Better Buildings Residential Network Peer Exchange Call Series:

Resiliency in the Face of Disaster: Energy Efficiency's Role

January 24, 2018

Agenda and Ground Rules

- Agenda Review and Ground Rules
- Opening Poll
- Residential Network Overview and Upcoming Call Schedule
- Featured Speakers:
  - **Eliza Hotchkiss**, National Renewable Energy Laboratory
  - **Alex Wilson**, Resilient Design Institute
  - **Pasha Majdi,** American Council for an Energy-Efficient Economy
- Open Discussion
- Closing Poll and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

The views expressed by speakers are their own, and do not reflect those of the Dept. of Energy.

Better Buildings Residential Network

Join the Network

Member Benefits:

- Recognition in media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- Solution Center guided tours

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year, or equivalent.

Upcoming calls:

- February 14th: We Love Our National Labs: Research Results (Part 1)
- February 28th: We Love Our National Labs: Research Results (Part 2)
- March 14th: Is PACE the Pot of Gold at the End of the Financing Rainbow?

Peer Exchange Call summaries are posted on the Better Buildings website a few weeks after the call

For more information or to join, for no cost, email bbresidentialnetwork@ee.doe.gov, or go to energy.gov/eere/bbrn & click Join

Eliza Hotchkiss
National Renewable Energy Laboratory

U.S. DEPARTMENT OF ENERGY

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Resilience in the Face of Disaster: *Energy Efficiency's Role*

Eliza Hotchkiss
Disaster Recovery and Resilience Lead, NREL

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WHAT IS RESILIENCE?

"the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through **adaptable and holistic planning and technical solutions**".

www.nrel.gov/tech_deployment/resilience-planning-roadmap/

Disasters are unfortunate, but offer a unique opportunity for improving the energy performance of building stock during the recovery phase.

- Develop construction, retrofit and recovery methods that improve energy efficiency, durability and resilience of new and existing homes
- Reduce risks and facilitate more efficient recovery (i.e., reduce impacts, cost and waste from damage)
- Enable households to better tolerate short-term disruptions of fuel supplies and infrastructure

Image source: Business Insider

There is Not a One-Size Fits All Solution to Resilience

- Where do we begin with resilience projects?
- How are we defining resilience?
- What are the technical solutions?
- What are we becoming resilient TO?
- What are the policies and processes that enhance resilience?

Energy Use in Buildings
Dictated by Climate Zones

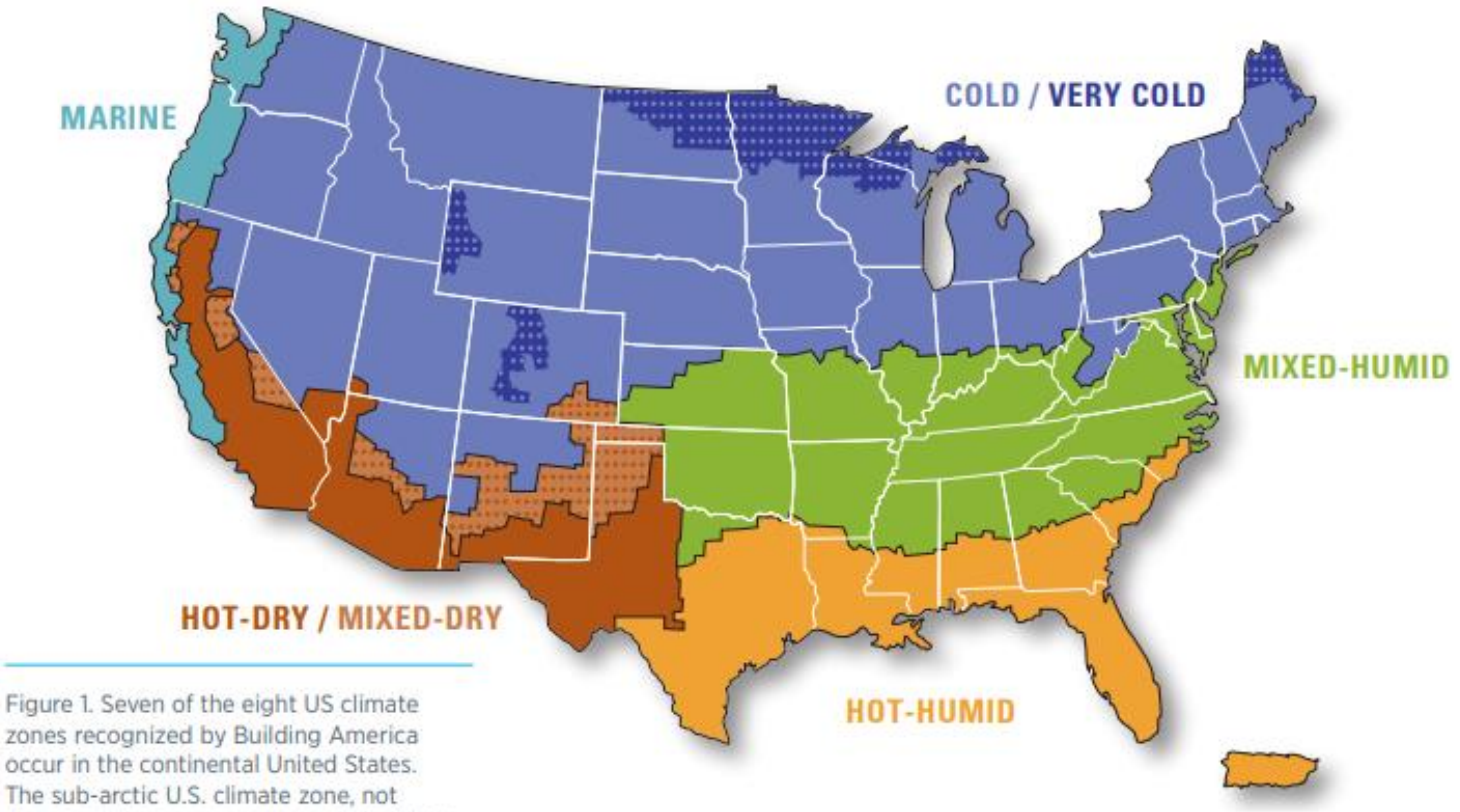
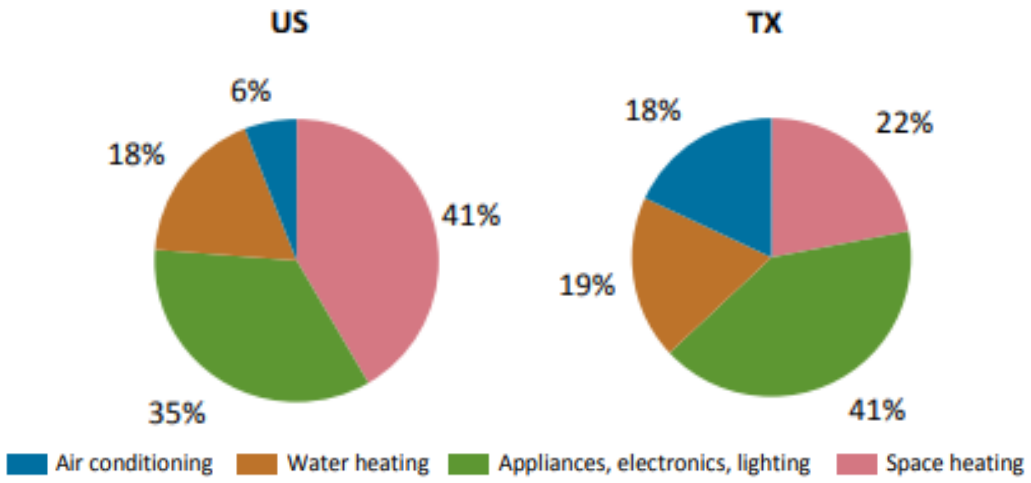


Figure 1. Seven of the eight US climate zones recognized by Building America occur in the continental United States. The sub-arctic U.S. climate zone, not shown on the map, appears only in Alaska.

Image credit: PNNL

Energy Use in Buildings

U.S. Energy Consumption



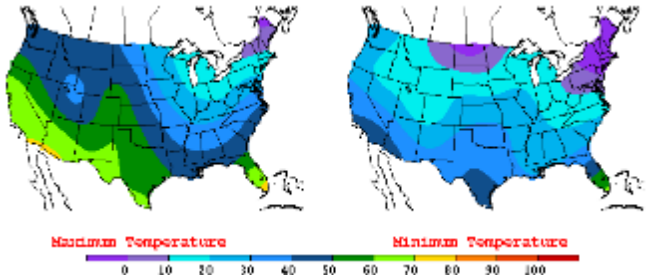
Data source: EIA and Texas SECO

- Texas leads the nation in energy consumption and is the fifth largest energy consumer in the world. Buildings account for almost 40% of the state's total energy usage and 70% of electricity usage, representing a significant opportunity for energy savings.
- The average annual electricity cost per Texas household is $1,801, among the highest in the nation, although similar to other warm weather states like Florida.
- Compared to other areas of the country, the warmer climate in Texas means that air conditioning accounts for a greater portion of home energy use (18%), while space heating accounts for a much smaller portion (22%). Appliances, electronics and lighting are 41% of the end-use in Texas.

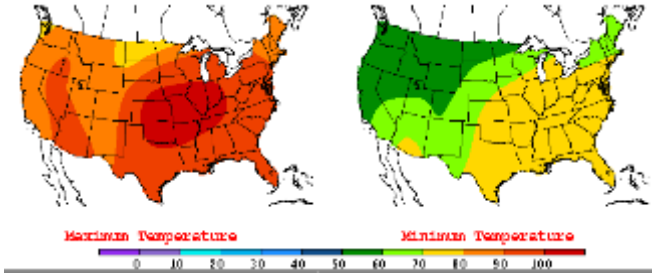
Example Analysis: Heat and Cold Waves

- Ran analysis of outages during a heat wave and cold wave using historical weather data
  - Cold wave: 2014 polar vortex (1/3-1/7) in Buffalo, NY, outage starts at 9 pm
  - Heat wave: 2012 heat wave (7/6-7-10) in Chicago, IL, outage starts at noon
- For each case, 2 outage durations were simulated: 8 hours and 4 days to capture short/long outages
- Simulations were performed for the single family detached housing stock at these locations using ResStock

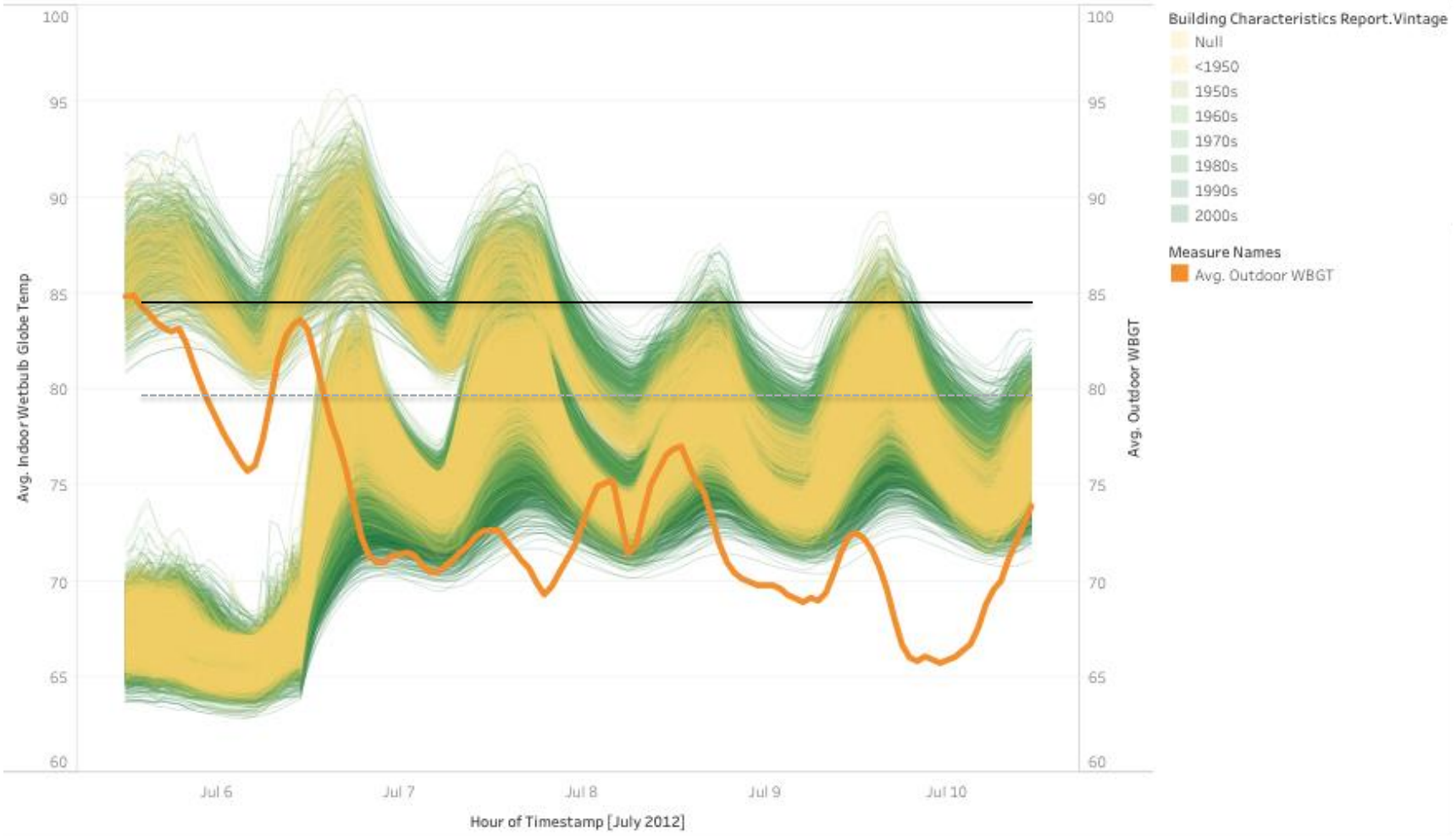
Cold Wave Temperatures



Heat Wave Temperatures

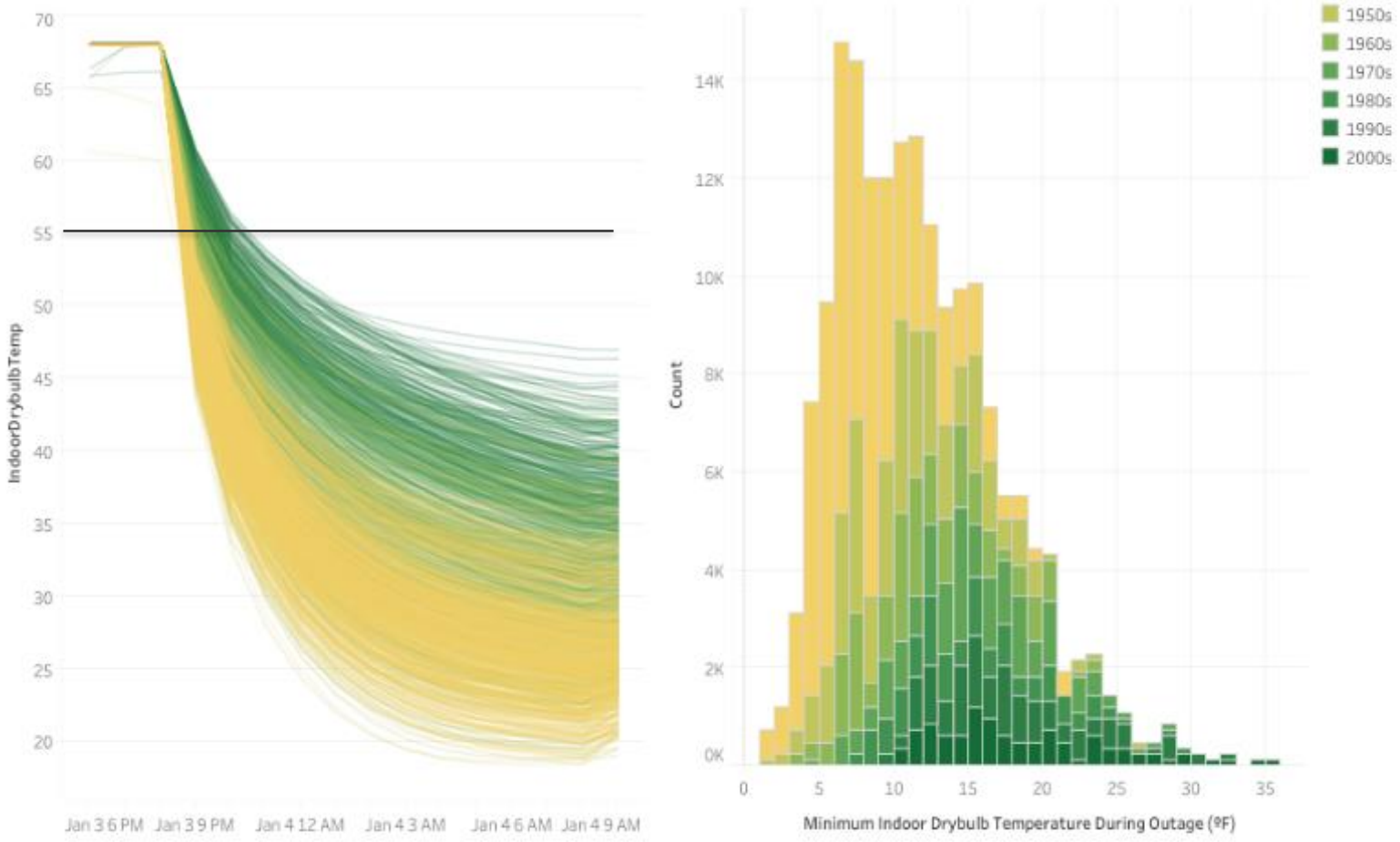


Heat Wave Results: Heat Wave in Chicago, Il



Graph results courtesy Eric Wilson, Jeff Maguire, NREL

Cold Wave Results: Polar Vortex in Buffalo, NY



Graph results courtesy Eric Wilson, Jeff Maguire, NREL

Solutions Vary

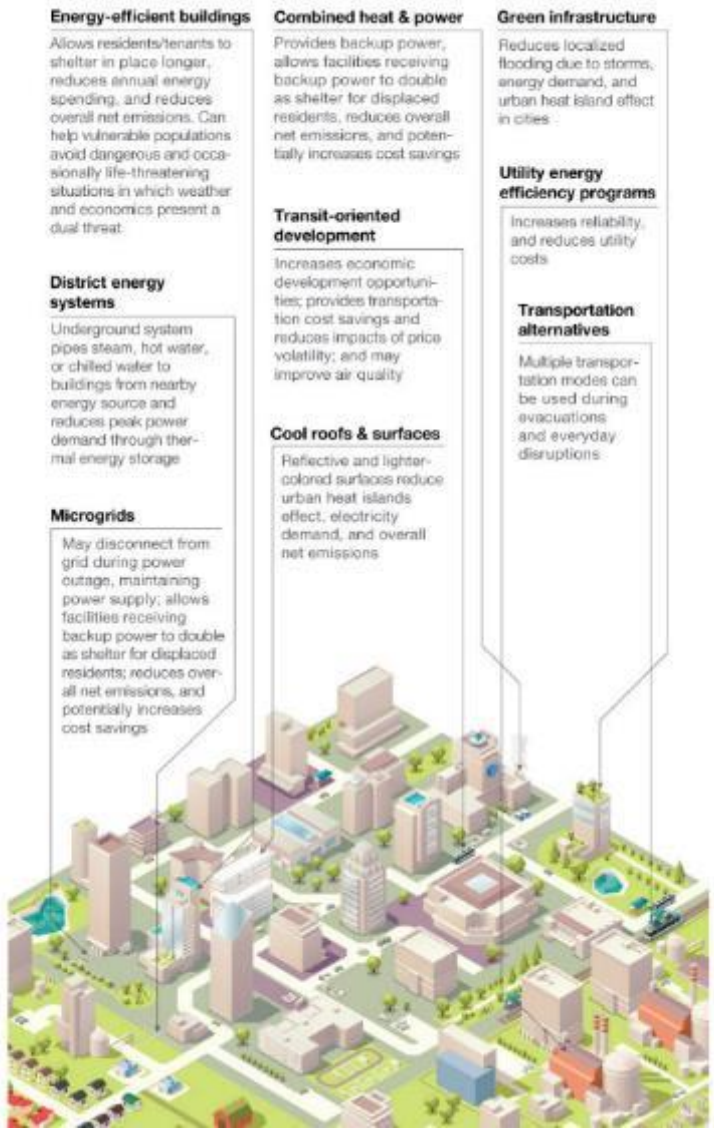


Image source ACEEE

- Climate zone and geographic location will dictate which measures are most effective for ensuring “passive survivability”
- Resilience cannot be achieved in a silo – community and holistic approach will be more effective
- Energy efficiency is important to consider along with solutions that address critical infrastructure resilience, transportation, green infrastructure, microgrids, alternative on-site energy
- Mitigation efforts are different than recovery efforts and new construction is different than retrofits

Strategies to Consider

Consumer education is key when replacing appliances, lighting, air conditioning units and water heaters. Appliances use a high percentage of energy indicating there is room for improving energy performance through higher efficiency equipment. Direct residential or commercial property owners to www.energystar.gov/products.

Strategies to Consider

Building codes set minimum requirements for building quality, safety, and energy performance. Updating and enforcing the latest residential energy efficiency codes ensures new homes or major renovations, are built to the highest standards. State Energy Offices can look for opportunities to integrate disaster mitigation and resilience into future versions of building codes. New construction is the most cost-effective phase in which to establish energy efficiency elements. Building energy codes serve as a starting point to reduce energy dependence and extend natural resources.

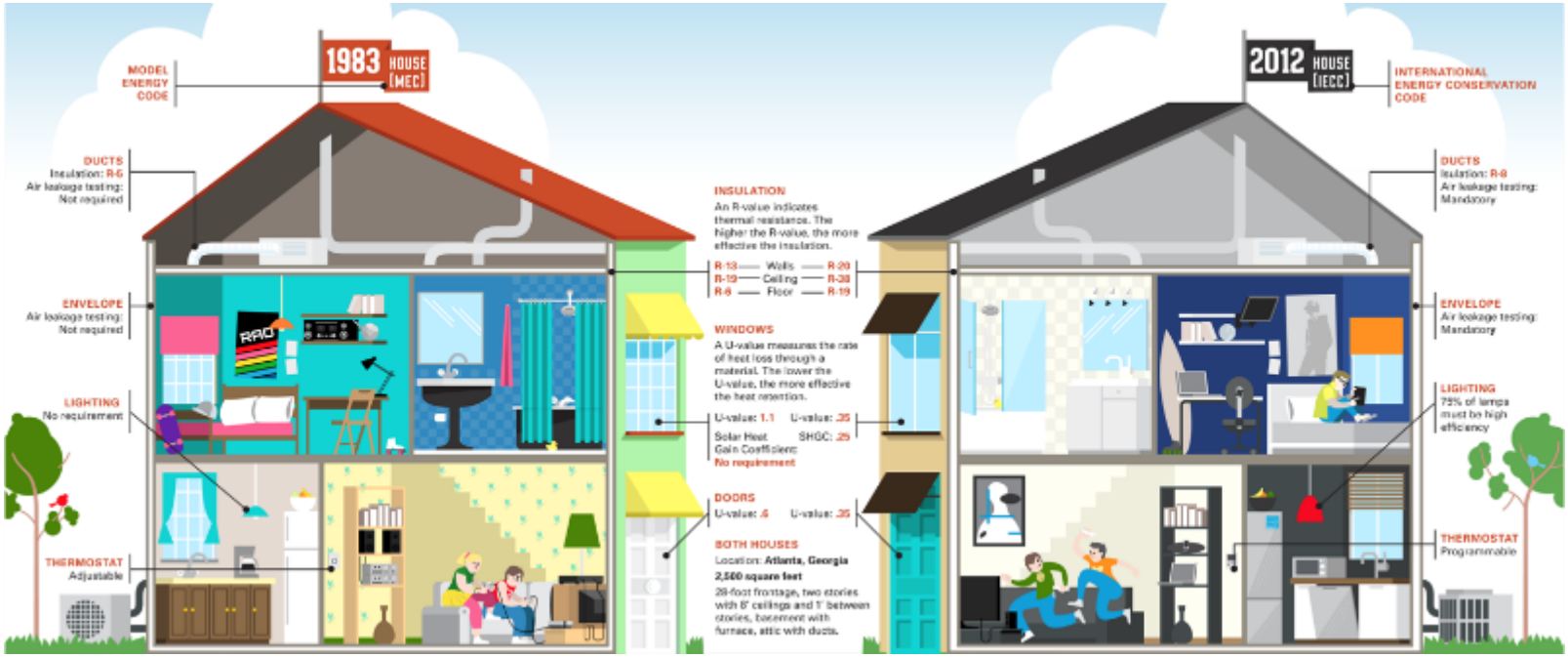


Image source: Global Buildings Performance Network

Strategies to Consider

When flood proofing or elevating a building, consider how these changes will increase infiltration or building envelope exposure (e.g., raising a floor will increase the exposed surface area). Energy efficiency measures that can be deployed are weather stripping, air sealing, and increasing the R-value of insulation.

Image sources: left Sharon Karr, FEMA right Adam DuBrowa, FEMA

Case Study: Efficiency and Resilience in Practice

In December 2013 an ice storm hit Maine and temperatures in Belfast, Maine reached -5˚F. Power was out for days in Central Maine Power and Bangor Hydro Electric territory with 160,000 homes and businesses left without power. Shelters saw a total of 255 overnight stays and served 1,600 meals and snacks.

Belfast Eco-village was built to Passivhaus standards, has 10” thick walls, triple paned windows, and high levels of insulation. Some homes in the village have solar PV and solar hot water. After 4 ½ days without power the temperature inside one of the homes was recorded at 58˚F.

Portland Press Herald
Co-housing Association of the United States
Images from Belfast Co-housing and Ecovillage

Tools and Resources

Building America Solution Center

Provides access to expert information on hundreds of high-performance construction topics, including air sealing and insulation, HVAC components, windows, indoor air quality, and much more. Visit https://basc.pnnl.gov/ to learn more!

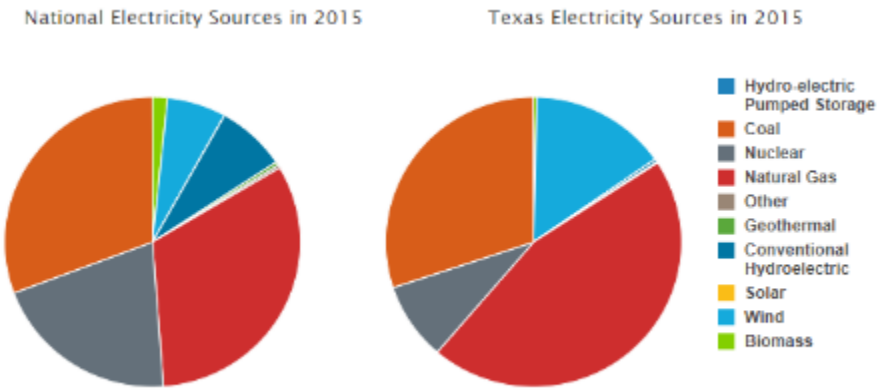
Tools and Resources

Cities Leading through Energy Analysis and Planning

The Cities Leading through Energy Analysis and Planning (Cities-LEAP) program

Information, resources and tools that may be valuable during recovery. Cities-LEAP delivers standardized, localized energy data and analysis that enables cities to integrate strategic energy analysis into decision making. Cities-LEAP supports the widespread implementation of city-sponsored data-driven energy policies, programs, and projects that have the potential to drive a sea change in the national energy landscape. Resources can help:

- Set energy goals
- Prioritize and implement energy strategies
- See the impacts of potential climate or energy action plans
- Learn from peers about city energy planning best practices
- Get access to credible data and transparent, usable analytic methodologies
- Make data-driven energy decisions



Visit https://energy.gov/eere/cities-leading-through-energy-analysis-and-planning to learn more!

Resilience Roadmap

A Collaborative Approach to Multi-Jurisdictional Planning

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

To mitigate hazards and risks, the Resilience Roadmap offers comprehensive guidance for federal, state, and local entities to effectively convene at the regional level for adaptable and holistic planning. This multi-jurisdictional approach requires major cooperation across boundaries, considerable reliance on partnerships and multi-agency collaborations, and significant utilization of interdisciplinary teams.

WHAT IS RESILIENCE?

The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions.

Step-by-Step Process

To constructively lead intergovernmental planning efforts with tangible outputs, follow these steps in order:

1. Intergovernmental Preparation and Coordination
2. Planning and Strategy Development
3. Plan Adoption, Implementation, and Evaluation

The National Renewable Energy Laboratory developed this application with support from the U.S. Department of Energy's Federal Energy Management Program. For information about working with NREL on resilience planning, contact Eliza Hotchkiss.

https://www.nrel.gov/resilience-planning-roadmap/

Key Points

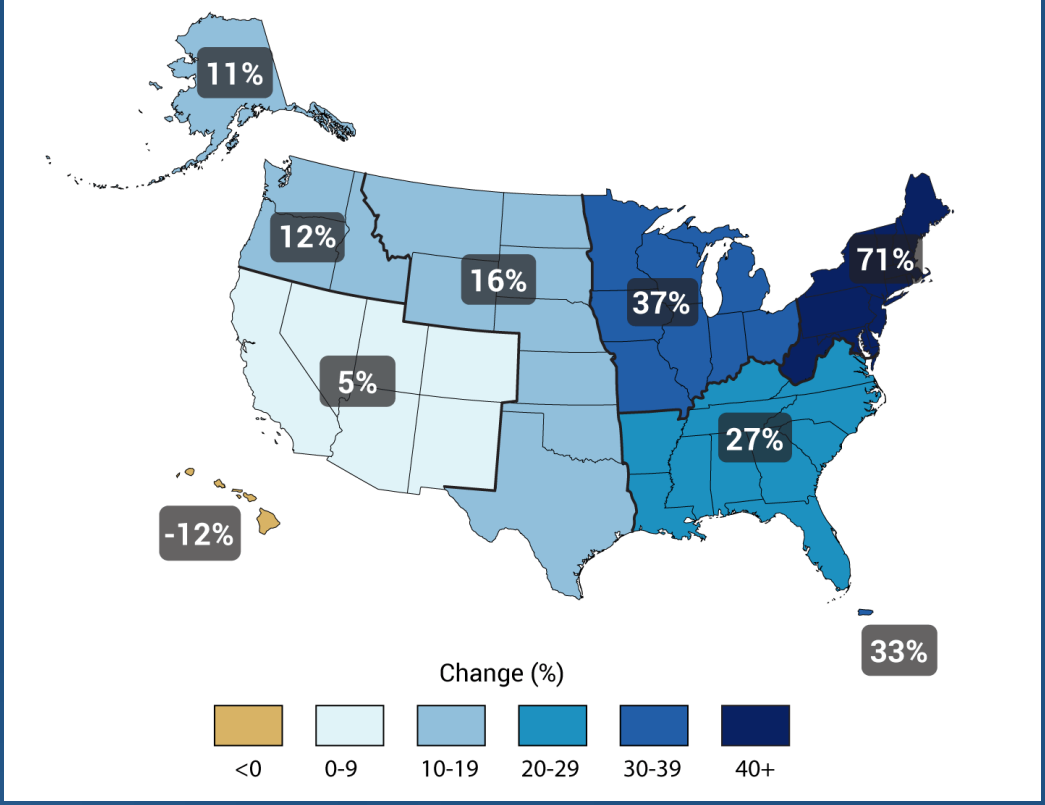
- No one-size-fits-all solutions; must consider local peculiarities in climate, construction, etc.
- Look for opportunities to integrate disaster mitigation and resilience into future versions of building codes
- NREL has developed a Resilience Roadmap which can guide governmental planning efforts

Alex Wilson
Resilient Design Institute

U.S. DEPARTMENT OF ENERGY

Power outages to become more frequent

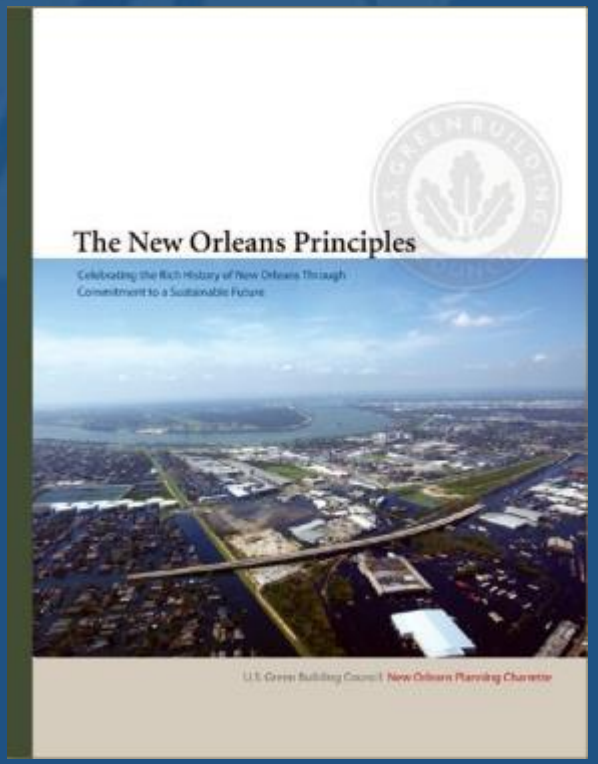
- Climate change related:
  - More intense storms
  - Sea level rise
  - Coastal storm surge
  - Heat waves stressing electrical loads
  - Drought
  - Wildfire
- Non climate-change related
  - Earthquakes
  - Space weather
  - Equipment malfunctions
  - Terrorism



Percent increase in very heavy precipitation 1958-2012 (defined as the heaviest 1% of all events). Source: 2014 National Climate Assessment

Introducing "passive survivability"

Charrette on Gulf Coast reconstruction in the fall of 2005—introducing "Passive Survivability. Photo: Alex Wilson



The New Orleans Principles

8 · *Provide for passive survivability*

Homes, schools, public buildings, and neighborhoods should be designed and built or rebuilt to serve as livable refuges in the event of crisis or breakdown of energy, water, and sewer systems.

Addressing passive survivability

BR 6

Analyze Strategies to Maintain Habitability During Power Outages

Issue:
Research on climate change indicates that there will be an increase in the frequency and severity of events that can disrupt the city's power, water, sewer and transportation infrastructure. In the event that city services are not usable, passive and dual-mode functions will be critical.

Recommendation:
Undertake a comprehensive study of passive survivability and dual-mode functionality, then propose code changes to incorporate these concepts into the city's building codes. Also include a study on refuge areas in sealed buildings.

Benefits	Costs
N/A Savings	N/A Cost
Health & Safety	
Environment	

New York City – Greening the Codes Task Force Report - 2010

Addressing passive survivability

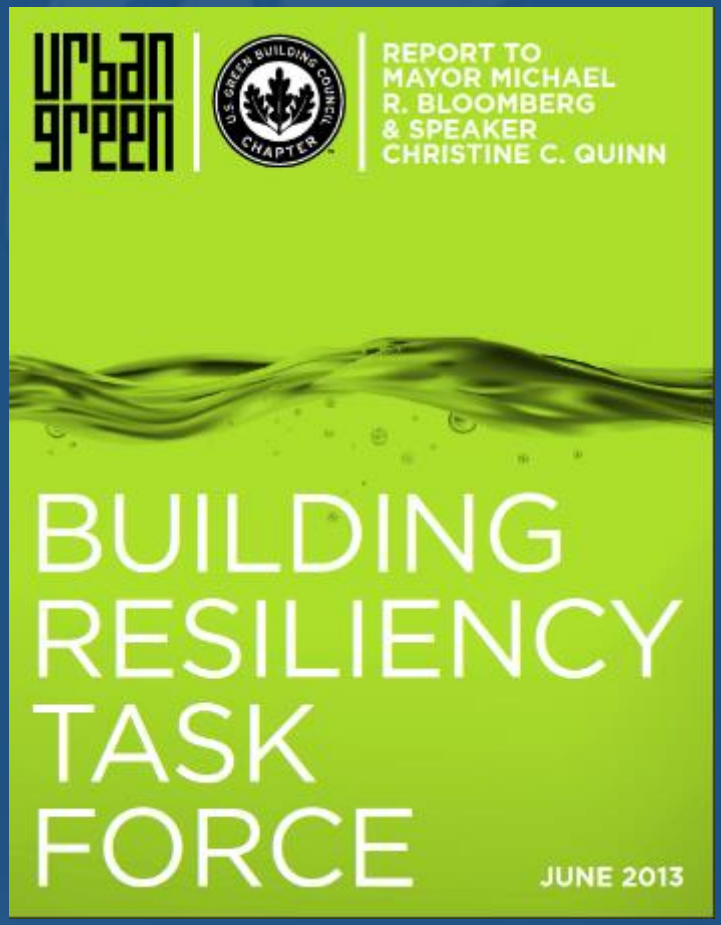
27 Maintain Habitable Temperatures Without Power

Issue: Utility failures often disable heating and cooling systems, leaving interior building temperatures dependent on whatever protection is provided by the insulation and air sealing of a building's walls, windows, and roof.

Recommendation: Extend the mandate of the Task Force through Fall 2013 to develop a multiyear strategy for ensuring that new and substantially altered buildings maintain habitable temperatures during utility failures. Clarify requirements for tightly sealing new windows and doors and upgrading roof insulation during roof replacement.

✚ further action

Recommendation from the Building Resiliency Task Force



Building Resiliency Task Force in New York City – Final Report, June, 2013

Addressing passive survivability

May 2013 RDI charrette in NYC on metrics of passive survivability. Photo: Alex Wilson

BRI Building Research & Information 2016
Vol. 44, No. 1, 1–19, http://dx.doi.org/10.1080/09613218.2015.1033875

Routledge
Taylor & Francis Group

INFORMATION PAPER

Overheating and passive habitability: indoor health and heat indices

Seth H. Holmes[1], Thomas Phillips[2] and Alex Wilson[3]

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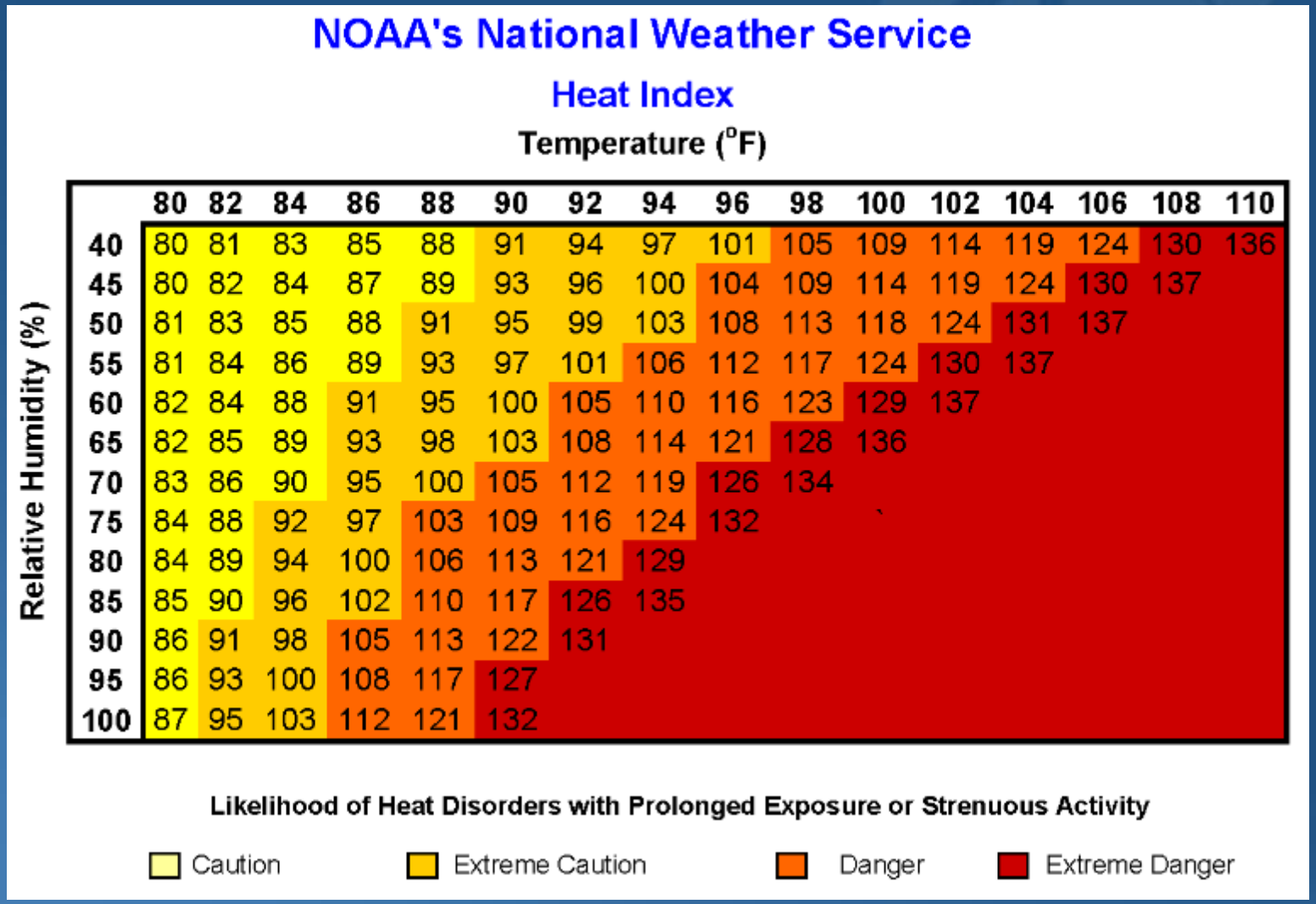
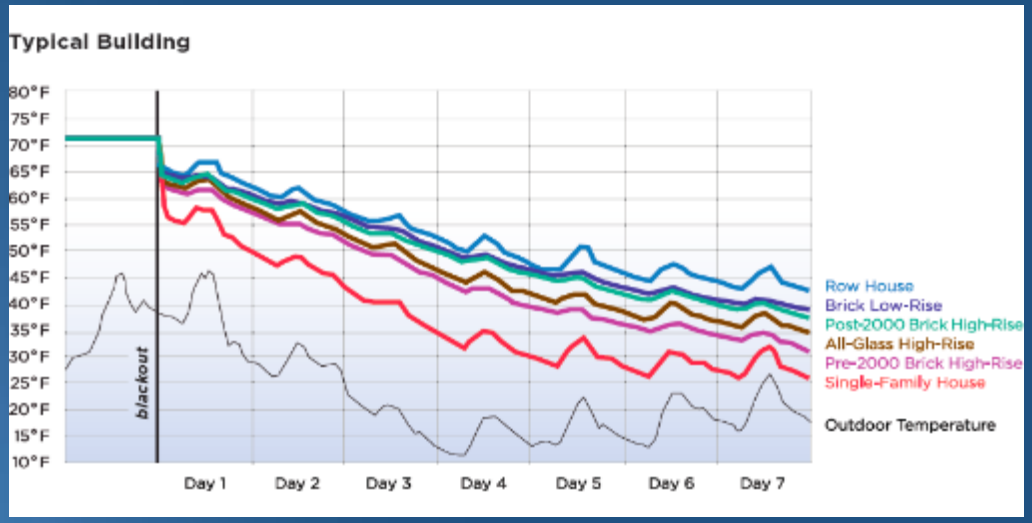
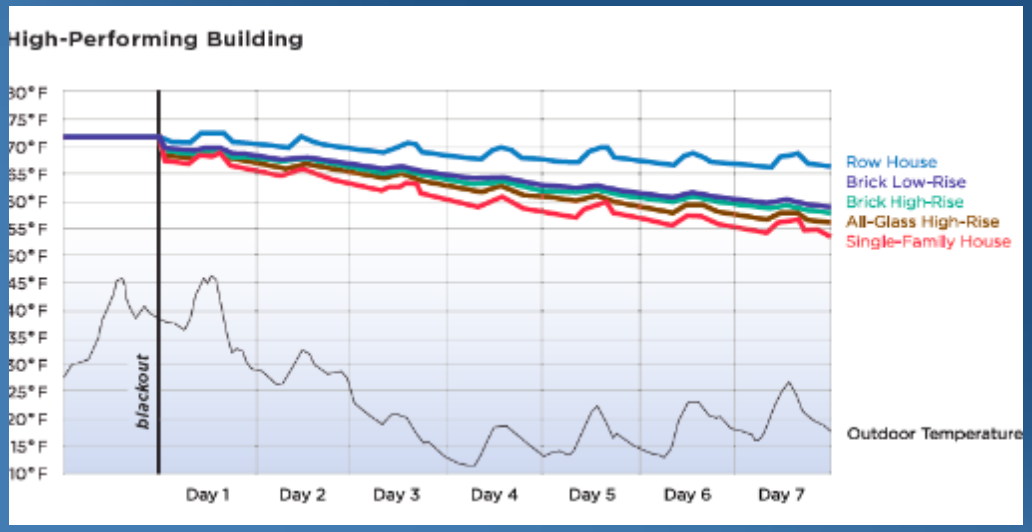
As extreme heat and weather events are predicted to increase due to global warming, the risk of human heat stress within buildings will increase. To be resilient, buildings will need the capacity to provide habitable indoor conditions without power for limited amounts of time. Additional indoor thermal standards are required for public health to address 'passive habitability' during power outages. Current research on building-related heat stress and numerous heat indices is examined in relation to the development of a new heat-safety metric for use in passively conditioned buildings. Most indoor overheating research relies on outdoor temperature data and has no common indoor heat index for evaluating indoor heat stress. A recommendation is made for using the wet-bulb globe temperature (WBGT) and predicted heat strain (PHS) indices for modelling and monitoring of indoor heat stress in healthy adult populations because both indices utilize the primary thermoregulation variables, have associated heat-stress thresholds, and can be assessed or tracked with existing environmental monitoring methods and predictive energy modelling techniques. Further research is recommended on health effects and exposure limits of vulnerable populations, and the variation in thermal factors within buildings and the building stock.

Habitability isn't just about temperature



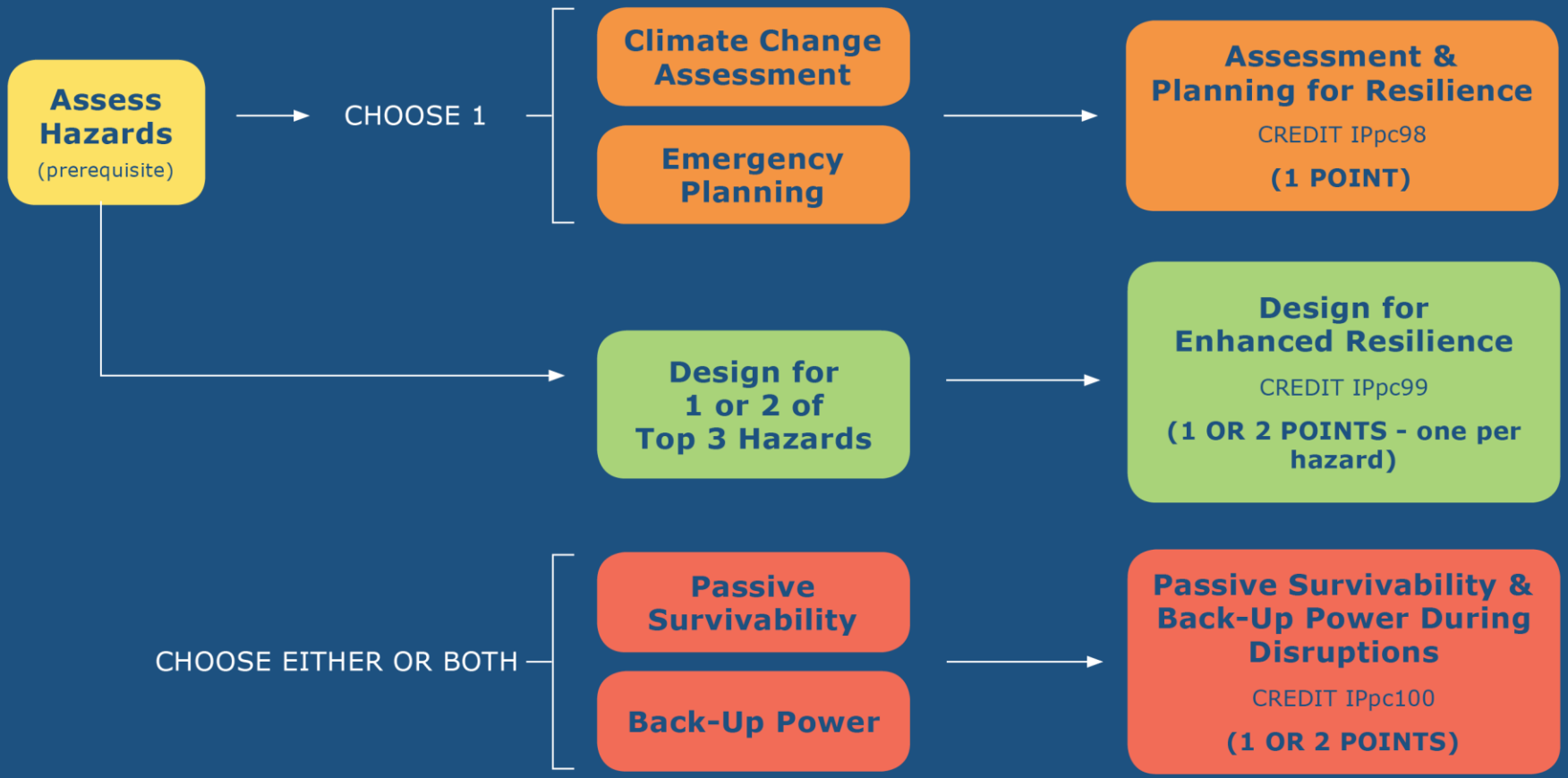
Addressing passive survivability



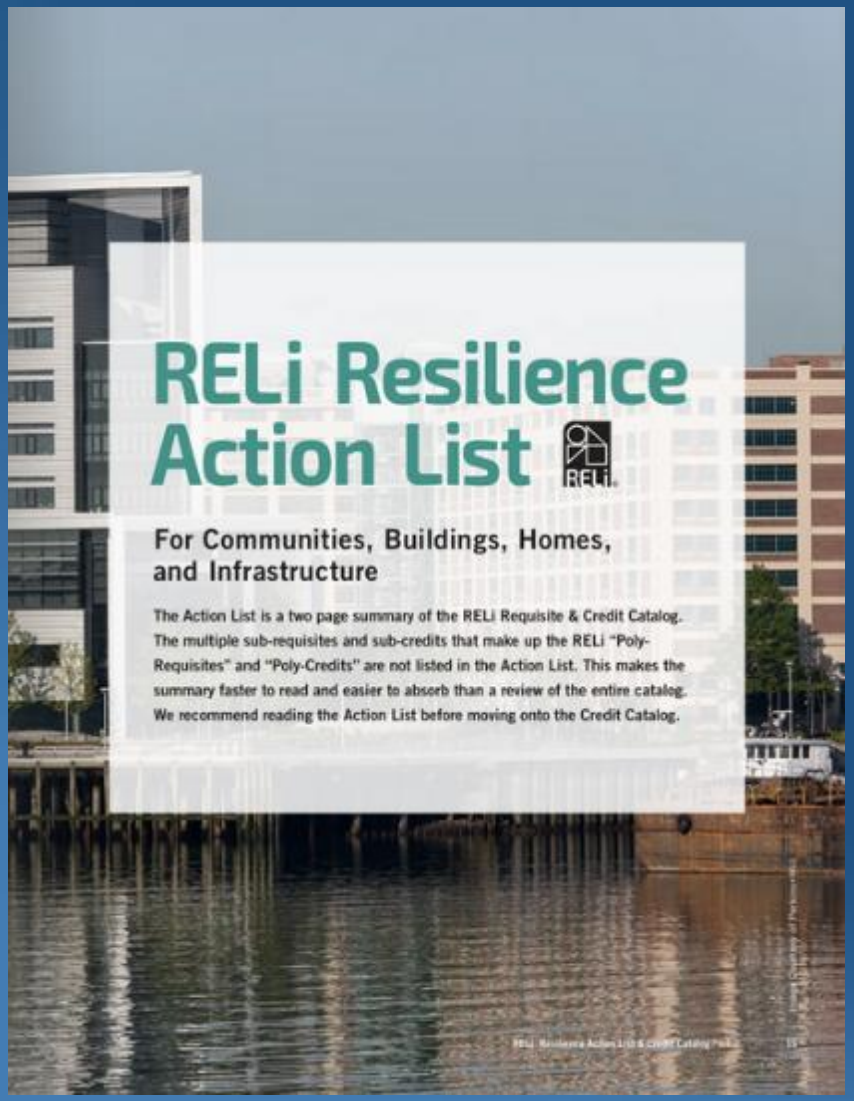


Baby It's Cold Inside report from Urban Green - June, 2013

Addressing passive survivability LEED pilot credits on Resilient Design



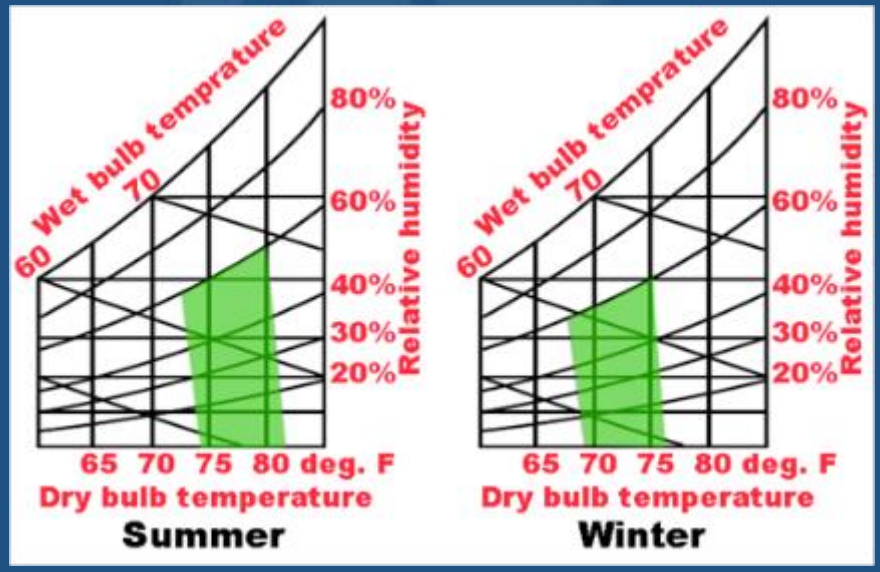
Addressing passive survivability
RELi Rating System – "Thermal safety"



- Credit 3.2 – Advance thermal safety during emergencies

Understanding the "Habitability Zone"

- Different from "Comfort Zone"
- "Habitability zone" much wider
- Influenced by temperature, humidity, mean radiant temperature
- For LEED Pilot Credit 100, we decided on SET temperature
- From low of 54°F SET to high of 86°F SET
- Defining how much time a building can deviate from that habitability zone
- Based on limited physiological data



Conventional "Comfort Zone"
Jonathan Ochshorn, 2010

LEED Pilot Credit 100: Thermal Habitability

Requirements:

- Demonstrate through thermal modeling that a building will passively maintain "habitable temperatures" during a power outage that lasts 4 days during peak summertime and wintertime conditions of a typical year.

Key Definitions:

- Standard Effective Temperature (SET) factors in relative humidity and mean radiant temperature
- Habitable Zones: Defined by team
- Occupant Density: necessary to accommodate the total building population in the habitable zones.
- Ventilation: All habitable zones must have access to natural ventilation

Livable temperature:

- Cooling: Not to exceed 9 °F SET-days (216 °F SET-hours) above 86°F SET for residential buildings.
- Cooling Not to exceed 18 °F SET-days (432°F SET-hours) above 86°F SET for non-residential buildings.
- Heating: Not to exceed 9 °F SET-days (216 °F SET-hours) below 54° SET for all buildings.

Passive House certification

Passive House-certified Kawahara residence in Santa Cruz, CA - photo: Alex Wilson

- The German Passive House standard and the U.S. adaptation of that standard provide reasonably good indicators of passive survivability
- Thus, Passive House certification has been accepted as an alternative compliance path for passive survivability in the LEED pilot credits
- With natural ventilation

Passive survivability – Kenogami House

Kenogami House in Northern Quebec. Photo: Alain Hamel

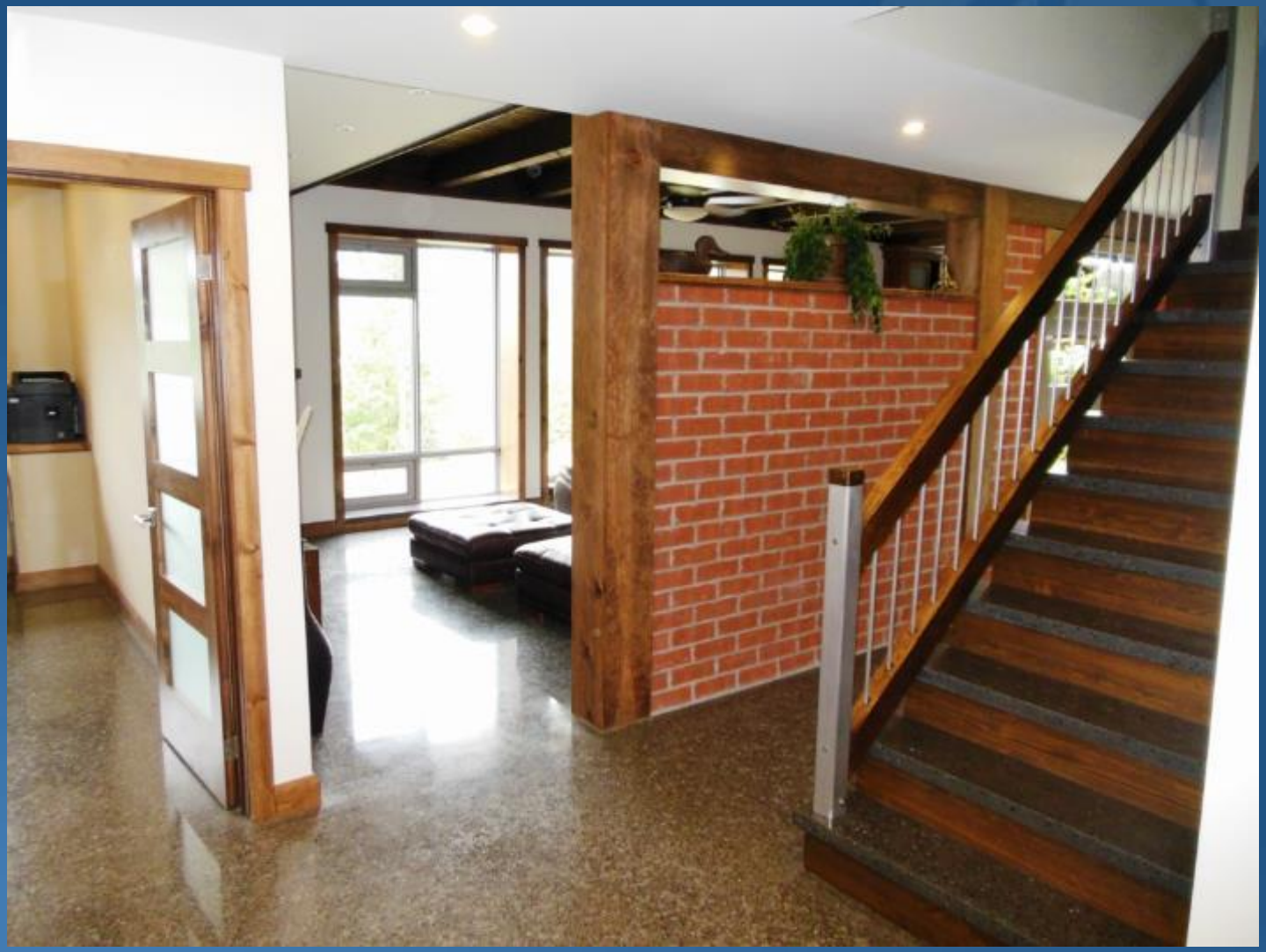
- One of the most resilient homes in North America
- Extreme climate:
  - 10,450 ° F HDD
  - 130 miles north of Quebec City
- Very heavy snow loads
- 2,200 sf home built in 2012

Kenogami House – passive survivability

Kenogami House in Northern Quebec. Photo: Alain Hamel

- Extremely high insulation levels:
  - R-80 walls and foundation walls
  - R-64 floor
  - R-150 roof
- Triple-glazed, dual-low-e, high-SHGC windows
- Tighter than Passive House (0.5 ACH_{50})
- Snow load double the code requirement

Kenogami House – passive survivability



Kenogami House in Northern Quebec. Photo: Alain Hamel

Spaulding Rehab Hospital – passive survivability

Photo: Perkins+Will

Operable windows

Photo: Alex Wilson

Photo: Anton Grassl/Esto, Courtesy of Perkins+Will

High-performance envelope

- Triple glazing throughout
- Spectrally selective glazing
- High insulation levels
- Insulated spandrel panels
- Passive shading system

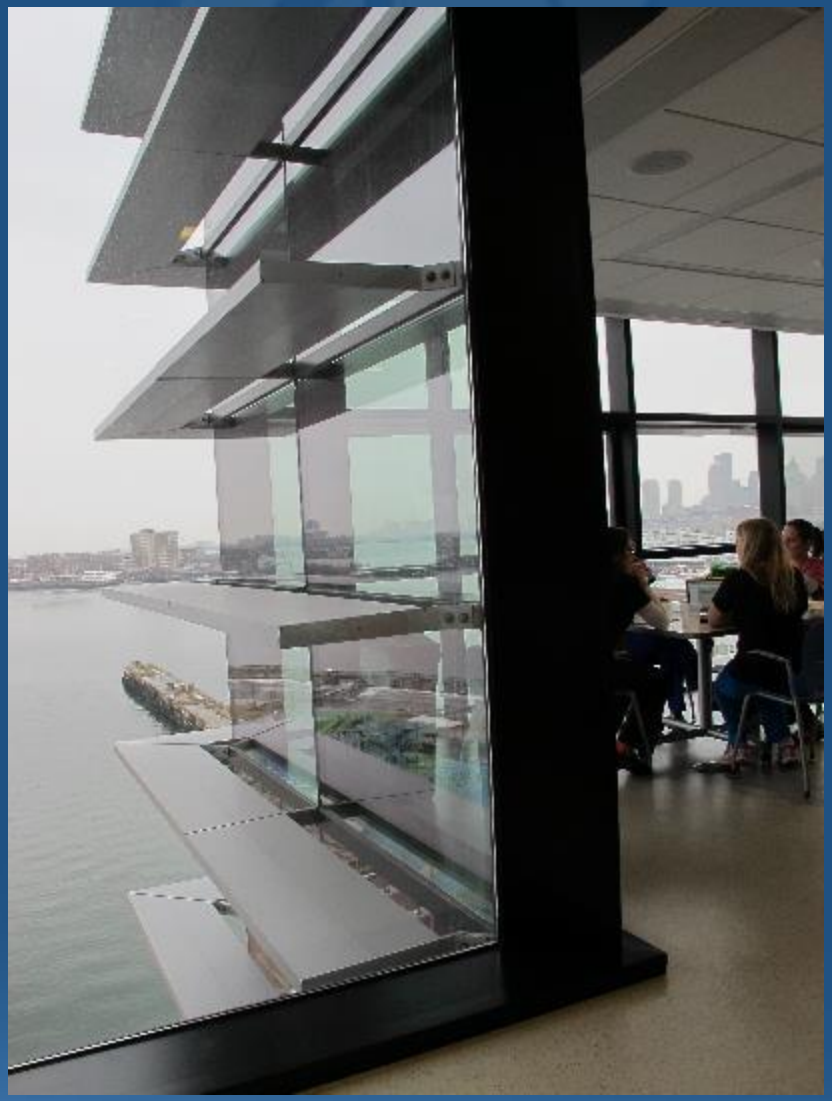


Photo:
Alex Wilson

Floodable first floor

- Wet floodproofing
- 100% wettable materials (tile, polished concrete, etc.)
- Therapeutic pool
- Therapeutic exercise area with portable equipment
- Avoidance of mechanical systems

Photo: Spaulding Rehab Hospital

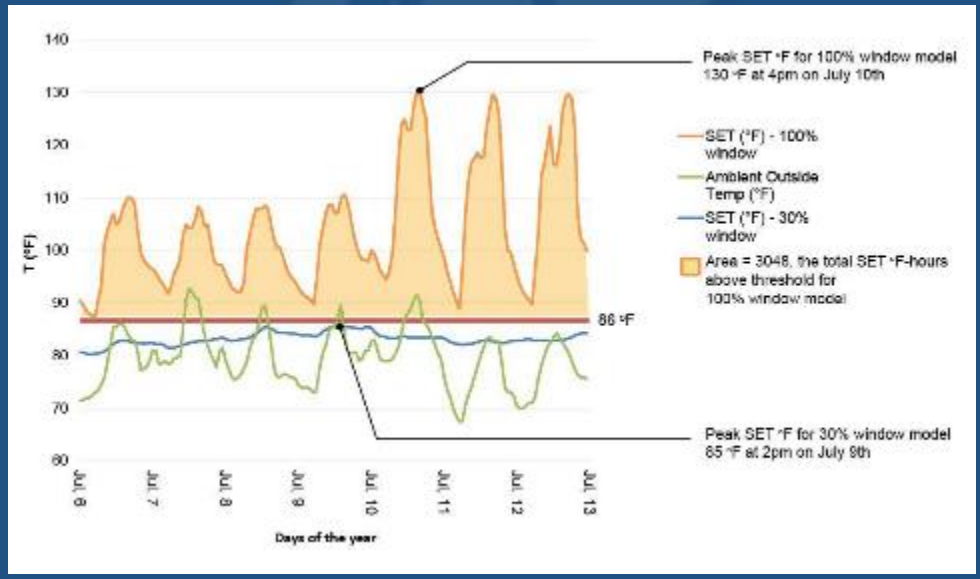
Elevated mechanical equipment

- Utility service in penthouse floor
- Rooftop CHP system
- Chillers, air handlers, ventilation, boilers in two penthouse floors
- Two back-up generators in penthouse - either could operate hospital
- Most diesel fuel stored in basement - bunkerized

Photo: Alex Wilson

The road ahead – Research Needs

- Refining the metrics of passive survivability—what are the best metrics?
- Gaining a better understanding of human health and indoor conditions during extremes
- Creating robust methodologies for assessing passive survivability
- Developing strategies for incentivizing or codifying passive survivability



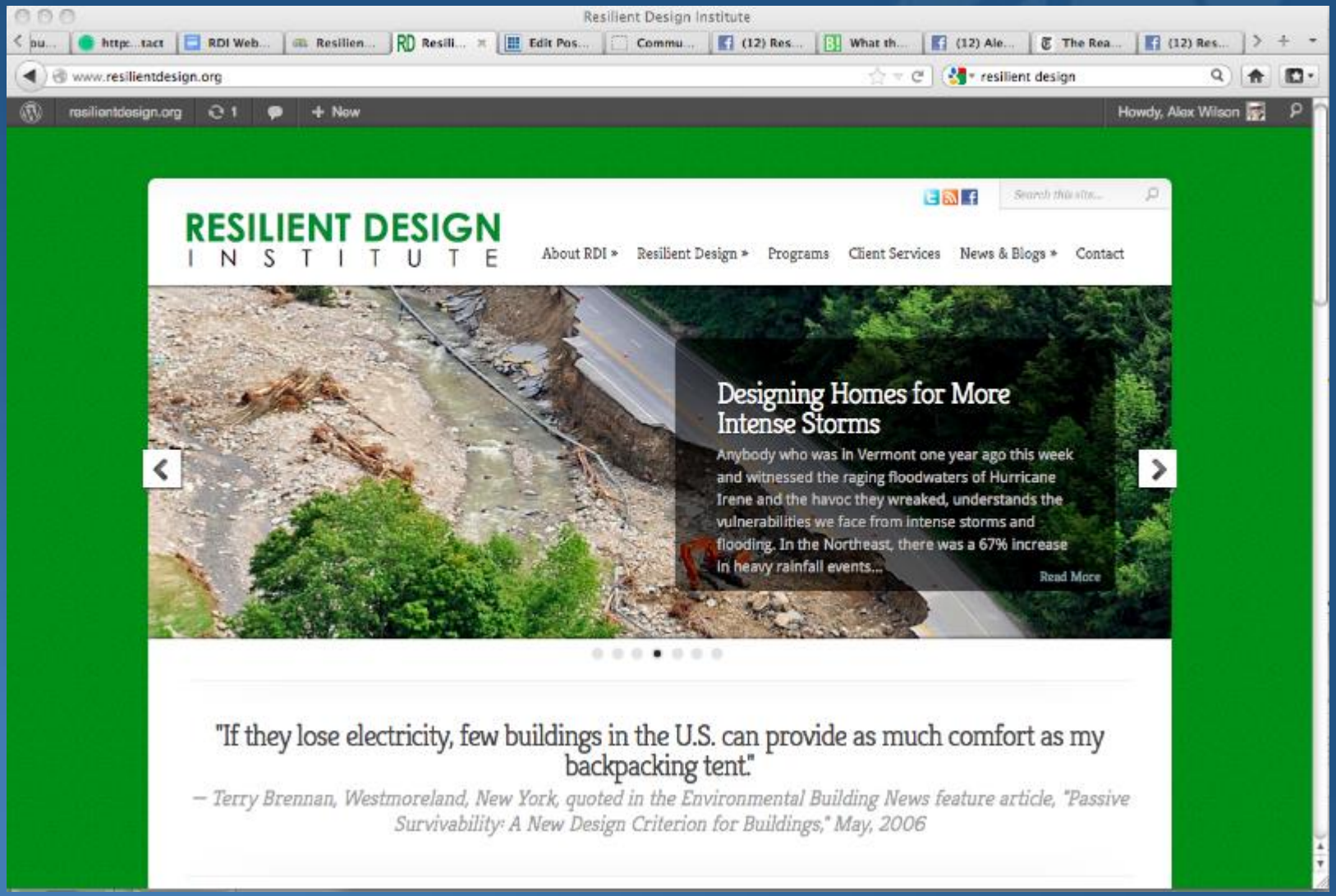
Analysis done by Erik Olsen of Transsolar in New York City to test the SET methodology being used in the LEED pilot credits – Image: Transsolar

Three take-away points:

1. More energy-efficient buildings are more resilient
2. Keeping people safe can be a motivation for creating highly energy-efficient buildings
3. While this is an adaptation strategy, it also reduces energy consumption and CO_2 emissions—so it is a climate change mitigation strategy

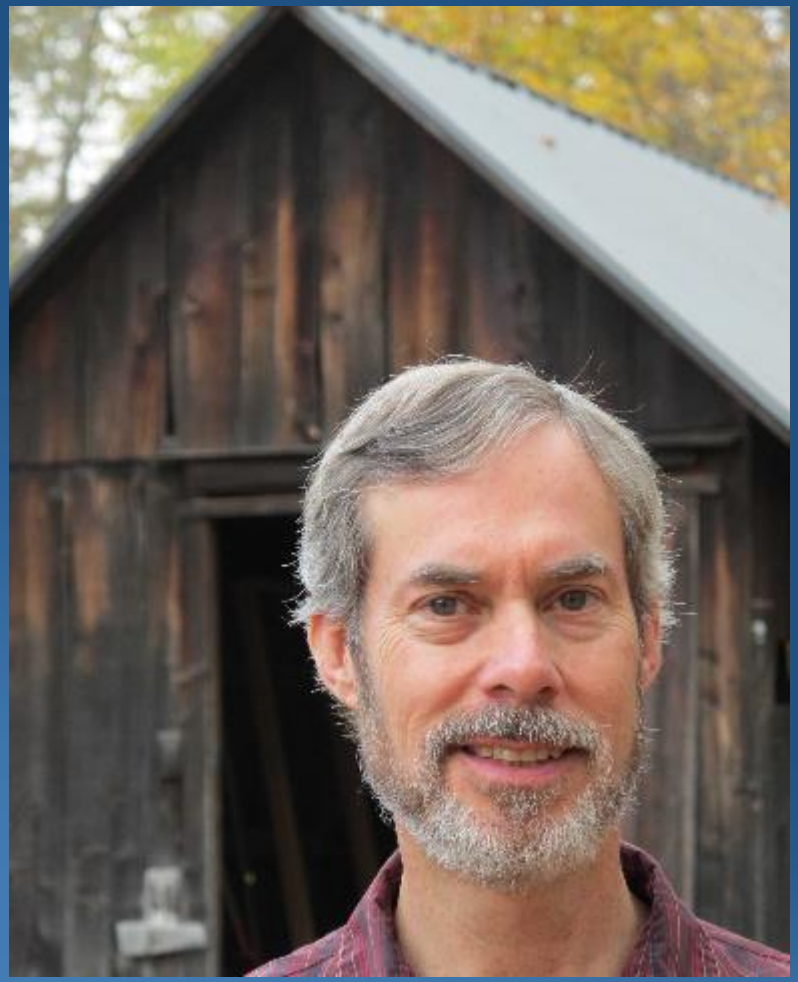
Our renovated, net-zero-energy house in Dummerston, Vermont – photo: Alex Wilson

Resilient Design Institute
www.ResilientDesign.org



Passive survivability

Resiliency and energy efficiency hand-in-hand



Resiliency in the Face of Disaster: Energy Efficiency's Role

DOE Webinar

January 24, 2019

Alex Wilson, President
Resilient Design Institute
Founder, BuildingGreen

Key Points

- More energy-efficient buildings are more resilient
- Keeping people safe can be a motivation for creating highly energy-efficient buildings
- While this is an adaptation strategy, it also reduces energy consumption and CO2 emissions—so it is a climate change mitigation strategy

Pasha Majdi
American Council for an Energy-Efficient Economy

U.S. DEPARTMENT OF ENERGY

Opportunities for the Federal Government to Increase Resilience and Disaster Preparedness through Building Energy Codes

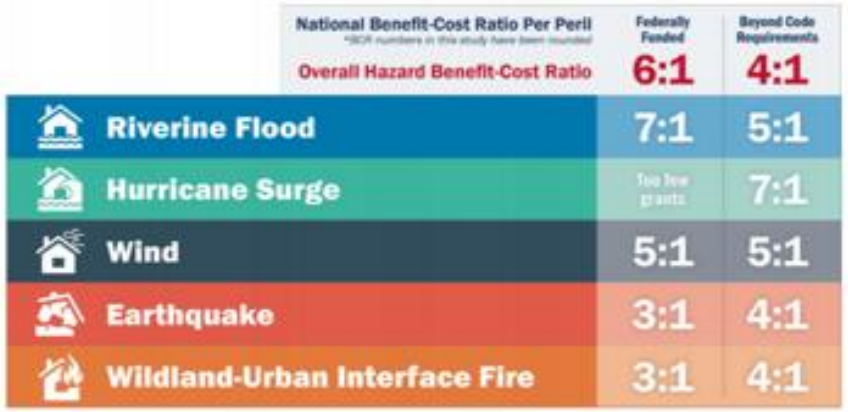
Pasha Majdi

American Council for an Energy-Efficient Economy

ACEEE
American Council for an Energy-Efficient Economy

Disaster Recovery Reform Act

- Reforms FEMA, Stafford Act
- Passed Senate 93-6 Oct. 3, signed into law Oct. 5 2018
- Not yet implemented
- Ounce of prevention…



National Benefit-Cost Ratio Per Peril	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
Riverine Flood	7:1	5:1
Hurricane Surge	Too few grants	7:1
Wind	5:1	5:1
Earthquake	3:1	4:1
Wildland-Urban Interface Fire	3:1	4:1

National Institute of Building Sciences (NIBS) 2017 Interim Report Summary of Findings
Table 1: Benefit-Cost Ratio by Hazard and Mitigation Measure

ACEEE
American Council for an Energy-Efficient Economy

Building Codes

- Building **energy** codes should be included in DRRA implementation because they improve hazard mitigation and resilience.

- Building codes and standards **establishment** should be a high priority for predisaster mitigation funds.

Federal Role?

- Yes!

FEMA Administrator Brock Long:

"Until we get building codes passed at local and state levels that are meaningful, then we're going to continue to see a lot of damage and destruction."

Flavelle, Christopher. "FEMA Administrator Slams Failures to Prepare, Evacuate Before Storms." *Bloomberg*, October 12, 2018.

"Working with our state partners is critical to ensuring our shared responsibility of preparing for & responding to all hazards. #resilience"

FEMA_Brock. July 15, 2017, 11:59 AM. Tweet.

Building Energy Codes

"Consensus-based codes and standards"

1. ANSI/ASHRAE/IES Standard 90.1
2. International Energy Conservation Code (IECC)
3. 2018-IgCC (2018 International Green Construction Code Powered by ANSI/ASHRAE/ICC/USGBC/IES - Standard 189.1)

Building Energy Codes Enhance Resilience

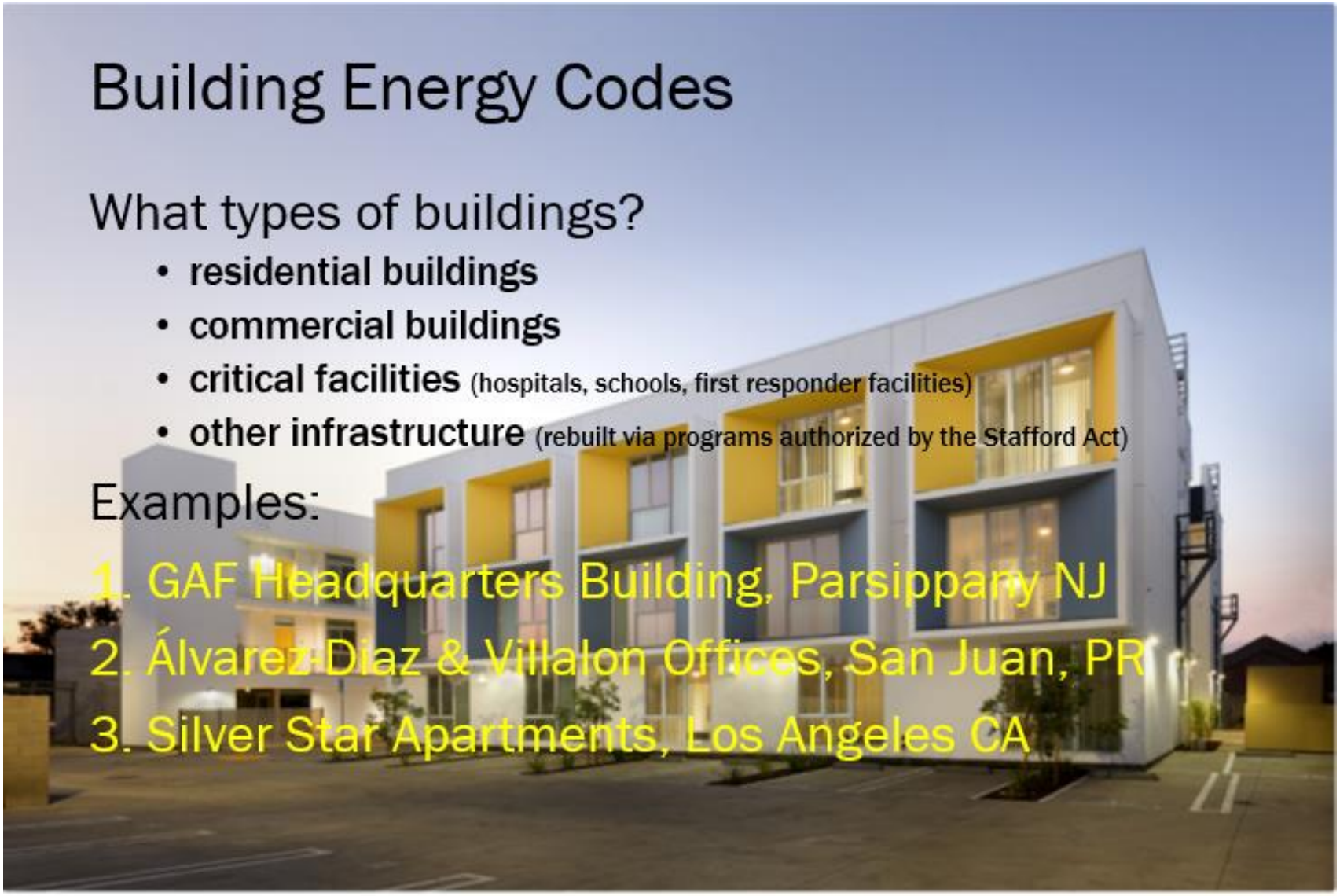
Resilience benefits:

1. backup power
2. reduce electric demand
3. maintain temperatures better (comfort/survivability)

Resilient technologies and strategies:

1. back-up power generation (CHP, microgrids, district energy systems)
2. securable and durable building envelopes
3. efficient heating and cooling systems
4. interior lighting control systems for individual occupants
5. greywater systems for irrigation and indoor non-potable water usage
6. access to multiple modes of transportation including public transit and electric vehicles
7. cool roofs and surfaces
8. employment of microgrids
9. incorporation of green infrastructure
10. ...other...

Building Energy Codes



What types of buildings?

- **residential buildings**
- **commercial buildings**
- **critical facilities** (hospitals, schools, first responder facilities)
- **other infrastructure** (rebuilt via programs authorized by the Stafford Act)

Examples:

1. GAF Headquarters Building, Parsippany NJ
2. Álvarez-Díaz & Villalon Offices, San Juan, PR
3. Silver Star Apartments, Los Angeles CA

Energy Efficiency and Resilience Examples

Texas Medical Center – Hurricane Harvey

Co-op City – Superstorm Sandy

Princeton University microgrid – Superstorm Sandy

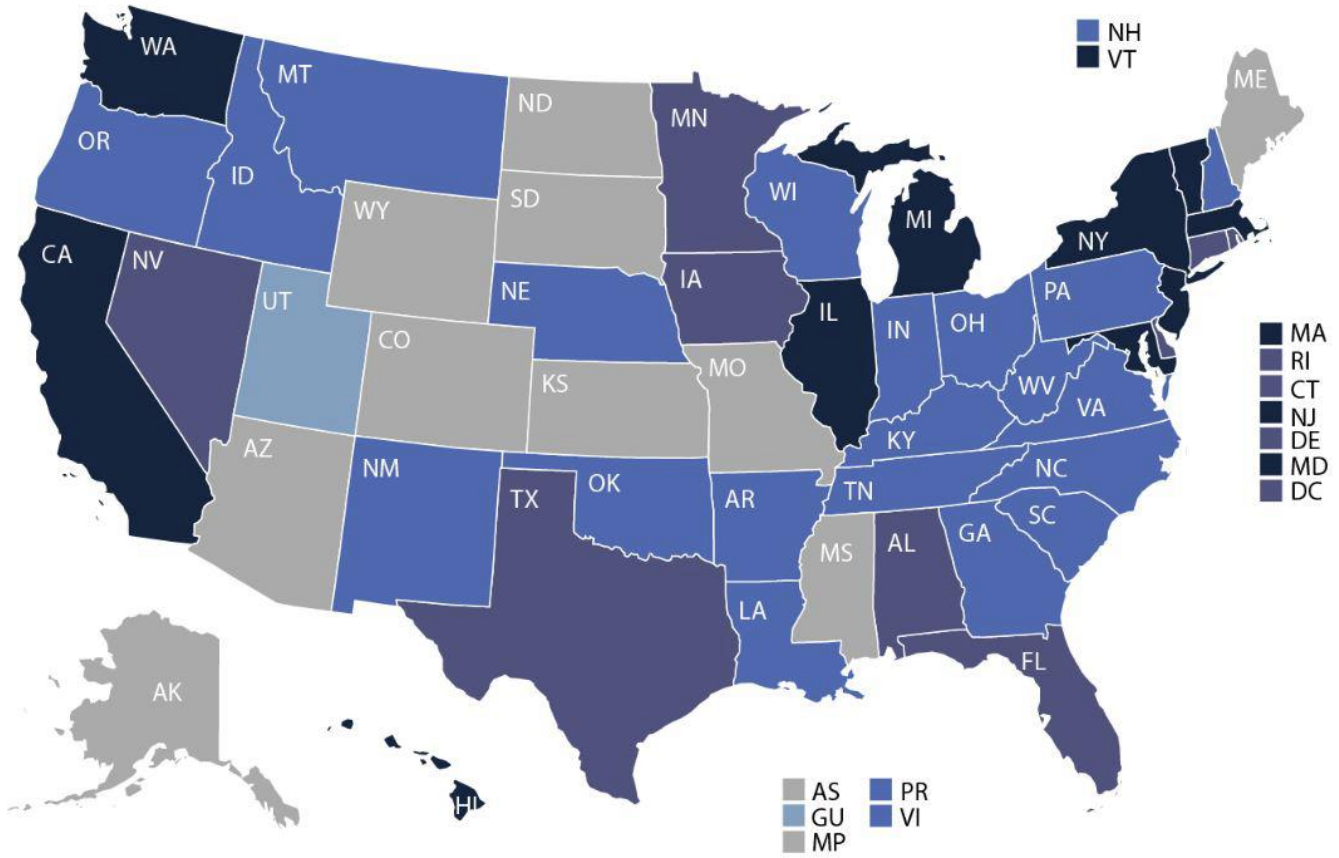
Code adoption and enforcement

Building codes and standards establishment should be a high priority for pre-disaster mitigation funds

How will this be implemented?

- Key features: floodplain avoidance, resilient roof structures, emergency supplies, shelter-in-place capability, fire suppression systems, mold resistant materials, and others
- Nine states do not have statewide commercial building codes.
- Only 12 states have codes that either meet or exceed ASHRAE 90.1-2013 standards.

Residential Code Status



Meets or exceeds the **2015 IECC** or equivalent (10)

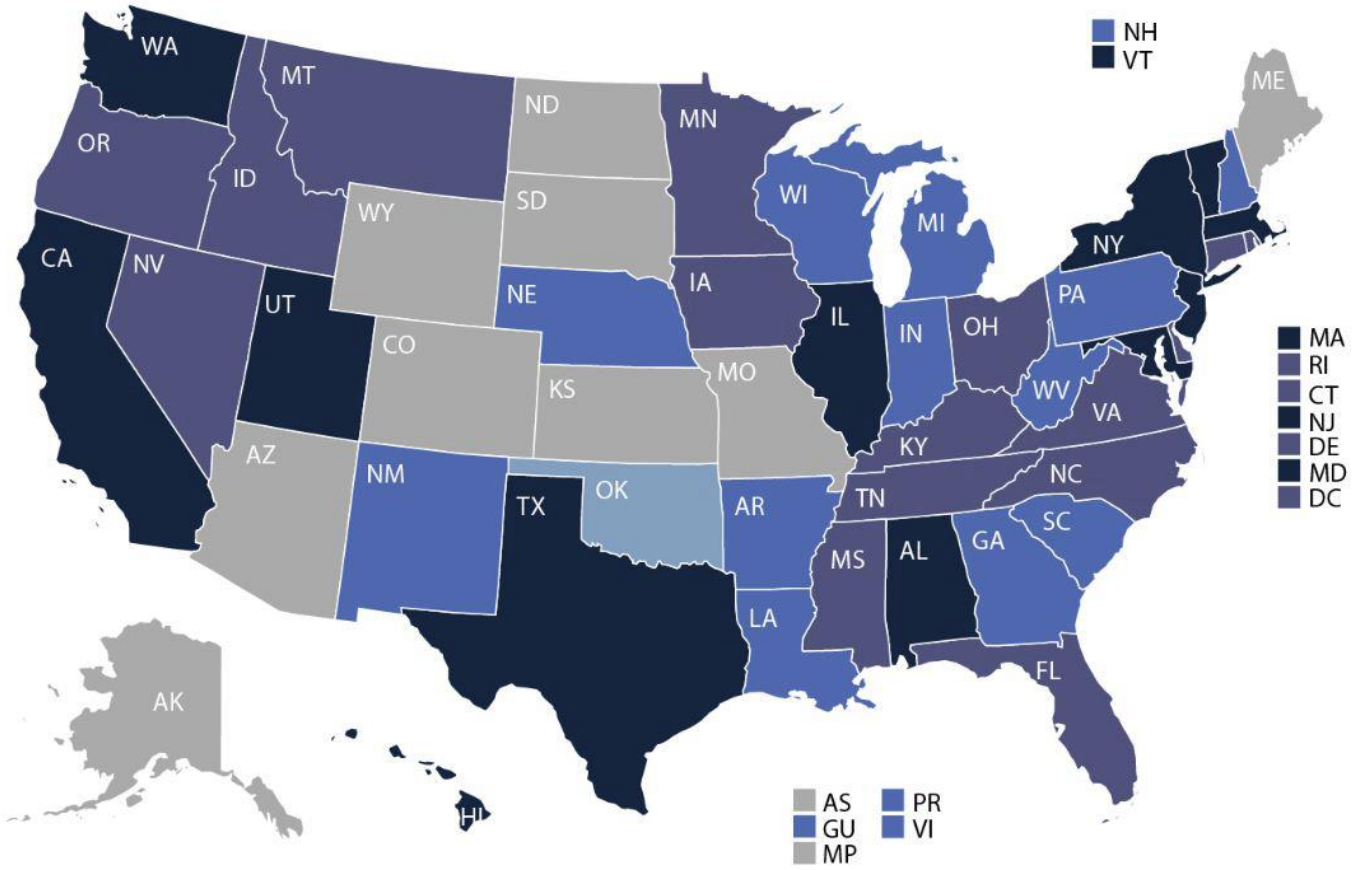
Meets or exceeds the **2012 IECC** or equivalent (10)

Meets or exceeds the **2009 IECC** or equivalent (22)

Meets or exceeds the **2006 IECC** or equivalent (2)

No statewide code or predates the 2006 IECC (12)

Commercial Code Status



Meets or exceeds **ASHRAE 90.1-2013** or equivalent (12)

Meets or exceeds **ASHRAE 90.1-2010** or equivalent (17)

Meets or exceeds **ASHRAE 90.1-2007** or equivalent (15)

Meets or exceeds **ASHRAE 90.1-2004** or equivalent (1)

No statewide code or predates ASHRAE 90.1-2004 (11)

I want my two (billion) dollars!

Increased funding for predisaster mitigation assistance:

- "The President **may** set aside from the Disaster Relief Fund, with respect to each major disaster, an amount equal to 6 percent of the estimated aggregate amount…"

- Over $2B for FY19

- statutory allocation

"Better Off Dead" paperboy/fiscal accountability enthusiast

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Additional Recommendations

1. **Prehazard mitigation grant programs should prioritize resilience**
   - Beyond codes, grants should value resilient technologies such as CHP, microgrids, district energy systems, and high quality building envelopes

2. **Consult government experts**
   - DOE BTO, including Building America, Better Buildings Initiative, etc.
   - Building Technologies Research and Integration Center (BTRIC) at Oak Ridge National Laboratory
   - U.S. Environmental Protection Agency (EPA): ENERGY STAR, Adaptation Resource Center (ARC-X) etc.
   - State governments such as Florida and Texas, see also NASEO and DOE SEP

3. **Use the design and construction industry consensus definition of "resilience"**
   - "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events."

Questions?

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Key Points

- Use code adoption and enforcement planning activities as an opportunity to integrate resilience considerations
- Increase funding for pre-disaster mitigation via statutory allocation of Disaster Relief Fund monies
- Pre-hazard mitigation grant programs should prioritize resilience

Explore the Residential Program Solution Center

Resources to help improve your program and reach energy efficiency targets:

- Handbooks - explain *why* and *how* to implement specific stages of a program.
- Quick Answers - provide answers and resources for common questions.
- Proven Practices posts - include lessons learned, examples, and helpful tips from successful programs.
- Technology Solutions NEW! - present resources on advanced technologies, **HVAC** & **Heat Pump Water Heaters**, including installation guidance, marketing strategies, & potential savings.

https://rpsc.energy.gov

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