

# All Hands-on Deck: Raising the Bar on Performance-Based Codes Compliance



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# New ASHRAE 90.1 Energy Code Performance- based Compliance Forms

Michael Tillou, PE



PNNL is operated by Battelle for the U.S. Department of Energy

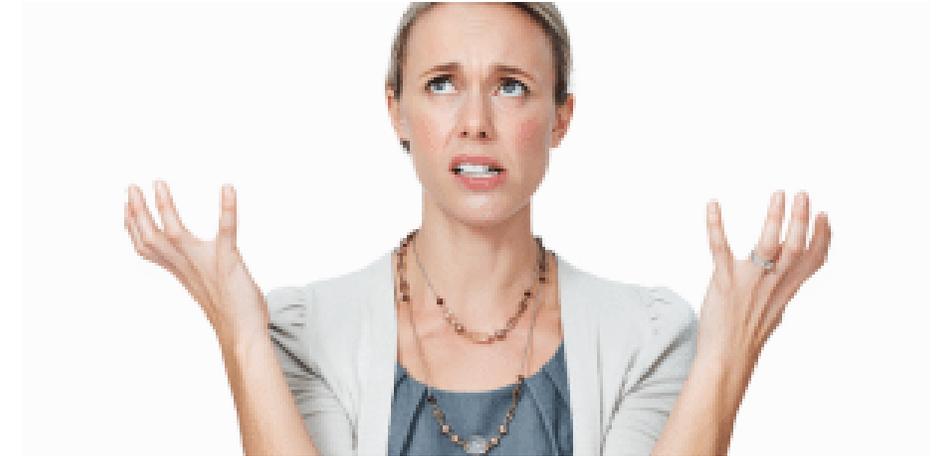


# Project Initiation

In recent years jurisdictions have seen a big increase in performance-based submittals, having no idea how to deal with them, they sought help from DOE and PNNL.

*The U.S. Department of Energy (DOE) is directed to participate in industry processes to develop model building energy codes, issue determinations as to whether updated codes result in energy savings, and provide technical assistance to states to implement and comply with the codes.*

<https://www.energycodes.gov/about>



## Goals

- Gather information on performance-based compliance, adoption challenges and best practices;
  - Develop a roadmap to address the identified quality assurance and quality control (QA/QC) infrastructure gaps;
  - Implement tools identified as a high priority;
  - Identify how to maintain tools that enhance QA/QC infrastructure.
- 
- Schedule: 3/2019 – 6/2021 with possible follow-up



Pixabay.com

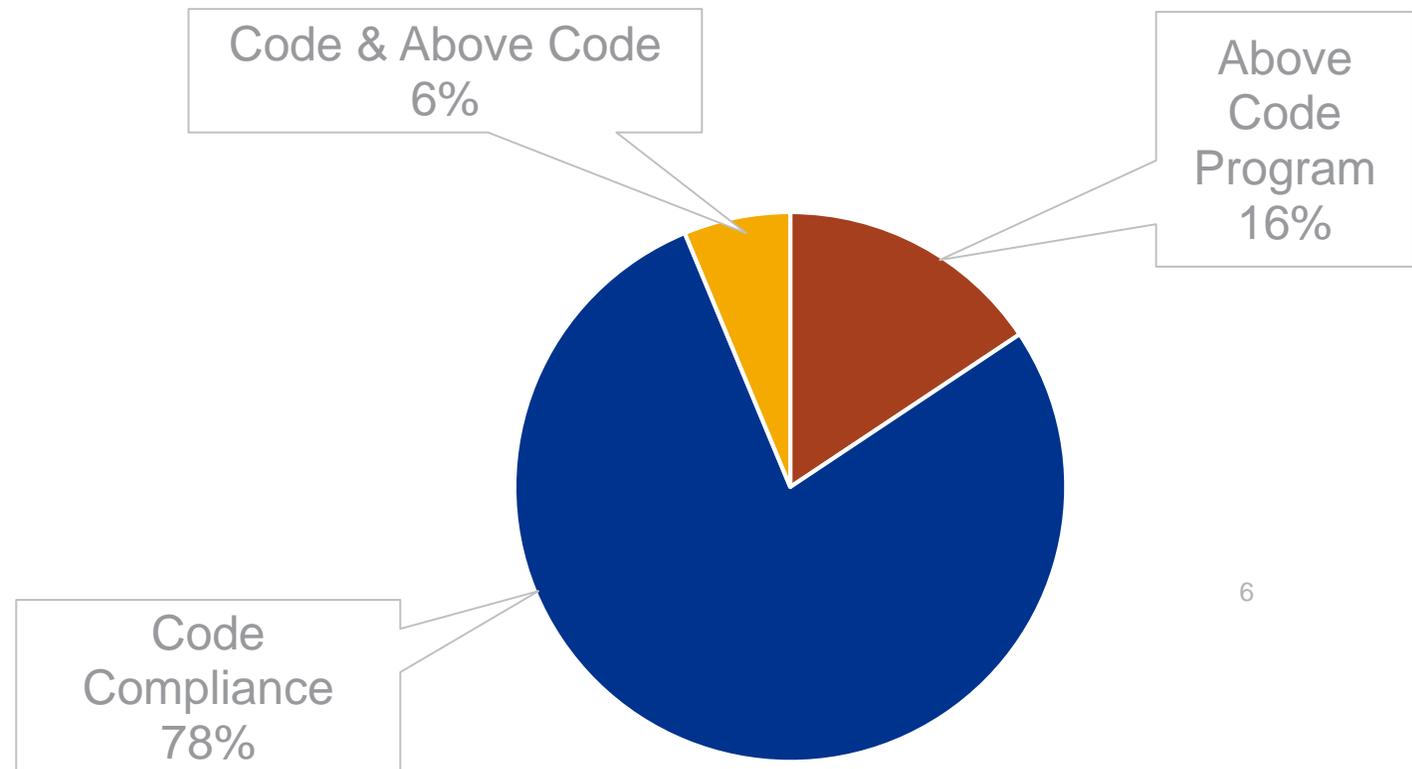
## 70+ Stakeholders

- 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.



# Information Gathering: Stakeholder Survey

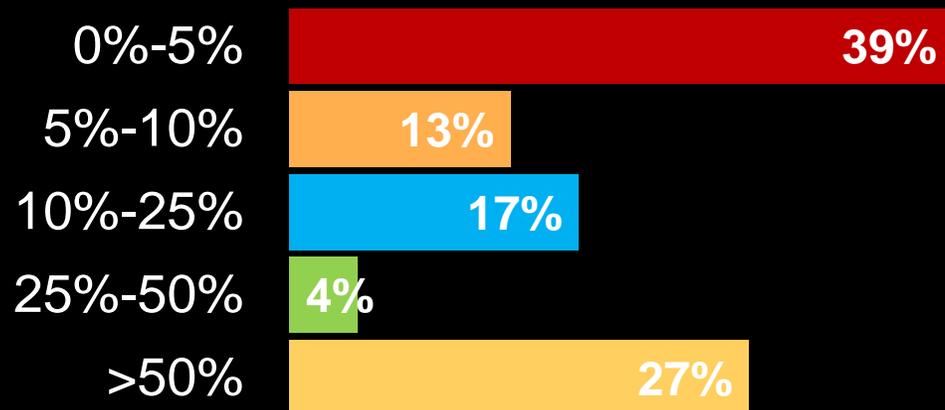
- 30+ questions on the current state of performance-based compliance, challenges and best practices
- 35 surveys returned
- Sponsored by Northwest Energy Efficiency Alliance and conducted by Karpman Consulting



# Energy Modeling for Code Compliance

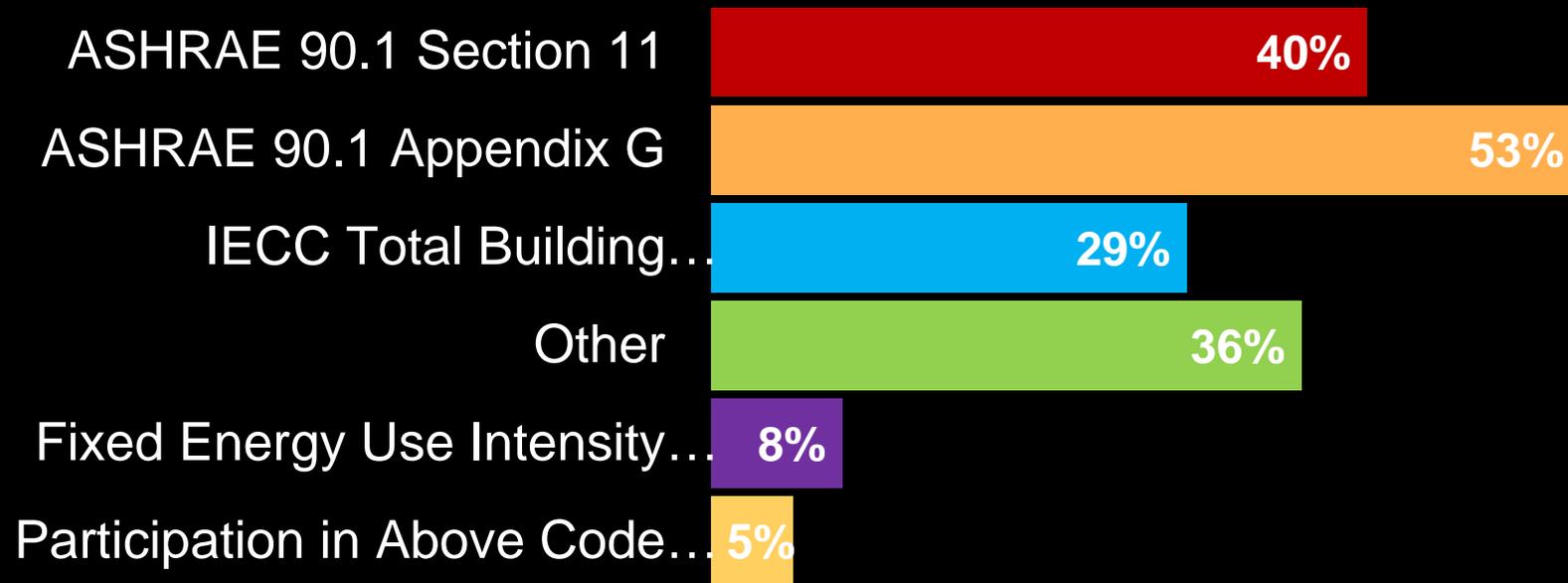
- Currently used by a minority of projects in most jurisdictions.
- However, projects that use modeling for compliance typically involve large, energy intensive buildings and thus account for an unproportionally large percentage of permitted floor area.
- Some jurisdictions are looking to require energy modeling for ALL projects in future code cycles.

## What percentage of projects use energy modeling to document code compliance in your jurisdiction?



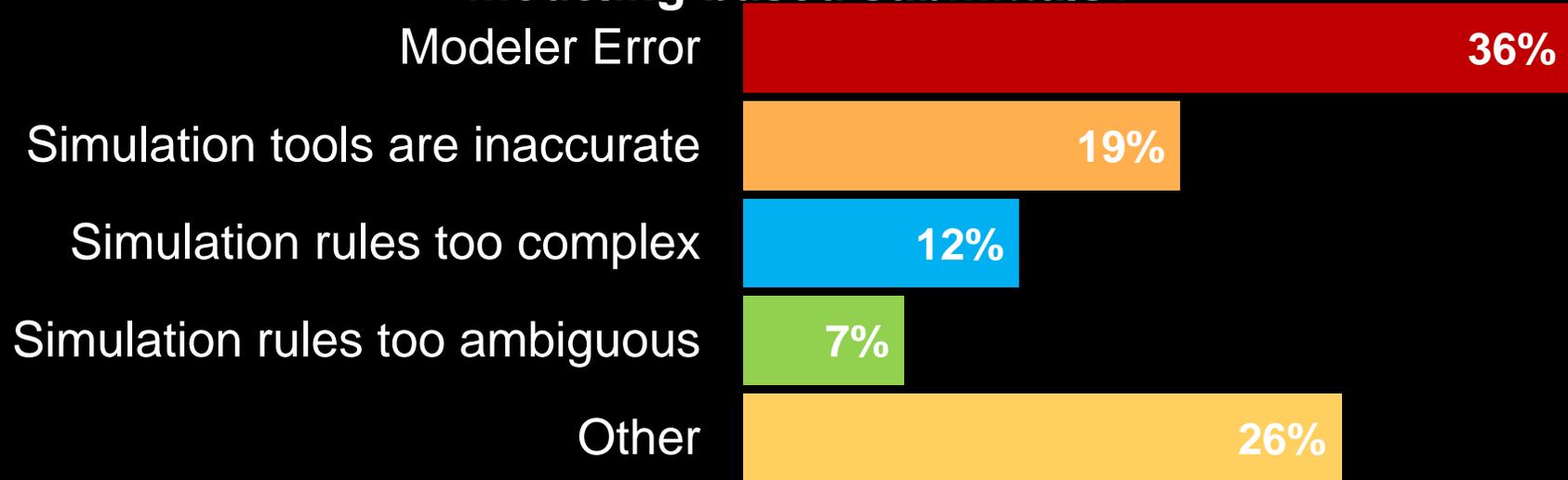
# Commonly Used Energy Modeling Standards

What performance-based compliance options are currently allowed in your jurisdiction?



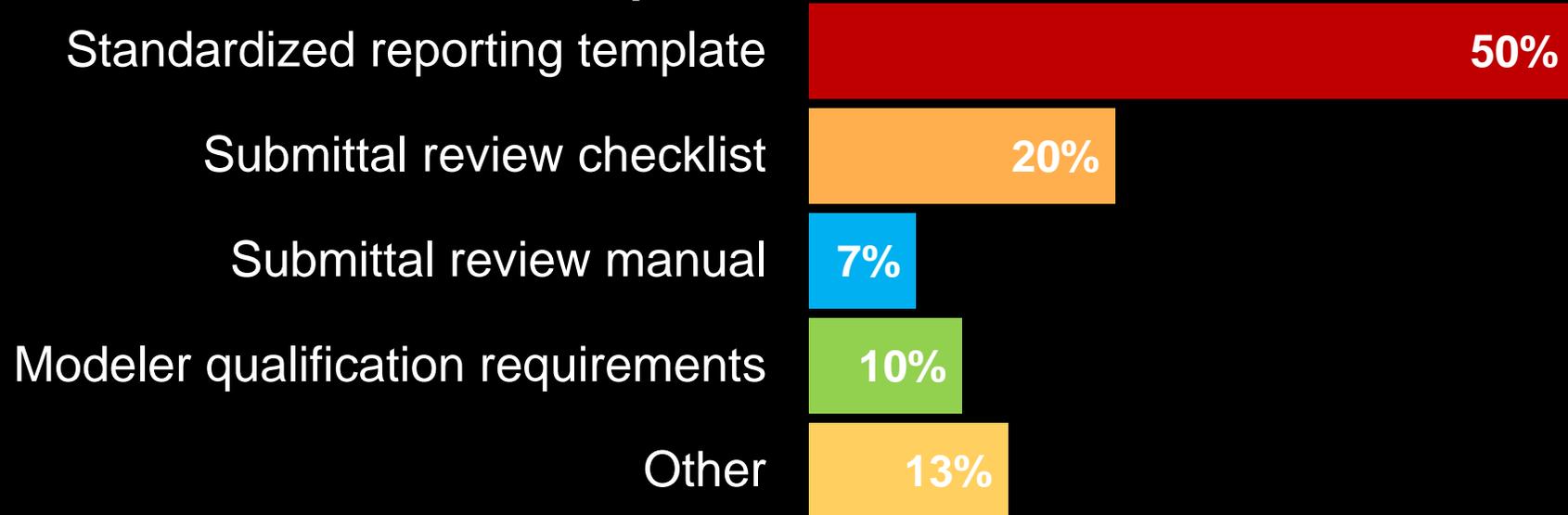
# Perceived Reasons for Inconsistent Compliance Outcomes

What do you think are the main reasons for mistakes in the modeling-based submittals?



# Short Term Priorities Identified by Stakeholders

What QA/QC tools and resources would you like to see developed in the near future?



## Survey Results

Commonly Used Standards: *90.1 Section 11 and Appendix G*

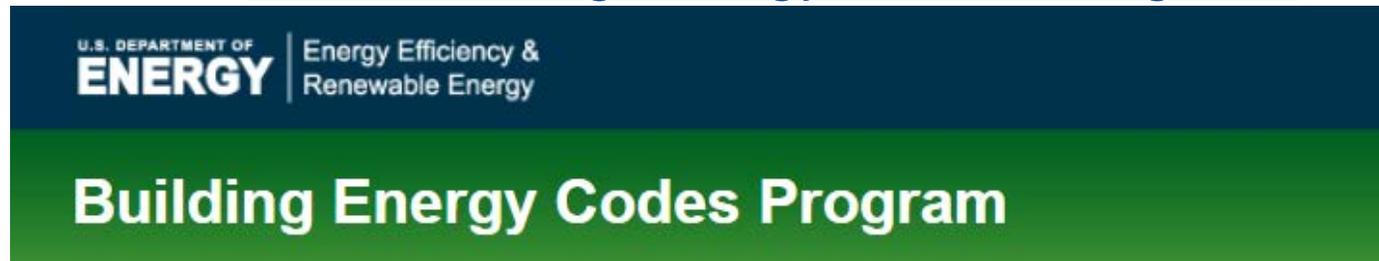
Biggest Compliance Issue: *Modeler Error*

Highest Short-Term Priorities: *Compliance Form, Submittal Checklist & Manual*

**Based on the stakeholder survey results it was decided to prioritize a new 90.1 energy model compliance form and submittal manual/checklist**

## 90.1 Section 11 and Appendix G Compliance Forms

- Supports 90.1-2016 and 90.1-2019
- Posted at [DOE Building Energy Codes Program](#) website



### ASHRAE Standard 90.1 Performance Based Compliance Form

- Summary of Features
  - MS Excel Format
  - Helps establish modeling inputs using built-in code look-ups and calculators
  - Allows importing simulation results from DesignBuilder, EnergyPlus, eQUEST, TraneTrace 3D Plus, Trane Trace 700 and Open Studio  
(Any tool can be used these have automated support within the tool)
  - Automates many of the required compliance calculations

# ASHRAE 90.1 Reporting Requirements

## STANDARD

**ANSI/ASHRAE/IES Standard 90.1-2019**  
(Supersedes ANSI/ASHRAE/IES Standard 90.1-2016)  
Includes ANSI/ASHRAE/IES addenda listed in Appendix I

## Energy Standard for Buildings Except Low-Rise Residential Buildings (I-P Edition)

## Appendix G G1.3.2 Application

Simulated performance shall be documented, and documentation shall be submitted to the *rating authority*. The information shall be submitted in a report and shall include the following:

- a. A brief description of the project, the key *energy efficiency* improvements compared with the requirements in Sections 5 through 10, the *simulation program* used, the version of the *simulation program*, and the results of the *energy analysis*. This summary shall contain the calculated values for the *baseline building performance*, the *proposed building performance*, and the percentage improvement.
- b. An overview of the project that includes the number of stories (above and below grade), the typical floor size, the uses in the *building* (e.g., office, cafeteria, retail, parking, etc.), the gross area of each use, and whether each use is *conditioned space*.
- c. A list of the *energy*-related features that are included in the design and on which the performance rating is based. This list shall document all *energy* features that differ between the models used in the *baseline building performance* and *proposed building performance* calculations.
- d. A list showing compliance for the *proposed design* with all the requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 (mandatory provisions).
- e. A list identifying those aspects of the *proposed design* that are less stringent than the requirements of Sections 5.5, 6.5, 7.5, 9.5, and 9.6 (prescriptive provisions).
- f. A table with a summary by end use of the *energy* cost savings in the *proposed building performance*.
- g. A site plan showing all adjacent *buildings* and topography that may shade the *proposed building* (with estimated height or number of stories).
- h. *Building elevations* and *floor plans* (schematic is acceptable).
- i. A diagram showing the *thermal blocks* used in the computer simulation.
- j. An explanation of any significant modeling assumptions.
- k. Backup calculations and material to support data inputs (e.g., *U-factors* for *building envelope* assemblies, NFRC ratings for *fenestration*, end-uses identified in Table G3.1, "1. Design Model," paragraph [a]).
- l. Input and output reports from the *simulation program* or compliance software, including a breakdown of *energy* use by at least the following components: lights, internal *equipment* loads, *service water-heating equipment*, *space-heating equipment*, *space-cooling* and heat rejection *equipment*, fans, and other HVAC *equipment* (such as pumps). The output reports shall also show the amount of *unmet load hours* for both the *proposed design* and *baseline building design*.
- m. *Purchased energy rates* used in the simulations.
- n. An explanation of any error messages noted in the *simulation program* output.
- o. For any exceptional calculation methods employed, document the predicted *energy* savings by *energy* type, the *energy* cost savings, a narrative explaining the exceptional calculation method performed, and theoretical or empirical information supporting the accuracy of the method.
- p. The reduction in *proposed building performance* associated with *on-site renewable energy*.
- q. The version of the software and the link to the website that contains the ASHRAE Standard 140 results for the version used in accordance with Section G2.2.4.

## Section 11 11.7.2 Permit Application Documentation

Compliance shall be documented and submitted to the *building official*. The information submitted shall include the following:

- a. The *energy cost budget* for the *budget building design* and the *design energy cost* for the *proposed design*.
- b. The *simulation program* used and the version of the *simulation program*.
- c. An overview of the project that includes the number of stories (above and below grade), the typical floor size, the uses in the *building* (e.g., office, cafeteria, retail, parking, etc.), the gross area of each use, and whether each use is conditioned.
- d. A list of the *energy*-related features that are included in the design and on which compliance with the provisions of Section 11 is based. This list shall document all *energy* features that differ between the models used in the *energy cost budget* and the *design energy cost* calculations.
- e. A list showing compliance for the *proposed design* with all the requirements of Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 (mandatory provisions).
- f. *Building elevations* and *floor plans*.
- g. A diagram showing the *thermal blocks* used in the computer simulation.
- h. An explanation of any significant modeling assumptions.
- i. Backup calculations and material to support data inputs (e.g., *U-factors* for *building envelope* assemblies, NFRC ratings for *fenestration*, end uses identified in Table 11.5.1, "1. Design Model," paragraph [a]).
- j. The input and output reports from the *simulation program*, including a breakdown of *energy* usage by at least the following components: lights, internal *equipment* loads, *service water-heating equipment*, *space-heating equipment*, *space cooling* and heat-rejection *equipment*, fans, and other HVAC *equipment* (such as pumps). The output reports shall also show the amount of time any loads are not met by the HVAC system for both the *proposed design* and *budget building design*.
- k. *Purchased energy rates* used in the simulations.
- l. An explanation of any error messages noted in the *simulation program* output.
- m. For any exceptional calculation methods employed, document the predicted *energy* savings by *energy* type, the *energy* cost savings, a narrative explaining the exceptional calculation method performed, and theoretical or empirical information supporting the accuracy of the method.
- n. The reduction in *design energy cost* associated with *on-site renewable energy*.
- o. The version of the software and the link to the website that contains the ASHRAE Standard 140 results for the version used in accordance with Section 11.4.1.4.

## Key Reporting Requirements of 90.1 Appendix G

- Systems and equipment that differ between the baseline and proposed design models
- Summary of energy efficiency trade-offs documenting whether features are more or less efficient than **90.1 prescriptive requirements**
- A report showing compliance with **90.1 mandatory provisions**
- A summary, by end use, of the energy cost savings
- Energy end use breakdown and unmet load hours for the baseline and proposed design
- **Backup calculations** and material to support data inputs

14

(Information not input or output from the energy simulation)

# From Design Documents to Simulation Inputs

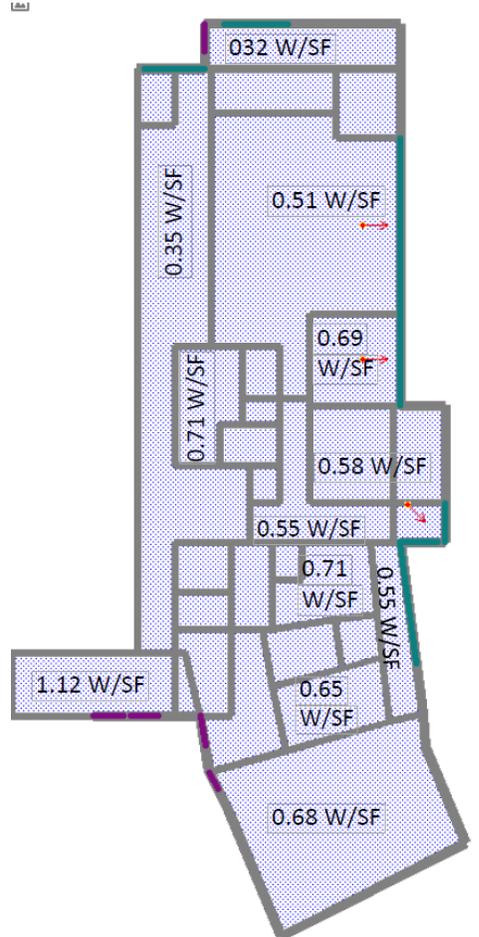
Design Documents Lighting Plans and Schedules



| NO. | DESCRIPTION | SPICE | SPICE PARAMETERS | TYPE | UNIT |
|-----|-------------|-------|------------------|------|------|
| 100 | RECEPTION   | 1.0   | 1.0              | 1.0  | 1.0  |
| 101 | OFFICE      | 1.0   | 1.0              | 1.0  | 1.0  |
| 102 | CONFERENCE  | 1.0   | 1.0              | 1.0  | 1.0  |
| 103 | LABORATORY  | 1.0   | 1.0              | 1.0  | 1.0  |
| 104 | RESTROOM    | 1.0   | 1.0              | 1.0  | 1.0  |
| 105 | STORAGE     | 1.0   | 1.0              | 1.0  | 1.0  |
| 106 | MEETING     | 1.0   | 1.0              | 1.0  | 1.0  |
| 107 | RECEPTION   | 1.0   | 1.0              | 1.0  | 1.0  |
| 108 | OFFICE      | 1.0   | 1.0              | 1.0  | 1.0  |
| 109 | CONFERENCE  | 1.0   | 1.0              | 1.0  | 1.0  |
| 110 | LABORATORY  | 1.0   | 1.0              | 1.0  | 1.0  |
| 111 | RESTROOM    | 1.0   | 1.0              | 1.0  | 1.0  |
| 112 | STORAGE     | 1.0   | 1.0              | 1.0  | 1.0  |
| 113 | MEETING     | 1.0   | 1.0              | 1.0  | 1.0  |
| 114 | RECEPTION   | 1.0   | 1.0              | 1.0  | 1.0  |
| 115 | OFFICE      | 1.0   | 1.0              | 1.0  | 1.0  |
| 116 | CONFERENCE  | 1.0   | 1.0              | 1.0  | 1.0  |
| 117 | LABORATORY  | 1.0   | 1.0              | 1.0  | 1.0  |
| 118 | RESTROOM    | 1.0   | 1.0              | 1.0  | 1.0  |
| 119 | STORAGE     | 1.0   | 1.0              | 1.0  | 1.0  |
| 120 | MEETING     | 1.0   | 1.0              | 1.0  | 1.0  |



BEM Tool Input

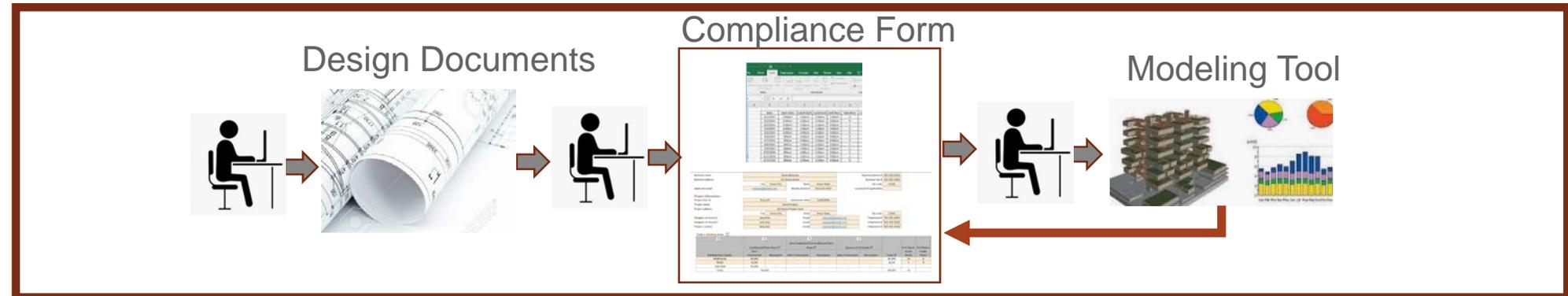


# Compliance Process Improvement

## Current Process



## Streamlined Process using the Compliance Form



# Programs Planning to Use the Compliance Form for Reporting

## Jurisdictions

- ✓ Washington State
- ✓ Seattle
- ✓ New York City

## Above Code Programs

- ✓ LEED NC
- ✓ EPA ENERGY STAR multifamily program
- ✓ NEEA



Some of the features may need to be customized to account for program-specific rules



**Pacific  
Northwest**  
NATIONAL LABORATORY

**Thank you**





**KARPMAN**  
CONSULTING

# ASHRAE Standard 90.1 Section 11 and Appendix G Compliance Form

Maria Karpman

[www.karpmanconsulting.net](http://www.karpmanconsulting.net)

# Agenda

- Tour of the Compliance Form
- Planned New Features and Tools

# Compliance Form Tour

# Trainings

## **Recorded Compliance Form Training (2 hours)**

- 90.1 reporting and documentation requirements applicable to performance-based projects
- Demonstration for filling out sample tabs
- Productivity tips, efficient workflow, common mistakes

## **Performance-based Compliance for Submittal Reviewers (12/8 1-3pm EST, 2 hours)**

- How to use the Compliance Form to perform submittal reviews
- Review steps and methodology for prioritizing review effort

See [energycodes.gov/training](https://energycodes.gov/training) for additional information



# Planned New Compliance Form Features and Tools

## ✓ Updates to the Compliance Form

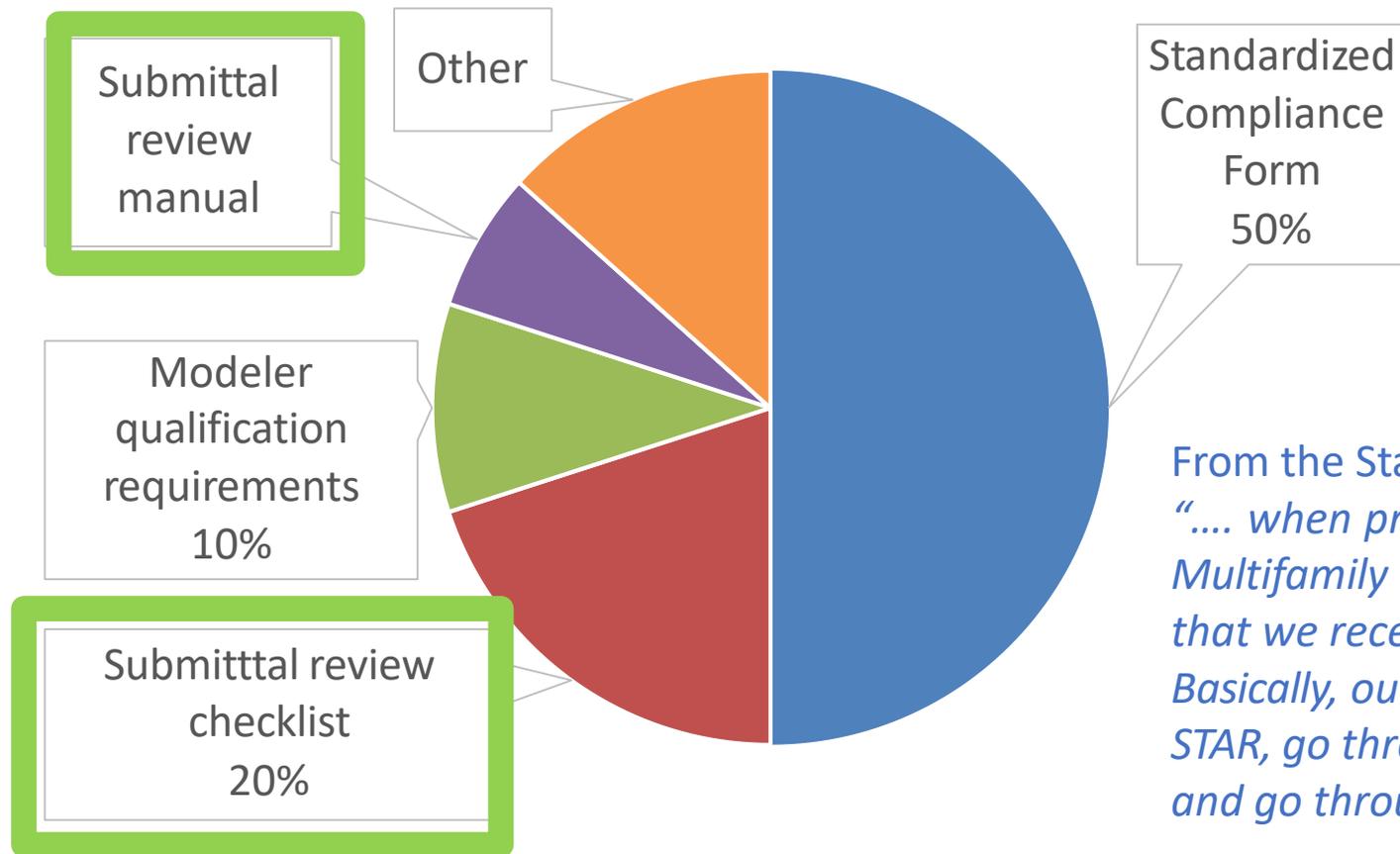
- New Quality Control tab
- Customized versions for jurisdictions and rating authorities
- Compliance reports
- Data exchange with external tools

## ✓ Tools under development

- Submittal Review Manual
- Technical support documents to facilitate adoption of 90.1 Appendix G



# Short Term Priorities Identified by Stakeholders



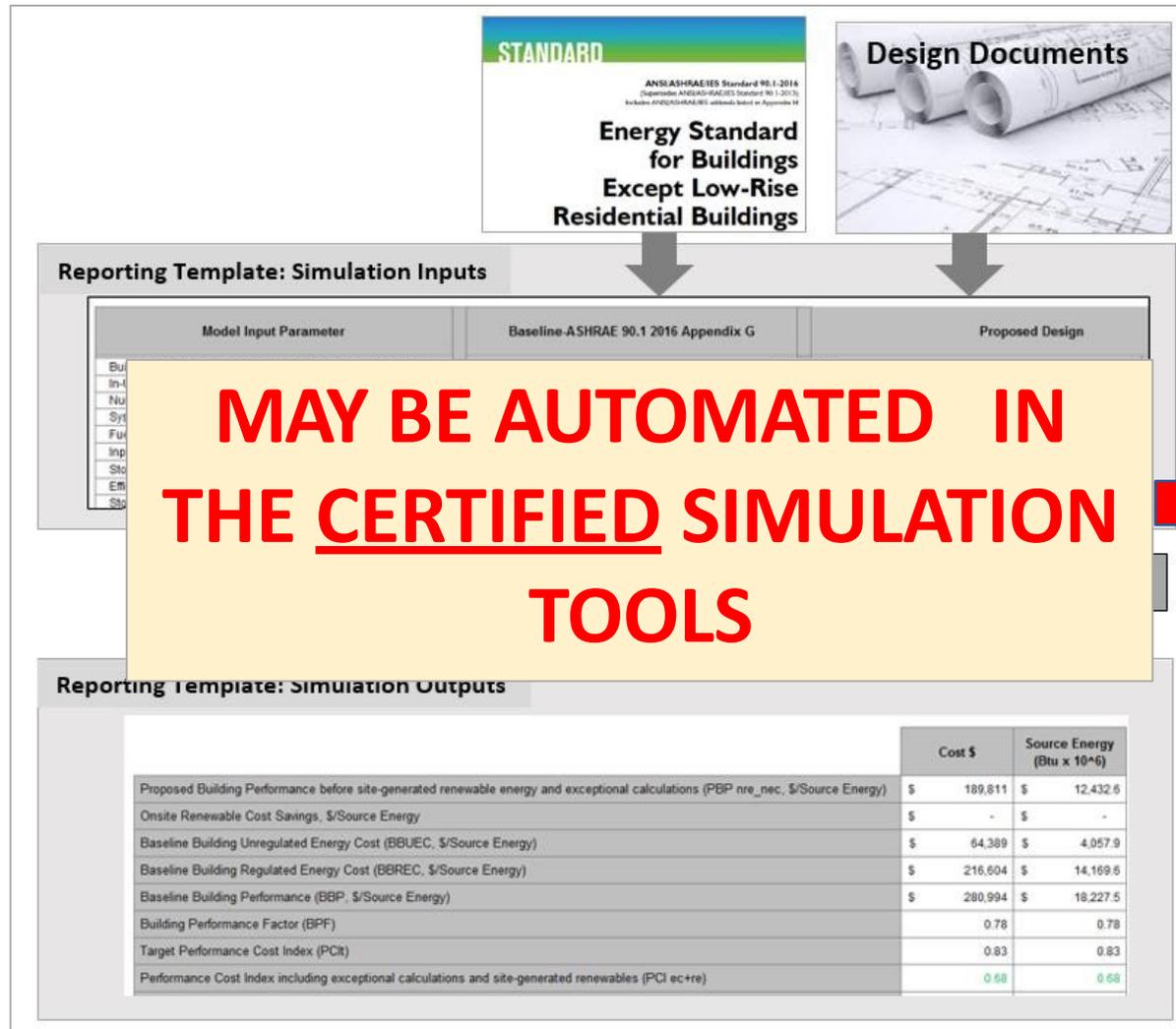
From the Stakeholder Survey:

*"... when project participates in both the ENERGY STAR Multifamily Highrise Program and LEED, the comments that we receive from each program are different. Basically, our process has been to submit for ENERGY STAR, go through their comments, then submit to GBCI, and go through their iterative review process."*

Percent of responders that picked the option as the top priority.



# Review Steps

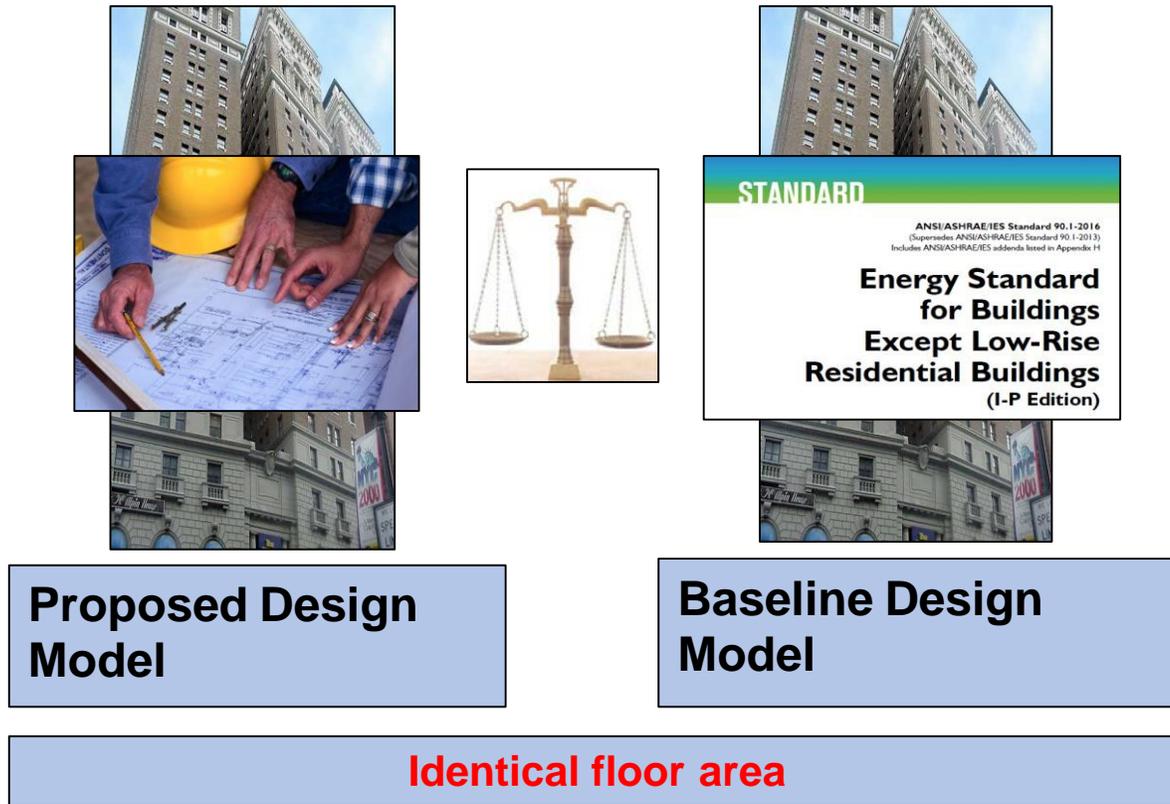


Verify that ...

- Reported proposed design reflects design documents.
- The baseline design is correctly established following 90.1
- The baseline and proposed designs are modeled as described in the Compliance Form
- Compliance is established correctly based on simulation results and 90.1 rules.



# Example: Verifying Building Floor Area



- ✓ What simulation reports show the floor area?
- ✓ Modeled floor area rarely matches design documents
  - Gross floor area is defined differently in IBC vs 90.1
  - Model workarounds (multi-level spaces, modeling un-enclosed spaces such as vented garages as ambient conditions)
  - Model is based on preliminary design
- ✓ What difference between modeled and actual floor area is acceptable?



# Submittal Review Manual

- Focuses on review of the modeling-based submittals.  
The steps that are the same for prescriptive and performance projects, such as verifying compliance with mandatory provisions, are not specifically addressed.
- Includes several hundred review checks
  - Provides a software-neutral description of each check.
  - Software-specific sections include the annotated simulation input/output reports illustrating how to complete the checks in the supported tools
  - Supported tools include (alphabetically) Carrier HAP, DesignBuilder, EnergyPlus, eQUEST, IES-VE (pending), Trane TRACE 3D Plus, Trane TRACE 700, OpenStudio
- Describes review prioritization strategies.
- Lists the key elements of the enforcement infrastructure such as modeler and reviewer qualification requirements and adoption of a detailed Compliance Form.



# Annotated Simulation Reports

## BUILDING AREAS By Trane

BE6, BE7: Areas of the building envelope for the proposed and baseline

| Sys                  | Zon | Room         | Number of Duplicate Floors | Number of Rooms | Floor Area/ Duplicate Room ft² | Total Floor Area ft² | Partition Area ft² | Int Door Area ft² | Exposed Floor Area ft² | Skylight Area ft² | Net Roof Area ft² | Window Area ft² | Window/ Wall % | Ext Door Area ft² | Net Wall Area ft² |
|----------------------|-----|--------------|----------------------------|-----------------|--------------------------------|----------------------|--------------------|-------------------|------------------------|-------------------|-------------------|-----------------|----------------|-------------------|-------------------|
| <b>Alternative 1</b> |     |              |                            |                 |                                |                      |                    |                   |                        |                   |                   |                 |                |                   |                   |
|                      |     | W1-R1 N      | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 540             | 45             | 0                 | 660               |
|                      |     | W1-R2 E      | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 480             | 40             | 0                 | 720               |
|                      |     | W1-R3 Int    | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 0               | 0              | 0                 | 0                 |
|                      |     | W1-R4 W      | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 240             | 20             | 0                 | 960               |
|                      |     | W1-R5 Int    | 1                          | 1               | 6,400                          | 6,400                | 0                  | 0                 | 0                      | 0                 | 6,400             | 0               | 0              | 0                 | 0                 |
|                      |     | W2-R6 N      | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 540             | 45             | 0                 | 660               |
|                      |     | W2-R7 E      | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 480             | 40             | 0                 | 720               |
|                      |     | W2-R8 S      | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 360             | 30             | 0                 | 840               |
|                      |     | W2-R9 Int    | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 0               | 0              | 0                 | 0                 |
|                      |     | W2-R10 Int   | 1                          | 1               | 6,400                          | 6,400                | 0                  | 0                 | 0                      | 0                 | 6,400             | 0               | 0              | 0                 | 0                 |
|                      |     | W3-R11 Int   | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 0               | 0              | 0                 | 0                 |
|                      |     | W3-R12 E     | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 480             | 40             | 0                 | 720               |
|                      |     | W3-R13 S     | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 360             | 30             | 0                 | 840               |
|                      |     | W3-R14 W     | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 240             | 20             | 0                 | 960               |
|                      |     | W3-R15 Int   | 1                          | 1               | 6,400                          | 6,400                | 0                  | 0                 | 0                      | 0                 | 6,400             | 0               | 0              | 0                 | 0                 |
|                      |     | W4-R17 Int   | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 0               | 0              | 0                 | 0                 |
|                      |     | W4-R18 N     | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 540             | 45             | 0                 | 660               |
|                      |     | W4-R19 W     | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 240             | 20             | 0                 | 960               |
|                      |     | W4-R20 Int   | 1                          | 1               | 6,400                          | 6,400                | 0                  | 0                 | 0                      | 0                 | 6,400             | 0               | 0              | 0                 | 0                 |
|                      |     | W4-R18 S     | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 360             | 30             | 0                 | 840               |
|                      |     | W5-R21 Int   | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 0               | 0              | 0                 | 0                 |
|                      |     | W5-R22 Int   | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 0               | 0              | 0                 | 0                 |
|                      |     | W5-R23 Int   | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 0               | 0              | 0                 | 0                 |
|                      |     | W5-R24 Int   | 1                          | 1               | 900                            | 900                  | 0                  | 0                 | 0                      | 0                 | 900               | 0               | 0              | 0                 | 0                 |
|                      |     | W5-R25 Int   | 1                          | 1               | 6,400                          | 6,400                | 0                  | 0                 | 0                      | 0                 | 6,400             | 0               | 0              | 0                 | 0                 |
|                      |     | System - 001 |                            |                 |                                | 50,000               | 0                  | 0                 | 0                      | 0                 | 50,000            | 4,860           | 34             | 0                 | 9,540             |

Total building Window Area: 4,860 ft²

Total building Skylight Area: 0 ft²

Total building Wall Area: 14,400 ft²

Total building Roof Area: 50,000 ft²

Total building Floor Area: 50,000 ft²

Building Total Window %: 33.8%

Building Total Skylight %: 0.0%

BE7: Baseline and Proposed Fenestration Areas



# Compliance Form Updates: Quality Control Tab

## Quality Control Checks

### Table of Contents

[Simulation General \(SG\)](#)

[Utility Rates \(UR\)](#)

[Compliance Calculations \(CC\)](#)

[Envelope \(BE\)](#)

[Interior Lighting \(LI\)](#)

[Exterior Lighting \(LE\)](#)

[Miscellaneous Loads \(ML\)](#)

[Service Water Heating \(SWH\)](#)

[Air-Side HVAC Systems \(AHVAC & AHM\)](#)

[Water-Side HVAC Systems \(WHVAC & WHM\)](#)

[Other Equipment \(OE\)](#)

- Includes the full list of the review checks included in the Review Manual
- Allows identifying the checks that should be performed on a given project based on the identified high impact areas and available review budget.
- Many checks are performed automatically based on the information available in the compliance form
- References the appropriate sections of the Review Manual for additional details
- Allows recording the review outcome (pass/fail) and review comments for each completed check



# Compliance Form Updates: Custom Versions

## General Information

[Return to Dashboard](#)

[Adjust Column Widths and Row Heights](#)

### Table of Contents

[Energy Model Information](#)

[Table 1: Building Areas](#)

[Table 2: Dwelling Units](#)

[Renovations and Yet to Be Designed Systems and Components](#)

### Instructions

1. Complete the "General Information" tab before completing any other tabs because some of the inputs on this tab determine the selections available within other tabs.

### Energy Model Information

|   |                              |                         |                        |
|---|------------------------------|-------------------------|------------------------|
| <a href="#">?</a> Compliance path                                       | ASHRAE 90.1-2016: Appendix G | Minimum Code Compliance | YOUR STATE ENERGY CODE |
| <a href="#">?</a> Energy model based on                                 | Document date                |                         |                        |
| <a href="#">?</a> Simulation program                                    | <Specify version number>     | ASHRAE Std 140 Tests    |                        |
| <a href="#">?</a> Simulation weather station                            |                              |                         |                        |
| Type of weather data  |                              |                         |                        |
| Name of simulation weather file   |                              |                         |                        |
| Climate zone  |                              |                         |                        |
| <a href="#">?</a> Were the <i>exceptional calculation</i> methods used? |                              |                         |                        |
| <a href="#">?</a> Describe areas excluded from the energy model, if any |                              |                         |                        |

YOUR STATE ENERGY CODE

- Default - Selected Version of 90.1
- EPA Multifamily New Construction Version 1
- LEED BD+C V4.1
- Seattle Commercial Energy Code
- Washington State Energy Code-Commercial
- YOUR STATE ENERGY CODE**



# Customization Example: Compliance Calculations

Published Compliance Form uses ASHRAE 90.1 Building Performance Factors (BPFs)

Table 7: Compliance Calculations

Table 4.2.1.1 Building Performance Factor (BPF)

| Building Area Type* | 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 |

| Parameter   | BBUEC   | BBREC                   | BBP     | BPF  | PCI <sub>t</sub> | PCI <sub>nre_nec</sub> | PCI <sub>ec</sub> | PCI | PCI <sub>adjusted</sub> | GHG Emissions Mt CO <sub>2</sub> e |
|---|---------|-------------------------|---------|------|------------------|------------------------|-------------------|-----|-------------------------|------------------------------------|
| Proposed building performance before site-generated renewable energy and exceptional calculations         | 629,111 | 720                     | 2,015   |      |                  |                        |                   |     |                         | 290                                |
| ? On-site renewable savings   |         |                         |         |      |                  |                        |                   |     |                         | -                                  |
| ? Exceptional calculations savings excluding on-site renewable energy                                     |         |                         |         |      |                  |                        |                   |     |                         | -                                  |
| Proposed building performance including on-site renewable energy and exceptional calculations             |         |                         |         |      |                  |                        |                   |     |                         | 290                                |
| Proposed building performance including exceptional calculations and excluding on-site renewable energy   |         |                         |         |      |                  |                        |                   |     |                         | 290                                |
| Baseline building unregulated energy, GHG emissions, and/or energy cost                                   | 629,111 | 720                     | 2,015   |      |                  |                        |                   |     |                         | 61                                 |
| Baseline building regulated energy, GHG emissions, and/or energy cost                                     |         | 130,884                 | 5,142   |      |                  |                        |                   |     |                         | 352                                |
| Baseline building performance   |         | BBP                     | 159,994 |      |                  |                        |                   |     |                         | 413                                |
| Building Performance Factor   |         | BPF                     | 0.73    | n/a  | n/a              | n/a                    | n/a               | n/a | n/a                     | n/a                                |
| Performance Index Target  |         | PCI <sub>t</sub>        | 0.78    | n/a  | n/a              | n/a                    | n/a               | n/a | n/a                     | n/a                                |
| Performance index without on-site renewable energy and exceptional calculations                           |         | PCI <sub>nre_nec</sub>  | 0.69    | 0.71 | 0.69             | 0.70                   |                   |     |                         | 0.70                               |
| Performance index including exceptional calculations  |         | PCI <sub>ec</sub>       | 0.69    | 0.71 | 0.69             | 0.7                    |                   |     |                         | 0.7                                |
| Performance Index including exceptional calculations and on-site renewable energy                         |         | PCI                     | 0.69    | 0.71 | 0.69             | 0.7                    |                   |     |                         | 0.7                                |
| ? Performance Index adjusted based upon ASHRAE 90.1-2019 Section 4.2.1.1                                  |         | PCI <sub>adjusted</sub> | 0.69    | 0.71 | 0.69             | 0.7                    |                   |     |                         | 0.7                                |
| % improvement beyond ASHRAE 90.1-2016, excluding on-site renewable energy and exceptional calculations    |         | -                       | 11.5%   | n/a  | n/a              | n/a                    |                   |     |                         | n/a                                |
| % improvement beyond ASHRAE 90.1-2016, inclusive of on-site renewable energy and exceptional calculations |         | -                       | 11.5%   | n/a  | n/a              | n/a                    |                   |     |                         | n/a                                |

PROJECT COMPLIES. The Performance Cost Index (PCI<sub>adjusted</sub>) does not exceed the Performance Cost Index Target (PCI<sub>t</sub>). The project complies with 90.1 via the Appendix G Performance Rating Method.



# NYCECCC 2020 Compliance Calculations

NYC ECCC cost-based BPFs in lieu of 90.1 BPFs

Table 4.2.1.1 *Building Performance Factor (Cost)* (BPF<sub>cost</sub>)

| Building Area Type   | Climate Zone |      |      |
|----------------------|--------------|------|------|
|                      | 4A           | 5A   | 6A   |
| Multifamily          | 0.67         | 0.67 | 0.64 |
| Healthcare/ hospital | 0.54         | 0.54 | 0.51 |
| Hotel/motel          | 0.62         | 0.56 | 0.56 |
| Office               | 0.54         | 0.54 | 0.55 |
| Restaurant           | 0.56         | 0.55 | 0.55 |
| Retail               | 0.45         | 0.42 | 0.44 |
| School               | 0.45         | 0.46 | 0.46 |
| Warehouse            | 0.42         | 0.42 | 0.46 |
| All others           | 0.53         | 0.52 | 0.52 |

NYC ECCC site-to-source energy conversion factors

Table 4.2.1.2 Site to Source Energy Conversion Ratios

| Energy Type   | New York Ratio |
|---|----------------|
| Electricity (Grid Purchase)                         | 2.55           |
| Electricity (On-site Renewable Energy Installation) | 1.00           |
| Natural Gas   | 1.05           |
| Fuel Oil  | 1.01           |
| Propane & Liquid Propane                            | 1.01           |
| Steam   | 1.20           |
| Hot Water   | 1.20           |
| Chilled Water, Coal, Wood, Other                    | 1.00           |

Compliance calculations using either energy cost or source energy

Table 4.2.1.3 *Building Performance Factor (Source)* (BPF<sub>source</sub>)

| Building Area Type   | Climate Zone |      |      |
|----------------------|--------------|------|------|
|                      | 4A           | 5A   | 6A   |
| Multifamily          | 0.68         | 0.68 | 0.65 |
| Healthcare/ hospital | 0.56         | 0.56 | 0.54 |
| Hotel/motel          | 0.62         | 0.56 | 0.54 |
| Office               | 0.55         | 0.55 | 0.56 |
| Restaurant           | 0.63         | 0.64 | 0.63 |
| Retail               | 0.45         | 0.42 | 0.43 |
| School               | 0.45         | 0.45 | 0.45 |
| Warehouse            | 0.44         | 0.46 | 0.49 |
| All others           | 0.55         | 0.54 | 0.54 |



# Compliance Form Updates: Reporting

- Based on the stakeholder survey, lack of coordination between the energy model and design documentation is one of the most prevalent issues that has yet to show improvement
- **Compliance Report** will allow printing compliance information on design documents to facilitate plan reviews
- **Site Inspection Report** will include a subset of information from the compliance form with the goal to facilitate site inspections



# Compliance Form Updates: Data Exchange with External Tools

- **Data Export** allows copying a subset of project information from the Compliance Form into third-party tools
  - Track projects in central databases
  - Facilitated custom calculations such as to determine utility incentives
- **Data Import** allows populating the Compliance Form using information from third party tools
  - BEM software
  - Inhouse tools used by modelers, such as to calculate lighting power density



# Data Import / Export – COMNET Example



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- <enduseResults>
  <Enduse>Interior lighting</Enduse>
  <Regulated>0</Regulated>
  <EnergyType>Electricity</EnergyType>
  <EnergyUnits>kWh</EnergyUnits>
  <DemandUnits>kW</DemandUnits>
  <BaselineZeroSite>638476</BaselineZeroSite>
  <BaselineNinetySite>0</BaselineNinetySite>
  <BaselineOneEightySite>0</BaselineOneEightySite>
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  <BaselineSiteMMBtu>2178.480112</BaselineSiteMMBtu>
  <BaselineSourceMMBtu>6099.7443136</BaselineSourceMMBtu>
  <BaselineGHGMTon>343.111942882065</BaselineGHGMTon>
  <ProposedCost>24672.4696041366</ProposedCost>
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</enduseResults>
    
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<buildingarea>
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  <RenovationUnenclosedsf>0</RenovationUnenclosedsf>
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  <belowgradefloors>0</belowgradefloors>
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  <BPFSite>n/a</BPFSite>
    
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```

<contactInfo>
  <ContactType>Architect</ContactType>
  <LastName>Nicholas J. Netta</LastName>
  <FirstName>Nicholas J. Netta</FirstName>
  <Title>Engineer 2</Title>
  <Company>Netta Architects</Company>
  <Email>info@nettaarchitects.com</Email>
  <Workphone>973-379-0006</Workphone>
  <Mobilephone>973-379-0006</Mobilephone>
  <LicenseNum>0</LicenseNum>
  <ProjRole>0</ProjRole>
</contactInfo>
    
```

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</EnergyCost>
<EnergyCost>
  <energyType>Natural Gas</energyType>
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  <PRdollarUnit>0.92</PRdollarUnit>
</EnergyCost>
    
```



# Technical Support Documents to Facilitate Adoption of 90.1 Appendix G

- Methodology to address “fuel switching”
- Establishing compliance using units other than energy cost, such as source energy or green-house gas emissions
- Calculating energy and demand savings of the proposed design relative to code by fuel type
- Avoiding unfavorable outcomes for projects with electric space and service water heating





**KARPMAN**  
CONSULTING

# Thank You!

Maria [Karpman@karpmanconsulting.net](mailto:Karpman@karpmanconsulting.net)



# Examples of Above-Code Programs

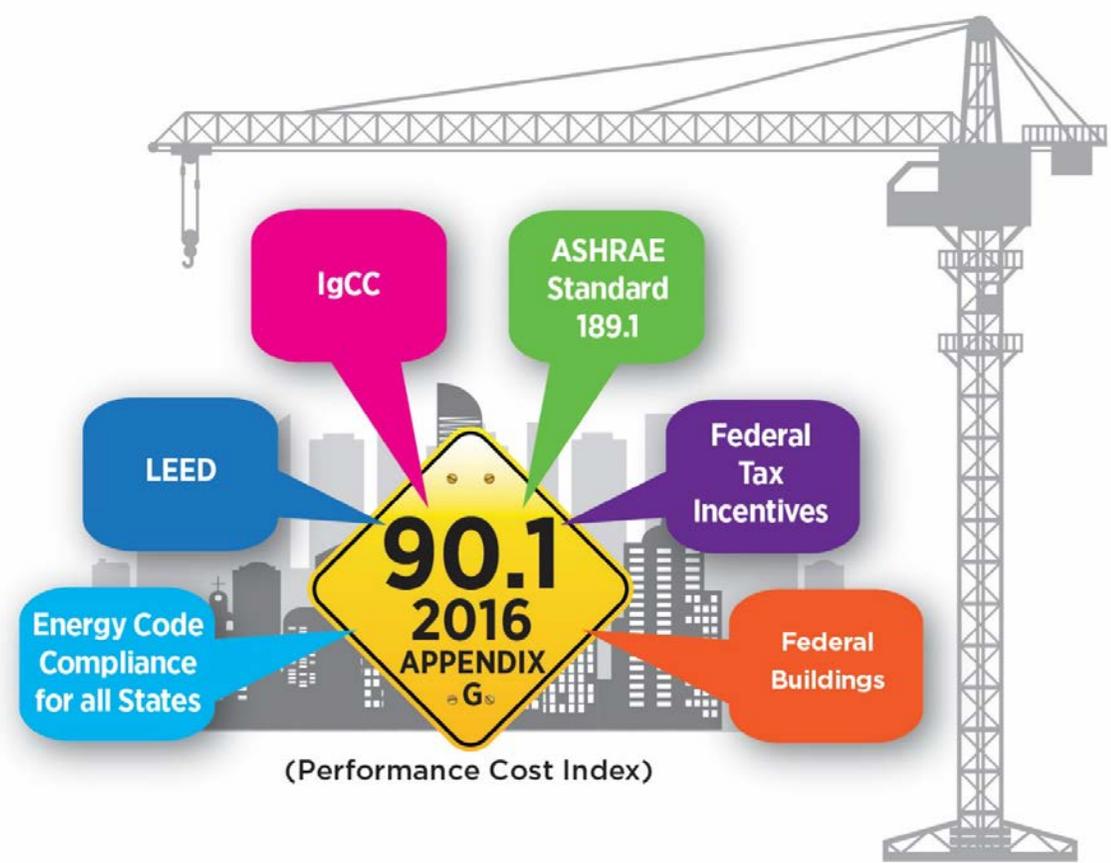
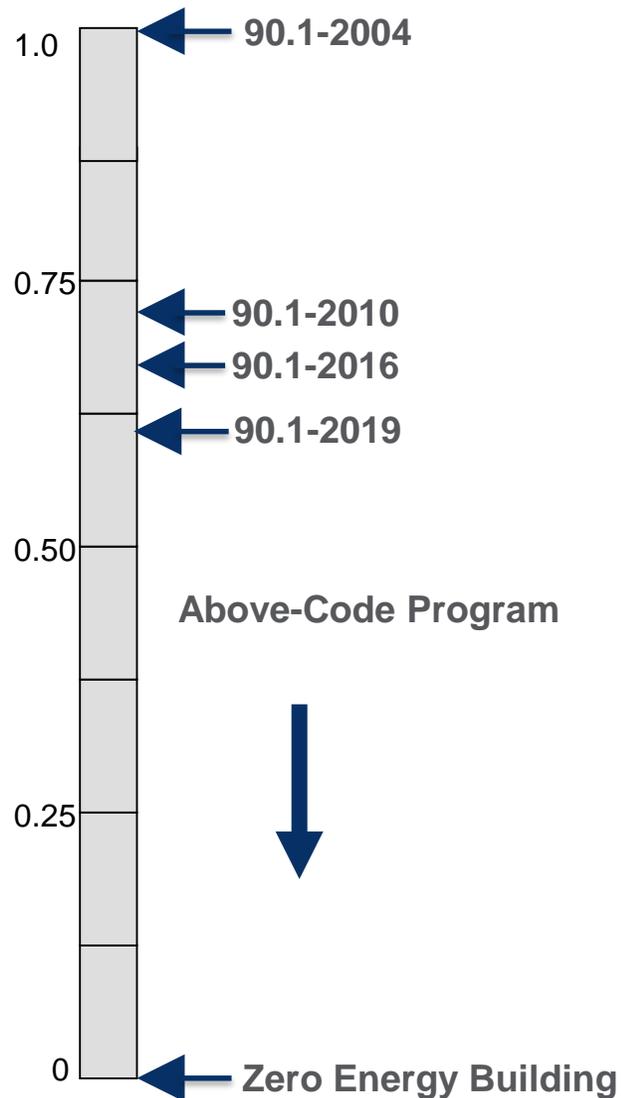
**Bing Liu, P.E., ASHRAE Fellow**  
Sr. Manager, Codes, Standards & New Construction  
Northwest Energy Efficiency Alliance



# Agenda

- Examples
  - Utility Incentive Program
  - ENERGY STAR Multifamily
  - Stretch Code
- Takeaways and resources

# Appendix G provides a pathway to set up energy targets for both code compliance and above-code programs.

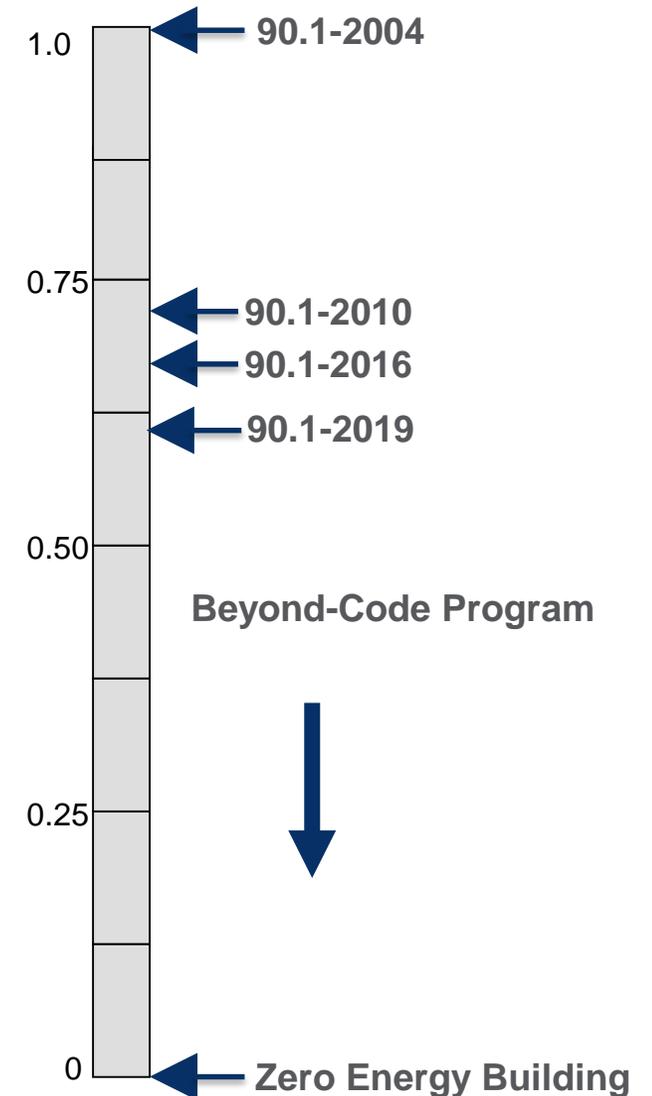


# Common Issues

Since Appendix G baseline is 90.1-2004, how can the following be calculated:

- Site, source energy or carbon emissions savings of the proposed design relative to the current code
- Cost-effectiveness of the individual measures (EEMs)
- Fuel-level savings of the proposed design relative to current code

Performance Index





# *Example 1*



## 2. Use the real project to model the Appendix G baseline energy use (annual site energy, kBtu/sf)

(The numbers below are made up. Assumed to be from Appendix G Baseline Model)

| STD2004 | Light.Int | Light.Ext | SHW  | Heat | Humidfy | Cool | Ht.Rej | Fans | Ht.Rcvy | Pumps | Refrig | Elevator | Txfmr | Cook | IT   | Equip | Total  |
|---------|-----------|-----------|------|------|---------|------|--------|------|---------|-------|--------|----------|-------|------|------|-------|--------|
| CZ 4C   | 11.24     | 4.57      | 1.79 | 9.08 | 0.00    | 4.03 | 0.00   | 2.01 | 0.00    | 0.00  | 0.00   | 3.56     | 0.69  | 0.00 | 0.00 | 13.04 | 49.999 |

### 3. Calculate the current code (90.1-2016) energy use for the real project (annual site energy, kBtu/sf)

|        | Light.Int | Light.Ext | SHW   | Heat  | Humidfy | Cool  | Ht.Rej | Fans  | Ht.Rcvy | Pumps | Refrig | Elevator | Txfmr | Cook | IT | Equip |
|--------|-----------|-----------|-------|-------|---------|-------|--------|-------|---------|-------|--------|----------|-------|------|----|-------|
| Step 1 | 0.552     | 0.211     | 0.966 | 0.383 |         | 0.505 |        | 0.709 |         | 1.000 |        | 0.945    | 0.349 |      |    | 0.912 |

(The numbers below are made up. Assumed to be from Appendix G Baseline Model)

| STD2004 | Light.Int | Light.Ext | SHW  | Heat | Humidfy | Cool | Ht.Rej | Fans | Ht.Rcvy | Pumps | Refrig | Elevator | Txfmr | Cook | IT   | Equip | Total  |
|---------|-----------|-----------|------|------|---------|------|--------|------|---------|-------|--------|----------|-------|------|------|-------|--------|
| Step 2  | 11.24     | 4.57      | 1.79 | 9.08 | 0.00    | 4.03 | 0.00   | 2.01 | 0.00    | 0.00  | 0.00   | 3.56     | 0.69  | 0.00 | 0.00 | 13.04 | 49.999 |

Step 3 = Step 1 x Step 2

| STD2016 | Light.Int | Light.Ext | SHW  | Heat | Humidfy | Cool | Ht.Rej | Fans | Ht.Rcvy | Pumps | Refrig | Elevator | Txfmr | Cook | IT   | Equip | Total |
|---------|-----------|-----------|------|------|---------|------|--------|------|---------|-------|--------|----------|-------|------|------|-------|-------|
| Step 3  | 6.20      | 0.97      | 1.73 | 3.47 | 0.00    | 2.03 | 0.00   | 1.42 | 0.00    | 0.00  | 0.00   | 3.36     | 0.24  | 0.00 | 0.00 | 11.89 | 31.32 |

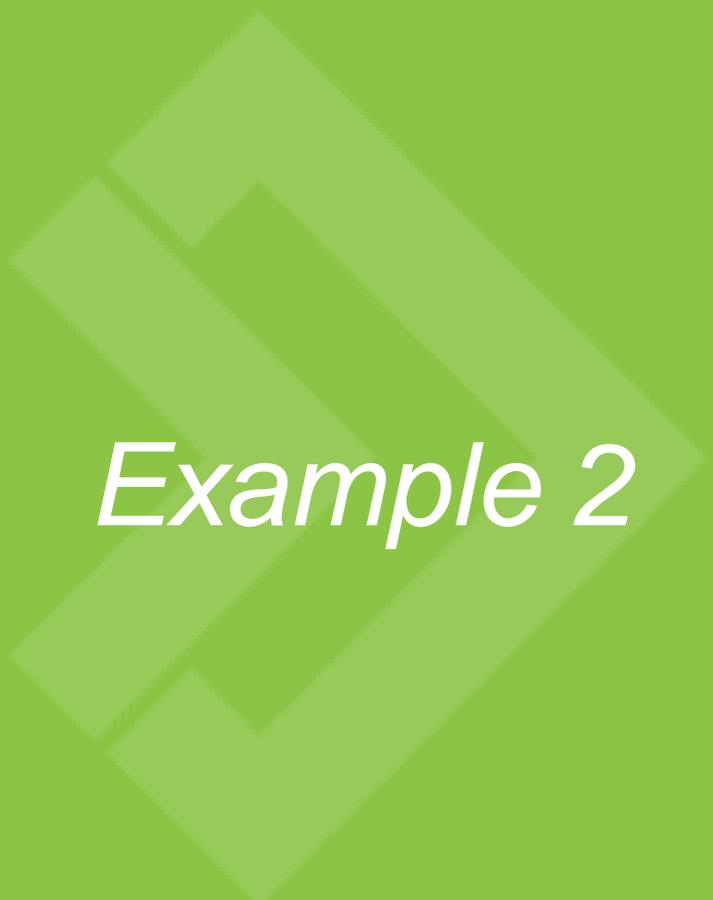
## 4. Calculate the proposed design energy use for the real project (annual site energy, kBtu/sf)

(The numbers below are made up. Assumed to be from Appendix G Proposed Model)

| Proposed Building | Light.Int | Light.Ext | SHW   | Heat  | Humidfy | Cool  | Ht.Rej | Fans  | Ht.Rcvy | Pumps | Refrig | Elevator | Txfmr | Cook  | IT    | Equip | Total  |
|-------------------|-----------|-----------|-------|-------|---------|-------|--------|-------|---------|-------|--------|----------|-------|-------|-------|-------|--------|
| Step 4            | 4.692     | 0.700     | 1.201 | 2.730 | 0.000   | 1.487 | 0.000  | 0.999 | 0.000   | 0.000 | 0.000  | 2.602    | 0.178 | 0.000 | 0.000 | 9.015 | 23.604 |

## 5. Savings of real project compared to current code (90.1-2016)

| Proposed Building   | Light.Int | Light.Ext | SHW   | Heat  | Humidfy | Cool  | Ht.Rej | Fans  | Ht.Rcvy | Pumps | Refrig | Elevator | Txfmr | Cook  | IT    | Equip | Total |
|---|-----------|-----------|-------|-------|---------|-------|--------|-------|---------|-------|--------|----------|-------|-------|-------|-------|-------|
| <b>Site Energy Savings in kBtu/sq ft/yr over Current Code (90.1-2016)</b> |           |           |       |       |         |       |        |       |         |       |        |          |       |       |       |       |       |
| Step 5  | 1.510     | 0.267     | 0.526 | 0.743 | 0.000   | 0.548 | 0.000  | 0.426 | 0.000   | 0.003 | 0.000  | 0.760    | 0.062 | 0.000 | 0.000 | 2.872 | 7.715 |
| <b>% Energy Savings over Current Code (90.1-2016)</b>                     |           |           |       |       |         |       |        |       |         |       |        |          |       |       |       |       |       |
| Step 5  | 24.3%     | 27.6%     | 30.4% | 21.4% |         | 26.9% |        | 29.9% |         | 93.9% |        | 22.6%    | 25.7% |       |       | 24.2% | 24.6% |



# *Example 2*



# ENERGY STAR®

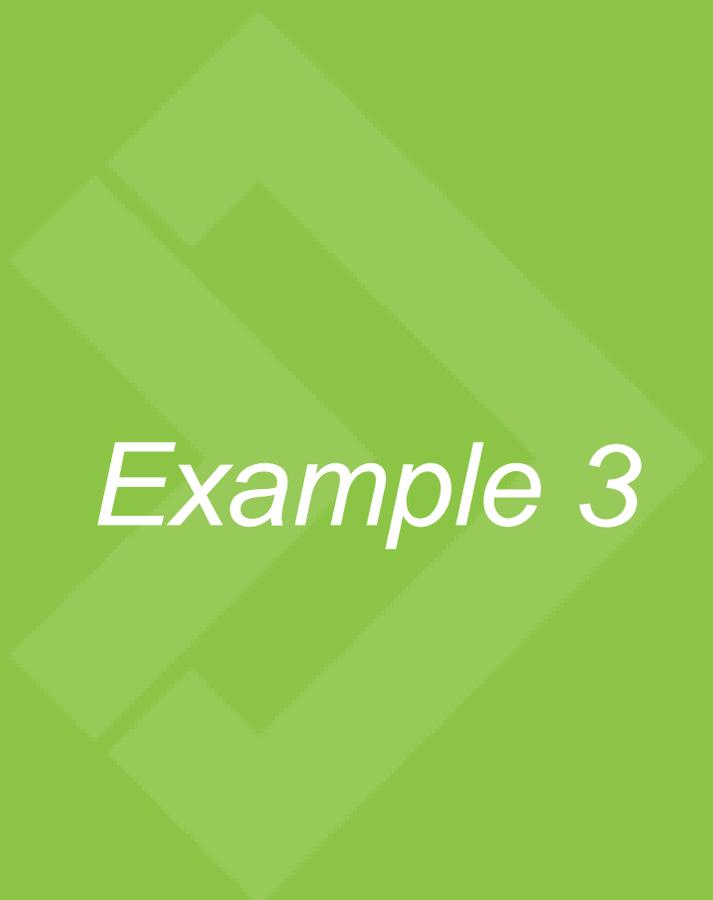
## MULTIFAMILY NEW CONSTRUCTION PROGRAM

### Simulation Guidelines-Appendix G 90.1-2016

Table 1: Multifamily Building Performance Factors (BPF)

| 90.1 Edition | 1A   | 1B   | 2A   | 2B   | 3A   | 3B   | 3C   | 4A   | 4B   | 4C   | 5A   | 5B   | 5C   | 6A   | 6B   | 7    | 8    |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2007         | 0.96 | 0.96 | 0.93 | 0.91 | 0.93 | 0.92 | 0.85 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.93 | 0.95 |
| 2010         | 0.92 | 0.91 | 0.88 | 0.86 | 0.87 | 0.87 | 0.8  | 0.9  | 0.93 | 0.92 | 0.88 | 0.92 | 0.92 | 0.88 | 0.91 | 0.83 | 0.89 |
| 2013         | 0.78 | 0.78 | 0.76 | 0.74 | 0.79 | 0.78 | 0.73 | 0.83 | 0.86 | 0.86 | 0.81 | 0.85 | 0.86 | 0.81 | 0.84 | 0.79 | 0.85 |
| 2016         | 0.73 | 0.73 | 0.71 | 0.69 | 0.74 | 0.73 | 0.68 | 0.78 | 0.81 | 0.81 | 0.76 | 0.8  | 0.81 | 0.76 | 0.79 | 0.74 | 0.8  |

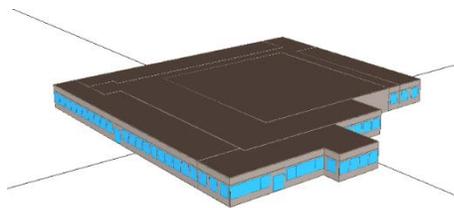
[Link: ENERGY STAR Multifamily New Construction Program Simulation Guidelines](#)



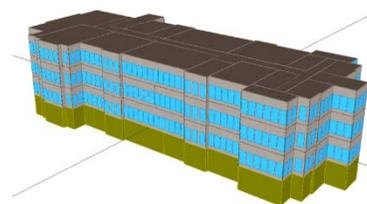
# *Example 3*

# Applying Appendix G to Codes

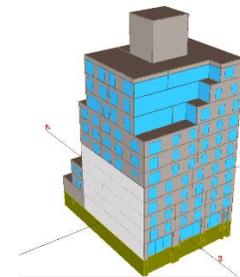
| Building Area Type  | 90.1-2016 | Washington State | Seattle |
|---------------------|-----------|------------------|---------|
| Multifamily         | 0.81      | 0.58             | 0.52    |
| Healthcare/hospital | 0.55      | 0.54             | 0.49    |
| Hotel/motel         | 0.62      | 0.64             | 0.58    |
| Office              | 0.58      | 0.56             | 0.51    |
| Restaurant          | 0.6       | 0.70             | 0.63    |
| Retail              | 0.6       | 0.47             | 0.43    |
| School              | 0.59      | 0.36             | 0.32    |
| Warehouse           | 0.63      | 0.48             | 0.43    |
| All others          | 0.61      | 0.54             | 0.49    |



Office



School



Multifamily



# Takeaways

- Appendix G provides a pathway to set up energy **performance targets** for both code compliance and above-code programs.
- **Customize performance targets** based on local code and the technologies that the program wants to promote.
- **Align reporting requirements** with other national and local programs that use Appendix G, to reduce overhead for participants and streamline submittal reviews.

# Resources



- **Methodology**
  - PNNL Report [Link](#)
  - Coming soon: Savings compared to the current code, different metric to support policy goals
- **Appendix G Compliance Form**
  - Compliance Tool is available [here](#) (DOE/PNNL)
  - Appendix G Training: [energycodes.gov](http://energycodes.gov)
  - Appendix G Pilot Projects (NEEA and Energy350)

PNNL-25202 Rev. 1



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## Developing Performance Cost Index Targets for ASHRAE Standard 90.1 Appendix G – Performance Rating Method

**March 2016**

M Rosenberg  
R Hart

---

**U.S. DEPARTMENT OF ENERGY** Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830



## *Above-Code Programs*

- ENERGY STAR Multifamily New Construction
  - Karpman Consulting
- NYSERDA Multifamily New Construction
  - Karpman Consulting
- New Jersey P4P New Construction Program
  - TRC
- Energy Trust of Oregon New Construction Program
  - CLEAResult



# Thank you for your time!

## QUESTIONS?

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- 11/05: Remote and Virtual Inspections
- 11/12: New for ASHRAE Standard 90.1
- 11/19: 2021 IECC Residential
- 12/03: Advanced Technology and Codes
- 12/10: Policies for EE + Resilience
- 12/17: Field Studies in the NW Region