Northwest **Power** and **Conservation** Council

December 6, 2022

MEMORANDUM

TO: **Power Committee Members**

FROM: **Tina Jayaweera, Manager, Power Planning Resources**

SUBJECT: **Energy Codes and Passive House**

BACKGROUND:

Presenter: Mark Lyles, New Buildings Institute

Summary: Mark Lyles will speak to work that the New Buildings Institute (NBI) is doing to enhance building codes, aiming for a "passive house" that is extremely energy efficient. The requirements for new construction will educate contractors who can then translate those practices into retrofitting existing structures to improve their efficiency as well as resilience to extreme weather events or power outages. Adopting these practices will also improve comfort and indoor air quality for occupants. Mark will share some examples from jurisdictions that have adopted these principles as a means to decarbonize their building stock.

Relevance: Significant weather events and power outages have resulted in loss of life that may have been prevented if the building had been better built or weatherized.

Background: https://www.phius.org/passive-building/what-passive-building/passive-building-principles

More Info: https://newbuildings.org/

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Energy Codes and Passive House

Creating resilience in cold climates through energy codes

Mark Lyles, Senior Project Manager

Agenda

1. Introduction
2. Overview of Energy Codes
3. Introduction to Passive House (and associated benefits)
4. The Case for Deep Efficiency/Passive House Codes
5. Three Leading States
6. Q&A

New Buildings Institute (NBI)

- 501(c)(3) nonprofit
- 25-year history
- **Mission**: to push for better buildings that achieve zero energy, zero carbon, and beyond – through research, policy, guidance, and market transformation – to protect people and the planet.

NBI works for an equitable transition to net zero outcomes in all new and existing buildings. We shape a new energy future with innovation, research, design guidance, and advanced building policy.

Leadership & Market Development
Driving scale in zero energy and zero carbon buildings

Building & Program Innovation
Best practices in new and existing buildings

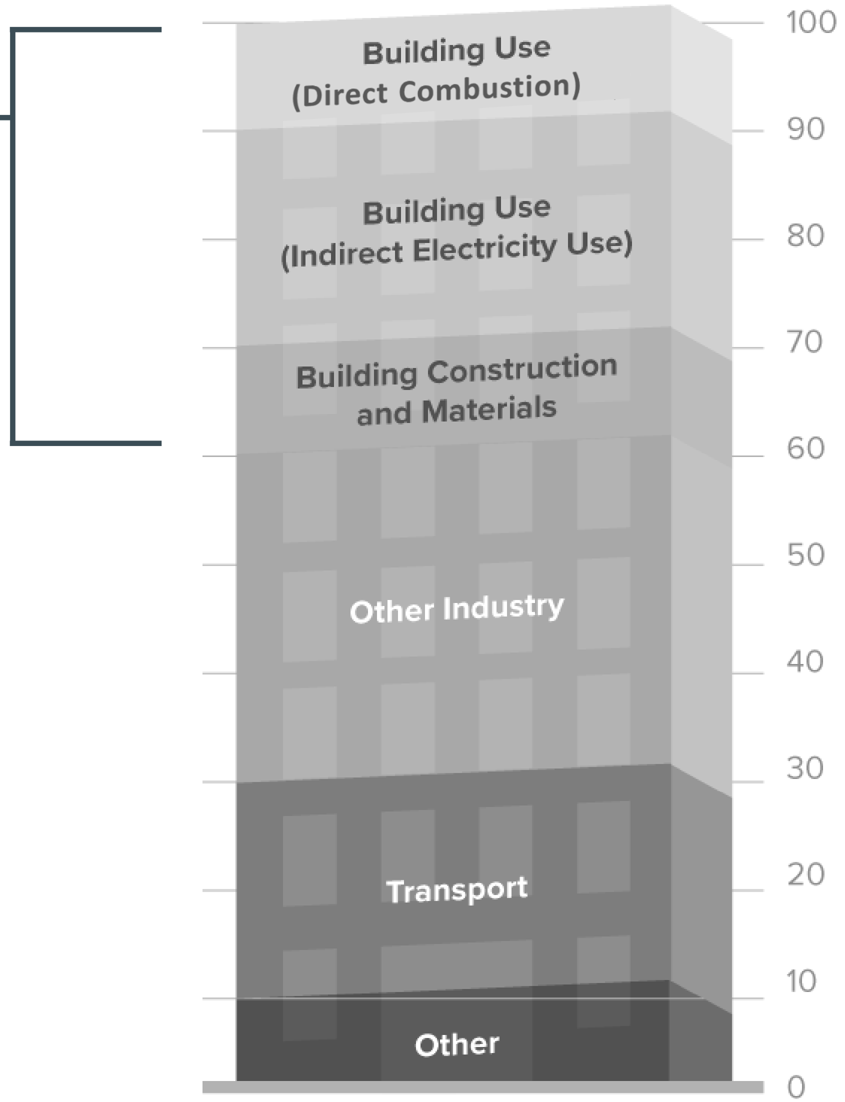
Advancing Codes & Policy
Continuous code and policy innovation

Introduction

Carbon Emissions and Buildings

Building Construction and Operations account for

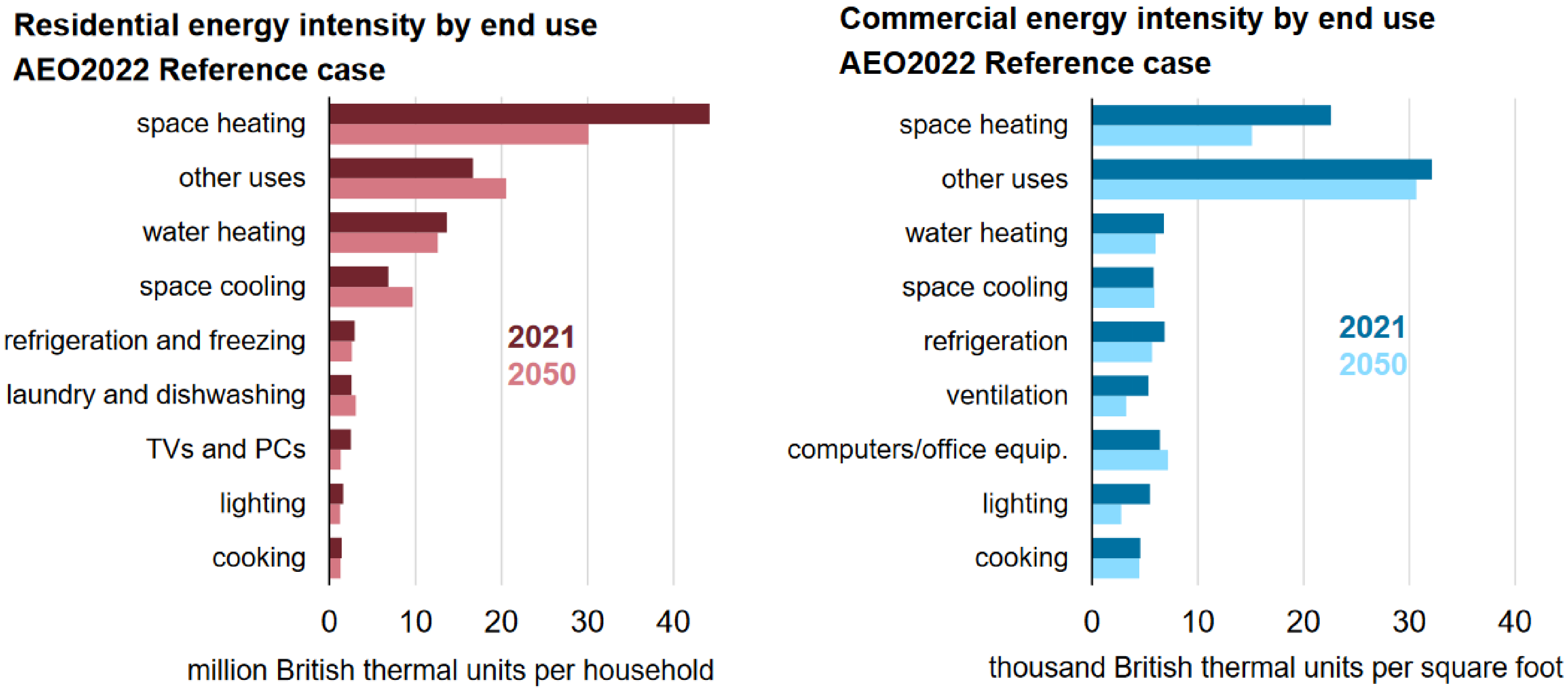
39% of CO_2 Emissions in the US



Source: IEA, 2019. % shares.

How Buildings Use Energy

Residential and commercial overall energy intensity by end use



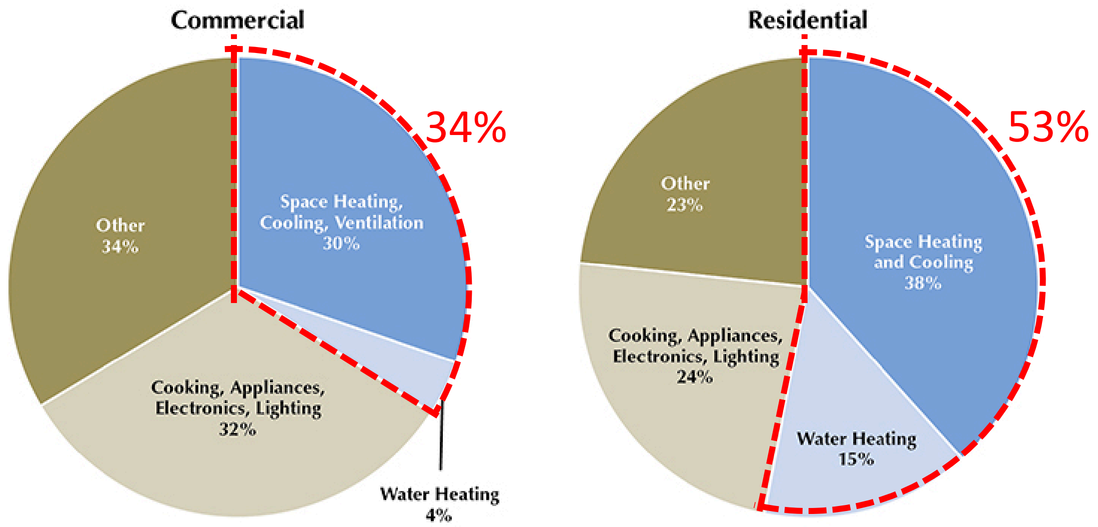
Note: Intensities reflect all energy sources consumed, including both purchased electricity and electricity produced onsite for own use.

Source: US EIA, Annual Energy Outlook 2022

Carbon Emissions and Buildings

- Energy consumption from residential buildings **accounts for 19% of CO2 emissions**
- Energy consumption from commercial buildings **accounts for 16% of CO2 emissions**
- **Space conditioning and water heating end uses account for over half (53%)** of residential emissions

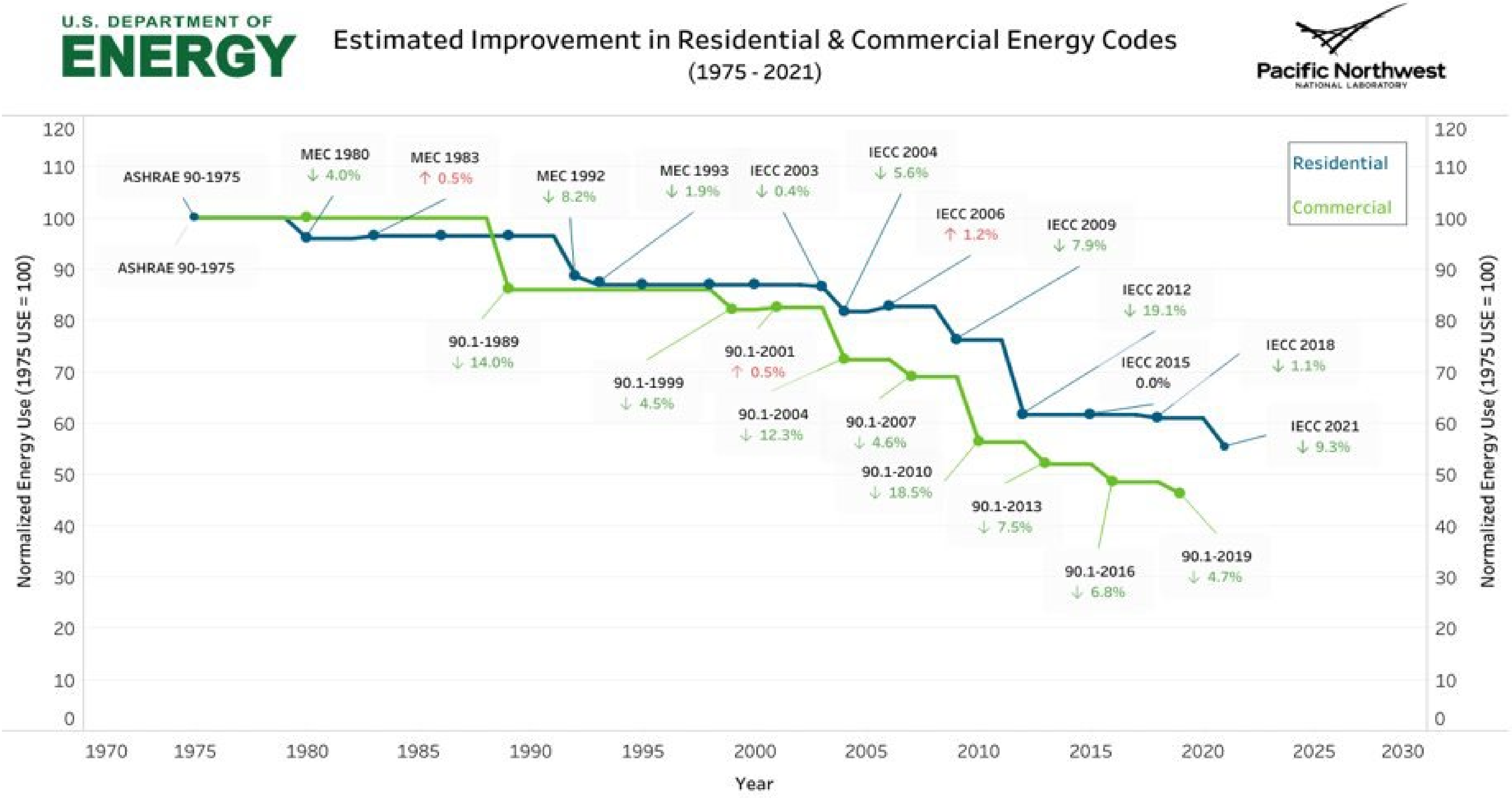
FIGURE 1: Total CO_2 Emissions from the Commercial and Residential Sectors (2016)



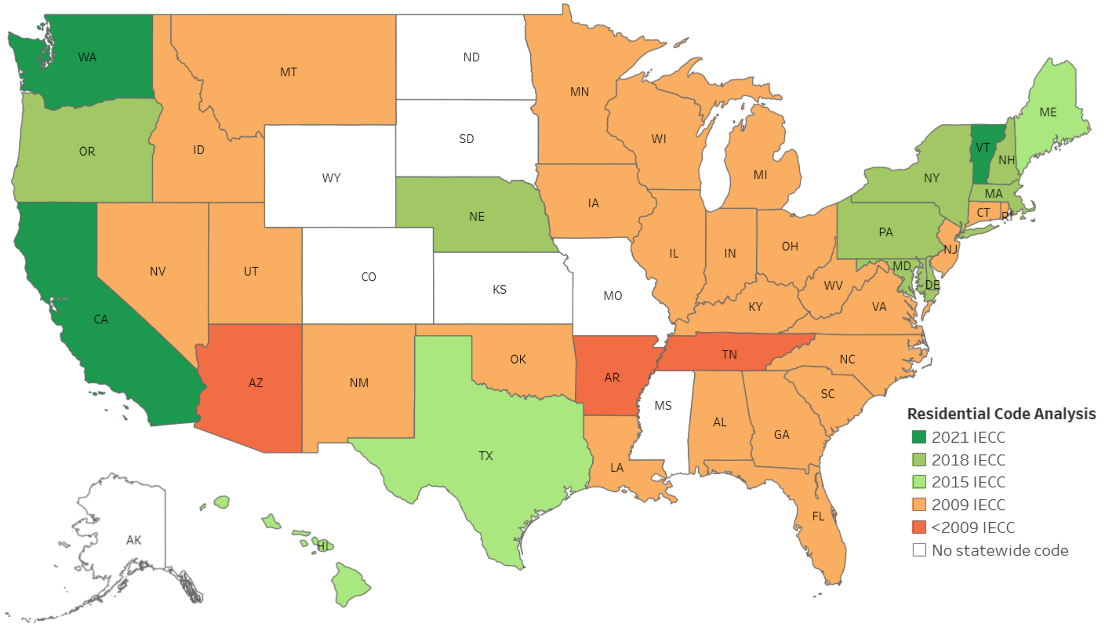
"Other" in both the commercial and residential sector includes items such as data servers, medical imaging equipment, ceiling fans, and pool pumps which are categorized as "miscellaneous electric loads" by EIA.

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018 *(Washington, DC: U.S. Department of Energy, 2018), https://www.eia.gov/outlooks/aeo.*

Model Energy Codes

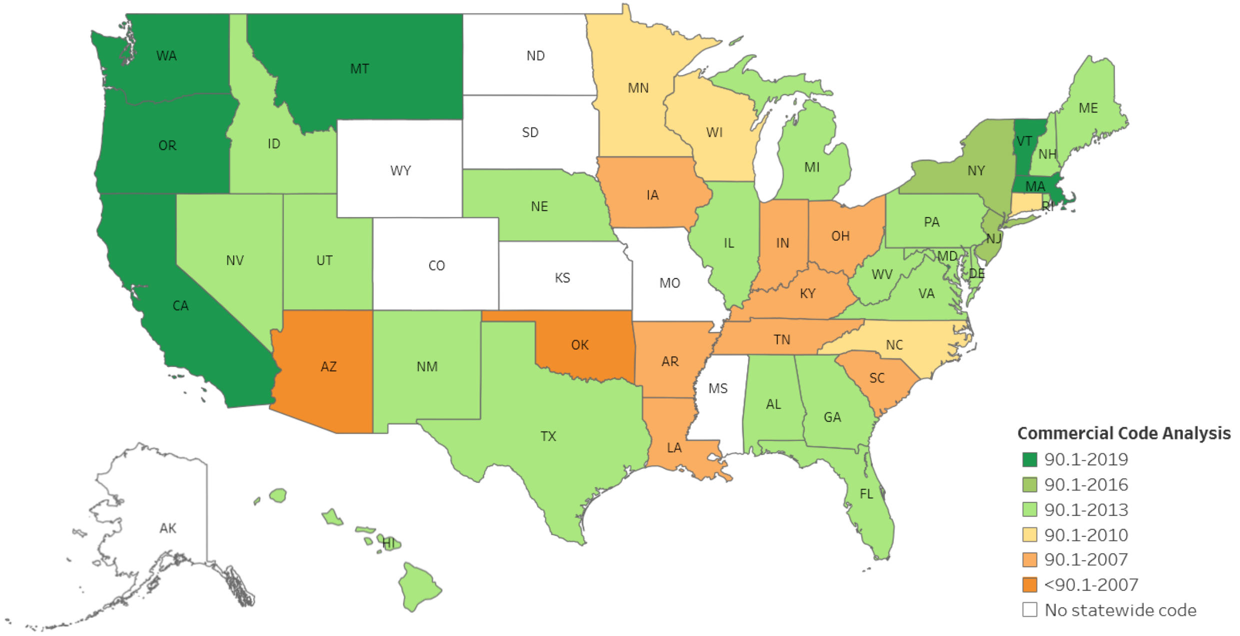


State code adoption



1. *Energy code categorization is established by comparing the state site energy index to the energy index of all model energy codes. If a state energy index is not more than 1% higher than that of an IECC or Standard 90.1 edition, then the state code is considered equivalent to that code edition. If not, the state is categorized at the next closest code edition.*

US DOE BECP: Status of State Energy Code Adoption - https://www.energycodes.gov/status/residential
State Energy Index Data:https://www.energycodes.gov/sites/default/files/2022-06/StateLevelResidentialCodesEnergyUseIndex_FY2022Q3.xlsx
Updated as of 09/30/22



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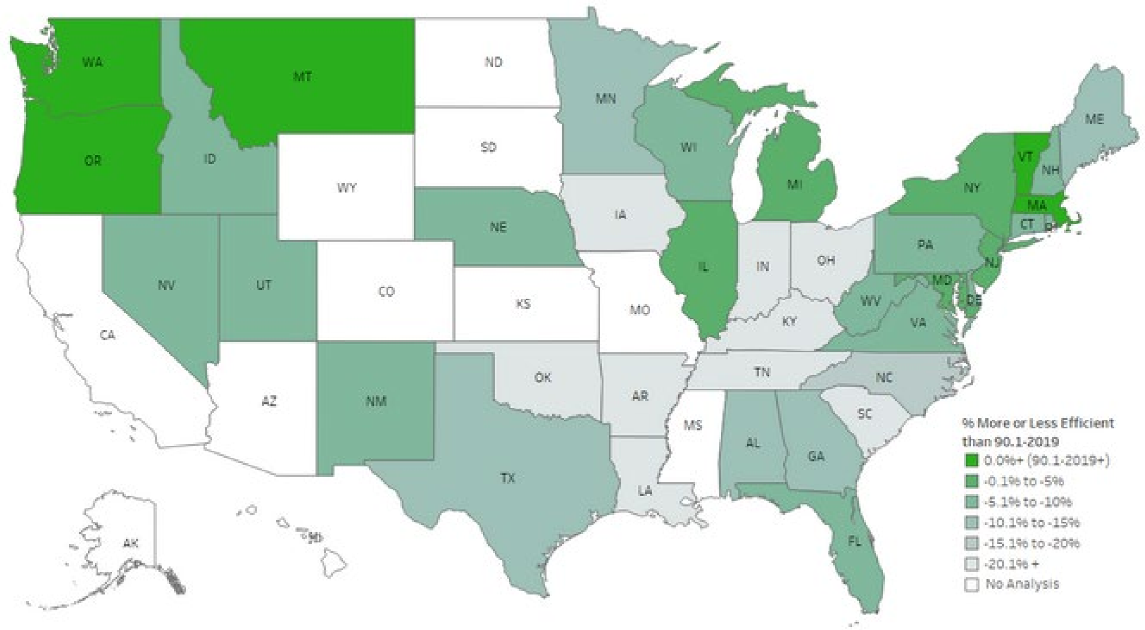
Updated as of 09/30/22

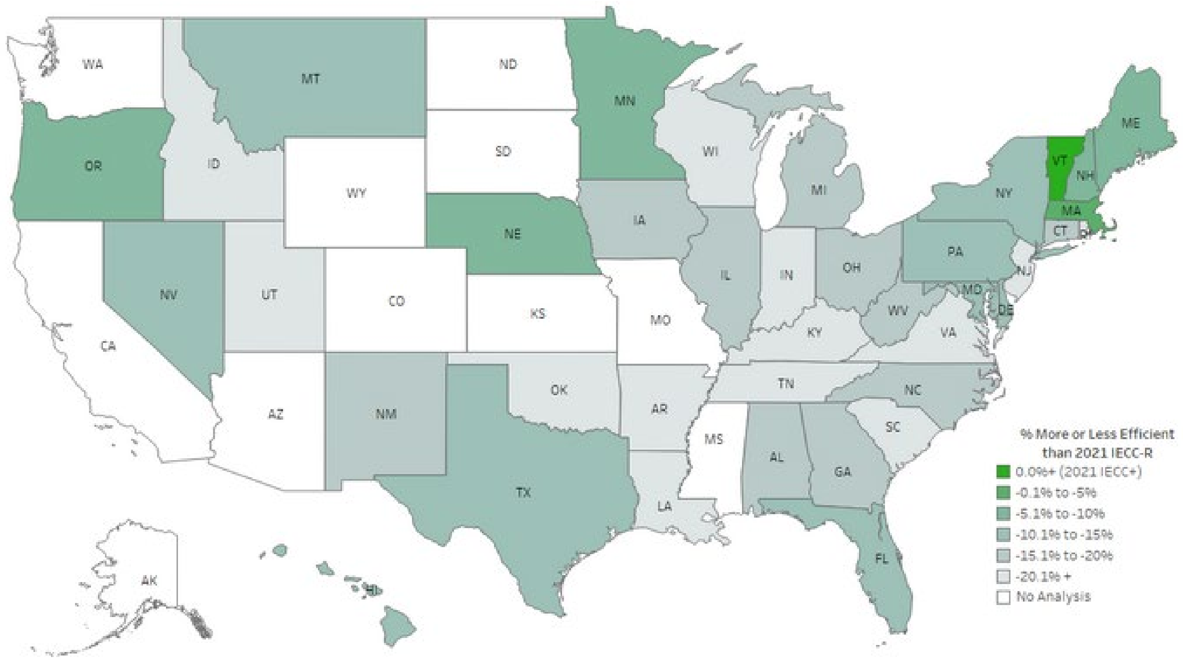
Codes in the Northwest

Commercial Energy Code: State Energy Index Relative to Current Model Code (90.1-2019)



US DOE BECP: Status of State Energy Code Adoption - https://www.energycodes.gov/status/commercial
State Energy Index Data: https://www.energycodes.gov/sites/default/files/2022-09/StateLevelResidentialCodesEnergyUseIndex_FY2022Q4.xlsx
Updated as of 09/30/22

Residential Energy Code: State Energy Index Relative to Current Model Code (2021 IECC)



US DOE BECP: Status of State Energy Code Adoption - https://www.energycodes.gov/status/residential
State Energy Index Data: https://www.energycodes.gov/sites/default/files/2022-09/StateLevelResidentialCodesEnergyUseIndex_FY2022Q4.xlsx
Updated as of 09/30/22

source: https://www.energycodes.gov/infographics

Challenges ahead

- Energy codes generally don’t consider, or reward resilient building features
- Limitations of NAECA and EPCA on reducing HVAC, SHW and equipment loads
- Limits associated with prescriptive code approach:
    - Doesn't lead to performance outcomes or reflect actual energy use of buildings
    - Diminishing returns associated with increasing provisions
    - No way to realize better design choices

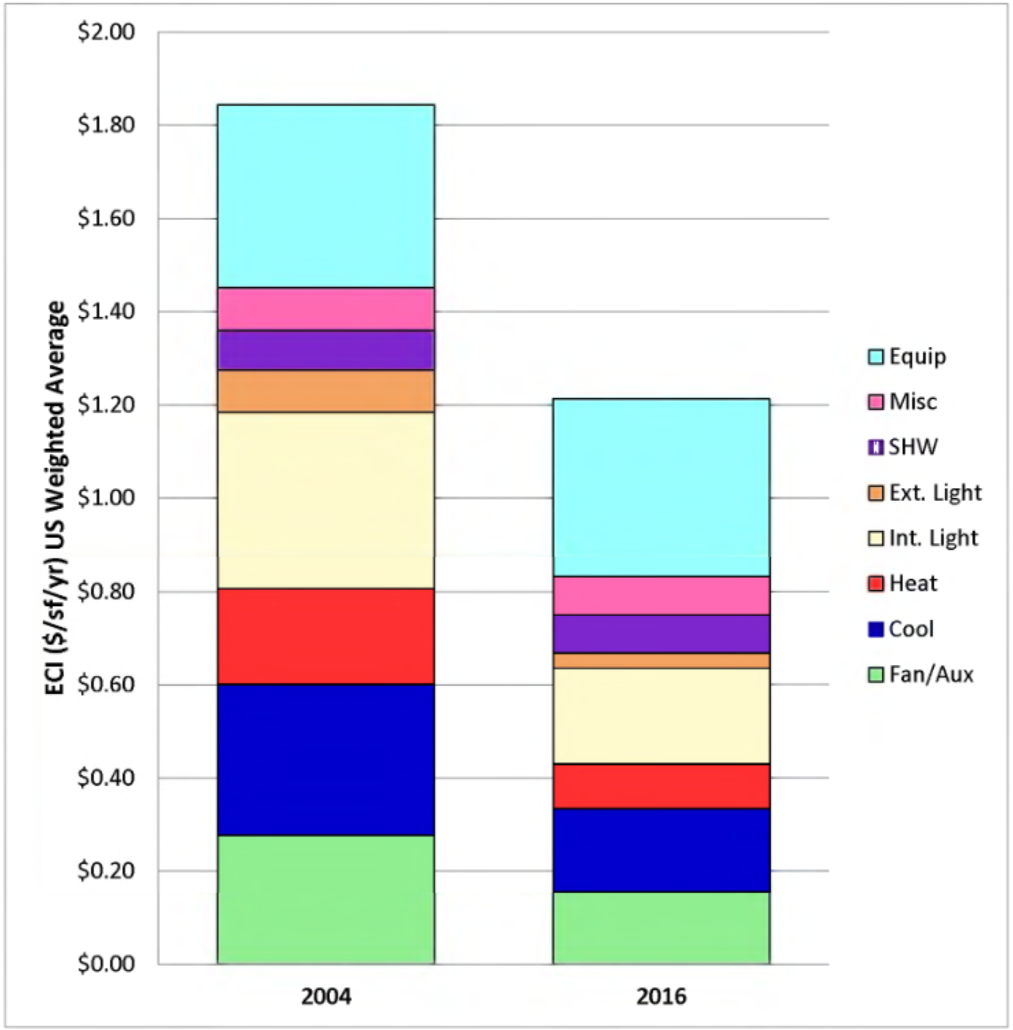


Figure 4. Standard 90.1 end-use cost improvement

source: PNNL: *End Use Opportunity Analysis Based on Standard 90.1-2016*

Introduction to Passive House (and associated benefits)

A Brief History…

- Concept originated in US and Canada – OPEC oil embargo. Published in *Energy Review* in 1986
- Picked up in Europe in the early 90’s
- Creation of a formal standard based on the heating needs of buildings: Peak demand of 1 W/ft2 resulted in an annual heating demand of around 15 kWh/m2/yr (4.75 kBtu/ft2/yr)
- Principles adapted to US Climate Zones by Passive House Institute US (PHIUS) in 2007

First Passive House project in Darmstadt Germany in 1990

Passive House Design Principles

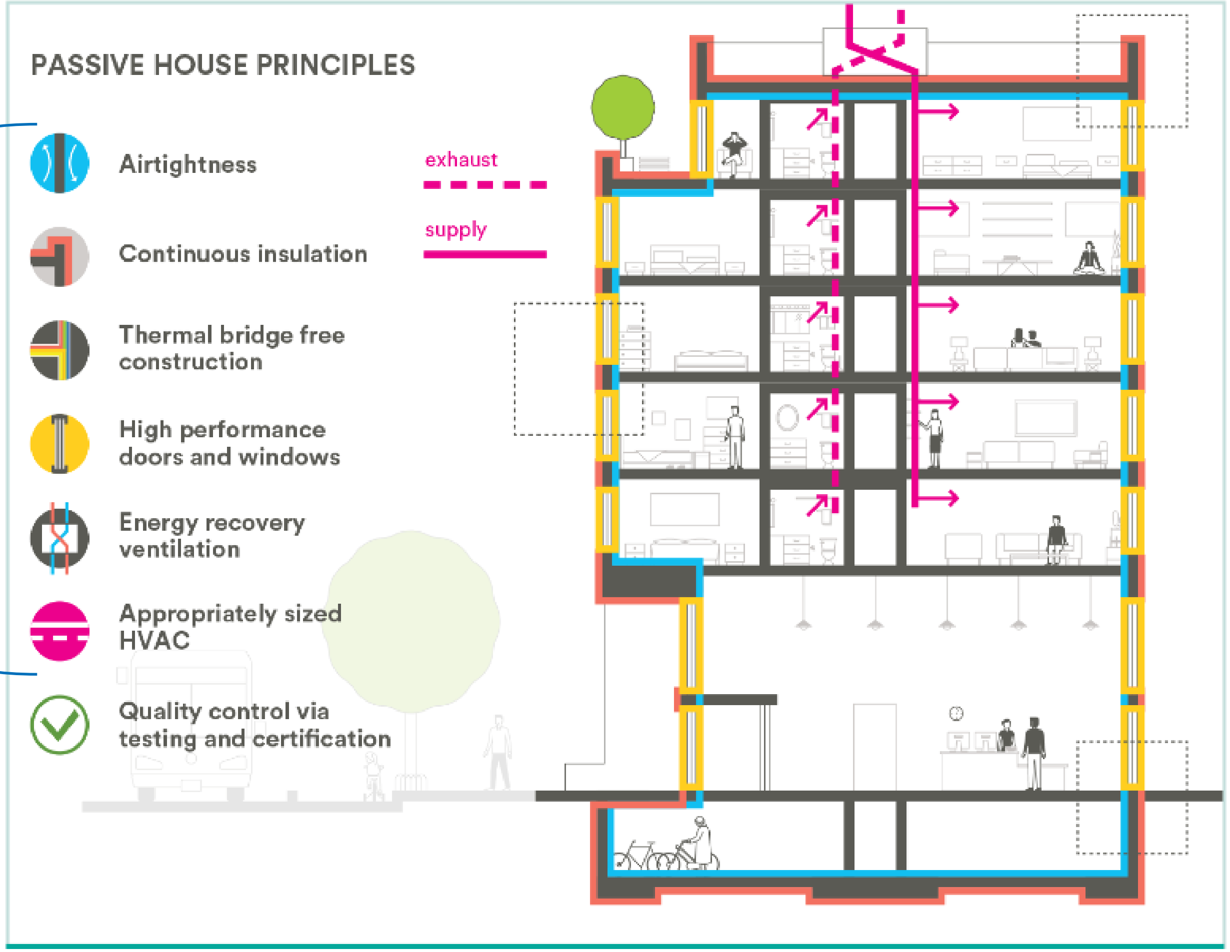
Enhanced envelope

+

Energy Recovery (ERV)

=

Low HVAC loads



Source: building energy exchange

Passive House Design Principles

- Comfort drives energy performance
- This means high performance envelope components:
  - Thermal bridge-free design
  - Superior windows
  - High quality-insulation
  - Airtight construction
- Reduce remaining mechanical load by:
  - Managing solar gains
  - Utilizing heat recovery ventilation

RMI Innovation Center Photo: Tim Griffith

The Two Standards

PERFORMANCE REQUIREMENTS

Source Energy, Residential	kWh/person/yr	≤ 3840 kWh/person/yr
	Occupancy	(# of Bedrooms + 1), per unit
Source Energy, Non-Residential	$kBTU/ft^2_{iCFA}/yr$	≤ 34.8
Airtightness	CFM_{50}/ft^2 of gross enclosure area	≤ 0.060
Airtightness, MF ≥ 5 stories, non-comb.		≤ 0.080
Annual Heating Demand	$kBTU/ft^2_{iCFA}/yr$	Climate Specific
Annual Cooling Demand		Climate Specific
Peak Heating Load	**AND** $BTU/ft^2_{iCFA}/hr$	Climate Specific
Peak Cooling Load		Climate Specific

PRESCRIPTIVE REQUIREMENTS

PHIUS+ Ventilation Protocol	CFM	Balanced Ventilation, see Guidebook 3.5.3.3
Thermal Bridge Mold Risk	%RH	< 80% using ISO 13788/ASHRAE 160 calc
Window Condensation Risk	%RH	< 100% using ISO 13788/LTIE calc
Window Comfort Assessment	Max U-Value	Based on climate + window height, see calculator.
Assembly Moisture Risk	various	See Guidebook 3.4.3 & Appendix B
PHIUS+ QA/QC Protocol	various	Pre-Certification and On-Site Verification
Supporting 3rd Party Verifications	various	EPA Indoor AirPLUS, EPA Energy Star, DOE ZERH

PHIUS+ 2018

Primary Energy	$kBTU/ft^2/yr$	38
Airtightness	ACH_{50}	0.6
Annual Heat Demand / Annual Cooling Demand	$kBTU/ft^2/yr$	4.75
Peak Heat Load	$BTU/ft^2.hr$	3.17
Peak Cooling Load		2.54
Ventilation	% efficiency	75%
	W/cfm	≤ 0.76
Thermal Envelope	$hr.\ ft^2{}^\circ F/BTU$	≥ R-38.5
	$BTU/hr.\ ft^2\ {}^\circ F$	≤ U-0.026
Thermal Bridge Free	$BTU/\ hr.\ ft\ {}^\circ F$	$\Psi \leq 0.006$
Windows Installed	$BTU/hr.\ ft^2\ {}^\circ F$	Uw-install ≤ 0.15
SHGC	%	≈ 0.50 - 0.55

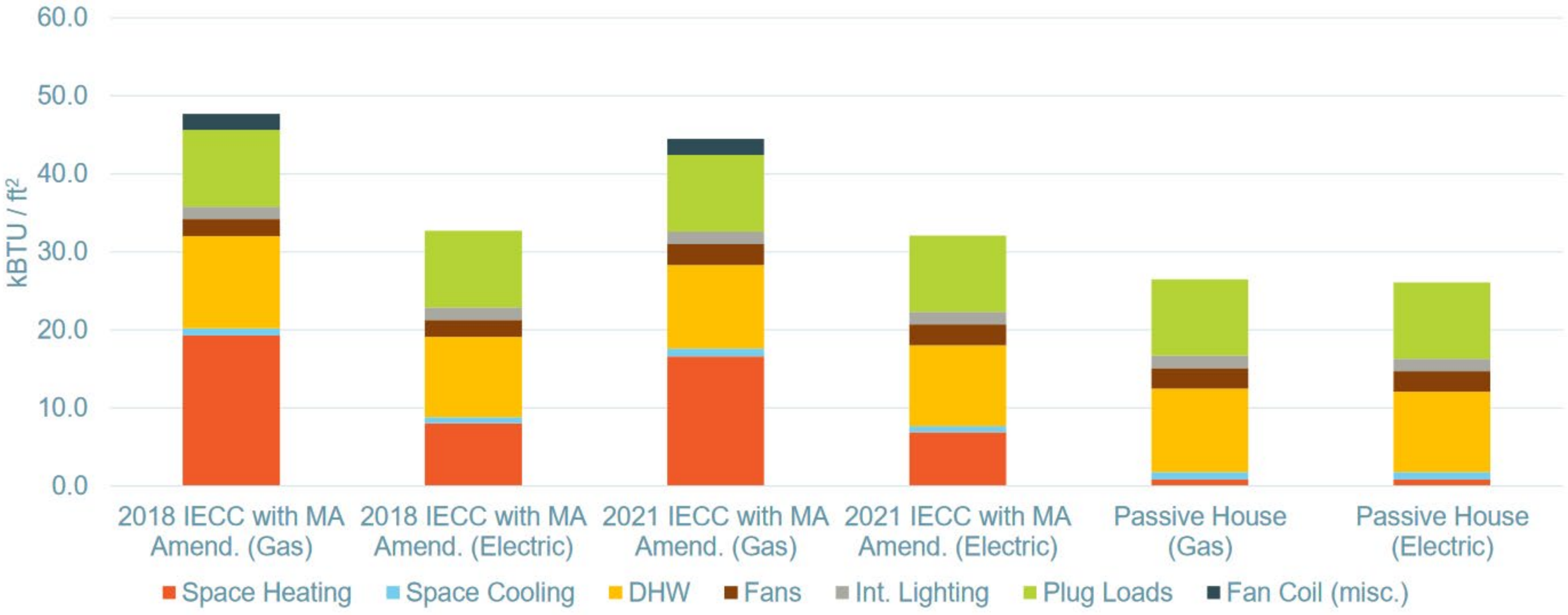
Passivhaus Criteria

Note: PHIUS updated its standard in 2021 to include PHIUS Zero designation

Optimizing "the good stuff"

Multi-Family (Low Rise)

Site EUI - by Energy End Use



Improved IAQ

- Tight construction/low infiltration rate limits the amount of “uncontrolled” air moving through the envelope
- Filtered fresh air delivered to all habitable spaces 24/7 via HRV/ERVs
- Critical strategy for developed areas subject to wildfire smoke events

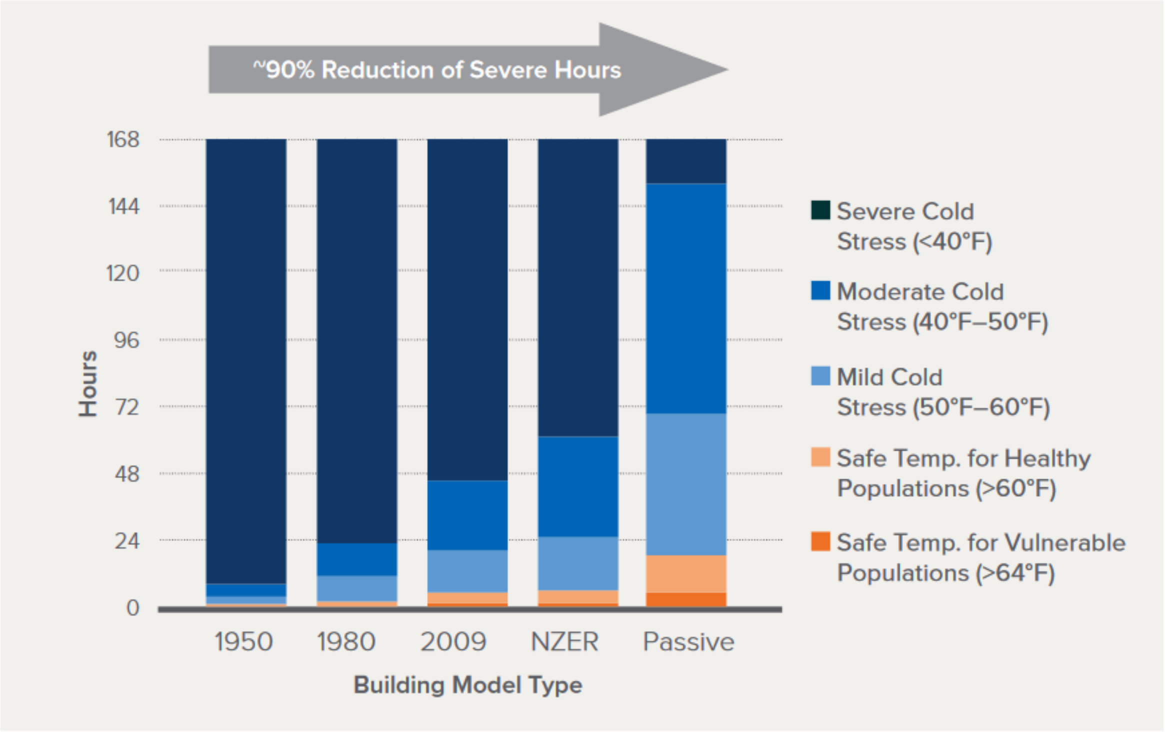
Seattle, September 2020
Source: Kurt Ricketts

Resilience during power outages

- RMI analysis of a Passive House home compared to older homes
- Modeled during a power outage in Minnesota
- The Passive House building was able to buffer the cold temperatures for the longest period during the outage

EXHIBIT 4

Percent Reduction in Severe Cold Stress Hours from 1950s Model to Passive House

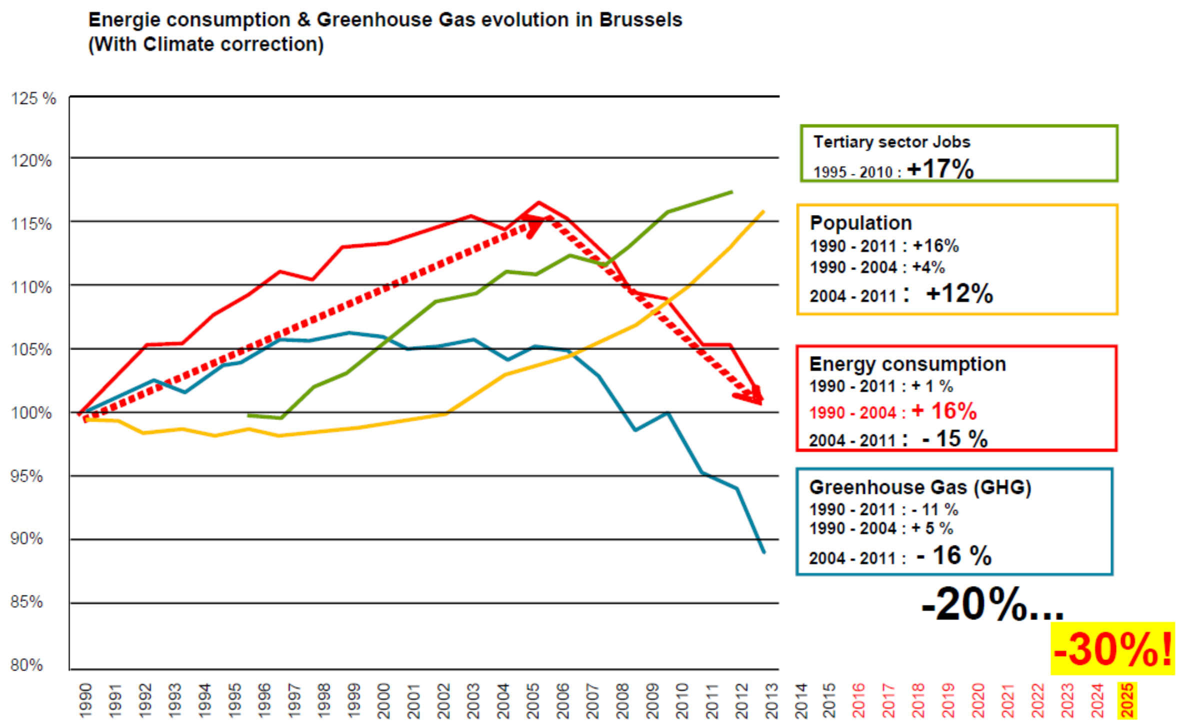


Source: RMI *Hours of Safety in Cold Weather*

The Case for Deep Efficiency/Passive House Codes

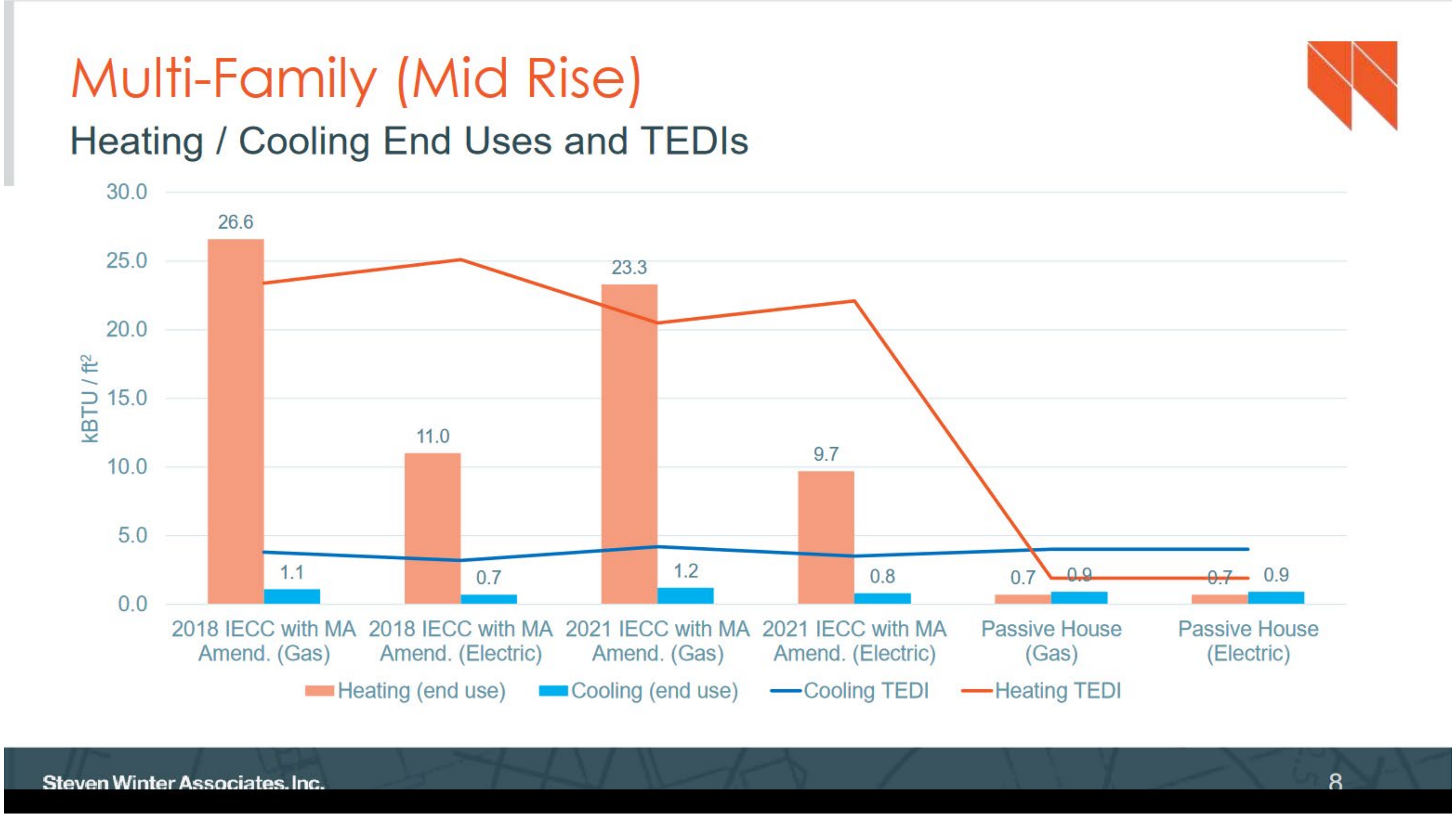
Optimized Code Efficiency Target

- Whole-building design approach where the efficiency is “baked in”
- Prioritizes occupant comfort and health and recognizes that buildings don’t use energy – people do
- Highly reduced loads makes Net Zero codes achievable



Source: Sebastian Moreno-Vacca

Effective way to minimize thermal loads



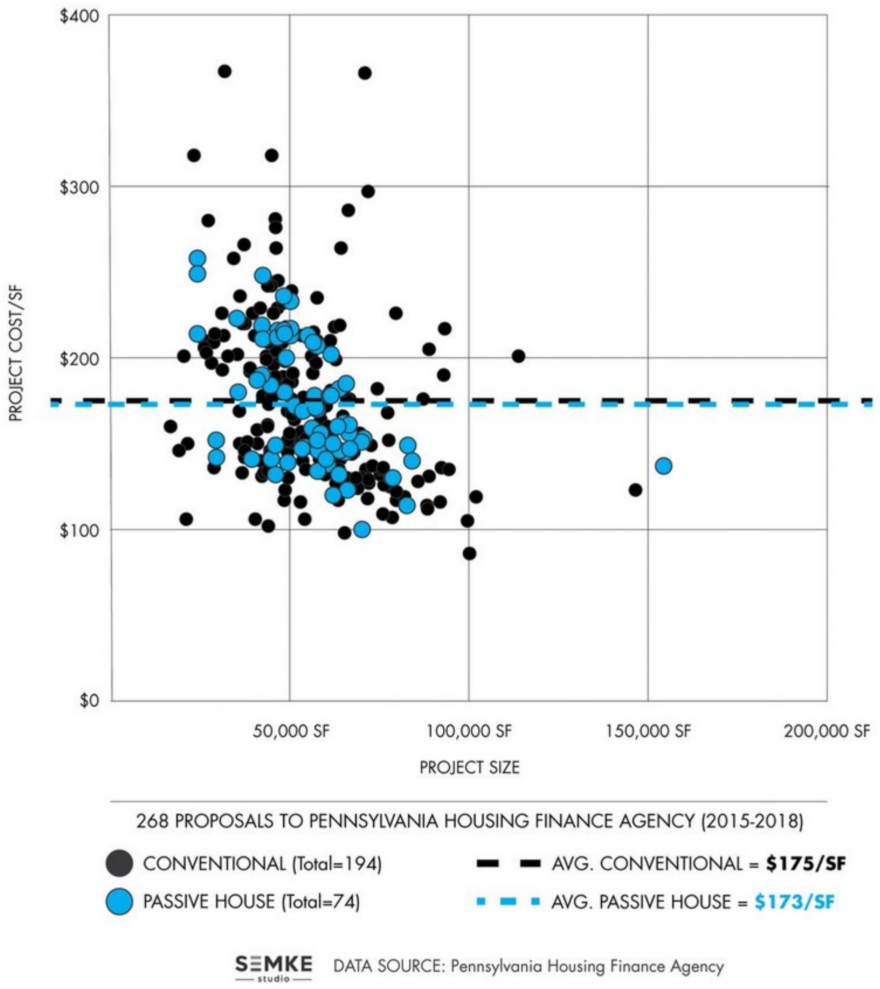
Analysis of heating and cooling loads in Massachusetts

Tipping points: Efficient HVAC equipment

- Envelope investments allows HVAC equipment to be downsized
- Lower thermal demand make highly efficient heat pump technology a design solution in colder climates
- Greater product visibility for cold climate heat pumps via NEEP spec and Energy Star

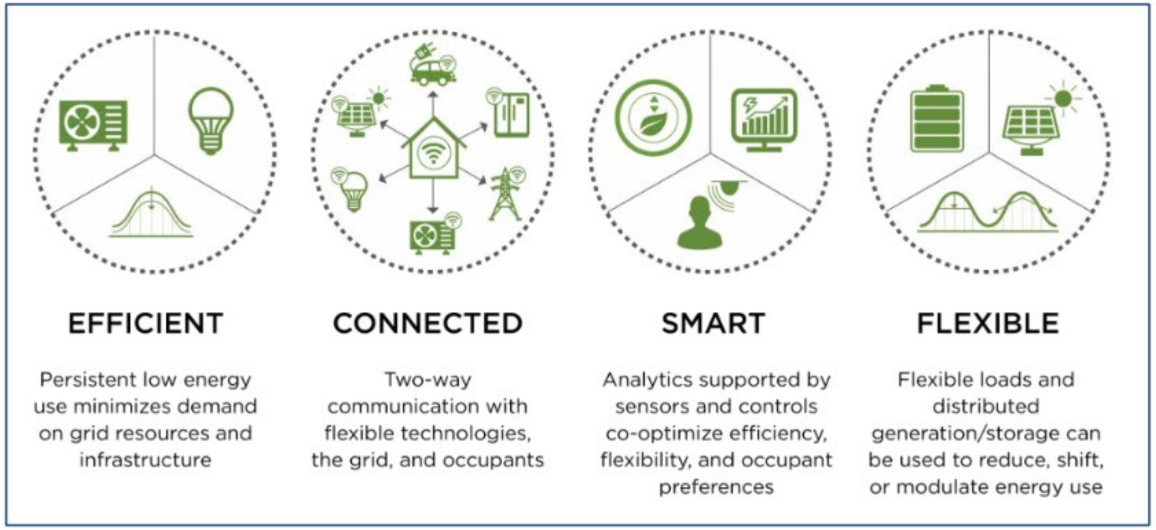
Tipping points: Cost effectiveness

- Some states offer low-income tax credits for Passive House buildings offering insights on costs
- In Pennsylvania there was cost parity between Passive House projects and conventional projects
- NYSERDA's Buildings of Excellence program saw a cost premium of just 2% for projects, with nearly half being Passive House projects



Looking forward: Grid impacts

- Efficiency is a critical component of Grid-interactive Efficient Buildings (GEB)
- Compounded by rapid deployment of solar PV
- Energy codes will need to ensure our buildings these characteristics
- Buildings with Passive House design features can be an asset to the grid – especially during peak heating/cooling events

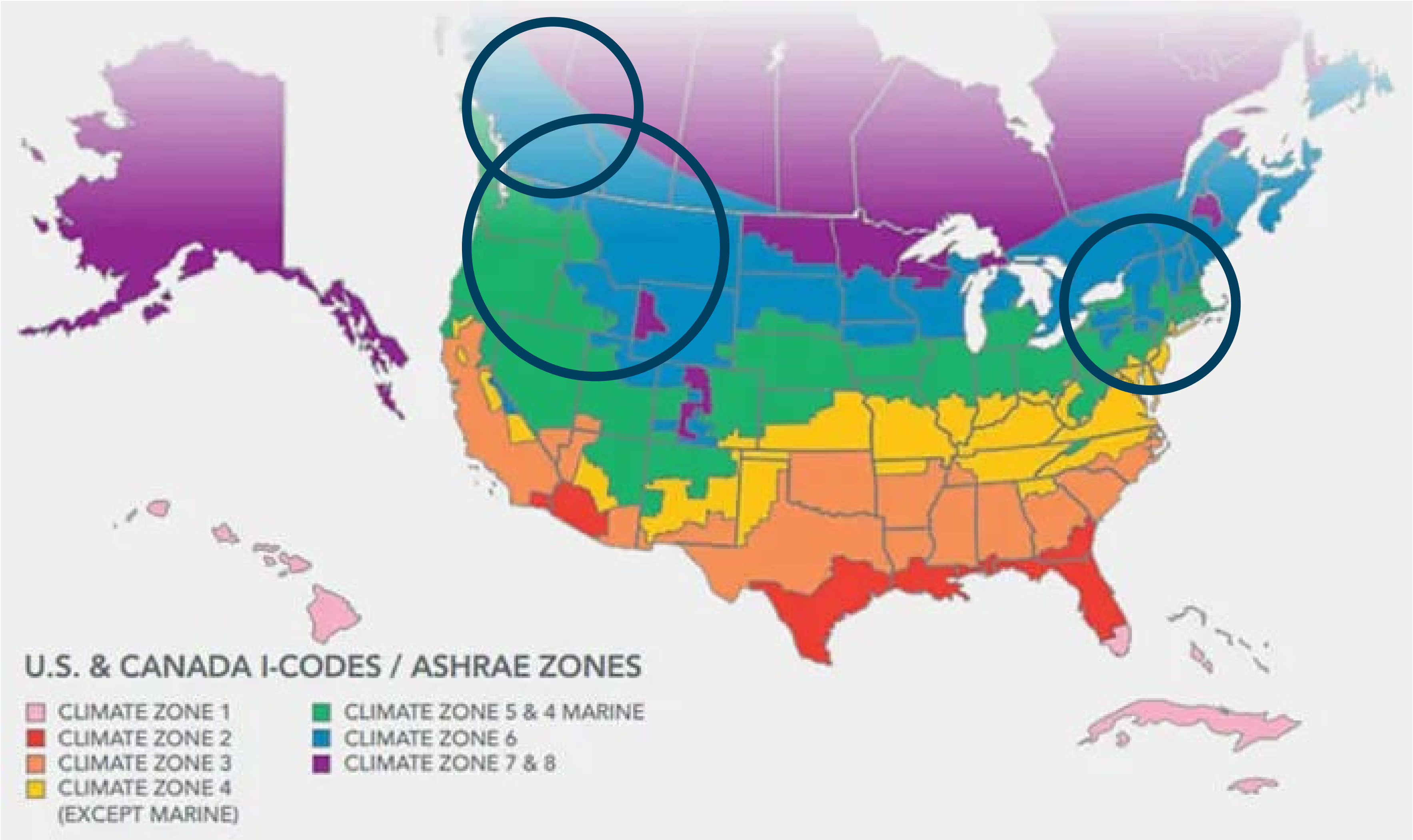


Characteristics of GEB; Source: US DOE 2019

Three Leading Examples

Climate Zones

- Massachusetts – 5
- New York – 5 + 6
- British Columbia – 6
- PNW – 5+6



Massachusetts

- 2021 Climate Act requires a 50% reduction in GHG emissions by 2030
- Tasks DOER with development of Stretch Codes
- Includes the development of a specialized stretch “Net Zero” code
- Specialized stretch code can be adopted by any of the 299 “green communities”

Base Code (IECC 2021)

- New construction in towns & cities not a green community
- **52 communities**

Expected from BBRS: **July 2023**

Stretch Code (2023 update)

- New construction in towns & cities that are a green or stretch community
- **299 communities**

Residential : Jan 2023
Commercial: July 2023

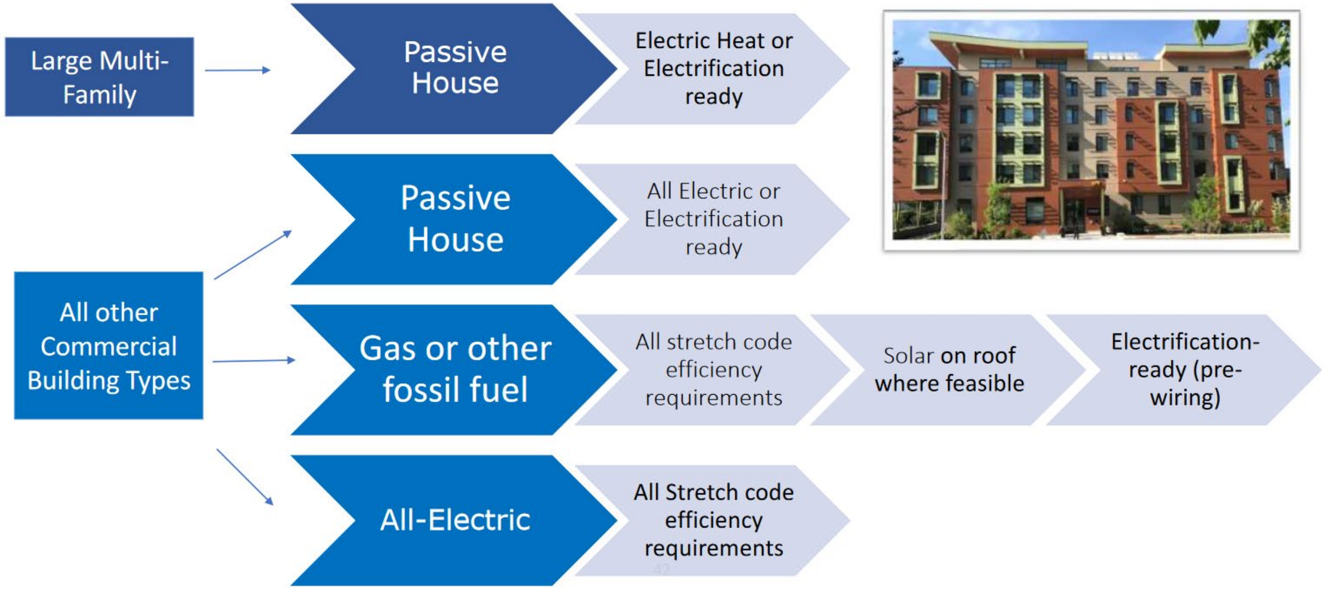
Specialized Code (“Net-Zero”)

- New Construction in towns & cities that vote to opt-in to this code
- **Effective date:** Typically 6-11 months after Town/City vote

Source: MA DOER

Massachusetts

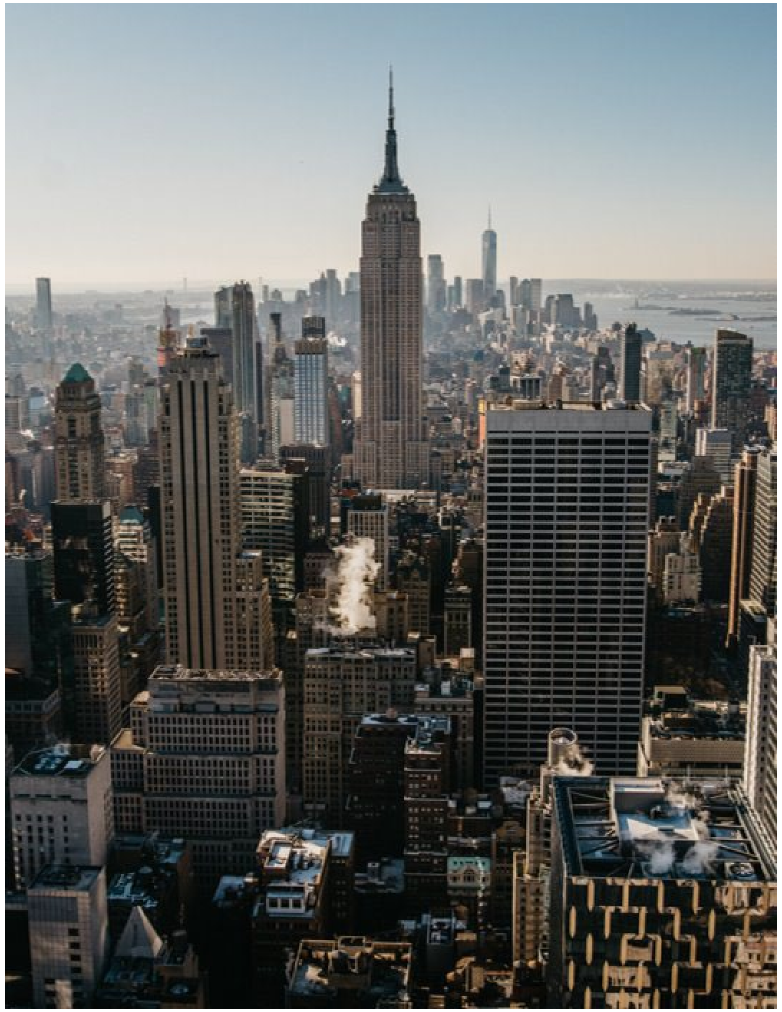
- LCCA analysis using modeled data found:
  - The same or lower peak electric use for most building types
  - Modes peak increases in residential
  - About a 5% increase in peak electric load



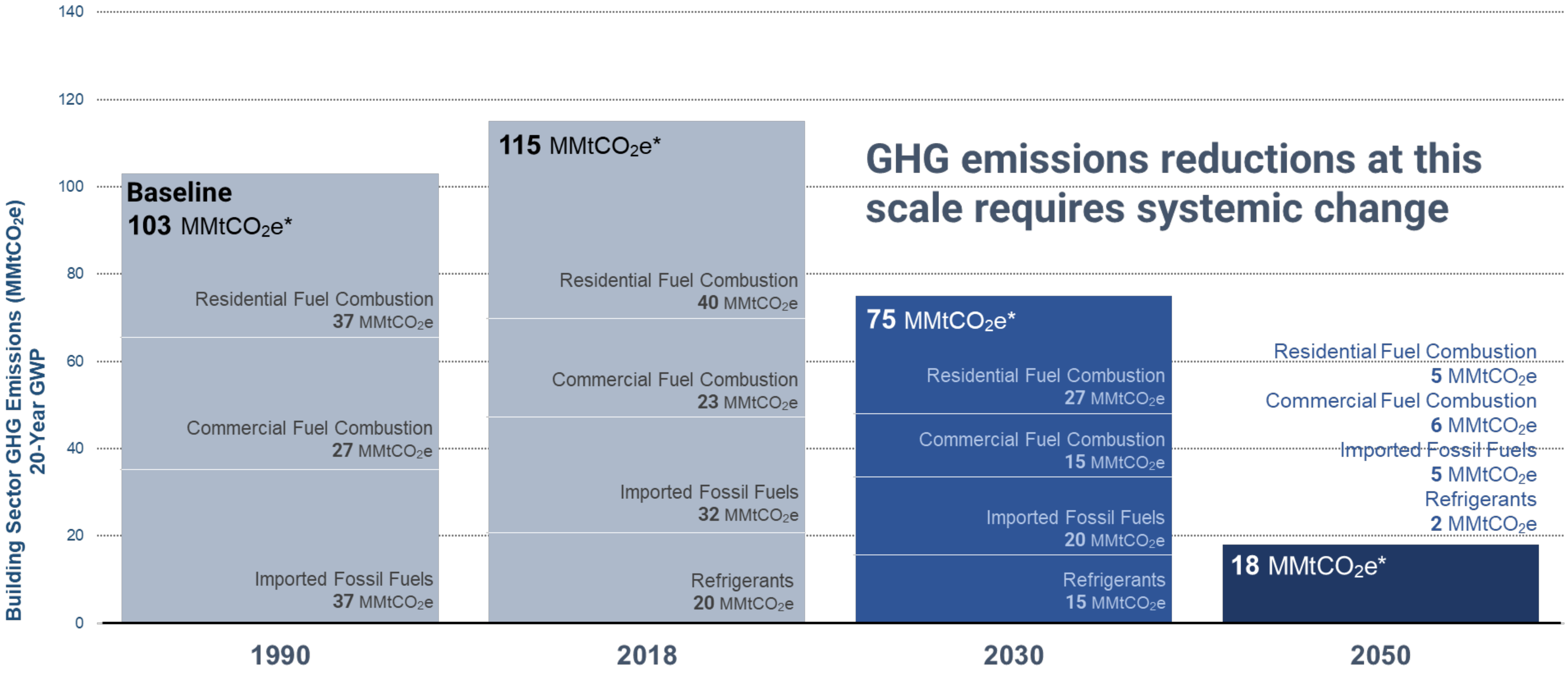
Source: MA DOER

New York: Climate Leadership and Community Protection Act of 2019

- Committed to the most aggressive clean energy and climate agenda in the country
- Climate Leadership and Community Protection Act (Climate Act) goals empower every New Yorker to fight climate change at home, at work, and in their communities
- Climate Act goals look to reduce carbon emissions by 85% by 2050 across sectors.
- Equity goals on equal footing with climate goals
- Buildings contribute ~30% of total direct carbon emissions.



New York



* million metric tons carbon dioxide equivalent

Draft values subject to public review process for annual emissions accounting

New York: 2023 NYStretch update

- Thermal envelope prioritized
  - High efficiency wall assemblies
  - Thermal bridging addressed
  - Reduced infiltration
- Electrification incentivized
  - Heat pump baseline
  - No additional efficiency credits for gas HVAC and hot water heating equipment
- Electric readiness required for where gas equipment is installed
- Mandatory code for NYC (early 2023)

British Columbia: Step Code

- Introduced in 2017 as part of the provincial building code to achieve zero energy ready buildings by 2032
- Comprised of a series of performance “steps” using consistent metrics and testing requirements with the final step representing zero energy ready performance (roughly equivalent to Passive House)
- Established a three-year grace period for jurisdictions to adopt step code approach
- Most commercial buildings: meet Total Energy Use Intensity (TEUI) and Thermal Energy Demand Intensity (TEDI) targets
- Must meet air leakage rate targets
- Requires energy modeling

Source: British Columbia

Vancouver, British Columbia

- Zero Emissions Building Plan
  - Passed in 2016 and calls for 90% reduction in emissions from new buildings by 2025 and zero emissions by 2030
- Green Rezoning Policy
  - Large commercial and multi-unit residential projects must meet PH House certification or demonstrate compliance with TEDI
  - Impacts 60% of SF developed in the City
- Thick wall exclusion (incentive)
  - Buildings can exclude the area used for insulation exceeding code requirements in floor space ration calculation and relaxed height and setback requirements

Regional resource: Passive House Northwest

Passive House Northwest

About Events Resources Membership

Search

WELCOME TO PASSIVE HOUSE NORTHWEST

Passive House Northwest is a group of Certified Passive House Consultants and other individuals and organizations whose goal is to promote highly energy efficient construction through implementation of the passive house concept.

We are motivated by the long-term protection of the environment and climate; the promotion of sustainability, quality, and durability in building construction; the creation of a built environment that is healthy for its inhabitants; and the advancement of energy independence and the reduction of operating costs for building occupants and owners.

The primary strategies that we employ are: building and strengthening the Passive House community in the northwest by facilitating communication and resource sharing; collecting and disseminating knowledge and facilitating education on the Passive House standard and developments in the field; practicing outreach through publicity and providing information to the general public; advocating for policies promoting Passive House as well as the protection of the standard; collaborating with other regional, national, and international Passive House organizations, as well as other related organizations; and promoting regional production of building elements needed for Passive House construction.

IDeAs Z2 DesIgn FAcIlIty, San Jose (Credit: David Wakely)

nbi new buildings institute

Thanks!

Mark Lyles, Sr. Project Manager (CPHC)
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