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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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.

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.
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.

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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.

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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Indicators</th>
</tr>
</thead>
</table>
| 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.
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

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Number of Post-2000 Structures</th>
<th>Money Saved (Annual Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood</td>
<td>786,000</td>
<td>$484 million</td>
</tr>
<tr>
<td>Hurricane wind</td>
<td>2.4 million</td>
<td>$60 million</td>
</tr>
<tr>
<td>Earthquake</td>
<td>9.2 million</td>
<td>$1.1 billion</td>
</tr>
</tbody>
</table>

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 widespread devaluation within the housing stock could also lead to significant economic losses at the local level. 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 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.

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. Another study estimated the “unpriced flood costs” are already at $520 billion today and could reach $643 billion by 2050.

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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with properties not at risk. 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. 


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.

COUNTRYWIDE IMPACT DUE TO OVERALL FLOOD IMPACT

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 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. 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.

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. Similar shifts have been projected for wildfire, drought, temperature, and precipitation, as well as the severity of storm events. 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 popu-

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13 Climate Toolbox: Future Climate Dashboard. Created by University of California Merced.
ulations for both flooding and extreme temperatures than what was reported for reference populations.\textsuperscript{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.\textsuperscript{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.

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.

<table>
<thead>
<tr>
<th>Low Income</th>
<th>Minority</th>
<th>No High School Diploma</th>
<th>65 and Older</th>
</tr>
</thead>
<tbody>
<tr>
<td>-15%</td>
<td>-10%</td>
<td>-5%</td>
<td>0%</td>
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<tr>
<td>-5%</td>
<td>0%</td>
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<td>30%</td>
<td>35%</td>
<td>40%</td>
<td>45%</td>
</tr>
</tbody>
</table>

- **Minorities** are 41% more likely than non-minorities to currently live in areas with the highest projected increases in traffic delays from high-tide flooding associated with 50 cm of global sea level rise.
- **Those with no high school diploma** are 3% less likely than those with a high school diploma to currently live in areas with the highest projected extreme temperature mortality impacts with 2°C of global warming.

**AIR QUALITY AND HEALTH**
New asthma diagnoses in children due to particulate air pollution.

**EXTREME TEMPERATURE AND HEALTH**
Deaths due to extreme temperatures.

**EXTREME TEMPERATURE AND LABOR**
Lost labor hours for weather-exposed workers.

**COASTAL FLOODING AND TRAFFIC**
Traffic delays from high-tide flooding.

**COASTAL FLOODING AND PROPERTY**
Property inundation due to sea level rise.

**INLAND FLOODING AND PROPERTY**
Property damage or loss due to inland flooding.

4 INADEQUATE AND/OR UNAFFORDABLE COVERAGE

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 risQ20 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.”

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.
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 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.”

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.”

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. 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. 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 and long-term insurance products that incentivize investments in resilience, 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

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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). 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.

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.

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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.\textsuperscript{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\textsuperscript{1} high scenario

<table>
<thead>
<tr>
<th>Potential devaluation of Florida real-estate market due to tidal flooding,\textsuperscript{2} $ billion, 2018 dollars</th>
<th>Average devaluation of Florida real estate compared to similar unexposed homes, %</th>
<th>Number of impacted homes in Florida, thousand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Today 2030 2050</td>
<td>15–35</td>
<td>550</td>
</tr>
<tr>
<td>Potential devaluation of homes based on trend observed today</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential additional devaluation if homes flooding &gt;50x per year become entirely undesirable for future buyers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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%.

\textsuperscript{1}US Army Corps of Engineers.

\textsuperscript{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.


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 and some towns have already become ghost towns because of these climate shifts. 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.

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.

“Repeated shocks from hurricanes, fires and floods are pushing some rural communities, already struggling economically, to the brink of financial collapse.” 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.

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Exhibit 8  Rural Capacity Index

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

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

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)

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.


\(^{39}\) 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.

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)

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. 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.”

“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)”

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.
**HOW BUILDING CODES INFLUENCE RESILIENCE**

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

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


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,
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.\(^4^5\) 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.\(^4^6\) 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.\(^4^7, 4^8\)

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-

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\(^{4^5}\) 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.

\(^{4^6}\) Michael Gollner, Assistant Professor and Deb Faculty Fellow, Dept of Mechanical Engineering, University of California at Berkeley; email correspondence, January 10, 2022.

\(^{4^7}\) Ibid.

\(^{4^8}\) 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).

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.

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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

![Exhibit 14 diagram](image)

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

<table>
<thead>
<tr>
<th>REFERENCED CODES AND STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLOOD</strong></td>
</tr>
<tr>
<td><strong>FIRE</strong></td>
</tr>
<tr>
<td><strong>TEMP</strong></td>
</tr>
<tr>
<td><strong>WIND</strong></td>
</tr>
</tbody>
</table>

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

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


## Exhibit 18  Aspects of resilience already captured in IBC

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

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

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

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

*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)

<table>
<thead>
<tr>
<th>Type</th>
<th>Number (thousands)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family Homes</td>
<td>102,820</td>
<td>89.7%</td>
</tr>
<tr>
<td>Multifamily Residential</td>
<td>5,184</td>
<td>4.5%</td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
<td>4.5%</td>
</tr>
<tr>
<td>Industrial</td>
<td></td>
<td>0.3%</td>
</tr>
</tbody>
</table>

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. 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

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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 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

Suitability
Inside FEMA V Zones, new, substantially damaged, and substantially improved buildings must be elevated on piles, piers, or posts with open foundations in these zones, the use of fill to elevate a structure is prohibited. In FEMA Coastal A Zones, the same practices are recommended.

Source: Coastal Flood Resilience Design Guidelines
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).”

<table>
<thead>
<tr>
<th>Exhibit 26  FEMA Program Reference Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program</strong></td>
</tr>
<tr>
<td>Sea level rise &amp; flood maps</td>
</tr>
<tr>
<td>Mitigation planning</td>
</tr>
<tr>
<td>Building resilient infrastructure &amp; communities</td>
</tr>
<tr>
<td>National flood insurance program</td>
</tr>
<tr>
<td>Flood mitigation assistance</td>
</tr>
<tr>
<td>National exercise program</td>
</tr>
<tr>
<td>Fire-adapted communities</td>
</tr>
<tr>
<td>Public assistance</td>
</tr>
<tr>
<td>Hazard mitigation grant program</td>
</tr>
<tr>
<td>Hazard mitigation grant program post-fire</td>
</tr>
</tbody>
</table>

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.

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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.
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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Michael Freedberg  Senior Advisor for High Performance Buildings
Aaron Gagné  Community Planning and Development Specialist
Terrance Ware  Disaster Recovery Specialist

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International Code Council
Michelle Foster  Vice President, Sustainability
John B. Peavy  Director, Building Science Division
Home Innovation Research Labs
Antonio Gárate  Vice President & Director of Development for Puerto Rico
McCormack Baron Salazar
James Gascon, P.E.  Director, Code and Administration Division
Miami–Dade County
Michael Gollner  Asst. Prof. & Deb Faculty Fellow; Department of Mechanical Engineering
University of California at Berkeley
Patty Hernandez  Executive Director
Headwaters Economics
Donald Hornstein  Public Board Member NCIUA, Aubrey Brooks Prof of Law at UNH Chapel Hill
North Carolina Insurance Underwriting Association; UNC Chapel Hill
Linda Langston  President
Langston Strategies, former FEMA Advisory Committee member
Samantha Medlock  Senior Counsel
U.S. House of Representatives Select Committee on the Climate Crisis
Michael Newman  Senior Director, Law and Public Policy
Insurance Institute of Building and Home Safety
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Community Enterprise Partners
Julie Shiyou-Woodard  President & CEO
Smart Homes America
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* These experts contributed insights on one or more specific topics within the toolkit.
Appendix A
Code Requirements by State
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<tbody>
<tr>
<td>Arizona</td>
<td>2018 IBC</td>
<td>2018 IRC</td>
<td>No statewide code</td>
<td>2018 IPC</td>
<td>No statewide code</td>
<td>2018 IMC</td>
<td>No state mandate</td>
<td>2004 90.1</td>
<td>2018 IFC</td>
<td>No</td>
<td>X</td>
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Current as of February 2022
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</thead>
<tbody>
<tr>
<td>Kansas</td>
<td>n/a</td>
<td>No statewide code</td>
<td>No statewide code</td>
<td>2006 IPC</td>
<td>No state-wide code</td>
<td>No state mandate</td>
<td>2006 90.1</td>
<td>2006 IFC</td>
<td>X</td>
<td></td>
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<tr>
<td>Mississippi</td>
<td>2018 IBC</td>
<td>2018 IRC</td>
<td>2018 IEBC</td>
<td>2018 IPC</td>
<td>No state-wide code</td>
<td>2018 IMC</td>
<td>No state mandate</td>
<td>2010 90.1</td>
<td>2018 IFC</td>
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<tr>
<td>Missouri</td>
<td>2021 IBC</td>
<td>No state-wide code</td>
<td>No statewide code</td>
<td>2021 IPC</td>
<td>No state-wide code</td>
<td>2018 IMC</td>
<td>No state mandate</td>
<td>2015 IECC</td>
<td>No state-wide code</td>
<td>X</td>
<td></td>
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<tr>
<td>Nebraska</td>
<td>2018 IBC</td>
<td>2018 IRC</td>
<td>No statewide code</td>
<td>2018 UPC</td>
<td>2017 NEC</td>
<td>No statewide code</td>
<td>2018 IECC</td>
<td>2016 90.1</td>
<td>2012 NFPA 1</td>
<td>X</td>
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<td></td>
<td>Assessed from this research and unpublished IBHS data</td>
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<tr>
<td>South Dakota</td>
<td>2021 IBC</td>
<td>No statewide mandate</td>
<td>No statewide code</td>
<td>2015 UPC</td>
<td>2020 NEC</td>
<td>2015 IMC</td>
<td>No mandatory state code</td>
<td>No statewide code</td>
<td>2021 IFC</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Tennessee</td>
<td>2012 IBC</td>
<td>2018 IRC</td>
<td>No statewide code</td>
<td>2012 IPC</td>
<td>2017 NEC</td>
<td>2012 IMC</td>
<td>No statewide mandate</td>
<td>2006 IECC or 2012 IECC for certain types of commercial buildings and state-owned buildings</td>
<td>2012 IFC</td>
<td></td>
<td>X</td>
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</tbody>
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<tbody>
<tr>
<td><strong>Wyoming</strong></td>
<td>2021 IBC</td>
<td>n/a</td>
<td>2021 IEBC</td>
<td>2018 IPC</td>
<td>2020 NEC</td>
<td>2021 IMC</td>
<td>no state mandate</td>
<td>no statewide code</td>
<td>2021 IFC</td>
<td>X</td>
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</table>

* 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](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](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](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  
Topography, Geology, Weather, Temperature: NA  
Language: Legislative  
Reason: Yes, with supporting data and documents  
Cost: Recommended  
Stakeholders: Recommended  
Filed with/approved by state: NA

DELWARE

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](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](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  
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](https://www.dca.ga.gov/node/4963) (state) [https://www.dca.ga.gov/node/4962](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 it is 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  
**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/](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

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 are adopted 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
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](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](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](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  
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)  
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/](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  
**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
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/](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  
**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  
**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  
**Topography, Geology, Weather, Temperature:** No
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/](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:**  
  (building)  
- [https://www.ok.gov/oubcc/documents/2015%20IECC%20Comment%20Form.pdf](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](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: yes, stricter only
Local Amendments allowed: yes
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
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=

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/](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/](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](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
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.


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](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](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  
**File 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](https://firesafety.vermont.gov/buildingcode/codes)  
**Adopting entity:** Division of Fire Safety with legislative committee review,
Local jurisdictions adopt residential code.

**VIRGINIA**

**Tel:** 804-371-7150  
**Website:** [https://www.dhcd.virginia.gov/code-development](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/](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](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
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](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](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](https://dsps.wi.gov/Pages/BoardsCouncils/CommercialBuilding/Default.aspx)  
Dwellings: [https://dsps.wi.gov/Pages/BoardsCouncils/UniformDwelling/Default.aspx](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
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

- WILDFIRE
- FLOODING
- EXTREME HEAT AND COLD
- WIND

Coastal (sea level rise + storm surge)
Inland (extreme rainfall)

Key model codes referenced

<table>
<thead>
<tr>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Building Code</td>
</tr>
<tr>
<td>International Residential Code</td>
</tr>
<tr>
<td>International Fire Code</td>
</tr>
<tr>
<td>International Mechanical Code (HVAC — heating, ventilation, air conditioning)</td>
</tr>
<tr>
<td>International Plumbing Code (water and wastewater)</td>
</tr>
<tr>
<td>International Wildfire Urban Interface Code</td>
</tr>
<tr>
<td>International Existing Building Code</td>
</tr>
<tr>
<td>International Energy Conservation Code</td>
</tr>
<tr>
<td>Uniform Mechanical Code</td>
</tr>
<tr>
<td>Uniform Plumbing Code</td>
</tr>
<tr>
<td>National Electric Code</td>
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</table>

Key standards referenced

<table>
<thead>
<tr>
<th>Standard referenced</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACEC 7 (wind)</td>
</tr>
<tr>
<td>ACEC 24 (flooding)</td>
</tr>
<tr>
<td>ASHRAE 90.1 (heating and cooling considerations)</td>
</tr>
<tr>
<td>NFPA (fire safety)</td>
</tr>
</tbody>
</table>
Exhibit 28  Modifications to code requirements for commercial buildings (IBC)

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

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

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

<table>
<thead>
<tr>
<th>Subject</th>
<th>Code Section</th>
<th>2012</th>
<th>2015</th>
<th>2018</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete slabs</td>
<td>322</td>
<td>No requirement</td>
<td>No requirement</td>
<td>New requirements for slabs subject to scouring/erosion</td>
<td>No change</td>
</tr>
<tr>
<td>Stairs and ramps</td>
<td>322</td>
<td>No requirement</td>
<td>No requirement</td>
<td>New requirements and options to resist or avoid flood loads</td>
<td>No change</td>
</tr>
<tr>
<td>Tanks</td>
<td>322</td>
<td>No requirement</td>
<td>New requirements for tank anchoring</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Structure</td>
<td>322</td>
<td>No requirement</td>
<td>New requirement in Coastal Zone A for first floor horizontal structure to be 1 foot above the base flood or design flood elevation</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Openings</td>
<td>322</td>
<td>No change</td>
<td>Additional details with regard to openings serving areas below design flood elevation</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Subject</td>
<td>Code Section</td>
<td>2012</td>
<td>2015</td>
<td>2018</td>
<td>2021</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------</td>
<td>----------</td>
<td>------------------------------------------</td>
<td>------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Wind / Hurricane / Tornado</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windows and sliding doors</td>
<td>609</td>
<td>No change</td>
<td>Allows comparative analysis for different sizes than those tested</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Exterior openings with glazing</td>
<td>609</td>
<td>No change</td>
<td>No change</td>
<td>Testing requirements for impact protection</td>
<td>No change</td>
</tr>
<tr>
<td>Garage doors</td>
<td>609</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
<td>Testing requirements for wind pressure</td>
</tr>
<tr>
<td>Soffits</td>
<td>704</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
<td>Requirements for soffit uplift and nailing</td>
</tr>
<tr>
<td>Photovoltaic shingles</td>
<td>905</td>
<td>No change</td>
<td>Additional requirements for high wind and wind resistance</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Photovoltaic systems</td>
<td>907</td>
<td>No change</td>
<td>New requirements for roof-mounted systems</td>
<td>No change</td>
<td>Consolidated with 609</td>
</tr>
<tr>
<td>Photovoltaic panel systems</td>
<td>909</td>
<td>No change</td>
<td>New requirements for roof-mounted systems</td>
<td>No change</td>
<td>Consolidated into 607</td>
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<tr>
<td>Energy Efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ducts</td>
<td>1103</td>
<td>No requirement</td>
<td>No requirement</td>
<td>Requirements for ducts buried in ceiling insulation added</td>
<td>No change</td>
</tr>
<tr>
<td>Heat recovery</td>
<td>1103</td>
<td>No requirement</td>
<td>No requirement</td>
<td>No requirement</td>
<td>Heat recovery ventilation required in some zones</td>
</tr>
<tr>
<td>Reports</td>
<td>1106</td>
<td>No requirement</td>
<td>Compliance reports required for permits and C of O</td>
<td>No change</td>
<td>Added detail to compliance reports requirements</td>
</tr>
<tr>
<td>Required energy efficiency options</td>
<td>1108</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
<td>Additional energy efficiency package options</td>
</tr>
<tr>
<td>Solar</td>
<td>Appendix T</td>
<td>No requirement</td>
<td>No requirement</td>
<td>Requirement for solar ready zone added</td>
<td>No change</td>
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<tr>
<td>Extreme Temperatures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat recovery</td>
<td>1103</td>
<td>No requirement</td>
<td>No requirement</td>
<td>No requirement</td>
<td>Heat recovery ventilation required in some zones</td>
</tr>
<tr>
<td>Required energy efficiency options</td>
<td>1108</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
<td>Additional energy efficiency package options</td>
</tr>
</tbody>
</table>
### Exhibit 30 Modifications to code requirements for commercial buildings (IECC)

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

Wildfire risk has been increasing steadily over the past few decades. Since 1991, 19 billion-dollar disasters have been directly tied to wildfires. 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. The increase in fire risk has been tied to changes in climate, including a shift in the onset of peak wildfire season.

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.

56 EPA. Climate Change Indicators: Wildfires.
57 Ibid.
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.
Montana and Washington have since adopted 2018 IWUIC

**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).
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

<table>
<thead>
<tr>
<th>Fire Hazard Severity</th>
<th>Moderate Hazard</th>
<th>High Hazard</th>
<th>Extreme Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Supply</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defensible Space</td>
<td>Conforming</td>
<td>Nonconforming</td>
<td>Conforming</td>
</tr>
<tr>
<td>Nonconforming</td>
<td>IR 2</td>
<td>IR 1</td>
<td>IR 1 N.C.</td>
</tr>
<tr>
<td>Conforming</td>
<td>IR 3</td>
<td>IR 2</td>
<td>IR 2</td>
</tr>
<tr>
<td>1.5 x Conforming</td>
<td>Not required</td>
<td>IR 3</td>
<td>IR 3</td>
</tr>
</tbody>
</table>


**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


Exhibit 37  Exterior walls subcomponents and new construction cost

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 114058)
- Removal or control of fuel sources (Requires compliance with NFPA 114059)
- 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.
Flooding — Coastal and Inland

Flooding has significant impacts to buildings, their occupants, 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. 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

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.*

**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.

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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
Specific deep foundation types where erodible soils are present

Breakaway walls must fail without causing damage to the structure.

Special requirements for materials used in construction based on flood design class.

Interior and exterior finish and trim materials shall be flood damage resistant.

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.

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.

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.

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.
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.

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\(^{62}\) 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

WIND ZONE MAP

| Zone 1 / 0–90 mph |
| Zone 2 / 91–120 mph |
| Zone 3 / 121–140 mph |
| Zone 4 / 141–150 mph |

Special Zone 1
Special Zone 2
Special Zone 3

Zones are based on values that are nominal design 3-second gust wind speeds in miles per hour (mph) at 33 feet above grade for Exposure Category C. Special zones indicate level of risk for tornado and other straight-line wind events.

Map produced by GCCDS for this guide from FEMA wind data to show both hurricane wind zones and tornado wind zone activities.

Source: FLASH. Resilient Design Guide.

Exhibit 39  Evolution of IRC wind requirements (coastal wind)

Source: IBHS (unpublished data) and FEMA (2020)
**Current State of Practice for Building Codes and Wind**

**Exhibit 40  Evolution of IRC requirements (inland wind)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Requirements/Incorporation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Conventional construction methods can only be used in certain non-high wind areas.</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>Required wind pressure rating of garage doors.</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Significant improvements to wall bracing methods.</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Improved requirements for connecting roofs to walls.</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>Improvements to minimal fastening requirements for wood frame construction including the roof deck.</td>
<td></td>
</tr>
</tbody>
</table>

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 incorporated 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 ratios are calculated for tornado-based building code interventions and from whose perspective.

**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...
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 policyholders to install Fortified Roofs through their **Strengthen Your Roof** program ([https://strengthenyourroof.com/](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

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65 Smart Home America. [List of Mitigation Insurance Discounts and Tax Savings](https://fortifiedhome.org/).
- 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 is 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 is 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

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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 800 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 is 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.
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.
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.
**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

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

<table>
<thead>
<tr>
<th>SMART SURFACE STRATEGY</th>
<th>WHERE TO USE</th>
<th>BENEFITS SUMMARY</th>
</tr>
</thead>
</table>
| 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 temperatures  
                         - 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 |

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.

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.