All Hands On Deck: Raising the Bar on Whole Building Performance-Based Code Compliance and Above-Code Programs

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ABSTRACT

In 2019 a large-scale national effort was launched with support from U.S. Department of Energy, Pacific Northwest National Laboratory and Northwest Energy Efficiency Alliance (NEEA). The project aimed to develop a long-term vision and a roadmap for achieving a practical application of whole building performance-based code and above code program compliance in commercial buildings. The work was aided by engaging over 70 stakeholders across the country representing jurisdictions, above-code programs such as Leadership in Energy and Environmental Design (LEED) and ENERGY STAR Multifamily Program, members of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 and other Standard committees, the International Building Performance Simulation Association (IBPSA) and software developers.

The performance path requires whole building energy modeling and is gaining momentum. Many see it as the future of the commercial energy codes and the main pathway for achieving zero energy buildings. The paper describes the findings from a stakeholder survey funded by NEEA on the current state of performance-based path, its market penetration, trends, implementation practices and adoption challenges. It discusses the patterns revealed by experience of the states with decades-long history of performance-based compliance such as Florida and California and opportunities for taking advantage of the synergies between code and above-code programs. In addition, the paper provides an overview of the tools and resources developed as part of the effort including the compliance form for ASHRAE Standard 90.1 Section 11 and Appendix G, modeling submittal review manual, and modeler and reviewer qualification requirements. The tools and resources would help remove market barriers, deliver immediate benefits to jurisdictions and rating authorities, and achieve energy efficiency through whole-building performance path.

Background

The whole building performance path for compliance with energy codes allows projects to not meet some prescriptive code requirements in some areas and make up for the associated energy penalty by exceeding code in other areas. For example, a project may show that savings from better than code lighting compensates for the penalty from a worse than code envelope. Under most codes, performance-based code compliance is established by comparing the energy cost of a proposed design model, that reflects the specified systems and components, to a model of a virtual building serving as a point of reference. This method, often referred to as a reference building approach, is the basis of ASHRAE Standard 90.1[1] Energy Cost Budget Method (ECB, Section 11) and the Performance Rating Method (PRM, Appendix G), the International Energy Conservation Code (IECC) Section C407 Total Building Performance (TBP) and the California Title 24 Alternative Calculation Method (ACM) among others (ASHRAE 2019; ICC 2018; CEC 2019).

Enforcing performance-based compliance is notoriously difficult due to the complexity of energy modeling. Jurisdictions and rating authorities often lack the necessary budget and technical expertise, and nationally vetted tools and resources that they can lean on are scarce. In 2019 a large-scale national effort was launched with support from U.S. Department of Energy (DOE), Pacific Northwest National Laboratory (PNNL) and the Northwest Energy Efficiency Alliance (NEEA) with the goal to facilitate performance-based compliance with commercial energy codes and above-code programs. It included the following focus areas:

- Gather information on the current state of performance-based compliance, compliance and enforcement challenges, and best practices
- Develop a roadmap to address the compliance challenges and implementation timeframe
- Identify the elements of quality control and quality assurance (QA/QC) infrastructure, including tools necessary for effective and efficient compliance and enforcement
- Create and deploy tools identified as high priority
- Identify opportunities for maintaining the created tools beyond the initial effort, to support evolving compliance needs.

Stakeholder Survey

The project team engaged with over 70 stakeholders representing the key market segments involved with performance-based compliance. These key stakeholders included 27 code jurisdictions; eight administrators of above-code programs; members of the ASHRAE Standard 90.1, 140 and 189 committees; the IBPSA; the Commercial Energy Services Network (COMNET); New Buildings Institute; the Institute for Market Transformation; vendors of building energy modeling tools; building design consultants; and energy consultants. In addition, stakeholders involved with the Residential Energy Services Network (RESNET) shared their experience.

Under a parallel effort supported by NEEA, the stakeholders were asked to complete a survey that included over 30 questions related to performance path market penetration and trends, compliance and enforcement practices, and perceived short- and long-term priorities for improving compliance. Thirty-three stakeholders working for jurisdictions and above-code programs across the country provided the detailed responses that are summarized in the following sections.

According to the stakeholder surveys the performance path is used by less than 5% of projects in most jurisdictions. However, these projects typically involve large buildings and therefore account for an unproportionally large fraction of the floor area. For example, a Seattle

[1] ANSI/ASHRAE/IES Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings is designated in U.S. legislation as the national model energy code for commercial buildings.

stakeholder estimated that 5% of projects use the performance path and represent approximately 40%-50% of the permitted floor area. Use of the performance path for new commercial projects is the highest in Florida (over 90% of permits), California (over 50% of permits) and Washington, DC (~50% of the permits).

As prescriptive requirements become more stringent and are more rigorously enforced, more projects are seeking the flexibility of performance-based compliance. In Washington State, the prescriptive path requires dedicated outdoor air systems combined with cycling heating and cooling fans in schools, offices, and retail buildings (with some exceptions) (WSEC 2018). Consequently, projects with all other HVAC system designs must use the performance path. Some jurisdictions now require the performance path (with energy modeling) for certain types of projects. For example, all new construction projects in Boulder, Colorado over $500,000 valuation must submit energy modeling results with their permit application (ICC 2017). In Oregon, energy modeling is required for construction projects that receive state funding (ODOE 2006). The Federal Energy Management Program under DOE requires all new buildings to exceed ASHRAE Standard 90.1 as demonstrated by modeling in accordance with the PRM (USDOE 2015).

Standard 90.1's ECB path and IECC's TBP path are currently used most often for minimum code compliance. Appendix G (i.e., Standard 90.1's PRM path), which was originally created specifically for evaluating high-performance designs, is an overwhelming favorite for above-code programs. Starting with the 90.1-2016 edition, Appendix G became an approved performance path for documenting minimum code compliance with Standard 90.1, but some jurisdictions with codes prior to 90.1-2016, such as New York State, have already accepted it as a compliance option.

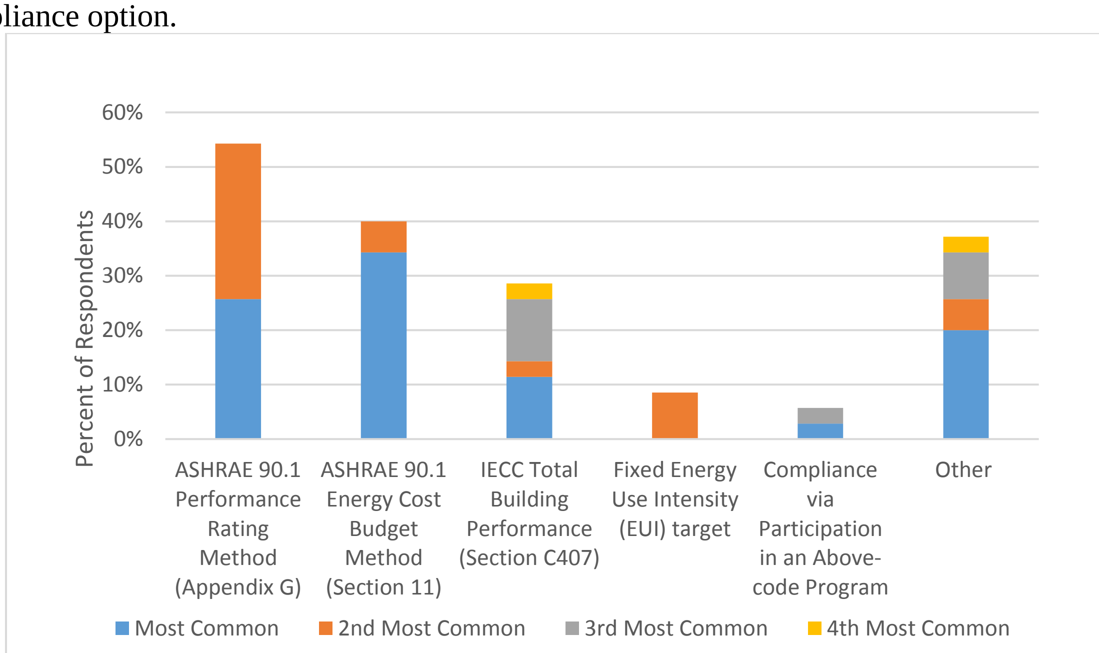

Figure 1. Compliance Options Used by Code and Above-code Programs

Most jurisdictions have multiple performance-based compliance options – e.g. many accept ECB, PRM and TBP, often with state-specific amendments. Some also accept documented participation in approved above-code programs as a proxy for code compliance. Figure 1 shows the relative market penetration of performance-based compliance options based on the stakeholder surveys. For example, 54% of stakeholders picked PRM as either the first or the second most commonly used compliance option.

Appendix G is being actively developed in ASHRAE Standard 90.1 and is perceived as the future of performance-based compliance by the 90.1 committee (D. Erbe, Chair SSPC 90.1. pers. comm., March 16, 2020). Conversely, TBP use is going down. Some jurisdictions (e.g. New York and Rhode Island) no longer allow it for energy code compliance; Washington State replaced a TBP-based approach with the PRM in the 2018 code cycle (WSEC 2018).

Performance-based compliance is used most often for school/university, office, hotel and multifamily projects according to the stakeholders, and commonly involves trading worse than code envelope performance for better than code lighting and HVAC (Figure 2). In New York City (NYC), most performance-based projects are high-rise multifamily buildings over 50,000 ft² that trade off poorly performing envelope, excessive glazing and lack of exhaust air energy recovery for better-than code lighting and high efficiency mechanical systems (E. Hoffman, Director, Energy Code Compliance at NYC Department of Buildings. pers. comm., March 16, 2020).

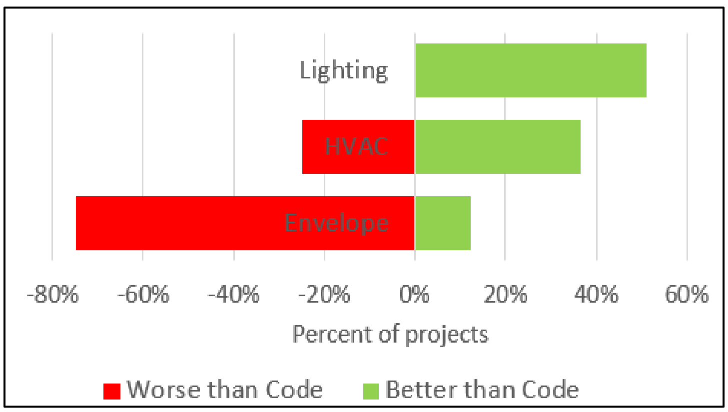

Figure 2. Common Systems Traded Off on Performance Path Projects. *Source:* Attendee polls at the 2019 DOE Energy Codes Conference

While some stakeholders noted a general trend of improvement in compliance and enforcement, it varies significantly among jurisdictions. Large cities tend to provide more thorough submittal reviews than the smaller ones. In some jurisdictions, reviews may take over 40 hours and require three or more iterations before approval. Others spend less than 2 hours per project, and some automatically accept any submittal stamped by a licensed professional.

In most jurisdictions, submittal reviews are funded through permit fees which are independent of the actual review effort on a given project. For example, in NYC, the permit fee is $220 for all projects irrespective of the floor area and the compliance path. In a handful of jurisdictions permit applicants cover the actual review effort – e.g., in Seattle, reviews take 10-50 hours and the applicants bear the cost based on the actual time spent by reviewers at approximately $200/hr. The fee-based review approach was noted to encourage better quality submittals.

Forty-two percent of the survey respondents were concerned that, due to inherent technical complexity and enforcement challenges, the performance path may become a loophole to circumvent code. A pattern emerged that adopters who spent more time on the submittal reviews had less confidence in the quality of the models, likely due to increased awareness of the underlying complexities, frequency and severity of uncovered issues. The inconsistencies in the submittals were perceived to be driven by modeler errors, imprecision of the simulation tools, and complexity and ambiguity of the underlining modeling standards. Lack of coordination between the energy model and design documentation was identified by several stakeholders as one of the most prevalent issues that has yet to show improvement.

Half of the respondents named the development of standardized compliance forms as the top short-term priority for improving performance-based compliance. Other high-priority tools named by the stakeholders included a review checklist and manual and establishing modeler qualification requirements. The perceived long-term goals included automating compliance modeling in the software tools, creating a national network of accredited modelers and reviewers and establishing a national certification process for compliance modeling software.

A Roadmap to Establishing Quality Control and Quality Assurance Infrastructure for Performance-Based Compliance

Adoption Challenges

Commercial buildings are complex systems composed of numerous interacting components that are influenced by external factors such as weather and occupant behavior. Building energy modeling tools use physics-based equations to calculate building energy use at hourly or sub-hourly timesteps. Using this inherently complex analysis methodology to demonstrate code compliance or improvement over code requirements is further complicated by deficiencies in the modeling protocols, limitations of the simulation tools, and ad hoc adoption practices.

Modeling Requirements

1. Modeling protocols lack the specificity necessary to support consistent application to diverse commercial designs and overlook some impactful parameters necessary for a complete energy model. For example, HVAC systems operate at part load most of the time, however, ASHRAE 90.1 modeling protocols do not provide part load performance curves. Thermal bridging is known to have a substantial impact on the performance of the building envelope but is not addressed in 90.1 modeling protocols. Some jurisdictions and above-code programs develop supplemental requirements to address these gaps, however there is little cross-pollination between adopters leading to redundant effort and variation in requirements that are confusing to the modelers and simulation software vendors.
2. ECB and PRM leave some of the modeling rules up to the adopters. For example, jurisdictions and rating authorities are expected to approve weather data, utility rates, daylighting analysis methodology and how to treat components that cannot be modeled in the simulation software (exceptional calculations). However, adopters often lack the

resources necessary to formulate the requirements and consequently leave these areas unprescribed, which makes programs vulnerable to gaming and increases the variability of outcomes among projects.

3. Starting with the 2016 edition of Standard 90.1, the PRM baseline is aligned with 90.1-2004. Many above-code programs that traditionally used the PRM are required to report electricity and fossil fuel savings of the proposed design relative to current code and struggle with adapting to the new methodology.

Simulation Software

1. Development of the modeling protocols largely focuses on keeping up with the evolving prescriptive code requirements to ensure that they can be "traded off". Making models more predictive of post-occupancy energy use is also perceived as a priority. Consideration of simulation software capabilities is secondary and often limited to confirming that the building system or component is "supported" in the common tools. For example, envelope air leakage tests in ASHRAE Standard 140 are based on keeping the infiltration rate independent of wind speed, indoor/outdoor temperature difference, or other variables (ASHRAE 2014). However, the PRM requires that infiltration is modeled with adjustments for weather and building operation in both the proposed design and the baseline building design. There is no evidence that the results of these more complex methods are in a general alignment among different simulation tools.
2. Modern simulation software tools provide multiple ways of capturing the energy use of many systems and components. For example, IES VE, eQUEST and EnergyPlus each offer several different daylighting modeling methods. In addition, the PRM, ECB and TBP allow using a specialized daylighting tool and importing savings into the whole building simulation by adjusting lighting schedules. EnergyPlus alone includes five different options for accounting for ground-coupled heat transfer. Availability of multiple methods within the tools increases variability of outcomes.
3. Several software vendors have implemented compliance shells that automate baseline generation. However, there are currently no procedures for evaluating their fidelity to the underlying standard and consistency of implementation across the tools. The Standard 90.1 subcommittee charged with the maintenance and development of ECB and PRM often receives interpretation requests from modelers and program administrators on applying the rules to various real-life scenarios. However, no software vendor has submitted any interpretation requests in recent memory, even though implementing compliance shells[2] requires the capability of the software to generate the baseline model for any possible configuration of the proposed design.

Adoption Practices

1. There are significant variations on the level of resources that authorities having jurisdiction (AHJs) and rating authorities (RAs) can dedicate to submittal reviews.

[2] Compliance shells implement the rules of simulation-based compliance protocols, some automatically, while controlling inputs to and report outputs from modeling software.

Models rely on thousands of user inputs, and it is impossible and impractical to check them all. There is no established methodology for prioritizing submittal reviews to best utilize available resources.

2. Existence of three significantly different performance-based compliance options (ECB, PRM and TBP) in the national model codes complicates compliance and enforcement because modelers and reviewers must be proficient with the different protocols, jurisdictions must develop and maintain reporting templates and review processes for the alternative protocols, and permit applicants can “shop around” for a protocol that is more lenient for the project at hand.
3. Program administrators often modify the rules of the national protocols, e.g., change configuration of the baseline model to avoid fuel switching or to reflect local standard practice, without considering the implications of such customization on the program. For example, compliance shells developed for the national protocols could no longer be used, forcing modelers to manually create the baseline and increasing submittal review effort; and standardized compliance forms will have to be modified, etc.
4. The IECC and 90.1 do not include standardized compliance forms that are sufficiently detailed to support a meaningful submittal review. The ECB forms included in the 90.1-2013 Users’ Manual package largely recycle prescriptive forms, making it easy to overlook reporting requirements specific to performance-based projects (ASHRAE 2016A). Jurisdictions often receive a thick bundle of simulation output reports that are difficult to interpret. In addition, these simulation output reports are not clearly related to important code requirements to be inspected on site and are not directly tied to project information shown on drawings. Some adopters develop reporting templates in-house, but they often lack rigor due to limited resources. A hodgepodge of reporting requirements increases the cost of documenting compliance – for example, a project that uses Appendix G for LEED certification, for an incentive program, and for code compliance may have to fill out three different reporting forms, respectively, and have to respond to comments from three different reviewers.
5. The Building Energy Modeling Innovation Summit cited the difference in the simulation results obtained by different modelers simulating the same building using the same simulation software as one of the top issues affecting building energy modeling (BEM) credibility (RMI 2011). DOE’s draft report Roadmap for Building Energy Modeling identified better training of energy modelers as the highest-priority task for improving BEM accuracy (USDOE 2016). Yet, many adopters have no or lax qualification and training requirements for modelers and reviewers. Some focus on simulation tools instead, encouraging or requiring the use of more complex tools, which only increases probability of modeler errors.
6. There are limited training opportunities for modelers and submittal reviewers that focus on performance-based compliance. Common trainings and certifications (e.g., ASHRAE Building Energy Modeling Professional, BEMP) largely address general modeling skills.

Recommendations

Reviews of mature performance-based programs reveal several important patterns. They all required a multi-year commitment of an organization administering the program, such as the states of California, Florida and RESNET. Furthermore, the program administrators identified similar elements necessary for a meaningful enforcement, such as simulation software testing and certification procedures, standardized reporting, and have developed solutions to address them. For example, the Florida Building Commission that provides ongoing code development and implementation oversight has a $400,000 annual research budget some of which goes toward support of performance-based compliance including development and maintenance of the 158-page Energy Simulation Tool Approval Technical Assistance Manual. Similarly, California Energy Commission (CEC) funds continuous development of the software called California Building Energy Code Compliance (CBECC-Com) that is used to benchmark and certify 3rd party software tools with the goal of providing two CBECC-Com releases per year. In addition, CEC maintains a comprehensive Alternative Calculation Method (ACM) Reference Manual that contains the requirements needed for the approval of compliance software, develops and maintains the reference test suite for each version of CBECC-Com, and oversees third party software certification.

Many states and above-code programs do not have financial and technical resources necessary to create such frameworks in-house. Furthermore, many of the key elements of this framework are best addressed on the national level. For example, having a national testing and certification process for the simulation software will provide potential for higher technical rigor and better engagement of software tool vendors. Thus, the proposed long-term solution is to facilitate creation of a national certifying body(s) that will develop, coordinate, and maintain the adoption framework based on national standards such as ASHRAE 90.1 and 140. The certifying body will perform the following functions:

- Certify simulation software
- Maintain a national network of certified modelers, reviewers and training providers
- Work with the rating authorities and jurisdictions to provide packaged enforcement solutions that they can oversee independently or through the certifying body
- Provide on-going quality assurance and update the processes and tools.

The short-term recommendations focus on the development of tools that would result in an immediate improvement in performance-based compliance and investigating pathways for creating a certifying body(s). The tools will support ASHRAE 90.1 ECB and PRM compliance paths, which are most commonly used for performance-based code compliance. The compliance tools include the following:

- Submittal review manual and checklist
- Compliance form or reporting template
- Suggested minimum qualification requirements for modelers and reviewers
- Training for modelers and reviewers focused on performance-based compliance
- Supplemental technical documents to facilitate consistent interpretation of the modeling requirements and address common adoption challenges
- Training for the AHJs and RAs on the quality assurance and quality control infrastructure necessary for meaningful enforcement and available tools and resources

- New ASHRAE standard for evaluating software implementation of compliance protocols.

Activities funded under the current project are focused on the first three short-term recommendations, while parallel efforts are addressing the last four. Medium-term recommendations target three general areas:

- Refining PRM modeling requirements
- Improving software-related infrastructure
- Facilitating the creation of the certifying body(s).

The current work largely focuses on the PRM (not ECB) since it is expected to dominate performance-based compliance based on the current trends.

High Priority Tools

Submittal Review Manual and Checklist

Review of the performance-based modeling submittals is a challenging endeavor. Models for even simple projects include thousands of inputs of which many can be incorrect. Mistakes may include deviation between the proposed design model and the actual parameters of the proposed design, not following the rules of the modeling protocol for the baseline or proposed design and incorrect use of the simulation software. Reviews are further complicated by the use of different simulation software tools (there are over a dozen tools on the IRS Section 179D software list). Each software tool has different capabilities, nomenclature, format and content of simulation input and output reports. Submittal reviewers often do not have experience with the tools used on projects that they have to review, and struggle with identifying inputs and outputs of interest – simulation reports generated by the tools sometimes span hundreds of pages.

The Review Manual and Checklist developed as part of this project were based on a similar document funded by the New York State Energy Research and Development Authority, meant to address the same challenges (NYSERDA 2018). The updated document includes several hundred checks for verifying the baseline and proposed design models. Since it is impractical to perform all checks for each project, the manual provides strategies for prioritizing reviews based on project specifics and helps to identify and focus on the most impactful systems and components.

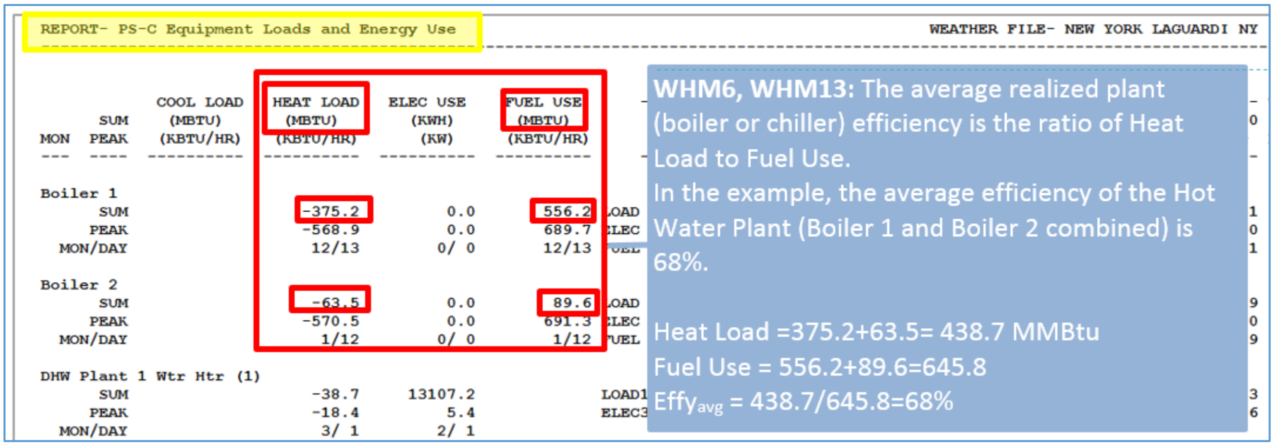

Figure 3. Sample Annotated Software Report

In the Review Manual, each check is first formulated in a software neutral fashion (e.g., check that modeled cooling efficiency reflects specified equipment), and is then expanded in the software-specific sections of the Manual that describe how to perform the checks using simulation reports generated by different simulation software. A sample is provided in Figure 3. The software-specific sections were developed in collaboration with the simulation software vendors and cover simulation software including Carrier HAP, DesignBuilder, EnergyPlus, eQUEST, IES-VE, Trane TRACE 3D Plus, Trane TRACE 700 and OpenStudio. It also includes annotated reports that describe how to perform the review checks in different software.

Compliance Form

The compliance form is a spreadsheet-based tool that provides a standardized template that projects can use to submit compliance information. It aims to meet the following goals:

1. Support the immediate needs of jurisdictions and rating authorities in performing model reviews and site inspections
2. Develop a format that meets 90.1 reporting requirements and may become an official 90.1 compliance form
3. Limit overhead for modelers where possible
4. Establish the necessary modeling inputs using built-in code lookups and calculators
5. Automate compliance calculations
6. Incorporate data exchange between the existing BEM tool reports and the reporting template, within limits of available development budget and schedule
7. Identify the necessary reporting capabilities of the BEM tools.

The compliance documentation process is illustrated in Figure 4. Each smaller box within the bigger box labeled as Compliance Form represents a separate tab in the spreadsheet tool; arrows illustrate information flow between design documents, the compliance form and BEM software that is used to create the baseline and proposed design models.

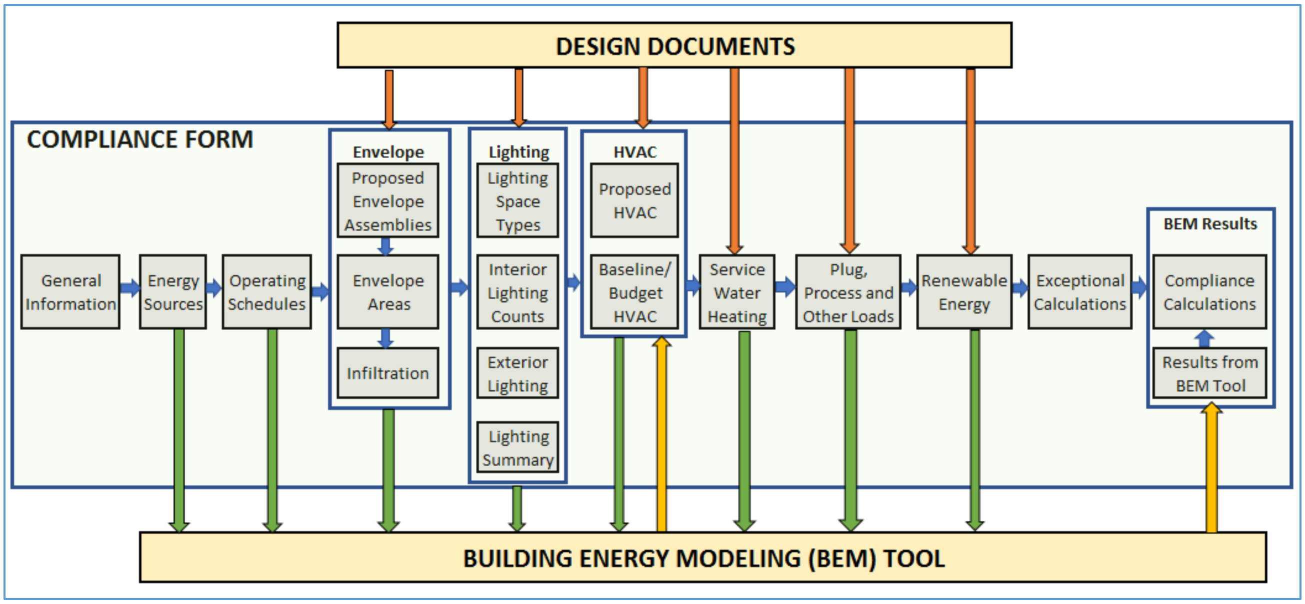

Figure 4: Compliance Documentation Process

Figure 5 illustrates the Dashboard Tab in the Compliance Form showing the completion status for each tab, including the design team member and modeler sign-off, and the overall project compliance status.

Dashboard

Compliance Status: This project complies with ASHRAE 90.1 2016 Appendix G.

Tabs Navigator	Design Professional Sign-off ?			Modeler Sign-off ?		
	Status	Name	Date	Status	Name	Date
Instructions	N/A	-	-	N/A	-	-
Documentation Process Overview	N/A	-	-	N/A	-	-
General Information	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Energy Sources	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Operating Schedules	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Proposed Envelope Assemblies	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Envelope Areas	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Infiltration	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Lighting Space Types	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Interior Lighting Counts	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Exterior Lighting	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Lighting Summary	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Service Water Heating	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Ventilation - Multifamily	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Proposed HVAC	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Baseline HVAC App G	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Budget HVAC Section 11	N/A	-	-	N/A	-	-
Plug, Process and Other Loads	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Results from BEM Tool	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Renewable Energy	N/A	-	-	N/A	-	-
Exceptional Calculations	N/A	-	-	N/A	-	-
Compliance Calculations	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Submittal Checklist	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020
Quality Control Checks	Complete	Jane Doe	1/30/2020	Complete	Sarah Doe	1/30/2020

Figure 5. The Dashboard Tab

Each input tab includes a hyperlinked Table of Contents at the top for easy navigation within the tab; model inputs prescribed by Standard 90.1 are automatically populated and shown against the white background, helping the modeler with the baseline model development (Figure 6). Simulation results for the baseline and proposed design models may be imported into the Compliance Form from the standard reports generated by commonly used energy modeling software to avoid manual data entry. This functionality was implemented in collaboration with the modeling software vendors and is available for all the software supported in the Review Manual.

The Submittal Checklist tab (Figure 7) lists all materials that must be included in the submittal and is context sensitive. For example, if a project includes calculations performed outside of the whole building simulation software, the requirement to provide supporting documentation is added to the list.

The Quality Control Checks tab includes the checks described in the Review Manual. It allows reviewers to identify the checks to be included in the review based on the prioritization strategies described in the Review Manual, and record Pass/Fail review outcome and comments for each completed check. Some of the checks are automated in the Compliance Form. For example, if the baseline model does not include any electric space heating based on the information provided on the Baseline HVAC tab, but simulation results show electric heating in the baseline model, the appropriate check will flag the inconsistency. The status of the quality control checks is shown on the Dashboard tab, and modelers are expected to address the flags before submitting the package for review. This will improve the initial quality of the submittal and reduce review iterations.

Envelope - Return to Dashboard

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Table 1: Opaque Envelope - Baseline and Proposed Surface Areas and Properties

Instructions

1. List opaque surfaces of the proposed design. Include separate rows for each construction type by orientation, new versus existing, space-conditioning category, and building area type.
2. Exterior surfaces whose azimuth orientation and tilt differ by less than 45 degrees and are otherwise the same may be combined and entered in one row.
3. In order for the cells with the Baseline/Budget Design thermal properties to auto-populate, make sure to enter the project Climate Zone on the General

				?	Proposed Design		Baseline Design ?		Prescriptive Requirement ?	
Modeled Construction Name	New, Existing to Remain, or Retrofitted	Building Area Type (for Appendix G Projects Only, 90.1 Section G3.1.1-1)	Orientation	Space-Conditioning Category	? Net Wall Area, ft²	Plans / Specs	Assembly U/F/C-Factor	Roof Solar Reflectance/ Thermal Emittance	Assembly U/F/C-Factor	Roof Solar Reflectance/ Thermal Emittance
AGW1	New	Other	North	Residential	3,606	A-301	U-0.064	n/a	U-0.064	n/a
AGW1	New	Other	East	Residential	9,881	A-302	U-0.064	n/a	U-0.064	n/a
AGW1	New	Other	South	Residential	3,606	A-303	U-0.064	n/a	U-0.064	n/a
AGW1	New	Other	West	Residential	9,881	A-304	U-0.064	n/a	U-0.064	n/a
AGW1	New	Retail (stand alone)	North	Nonresidential	2,498	A-301	U-0.124	n/a	U-0.064	n/a
AGW1	New	Retail (stand alone)	East	Nonresidential	2,736	A-302	U-0.124	n/a	U-0.064	n/a
AGW1	New	Retail (stand alone)	South	Nonresidential	2,498	A-303	U-0.124	n/a	U-0.064	n/a
AGW1	New	Retail (stand alone)	West	Nonresidential	6,840	A-304	U-0.124	n/a	U-0.064	n/a
Roof1	New	Other	Horizontal	Residential	8,436	A-301	U-0.063	0.3 /0.9	U-0.032	n/a
SOGFL	New	Retail (stand alone)	Horizontal	Residential	8,436	A-301	F-0.73	n/a	F-0.52	n/a

Figure 6. Sample Tab of the Compliance Form

#	Required Documentation per ASHRAE 90.1-2016 Sections 11.7 and G1.3	Submitted?
1	Design documents that submital is based on which was reported as the 100% Construction Documents	Yes
2	A diagram showing the thermal blocks used in the computer simulation	Yes
3	Purchased energy rates used in the simulation with supporting documentation	Yes
4	(Appendix G only) A site plan showing all adjacent buildings and topography that may shade the proposed building, with the estimated height or number of stories	Yes
5	An explanation of any error messages noted in the simulation program output	Yes
6	An explanation of any significant modeling assumptions	Yes
7	Backup calculations and materials to support data inputs (e.g., U-factors for building envelope assemblies, NFRC ratings for fenestration, etc.)	Yes
9	All applicable tabs of this Compliance Form are fully filled out	Yes
10	Explanation is provided for all areas flagged on the "Quality Control Checks" tab	Yes
11	Weather file used in the simulation	Yes
13	Supporting documentation for each actual utility rate (any rate other than the default Energy Information Administration (EIA) rate) entered on the "Energy Sources" tab.	Yes
14	NFRC certifications and/or labels	Yes
17	Supporting documentation for justifying differences in the receptable and process loads.	Yes
20	Modeler resume documenting years of full-time equivalent modeling experience.	Yes
Simulation Files and Reports		
eQuest	<project name B>.SIM and <project name P>.SIM files with the detailed simulation reports for the baseline (budget) and proposed models	Yes
	Model files including <project name P>.pd2, <project name P>.inp for the proposed design, and <project name B>.pd2, <project name B>.inp for the baseline (budget) design. Projects that used eQUEST Parametric Runs must also include the appropriate *.prd file and the appropriate additional *.inp files	Yes

Figure 7: Submittal Checklist Tab

The Compliance Form provides the greatest value to the project team if it is completed prior to and concurrently with the energy modeling. If the energy modeler and project team wait to fill out the Compliance Form until near the completion of the building design, the team may discover that some ASHRAE 90.1 requirements have been overlooked or some modeling requirements have not been addressed, and additional time may be required to review the models and/or design to show compliance.

Recommended Modeler and Reviewer Qualifications

Modeler errors were perceived as the main reason for inconsistent submittals and may be addressed by establishing minimum qualification requirements for the professionals who perform or sign off on the work. To address that, the following requirements may be set by adopters:

- Broad experience with energy systems and operating characteristics similar to those in the submitted project.
- In-depth understanding of Standard 90.1 Section 11 and Appendix G compliance options.

- Three or more years of full-time equivalent modeling experience with computerized building modeling tools used for energy analysis, or two years of modeling experience and a certification such as ASHRAE BEMP or Certified Building Energy Simulation Analyst.
- Demonstrated capability to model basic building features such as internal gains, multiple zones with central HVAC systems, and envelope measures.

Similar qualification requirements may be used for third-party reviewers, except the hands-on modeling experience is replaced by experience with submittal reviews, International Code Council certification for commercial energy code compliance, and completion of an energy modeling for code course.

Conclusions

Performance-based compliance with energy codes and above-code incentive programs using building energy modeling is growing in popularity, but a number of steps need to be taken to ensure the quality of simulation-based project submittals and build confidence in energy performance results. Among the short-term needs are standardized tools such as a compliance form, a manual and checklist to help jurisdictions and rating authorities perform submittal reviews, and recommended qualifications of modelers and reviewers. Medium-term needs include refining the performance-based compliance protocols in model codes, improving software-related infrastructure, and facilitating the creation of a certifying body. Long-term needs include the actual creation of a certification body that can approve certification of modelers, simulation programs, and potentially model reviewers. Several entities including the states of California and Florida and RESNET provide models for some of these recommendations. The current project learned from these existing efforts and the input of over 70 stakeholders and developed tools to address the identified short-term needs related to the performance paths in Standard 90.1. It also provided a roadmap to meeting the remaining short-, mid- and long-term needs.

Acknowledgments

The authors would like to acknowledge the U.S. Department of Energy Building Energy Codes Program and the Northwest Energy Efficiency Alliance for supporting this work. Other members of the project team involved in the development of the tools included Christina LaPerle (Karpman Consulting) and Michael Tillou (PNNL). We would also like to thank all the stakeholders who contributed with special acknowledgement to (alphabetically) Sally Blair (NORESCO), Caitlin Bohnert (Trane), Liam Buckley (IES Ltd), Kimberly Cheslak (IMT), Dimitri Contoyannis (Model Efficiency), Larry Froess (California Energy Commission), Jason Glazer (GARD Analytics), Gail Hampsmire (GBCI), Emily Hoffman (NYC Department of Buildings), Duane Jonlin (Seattle Department of Construction and Inspections), Adam Krokstrom (Trane), Gregory McCall (City of Vancouver), Andrew Parker (NREL), Jim Pegues (Carrier), Jonathan Rodriguez (Trane) and Andy Tindale (DesignBuilder).

References

ASHRAE. 2014. Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs. Atlanta, GA. ASHRAE.

ASHRAE. 2016. ASHRAE Standard 90.1-2016 Energy Standard for Buildings Except Low-Rise Residential Buildings. Atlanta, GA. ASHRAE.

ASHRAE. 2016A. ASHRAE Standard 90.1-2016 User's Manual. Atlanta, GA. ASHRAE.

CEC. (California Energy Commission). 2019. Nonresidential Alternative Calculation Method Reference Manual. Sacramento, CA. California Energy Commission.

ICC (International Code Council). 2018. International Energy Conservation Code. Washington, D.C. International Code Council.

ICC. (International Code Council). 2017 City of Boulder Energy Conservation Code. Washington, D.C. International Code Council.

ODOE. (Oregon Department of Energy). 2006. State Energy Efficient Design (SEED) Program. Salem, OR. Oregon Department of Energy.

RMI. (Rocky Mountain Institute). 2011. *Post Report from the BEM Innovation Summit.* Boulder, Colorado. Rocky Mountain Institute.

NYSERDA. (The New York State Energy Research and Development Authority). 2018 *Performance-Based Energy Code Enforcement Manual for Authorities Having Jurisdiction.* Albany, NY. NYSERDA. https://www.nyserda.ny.gov/-/media/Files/Programs/energy-code-training/performance-path-review-manual.pdf

USDOE. (United States Department of Energy) 2015. *Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings' Baseline Standards Update*. Washington, D.C. Department of Energy. https://www.federalregister.gov/documents/2015/11/06/2015-28078/energy-efficiency-standards-for-new-federal-commercial-and-multi-family-high-rise-residential.

USDOE. (United States Department of Energy) 2016. *Research & Development Roadmap for Building Energy Modeling—Draft—for Review Only*. Washington, D.C. Department of Energy. https://www.energy.gov/sites/prod/files/2016/02/f29/DOE-BTO-BEM-Roadmap-DRAFT-2-1-2016.pdf

WSEC. 2018. *Washington State Energy Code, 2018*. Washington State Building Code Council. Accessed March 16, 2020 at https://sbcc.wa.gov/sites/default/files/2020-02/2018%20WSEC_C%20Final%20Package.pdf