arrestors of 12 gage wire with openings not exceeding ½ inch.

9 In states or municipalities that have adopted NFPA 1 (2021 and several previous editions) the jurisdiction can identify areas to be classified as a wildland/urban interface. In these areas the jurisdiction can require a wildland fire hazard assessment. The assessment would include the relative risk, the extent of wildland fire hazard, and applicable mitigation measures.

ITEMS ADDRESSED BY THE ASSESSMENT WOULD INCLUDE:

- Location of structure geographically
- Weather conditions at various times of the year
- Other exposing/exposed structures
- Combustibility of materials used in structure
- Vegetative fuels adjacent to the structure
- Vehicles or fixed or mobile equipment that may present an ignition source
- Other sources of fuel, fire spread or ignition that may impact the structure

The assessment can then be used to determine which mitigation measures are required. These may include:

- Ignition source reduction
- Modification of structure construction elements (Requires compliance with NFPA 1140[58])
- Removal or control of fuel sources (Requires compliance with NFPA 1140[59])
- Maintenance schedule for continued mitigation
- Emergency services access to the site
- Firefighting water supply

58 NFPA 1140 - Standard for Wildland Fire Protection

59 NFPA 1140 - Standard for Wildland Fire Protection

MITIGATION MEASURES IN NFPA 1 AND NFPA 1140 INCLUDE THE FOLLOWING ITEMS:

1. Ignition sources, such as smoking materials, may only be used within the structure or in areas designated by the authorities. Outdoor fireplaces, permanent barbecues, and grills shall not be built, installed, or maintained in hazardous fire areas without prior approval of the authorities. Openings in these devices shall have spark arrestors, screens, or doors. Fireplace and wood stove chimneys and flues shall be provided with spark arrestors with openings not exceeding ½ inch. Fuel powered model plans, rockets or balloons may not be used in hazardous areas. Lighted and smoldering materials associated with bee keeping are not allowed unless permitted by authorities.
2. Emergency services are required to have apparatus access to building sites via a fire road or similar path to within 50 feet of a building entrance. The distance for sprinklered one- and two-family dwellings and townhouses may be increased to 150 feet. This requirement may be modified by the authorities for existing one- and two-family dwellings and new one- and two-family dwelling protected by an automatic sprinkler system. The requirement for private garages, carports, agricultural buildings, and detached buildings having and area of 400 square feet or less may also be modified.
3. The access road shall be extended to within 150 feet of all portions of the exterior building wall or 450 feet if the building is provided with automatic sprinklers throughout.
4. An approved water supply capable of supplying the required fire flow for fire protection shall be provided to all buildings, or portions of buildings constructed or moved. The fire flow requirement is based on building size, construction type, separation, and the presence of automatic sprinkler protection throughout. For example, fully sprinklered, one- and two-family dwellings under 5,000 square feet in total area are required to provide 15,000 gallons of stored water for fire flow at 500 gpm. There are numerous means to provide the fire flow subject to the approval of the authorities (reservoirs, pressure tanks, elevated tanks, fire department tanker shuttles, etc.).
5. Combustibles within 30 feet of the primary structure or the distance determined in the fire hazard assessment shall be removed.
6. Exterior walls shall be sided with non-combustible material, ignition resistant material or fire retardant treated material, or have a one-hour fire rating. The underside of overhanging buildings and structural elements shall be constructed of non-combustible material, ignition resistant material, heavy timber, or fire retardant treated material or have a one-hour fire rating. Overhanging projections shall be constructed of non-combustible material, ignition resistant material, heavy timber, or fire retardant treated material.
7. Roof coverings rated as Class A shall be used. The roof coverings shall be tested with all of the assembly components of the as-built condition.
8. Exterior glazing shall be tempered glass, multilayered glazed panels, glass block or have a fire resistance rating of not less than 20 minutes with non-combustible screening (if provided). Doors shall be 1-3/4-inch solid code wood, of non-combustible materials, or have a fire rating of not less than 20 minutes.
9. Roof gutters and downspouts shall be of noncombustible material and covered with a noncombustible means to prevent debris accumulation.
10. Accessory structures shall be located a minimum of 30 feet from the primary structure. An alternative is to meet all the requirements for the primary structure.

Oliver Rich flickr.com/photos/casualcapture/8135798807

Flooding — Coastal and Inland

Flooding has significant impacts to buildings, their occupant,s and the community as a whole. Flooding can occur in coastal areas as a result of storm surge and wave run-up, as well as the slower more gradual impacts of sea level rise. Coastal flooding also introduces salinity into systems which can lead to extensive corrosion of concrete and metal materials. Inland flooding is often the result of intense and/or long-duration precipitation events which ultimately overwhelm either the natural systems (e.g., overbanking of streams and rivers) and/or human-made systems (e.g., storm drains, stormwater systems, holding ponds, levee systems).

As with other extreme weather-events, there has been a steady increase in the number of billion-dollar disasters associated with both types of flooding events. There have been recorded increases in extreme precipitation events and worsening of hurricane storm surge flooding as a result of sea level rise.[60] The majority of the existing housing stock was not designed to account for these changes which is reflected in the increasing costs associated with these types of events (same reference as above). Adjusting building codes to address these hazards in new construction is one way to incorporate greater resilience into housing, and it also provides a

60 Smith, A.B., 2022. **2021 U.S. billion-dollar weather and climate disasters in historical context**.

guide to improved standards that could be referenced in upgrading existing building stock — either proactively or building back following an event.

Current State of Practice for Building Codes and Flooding

Challenge: The code often references outdated, historical data to inform design. Currently, the code references historical climate data to inform the extent and depth of flooding, as well as the calculations used by engineers to size pipes and catchment areas for that flooding. It can also focus more on averages and less so on extreme events. Current models often underestimate the intensity of rain events, especially with respect to climate change.

Solution: Using future climate projection data in designs will accommodate how precipitation and flooding patterns may shift over the expected life cycle of the asset. This can be calculated both for riverine flows and surface flows. If there is not ready access to engineering data or mapping, online, open-source mapping can provide a useful first order proxy.

Where to find climate projection data:

- **Precipitation shifts**
- **Mapped extents of inland and coastal flooding**
- **Mapped extents of coastal flooding**

Challenge: Fire safety codes can prohibit the installation of fuels on top of the roof. This can be an issue if back-up generators and fuel tanks are located in areas of projected flooding.

Solution: Above-ground tanks can be elevated on foundations designed to resist the forces associated with flooding. **Installing tanks within vaults** with access openings above the design flood elevation is another option. In coastal high hazard areas and coastal A zones, the only option is to locate the tank above the design flood elevation on a foundation designed to resist flood loads, wave action and potentially impact from floating debris.

For **below-ground tanks, flood related loads are required to consider the potential eroded ground elevation.** Below-ground tanks are not allowed to be located under elevated structures or attached to structures at elevations below the design flood elevation.

When determining the forces on tanks for the design of foundations and the tanks, the potential flood related forces acting on tanks needs to be increased by 50% for both below ground and above ground tanks.

Challenge: Nature-based solutions are less common than more traditional, engineering solutions. Owners, developers, and contractors can be hesitant to try something "new" or use technologies with fewer case studies, lifecycle analyses, and standardized performance metrics. Alternate means of compliance could also require approval from the authorities or a variance from an appeal board.

Solution: While nature-based solutions have received less industry attention than traditional interventions, there has been a significant effort to reverse that trend over the past two decades. Today, a robust archive of peer-reviewed industry standards exists that can be leveraged with deep practitioner expertise to further explore these solutions. A good place to start is **Building Community Resilience with Nature-Based Solutions**.[61]

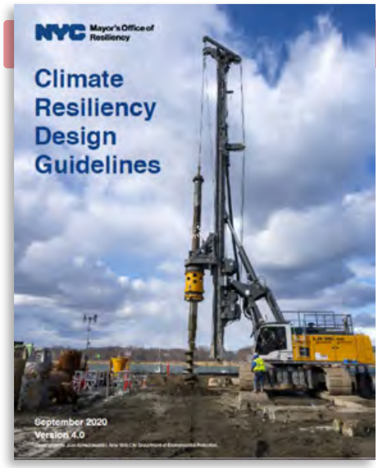
Challenge: A strict reading of ADA and egress codes could restrict the use of perimeter flood barriers. This could be a challenge as permanent flood barriers or elevation of a structure could prove too costly for the owner.

Solution: Accessibility codes do not apply to one- and two-family dwellings. For other buildings, accommodations can be provided to make travel over the barriers accessible or delay installation of gates in the barrier until egress is completed. Some alternatives may require approval by the authorities.

Challenge: Building codes focus on the particular asset when a community-based approach may be more effective and economical in addressing flood risk. The root cause of flooding often extends beyond the asset itself and may be best addressed at the watershed level or the infrastructure system (e.g., storm drain system, extensive use of non-permeable surfaces such as paved roadways, ditches, parking lots, dam and levee systems, etc.).

Solution: It may be beneficial to work in parallel with the local planning board **to create zoning ordinances and overlays** to address the land use and modification opportunities that fall more within the planning realm than the code realm. Likewise, if the root cause of the flooding is linked to **inadequacies in the design of the drainage and flood control systems**, then the efforts to address that will be **governed by industry-specific codes and regulations**, including the general welfare of the community and end users.

61 FEMA, 2021. **Building Community Resilience with Nature-Based Solutions: A Guide for Local Communities**.

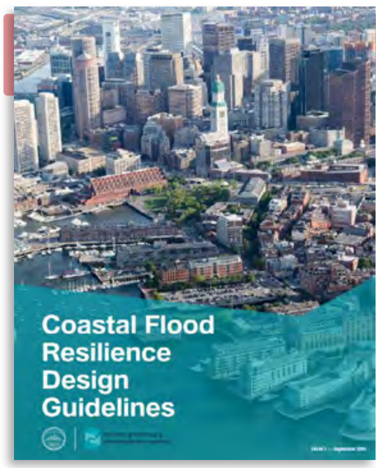


NYC'S RESILIENCE PROGRAM

New York City has taken a joint approach to tackling climate change, leveraging both the existing codes structure as well as planning and land-use related interventions.

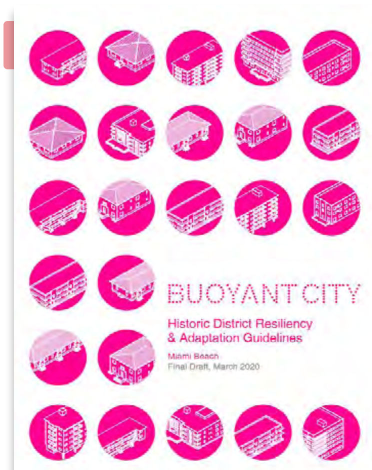
These **Climate Resilience Design Guidelines** dictate how climate change will be incorporated into city-funded capital projects. It requires that resiliency report cards be issued for all city projects and that those projects be designed to meet the design criteria outlined in the standards.

The companion piece, **Zoning for Coastal Flood Resiliency,** examines the role that land use and planning can achieve in meeting resilience objectives and proposes complementary solutions to those proposed at the building level.



BOSTON'S COASTAL FLOOD RESILIENCE DESIGN GUIDELINES AND FLOOD RESILIENCE OVERLAY DISTRICT

Boston has adopted a similar approach to NYC in adopting both **building-specific guidance** for new construction and building in areas of the city which will be impacted by sea level rise and coastal storms, and combining those efforts with the recently adopted **Coastal Flood Resilience Overlay District** that uses climate projections to inform zoning decisions related to proposed use and dimensional aspects of buildings.



MIAMI BEACH — BUOYANT CITY

Buoyant City provides a comprehensive look, combining both land use and building code criteria, to address resilience across a variety of lenses, including within building typologies, at the level of landscapes and streetscapes, accounting for historic preservation needs and providing guidance by type and strategy.

Detailed code considerations

In states or municipalities that have adopted the International Residential Code (IRC 2021) the jurisdictions have significant input into elements associated with flooding.

ITEMS ADDRESSED BY THE IRC:

- Limits authority's ability to grant modifications to requirements
- Require use of flood hazard maps or to work with official to determine design flood elevations
- Documentation of flood related areas and heights on site plans and building plans (lowest floor or lowest floor structure where wave action is possible)
- Addresses both new buildings and substantially renovated buildings (damaged or improved)
- Reference to ASCE 24, Flood Resistant Design and Construction for buildings in floodways
- Allows conformance to ASCE 24 as an alternative to meeting IRC requirements
- Requirements for mechanical, electrical and plumbing systems related to location or protection.
- Detailed requirements for design of buildings in high-hazard areas, Coastal A zones and flood hazard areas
- Manufactured home's heights, foundations, and anchorage
- Use limitations for spaces that are below or at base flood elevation
- Floodway analysis to demonstrate the work will not increase design flood elevations > 1 foot
- Flood hazard documentation as to how the buildings are designed to resist flooding
- Requirements for flood-damage-resistant-materials for interior finishes and construction materials
- Existing building provisions (Appendix AJ, if adopted) refer to the provisions in the base code.

In states or municipalities that have adopted the International Building Code (IBC 2021) the jurisdictions have significant input into elements associated with flooding.

ITEMS ADDRESSED BY THE IBC:

- Limits authority's ability to grant modifications to requirements
- Documentation of flood related areas and heights on site plans and building plans (lowest floor or lowest floor structure)
- Flood structural loads for structures in flood hazard areas, coastal high hazard areas, and coastal A zones (IBC)
- Addresses both new buildings and substantially renovated buildings (damaged or improved)
- Reference to ASCE 24, Flood Resistant Design and Construction
- Reference to ASCE 7, Minimum Design Loads for Buildings and Other Structures
- Require use of flood hazard maps or conduct study to establish design flood elevations
- Conduct floodway analysis to demonstrate the work will not increase design flood elevations > 1 foot
- Provide flood hazard documentation as to how the buildings are designed to resist flooding
- Requirements for flood-damage-resistant-materials for interior finishes and construction materials

- Protection requirements for fire pumps
- Limitations on grading and fill
- Locations for emergency power equipment
- References to ASME A17.1, Safety Code for Elevators and Escalators, for vertical transportation equipment

Appendix G (if adopted) contains management and administrative requirements in order to meet the National Flood Insurance Program.

Appendix J (if adopted) contains requirements associated with grading of sites.

The International Existing Building Code (IEBC) requires conformance to the base code requirements when the work qualifies as substantial improvement. The definition of substantial improvement is: For the purpose of determining compliance with the flood provisions of this code, any repair, alteration, addition or improvement of a building or structure, the cost of which equals or exceeds 50 percent of the market value of the structure, before the improvement or repair is started. If the structure has sustained substantial damage, any repairs are considered substantial improvement regardless of the actual repair work performed.

Design and construction requirements

ASCE 24 Indicates new construction and substantial improvements need to meet the following requirements in flood hazard areas. Dry floodproofing is not allowed in residential structures, residential portions of mixed-use structures or in Coastal High Hazard Areas and Coastal A Zones.

1. The lowest occupied floor is required to be elevated to or above the design flood elevation. Parking areas or storage spaces are not considered occupied floors; however, these spaces need to meet specific requirements with regard to wet floodproofing.
2. Foundations, piers, posts, columns, and piles need to be designed to resist hydrodynamic pressures, hydrostatic pressures, buoyancy, debris impact, and other loads such as soil and wind. Required foundation element's depth and arrangement is a function of the geotechnical conditions on the site.
3. If used, fill must be designed to be stable during all phases of flooding. This includes rapid rise, rapid drawdown, prolonged inundation, erosion and scouring.
4. The structure needs to be anchored and connected to the foundation elements to resist the effects of vertical loads, including uplift, and the aforementioned lateral loads.
5. Enclosed areas that are used for parking, building access, or storage shall be provided with engineered or prescriptive openings to allow flood waters to automatically enter and exit the structure. Openings are required in foundations and in breakaway walls.
6. Structures may not be built in areas subject to high velocity flows, ice jams and debris, flash flooding, mudslides, erosion, or at an alluvial fan apex, unless protective works are provided. Very specific requirements apply to Coastal High Hazard Areas and Coastal A Zones. These requirements address the following items.
   - a Siting above the mean high tide
   - b Elevation of the lowest structural floor member above the design flood elevation

   c. Specific deep foundation types where erodible soils are present
   d. Breakaway walls must fail without causing damage to the structure.
7. Special requirements for materials used in construction based on flood design class.
8. Interior and exterior finish and trim materials shall be flood damage resistant.
9. Electric panelboards, disconnect switches and circuit breakers shall be located above the required flood elevation based on building class. Electric conduits and cables below the design flood elevation are required to be waterproofed or conform to the provisions in the electric code for wet locations. A minimum number of 120-volt circuits may be located below the elevation provided they are designed for wet locations and on ground-fault circuit-interrupters breakers.
10. Plumbing systems components that are below the design flood elevation are required to have backwater valves or backflow prevention devices. Underground piping is required to be buried to a depth sufficient to prevent loss due to flooding and erosion. Above ground piping shall be anchored and protected to withstand the effects of buoyancy, hydrodynamic forces, and debris impact.
11. Mechanical system fuel supply lines require a float operated; automatic shutoff valve arranged to operate when floodwaters exceed the design flood elevation (DFE). Ductwork either needs to be located above the DFE or designed to resist flood related loads and be waterproofed to prevent water from entering the ductwork. Air intake and exhaust openings are required to be above the design flood elevation. Tanks associated with the equipment are required to be designed to resist flood induced loads such as buoyancy and debris impact or located above the design flood elevation. All tank openings are required to be either above the design flood elevation or designed to prevent the release of contents or the infiltration of flood waters into the tank.
12. Elevators are allowed, but the machine rooms need to be located above the design flood elevation. The equipment below the DFE need to be protected against flood damage. Controls need to be provided to prevent the elevator from descending below the DFE during a flood. The elevator shaft walls do not need to have flood openings nor are they required to be breakaway.


Dave Brenner flickr.com/photos/davebrenner/6988616867

Wind — Extreme Events

Winds associated with severe thunderstorms account for 50 percent of all damage in severe weather-related events in the US, and are more common than tornadoes.[62] Damaging winds have speeds that exceed 50 mph and may present as downdrafts, macrobursts or microbursts, derechos, and gust fronts.[63] The term "straight-line winds" is used to differentiate these types of winds from those that are rotational and could spawn tornadoes.

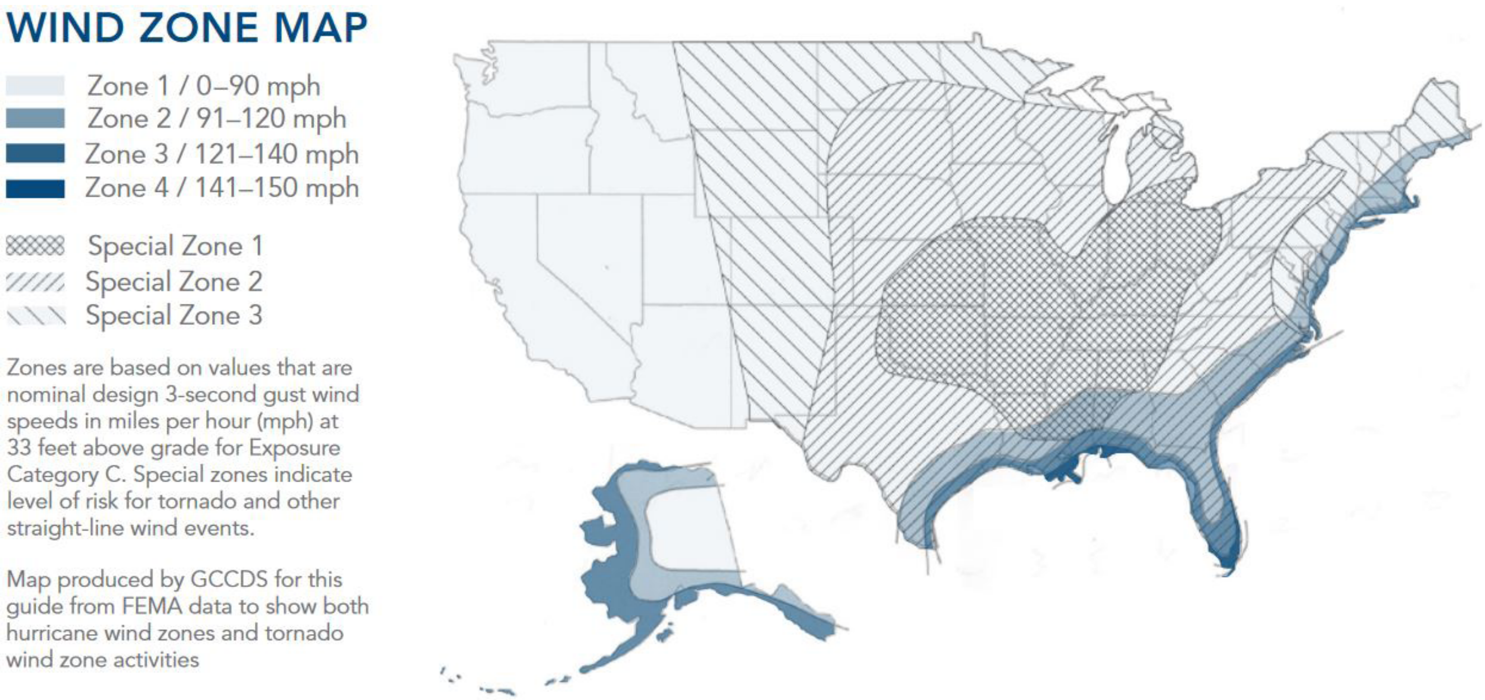
Buildings have been constructed to take wind loads into account. Roofs are especially prone to damage during these events, and wind-borne debris is a concern for all aspects of the house. In areas of tornadoes, storm shelters are common places of refuge, although they may not be specifically required by code.

62 NOAA National Severe Storms Laboratory. **Severe Weather 101: Damaging Wind Basics**.

63 NOAA National Severe Storms Laboratory. **Severe Weather 101: Damaging Wind Basics — Types**

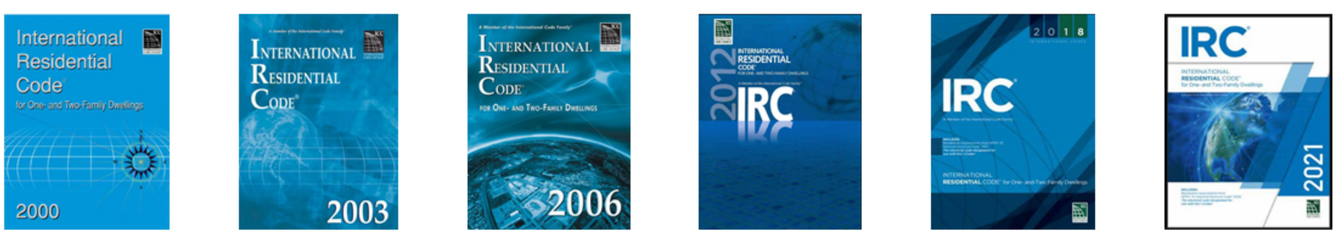
Exhibit 38 Wind zone map

Nearly 30 million US households are located in high wind zones where there is an expected three second gust of 100 mph or greater



Source: FLASH. Resilient Design Guide.

Exhibit 39 Evolution of IRC wind requirements (coastal wind)



2000

National wind standard including limits for wind design and protecting openings

IBC and IRC reference 7-98 wind maps

2003

Required wind testing for asphalt shingles

2006

Impact protection for windows and glass doors in wind-borne debris regions

Required wind pressure rating of garage doors

Geographic region of required wind design expanded in Gulf and Atlantic coastal areas

IBC requires opening protection in Wind-Borne Debris Region

2012

Enhanced roof underlayment requirements to minimize water intrusion if roof covering lost or damaged

IBC and IRC reference ASCE 7-10 updated wind maps

2018

Update in wind standard to significantly improve the connection of plywood/OSB roof decks to roof framing

I-Codes reference ASCE 7-16 with updated wind maps and updated roof design loads

2021

Significant improvements in roof overhand soffit construction to limit damage and water intrusion

In some areas, roofs required to have a sealed roof deck to minimize water intrusion

Source: IBHS (unpublished data) and FEMA (2020)

Current State of Practice for Building Codes and Wind

Exhibit 40 Evolution of IRC requirements (inland wind)

2000
Conventional construction methods can only be used in certain non-high wind areas

2006
Required wind pressure rating of garage doors

2009
Significant improvements to wall bracing methods

When installed, storm shelter has been designed and tested in accordance with ICC 500

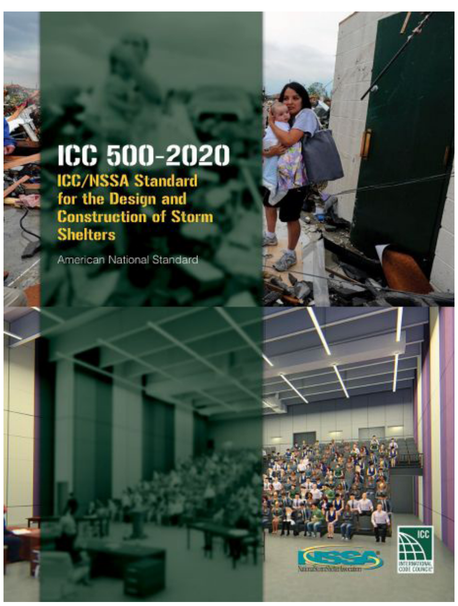
2012
Improved requirements for connecting roofs to walls

2021
Improvements to minimal fastening requirements for wood frame construction including the roof deck

Source: IBHS (unpublished data) and FEMA (2020)

Challenges: How do I determine expected wind speeds in my area? It can be difficult to know what sources to use and which ones have relevance for building code considerations.

Solution: The American Society of Civil Engineers (ASCE) is the professional organization that issues the standards for wind code design that are incorporate by reference into building codes used in the United States. The organization offers **an online tool** that lets individuals search for wind code requirements based on address.



Challenges: What resources exist for tornado resilient building codes? Storm shelters are a viable solution for people living in tornado-prone areas. However, the inability to predict a tornado's geographic impact and intensity can make it difficult to construct a business case based on traditional metrics. There is ongoing controversy about how cost-benefit rations are calculated for tornado-based building code interventions and from whose perspective.[64]

Solution: Existing standards for storm shelters can be referenced for individuals and communities that are interested in working beyond required code standards for both new construction and existing buildings (**ICC/NSSA 500 Standard for the Design and Construction of Storm Shelters**). Some states, like Alabama, have mandated the 2014 ICC/NSSA-500 Standard for

64 As an example, see **How the Building Industry Blocked Better Tornado Safeguards**, *New York Times*.

certain building types and uses, and could be a good model for other states and communities looking to do the same.

Challenge: What industry standards exist for wind resilience? I live in a wind-prone area and would like to invest in resilience but am unsure what standards exist for wind-resilience, are they for new construction only, if there are opportunities for retrofits and whether I can afford it.

Solution: For those entities looking to build beyond minimal code requirements, there are voluntary-based programs which can be used to inform design and construction criteria. One example is the Fortified Home program led by the IBHS and developed in partnership with leading industry experts. **Fortified Wind is a nationally recognized standard** that requires that the roofs be structurally tied to the building in ways that minimize their likelihood of being lifted off and damaged during significant wind events.

The construction method was developed to address some of the key vulnerabilities in homes that made them less able to withstand wind damage from hurricanes, tornadoes and other severe storm events. The standard includes "beyond code" interventions that will greatly reduce enhance a structure's overall resilience to these events, with a focus on minimizing overall damage in order to reduce (or avoid) post-event repairs, relocations or interruptions to daily living. An easy-to-use **website** (https://fortifiedhome.org/) allows interested parties to learn more about the program, find qualified contractors in their area and an easily navigable roadmap about installing Fortified products following an event.

The North Carolina Insurance Underwriting Association (NCUIA) actually provides grants to eligible policy-holders to install Fortified Roofs through their **Strengthen Your Roof** program (https://strengthenyourroof.com/). NCUIA sets aside $15 million a year to underwrite the program and has recently started to offer similar incentives to inland residents.

Smart Home America has taken Fortified (enhanced resilience) guidance and turned it into readily-usable standards in Alabama and Louisiana. The organization also offers grants of up to $10,000 to all Alabama residents whose primary residence is in Alabama. They also provide information as to how individuals can qualify for additional tax and insurance incentives across not only Alabama, but including Connecticut, Florida, Georgia, Louisiana, Maryland, Mississippi, New Jersey, New York, North Carolina, Oklahoma, Rhode Island, South Carolina, and Texas.[65]

Detailed code considerations

In states or municipalities that have adopted the International Residential Code (IRC 2021) the jurisdictions have moderate input into elements associated with wind.

ITEMS ADDRESSED BY THE IRC:

- Where windborne debris protection is required
- Requirements for storm shelter information on documents submitted for permit

65 Smart Home America. **List of Mitigation Insurance Discounts and Tax Savings**.

- Protection of openings by requiring assemblies to pass missile tests in windborne debris regions
- Requirements for alternate protection using wood panels
- Roofing materials designed to resist high wind forces
- Roofing attachment requirements for high wind areas
- Design of structure to resist high wind forces (wall construction, anchorage details, etc.
- Reference to ICC 500, ICC/NSSA, 2020, Standard for the Design and Construction of Storm Shelters
- References to several standards and the IBC for high wind area design options

Windborne debris protection is required in areas where the site in a hurricane prone region and is within 1 mile of the coastal mean high-water line and the ultimate design wind speed is 130 mph or greater or in areas where an Exposure D condition[66] exists upwind at the water line and the ultimate design wind speed is 140 mph or greater: or Hawaii. Where windborne debris protection is required, glazed openings are required to meet the large missile test of ASTM E1886 and ASTM E1996 (as modified by IRC). As an alternative, wood panels 7/16 inch thick and less than an 8-foot span are permitted. Specific attachment requirements apply.

Special requirements apply to the design of buildings where the ultimate design wind speed exceeds 140 mph and the building is located in a special wind region as determined by the jurisdiction. The requirements apply to items such as attachment of the structure to the foundation, attachment of the roof to the walls, connections of the roof system members etc.

The designer has the option of designing to one of several codes/standards as follows.

1. AWC Wood Frame Construction Manual (WFCM)
2. ICC Standard for Residential Construction in High-Wind Regions (ICC 600)
3. ASCE Minimum Design Loads for Buildings and Other Structures (ASCE 7)
4. AISI Standard for Cold-Formed Steel Framing—Prescriptive Method for One- and Two-Family Dwellings (AISI S230)
5. International Building Code

In states or municipalities that have adopted the International Building Code (IBC 2021) the jurisdictions have significant input into elements associated with wind.

ITEMS ADDRESSED BY THE IBC:

- Where windborne debris protection is required

66 Exposure D. Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance of not less than 5,000 feet (1524 m) or 20 times the height of the building, whichever is greater. Exposure D shall apply where the ground surface roughness immediately upwind of the site is B or C, and the site is within a distance of 600 feet (183 m) or 20 times the building height, whichever is greater, from an Exposure D condition as defined in the previous sentence.

Surface Roughness B. Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

Surface Roughness C. Open terrain with scattered obstructions having heights generally less than 30 feet. This category includes flat open country, and grasslands.

Surface Roughness D. Flat, unobstructed areas, and water surfaces. This category includes smooth mud flats, salt flats and unbroken ice.

- Protection of openings by requiring assemblies to pass missile tests in windborne debris regions
- Requirements for alternate protection using wood panels
- Requirements for glazing in exterior handrails or guards
- Roofing materials designed to resist high wind forces
- Roofing attachment requirements for high wind areas
- Design of structure to resist high wind forces (wall construction, anchorage details, etc.)
- Requirements for storm shelters in emergency operation facilities and educations occupancies.
- Storm shelter construction and location
- Reference to ICC 500, ICC/NSSA, 2020, Standard for the Design and Construction of Storm Shelters
- Reference to ICC 600, 2020, Standard For Residential Construction In High-wind Regions

The Existing Building Code references ICC 500 for new storm shelters or storm shelters built in existing buildings.

Wind-related requirements

1. In windborne debris areas, as determined by wind speeds in figures within IBC, protection is required in areas where the site in a hurricane prone region and is within 1 mile of the coastal mean high-water line and the ultimate design wind speed is 130 mph or greater or in areas where an Exposure D condition exists upwind at the water line and the ultimate design wind speed is 140 mph or greater: or Hawaii. Where windborne debris protection is required, glazed openings within 30 feet of grade are required to meet the large missile test of ASTM E1996 and glazed openings located more than 30 feet above grade are required to meet the small missile test of ASTM E1996. As an alternative, wood panels 7/16 inch thick and less than an 8-foot span are permitted for R-3 and R-4 occupancies where the mean roof height is 33 feet or less. Specific attachment requirements apply. Protection is not required for openings located more than 60 feet above ground and over 30 feet above aggregate surfaced roofs located within 1,500 feet of the building.
2. Once the wind speed and exposure category are determined in accordance with the provisions in the IBC or ASCE 7, the design of the building with regard to connections, wall construction, and attachment to foundations shall be in accordance with the provisions of ASCE 7. There are several exception to this requirement for residential structures.
3. Laminated glass is required where glazing is installed in handrails or guards in windborne debris regions. Special requirements apply where the top rail is supported by the glazing.
4. Roofing materials are required to meet the manufacturer's installation and rating requirements for the wind speed applicable to the building.

John Benson flickr.com/photos/j_benson/40665457015

Extreme temperatures

Buildings are designed assuming a relatively consistent climate throughout their lifecycle, the relative rarity of extreme events, and the upper bounds that those extreme events will reach. While there have been yearly variations in weather, the overall average of those events (especially with respect to seasonal temperatures) has remained within a predictable range. In other words, until recently, there has been no apparent shift in average seasonal temperatures. However, that predictability has started to wane in the last decade, and what was once a non-trending variable is now showing significant shifts in some geographies.

Two recent examples include the heat dome in the Northwest in 2021 and the extreme cold snap that hit Texas that same year. Most of the buildings in either the Pacific Northwest or Texas were not designed to accommodate those types of fluctuations. Some of the challenges that occurred were the result of a lack of resilience within the buildings with respect to those extremes. People living in Oregon had never had to consider the intensity and duration of those heatwaves, although people in Texas surely have and designed their building stock to accommodate those. Likewise, the building stock in Texas was not designed to withstand such an intense and long-period of cold temperatures, while buildings in the Northeast have been built to withstand those very types of events. The impacts from those events were exacerbated by the lack of adaptive capacity (ability to withstand long-duration heat anomalies) within the building stock.

Exhibit 41 Evolution of code (HVAC — energy focus)

1975
ASHRAE Standard 90-1975: developed in response to the 1970s energy crisis

1999
ASHRAE 90.1

2000
IECC
Inaugural year

2001–2016
ASHRAE 90.1
3-year cycle

2003–2018
IECC
3-year cycle

2019
ASHRAE 90.1

2021
IECC

Sources: ASHRAE (2021); ICC (2021); DOE (2021)

Current state of practice for building codes and extreme temperatures

The International Energy Conservation Code and ASHRAE 90.1 Standard are both referenced when determining the appropriate climate considerations for sizing of HVAC (heating, ventilation and air conditioning) and related mechanical equipment. The design of these systems is based on an assumed external climate, balanced with the performance of indoor heating, cooling and ventilation needs. In general, the IECC includes requirements for both one- and two-family dwellings and commercial buildings (including multifamily buildings) that incorporates ASHRAE Standard 90.1 which speaks to multi-story commercial and multifamily buildings.

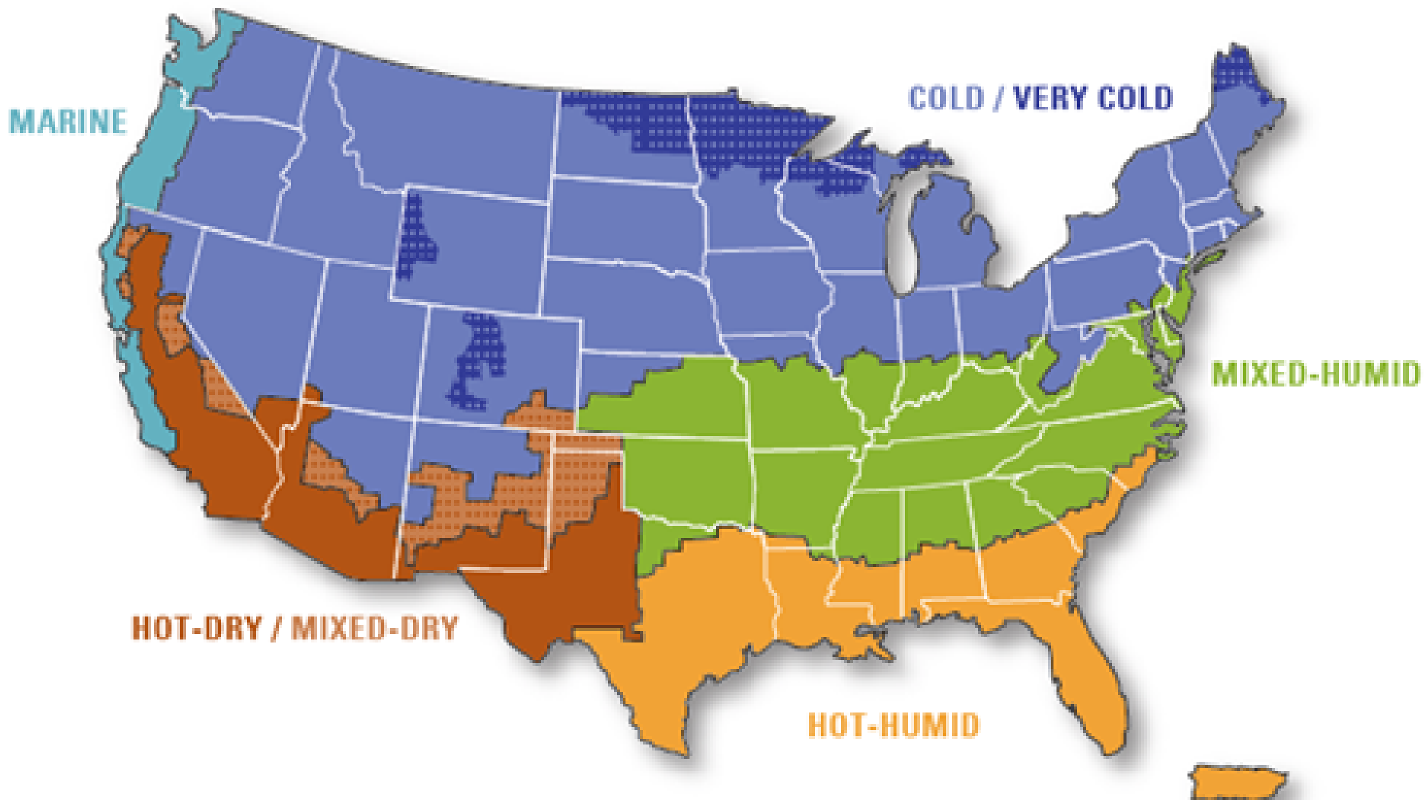
HEATING, VENTILATION, AIR CONDITIONING (HVAC) CODES —ASHRAE STANDARD 90.1 AND IECC

Air conditioners, heat pumps and HVAC units are all examples of equipment that are used to change indoor temperature and humidity levels. ASHRAE standards (referenced by the IECC) are used to specify the performance expectations of a unit and to size it based on occupant needs. The performance expectations are informed using a climate zone map that was developed by the Department of Energy. While this map is useful in relaying *historic* weather patterns, it does not account for climate change.

No requirements exist in the codes related to extreme heat or cold. However, there is the ability to change the inputs used to determine the boundaries of those systems and what is possible. There is the option to increase and decrease the high and low temperatures the systems are required to be designed to. Once that is done, the calculations are the same whether it is for current or future temperatures.

Exhibit 42 Climate region guide

Seven of the eight U.S. climate zones recognized by Building America occur in the continental United States. The sub-arctic U.S. climate zone, not shown on the map, appears only in Alaska.



Source: U.S. DOE (2015). **Guide to Determining Climate Regions by County**.

Challenge: The code often references outdated, historic data to inform design. Currently, the code references historic climate data to inform the specific sizing inputs (for example, average winter and summer temperatures, wet bulb and humidity averages). It also focuses heavily on averages, and does not adequately account for temperature extremes.

Solution: Using future climate projection data in designs will identify how those temperatures may shift over the expected life cycle of the asset. For example, most mechanical equipment has an average life expectancy of 30 years. The units should be designed to account for higher annual temperatures and flexibility to remain fully operational during more extreme and longer-duration heat waves.

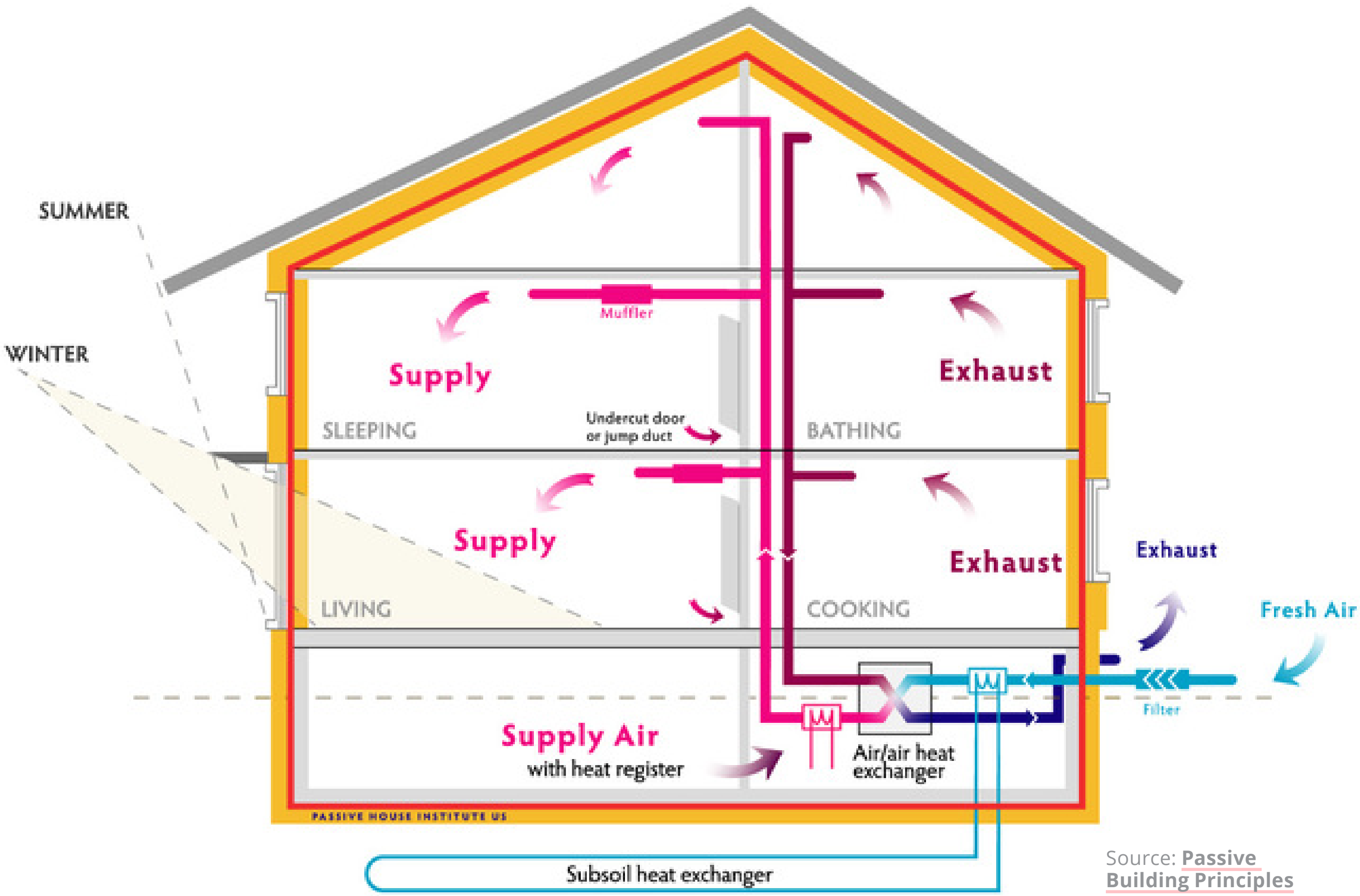
Where to find climate projection data:

- **Climate Toolbox:** Shift in average annual temperatures, number of days above and below 32 degrees F, and number of days greater than 90 and 100 degrees F
- **The Climate Explorer:** Similar data plus heating and cooling degree days

Challenge: How can buildings be designed to be more resilient to heat and cold while remaining energy efficient?

Solution: Well-insulated and ventilated buildings can enhance the overall resilience of a dwelling by allowing the occupant greater control over how heat is retained or dispersed during extreme events, while also reducing the overall energy requirements need to balance those extremes (e.g., onsite combustion of heating fuels or heavy use of air conditioning systems for cooling). The Passive House design strategy captures this intent and has been receiving more attention across the building sector because of that.

Exhibit 43 Passive house principles

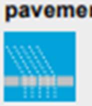


Source: Passive Building Principles

Challenge: What can be done to solve for cooling and heating needs for existing buildings?

Solution: Several existing strategies can be leveraged, many of which may not require amending current building codes. Below are representative examples:

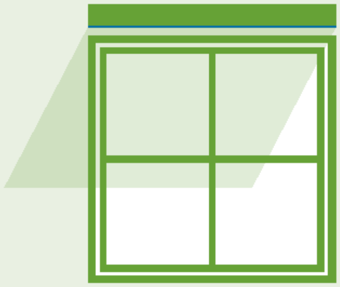
Exhibit 44 Passive measures

SMART SURFACE STRATEGY	WHERE TO USE	BENEFITS SUMMARY
Cool roofs 	• Globally applicable, with most benefits accruing in warmer climates • Highest efficiency gains in single story structures with high roof to wall area ratio	• Net energy savings • Improved indoor comfort • Air temperature reductions (at scale*) • Cancels warming effect of atmospheric GHGs • Does not interfere with occupants' use of the roof (e.g., sleeping space) • Compatible with rooftop solar PV installations.
Cool walls 	• Globally applicable with additional evaluation when applied to buildings that are close together and unshaded • More benefit on buildings with low roof to wall area and wall to window area ratios	• Net energy savings • Improved indoor comfort • Air temperature reductions (at scale*)
Cool pavements 	• Location-specific, with a focus on low-traffic and pedestrian areas • Highest thermal comfort benefit when applied to urban paved surfaces	• Net energy savings • Air temperature reductions (at scale*) • Improved pavement life • Reduced outdoor lighting needs/improved nighttime visibility • Cancels warming effect of atmospheric GHGs
Green roofs 	• Primarily applicable in areas with sufficient precipitation to support vegetation, on structures with sufficient support to bear the weight, and in areas where stormwater mitigation is a priority	• Net energy savings • Improved indoor comfort • Air temperature reductions (at scale*) • Extended roof life • Better stormwater management • Improved biodiversity and habitats • Potential for urban agriculture • Tends to increase property values • Compatible with solar PV installation
Green walls 	• Similar to green roofs	• Net energy savings • Improved indoor comfort • Air temperature reductions (at scale*) • Aesthetic value
Permeable pavement 	• Lower traffic areas such as parking lots, alleys, or curb lanes	• Better stormwater management • Cooler surface tempertures • Local cooling (if moisture is present) • Reduced traffic noise • Reduced ponding/surface water on roadways
Tree canopy and parks 	• Globally applicable where adequate water is available and appropriate local species that are suited to future climate conditions	• Energy savings (when properly positioned) • Improved indoor comfort (if shading buildings) • Air temperature reductions (at scale*) • Improved air quality • Improved thermal comfort for pedestrians • Improved biodiversity and habitats • Aesthetic and recreational value

Source: ESMAP. 2020. **Primer for Cool Cities: Reducing Excessive Urban Heat**. Energy Sector Management Assistance Program (ESMAP) Knowledge Series 031/20. Washington, DC: World Bank.

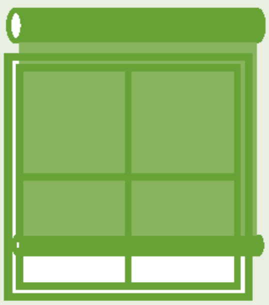
Representative shading strategies to reduce impact of extreme heat events on interior spaces:

Exhibit 45 Window shading exterior treatments

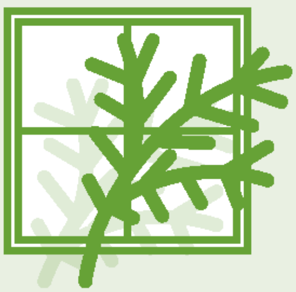


Overhangs.
Overhangs are best for south-facing windows. The sun is high overhead during hot summer months, and a relatively short overhang can provide effective shade.

Awnings.
Like overhangs, awnings block sunlight effectively. Awnings often extend further than overhangs work best on east- and west-facing windows.



Exterior roller screens, shades and shutters.
Roller screens, shades or shutters are more common in Europe. They block sunlight before it strikes the window, and some products provide high wind protection too. In the U.S., exterior roller shutters are used primarily in coastal locations prone to hurricanes. Most shade screens allow some visibility, even when fully deployed.

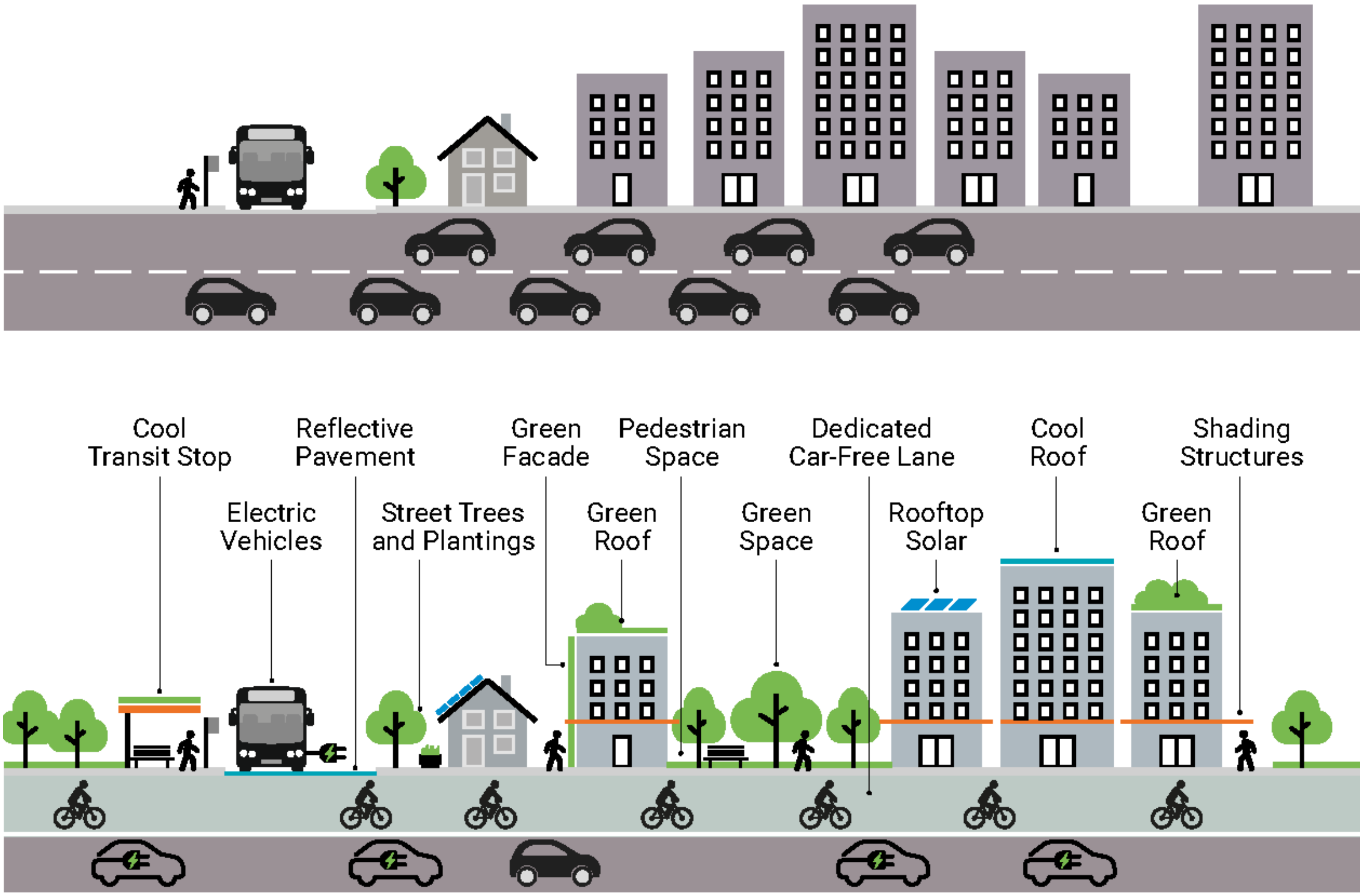


Vegetation.
Deciduous vegetation blocks sunlight in the summer. In the winter, when it sheds its leaves, it allows sunlight to penetrate. Greenery also provides important psychological and health benefits for residents.

Source: Enterprise Community Partners. **Strategies for Multifamily Building Resilience**.

City-scale strategies for addressing heat island impacts that combine building codes, land use ordinances, and other design, planning, and regulatory interventions:

Exhibit 46 Conventional (top) versus heat-resilient (bottom) urban areas



Source: RMI; **Beating the Heat: A Sustainable Cooling Handbook for Cities**
Note: in the figure, the conventional urban area has a high proportion of impervious surfaces and single-occupancy vehicles. By comparison, the heat-resilient urban area has a higher proportion of green space, cool surfaces, alternative modes of transport, and electric vehicles.