Advancing Energy Codes – Performance Based Energy Codes

2023 National Energy Codes Conference

May 2023

Michael Tillou, PNNL - The Transition to Performance Based Codes

Ryan Meres, RESNET - Residential Modeling and Quality Assurance

Maria Karpman, Karpman Consulting - Commercial Performance-based Code QA/QC

Learning Objectives

1. Learn about the role whole building performance plays in residential and commercial energy code compliance

2. Understand why performance-based compliance is becoming more popular in the transition to zero codes

3. Learn about the measures that are in place or are being developed to assure accuracy and quality control in performance based residential codes

4. Learn about the measures that are in place and are being developed to assure accuracy and quality control in performance

Michael Tillou, PNNL - The Transition to Performance Based Codes

Michael Tillou joined PNNL in 2020 as a Senior Research Scientist. He supports PNNL's commercial energy code development team providing technical analysis and support for cost-effective upgrades to national model energy codes and standards including ASHRAE Standard 90.1 and the International Energy Conservation Code. Michael has worked for over 25 years as an energy analyst supporting the design and operation of high-performance buildings, analyzing complex building systems, and, providing training to code officials and design professionals. He has combined his expertise in code development and building simulation to become a leader in the effort to transition to performance based energy codes.

Advancing Energy Codes – Performance Based Energy Codes

2023 National Energy Codes Conference
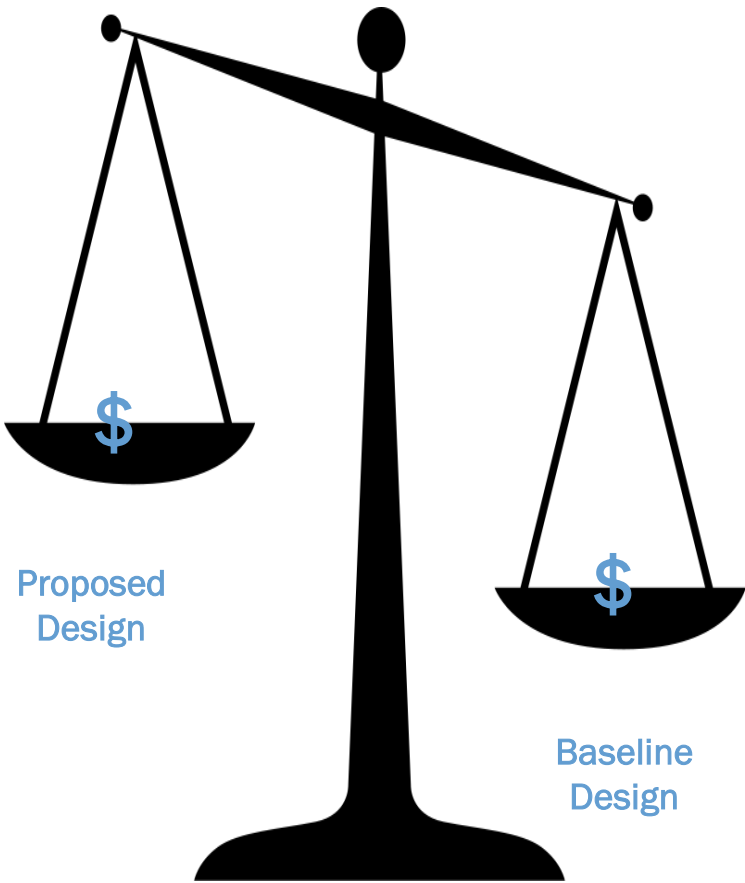
May 2023

Michael Tillou, PNNL

Topics

- Current Approaches for Commercial Code Compliance and Drawbacks

- Transition to Performance Based Codes and Potential Pitfalls

- PNNL Code Program Activities to Support this Transition

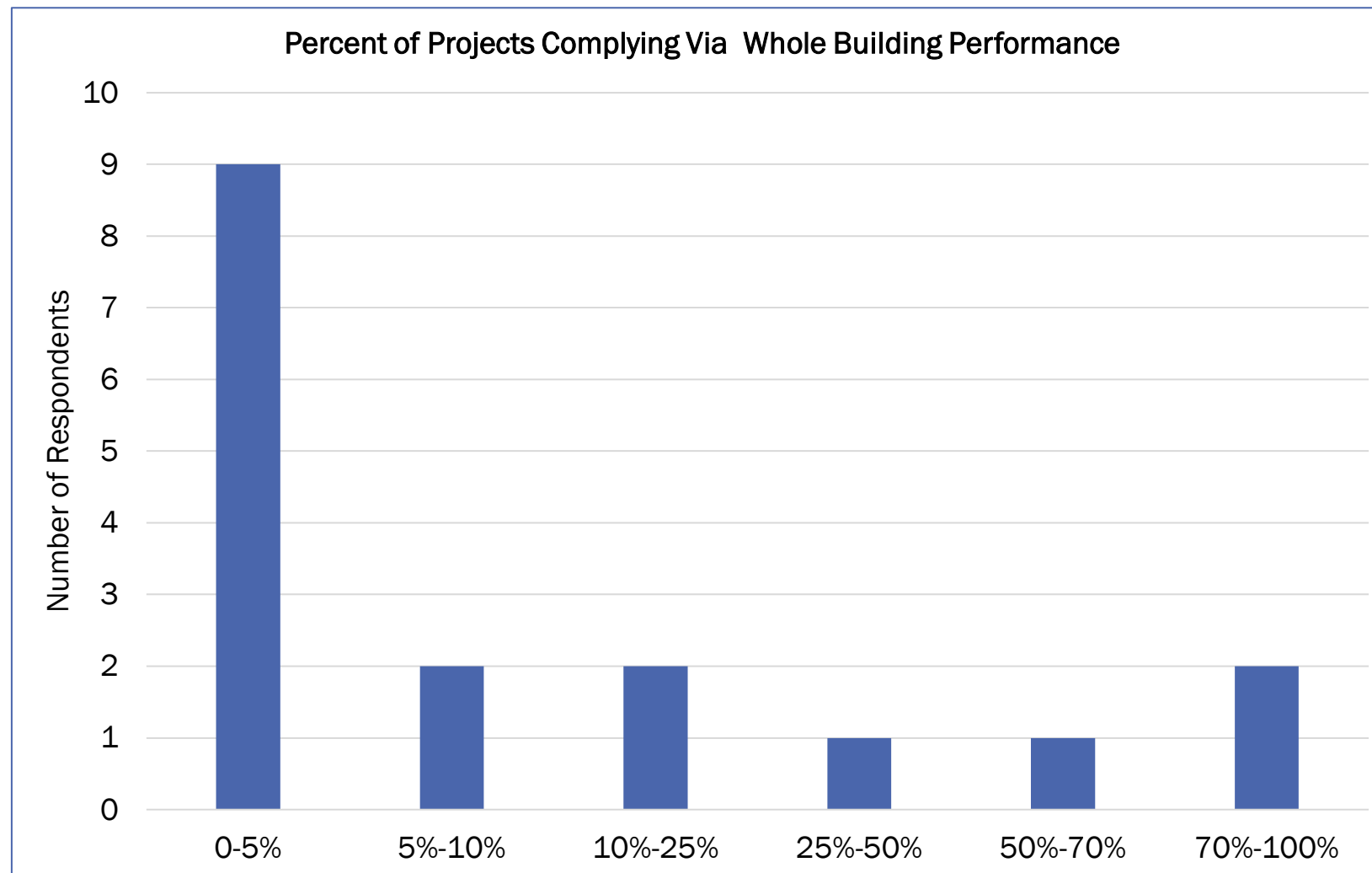# Current Status -Two Paths for Code Compliance

Prescriptive

Whole Building Performance


Proposed Design

Baseline Design
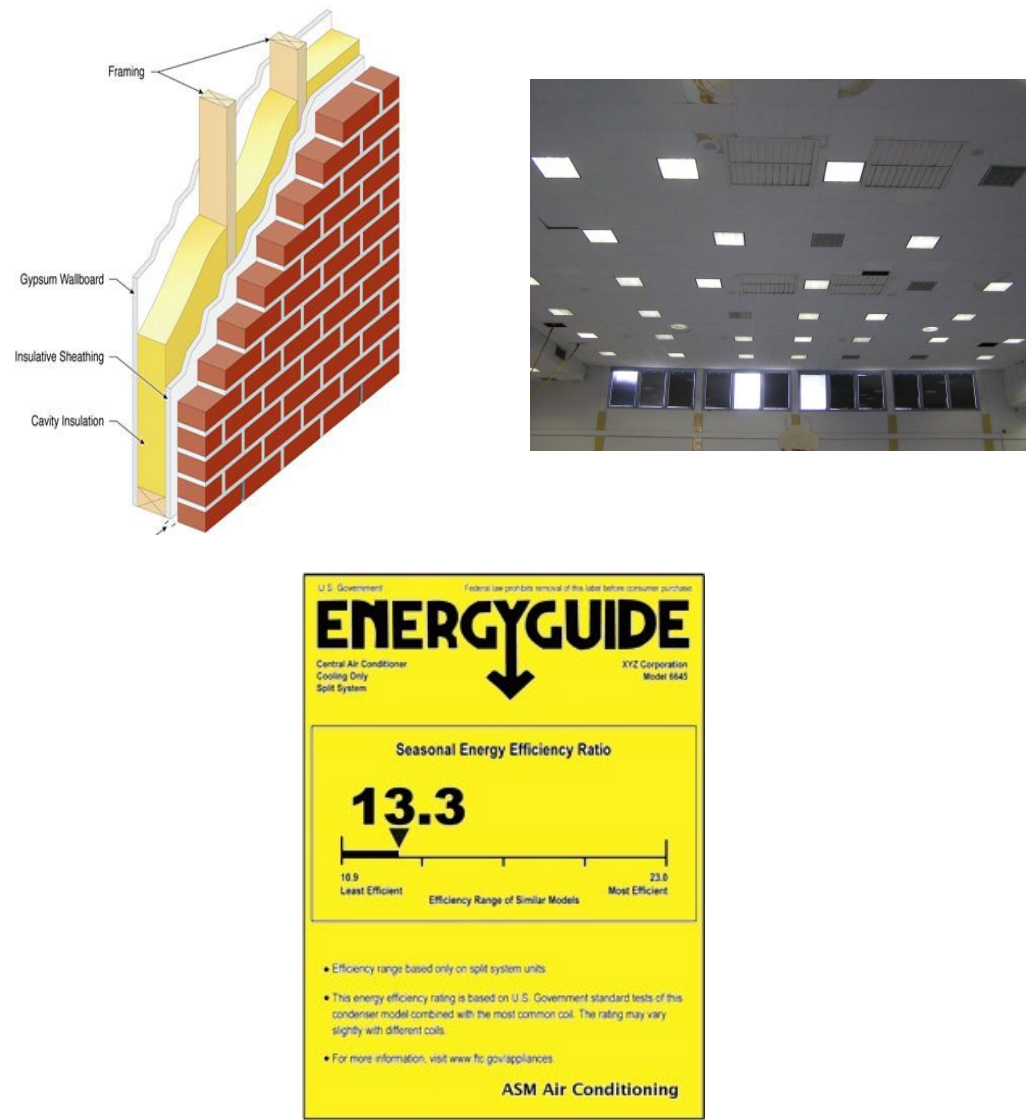
Prescriptive Path Dominates

- **Saturation varies by jurisdiction**
  - Most see very few performance path projects most of which are large or complex buildings

Percent of Projects Complying Via Whole Building Performance

Problems with Reliance on Prescriptive

- **Prescriptive path does not prescribe energy use or recognize good design choices**
  - Multitude of prescriptive options – each judged independently
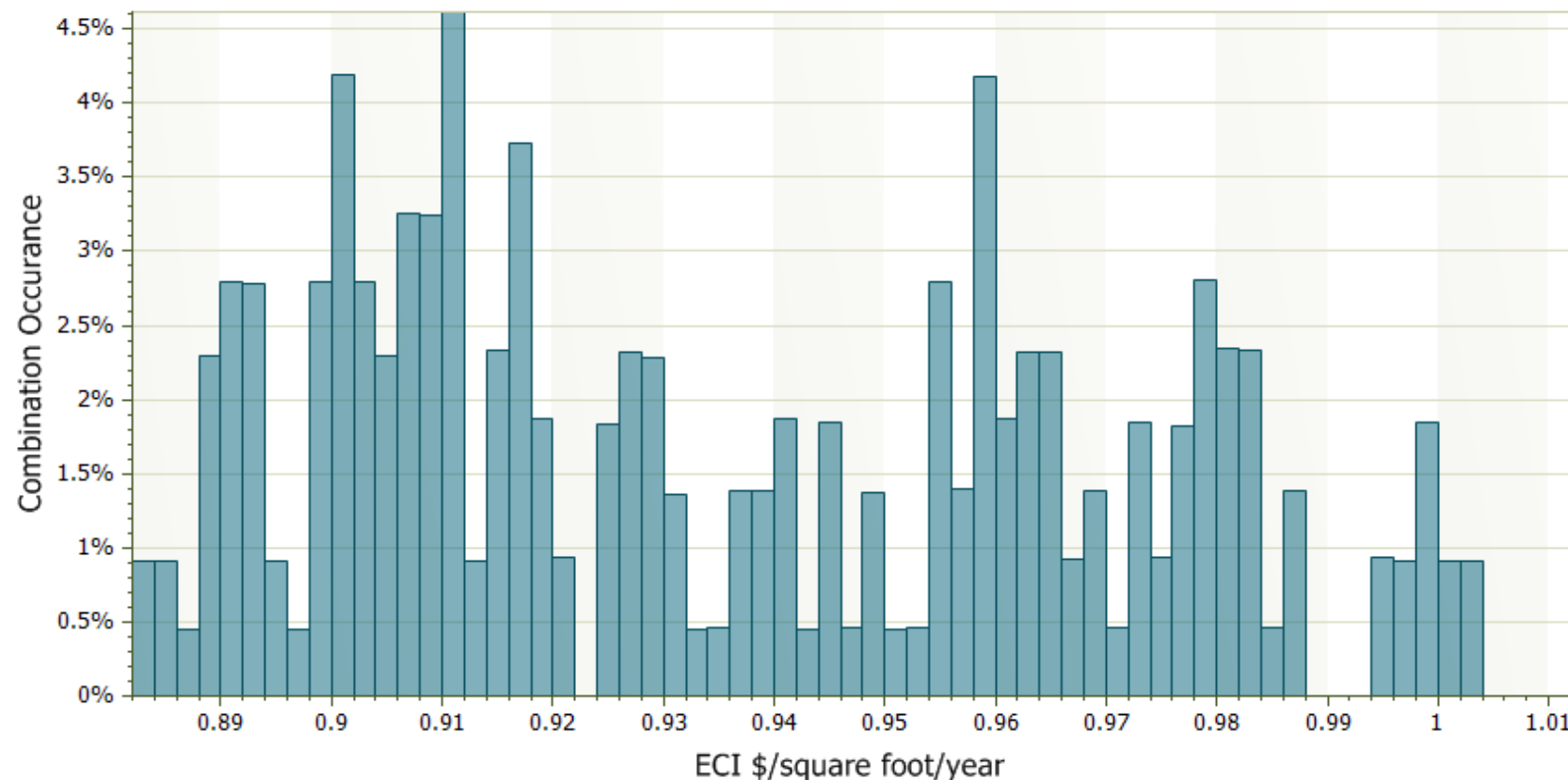 - Each combination chosen results in very different energy use
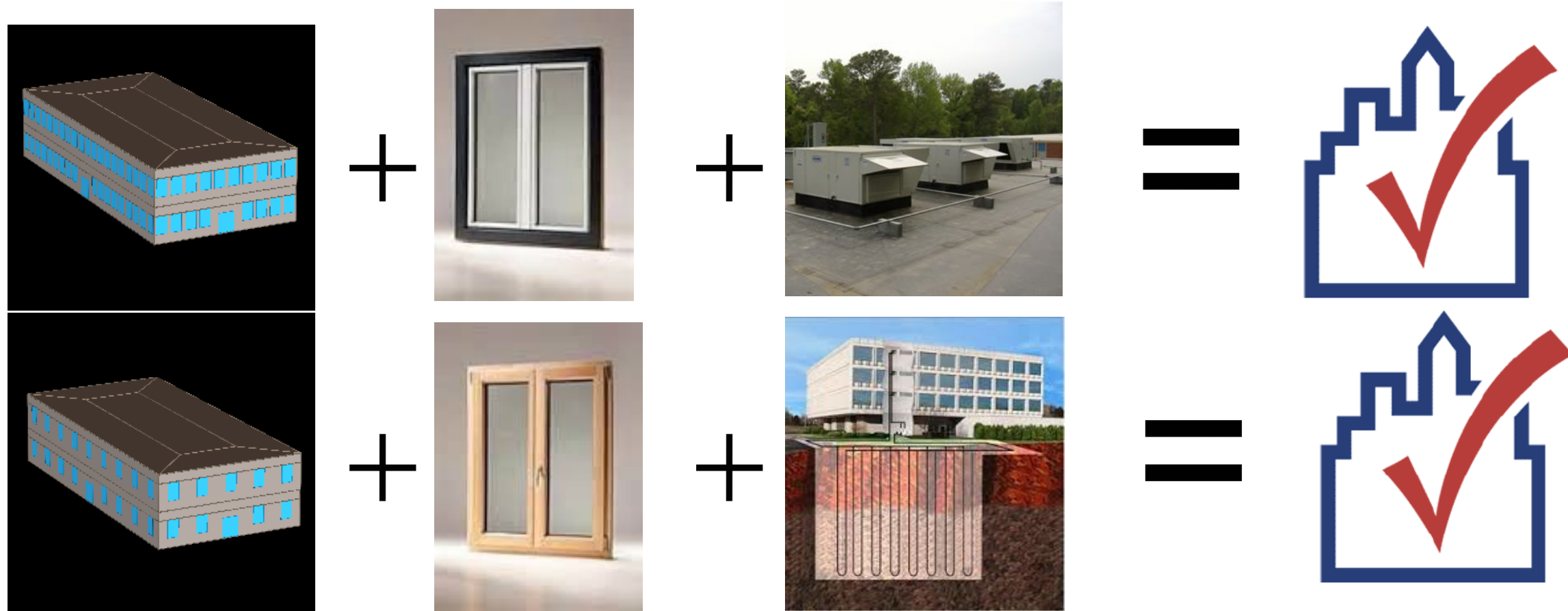
Problems with Reliance on Prescriptive

- **Wide variation in energy outcomes with prescriptive compliance**
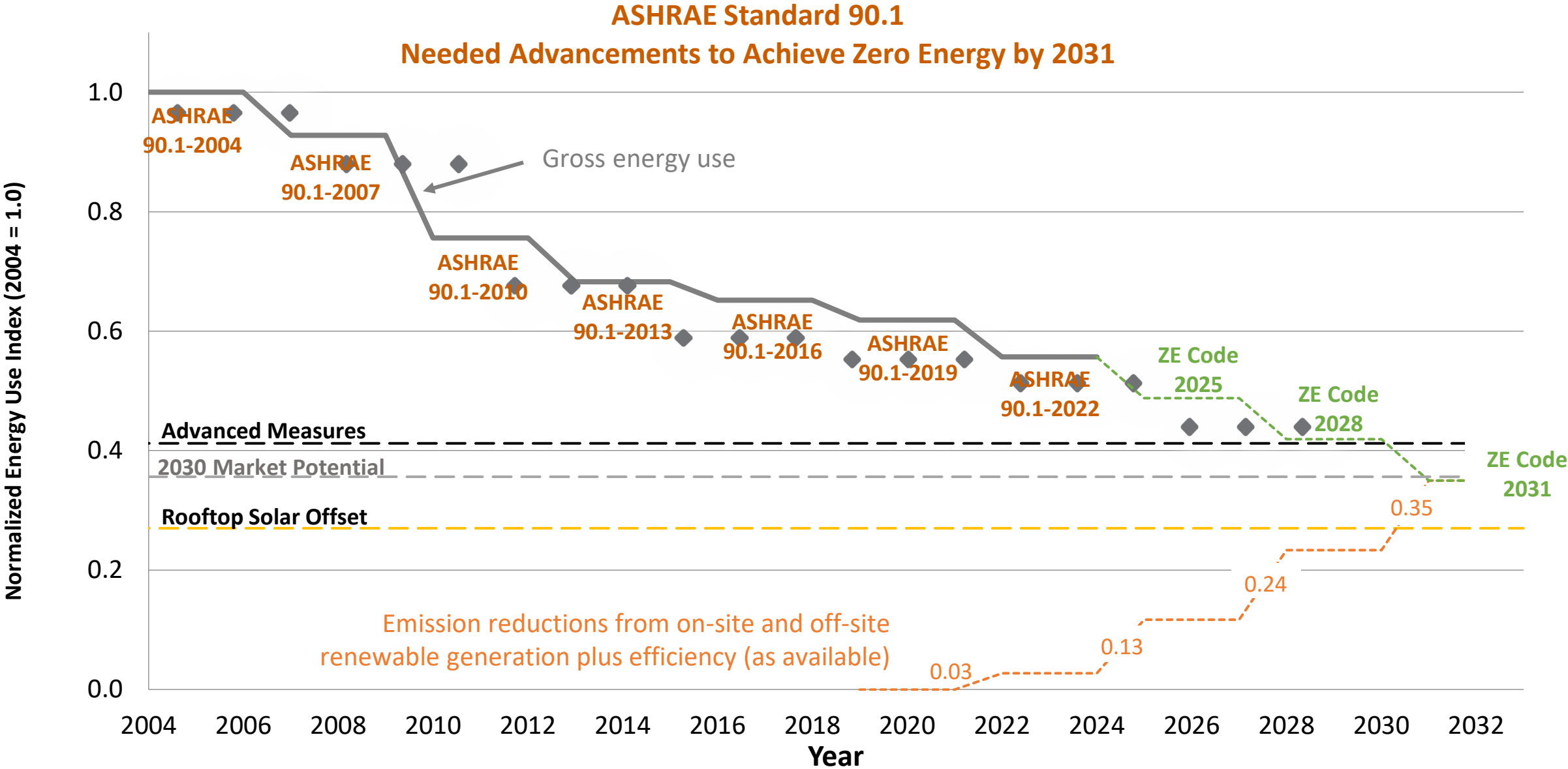
Varying just six parameters for:
- Medium Office Building
- Climate Zone 5A
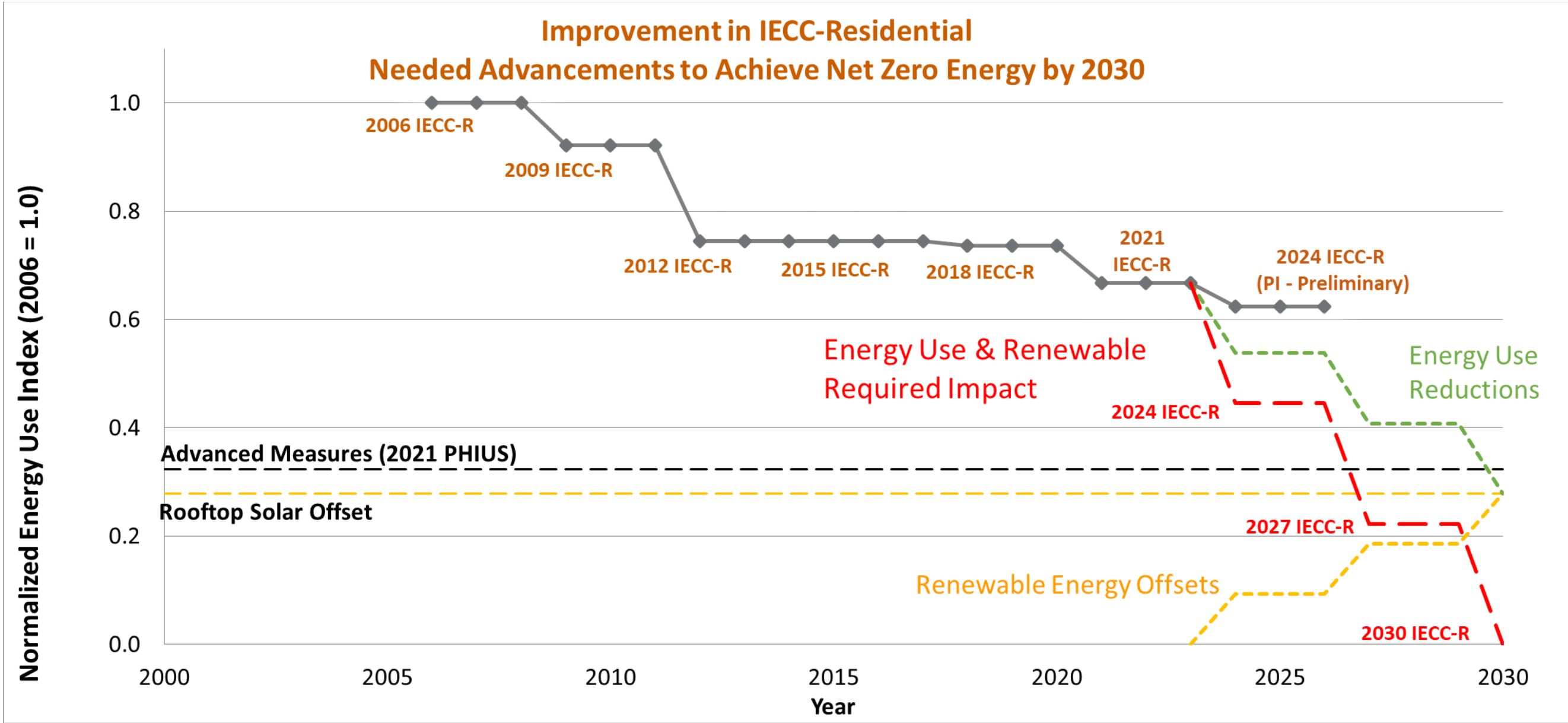- 14% variation in annual energy cost

- 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

Problems with Reliance on Prescriptive

- Unlikely to meet aggressive savings targets – Net Zero by 2030 (ASHRAE, AIA)
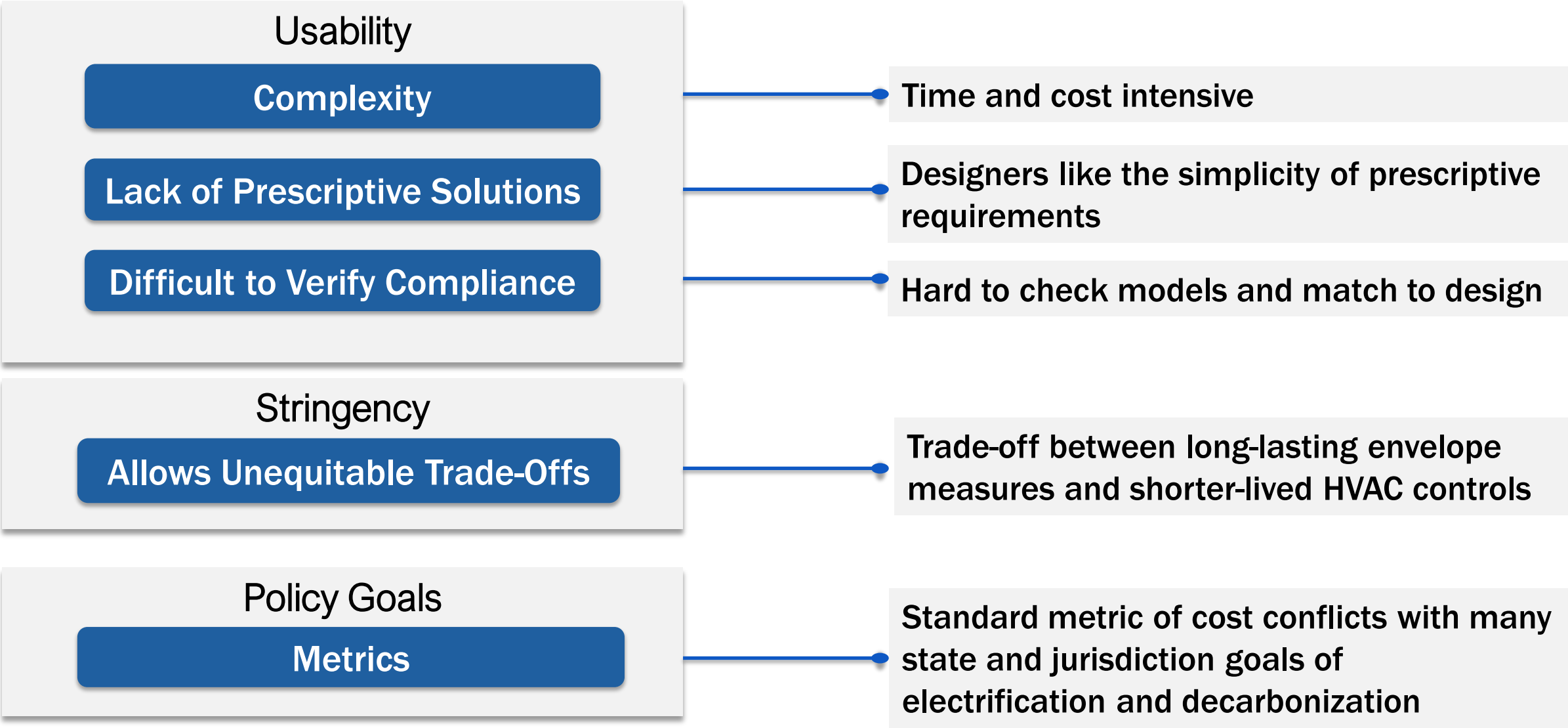

ASHRAE Standard 90.1
Needed Advancements to Achieve Zero Energy by 2031

Improvement in IECC-Residential
Needed Advancements to Achieve Net Zero Energy by 2030

Solution – Transition to Performance Based Codes
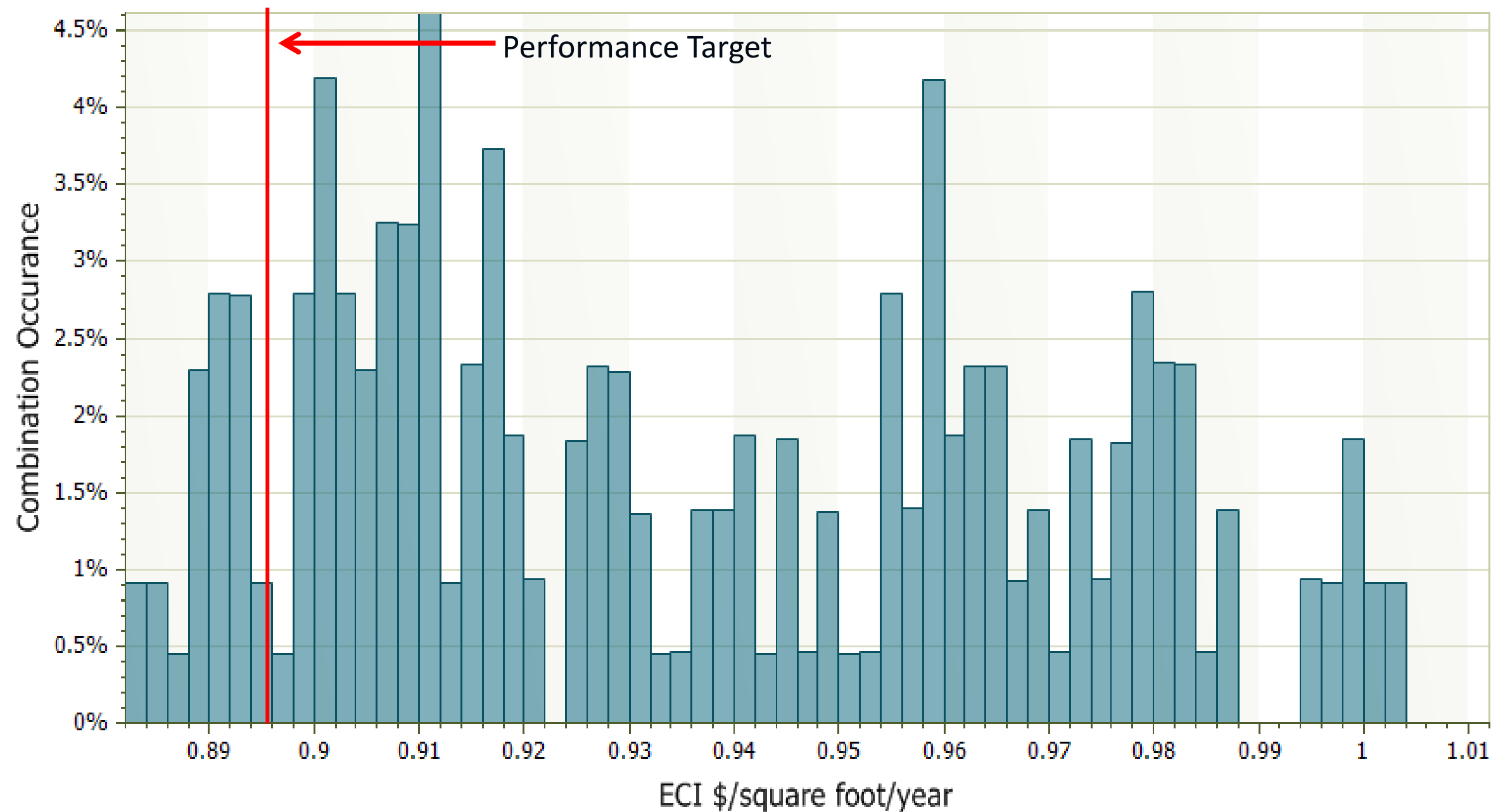
Challenges Faced in the Transition to Performance Based Code

Usability

- **Complexity** — Time and cost intensive
- **Lack of Prescriptive Solutions** — Designers like the simplicity of prescriptive requirements
- **Difficult to Verify Compliance** — Hard to check models and match to design

Stringency

- **Allows Unequitable Trade-Offs** — Trade-off between long-lasting envelope measures and shorter-lived HVAC controls

Policy Goals

- **Metrics** — Standard metric of cost conflicts with many state and jurisdiction goals of electrification and decarbonization
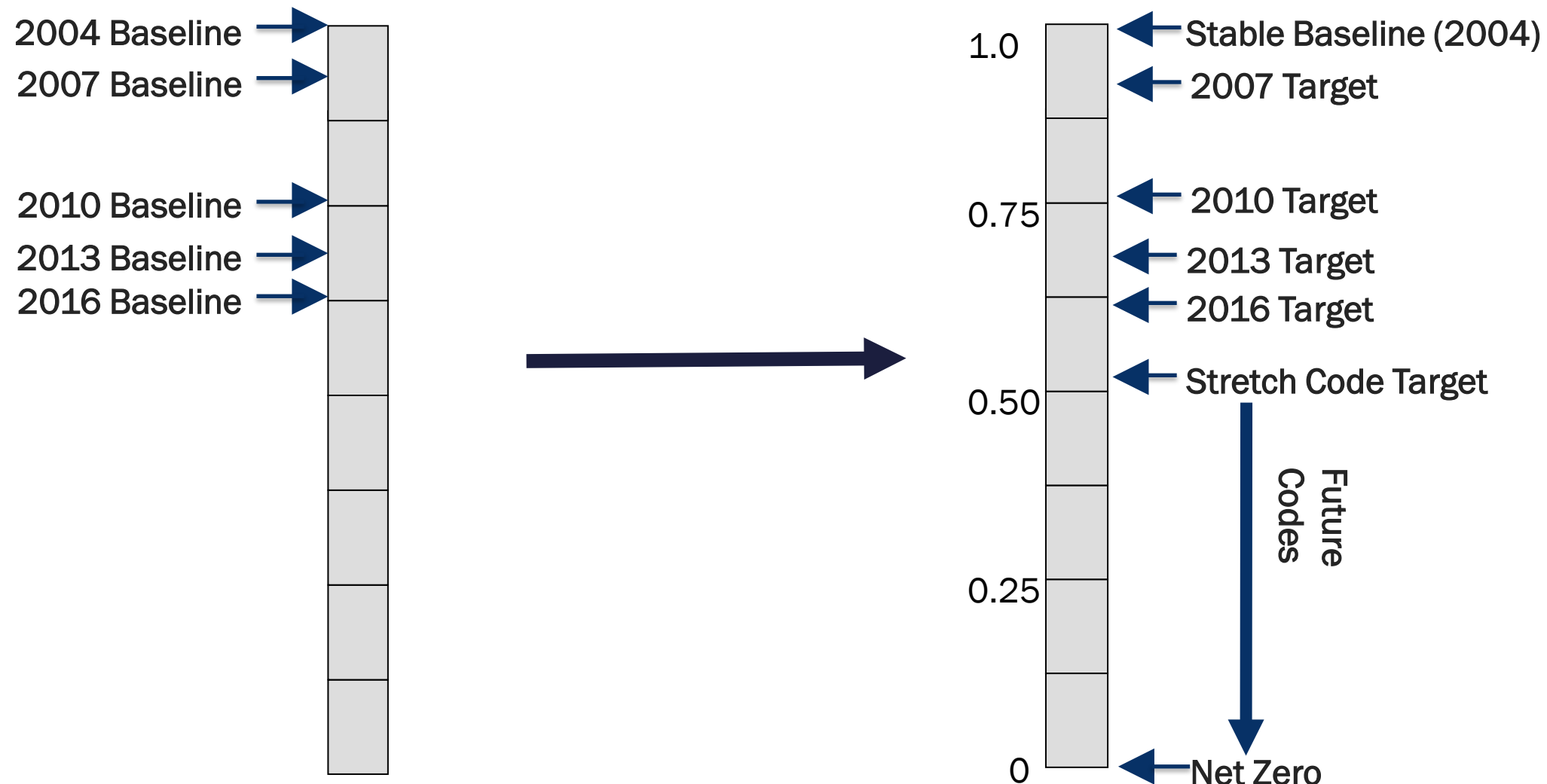
PNNL Code Program Activities Related to Transition to Performance Based Codes

Single Modeling Ruleset for Code or "Beyond Code" Programs

ASHRAE 90.1-2016 Appendix G – stable baseline

- Compliance requires meeting a performance target below the baseline
- Specific targets created for any code or beyond code program

Recent Improvements in Appendix G PRM

ASHRAE 90.1-2022 Appendix I – informative Appendix with guidance for jurisdictions to develop location specific Building Performance Factors (BPF) for Appendix G.

- BPF tables based on site energy, source energy or emissions rather than national average energy costs.
- Establishes a methodology for developing BPF based on local energy costs, source energy factors or emissions factors.
- Addresses feedback from stakeholders looking for alternatives that support local energy efficiency and decarbonization goals.

Appendix G Baseline Prototypes – PNNL completed the development of commercial building prototypes that follow the Appendix G Baseline rules.

- Better aligns BPF with practitioner outcomes
- Improves usability of Appendix G

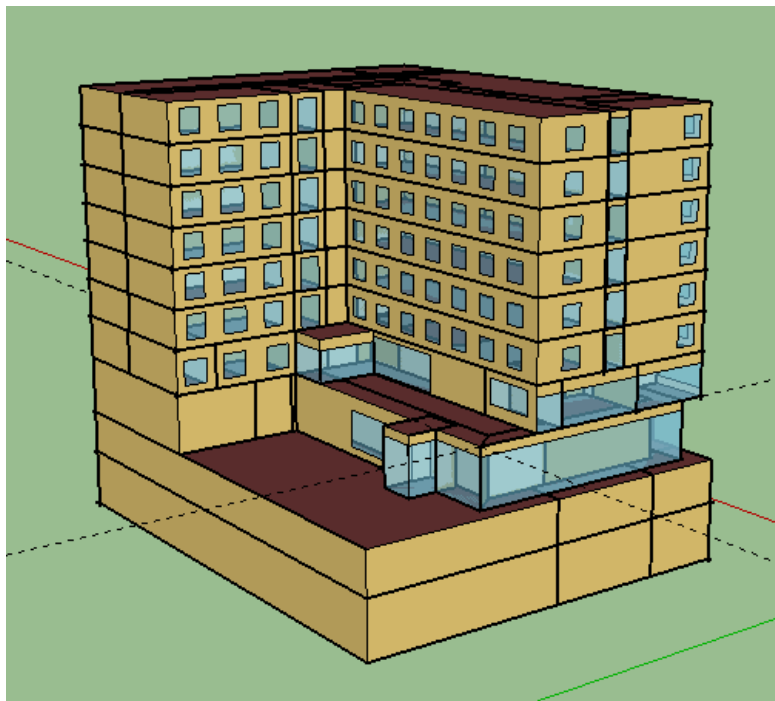# Simplified Approaches – Reduce Complexity

Simplified Energy Modeling Ruleset (SEM) –

Appropriate for small, simple buildings – 50% of non-res buildings <5,000 ft2
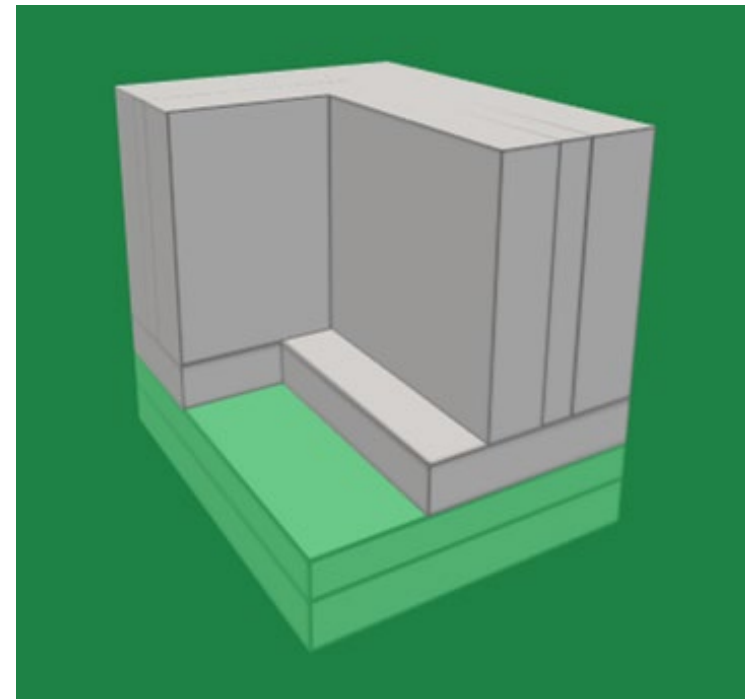
Reduces modeling time and cost

- Standard Appendix G model for 50,000 ft^2 project can require 75-100 hours
- Simplified Energy Model using Asset Score Tool may be 5 hours

Typical App G Energy Model

Asset Score Simplified Model

Limit Unequitable Trade-offs – Backstops

- **Establishes mandatory envelope performance minimums below which no trade-offs are allowed**
  - ASHRAE Standard 90.1 and New York Stretch Code use similar approach

*The proposed **envelope performance factor** shall not exceed the base envelope performance factor by more than 15% in residential buildings. For all other building area types, the limit shall be 7%.*
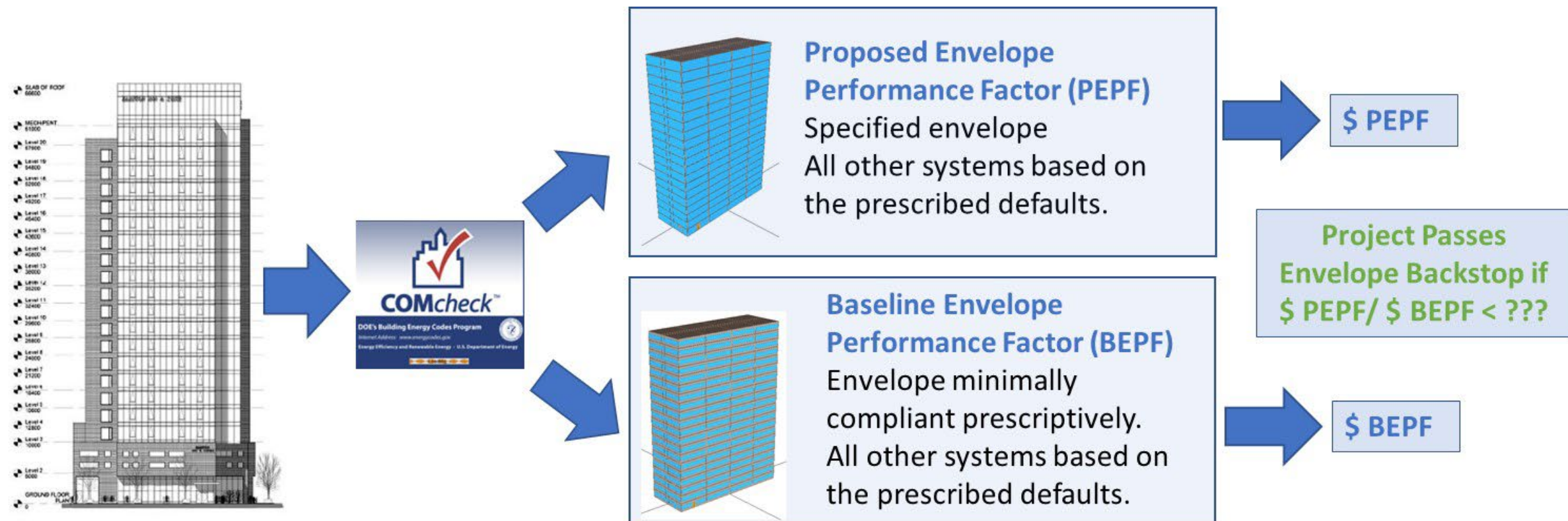
Reduce Complexity with Discipline Specific System Performance

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"

Whole Building Performance

Energy Modeling, Whole Building Integrated Design, LEED Certification,

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

Complex & expensive to implement

System Performance

Compare energy to system delivery

- Applicable to a range of buildings
- Includes system effect

Simple to implement

HVAC Total System Performance Ratio (TSPR)

The Basic TSPR Idea: Allow equivalent tradeoffs within the HVAC prescriptive requirements by comparing a buildings proposed TSPR to a target TSPR.

Currently TSPR has been adopted into **ASHRAE 90.1 -2022** and the **State of Washington Energy Code**

And is being considered for **IECC 2024 Commercial** and **NY Stretch 2023 in New York State.**

Why HVAC Performance?

- A particular building may have trouble with a prescriptive requirement like fan power limits or economizers
- TSPR allows trade off within HVAC system, allows credit for higher equipment efficiencies, reduced pump power or more DCV.
- TSPR results in equivalent energy input for a "good" system selection
- Reduces complexity compared to a whole building analysis

HVAC Performance Metric:

$$TSPR = \frac{\text{Heating + Cooling Loads Delivered}}{\text{Annual HVAC Operating Input*}}$$

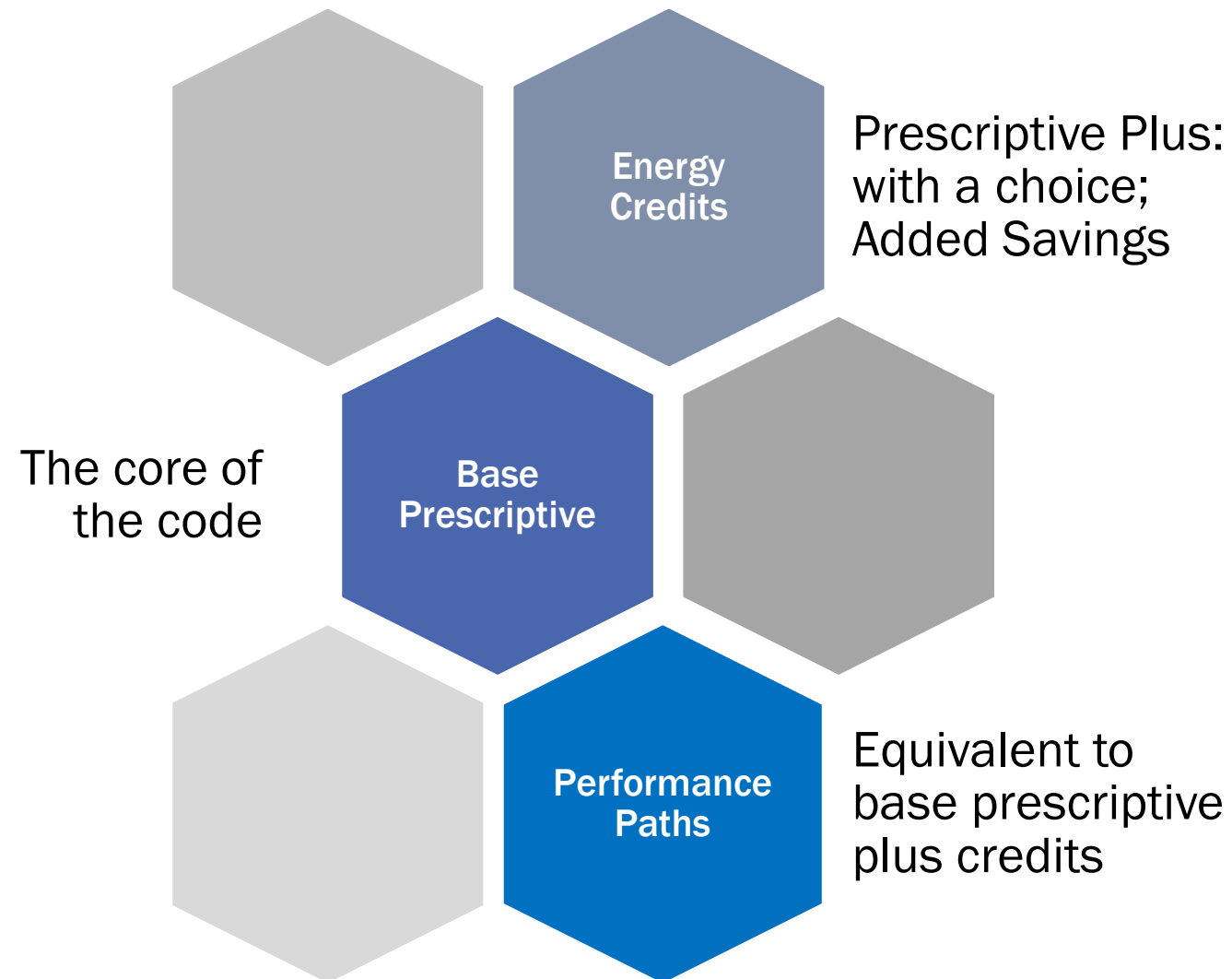**TSPR** is the HVAC system performance for the whole building HVAC system

TSPR accounts for part load performance unlike a 'Mechanical Power Density' limit, (therefore it's more like a seasonal heat pump rating than boiler efficiency)
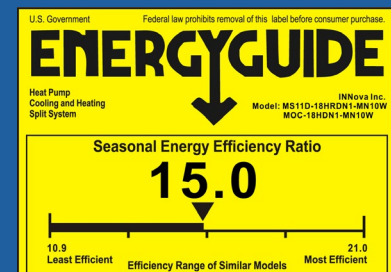
Maintaining Prescriptive Options – Performance Based Energy Credits

Energy Credits

Prescriptive Plus: with a choice; Added Savings

Base Prescriptive

The core of the code

Performance Paths

Equivalent to base prescriptive plus credits

Energy Credits expand on existing prescriptive path requirements with additional energy efficiency measures (EEM's) that can be custom selected for each building.

Energy Credit Measures

Efficiency Measures
- Envelope performance
- UA reduction (15%)*
- Envelope leak reduction*
- Add roof insulation*
- Add wall insulation*
- Improve fenestration*

HVAC Measures
- HVAC performance
- Heating efficiency
- Cooling efficiency
- Residential HVAC control
- Ground source heat pump*
- DOAS/fan control

Water Heating Measures
- SHW preheat recovery
- Heat pump water heater
- Efficient gas water heater
- SHW pipe insulation
- Point of use water heaters
- Thermostatic bal. valves
- SHW heat trace system*
- SHW submeters
- SHW flow reduction
- Shower heat recovery

*Only in IECC;
**Only in Standard 90.1

Improve Building Envelope

Improve Lighting

Improve HVAC Efficiency

Renewable Energy

Heat Pump Water Heating
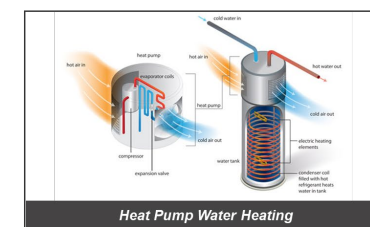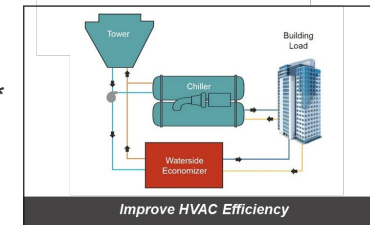
Lighting Measures
- Lighting dimming & tuning
- More occupancy sensors
- Increase daylight area
- Residential light control
- Light power reduction

Power & Equipment Measures
- Energy monitoring
- Efficient elevator
- Efficient commercial kitchen equipment
- Residential kitchen equipment
- Fault detection
- Guideline 36 controls**

Renewable & Load Management Measures
- Renewable energy
- Lighting load management
- HVAC load management
- Automated shading
- Electric energy storage
- Cooling energy storage
- SHW energy storage
- Building mass/night flush

Thank you!

Contact:

Michael Tillou

michael.tillou@pnnl.gov

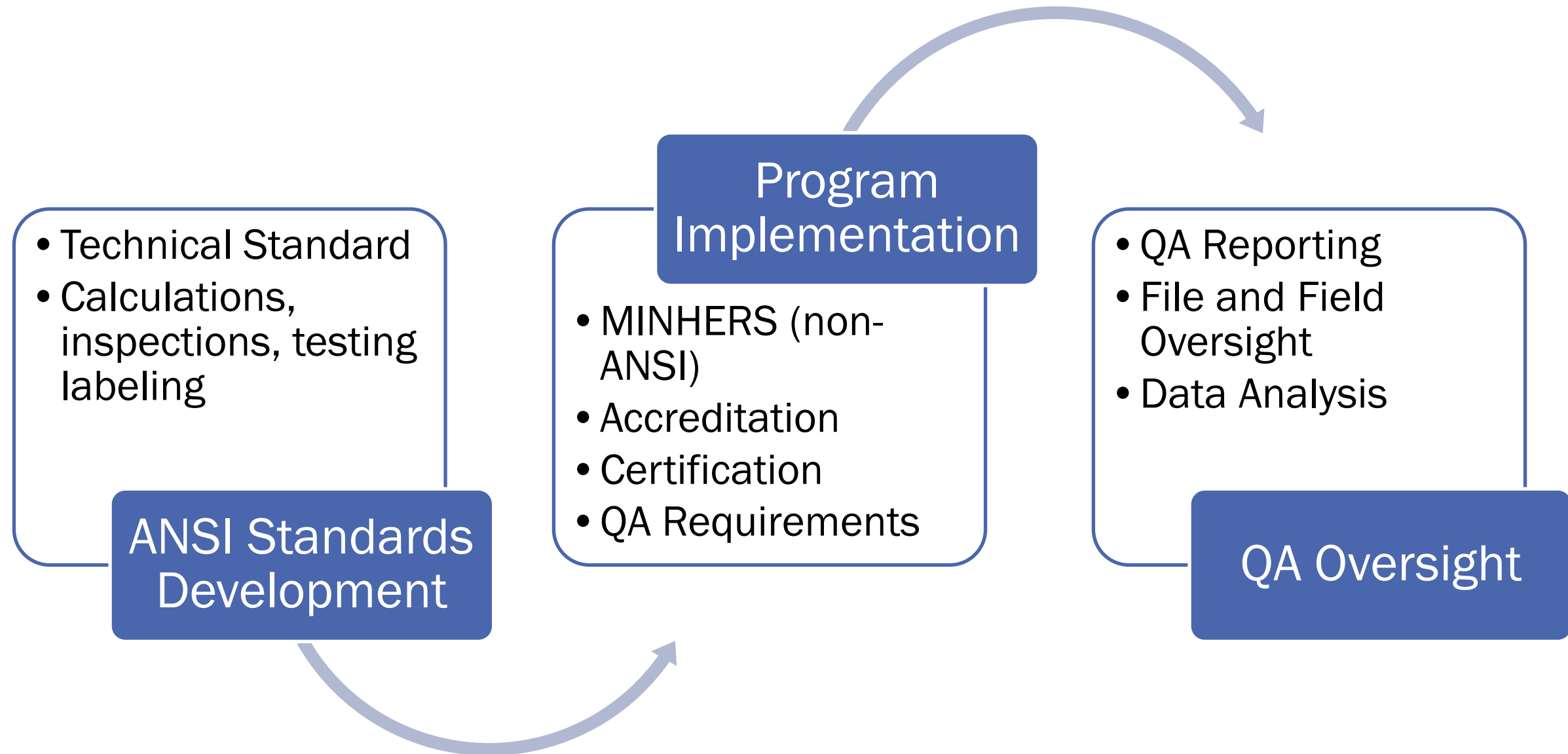Ryan Meres, RESNET - Residential Modeling and Quality Assurance

Ryan Meres has 16 years of experience in energy and water efficiency, energy policy and building energy codes. As the Program Director for RESNET, Ryan currently leads numerous programs, including implementation of RESNET's HERS$_{H2O}$ whole-house water efficiency standard; initiatives to get energy and water efficiency valued in the real estate transaction process and oversees RESNET's National Buildings Registry. Ryan holds a Bachelor's Degree in Architecture from the Savannah College of Art and Design and lives in Hubert, NC with his wife and their three children.

Residential Modeling and Quality Assurance

2023 National Energy Codes Conference
May 2023

Ryan Meres, RESNET

What Does RESNET Do?

ANSI Standards Development
- Technical Standard
- Calculations, inspections, testing labeling

Program Implementation
- MINHERS (non-ANSI)
- Accreditation
- Certification
- QA Requirements

QA Oversight
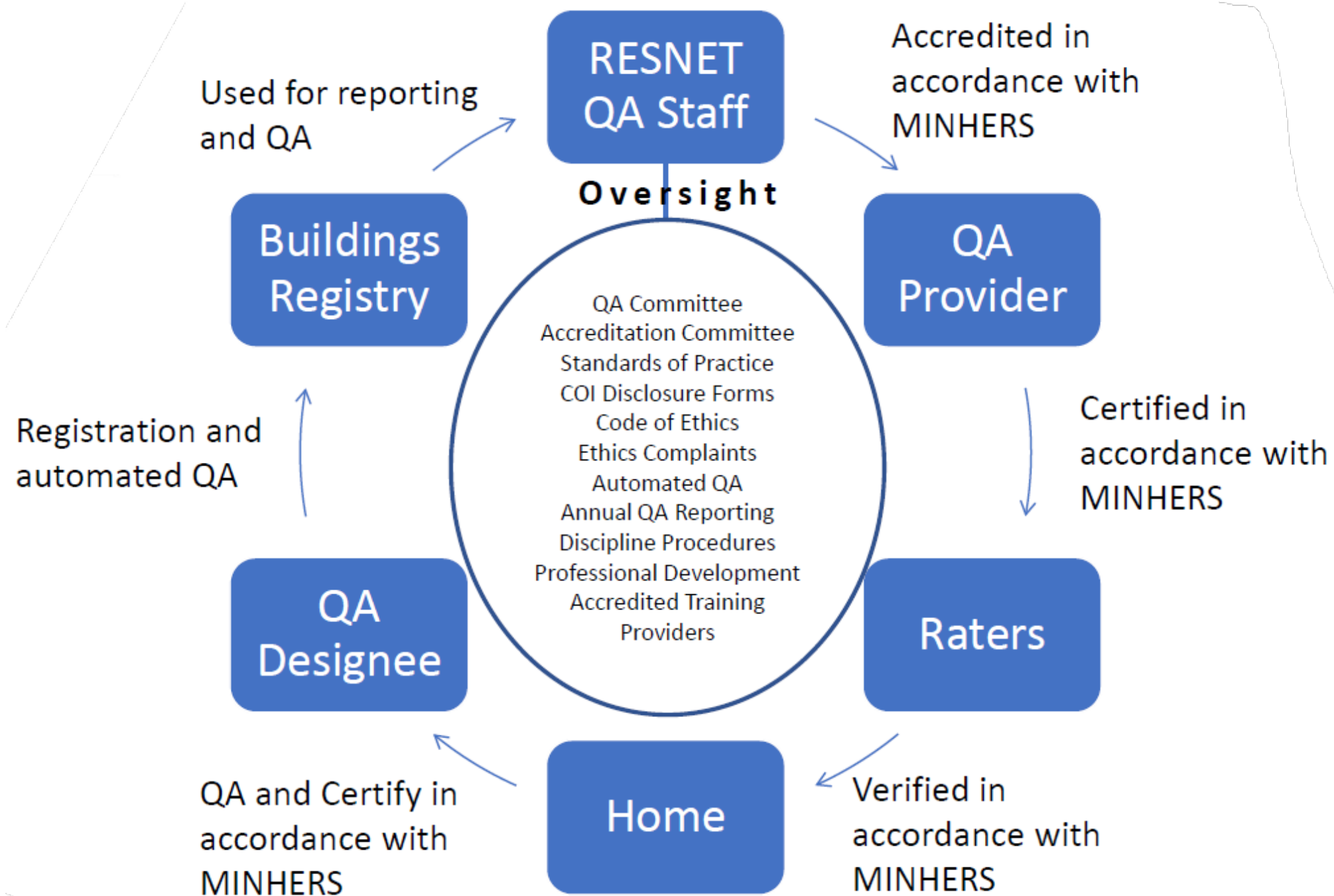- QA Reporting
- File and Field Oversight
- Data Analysis

What Does RESNET NOT Do?

RESNET does not:

- **Accredit software for code compliance**
  - RESNET only accredits software for HERS Ratings
- **Provide QA oversight of code-only homes**
  - Even when a HERS Rater is involved
  - No HERS Rating = No QA Requirement (one caveat, more on that later...)
 - *R406/ERI does not require QA

Home Certification Process

Used for reporting and QA

Accredited in accordance with MINHERS

RESNET QA Staff

Oversight

Buildings Registry

QA Provider

QA Committee
Accreditation Committee
Standards of Practice
COI Disclosure Forms
Code of Ethics
Ethics Complaints
Automated QA
Annual QA Reporting
Discipline Procedures
Professional Development
Accredited Training
Providers

Registration and automated QA

Certified in accordance with MINHERS

QA Designee

Raters

QA and Certify in accordance with MINHERS

Home

Verified in accordance with MINHERS

RESNET Survey of HERS Raters and RFIs.

Do you currently conduct energy code compliance verification services?
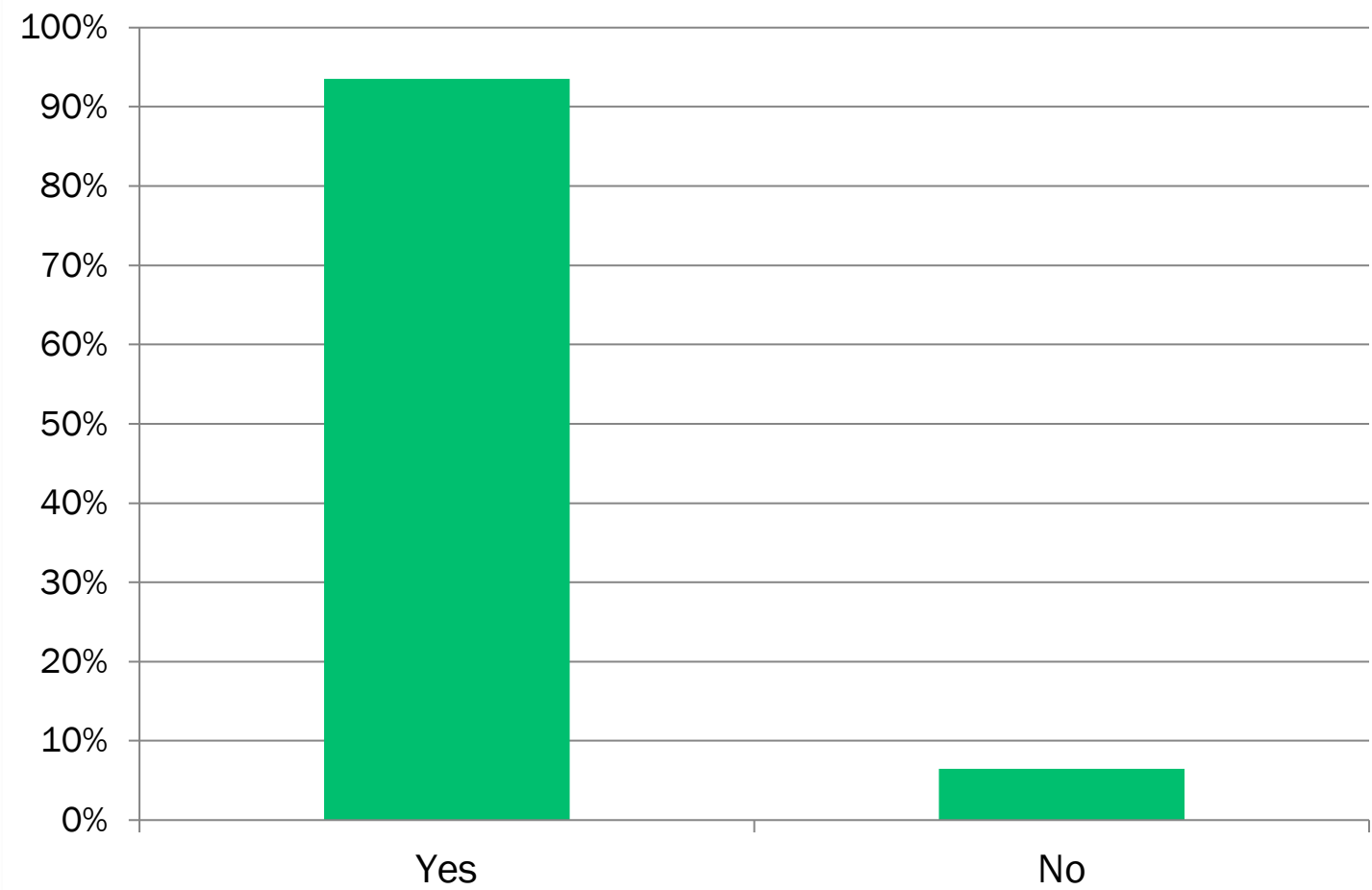
Approximately what percentage of your work is code compliance versus HERS ratings or other non-code compliance services?

198 Respondents

RESNET Survey of HERS Raters and RFIs.

What type of energy code compliance verification work do you perform?
(check all that apply)
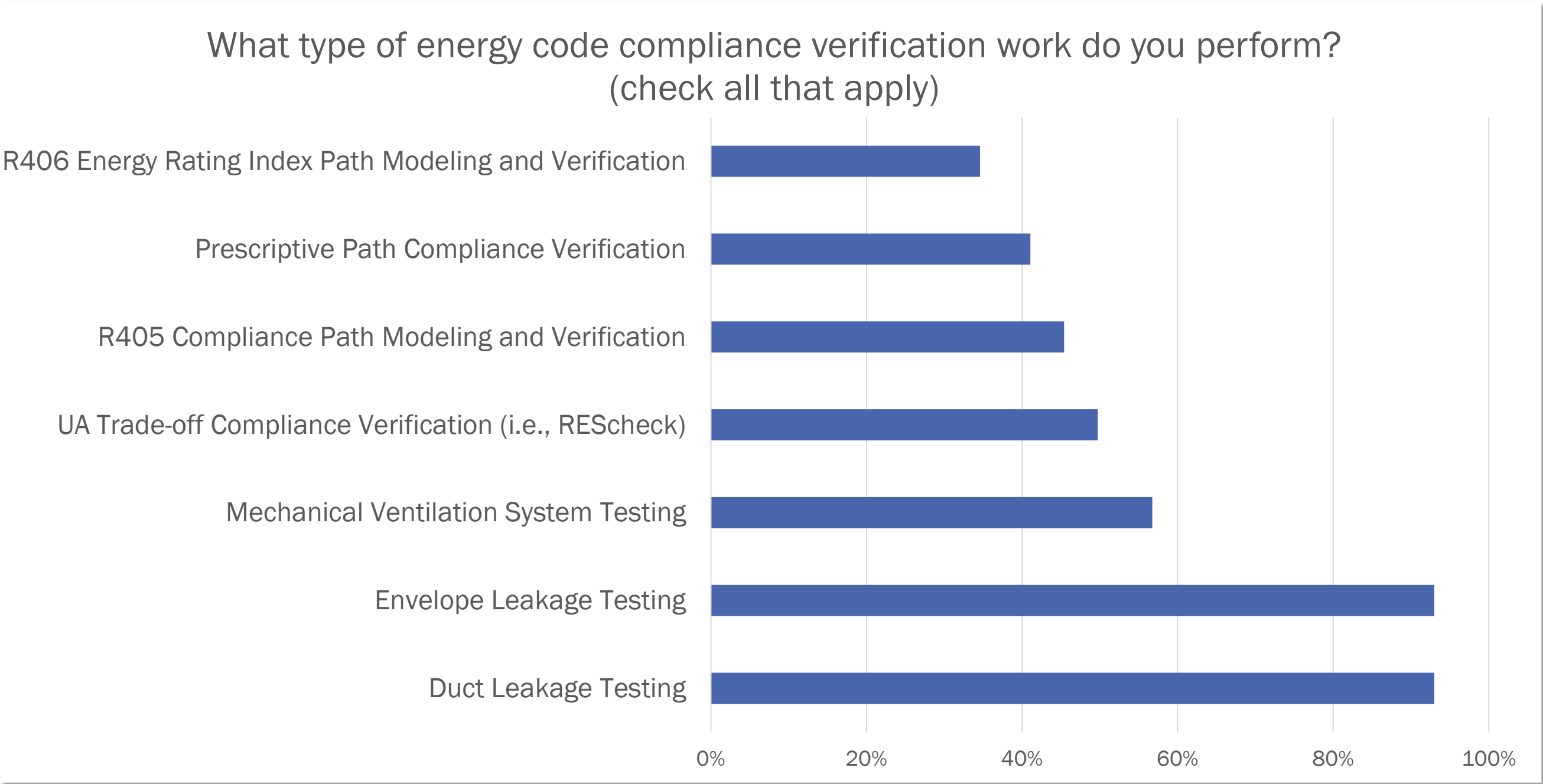
198 Respondents

IECC/HERS Compliance Specialist Designation

- ICC designation combines energy efficiency and building science knowledge with energy codes knowledge

- Available to certified HERS Raters and RFIs

- Must pass the Residential Energy Inspector/Plans Examiner Test

IECC/HERS Code Compliance Program

Consistent Compliance Documents!

- Three Parts:
  - Compliance Certificate
  - Mandatory Items Checklist
  - Building Components Summary

- Permit and C of O Docs

- 2009 and 2018 IECC

- Subject to Quality Assurance Oversight

2018 IECC Simulated Performance Alternative Compliance Certificate
Compliance Report for
Certificate of Occupancy

Property
Builder: xxxxxx
Address: xxxx
City/State: xxxxx, xx
Climate Zone: x

Rating Organization
Company: xxxxxx
Phone: (xxx) xxx-xxxx
Rater: xxxxx xxxxxx
Rater ID: xxxxxxx

Performance Path Information
Report: Certificate of Occupancy
Report No: xxxxxxx
Date Completed: xx/xx/xxxx
Rating Field Insp: xxxxx xxxxxx
RFI ID: xxxxxx

COMPLIANCE: *PASSES* using R405 Simulated Performance Alternative

IECC Standard Reference Design: $ xxxx Annual Energy Cost	This home: $ xxxx Annual Energy Cost	
Annual Energy Cost by End Use	2018 IECC	As Designed
Heating	19.26	11.77
Cooling	831.23	692.59
Water heating	257.48	254.20
Mechanical Ventilation Fan Energy	12.00	8.00
Total Estimated Energy Cost	$ 1119.97	$ 966.56	PASS

Utility Rates:
$XX/kWh, $XX/therm

Key Building Design Features

Ceiling Under Vented Attic:	R-X	Envelope Leakage Rate:	xx ACH50
Sealed Attic Assembly:	R-X	Windows:	U-Value: x.xx, SHGC: x.xx
Above Grade Walls:	R-X (Avg. R-value)	Heating System 1:	System Type, Efficiency
Foundation Walls:	Bsmt Interior: R-X Bsmt Exterior: R-X Crawlspace wall: R- X	Heating System 2:	System Type, Efficiency
Exposed Floor:	R-X	Cooling System 1:	System Type, Efficiency
Slab Edge:	R-X	Cooling System 2:	System Type, Efficiency
Under-Slab:	R-X	Water Heating System 1:	System Type, Efficiency, Capacity
Duct Insulation:	R-X	Water Heating System 2:	System Type, Efficiency, Capacity

This home, as built, MEETS the Simulated Performance Alternative requirements of Section R405.3 of the 2018 International Energy Conservation Code based on climate zone. In addition to the Simulated Performance Compliance, the other mandatory measures must be met. (See Mandatory Requirements on second page.)

Name: _____   Signature: _____

Organization: _____   Date: _____

Role of Software in R405 and R406 Compliance

- IECC has requirements for software and reporting

- Other than AHJ, there is no oversight

- Software develops their own certificates and compliance docs

- Software may interpret the code requirements differently

- Software fills gaps for variables the code doesn't address

- R406 ≠ HERS

New Electronic Data Analysis and Quality Assurance Tool

- Off-the-shelf program called Kibana

- Powerful data analysis tool

- For use by RESNET Staff and Accredited Rating Providers for QA

- Each Provider will have their own dashboard

- Ability to drill down into rating inputs

- QA Flags
  - Outlier inputs and Red Flags

New Electronic Data Analysis and Quality Assurance Tool

Filter Ratings by Rater, State or City
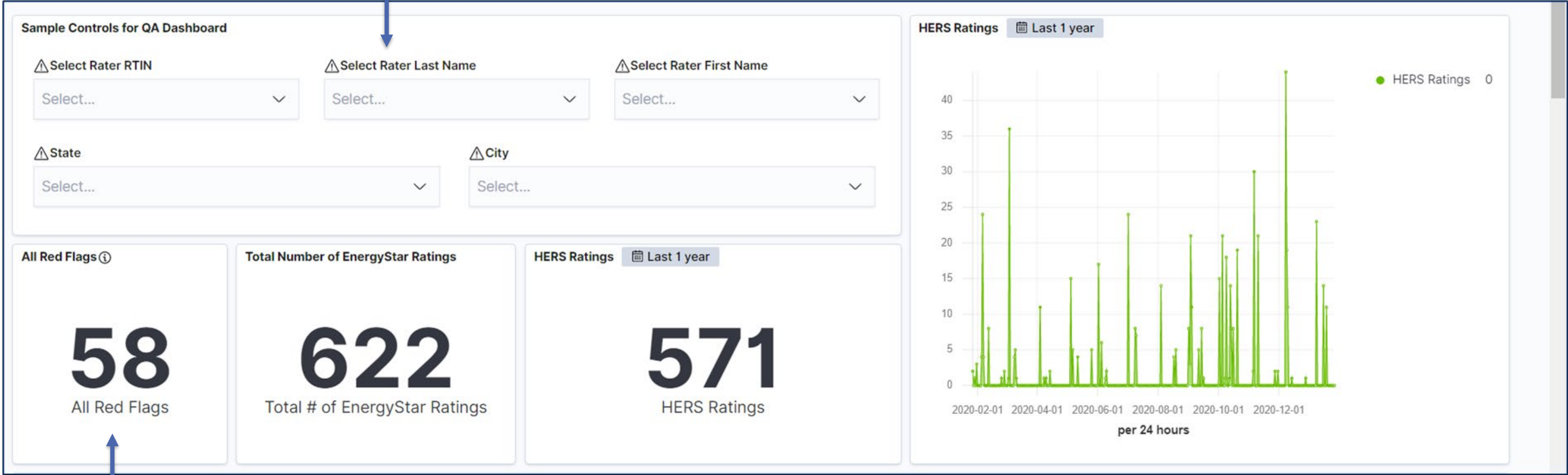
Number of Red Flags

A separate QA Drilldown Dashboard allows RESNET QA Staff and Providers to dig into what inputs may be causing flags.

QA Review App

- Moving from spreadsheet to app

- Tracks QA Reviews for Raters and RFIs
  - Field and file reviews
  - Reviews are scored in the app

- For file reviews it will pull in data from the Registry

- Submitted to RESNET Registry

- Will incorporate IECC/HERS Code Compliance Program
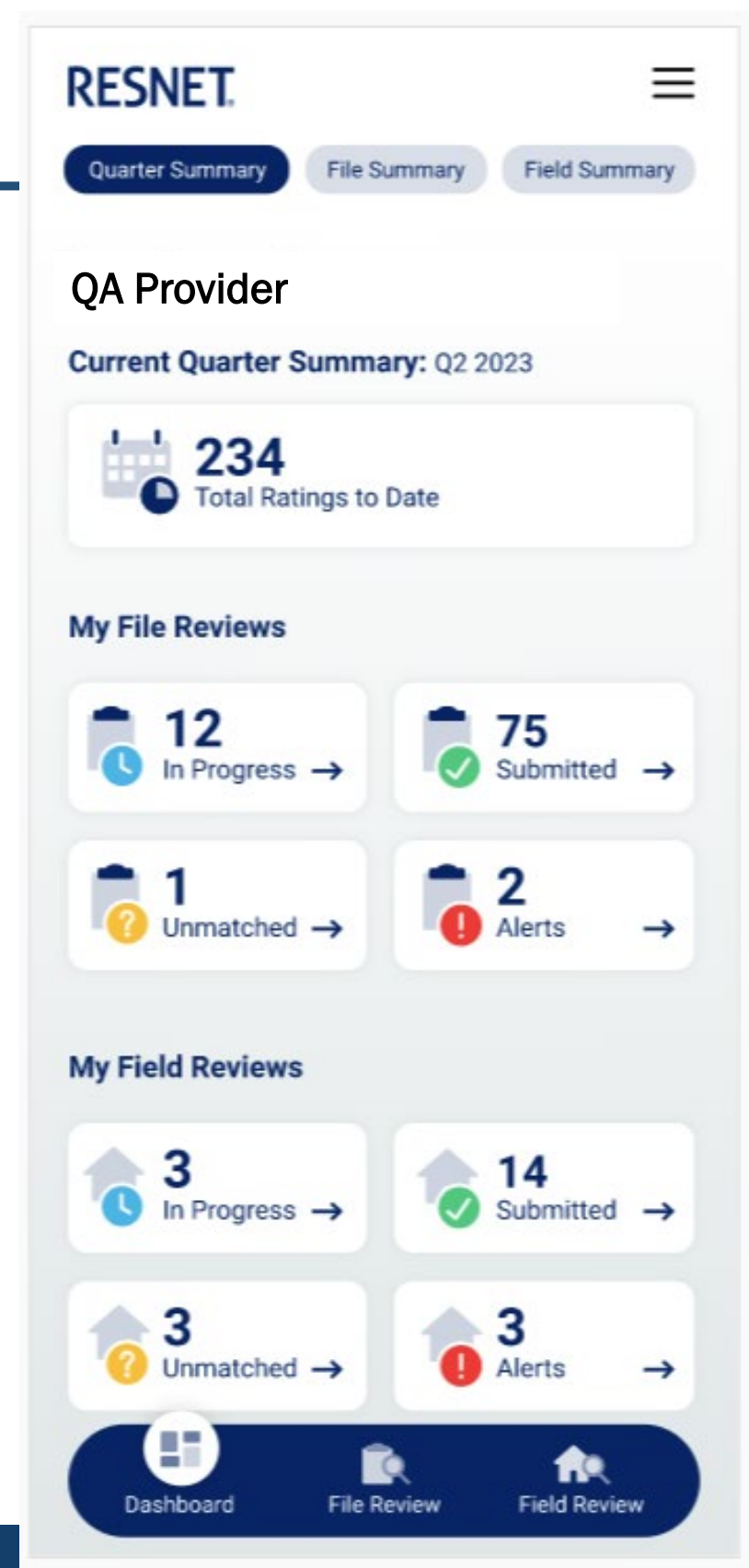
Where are HERS Ratings Happening?
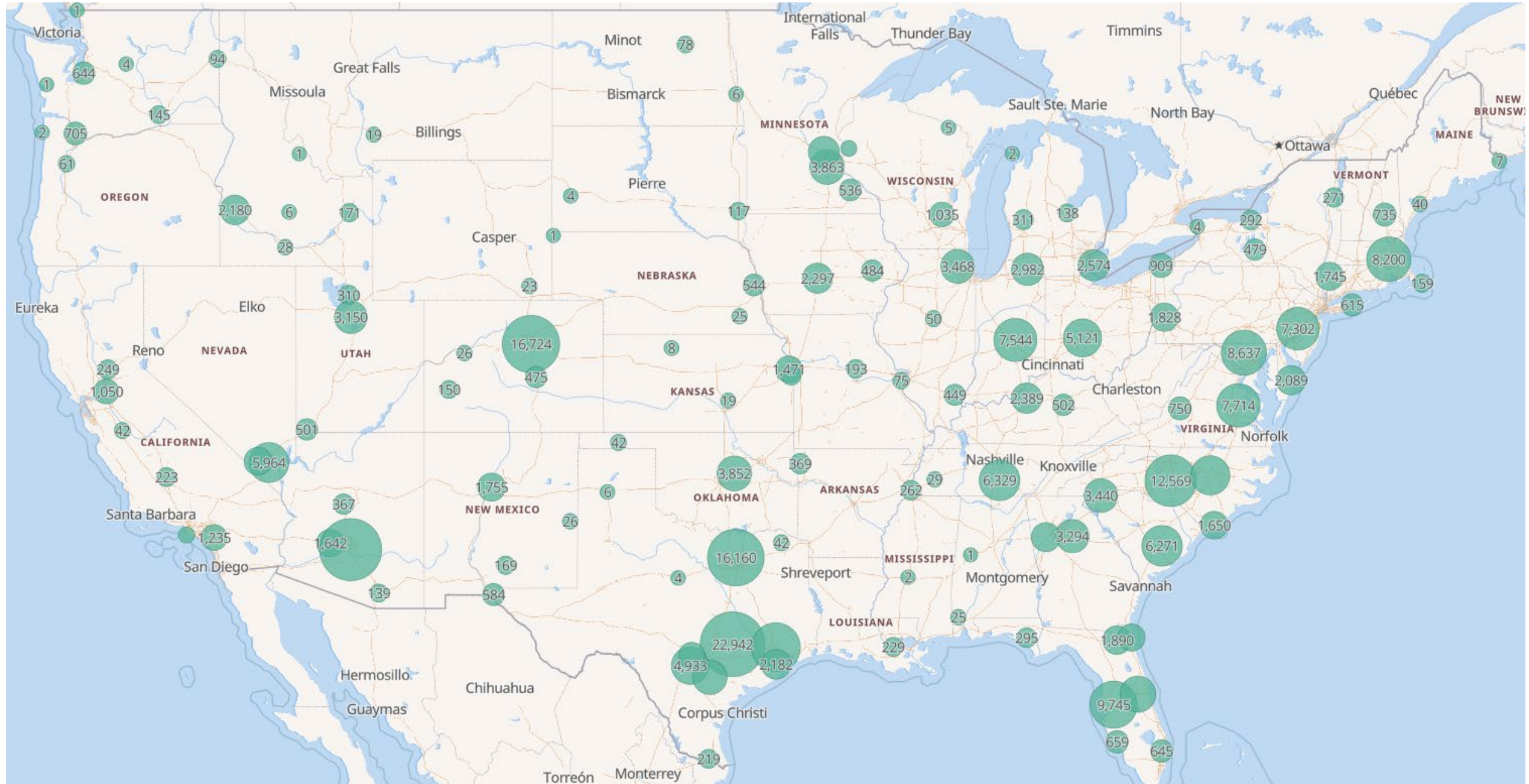
Last 12 months.

Thank you!

Contact:

Ryan Meres

ryan@resnet.us

Maria Karpman, Karpman Consulting - Commercial Performance-based Code QA/QC

Maria Karpman has over 20 years of experience in building science, energy modeling, and energy code. She is a voting member of the ASHRAE Standards 90.1, 140 and 229 committees, has led development of the whole building performance-based compliance options and simulation guidelines for multiple code and beyond-code programs including NYStretch Energy, MA Stretch Energy, EPA ENERGY STAR Multifamily Program and the large-scale modeling-based incentive programs for new and existing commercial and multifamily buildings. She is a principal investigator on a multi-year DOE/PNNL research project to facilitate quality assurance and quality control of performance-based submittals. Maria has developed and conducted numerous training on the energy code and energy modeling. She holds advanced degrees in mechanical engineering and computer science and is the principal of Karpman Consulting.

Commercial Performance-based Code QA/QC

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Maria Karpman, Karpman Consulting

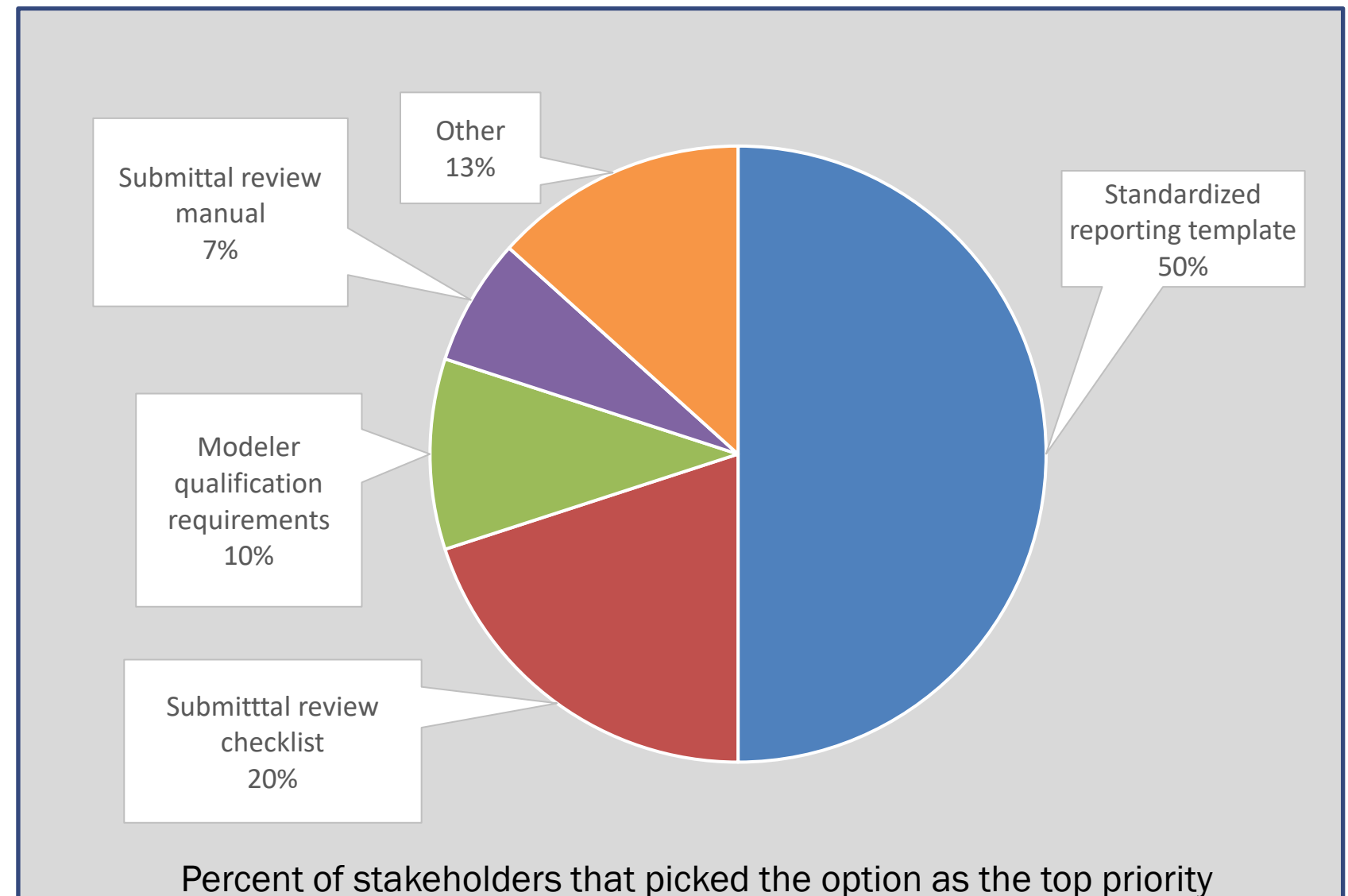# DOE/PNNL Performance-based Compliance Support Project
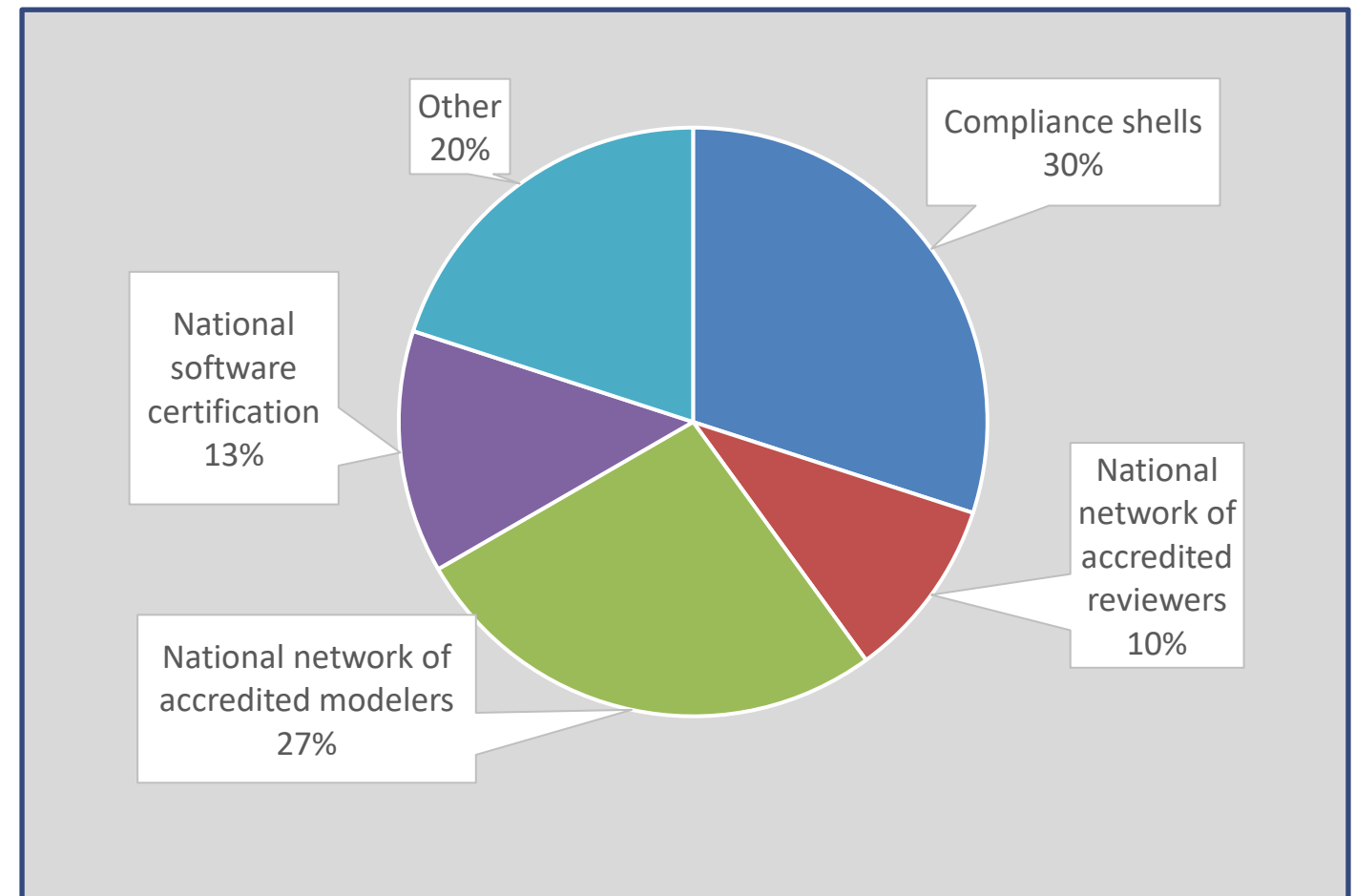
SCOPE

Identify gaps in the existing quality control and quality assurance infrastructure and develop pathways for addressing them

STAKEHOLDERS

- 27+ jurisdictions
- 9+ above-code programs (LEED, EPA ENERGY STAR MFHR, utility incentive programs)
- 7 software tool vendors
- Members of ASHRAE Standard 90.1, 140, 189, 209 committees
- Third parties representing COMNET, RESNET, IBPSA, NBI, IMT, etc.

SHORT TERM PRIORITIES IDENTIFIED BY STAKEHOLERS

Other 13%

Submittal review manual 7%

Standardized reporting template 50%

Modeler qualification requirements 10%

Submitttal review checklist 20%

Percent of stakeholders that picked the option as the top priority

DOE/PNNL Performance-based Compliance Support Project

SCOPE

Identify gaps in the existing quality control and quality assurance infrastructure and develop pathways for addressing them

STAKEHOLDERS

- 27+ jurisdictions
- 9+ above-code programs (LEED, EPA ENERGY STAR MFHR, utility incentive programs)
- 7 software tool vendors
- Members of ASHRAE Standard 90.1, 140, 189, 209 committees
- Third parties representing COMNET, RESNET, IBPSA, NBI, IMT, etc.

LONG TERM PRIORITIES IDENTIFIED BY STAKEHOLERS

Pie chart:
- Compliance shells 30%
- National network of accredited reviewers 10%
- National network of accredited modelers 27%
- National software certification 13%
- Other 20%

Percent of stakeholders that picked the option as the top priority

Completed and In-Progress Tools and Resources

- Standardized Reporting
  - 90.1 Section 11 and Appendix G DOE/PNNL Compliance Form

- Streamlining Submittal Reviews
  - 90.1 Section 11 and Appendix G DOE/PNNL Submittal Review Manual and Checklist
  - ASHRAE Standard 229 Ruleset Checking Tool

- Performance-based Compliance Adoption Infrastructure
  - Adopter Toolkit including the recommended modeler and reviewer minimum qualification requirements and 3rd party reviewer scope of work.
  - ASHRAE Standard 140 acceptance ranges and whole building tests
  - Establishing a RESNET-style national certifying body to vet modelers, submittal reviewers and simulation tools

DOE/PNNL 90.1 Section 11 and Appendix G Compliance Form

Summary of features

- Supports 90.1 2016 and 2019 Section 11 and Appendix G
- MS Excel format
- Provides a format for submitters to meet the reporting requirements of 90.1
- Helps establish the necessary modeling inputs using built-in code look-ups and calculators
- Allows importing simulation results from BEM tools including DesignBuilder, EnergyPlus, eQUEST, Trane TRACE 3D Plus, Trane TRACE 700, and OpenStudio
- Automates compliance calculations
- Includes Quality Assurance Checks tab to facilitate submittal reviews

Availability and Adoption

- Posted at DOE's Building Energy Codes website
- May be customized to incorporate local amendments to 90.1 Section 11 and Appendix G.
- **Adopted by the following jurisdictions:**
  - 2020 New York City Energy Conservation Code
  - 2022 Denver, Colorado Building and Fire Code
  - 2018 Seattle Energy Code
  - 2018 Washington State Energy Code
  - 2023 NY Stretch Energy (pending)
  - 2023 MA Stretch Code (pending
- **Adopted by the following beyond-code programs**
  - New Jersey Pay for Performance
  - Energize Connecticut Energy Conscious Blueprint
  - NYSERDA New Construction

ENERGY STAR Multifamily New Construction
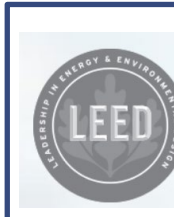
LEED v4 pilot ACP 111/v4.1

Submittal Review Manual

1. Companion to 90.1 Section 11 and Appendix G compliance form

2. Posted at [DOE Building Energy Codes website](#)

3. Comprehensive (250+ pages) reference covering the following topics

   ➢ Strategies for prioritizing review checks

   ➢ Review checks organized by building system including the following:

   ✓ Summary of the relevant 90.1 requirements

   ✓ Where to locate the relevant information in the design documents and the Compliance Form

   ✓ Common mistakes

   ➢ Simulation reports for DesignBuilder, EnergyPlus, eQUEST, OpenStudio, Trane TRACE 700, Trane 3D Plus annotated with tips on performing specific review checks

Table of Contents

Submittal Review Manual

Annotated simulation reports for the following tools:

Other Newly Available Resources

- Recorded on-demand Compliance Form and Review Manual trainings

- **ASHRAE Standard 90.1 Adopter Toolkit Navigator**

Recommendations for jurisdictions and beyond-code programs on organizing effective and efficient review of modeling submittals

- **Recommended Minimum Energy Modeler Qualifications** including work experience, professional credentials and completed trainings

- **Recommended Minimum Submittal Reviewer Qualifications** including work experience, professional credentials and completed trainings

- **Third Party Submittal Reviewer Scope of Work** template that may be used by jurisdictions and rating authorities who chose to engage external consultants for performing submittal reviews. Includes an overview of third-party review process, tasks and deliverables

Work in Progress: New ASHRAE Std 140 Whole Building Tests

- ASHRAE 90.1 requires modeling tools to be tested following **ASHRAE Standard 140, "Method of Test for Evaluating Building Performance Simulation Software"**.

- The existing Std. 140 tests are "shoebox" models and do not cover majority of systems found in commercial buildings such as boilers, chillers, fans, pumps, HVAC controls, daylighting, etc.

- DOE/PNNL funded research report "Building Performance Modeling Tools Physics and Sensitivity Testing in Support of Compliance Modeling" identified gaps in Std. 140 and priorities for addressing them.

- A new suite of "whole building tests" is being developed with systems and components found in 90.1 Appendix G baseline and in the common commercial designs
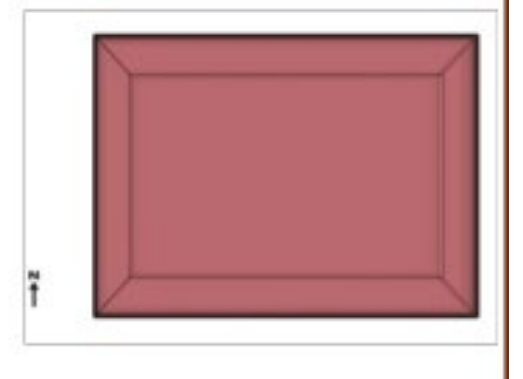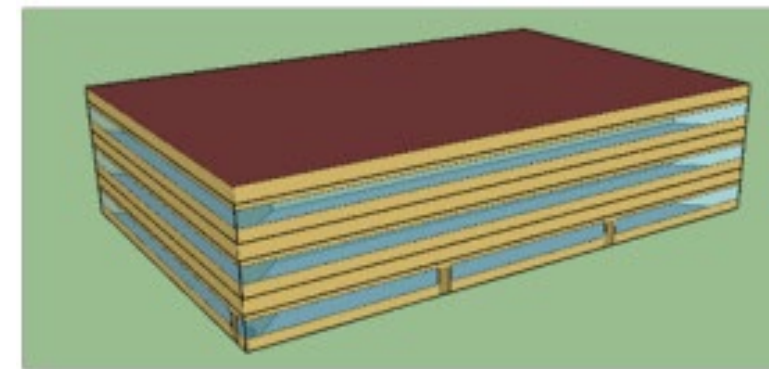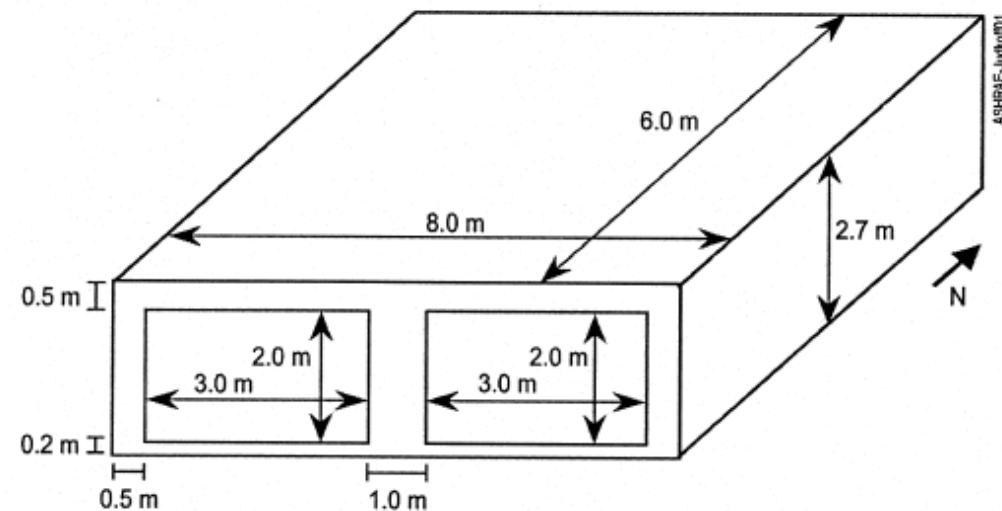
ASHRAE Standard 140 Acceptance Ranges

- Previously, Std. 140 had no acceptance ranges; 90.1 testing requirements could be met by simply running the tests and making results publicly available

- Std 140 2020 Addendum b added the acceptance ranges. BEM tool results must fit within the acceptance ranges for the set minimum number of test cases in order to pass.

Table A3-1 Low Mass Building—Annual Heating Load (MWh/yr)*

Range Case	Lower Limit	Upper Limit
Case 600	3.75	4.98
Case 610 – Case 600	–0.14	0.29
Case 620 – Case 600	–0.08	0.40
Case 630 – Case 620	0.02	0.74
Case 640 – Case 600	–2.17	–1.22
Case 660 – Case 600	–1.07	
Case 670 – Case 600	0.25	
Case 680 – Case 600	–2.54	
Case 685 – Case 600	0.33	
Case 695 – Case 685	–2.38	

Table A3-14 Acceptance Range Pass Criteria

| Test Group	Tables of Ranges	Number of Range Cases in Test Group	Minimum Number of Range Cases within the Test Group to Pass
Thermal Fabric Low Mass	A3-1, A3-2	21	18
Thermal Fabric High Mass	A3-3, A3-4	19	17
Cooling Equipment	A3-5	14	12
Heating Equipment	A3-6, A3-7	6	5
Air-side Equipment	A3-8, A3-9, A3-10, A3-11, A3-12, A3-13	54	48

Work in Progress: IBPSA-USA Certification Committee

- Investigates opportunities for creating a RESNET-style market-based certifying body that will implement QA/QC infrastructure for code compliance and beyond-code programs that use energy modeling.
  - Certify modelers and submittal reviewers following established qualification requirements
  - Certify simulation tools for compliance with Standard 90.1.
  - Oversee a network of qualified providers that can perform submittal review for jurisdictions and beyond-code programs.

Work-in-Progress: ASHRAE Standard 229P

A new standard for <u>automating model reviews</u> with the following key components:

- **Ruleset Model Description (RMD):** a neutral schema that includes aspects of the model relevant to code compliance

- **RMD Generation Software:** a module within the simulation tool or a stand-alone software tool that converts energy model inputs and outputs to the RMD format

- **Ruleset Checking Tool (RCT)**
  - Open-source software for checking adherence of the baseline and proposed design models to the rules of 90.1 2019 Appendix G
  - May be used by modelers for internal QC and by reviewers to automatically flag model errors.

- **Public review draft is expected in January 2024.**
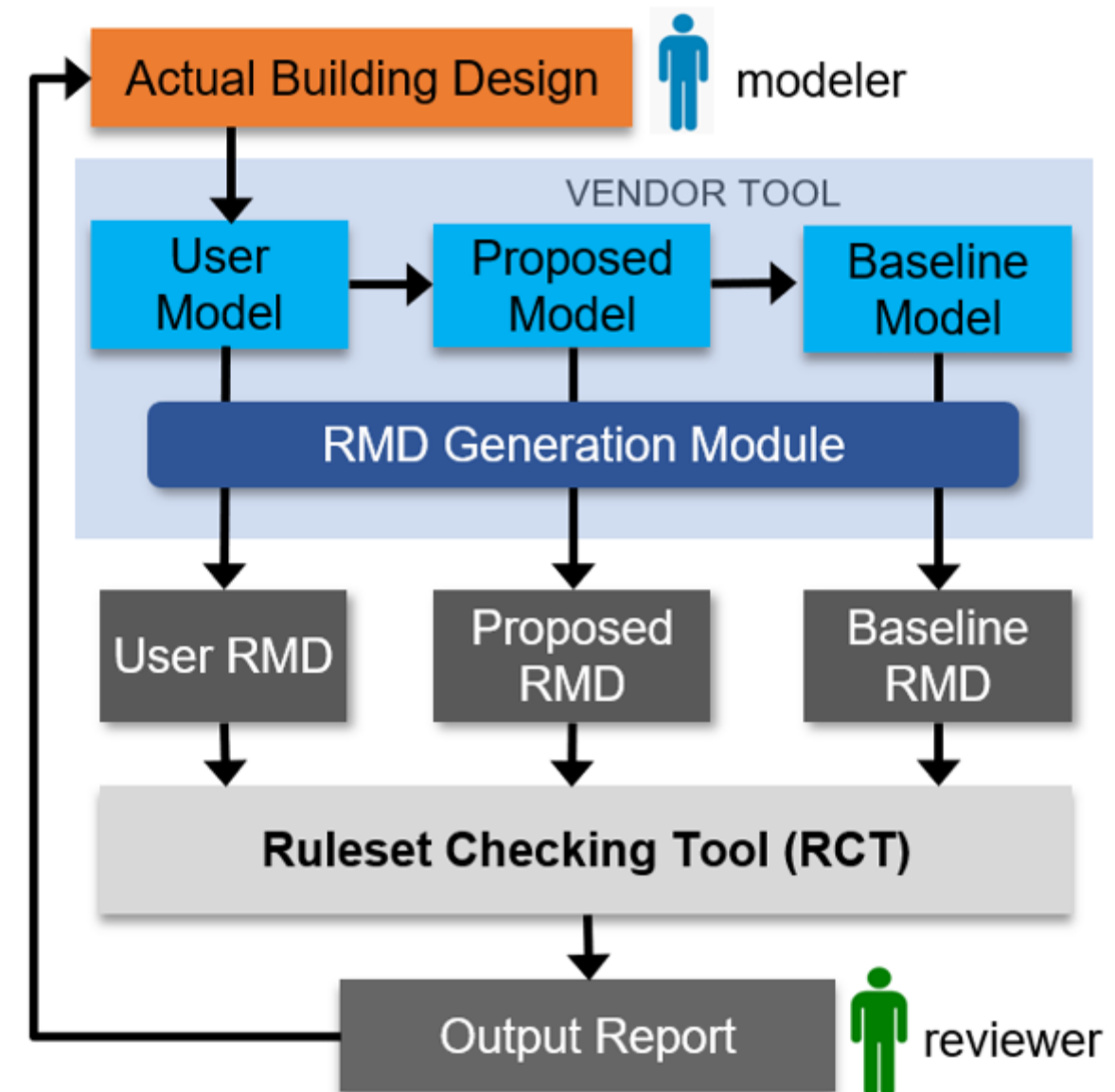
Vision of Future Automation
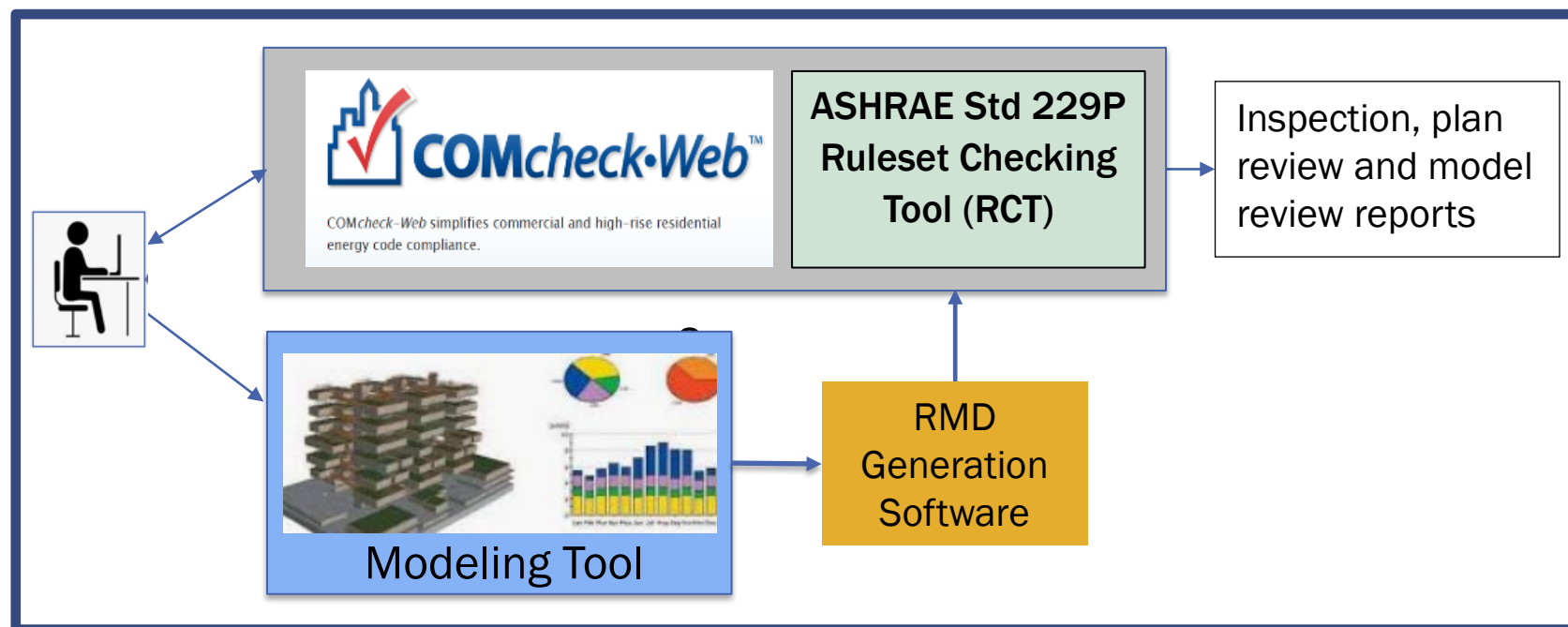
Permit Applicant/Modeler Responsibilities:
1. Enters project information not captured in the simulation tool (e.g., mandatory requirements) and necessary to generate simulation inputs (e.g., lighting fixture counts by space to get the LPDs) into COMcheck.
2. Creates baseline and proposed design models in the Building Energy Modeling (BEM) tool.
3. Uses RMD Generation Software to save the models in the RMD format and uploads the RMD files into COMcheck.

COMcheck Functionality
1. Populates COMcheck inputs using information from the RMD files where possible
2. Verifies alignment between model inputs and direct COMcheck inputs (e.g., was LPD modeled correctly?)
3. Checks models for compliance with 90.1 Appendix G rules using an internal RCT module and generates a Model Review report with comments for the modeler a Model Description report .
4. Confirms compliance with mandatory requirements; generates plan review and site inspection reports similar to prescriptive projects.

Submittal Reviewer Responsibilities
1. Performs plan review to verify alignment between design documents and COMcheck inputs (similar to prescriptive projects)
2. Verify aspects of the model that were flagged for manual review based in the Model Review report
3. Communicates review comments to permit applicant (similar to prescriptive projects)
4. Performs site inspections (similar to prescriptive projects).

Thank you!

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