U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Building Energy Codes: What's New and *Next*?

Building Energy Codes Program

Building Technologies Office Peer Review

April 15, 2019

WELCOME

Purpose: Discuss what's new, and what's expected next, in the model energy codes.

Objectives:

- Review **recent changes and emerging themes** in the model codes
- Discuss challenges associated with **performance-based codes**—and potential solutions
- Develop a preliminary understanding of how energy codes can address new technologies enabling **grid-interactive efficient buildings** (GEB)

AGENDA

Three parts for today:

Jeremy Williams, U.S. Department of Energy

Model Codes: What's Expected for the 2021 IECC & Standard 90.1-2019

Reid Hart, Pacific Northwest National Laboratory

Performance-based Codes: Challenges and Solutions

Ellen Franconi, Pacific Northwest National Laboratory

Codes and Grid-interactive Efficient Buildings

Q+A

PART I

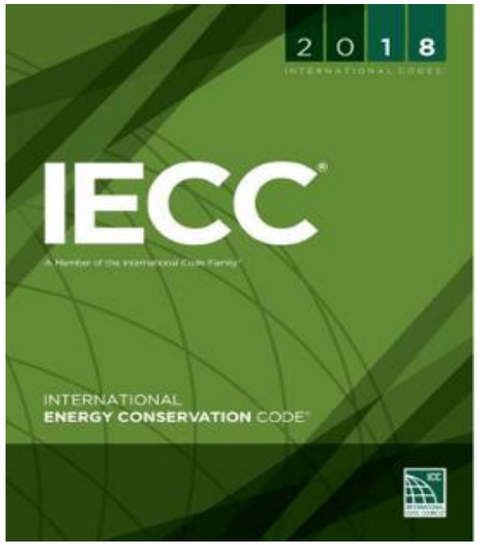
Model Building Energy Codes: 2021 IECC & Standard 90.1-2019

Jeremy Williams, U.S. Department of Energy

What Are the Model Building Energy Codes?

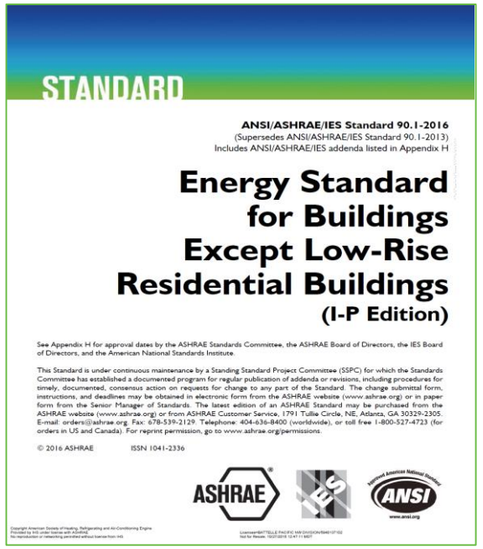
2018 International Energy Conservation Code (IECC):

- Low-rise residential buildings
- Administered by the International Code Council (ICC)
- Published in fall 2017 (part of 2018 suite of I-Codes)
- Next edition: 2021 IECC (proposals due January 2019)

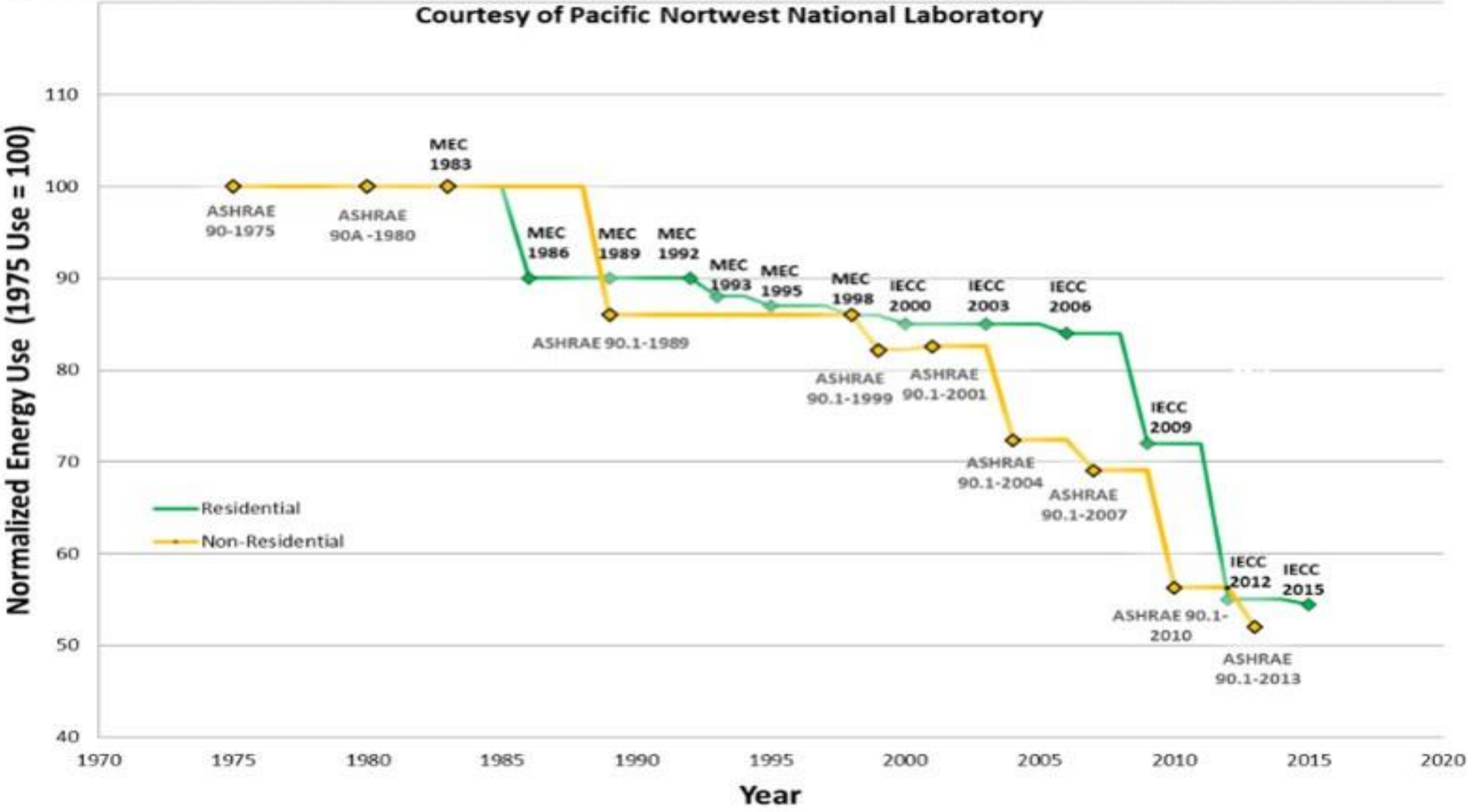


Standard 90.1-2016:

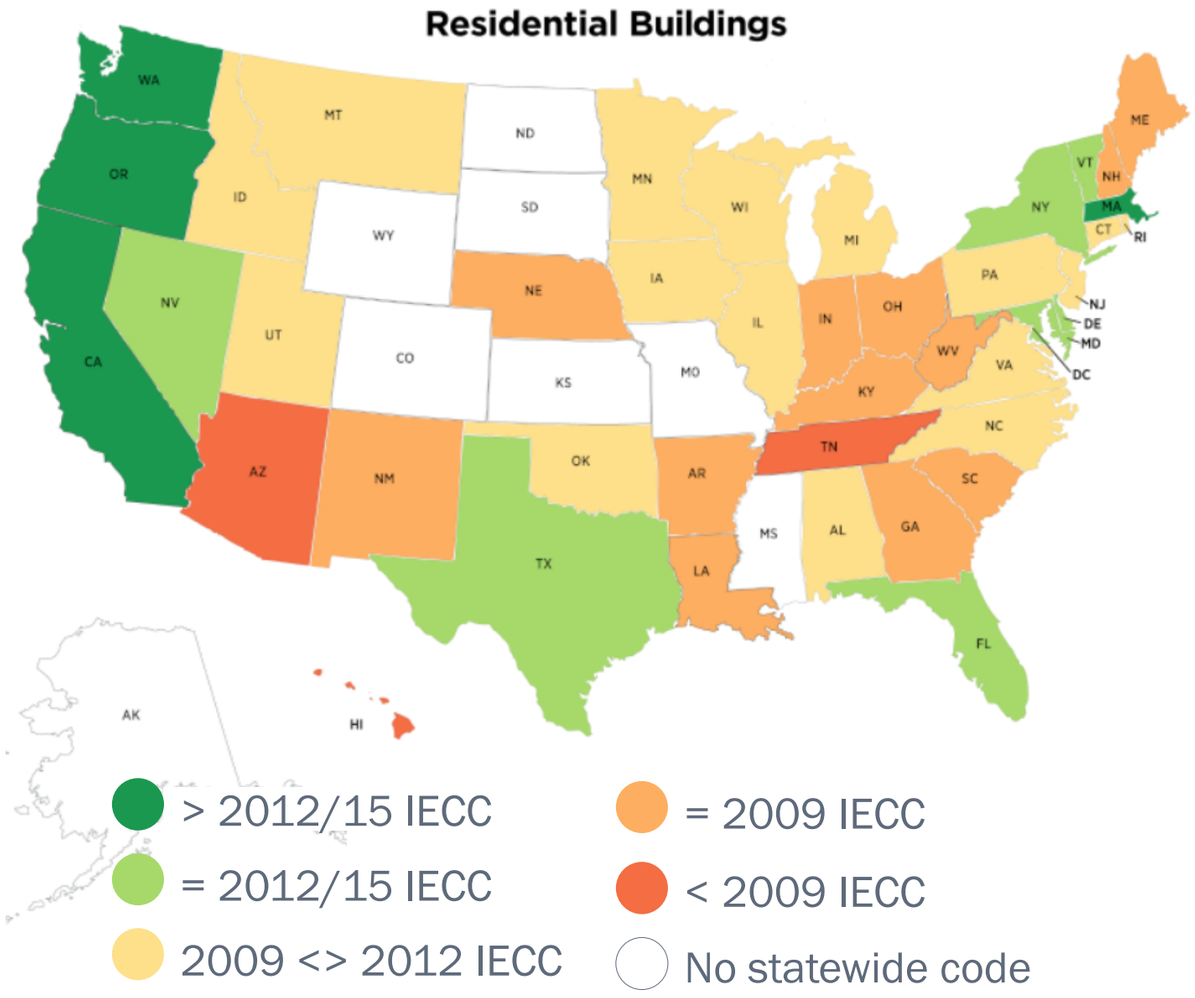
- Non-residential (commercial) buildings
- Administered by ASHRAE
- Next edition: 90.1-2019 (expected October 2019)

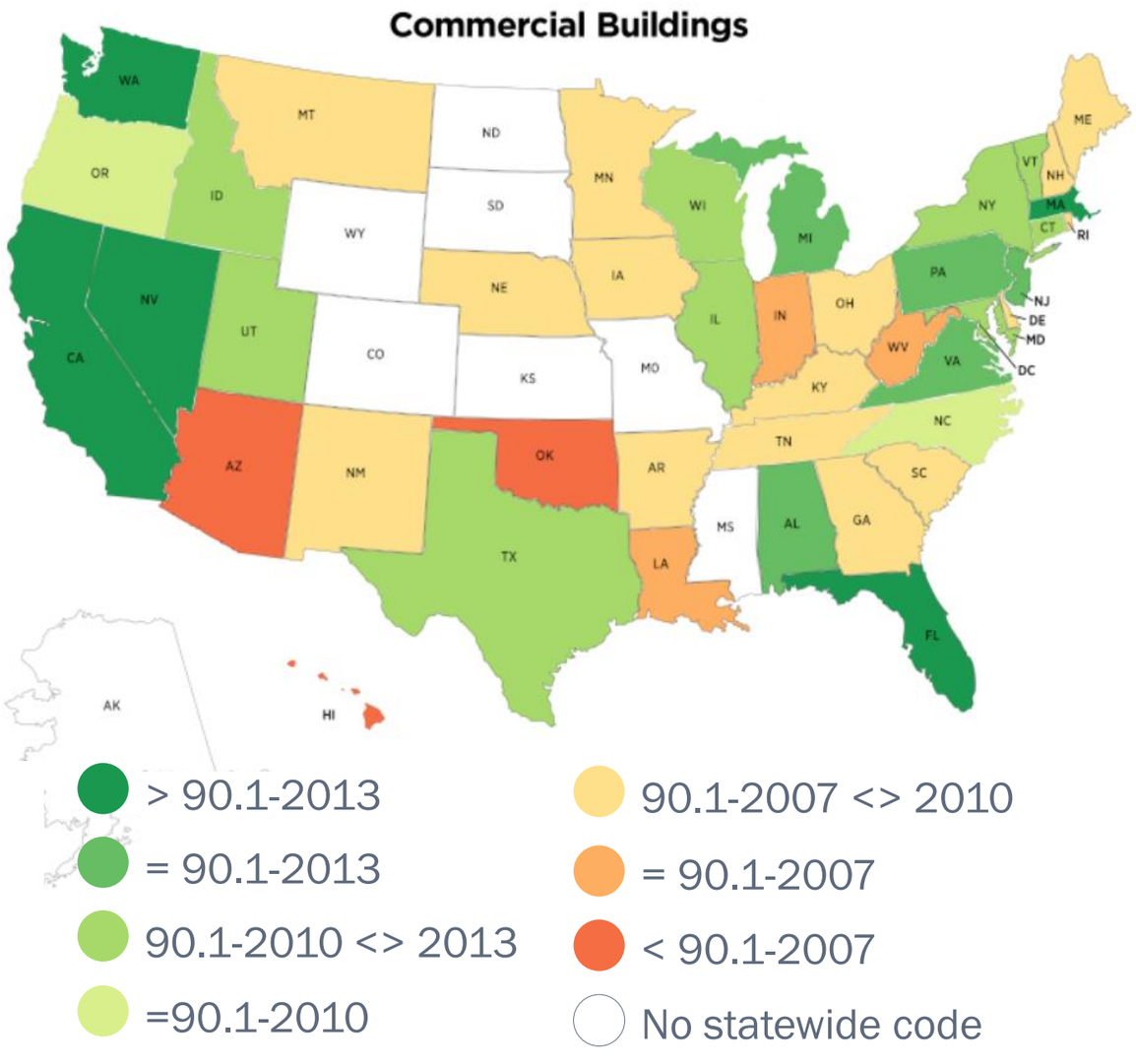


Improvement in Residential and Non-Residential Model Energy Codes (Year 1975-2015)



Current Status of State Energy Code Adoption





https://www.energycodes.gov/status-state-energy-code-adoption (as of December 2018)

Great.

So, what's NEW?

RESIDENTIAL: 2021 IECC HIGHLIGHTS

PRESCRIPTIVE:

- **Windows** and **Walls**: Various R-value and U-factor changes—better *and* worse
- **Insulation Installation Quality**: Requiring Grade I (RESNET Standard)
- **Lighting efficacy** improvements (LED) and scope expansion (exterior lighting)
- **Heat/Energy Recovery Ventilation** (climate zones 6 and 7)

CLARITY + USABILITY:

- Addition of **sampling protocols**—focus on multifamily buildings
- Clarifying *mandatory* vs. *prescriptive* requirements (+ reorganization)

RESIDENTIAL: 2021 IECC HIGHLIGHTS (continued)

PERFORMANCE:

- Allow **envelope air leakage tradeoffs**—must still run test (3 or 5 ACH50)
- Adjust **Energy Rating Index** (ERI) thresholds (+ envelope backstops)
- Re-introduce **equipment tradeoffs** in traditional performance path (R405)

NEW FORMATS:

- **Flex Points:** Menus of additional *prescriptive* requirements (similar to C406)

RESIDENTIAL: 2021 IECC HIGHLIGHTS (continued)

RENEWABLES:

- Add **Zero-energy** Appendix (optional state adoption)
- Explicitly add renewables to ERI and traditional performance path

GRID:

- Require **grid-enabled water heaters** (or high-efficiency alternatives)
- Incorporate **electric vehicle** (EV) energy to performance path calculations
- Add **energy storage** to performance path

COMMERCIAL: 90.1-2019 HIGHLIGHTS

- Reduced **lighting** power allowances (based on LED technology)
- **Windows**: Glazing improvements
- **HVAC equipment** efficiency updates
- **Heat recovery** for certain building types (e.g. hospitals)
- Coordination with ASHRAE Standard 90.4 (data centers)
- **Commissioning** requirements expanded and standardized
- Scope expansion to include separate/adjacent sites (e.g. parking lots) (*pending*)
- Reduce **thermal bridging**—focus on hotel and multifamily (*pending*)
- Prescriptive requirement for **renewables** (pending)

COMMERCIAL: 2021 IECC HIGHLIGHTS

PRESCRIPTIVE:

- **Envelope:** Variety of R-value and U-factor changes—better *and* worse
- Reduced stringency for **tropical climate** subzone
- **Air barrier testing** for certain commercial and multifamily buildings
- Reduced lighting power (alignment with 90.1 and 189.1)
- Expanded daylighting requirements
- Vestibule temperature controls—strengthening and weakening
- Elimination of economizer requirements with certain systems (e.g. VRF)
- **Energy recovery ventilation** (ERV) in multifamily buildings

COMMERCIAL: 2021 IECC HIGHLIGHTS (continued)

NEW FORMATS:

- Reorganization of **Additional Efficiency Package Options** (C406)
- Packages shift to credit-based system—several **new options** added (e.g. receptacle controls, fault detection, EV charging, energy storage systems)
- Reallocation of credits based on relative energy impacts

CLARITY + USABILITY:

- Reorganization of *mandatory* and *prescriptive* (mirrors residential effort)
- Clarification of refrigeration system language
- Coordination with ASHRAE for data centers (Standard 90.4)

COMMERCIAL: 2021 IECC HIGHLIGHTS (continued)

GRID:

- **Electrification**-ready (e.g. space requirements for heat pump water heaters)
- **Storage**-ready: Space and pre-wiring for future battery systems
- **Grid-enabled storage systems** acknowledge in performance path

RENEWABLES:

- Prescriptive requirement for **renewables**—allows renewable energy certificates (RECs) as alternative options (+ custody requirements)
- **Zero-energy** Appendix—option for state adoption (e.g. Architecture 2030 ZeroCode)

How can I learn more?

- Follow the Building Energy Codes Program @ www.energycodes.gov

  > Subscribe to our news, updates and alerts

- Participate in the ICC and ASHRAE model code processes—both are free and open to the general public

- Attend the **National Energy Codes Conference**!

2019 National Energy Codes Conference

Annual three-day collection of engaging discussions, educational sessions, and the latest on what's new and next on all things energy codes—*just around the corner*!

- Bill Ritter, 41st Governor of Colorado
- Martin Keller, NREL Director
- 30+ educational sessions
- Network with key stakeholders
- Poster reception
- NREL campus tour

PART II

Performance-based Codes: Challenges + Solutions

Reid Hart, Pacific Northwest National Laboratory

Pacific Northwest
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Building Energy Codes Update

April 15, 2019

Reid Hart and Ellen Franconi

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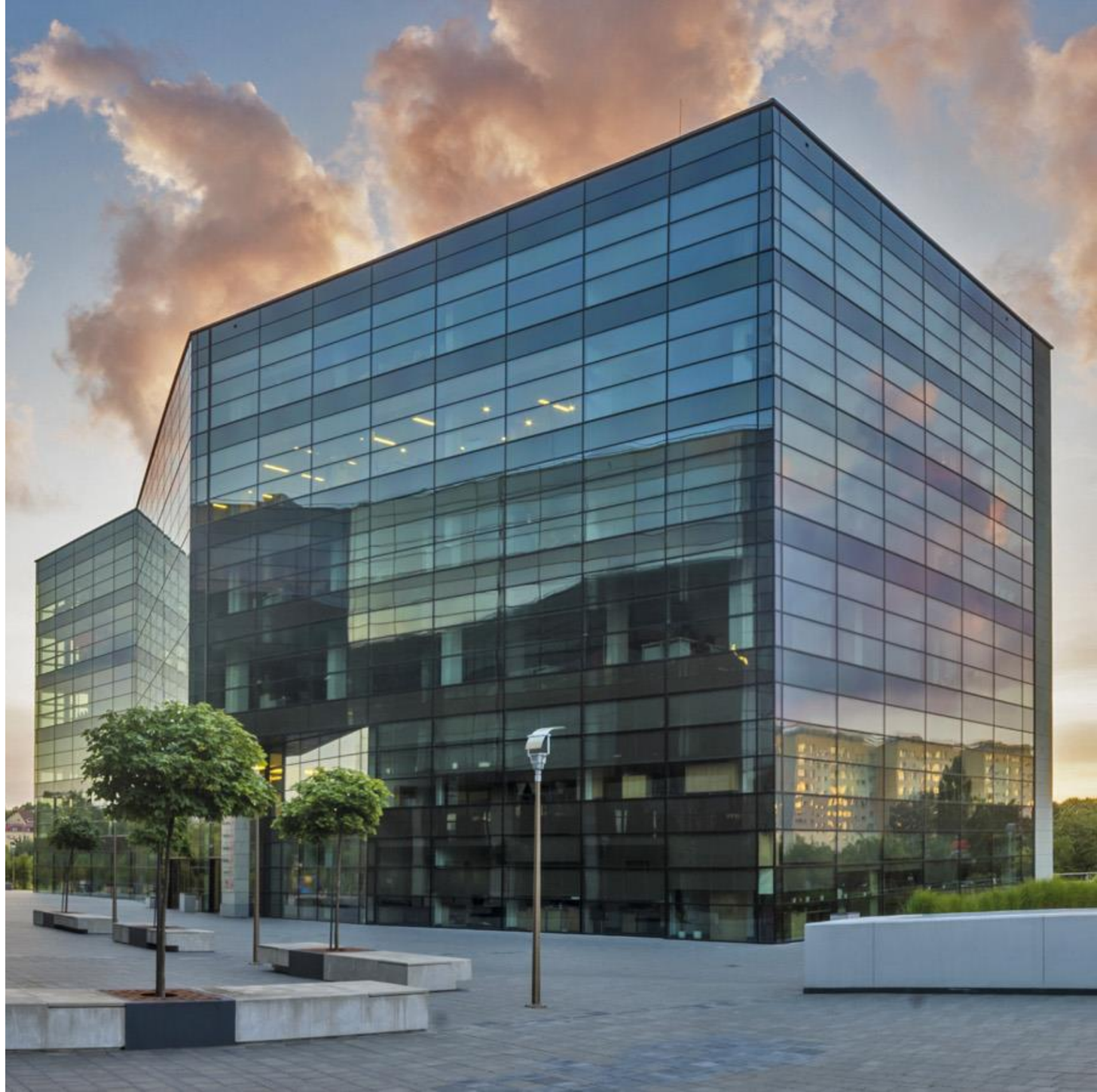

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Building Energy Codes Move Down the Road: Shifting from Prescriptive to Performance

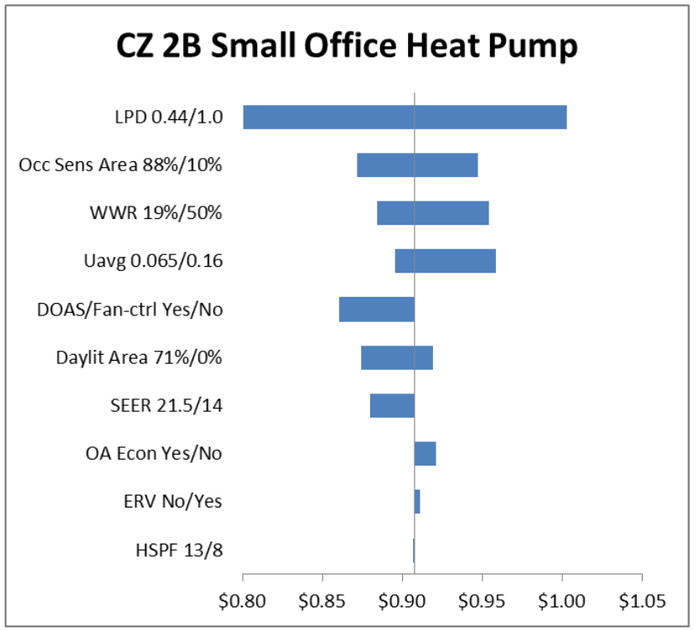
Reid Hart, PE
Pacific Northwest National Laboratory

Path to Performance

Roadmap for the Future of Commercial Energy Codes

January 2015; Rosenberg et al. PNNL-24009

- Energy performance targets
- Energy efficiency credits for added savings
- Total System Performance Ratio (TSPR)



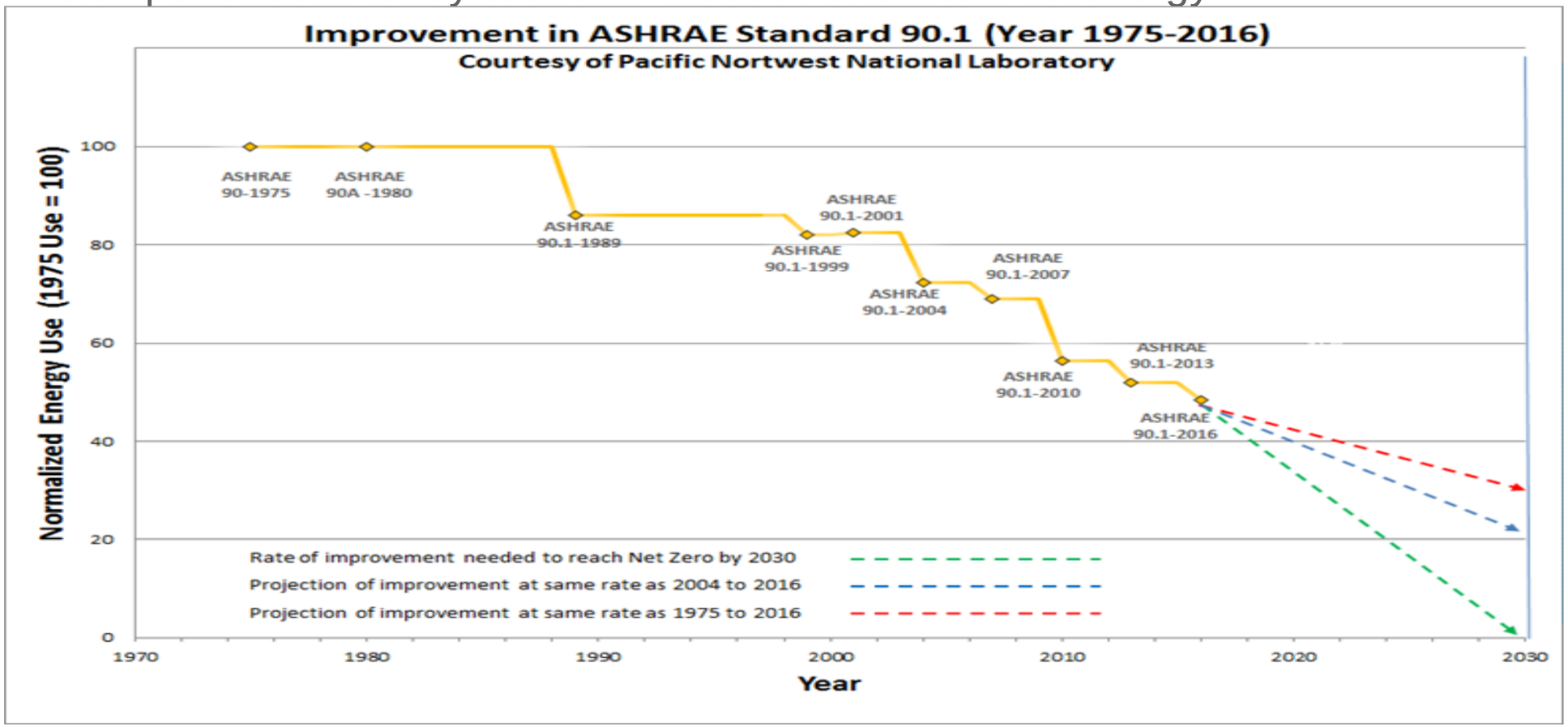
Limits of the Prescriptive Approach

Prescriptive approach is subject to diminishing returns

- Uninsulated wall + R-11 reduces heat loss by ~ 75%.

  Add an additional R-11: reduces only ~11% more.

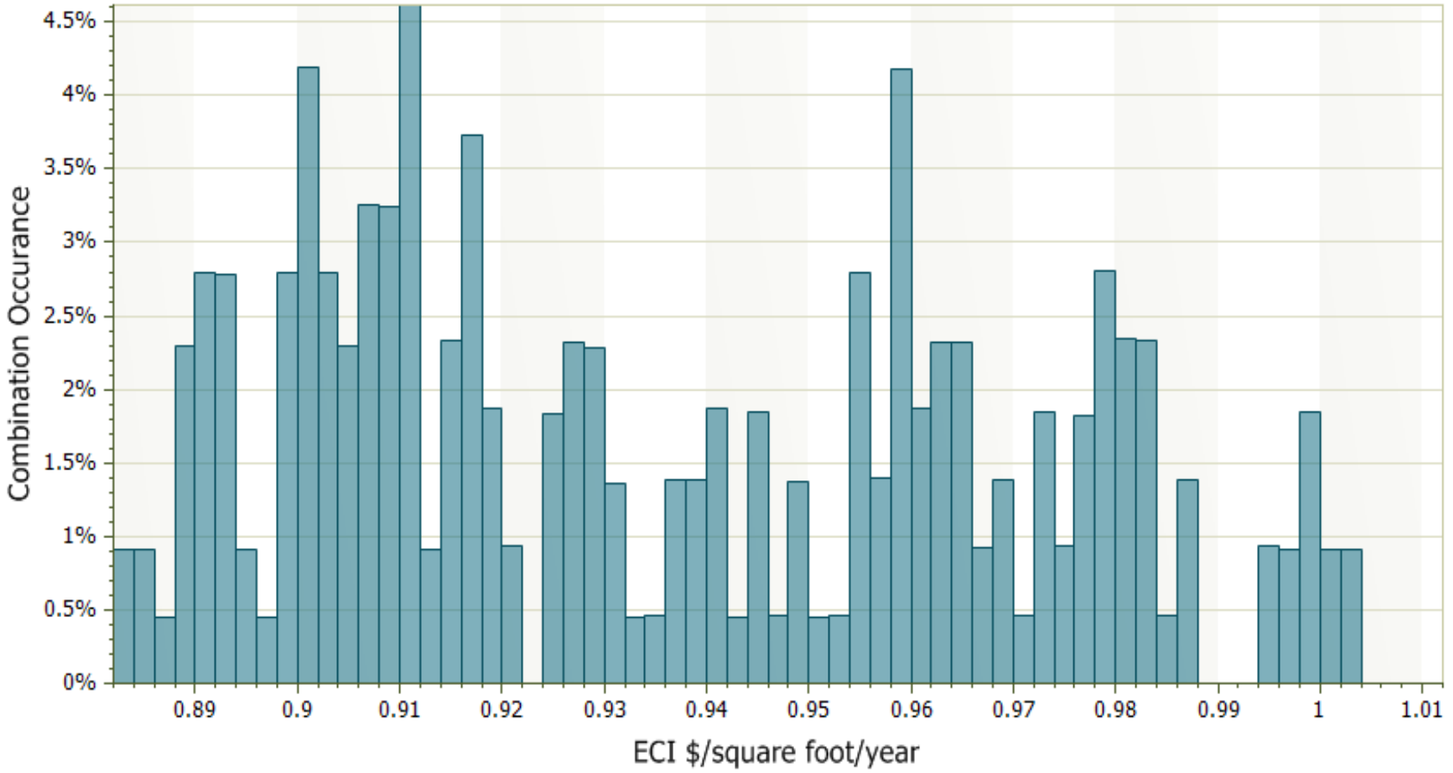
- Component efficiency alone will not achieve net zero energy



Energy Use Varies with Code Compliant Design Choices

Vary just six parameters for:

- Medium Office Building
- Climate Zone 5A
- **14% variation** in annual energy cost



- Window-wall ratio (WWR):
  25%→40%
- Window frame:
  metal→ non-metal
- HVAC size:
  small → large
- Roof insulation:
  above deck → below deck
- Wall type:
  steel frame → mass wall
- Heat source:
  electric →natural gas

Result: Wide range in Energy Cost Index (ECI) of various combinations.

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Code Roadmap: Lead with Performance Path

- Target levels set minimum performance
  - 90.1-2016 update to Appendix G created:
    - ✓ Stable baseline, i.e., 90.1-2004
    - ✓ Independent baseline, i.e., most parameters fixed
    - ✓ Developed through consensus process
- For simpler/smaller buildings (in development)
  - Represent 50% of floor space and 94% of buildings
  - Similar performance targets
  - No custom modeling costs required
  - Energy use calculator for simple buildings
  - A “standard design package” or “primary package”
    - ✓ Include reasonable prescriptive choices
    - ✓ Developed for each building type and climate zone
- For HVAC systems create a system assessment tool: TSPR
  - Express efficiency as [HVAC load output] / [HVAC energy input]

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Path to Performance: Large and Small Buildings

90.1 Ch 11

- Simulation
- Modeling rule set
- Energy $ compare

90.1 Apx G

- Stable and independent baseline
- Custom bldg. simulation
- Fixed scale to net-zero

Future Tools

- Automated baseline generation
- Assisted custom bldg. simulation
- Goal seeking solver

Energy Credits (added efficiency)

- Extra Efficiency
- Table of credits by building type and climate zone

Proposed for IECC

Energy Tradeoffs

- Expanded types of tradeoffs
- Tabular credits
- Allow simple building energy calculator

Move Prescriptive into Tradeoffs

- Simple bldg. calculator
- System efficiency (TSPR for HVAC)
- Simple bldg. simulator

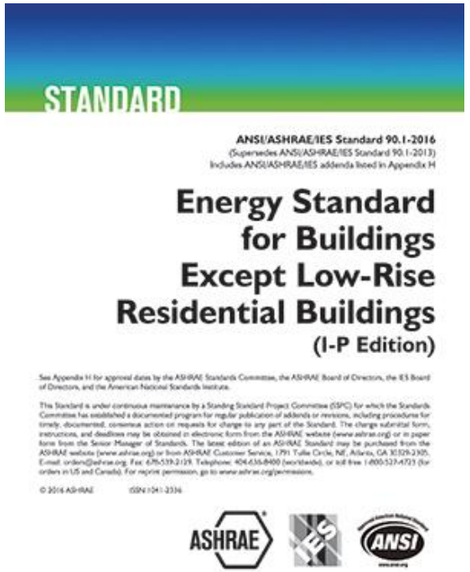
Creating Predictive Performance Targets

- Compare the energy use of the basic package to a stable baseline
  - 90.1 Appendix G uses a 90.1-2004 stable baseline
- Establish a performance target for each building and climate zone
- Building performance factor represents a performance target relative to approximately 90.1-2004
- Requires building simulation to comply; Just one BPF applies to each building

Table 4.2.1.1 *Building* Performance Factor (BPF)

Building Area Type[a]	Climate Zone																
	0A and 1A	0B and 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.73	0.73	0.71	0.69	0.74	0.73	0.68	0.78	0.81	0.81	0.76	0.80	0.81	0.76	0.79	0.74	0.80
Healthcare/ hospital	0.64	0.56	0.60	0.56	0.60	0.56	0.54	0.57	0.53	0.55	0.59	0.52	0.55	0.57	0.52	0.56	0.56
Hotel/motel	0.64	0.65	0.62	0.60	0.63	0.65	0.64	0.62	0.64	0.62	0.60	0.61	0.60	0.59	0.61	0.57	0.58
Office	0.58	0.62	0.57	0.62	0.60	0.64	0.54	0.58	0.60	0.58	0.60	0.61	0.58	0.61	0.61	0.57	0.61
Restaurant	0.62	0.62	0.58	0.61	0.60	0.60	0.61	0.58	0.55	0.60	0.62	0.58	0.60	0.63	0.60	0.65	0.68
Retail	0.52	0.58	0.53	0.58	0.54	0.62	0.60	0.55	0.60	0.60	0.55	0.59	0.61	0.55	0.58	0.53	0.53
School	0.46	0.53	0.47	0.53	0.49	0.52	0.50	0.49	0.50	0.49	0.50	0.50	0.50	0.49	0.50	0.47	0.51
Warehouse	0.51	0.52	0.56	0.58	0.57	0.59	0.63	0.58	0.60	0.63	0.60	0.61	0.65	0.66	0.66	0.67	0.67
All others	0.62	0.61	0.55	0.57	0.56	0.61	0.59	0.58	0.57	0.61	0.57	0.57	0.61	0.56	0.56	0.53	0.52

a. In cases where both a general *building* area type and a specific *building* area type are listed, the specific *building* area type shall apply.



90.1 Appendix G

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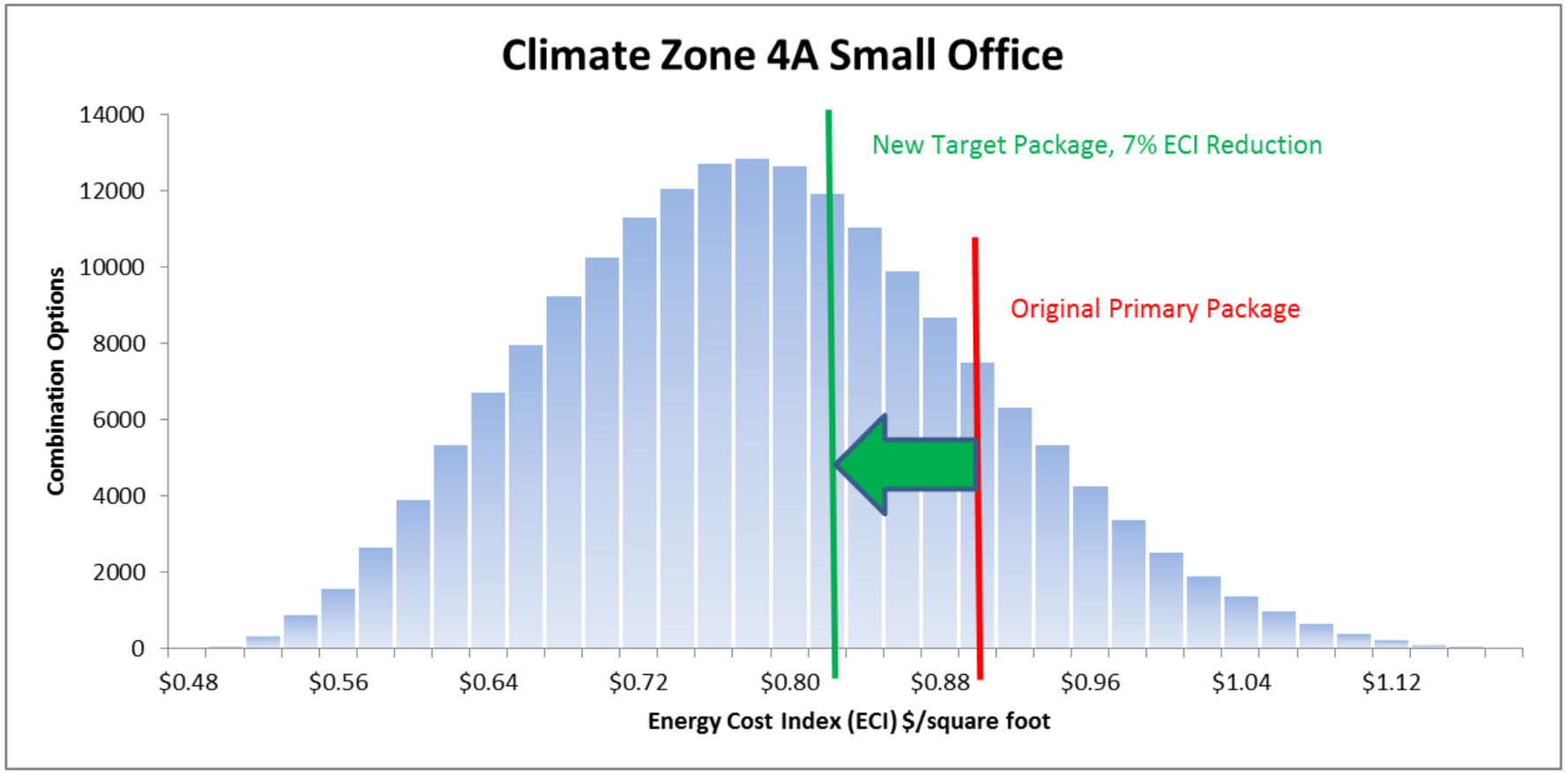
The Goal is an Easily Moved Performance Target

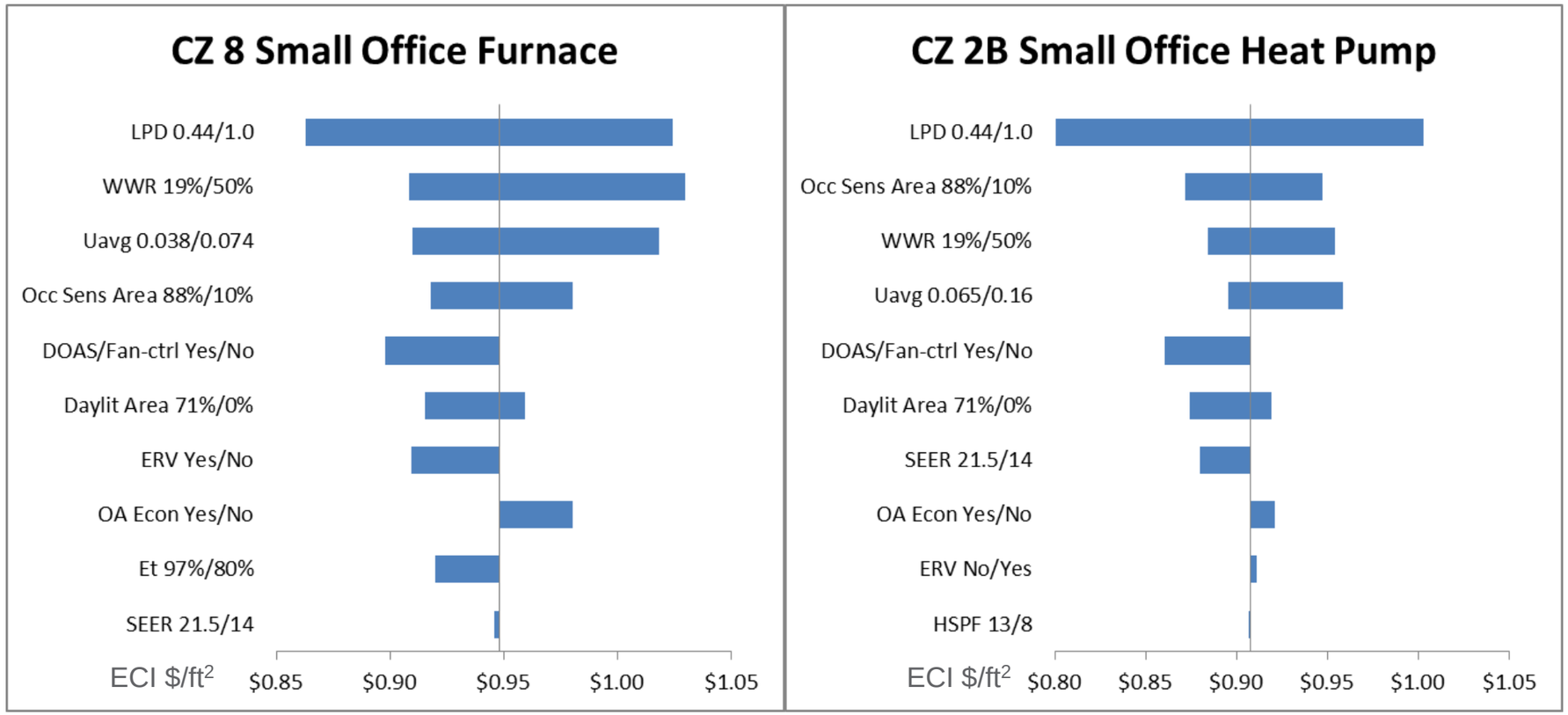


To achieve a % savings, just need to move the target

- Don’t need new consensus prescriptive requirements
- Does not require regeneration of the calculator regressions for simple buildings
- Just need to verify that can achieve the new target reasonably
- Like 90.1 Appendix G: stable and independent baseline

Energy Cost Impact of Options

- Reviewing simulation results shows option impact
- Determine high-impact parameters for simple buildings
- The basis for an energy calculator for simple buildings



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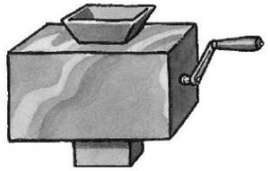
Develop an Energy Calculator for Simple Buildings

Parameter	Code	Proposed
Boiler thermal efficiency	0.80	**0.88**
Cooling EER	9.80	**12.00**
Total SP, in WG (SF+RF)	5.58	**5.58**
Window Wall Ratio	0.30	**0.33**
Area weighted average U-factor	0.188	**0.200**
Area weighted average LPD	0.82	**0.76**
% of floor Area Daylit	21%	**0%**
% of floor Area Occ Sensors	53%	**53%**
System Type	HyVAV	**HyVAV/DOAS**

- Input proposed building parameters
- Regressions used to calculate ECI
- Check against target: “Pass” or “Not Pass”
- Could limit inputs if backstops desired
- Could require minimum difference for credit



Simple Building EUI/ECI:	Base	Proposed	Savings
Electric EUI, kWh/sq. ft.	9.626	7.800	1.826
Gas EUI, therms/sq. ft.	0.032	0.150	-0.118
Electric ECI, $/sq. ft.	$0.990	$0.803	$0.188
Gas ECI, $/sq. ft.	$0.032	$0.148	-$0.117
Total Building ECI	**$1.022**	**$0.951**	**$0.071**

EUI = Energy Use Index; ECI = Energy Cost Index, $/sq. ft. - yr.

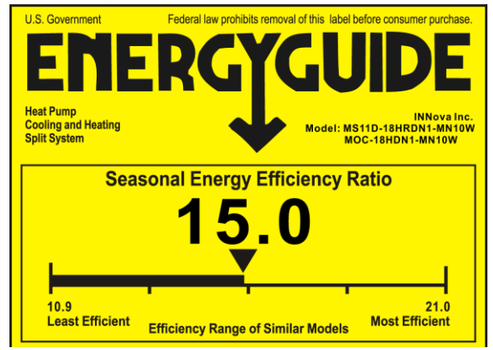
Total System Performance Ratio (TSPR)

TSPR = (annual)

Heating + Cooling Loads

HVAC Operating Input*

. . .for the whole building HVAC system (more like a seasonal heat pump rating than a boiler rating)



* HVAC operating input can be in terms of energy cost (ECI), energy use (site or source Btu's), or carbon emissions.
The higher the HVAC loads output relative to HVAC input, the more efficient the system is.

TSPR Can Bridge the Gap in Energy Code Progress

Prescriptive

SEER, AFUE, LED, LPD, Economizer, ERV, Motor Efficiency, Etc.

- Applies mostly to small and simple buildings
- Limited Options
- Doesn't achieve deep savings
- Options limited with increased code stringency

Simple & inexpensive to implement

"THE GAP"

Performance

Design Assistance, Energy Modeling, Whole Building Integrated Design, LEED Certification, Stretch Code Compliance

- Applicable to large/ complex buildings
- Achieves deeper savings
- Unlimited options
- Flexible

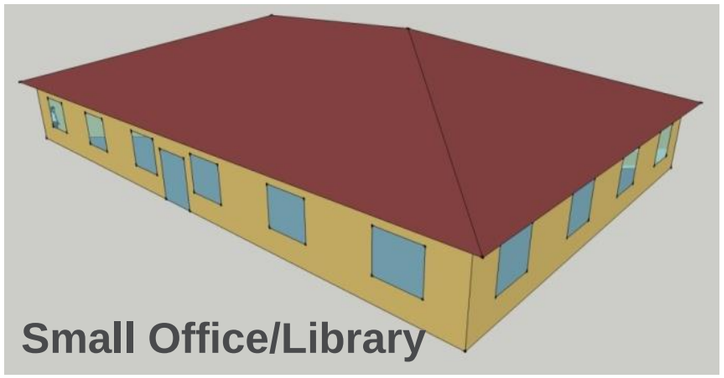
Complex & expensive to implement

Latest Progress:

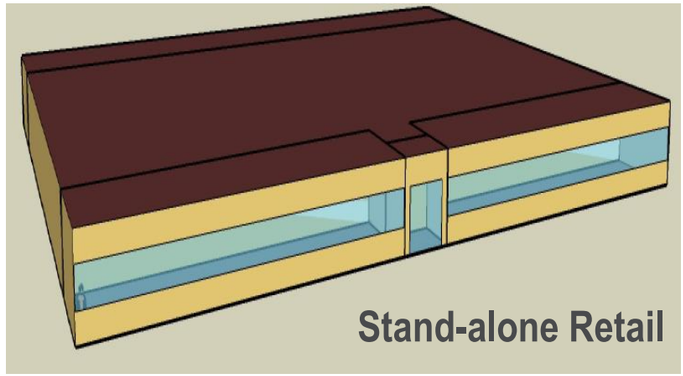
WA State Building Code Council voted TSPR for 2018 WA Energy Code proposed rulemaking.

California & NYC looking at TSPR for their codes.

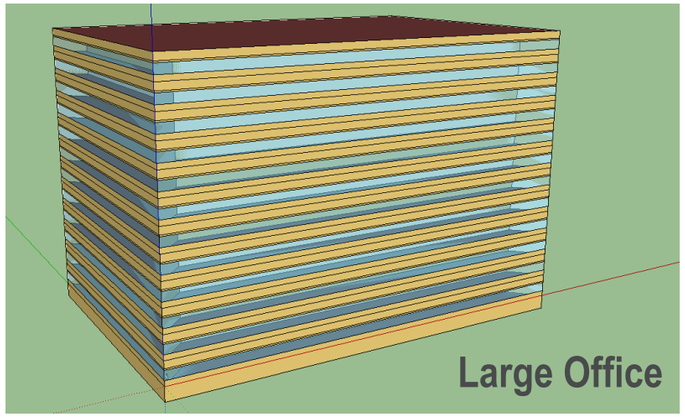
Baseline HVAC Systems for TSPR (WA selections)



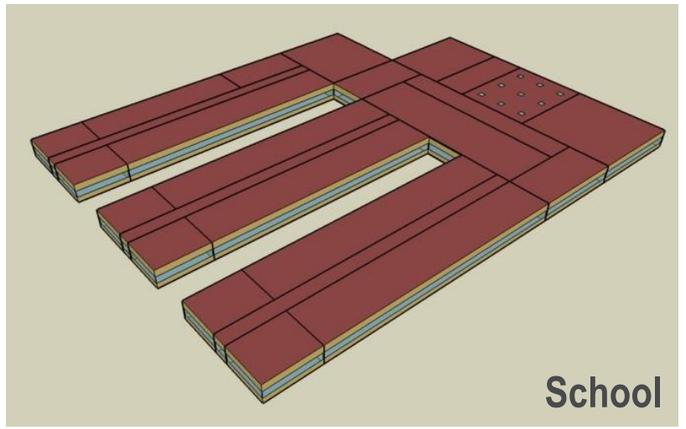
Continually running packaged heat pump → **cycling heat pump with DOAS/ERV**



Continually running packaged gas/dx → **cycling heat pump with DOAS/ERV**



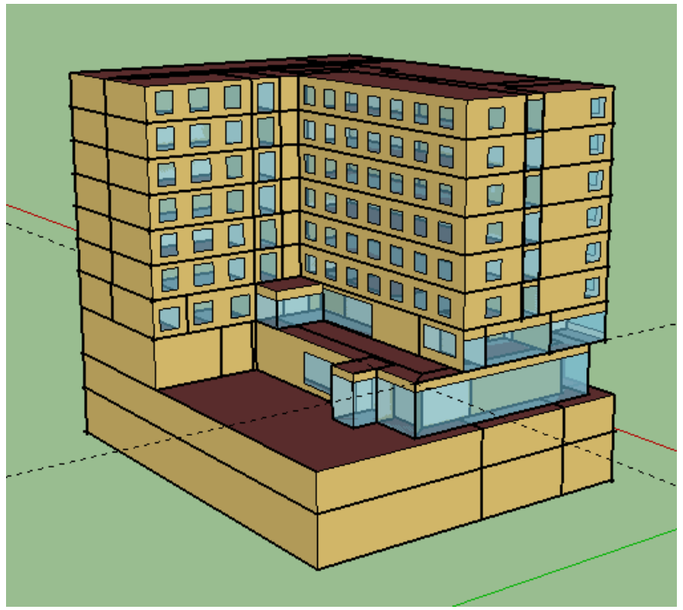
VAV reheat w/boiler and WC chiller → **WLHP w/DOAS/ERV**



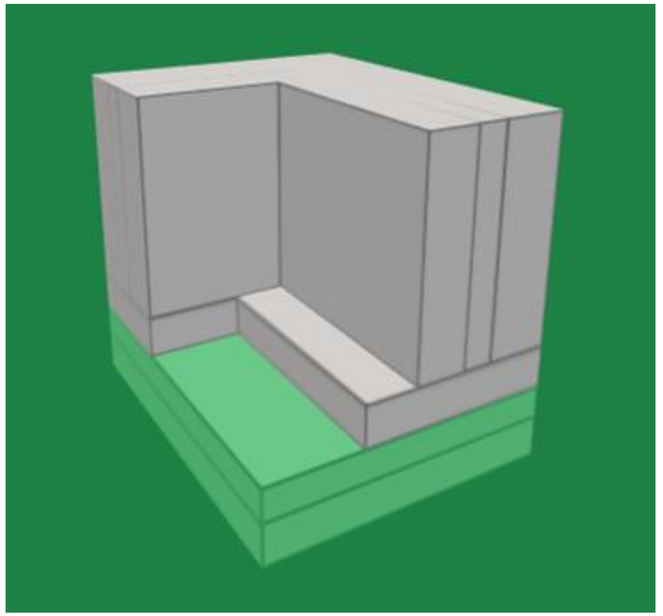
Packaged VAV reheat w/boiler → **cycling heat pump with DOAS/ERV**

TSPR: HVAC compliance calculation tool

- New module on top of DOE's (free) *Asset Score Tool*
  - Simplified tool for assessing building energy efficiency



Typical Energy Model



Asset Score Simplified Model

- Uses default loads and schedules (90.1 Appendix C)
- Lighting and envelope: baseline is same as proposed
- Takes only ~10% of the time as a fully customized energy model

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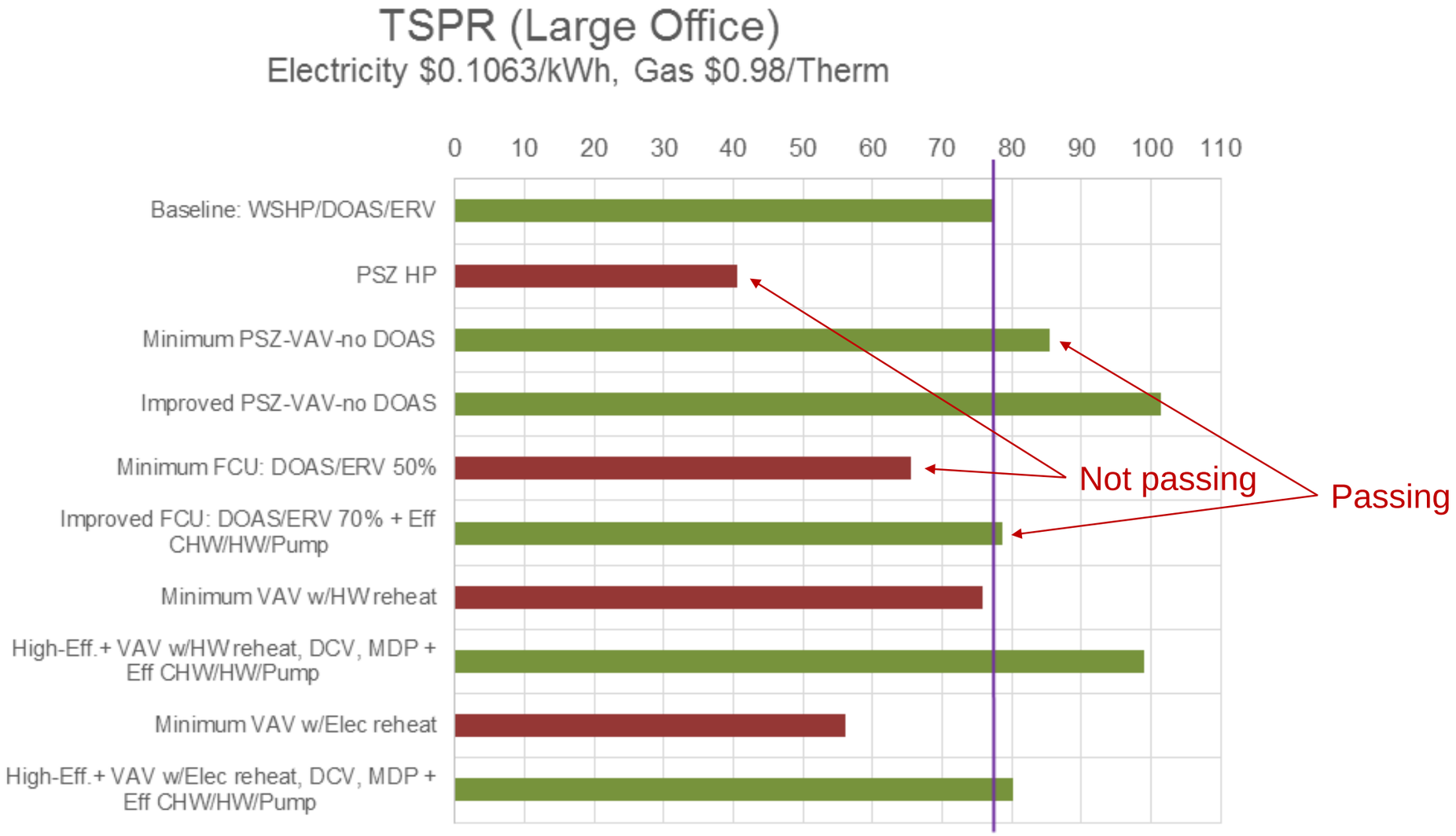
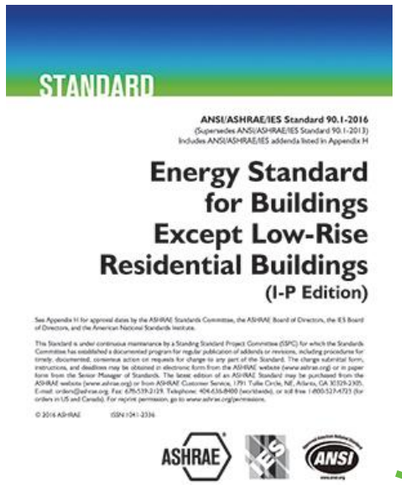
TSPR Large Office Example



TSPR compares total [HVAC load kBtu output] / [$ HVAC input]

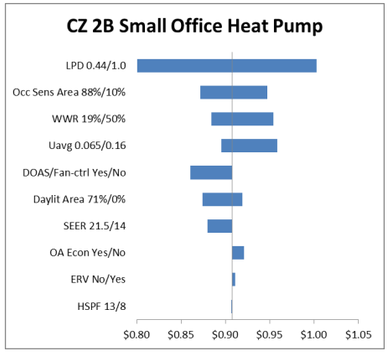
Building a Bridge to a Performance-Based Future

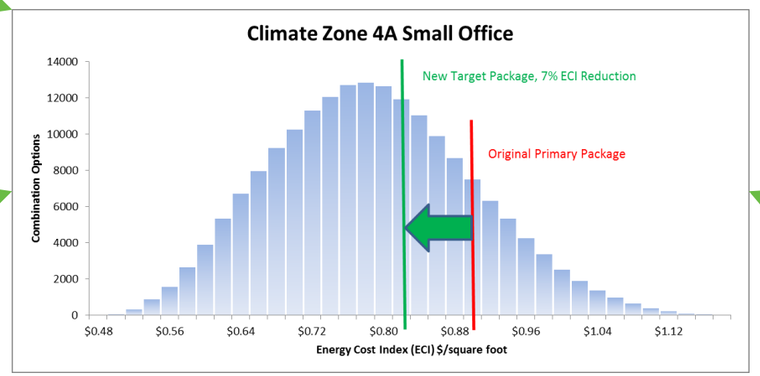


90.1 Appendix G

- Several ways to improve performance
  - More automation for Appendix G
  - Energy calculator for simple buildings
  - TSPR for HVAC system performance
- All help move the energy needle lower

Energy Calculator for Simple Buildings





HVAC System TSPR

PART III

Building Codes and Grid-interactive Efficient Buildings

Ellen Franconi, Pacific Northwest National Laboratory

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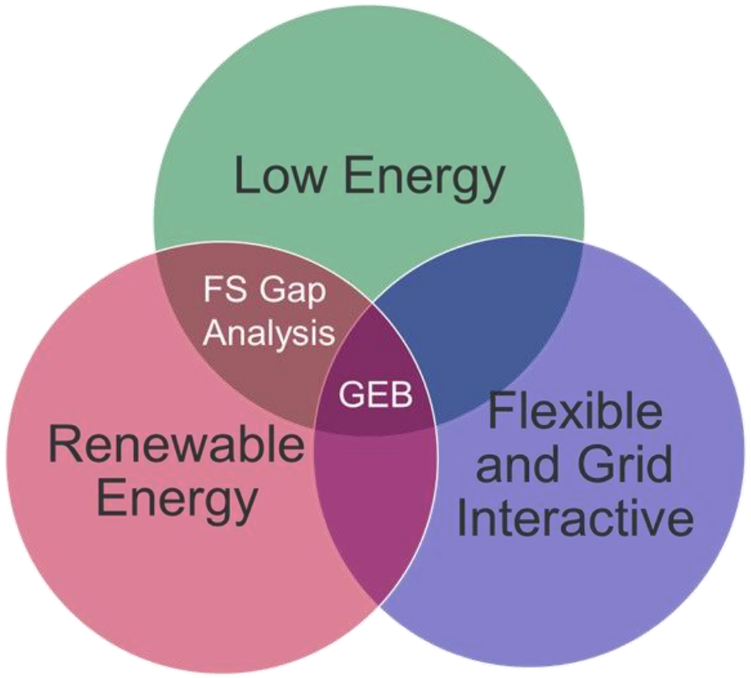
Grid-Interactive Efficient Buildings (GEB) in Codes

Ellen Franconi, PhD
Pacific Northwest National Laboratory

Project Summary



Project Descriptions:

GEB for Codes – Investigate Grid-Interactive Efficient Building (GEB) considerations addressed in current building codes, potential requirements for future codes, and their ability to deliver grid services.

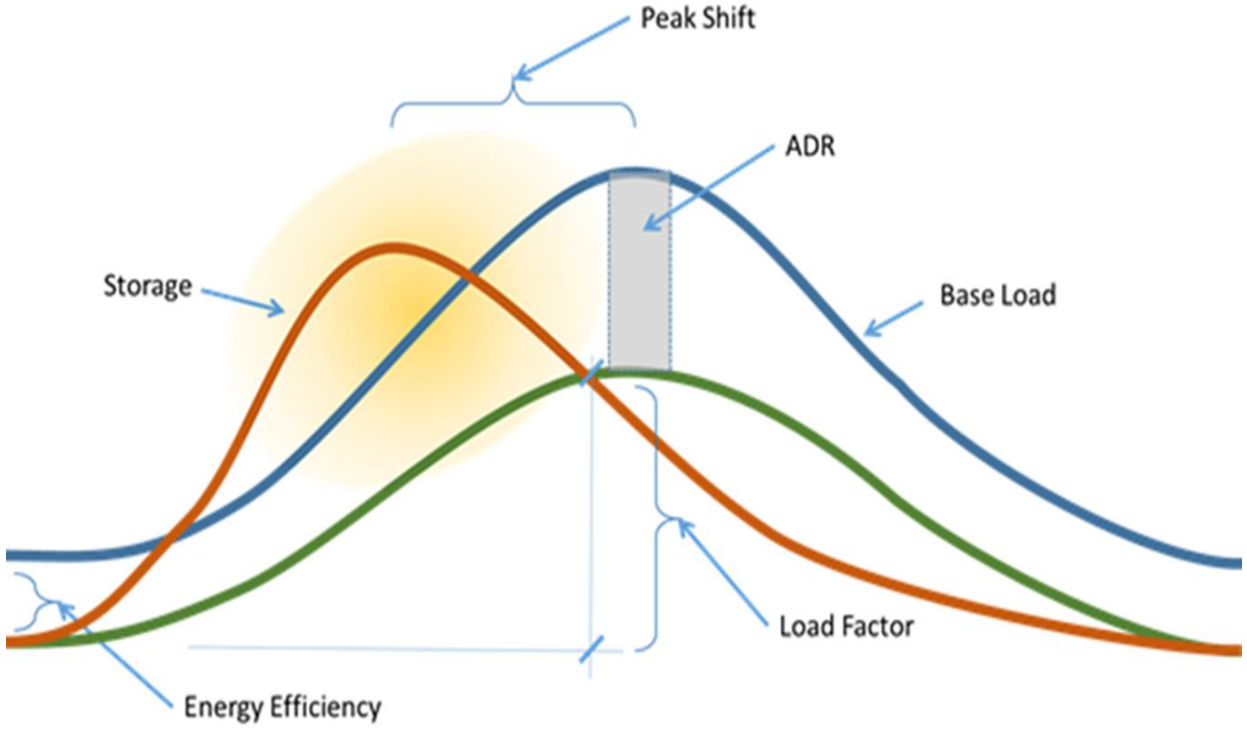
Feasibility Study Gap Analysis – Evaluate the energy efficiency performance gap in current codes. Identify and analyze advanced measures to fill the gap.

Challenge

A modern grid must have greater resilience, improved reliability, enhanced security, additional affordability, superior flexibility, and increased sustainability through additional clean energy and energy-efficient resources. Adapted from *US DOE Grid Modernization Multi-Year Program Plan*

GEB supports grid modernization

- Lowers total electricity demand
- Flattens peak demand
- Enables building load flexibility as a DER
- Includes dynamic two-way communication
- Supports a modern grid with a high penetration of renewables



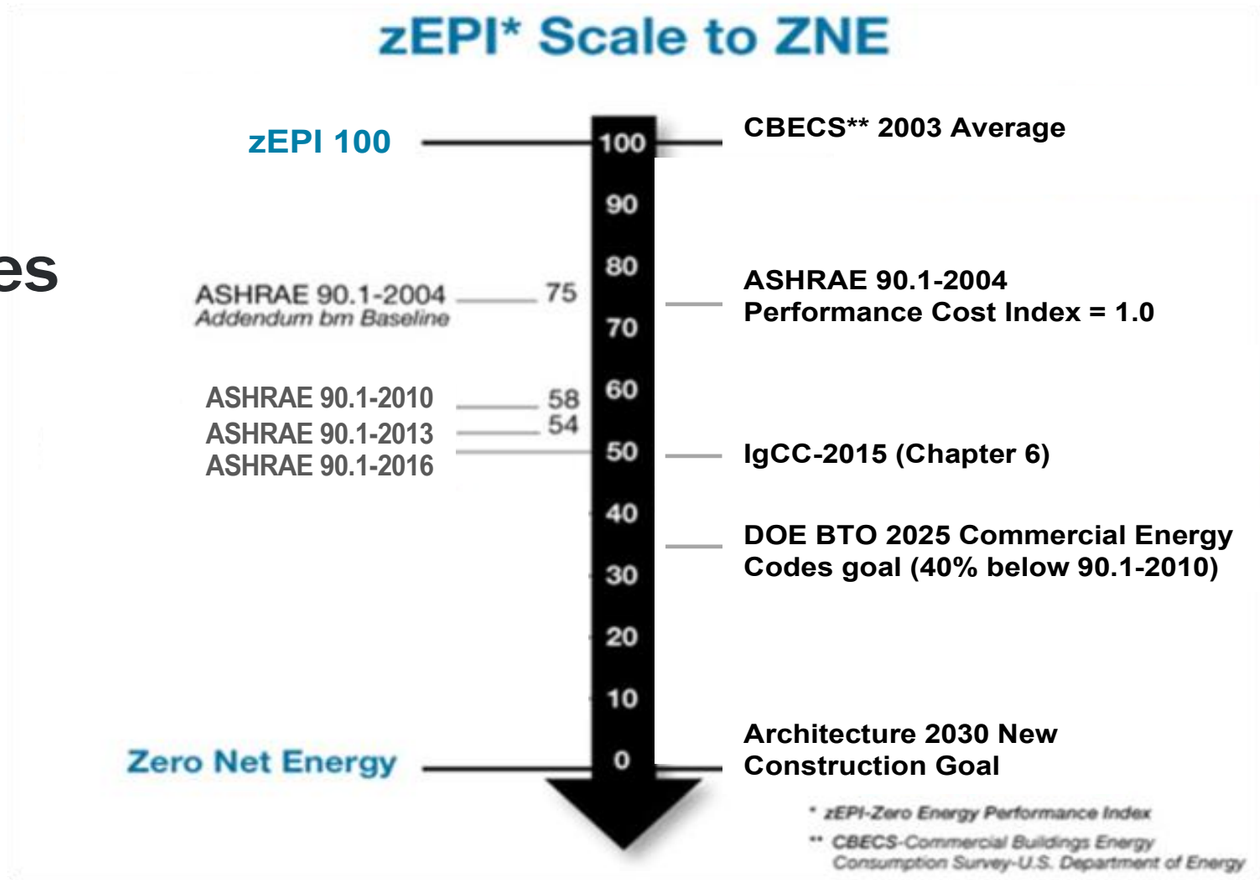
Project Approach

1. Review market-ready and near-market-ready GEB technologies for residential and commercial buildings.
2. Assess the current efficiency gap in codes based on code determination modeling results and the potential for advanced measures to fill the gap.
3. Qualitatively characterize the GEB measures to indicate their ability to provide various grid services and their relative value.
4. Quantitatively assess the importance of analysis input parameters through sensitivity studies using the code prototype models

Achieving Low Energy Buildings with Codes

Improved mechanisms

- Use prescriptive packages of measures and/or point options
- Move towards performance-based measures
- Include renewable energy requirements



Source: New Buildings Institute (modified from original)

GEB Measures in Current Model Codes

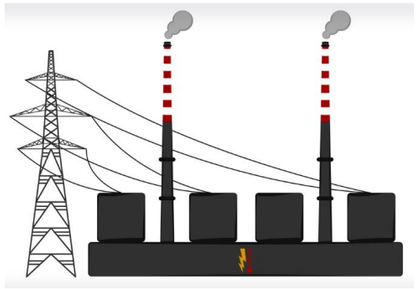
IECC 2018 Residential and ASHRAE 90.1-2016 Commercial

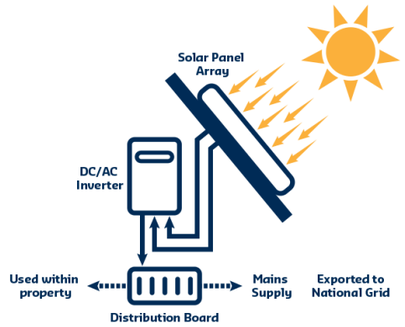
- **Load reducing and equipment efficiency measures**
- **Automated controls**
  - Thermostats and time-switches (IECC 2018R – 4 instances); Thermostats, lighting, ventilation, equipment, metering (90.1-2016 – 40 instances)
  - No grid-interactive control requirements
- **No prescriptive renewable energy requirements**
  - Prescriptive options (IECC 2018C); Solar ready provisions (non-mandatory Appendix RA, IECC 2018R)
- **Performance compliance approach allows on-site renewable energy to offset efficiency requirement**
  - Energy Rating Index with efficiency backstop (IECC 2018R);
  - ECB (5% PV backstop) and PCI (efficiency backstop w/ PV backstop to be consistent in 2019) (90.1-2106)
- **Proposals in place for 2021 Code**
  - Prescriptive requirement for PV (commercial)
  - Appendix RB Zero Energy Residential (residential)

Trends in Advanced Codes

Title 24 2019 and IgCC 2018

- Performance compliance target tied to source carbon
- Prescriptive requirements for solar energy (Title 24R, IgCC)
- Demand response controls adherence to OpenADR (Title 24)
- Demand responsive thermostats (Title 24)
- Demand responsive lighting (Title 24C, IgCC)
- Demand responsive HVAC (Title 24C, IgCC)





Considering GEB in Future Codes

Near Term

- Track kW and load factor reductions
- Expand existing measures that provide GEB value
  - Improve part-load efficiency
  - Include interconnectivity
- Encourage GEB-ready buildings
  - Non-mandatory appendices or options including the most valuable GEB measures
  - Qualitative, tiered assessment

Long Term

- GEB valuation inputs
  - Characterization of GEB measures
  - Characterization of regional net electricity supply curves
- GEB valuation analysis
  - Standardized modeling approach
  - Optimized response to grid signal
  - Metrics characterizing response impact

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Thank You

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Q + A