Energy Codes and Resilient Buildings

DOE Resources and Funding to Support Resilience Work

DOE Webinar: How Building Codes Facilitate Resilient Communities

September 21, 2023

Building Energy Codes Program

Mission

To support building energy code development, adoption, implementation and enforcement processes to achieve the maximum practicable, cost-effective improvements in energy efficiency while providing safe, healthy buildings for occupants.

Directive

To participate in industry processes to develop model building energy codes, issue determinations as to whether updated codes result in energy savings, and provide technical assistance to states to implement and comply with the codes.

Over the past two decades, the U.S. has experienced 265 weather and climate disaster events that exceed $1 billion in damages

How DOE defines energy resilience

Passive Survivability

The ability to maintain safe indoor conditions in the event of extended energy outage or loss of energy supply. In practice, passive survivability enables safe indoor thermal conditions, relying on building design measures that require no energy. As a measure of a building's thermal performance, passive survivability offers an integrated assessment of both energy efficiency and resilience.

Grid Resilience

Building energy technologies that provide efficiency and grid flexibility services. These technologies can provide grid services during peak demand periods. Demand load reductions alleviate energy supply and grid constraints, thereby decreasing the risk of power system failures.

www.energycodes.gov/energy-resilience

Find resources on codes and resilience on our resilience webpage

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Building Energy Codes Program

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Energy Resilience

Building energy codes play a prominent role in shaping energy resilience.

Energy resilience is the ability to operate building energy services, such as heating, cooling, ventilation, critical plug loads, and shelter, during and in response to a major disruption, and can be defined by two central functions shown in the table below.

Passive Survivability	Grid Resilience
The ability to maintain safe indoor conditions in the event of extended energy outage or loss of energy supply. In practice, passive survivability enables safe indoor thermal conditions, relying on building design measures that require no energy. As a measure of a building's thermal performance, passive survivability offers an integrated assessment of both energy efficiency and resilience.	Building energy technologies that provide efficiency and grid flexibility services. These technologies can provide grid services during peak demand periods. Demand load reductions alleviate energy supply and grid constraints, thereby decreasing the risk of power system failures.

Energy resilience may also encapsulate secondary benefits, including improved comfort, safety, and health. Together, these benefits contribute to the broader resilience of a community.

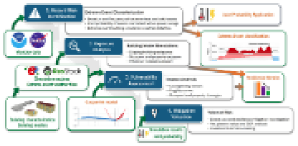
A variety of building technologies and materials can contribute to improved energy resilience. Enhanced building envelope, such as energy efficient wall insulation or windows, can enable a building to maintain safe conditions for occupants for a longer period of time during a heatwave or cold snap. On-site generation and energy storage systems can be a critical strategy to provide emergency power for essential equipment during an extended outage. In addition, grid-interactive technologies like demand responsive controls and appliances, occupancy sensors, and building energy management systems can mitigate strain on the electric grid. Deployed at scale, these technologies can potentially prevent loss of power from occurring in the first place.

The inclusion of strong resilience measures in energy codes, as well as existing buildings programs like building performance standards (BPS), can help ensure that new construction and major renovation projects are able to leverage their potentially life-saving resilience benefits. The Building Technologies Office, through the Building Energy Codes Program conducts research to explore the intersection between resilience and building energy codes. See below for resources from DOE, other federal agencies, and external partners.

RESOURCES

DOE Study: Enhancing Resilience in Buildings Through Energy Efficiency

The DOE Building Technologies Office commissioned three national research laboratories (Pacific Northwest National Laboratory, National Renewable Energy Laboratory, and Lawrence Berkeley National Laboratory) to develop a standardized methodology to quantitatively assess how energy-efficiency measures affect building thermal resilience. This report summarizes the research findings, reports initial findings resulting from the efficiency-resilience valuation effort, and identifies areas of need for continued research and analysis.



Methodology to Evaluate Energy Code Resilience diagram (click to enlarge)

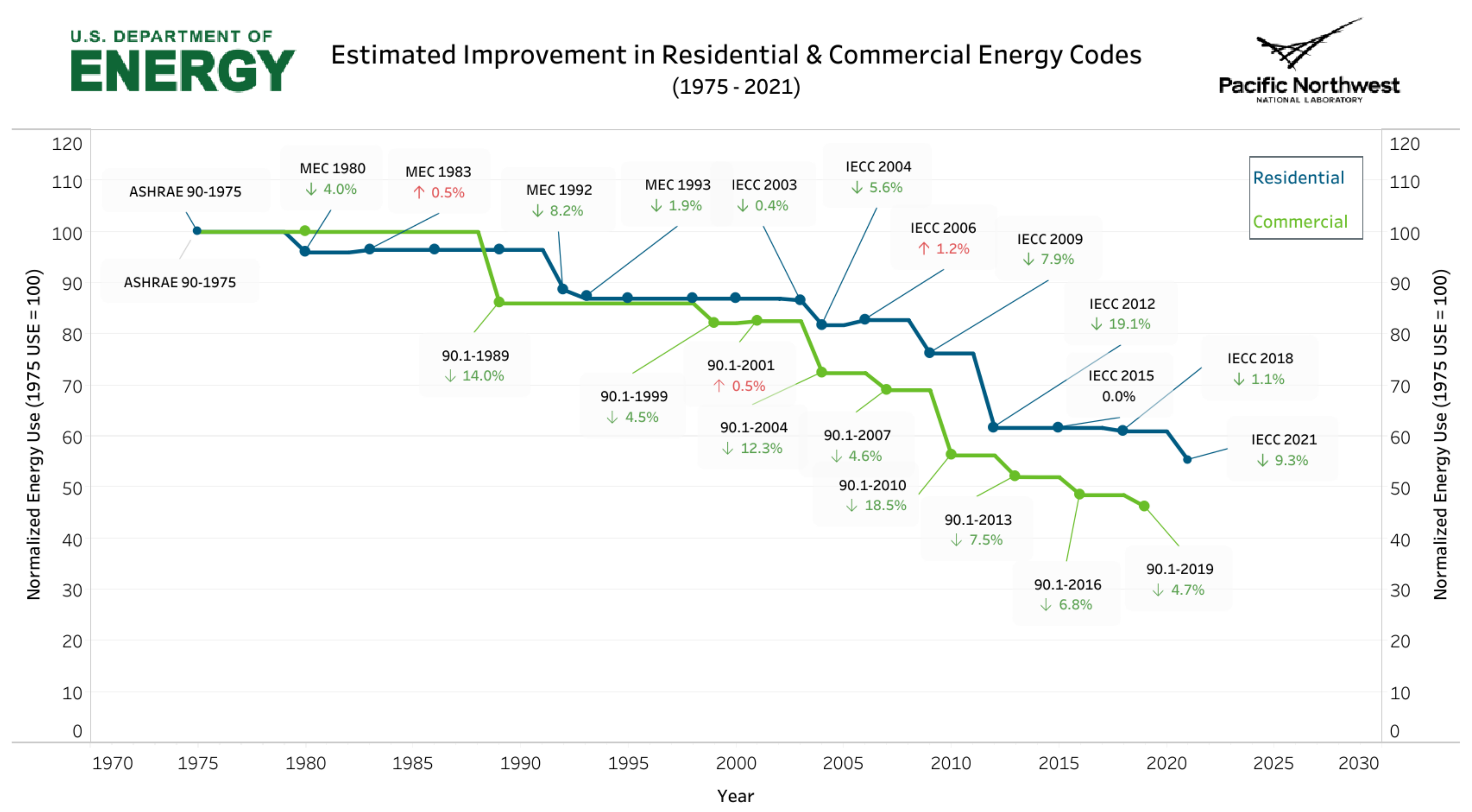
Community Guide: Community Energy Resilience Planning for Extended Power Outages

The DOE Building Energy Codes Program commissioned ICF, Inc. to develop a community resource guide to empower communities to find and use the best solutions for them to achieve overall health, safety, and prosperity goals and serve the needs of those with the greatest health and safety risks in extended power outages.

www.energycodes.gov/energy-resilience

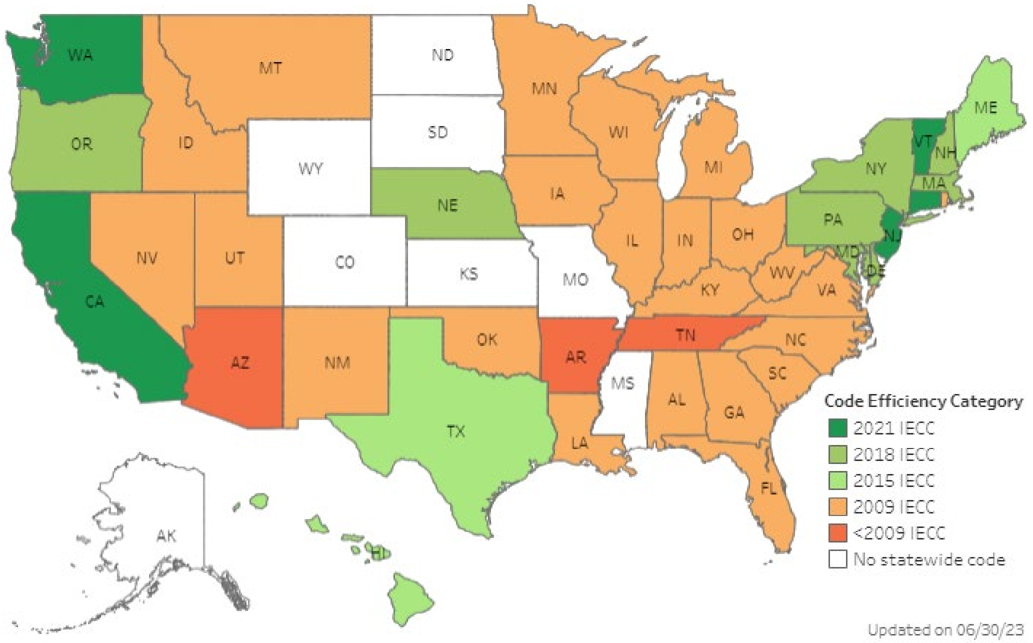
Adopting the latest codes can help improve resilience

Building energy codes have reduced building energy use for over 40 years

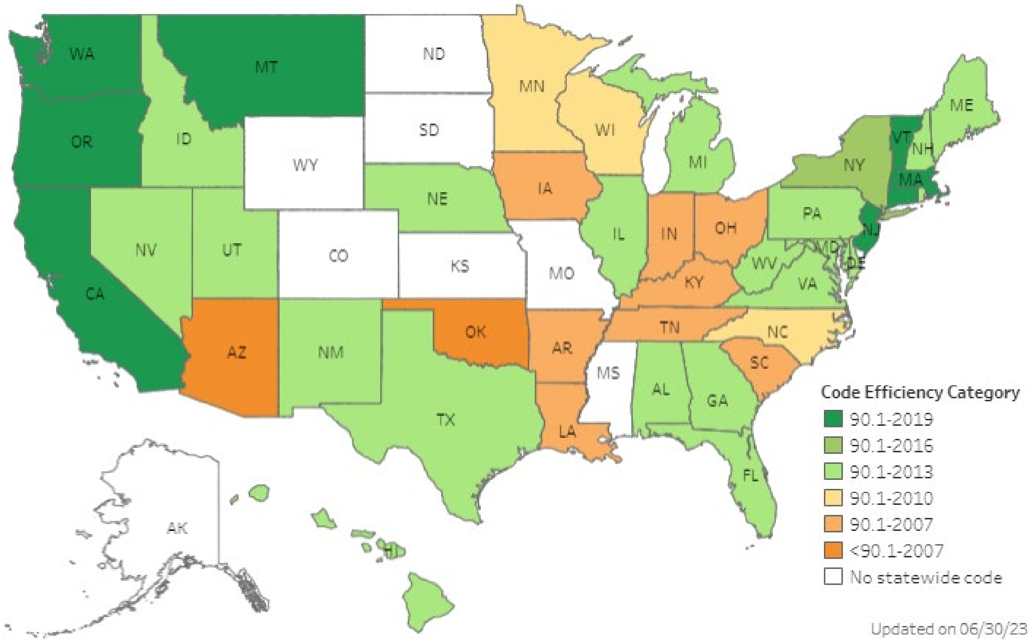


Many states still use outdated energy codes, and need support for key code activities like adoption, implementation, workforce training, and compliance.

Current status of state energy code adoption:



Residential Buildings (IECC)



Commercial Buildings (Standard 90.1)

$1.2 billion in new federal funding

$225 million	Bipartisan Infrastructure Law (BIL)
$1 billion	Inflation Reduction Act (IRA)

DOE awarded $90M to 27 projects for the first round of BIL funding

State and Local Code Adoption

- 2813-1520 - Slipstream Group Inc: Building a Strong Foundation for Wisconsin Code Adoption, Compliance, and Local Support
- 2813-1560 - Colorado Energy Office: Colorado Advanced Energy Code Adoption and Enforcement Program

Workforce Development

- 2813-1565 - Alaska Housing Finance Corporation: Framework for Responsive Code Development in Alaska
- 2813-1582 - Pennsylvania Department of Environmental Protection: Maximizing Workforce for Energy Efficient Buildings and Building Construction in Pennsylvania
- 2813-1549 - American Society of Heating, Refrigerating and Air-Conditioning Engineers: Energy Code Official – Training & Education Collaborative (ECO-TEC)
- 2813-1568 - Southeast Energy Efficiency Alliance: Securing Energy Code Advancements in Louisiana

Implementation and Compliance

- 2813-1522 - Southeast Energy Efficiency Alliance: Georgia Residential Energy Code Field Studies: Single-family and Multifamily
- 2813-1542 - Northeast Energy Efficiency Partnerships: Pennsylvania and Delaware Energy Code Field Studies
- 2813-1523 – International Code Council: CODES: Code Official Digitization and Efficiency Support
- 2813-1524 - Karpman Consulting, LLC: Automation of Performance-based Compliance Quality Control and Reporting
- 2813-1544 - California Energy Commission: Digital Infrastructure to Support Energy Code Compliance and Implementation
- 2813-1519 - Energy Futures Group: Vermont Building Energy Code Administration Project

Innovative Approaches

Stretch Codes

- 2813-1577 - Massachusetts Department of Energy Resources: Massachusetts Integrated Deployment of a Decarbonized Long-term Energy Code (MIDDLE-C)
- 2813-1510 - Center for Energy and Environment: Minnesota Advanced Energy Codes Partnership: A Path to Net Zero
- 2813-1595 – City of Fort Collins: Zero Carbon Performance Code Implementation
- 2813-1502 - New Buildings Institute: District of Columbia Net Zero Code Implementation

BPS

- 2813-1588 - Earth Advantage: Advancing Building Performance Standards in Oregon
- 2813-1554 - University of Cincinnati: Developing a cost-optimal, equitable approach to building performance standards in Ohio's large cities
- 2813-1580 - ClearlyEnergy, Inc.: Designing & Implementing Building Performance Standards in Small, Rural, and Justice40 Communities
- 2813-1537 - Institute for Market Transformation (IMT): Supporting Equitable Building Performance
- 2813-1528 - Elevate Energy: Building Performance Resource Hub
- 2813-1556 - Colorado Energy Office: Advancing Building Performance Standards (BPS) in Colorado

EEEJ

- 2813-1570 - Southeast Energy Efficiency Alliance: Closing Equity Gaps to Advance Codes and Standards
- 2813-1514 - Clean Energy Group, Inc.: Climate Resilient Energy Codes for Multifamily Affordable Housing

Partnerships

- 2813-1597 - Metropolitan Energy Center: Mid-America Collaborative for Codes Workforce Development and Implementation
- 2813-1553 - American Council for an Energy-Efficient Economy (ACEEE): National Energy Codes Collaborative
- 2813-1505 - New Buildings Institute: Resilient Southwest Building Code Collaborative

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Strong resilience focus

Resilient Southwest Regional Building Code Collaborative

New Buildings Institute
Principal Investigator: Sean Denniston, Sr. Project Mgr.

GOAL: Transform construction practices to achieve highly efficient and climate resilient buildings and communities while preserving affordability and regional characteristics through:

1) Expanded equitable public engagement;
2) Development of codes to reflect the climate realities of the southwest;
3) Development of a living implementation guide; and
4) Implementation of workforce curriculum designed to advance building practices and serve marginalized communities.

IMPACT: A sustainable workforce ready and able to implement regional resilient construction techniques in new and existing buildings, estimated to save $2 billion in utility cost savings and reduce annual CO_2 emissions by 13 MMT in five years.

Climate Resilient Energy Codes for Multifamily Affordable Housing

Seth Mullendore / Clean Energy Group

Technology Summary

The goal of the project is to establish and advance the implementation of a Climate Resilient Energy (CRE) Code, a first-in-the-nation stretch code for multifamily affordable housing to install energy technologies (solar, storage, efficient heating/ cooling, smart devices) for energy resilience and health benefits. Code adoption will facilitate more resilient housing and more equitable development of clean energy technology.

Key Personnel

American Microgrid Solutions; CT Dept. of Energy & Environmental Protection; CT Green Bank; CT Insurance Dept.; New Buildings Institute; Operation Fuel; Yale Center on Climate Change & Health

	Key Milestones & Deliverables
Budget Period 1	• Stakeholder input gathered and draft CRE Code released for public comment • Preliminary energy cost and cost impact analysis completed on CRE Code
Budget Period 2	• CRE code and impact analysis finalized and disseminated • CRE code adopted by multiple affordable housing providers

Technology Impact

The project will advance more equitable deployments of CRE systems with commitments from housing providers to adopt and implement the code, resulting in the installation of energy technologies benefitting thousands of economically and medically vulnerable affordable housing residents through 4.9 TBtu in decreased energy use, $125 million in cost savings, and 0.44 MMT of CO_2 reductions over the first five years.

Advancing energy equity and energy security in affordable housing

Thank you

Contact

Chris Perry

christopher.perry@ee.doe.gov

Building Energy Codes Program

https://www.energycodes.gov/

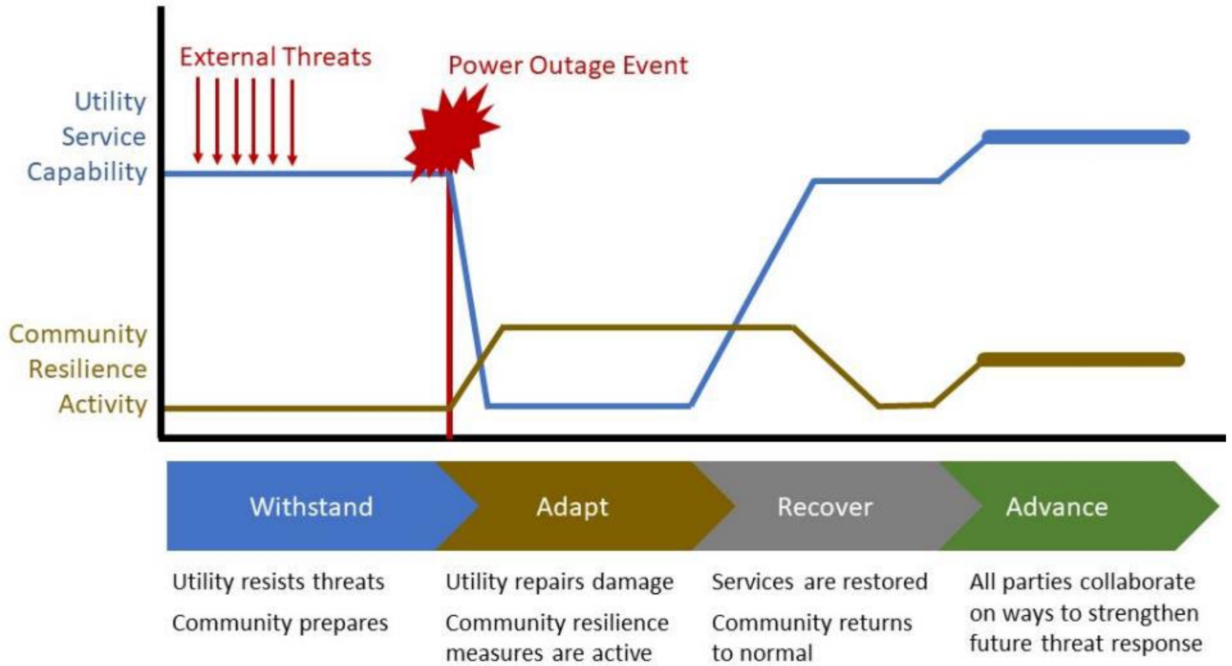
Community Energy Resilience Planning

Brian Levite
ICF Consulting

9/21/23

What is *energy resilience* in relation to communities?

Stages of Energy Resilience Strategies



1. Withstand

- Focus: Keeping the grid operational during threats
- Community Actions: Advanced energy efficiency, demand response, local regulations

2. Adapt

- Focus: Meeting essential community needs during power outages
- Community Actions: On-site generation, resilience hubs, communication plans

3. Recover

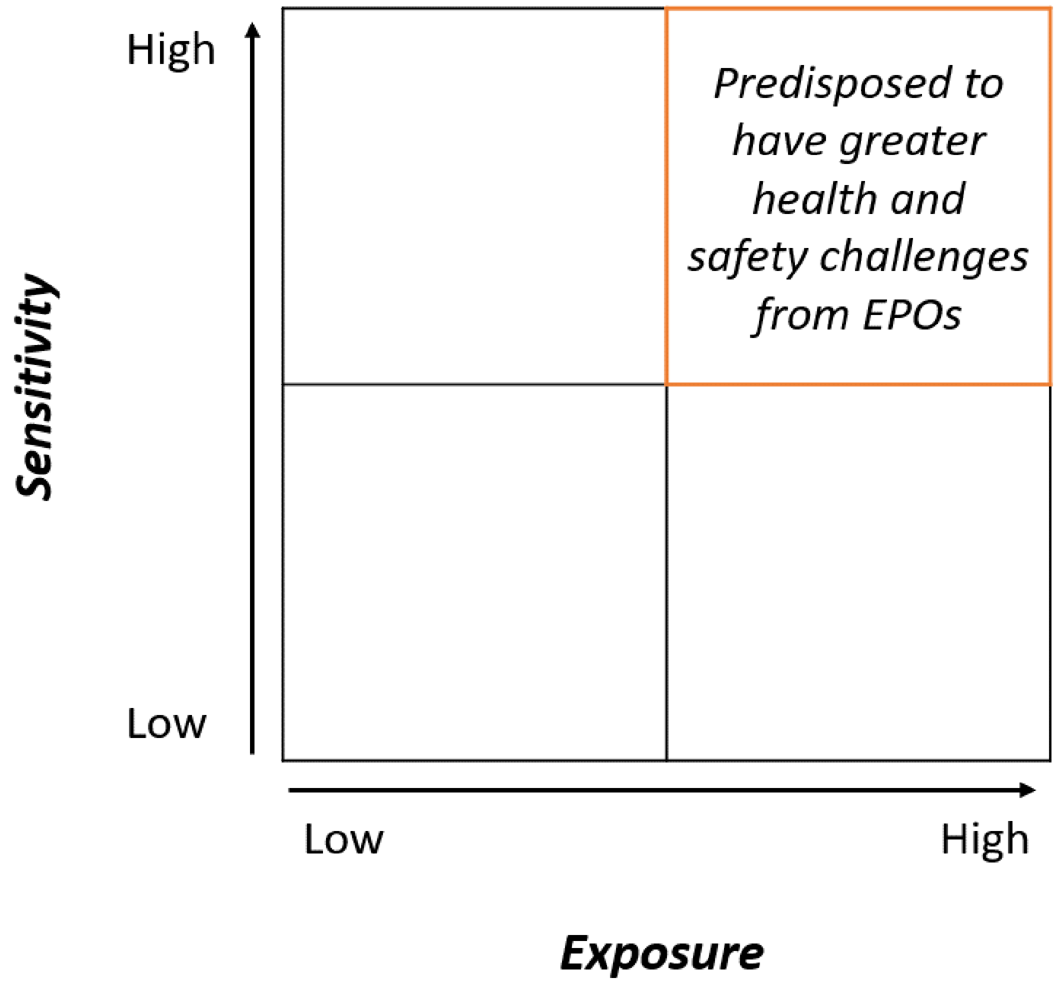
- Responsibility: Largely utility, with community support
- Examples: Clear routes for utility crews, logistical assistance

4. Advance

- Post-EPO Phase: Evaluate, update practices, and consider new solutions
- Collaboration: Closer cooperation with local utilities

Key terms

- **Extended Power Outage (EPO):** When service from the electric utility is lost for more than a day.
- **Exposure:** Likelihood of experiencing an EPO
    - Influenced by location, population, and infrastructure distribution
    - Example: Areas prone to wildfires or hurricanes may have more frequent EPOs
- **Sensitivity:** Impact of an EPO on individuals and communities
    - Influenced by adaptive capacity
    - Example: Older adults may be more sensitive to temperature changes
- **Adaptive Capacity:** Ability to respond to an EPO
    - Varies based on factors such as wealth, language proficiency, physical or mental abilities, access to resources, and community support networks



Benefits of Energy Resilient Communities

Safety

- Greater protection of community members' health, welfare, and productivity
- Example: Insulated homes and resilience hubs

Utility Reliability

- Increase security of energy, water, and other essential services supplies
- Example: Backup power capacity to water and wastewater systems

Equity

- Provide fair and just access to clean, reliable, and affordable energy
- The guide focuses on distributional equity

Cleaner Environment

- Reduce emissions by reducing energy usage and incorporating clean energy sources
- Example: Renewable power with battery storage, backup generators

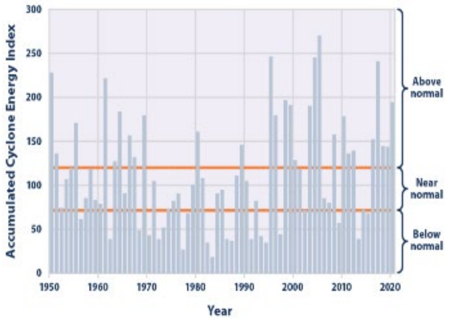
Economic Resilience

- Improve ability for local businesses to continue during and recover after EPOs
- Example: On-site power for businesses

Populations and Communities at Greater Risks in EPOs

Communities at Greater Risk

1. Hurricane



- Increasing hurricane severity and frequency, prolonged EPOs
- Extensive infrastructure damage, limited resources, and obstructed roads hindering emergency responders

Example Strategies

- Ensure local building codes (e.g., International Code Council)
- Create community resilience hub
- Evaluate drainage capabilities and choke points
- Engage community members in EPO planning
- Collaborate with the utility on vegetation management

2. Wildfire

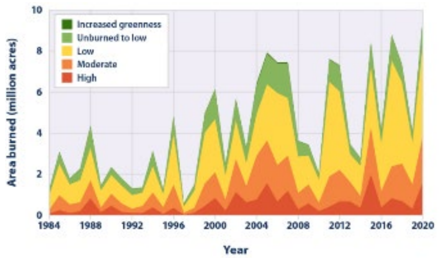


Figure 4: Damage caused by wildfires in the United States, 1984–2020[38]

- Increasing severity and growing wildfire areas
- Cause of power outage

Example Strategies

- Manage vegetation and infrastructure maintenance
- Update building codes and improve fire resistance in exterior building components
- Identify and support evacuation routes
- Establish plans for diverting wildlife fleeing nearby fires

3. Extreme Heat

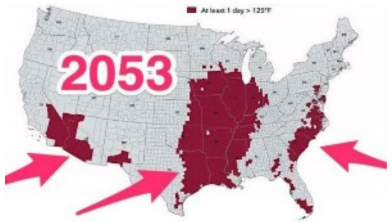


Figure 6: Areas expected to experience heat above 125 degrees F in 2053[46]

- Major concern for energy resilience in the U.S. cities
- Impact on the Electrical Grid

Example Strategies

- Focus on energy efficiency and demand respond capabilities
- Establish community resilience hubs, cooling centers
- Prioritize the elderly
- Work with local pharmacies for medication refrigeration
- Ensure extra water supplies

4. Extreme Cold

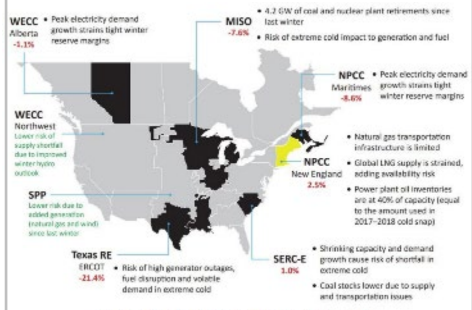


Figure 8: NERC 2022-2023 Winter Reliability Assessment[51]

- Increasing grid vulnerability
- Lack building codes requiring strong thermal envelopes, leading to inadequate insulation and window efficiency

Example Strategies

- Building codes and standard to improve thermal envelopes, support shelter
- Engage with the electric utilities (plowing/salting)
- Establish community resilience hubs, warming centers
- Prioritize elderly and unhoused populations

5. Flood

Figure 9: Integrated approach to flood risk management with multiple lines of defense[38]

- Cause: Extreme rainfall, coastal storm surge, infrastructure failures, and changes in runoff due to deforestation, urban development, and fires
- Vulnerability of Electrical Equipment

Example Strategies

- Zoning and building codes for proper drainage
- Nature-based solutions to create floodplains and drainage paths
- Elevating critical equipment – back up generation
- Pumping equipment for water relocation
- Fully-submersible switchgear for medium and low-voltage service

Populations at Greater Risk

Older adults

- Physical limitations
- Transportation challenges
- Medication dependency
- Evacuation reluctance
- Communication challenges

Strategies in action

- Shelter-in-place by New York City Housing Authority (NYCHA)
- AARP Disaster Resilience Tool Kit

People with limited disposable income and/or low wealth

- Time and financial constraints
- Work dilemma
- Less efficient infrastructure
- Sheltering challenges
- Slow recovery

Strategies in action

- Low Income Home Energy Assistance Program (LIHEAP)
- Weatherization Assistance Program (WAP)

People with underlying health issues

- Health risks and power loss
- Medication dependency
- Mobility challenges

Strategies in action

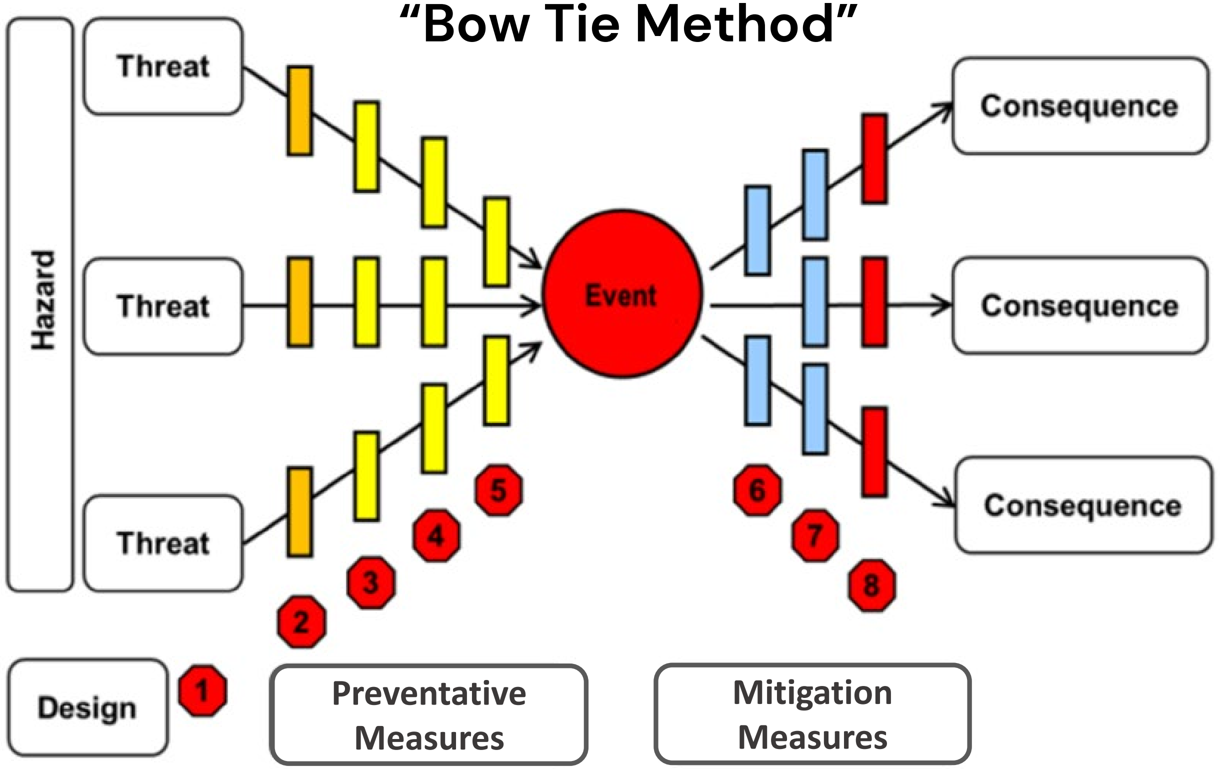
- Pinellas County, FL offers assistance to residents with specific medical needs

Developing Energy Resilience Solutions

Risk assessment methods

- **Understanding Threats**
  - Identify hazards and their impact on energy and people
  - Assess likelihood and impact of threats
  - Consider the impact of the lack of energy access
- **Mitigating Risks of EPO**
  - Identify and evaluate solutions that will prevent threats from leading to an EPO.
  - Consider which solutions could address multiple kinds of threats.
- **Mitigating Consequences of EPO**
  - Identify and evaluate solutions that will reduce the impact that an EPO will have on communities.
  - Consider which populations might be best protected.

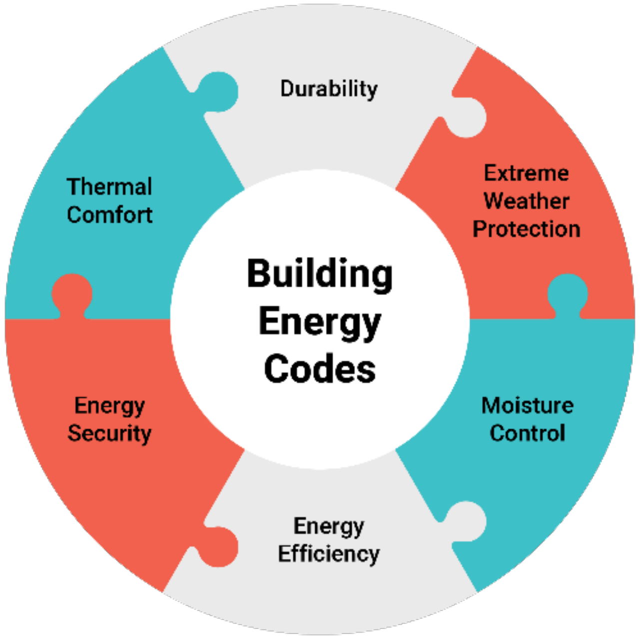
"Bow Tie Method"



- **Evaluation and Prioritization**
  - Qualitative – Select a blend of projects that address each threat and ensure that each population is addressed.
  - Quantitative – Develop a risk reduction score and a cost estimate for each solution and select projects with the lowest cost per risk reduced.

Energy Codes and Related Efficiency Opportunities

- Reduces electricity peak demand *[withstand]*
- Enables grid-interactivity for electric demand flexibility *[withstand]*
- Maintains indoor comfort for longer during outages *[adapt]*

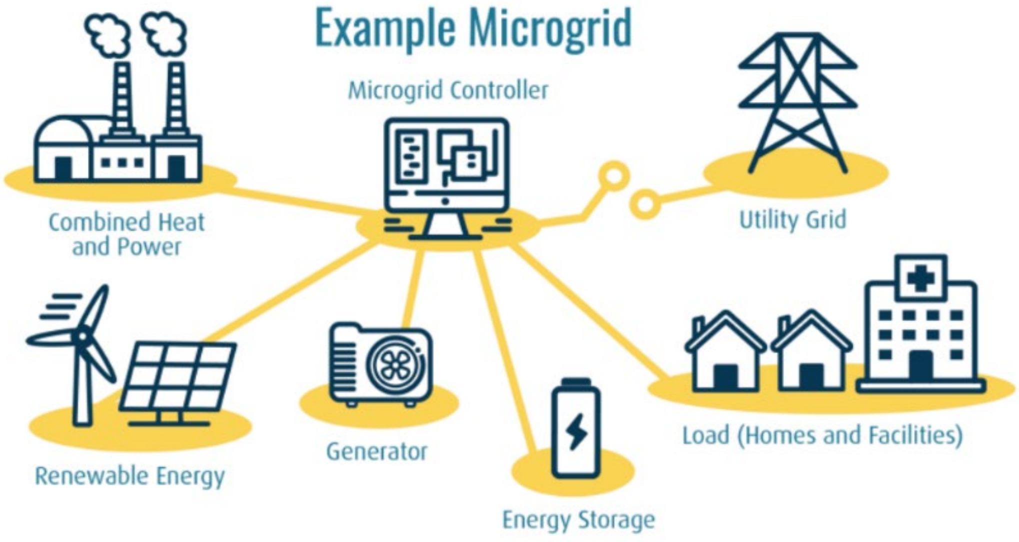


Thermal Insulation
- Reduces heat gain/loss, heating/cooling loads
- Enables smaller, cost-effective HVAC systems

High-performance Windows
- Enhances insulation and provides daylighting
- Promotes energy efficiency appropriate to the local climate

High-efficiency HVAC Equipment
- Exceeds federal minimum standards
- Right-sizing is crucial for efficiency and cost reduction

Energy Supply Opportunities



- Building codes can impact what technologies can be deployed and how.
- Are your building codes limiting the potential for on-site energy?
- Do existing building codes address interactions between energy sources?

Backup Diesel or Gas Generation
- Provides partial operation during blackouts
- Required by regulations for essential facilities
- Backup generation requires maintenance and emits pollution

Energy Storage
- Enables operation during grid outages, supports peak demand reduction and shifting
- Various battery types available (e.g., lithium-ion)
- Energy storage is expensive for extended use

Renewable plus Storage
- Coupled with energy storage for grid independence
- 'Green hydrogen' emerging as a storage solution
- Renewables plus storage are costlier

Thermoelectric Generators or Turbines
- Year-round operation for cost-effective electricity
- Natural gas or renewable alternatives
- Suitable for larger applications, but complex and costly

Combined Heat and Power (CHP)
- Captures waste heat for additional benefits, enhance system efficiency
- Provides both power and heat or cooling

Government Actions to Reduce Risks

Building Codes & Related Strategies

- **Establishing energy and building codes with resilience in mind**
  - A focus on how buildings will respond in an EPO
  - Avoiding codes or regulations that create an undue barrier to on-site resilience solutions
  - Model codes: Federal law mandates IECC (residential buildings) & ASHRAE Standard 90.1 (commercial)

- **Localities' roles in code adoption and enforcement**
  - Localities follow state laws, some with "home rule" flexibility
  - Apply building codes beyond new construction; other building activities such as building permits, building additions, renovations, and alterations
  - Examples include thermal performance standards for window replacement

- **Other regulatory strategies**
  - Mandatory Energy Benchmarking and Disclosure
    - Requires public reporting of energy performance to building owners
    - Encourages building performance upgrades, mainly in larger buildings
  - Building Performance Standards (BPS)
    - BPS require buildings to achieve defined levels of improvement, measured by on-site energy use and emissions
    - Some local governments go beyond benchmarking, specifying performance improvements
  - Providing broader development guidance
    - Make it clear to developers that resilience is a priority (potentially in your energy resilience plan)
    - Encourages developer focus on this area in hopes to improve chances of approval

Resilience Hubs

- **A central community facility with extra resilience measures taken, including on-site power generation or a micro grid, relief supplies and community communication**

  - **Characteristics**
    - Centrally located, accessible to all
    - Under Local government control for resilience investment
    - High energy efficiency with an excellent thermal envelope
    - Away from hazards
    - On a priority circuit for utility reconnection

  - **Resources**
    - Learn from successful hubs in cities like Minneapolis, Baltimore, Miami, San Francisco, and Vancouver
    - Explore technical systems via the Urban Sustainability Directors Network

Collaborating with energy and water utilities

- **Partnership Opportunities**
  - Identify critical facilities and at-risk populations
  - Coordinate emergency response procedures
  - Leverage technical expertise for resilience projects
  - Enable grid integration and demand response programs
  - Influence utility investments and support building codes

- **Engagement Approaches**
  - Collaborate as a stakeholder in utility planning
  - Communicate community needs with regulators or legislators
  - Utilize the permit process for influence, though late in the process

Potential funding sources for resilience efforts

- **Federal grant programs**
  - Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) provide funding
    - Energy codes training and technical assistance
    - Weatherization Assistance Program (WAP) for home energy upgrades
    - Energy Efficiency and Conservation Block Grants (EECBG) for local projects
    - Home energy efficiency and electrification rebates
- **Utilities**
  - Customer programs for energy efficiency, with a focus on disadvantaged communities
- **State and local housing improvement programs**
  - State housing agencies offer support for affordable housing and repairs, partnered with local government agencies and NGOS
- **Financing programs**
  - Property Assessed Clean Energy (PACE)
  - Pay As You Save (PAYS) for low upfront costs and positive cash flow
  - Revolving Loan Funds for building energy audits and upgrade projects
  - Green Banks for clean energy projects – EPA's Greenhouse Gas Reduction Fund

Developing a Community Energy Resilience Strategy

Elements for community energy resilience

In crafting your community's energy resilience strategy, consider these vital elements:

1. Assess at-risk population

- Assess populations at risk and their specific energy resilience needs

2. Hazard Assessment

- Identify climate-related hazards impacting energy resilience

3. Mapping Needs to Hazards

- Map population needs to climate hazards
- Recognize where vulnerabilities lie

4. Technical Solutions Definition

- Define technical solutions required to address these vulnerabilities
- Identify government actions that are most critical

5. Solution Selection and Prioritization

- Prioritize solutions that best align with your community's needs at the most acceptable cost

Are your codes and standards resilience-ready?

Thank you

Brian Levite, CEM
ICF Consulting
Brian.Levite@icf.com

National Initiative to Advance Building Codes

Implemented by the Mitigation Framework Leadership Group (MitFLG) Building Codes Task Force (BCTF)

Krystal Laymon
Senior Advisor for Resilience
FEMA

NIABC
National Initiative to Advance Building Codes

Why Advance Building Codes?

- Modern building codes **strengthen communities' resilience** against extreme weather events that are intensifying due to **climate change**.
- Hazard-resistant building codes **save lives, reduce property damage**, and help **communities recover quicker from natural hazards**.
- Building code adoption protects underserved and vulnerable communities, where disasters take a greater toll.

Why Building Codes?

Building Codes Save Lives and Property:

- Hazard-resistant building codes are projected to prevent $132 billion in losses over 30 years
- Building codes have $11:$1 return on investment
- Disaster-resistant building codes reduce the impact of climate change
- Protect vulnerable and underserved communities
- Advance equity by making resources, policies and best practices serve all communities

Background: Origins of the NIABC

- The White House National Climate Task Force directed Mitigation Framework Leadership Group (MitFLG) to spearhead the NIABC
- The MitFLG formed the Building Codes Task Force (BCTF). BCTF Federal agencies were asked to:
  - ✓ Conduct a landscape analysis
  - ✓ Create federal implementation plans
  - ✓ Update and amend programs and guidance
  - ✓ Submit progress reports to the White House

NIABC
National Initiative to Advance Building Codes

Participating BCTF Federal Agencies

US Army Corps of Engineers®

USDA

FEMA

SBA

GSA

NIST

NIABC
National Initiative to Advance Building Codes

NIABC Key Priorities

Modernize Building Codes

- Incentivize state, local, tribal and territorial governments to adopt and enforce current building codes
- Improve resilience to hazards
- Incorporate science and technology

Improve Climate Resilience

- Increase smart design and construction
- Build resilience to extreme weather events
- Save lives and reduce property damage

Reduce Energy Costs

- Increase energy efficiency
- Establish federal building performance standards
- Achieve net-zero emissions across federal buildings by 2045

Prioritize Underserved Communities

- Invest in capacity building for communities
- Provide tools to reduce damage and accelerate recovery
- Identify needs for rural and underserved communities

Create Good Jobs

- Develop equitable workforce training partnerships
- Assist federal, state and local agencies in creating high-quality job opportunities
- Prioritize needs of disadvantaged communities

NIABC Key Activities

From NIABC Fact Sheet:

- **Comprehensively review federal funding and financing** of building construction to ensure federally-supported housing and other building projects follow modern building codes and standards to the greatest extent feasible
- **Provide incentives and support for communities** to adopt current building codes and standards by providing technical assistance, implementing proven strategies and best practices
- **Lead by example** across the federal building portfolio by seizing opportunities to advance "above-code" resilience and energy efficiency standards in new projects.

*You can see how these activities are set in motion in the December 2022 NIABC Progress Report.

FEDERAL FUNDING refers to assistance in the form of grants, cooperative agreements or direct assistance.

FEDERAL FINANCING refers to guaranteed loans, insured loans or mortgage insurance.

NIABC
National Initiative to Advance Building Codes

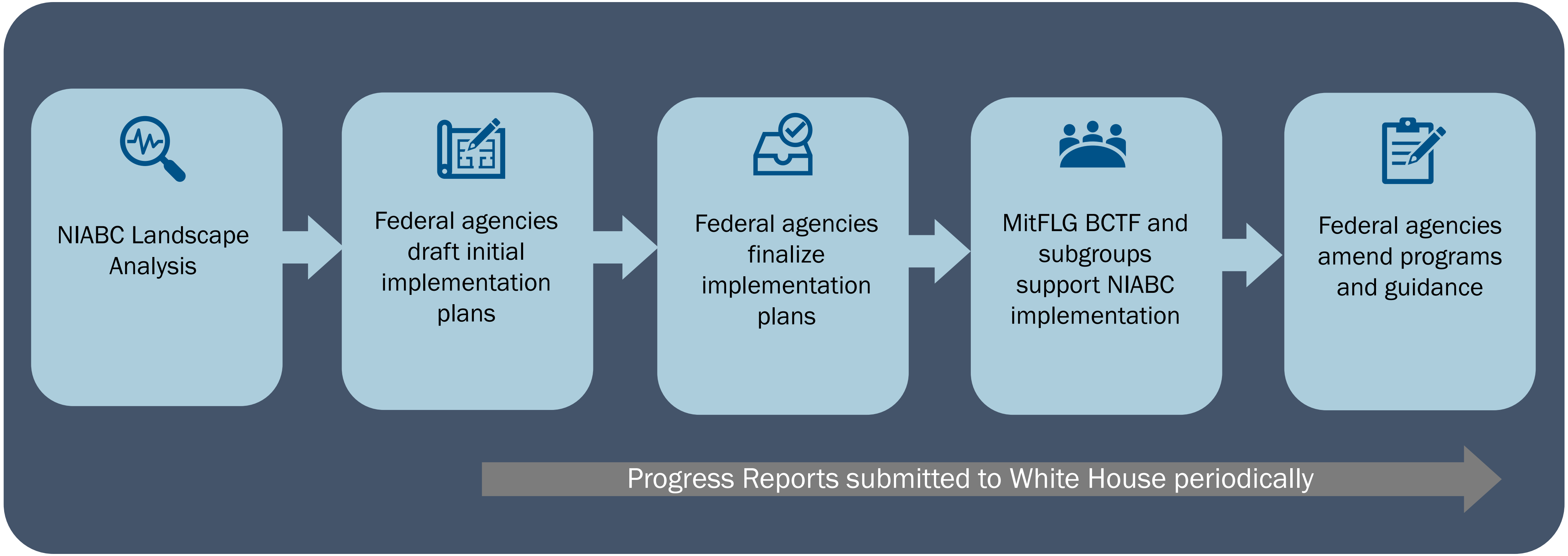
BCTF NIABC Implementation

2023 Key Target Activities:

- ❑ Define performance measures
- ❑ Advance codes and standards
- ❑ Incorporate equity and environmental justice across all activities
- ❑ Incorporate job quality and workforce development across all activities
- ❑ Develop communications strategy to socialize NIABC efforts and progress

NIABC
National Initiative to Advance Building Codes

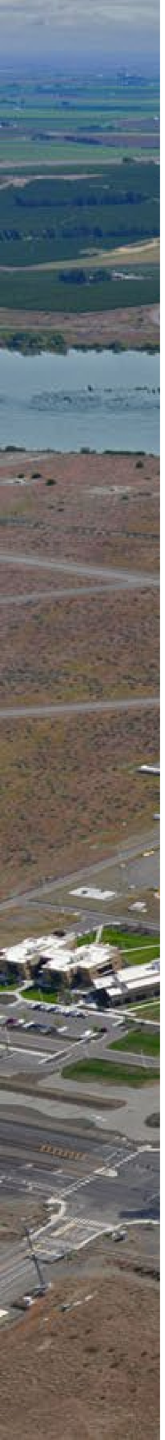
National Initiative to Advance Building Codes Milestones



Thank you.

Krystal Laymon
Senior Advisor for Resilience
FEMA

NIABC
National Initiative to Advance Building Codes



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DOE Building Energy Codes Program - How Building Codes Facilitate Resilient Communities

Valuing Energy Efficiency for Energy Resilience

Ellen Franconi
Pacific Northwest National Laboratory

September 21, 2023

U.S. DEPARTMENT OF ENERGY BATTELLE

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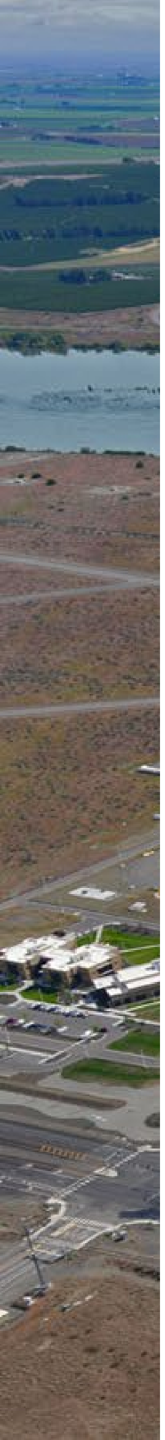

Project Team and Technical Advisory Group

Project Team and DOE Advisors

Pacific Northwest National Laboratory
- Ellen Franconi, Project PI and PNNL PM
- Luke Troup, Mark Weimar, Yunyang Ye, Chitra Nambiar, and Jeremy Lerond

National Renewable Energy Laboratory
- Eliza Hotchkiss, NREL PM
- Jordan Cox, Sean Ericson, Eric Wilson, Philip White, Conor Dennehy, Jordan Burns, Jeff Maguire, Robin Burton

Lawrence Berkely National Laboratory
- Tianzhen Hong, LBNL PM
- Linqian Sheng, and Kaiyu Sun

DOE BTO Building Energy Codes Program
- Michael Reiner, Christopher Perry, and Jeremy Williams

Technical Advisory Group

- Fred Malik, Insurance Institute for Business & Home Safety (IBHS)
- Rick Jones, Hartford Steam Boiler
- JiQiu (JQ) Yuan, National Institute of Building Sciences (NIBS)
- Ryan Colker, International Code Council (ICC) / Alliance for National and Community Resilience (ANCR)
- Sheila Hayter, ASHRAE / NREL
- Alex Wilson, Resilient Design Institute
- Camille Crains, FEMA, Building Resilient Infrastructure and Communities (BRIC)
- Daniel Nyquist, FEMA, Threat and Hazard Identification and Risk Assessment (THIRA)
- Steve Cauffman, Cybersecurity & Infrastructure Security Agency (CISA)
- Laurie Schoeman, Enterprise Community Partners
- Jesse Rozelle, Federal Emergency Management Agency (FEMA)
- Joshua Kneifel, National Institute of Standards and Technology (NIST)
- Ed Carley, National Association of State Energy Officials (NASEO)
- Rodney Sobin, National Association of State Energy Officials (NASEO)
- Jenn Kallay, Synapse Energy Economics
- Kristie Ebi, University of Washington
- Colby Tucker, U.S. EPA

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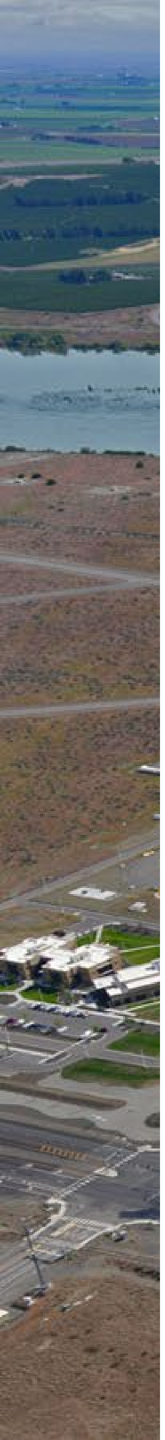

Valuation of Energy Efficiency for Energy Resilience

A collaborative **PNNL, NREL, and LBNL** project guided by a **technical advisory group** and **US DOE Building Energy Codes Program**

Purpose

- Expand energy efficiency cost effectiveness assessment to include resilience considerations
  - develop a **standardized** methodology to **quantitatively** assess how building efficiency impacts energy resilience
  - calculate **metrics** to support the quantification of impact

Focus

- Extreme heat and cold events **coincident with a power outage**

Application for investment decision making

- **Benefit cost ratio** annualized cost effectiveness calculation
- Metrics included as part of a **decision matrix**

Project Scope

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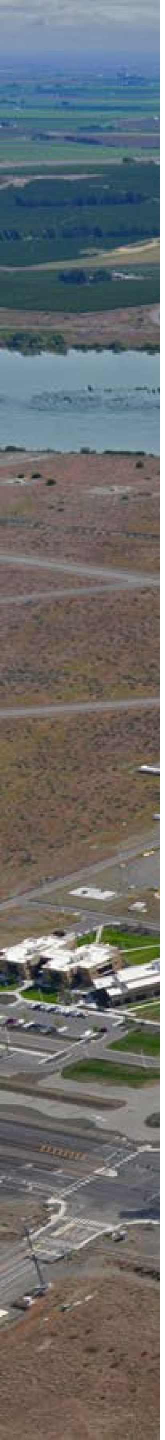
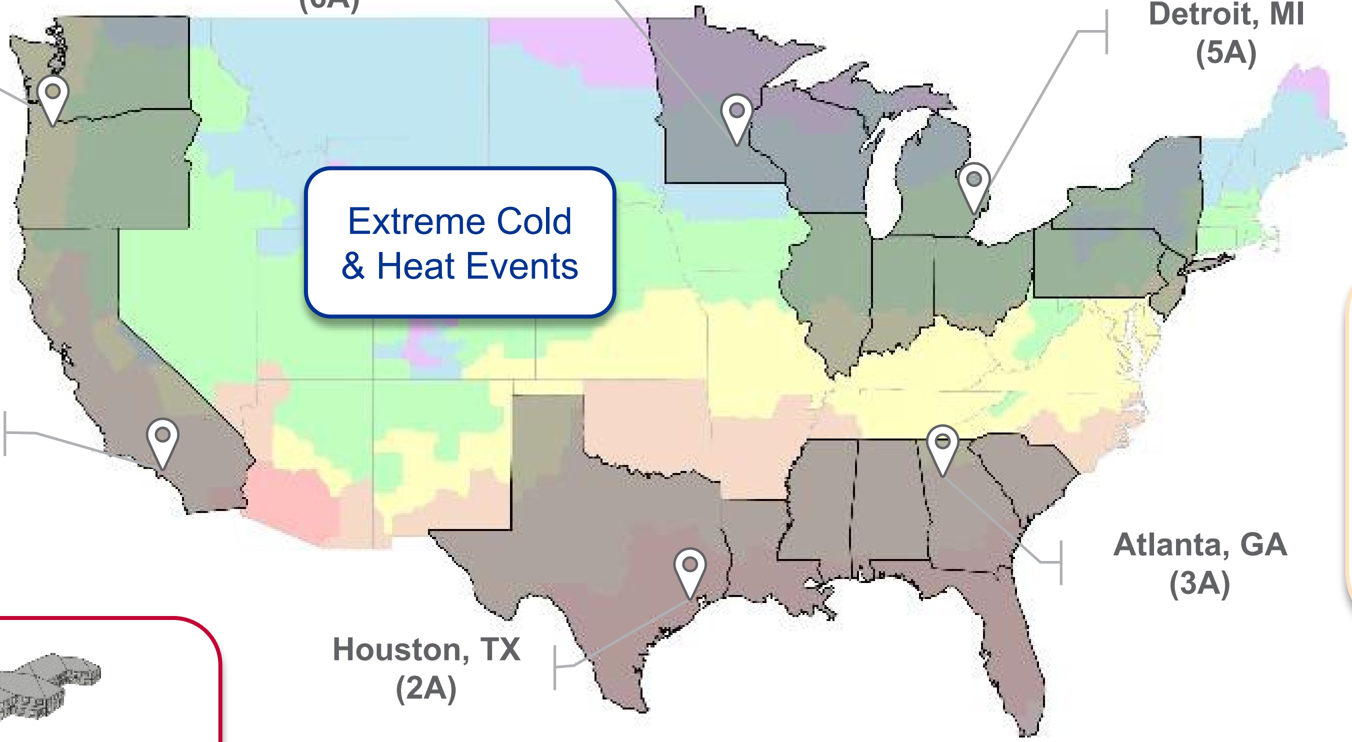
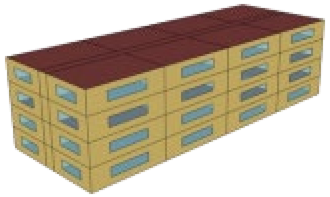




Extreme Cold
& Heat Events

Multi-Family

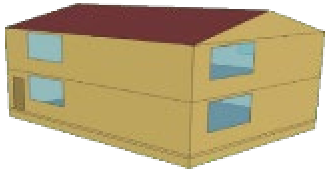


New & Existing

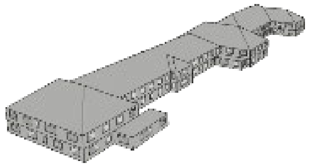
Baseline Condition
Historic Code/Existing Stock

Current Code
ASHRAE 90.1-2019 & IECC-R 2021

Beyond Code
Informed by 2021 Passive House



Single-Family



Assisted Living Facility

Counterfactual Case Study

2021 Texas Winter Storm and
Extreme Heat Event

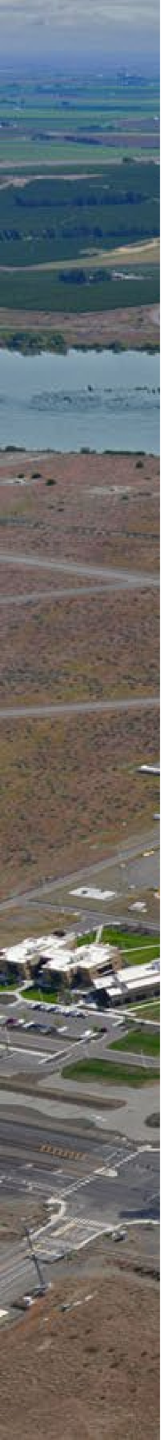
Metrics & Valuation

Thermal Resilience: Standard Effective Temperature, Heat Index
Mortality: Gasparrini Relative Rate Model
Investment: Benefit Cost Ratio (BCR),

Key metrics applied in study

Metrics are calculated for base case and improved conditons

Thermal resilience metrics indicating occupant exposure	
Standard Effective Temperature (SET)	Indoor conditions measurement that considers of temperature and relative humidity
SET Degree Hours	Cumulative hourly SET degrees that fall outside of a specified threshold (54°F and 86°)
Days of Safety	The time elapsed over a seven day period when the SET Degree Hours does not exceed a value of 216.
Occupant damage metrics	
Excess deaths	Deaths attributed to the extreme event
Economic metrics (for annualized net present value calculation)	
Measure investment costs	First costs for installation of measure package
Measure annual energy cost savings	Evaluated based on a typical weather year
Societal value of emissions reduction	Associated with annual energy use savings
Losses associated with excess deaths	Based on $10 million per excess death
Losses associated with property damage	Based on FEMA national risk data base values
Benefit cost ratio	Based on **annual coincident risk of extreme temperature events** and above economic values



Project Approach

Hazard Risk Analysis

- Historical extreme temperature event identification
- Severe weather - power outage data review

Coincident probability

Exposure Analysis

- Baseline and efficiency packages
- Building energy simulation models and analysis

Indoor condition effect on habitability

Damage Analysis

- Historical property damage data
- Epidemiological fragility models
- Related to extreme temperatures

Property damage and excess mortality

Mitigation Valuation

- Valuation of loss
- Mitigation costs
- Annualized impacts
- Net present value analysis

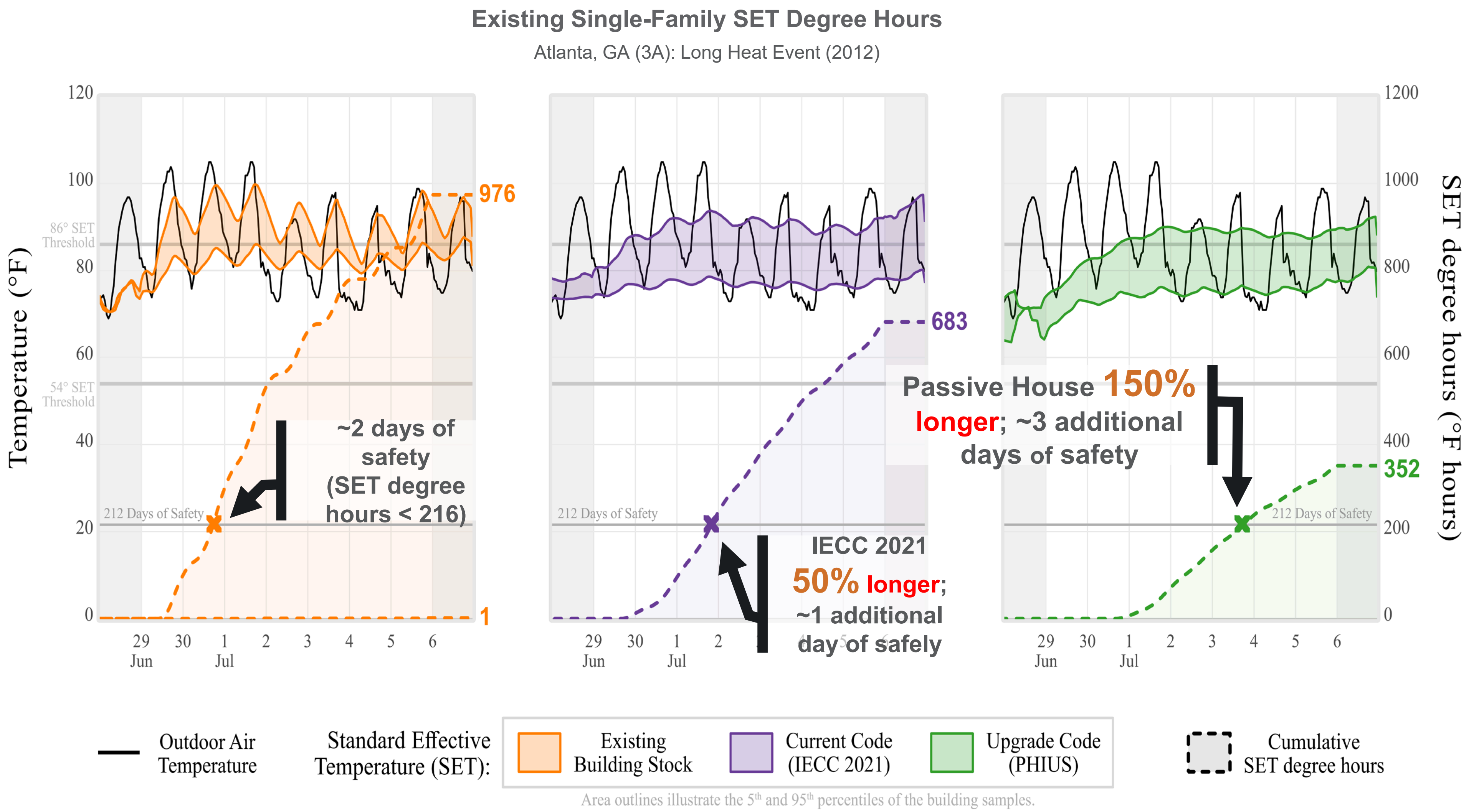
Return on investment

Exposure Analysis

Three thermal resilience metrics reported in the study include:

- SET
- SET degree hours
- Days of safety

What is the fluctuation in indoor comfort conditions extreme temperature events? How does it affect habitability?



Damage Analysis

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How do the study estimates compare to published data?

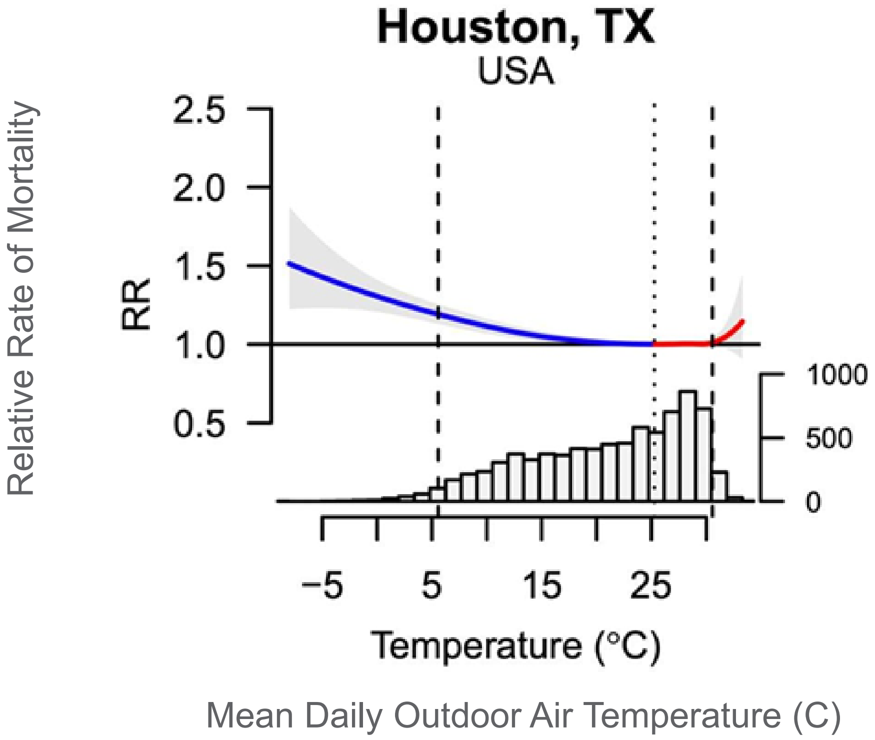
2021 Texas Winter Storm Event Case Study

	Texas	Harris County	Harris County
	Published	Published Prorated	Study Estimate
Excess mortality	755	249	202

Notes: The published value for excess mortality for Texas is 755 per Aldhous P, and Z Hirji. 2022. "Texas Is Still Not Recognizing the Full Death Toll of Last Year's Devastating Winter Storm." Buzzfeednews.com. Accessed June 1, 2022. The event occurred from February 13 to February 24, 2021. The study excess mortality analysis is for the entire event period over the 12 days.

How does extreme heat and cold impact mortality rate?

Relative rate of death curves as a function of **outdoor temperature** published by Gasparrini available for over 130 U.S. cities



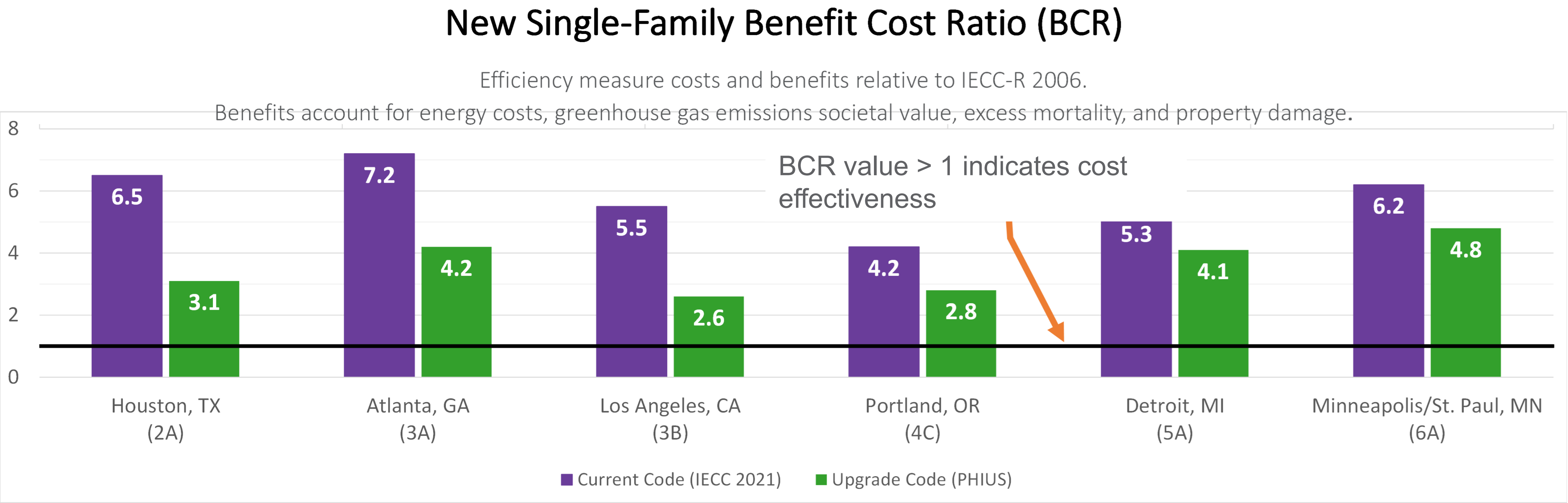
Notes: Vertical dashed lines indicate the temperature at 2.5th percentile and 97.5th percentile. The vertical dotted line indicates the temperature at which the relative rate of death is one or the temperature at which deaths are not attributed to severe temperatures

Methodology Robustness Assessment

Category	Component	Robustness
1. Hazard Risk Identification	Develop weather data files representative of extreme temperature events	5/5
	Develop coincident probability risk factors to annualize event losses and benefits	3/5
2. Exposure Analysis	Assess relative impact of efficiency measures on habitability	5/5
	Determine indoor habitability conditions exceeding thresholds	3/5
3. Vulnerability Assessment	Evaluate occupant exposure effect on mortality, health, and well-being	3/5
	Evaluate property exposure effect on active building state and systems	FUTURE
4. Mitigation Valuation	Quantify the monetary value of resilience	3/5
	Inform resilience planning efforts	3/5

Example Benefit Cost Ratio Results

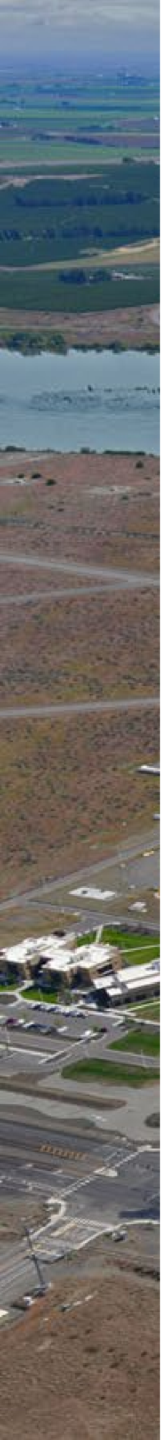
What is the return on building efficiency investment with **annual energy cost saving, societal value of reduced CO2e emissions, and annualized excess deaths?**



Example Decision Matrix

How can resilience metrics be used to inform investment decision-making?

Metric	Value		Assigned Weights	Normalized	
	Current Code IECC 2021	Beyond Code PHIUS		Current Code IECC 2021	Beyond Code PHIUS
BCR	0.63	0.68	30%	0.92	1.00
Levelized First Costs ($/ft²/year)	0.63	0.77	15%	1.00	0.82
Energy Savings (kWh/ft²/year)	3.1	4.1	15%	0.76	1.00
Lives Saved	62	93	10%	0.66	1.00
SET Degree Hours Reduced	985	1348	30%	0.73	1.00
			Weighted Total	**0.82**	**0.97**



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Key Take-Aways

- Improving envelope efficiency to meet or exceed code requirements extends occupant habitability during extreme temperatures.

- In nearly every situation, improving envelope efficiency saves lives during extreme temperature events.

- Increasing efficiency at the time of construction provides a good investment opportunity for addressing resilience.

- There are application limitations associated with some of the method components, which may lead to an underestimation of benefits. These components, which can be improved with better supporting data and application refinements.
    - Coincident probability of occurrence of power outage –extreme temperature events
    - Gasparrini relative rate of mortality fragility curves
    - Property damage estimation
    - Building performance based on future weather data

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Questions

Ellen Franconi

Ellen.Franconi@pnnl.gov

Final report is available at
https://www.energycodes.gov/energy-resilience