# Performance-based Code Compliance: Enforcement Practices and Software Policy Recommendations

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Task 1 Deliverable 2
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## Contents

## Abbreviations

ACM – Alternative Compliance Method
A/E – Architecture/ Engineering
AFUE – Annual Fuel Utilization Efficiency
ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers
BEMP – Building Energy Modeling Professional
BESF – Building Energy Simulation Forum
BSUG – Building Simulation User's Group
CBECC-Com – California Building Energy Code Compliance for COMmercial/Nonresidential buildings
CBECC-Res – California Building Energy Code Compliance for Residential buildings
COMNET - quality assurance program managed by the New Building Institute, a not-for-profit organization
DOE – Department of Energy
ECB – Energy Cost Budget method
ECCC NYS - Energy Conservation Construction Code of New York State
EF – Energy Factor
GBCI – Green Business Certification Inc.
HSPF – Heating Seasonal Performance Factor
HVAC – Heating Ventilation and Air Conditioning
IECC – International Energy Conservation Code
LEED – Leadership in Energy and Environmental Design
LPD – Lighting Power Density
MGP – Modeling Guidelines and Procedure
NYC DOB – New York City Department of Buildings
NYSERDA – New York State Energy Research and Development Authority
ODOE – Oregon Department of Energy
P4P – Pay for Performance program
PNNL – Pacific Northwest National Laboratory
PRM – Performance Rating Method
QC – Quality Control
SHGC – Solar Heat Gain Coefficient
SEER – Seasonal Energy Efficiency Ratio
TBP – Total Building Performance
USGBC – U.S. Green Building Council
WBA – Whole Building Approach
WWR – Window to Wall Ratio

## Executive Summary

This report provides an overview of the scope, trends, and enforcement practices of the performance path of compliance with the energy code, as well as policy recommendations for improving and streamlining the enforcement. The report draws from the input of:

1. Stakeholders representing design teams who develop submittals,
2. Jurisdictions that perform submittal reviews and set the rules at the state and municipal level, and
3. Members of the national committees and organizations driving the rulemaking at the national level.

The 2016 ECCC NYS performance-based compliance options include IECC 2015 Section 407, ASHRAE 90.1 2013 Section 11, and ASHRAE 90.1 2013 Appendix G Excerpts 2015. The 2016 New York City Energy Conservation Code allows both ASHRAE protocols, but not IECC 2015 Section 407. eQUEST is by far the most popular simulation tool used for compliance modeling. 97% of projects that participated in the NYSERDA Multifamily Performance Program were modeled in eQUEST. Similar trends are seen in the NYSERDA Commercial New Construction Program and incentive programs in the surrounding states. NYC DOB estimated that ~50% of the performance-based models are done in eQUEST, ~30% in DOE 2.1E, and the remainder split equally between Trane Trace and IES Virtual Environment.

Popularity of the performance path varies substantially from state to state. In California, the performance path is used by about 70% of projects. In New York, performance-based compliance is just starting to take hold, with only 1-3% of new buildings (30-90 projects per year) utilizing this option, based on NYC DOB estimates. Stakeholders from across the country expect an increase in the number of projects using the performance path as prescriptive requirements become more stringent. The report reviews compliance enforcement practices used by the selected states and municipalities, and draws from their experience to provide the recommendations for New York.

**Performance Path Policy Recommendations**

1. Reduce the number of performance-based compliance options, to make 90.1 Appendix G the only performance path in the future code cycles.
2. Establish qualification requirements for the modelers and reviewers
3. Use Third Party Reviewers
4. Adopt a detailed, well-structured 90.1 Appendix G submittal template, to ensure consistency of modeling submittals and standardize reviews across different modelers and reviewers.
5. Develop and document the review process that will include mandatory checks of high-impact areas, and the additional optional checks based on the review budget.
6. Provide review trainings to the code officials and/or third party reviewers.

**Performance Path Software Recommendations**

Short Term: Keep compliance software requirements aligned with 90.1, and engage with the vendors of the simulation tools used in New York to get input on the review checklist.

Medium Term: Request that simulation tool vendors expand the reporting capabilities of the tools to support the mandatory review checks, and implement a quality control module to automate selected checks. NYSERDA may consider offering funding toward implementation of compliance shell and automated QC functionality to the vendors of the software tools popular in New York, such as eQUEST.

Long Term: Make compliance shell a requirement in order for the software to be approved for compliance modeling.

## Study Methodology

The material presented in the report is largely based on the email exchanges and phone conversations with the stakeholders that represent the key market segments involved with the performance-based compliance, including design teams that develop submittals, jurisdictions that perform submittal reviews and establish rules at the state and municipal level, and members of the committees and organizations driving the rulemaking at the national level and with a birds-eye view of the current practices and trends. The stakeholders from both New York and other states were contacted, to learn from their experience and identify best practices. The discussion typically started with the questions included in Appendix A, tailored to the stakeholder's background, and often evolved into extensive follow-up dialogs, which zoomed in on the areas of interest where stakeholders had in-depth knowledge or unique perspective. The outreach focused on identifying individuals with the access to the information of interest, and covering the breadth of views and experiences. The following stakeholders (listed alphabetically) provided the input:

Shelley Beaulieu CEM BEMP (TRC, program manager of NYSERDA Multifamily Performance Program
Bill Bishop PE Pathfinder (Rochester, member of ASHRAE Standard 209P committee)
Gail Hampsmire (Technical Director, Energy/HVAC Team USGBC)
Emily Hoffman (PE, CEM, LEED® AP, CPMP Director Energy Code Compliance NYC Department of Buildings)
Joe Huang (chair of ASHRAE TC 4.7, Energy Calculations),
Duane Jonlin (Energy Code and Energy Conservation Advisor, City of Seattle)
Michael Rosenberg (Chief of PNNL's Commercial Energy Code Development Team, ASHRAE 90.1 Energy Cost Budget Committee member),
Ian Shapiro PE (the president of Ithaca-based Taitem Engineering, co-author of "Green Building Illustrated", author of "Energy Audits and Improvements for Commercial Buildings")
Michael Tillou PE, Atelier Ten (NYC, member of ASHRAE Standard 90.1 Energy Cost Budget committee)

## Overview of ECCC NYS Performance-based Compliance Options

The 2016 ECCCNYS in effect as of October 3, 2016 has the following performance-based compliance options:

a. IECC 2015 Section C407 – Total Building Performance (TBP)
b. ASHRAE 90.1 2013 Section 11, Energy Cost Budget Method (ECB)
c. ASHRAE 90.1 2013 Appendix G, Performance Rating Method (PRM)

The PRM compliance path is added via the 2016 New York State Supplement, which adopted addenda to 90.1-2013 included in the "Standard 90.1 Appendix G 2013 Performance Rating Method Excerpt from ANSI/ASHRAE/IES Standard 90.1-2013 (I-P)". New York City (NYC) Energy Conservation Code does not allow compliance via IECC Section C407, leaving only the two ASHRAE 90.1 options.

The performance path allows projects to not meet some of the prescriptive requirements, and make up for the associated energy penalty by exceeding mandatory and prescriptive provisions in other areas. For example, projects with a high performance HVAC system but below-code lighting may demonstrate compliance by showing that the annual heating/cooling energy savings compensate for the annual lighting energy penalty. This concept of trade-offs existed in ASHRAE Standard 90.1 since the first version of the standard published in 1975 (as Standard 90). The performance path involves creating two models using an approved simulation tool:

- Proposed Design, which is based on the systems and components specified in the drawings and specifications
- A virtual building (referred to as Budget Building in ECB, Baseline Building in PRM, and Standard Reference Design in TBP) which is used as a point of reference for evaluating the Proposed Design

The energy cost of the two models is compared to establish compliance. The concept is illustrated in Figure 1, based on 90.1 ECB.

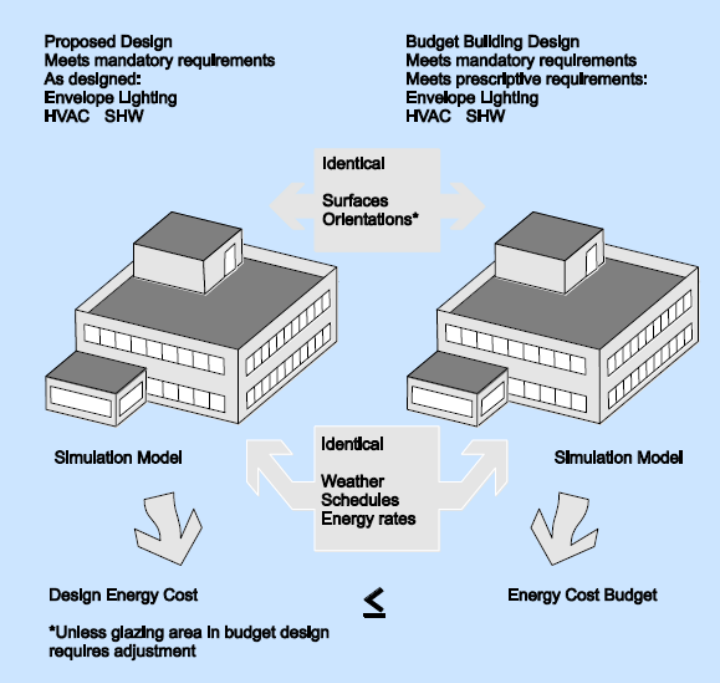



**Figure 1: Compliance through the ECB Method, New Building (From 90.1-2013 User's Manual)**

The three compliance options differ in many impactful ways. For example, with ECB the budget building complies with 90.1 2013 prescriptively; the IECC's Standard Reference Design is less efficient than prescriptively required (e.g. fenestration area may be up to 40% of the gross above-grade wall area compared to 30% prescriptive cap, additional efficiency package options from Section C406 are not included, etc.); and PRM's baseline design reflects the mandatory and prescriptive requirements of 90.1 *2004*. The different stringency of the virtual reference building explains the difference in the margin by

which the Proposed Design energy cost must improve over the virtual reference – with ECB it must not exceed the energy cost of the Budget Building; with IECC it must be 15% lower than the energy cost of the Standard Reference Design; and PRM prescribes different margins depending on the building type, climate zone, and percentage of the unregulated loads.

## Compliance Software Requirements

Required capabilities of the simulation tools used to document compliance with each path are included in IECC Section C407.6, 90.1 Section 11, and 90.1 Appendix G, and are summarized below.

1) Building operation for a full calendar year (8,760 hours) [IECC, App G], minimum 1400 hours per year, including representative days for the different months and seasons [ECB]
2) Climate data for a full calendar year (8,760 hours), and shall reflect approved coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location [IECC, App G, ECB]
3) Ten or more thermal zones [IECC, App G, ECB]
4) Thermal mass effects [IECC, App G, ECB]
5) Hourly variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads [IECC, App G, ECB]
6) Part-load performance curves for mechanical equipment [IECC, App G, ECB]
7) Capacity and efficiency correction curves for mechanical heating and cooling equipment [IECC, App G, ECB]
8) Air-side economizer with integrated control [App G, ECB]
9) Baseline building design characteristics specified in Section G3 (App G)
10) Ability to either (1) directly determine the proposed building performance and baseline building performance or (2) produce hourly reports of energy use by an energy source suitable for determining the proposed building performance and baseline building performance using a separate calculation engine [App G, ECB]
11) Capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with generally accepted engineering standards and handbooks (for example, *ASHRAE Handbook—Fundamentals*) for both the proposed design and baseline building design. [App G, ECB]
12) Tested according to ASHRAE Standard 140, except Sections 7 and 8, and. The results shall be furnished by the software provider. [App G, ECB] IECC includes only a general reference to testing with Standard 140

IECC and 90.1 Appendix G explicitly list DOE-2, BLAST and Energy/Plus as example of compliant tools. 90.1 Section 11 (ECB) does not mention Energy Plus, but this is likely an accidental omission.

ECB includes the following note to the adopting authority:

> ***Note to Adopting Authority:*** ASHRAE Standing Standard Project Committee 90.1 recommends that a compliance shell implementing the rules of a compliance supplement that controls inputs to and reports outputs from the required computer analysis program be adopted for the purposes of easier use and simpler compliance.

The standards also list the reporting requirements, and some of the reports must be automatically generated by simulation tools. For example, there is the following requirement in 90.1 Appendix G Section G1.4:

> Input and output report(s) from the simulation program or compliance software 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 unmet load hours for both the proposed design and baseline building design.

IECC requires that software can generate a printed code official inspection checklist listing each of the proposed design component characteristics from Table C407.5.1(1) determined by the analysis to provide compliance, along with their respective performance ratings including, but not limited to, R-value, U- factor, SHGC, HSPF, AFUE, SEER, EF.

## Commonly Used Simulation Tools

Energy modeling is used in two main contexts – to inform design, and to document compliance. Examples of modeling for design support include evaluating energy impact of the building shape and orientation during Schematic Design, informing HVAC system type selection during Design Development, identifying systems and components that may be down-graded to control costs with the minimal impact on the energy performance at the Construction Documents stage, or to select the most cost effective package of energy conservation measures for a retrofit project. The design support deliverables are submitted to the design team and/or building owner.

Compliance models are developed for programs such as tax deductions for commercial buildings (IRS Section 179D), incentive programs (e.g. NYSERDA Multifamily Performance Program and Commercial New Construction Program), green building programs (e.g. LEED®), or to demonstrate compliance with the energy code via the performance path. The results are submitted to the rating authorities (e.g. IRS, NYSERDA, GBCI, etc.) or jurisdictions (i.e. code officials). Design support models often evolve into compliance models, but compliance models may also be developed from scratch solely for documentation purposes.

A recent DOE-funded study estimated that 50%-60% of LEED® models are developed using either eQUEST or Trane/Trace[1]. In New York, eQUEST dominates the incentive program market for new

[1] [1] Research & Development Roadmap for Building Energy Modeling—Draft, C.E. Barbour, R. Zogg, E. Cross, D. Clark February 2016, Prepared by Navigant Consulting, Inc.

construction projects. For example, out of 257 projects that participated in the NYSERDA Multifamily Performance Program, 97% were modeled in eQUEST, 3% in DOE 2.1E, and 1% in Trane Trace. Similar trends are seen in NYSERDA Commercial New Construction Program, with eQUEST leading the pack. Software use data is not tracked for the Pay for Performance incentive program in the neighboring New Jersey, however the P4P pipeline manager estimated that out of 447 projects, which included both the new and existing buildings, about 60% were modeled in Trane Trace, 40% in eQUEST, and 2-3% in Carrier HAP. A similar trend was reported by the New York City Department of Buildings, with ~50% of the performance-based models done in eQUEST, ~30% in DOE 2.1E, and the remainder split equally between Trane Trace and IES Virtual Environment. In Oregon and Seattle, eQUEST and Trane Trace were also reported to be most commonly used for compliance, with Energy Plus also mention for Seattle.

The DOE study suggested that eQUEST and Trace are popular largely due to their simplicity and convenience, rather than the ability to evaluate sophisticated low-energy strategies. However, the study stakeholders did not corroborate this hypothesis. A member of the ASHRAE 209P committee on Energy Simulation-Aided Design for Buildings, reported that his A/E firm uses primarily eQUEST and also Trane Trace. A design engineer and member of the ASHRAE 90.1 Energy Cost Budget committee, indicated that most of their New York high performance projects are modeled in eQUEST/DOE2.2, and some in Design Builder. The company's California office uses a mix of eQUEST and IES/EnergyPlus. The president of an upstate New York engineering firm and an author of several books on green buildings and energy audits in commercial buildings indicated that his firm uses eQUEST for energy modeling.

As noted in the previous section, neither IECC nor Standard 90.1 provides the comprehensive list of the compliance software. DOE-2, BLAST and Energy/Plus are given as the examples of compliance tools. Some rating authorities and jurisdictions maintain a list of approved simulation tools, such as the list published for IRS Section 179D[2], which currently includes 13 tools including eQUEST, Trane Trace, IES VE, Carrier HAP, and several others. It should be noted that 179D certification requirements are aligned with ASHRAE 90.1, so the list can be used as a proxy for tools compliant with ASHRAE 90.1.

In New York, the approved software list is published by NY Secretary of State and includes DOE2.1, eQUEST, Trane Trace, and IES VE. In New York City, the approved tools include DOE2.1E, VisualDOE, EnergyPlus and eQUEST[3].

Stakeholders have stressed that the current software requirements set the bar low, and using a compliant tool does not guarantee quality of the results. For example, one responder has noted that "… when it comes to the modeling rules for Appendix G, you've got to be more discerning or else people and vendors will take advantage of the loopholes big time! … The best program from the users' point of view would be one that makes it easiest to show compliance to the code!"

[2] http://energy.gov/eere/buildings/qualified-software-calculating-commercial-building-tax-deductions
[3] http://www1.nyc.gov/site/buildings/codes/energy-conservation-code.page

## Performance Path Market Penetration and Trends

The chair of the ASHRAE Technical Committee 4.7 on Energy Calculations, estimated that about 70% of CA projects follow the modeling-based Alternative Compliance Method (ACM) to document compliance with the state energy code. He believes that the remaining 30% are either small or super-efficient / low-energy projects that can easily meet prescriptive requirements and chose the prescriptive path to simplify documentation.

The Energy Code and Energy Conservation Advisor with City of Seattle, estimated that ~5% of projects, accounting for ~ 10% of the floor area, follow the performance path. He believed that virtually every high rise, hospital, lab, and university building goes through modeling, with modeling used progressively less on smaller projects with simpler programs.

In New York, performance-based compliance is just starting to take hold. NYC DOB estimated that only ~1-3% of new buildings utilize the performance path (30-90 projects per year). Similar to Seattle, these projects usually involve larger buildings (50,000 square feet or more), accounting for a higher percentage of total permitted floor area. An Ithaca-based design firm that specializes in smaller commercial and residential projects has seen only a handful of projects that used performance path over the years. A Rochester A/E firm reported that about ~10% of their design projects use the performance path, while a NYC-based firm which specializes in high performance buildings estimated about 10-20%.

None of the stakeholders had exact data on the change in the number of projects that use the performance path over the years, however a majority anticipated an upward trend. NYC DOB estimated some increase in the number of projects this year compared to last year, but noted that the exact numbers are not tracked. The DOE is beginning a multi-year commercial compliance study which will document some related data.

Most stakeholders cited the increasing stringency of the prescriptive path as the key driver behind the trend toward performance-based compliance, with more projects taking advantage of trade-offs allowed by the performance path in lieu of meeting some of the prescriptive requirements. NYC DOB reported that many projects pursuing the performance path have high fenestration areas (i.e., large windows) and poor opaque envelopes; some also do not meet the ERV and lighting power density requirements. The large majority of these projects are 50,000+ square feet high-rise multifamily, and make up for the poorly performing envelopes, excessive glazing, and increased LPD by utilizing cogeneration systems.

In Seattle, larger buildings such as offices and residential high-rises, and more complex projects including labs and hospitals that have the budget and expertise to “deal” with modeling, have used the performance path most frequently. In Oregon, in addition to high fenestration area, avoiding economizers and having to insulate mass walls in warehouses and other storage facilities were among more common reasons.

In the State of Washington, most projects that followed the performance path under the previous version of the state energy code did so to circumvent envelope requirements, such as aggressive window thermal properties and the maximum 30% WWR. The new state code includes prescriptive trade-off options for such project, to allow buildings with up to 40% WWR to follow the prescriptive path of compliance by meeting more stringent requirements in other areas. However, in the new code, lighting allowances are substantially decreased, there is an aggressive Additional Efficiency Option requirement, and certain building types (office, school) are required to have dedicated outdoor air systems and cycling heating & cooling fans. As a result, stakeholders expect to see a decrease in the number of projects that use performance path to avoid meeting the WWR cap, but an overall increase in the number of performance-based projects, for example to avoid the costs associated with the Additional Efficiency Options.

The NYC design team respondent also mentioned the stricter enforcement of the prescriptive requirements among the reasons for the increase in the number of performance projects: "…this may also be in part due to increased oversight and review of energy code submissions. For example, the requirement of inspections in NYC has definitely increased the awareness of energy code issues on projects, where before no one would have cared."

## Performance-based Compliance Enforcement Practices

Responders working for states and municipalities listed the following strategies for mitigating complexity and streamlining enforcement of the performance path.

### *1. Third party reviewers*

This strategy has been used for many years in Oregon. The review process is illustrated in Figure 2.

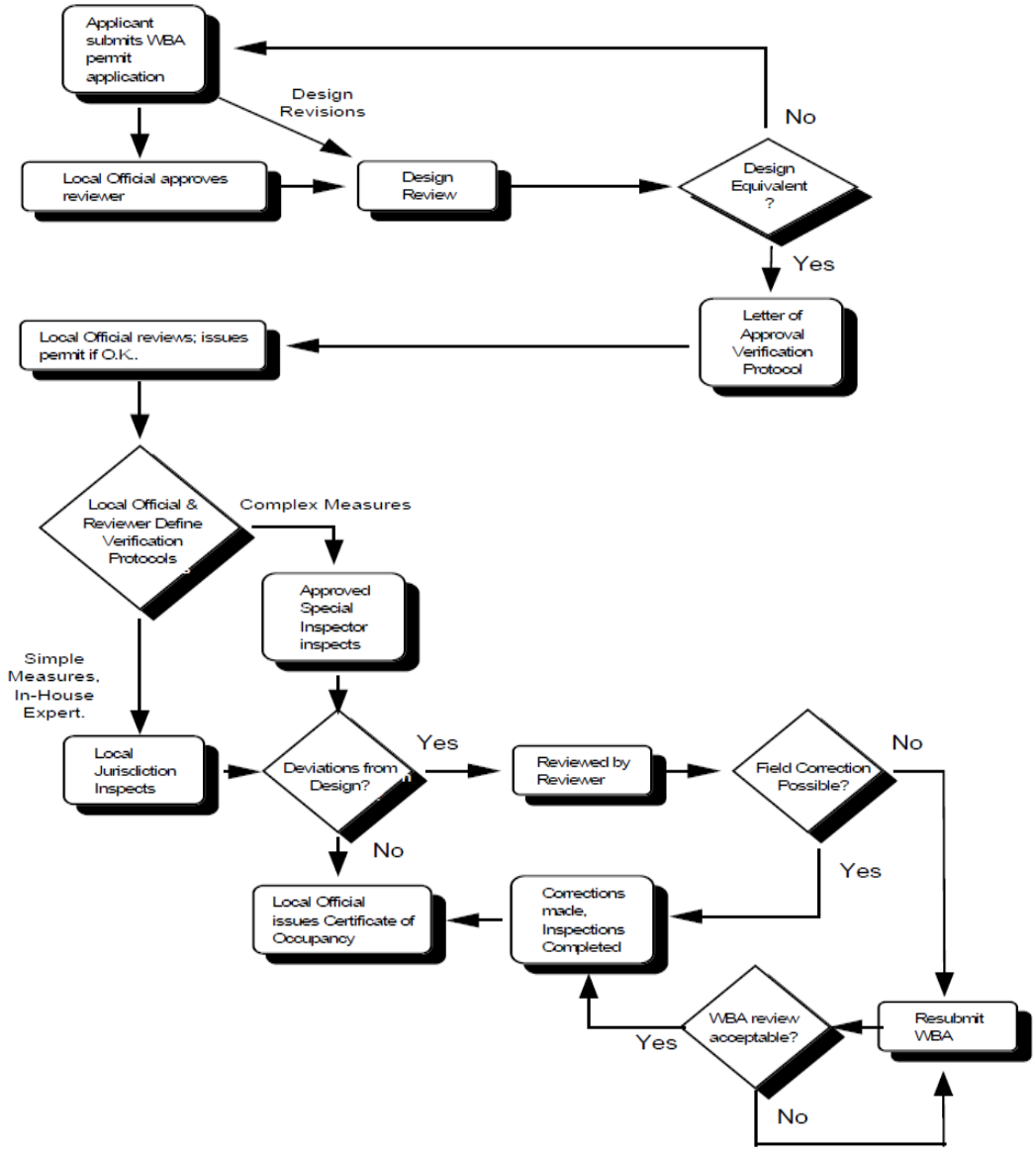



**Figure 2: Oregon Whole Building Approach (WBA) Review Process Schematic.**

Applicants had to pay for the expert review, which discouraged using the performance path, so that it was treated as a last resort. "….It worked great (for enforcing the rigor and discouraging the use of the performance path). We were very tough and the third party review process took away the burden from the building official. It was very expensive for the applicant … and we did everything we could to discourage the use of the WBA."

Seattle has a similar practice - applicants are charged an hourly fee for the model reviews. Thus, "it's in their best interest …to have all the ducks in a row before they come in. We also usually have a pre-submittal meeting with applicants to discuss how they're modeling any unusual conditions - this

saves a lot of time and headaches." Modeling reviews were reported to require an additional 20 – 30 hours of staff time, which was billed to the applicant at $190 per hour. The reviews are currently done in-house, but if the volume of performance-based submittals increases significantly over time, it may become necessary to contract external consultants. A concern was brought up that this may become a sensitive issue, because the expert modelers in Seattle know each other personally and in many cases, have worked together at the same firms, so they might be reluctant to give each other a hard time about modeling discrepancies. On the other hand, firms outside of Seattle may not have an expert-level understanding of "…our peculiar code".

### *2. Minimum Qualification Requirements for Modelers and Reviewers*

Oregon requires projects to use an approved modeler and an independent reviewer, and has the same qualification requirements for both, including but not limited to broad experience with building energy systems and operating characteristics similar to those in the building being evaluated; three or more years of full-time equivalent modeling experience, or two years of modeling experience and either a certificate of completion from the ODOE Modeling Training course or ASHRAE certification as a Building Energy Modeling Professional (BEMP); and a minimum of one year full time equivalent experience with the specific building modeling tool, and a demonstrated ability to perform energy studies evaluating energy-efficient designs that have been implemented and successfully operated. In addition, the state of Oregon provides rigorous training for modelers, and established the Building Simulation User's Group (BSUG), now Building Energy Simulation Forum (BESF), that holds monthly seminars to share modeling tips, requirements, and examples. In addition to performance-based compliance, these efforts support other state programs such as energy tax credits.

NYC DOB does not have formal qualification requirements for either modelers or reviewers; however the reviewers working on the performance path projects have background in energy modeling, and several staff members were trained to review energy models and have attended eQUEST training courses.

All design team stakeholders indicated that they have staff specializing in the energy modeling, doing it at least 50% of the time.

### *3. Clarifying Code Requirements*

NYC DOB noted that the lack of a "…manual or guidelines that clarify some of the ambiguities in the modeling protocol creates difficulties in our enforcement". Clarifying requirements of the performance path modeling was also brought up by Seattle stakeholder, who noted that "…it's a balancing act – if you want to accommodate more special conditions, the code gets more complex; simplicity is good but it makes the code more of a blunt instrument."

### *4. Established Submittal Review Process and Reporting Template*

Seattle has developed a detailed reporting form for the city's projects following the performance path. The stakeholder noted that even though it requires more time for the modelers to fill it out, it enables reviewers to easily track "… what they're doing, and how they're balancing energy savings

with code deficiencies". Oregon also uses a detailed template. Washington state recently added a requirement that the documentation delivered to the owner must include "electronic copies of the baseline and proposed model input and output file. The input files shall be in a format suitable for rerunning the model and shall not consist solely of formatted reports of the inputs".

NYC DOB has a standard checklist that each examiner uses to review the energy models. Based on the nuances of the modeling and building designs, additional items are often checked to ensure compliance. NYC DOB has also created a standardized submission template (see Appendix E) that must be included on the drawing plans. The template is similar to the LEED® V3 template, and requires the applicant to list energy modeling inputs and outputs with the references to the corresponding energy modeling reports, drawings and related documentation where each value is specified (e.g. insulation details, LPD, mechanical system capacities/efficiencies, etc.). The applicant must also submit the simulation output files that are referenced in the template.

Only one design team stakeholder indicated that they have an internal checklist to review models before they are submitted for review.

### *5. Discouraging Projects from Pursuing Performance Path*

Seattle and Washington State stakeholders expressed concern that buildings which use the performance path are less efficient than their prescriptively compliant peers. They argued that projects that follow the prescriptive path meet all the prescriptive requirements, and typically exceed some, while projects that follow the performance path fall below some of the prescriptive requirements. They noted that this inequality may be addressed through the rule-making, by increasing the margin by which the proposed design model must improve over the budget building. They also view performance path as generally undesirable due to its susceptibility to gaming, with multiple prescriptive packages being a possible future alternative. "If the primary reason for modeling remains increased glass, I think we should develop additional prescriptive high performance glazing paths. These might need to include requirements from other areas of the building beyond the envelope to be successful."

### *6. Compliance Shell*

IECC 2009 required that the approved simulation tools were able to support "…computer generation of the standard reference design using only the input for the proposed design. The calculation procedure shall not allow the user to directly modify the building component characteristics of the standard reference design." This requirement has been removed from the later versions of IECC because no existing simulation tools could meet it, which effectively made the IECC performance path not practically usable. Automation is also mentioned in a Note to Adopting Authority in 90.1 Section 11.4.1: "ASHRAE Standing Standard Project Committee 90.1 recommends that a compliance shell implementing the rules of a compliance supplement that controls inputs to and reports outputs from the required computer analysis program be adopted for the purposes of easier use and simpler compliance. "

California has the most extensive experience with compliance shell adoption. For over 20 years, the California Energy Commission had a procedure for certifying compliance shells, known as the Alternate Calculation Method (ACM). The related compliance manual spanned 300+ pages, and included the detailed rules and a set of 160 or so tests to demonstrate that the applicant shell is giving the right answers. For a long time EnergyPro, built on the DOE-2.1E simulation engine, was the only certified commercial program in addition to the Commission's ProForma software that had a rudimentary interface and also ran DOE-2.1E. About 10 years ago eQUEST was certified. The commercial vendors that incorporated ACM compliance shells into their tools (EnergyPro and eQUEST for non-residential, and EnegyPro and MicroPas for residential) did not receive any funding from the state to support the compliance functionality. However, the certification procedure was not well defined, largely due to issues with the benchmark program (ProForma), making the certification process largely qualitative, i.e., the vendor supplied their results to the certification suite of runs, and the Commission then approved them. In addition, the dependency on the commercial software vendors for upgrading their tools was perceived as a drawback.

In 2007 the Commission decided to switch its benchmark from DOE-2.1E to EnergyPlus, and around 2009 invested in development of CBECC-Com (and CBECC-Res). The initial plan was for CBECC-Com to serve as a free benchmark for certifying other commercial tools; however, in 2013 the Commission mandated CBECC-Com as the only allowed compliance shell, and reinterpreted the ACM to mean that vendors could connect their interfaces to a CBECC-Com API. So far, EnergyPro and IES-VE have agreed to do so.

The earlier compliance shell certification procedure, while leaving a lot to be desired mainly due to the complexities of validating the shells, gave the public a choice of compliance programs and did not require substantial on-going state funding. CBECC-Com reportedly cost the Commission over $3 million to develop, will likely require millions more to maintain, was several years behind schedule and, based on the evaluation study prepared for a California utility, has not been well received by the industry, due to issues with the interface and slow runtime. Those who continued using their favorite program (e.g. EnergyPro) struggled with increased calculation time and API bugs.

Stakeholders with first-hand knowledge confirmed that there are no plans for making the compliance shell a requirement in Standard 90.1. They cited the following reasons:

1. Difficulty with establishing software certification and approval process that can be agreed upon by the key stakeholders

2. Availability of the software tools that implement compliance shells
   Other than in CA, stakeholders indicated that they do not work with the software vendors. For example, the stakeholders from Washington State and the City of Seattle indicated that their jurisdictions "…are small markets, have a history of significant code changes every 3 years, and have a unique modeling rule set. Getting any custom shell developed has been a non-starter unless the region paid for it and so far, that has not happened. There have been a few discussions over the years but no one has stepped up with money." The recent change to 90.1 Appendix G that introduced a stable baseline fixed at 90.1 2004 level of stringency was cited as making the development of the commercial compliance shells more likely, however, it was noted that such an

approach would necessitate the development of the required percent better than baseline for the local code. Since the local code is very different, that process would be "…non-trivial, or done very quickly with the risk of being arbitrary and capricious". Coordinating with the software vendors was noted to be an "…. impossible task …given that we get submittals in four different software packages, each of which has multiple versions in use."

3. Absence of a detailed specification defining the performance path ruleset with the precision required to support consistent software implementation
   An ASHRAE 90.1 Committee member shared this insight: "The biggest problem implementing rulesets like appendix G … is that the methodology in the ASHRAE document is too vague to address all the issues and lots of interpretations need to be made. Sometimes there are inconsistencies or mistakes that cannot be simulated per the exact rule in 90.1 and you just have to do things a little different."

   There are two parallel efforts under way to fully formulate the rules, including COMNET Modeling Guideline and Procedures[4] (MGP) and PNNL Performance Rating Method Reference Manual[5] (PRM RM). However, both lag behind the current code (the most up-to-date versions are based on 90.1 2010), and development of the alternative protocols may undermine consistency. Furthermore, in order to be precise, the specification must address individual simulation tools. For example, it was noted that some consider "… COMNET too DOE-2-centric, but it's hard not to be tied to a specific program because otherwise you can only talk in generalities." "…. if you want consistent results, you must nail down all the inputs, including the defaults, to have apples-to-apples comparisons. This would require a group of experts for different programs to sit down together and work it out. However, there's too much rivalry for that to ever happen."

4. Political and financial reasons
   ASHRAE is not a regulatory body and relies on consensus, so it is unclear who would enforce the requirement, and who would be in a position to certify that the shells are compliant with 90.1. "ASHRAE … should not bear the political and financial cost to certify various programs ". "If a state mandates it, it would need to develop a certification procedure and then figure out who would do the certification (and expect a lot of push-back from the simulators and the software vendors)."

## Quality of Submittals and Market Reaction to Enforcement

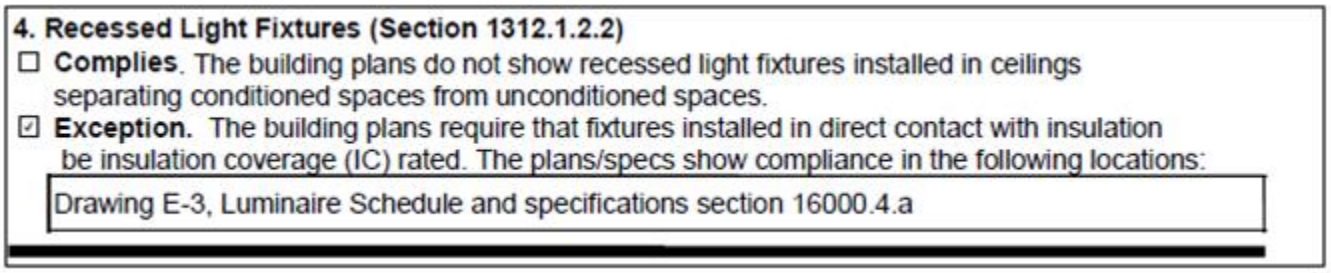
The Seattle responder did not see changes in quality of the modeling submittals, but "…definitely have noticed that some modelers are better than others". NY DOB noted a slight improvement in the submission quality among the 10 most frequent filing modeling firms, but echoed Seattle's observation on uneven quality "…we have seen 'new' firms submit energy models, and those submissions are very poor – lack of understanding of the modeling protocol (either Appendix G or ECB), lack of understanding of the modeling software, very poor correlation between the model and the design." NY DOB noted lack

[4] http://www.comnet.org/mgp/printpdf/book/export/html/2?purpose=0
[5] http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-25130.pdf

of coordination between the energy model and the design documentation (drawings and specifications) to be one of the most prevalent issues that has yet to show improvement.

The stricter enforcement was noted to cause pushback - "… oh, they love it and beg for more" (Seattle), "they hate it for most part" (Oregon). NYC DOB has stepped up enforcement of energy code compliance and modeling since January 2014. "The first year was the most difficult when we were establishing the enforcement program and modelers were not used to getting any comments on their models. It took them time and money and typically several revisions to … provide enough documentation to prove compliance, along with much pushback…. Now, we don't get as much pushback from the modeling firms, but more from owners who are frustrated that they are not receiving approval due to energy code. Most of the time, the drawings and model are not coordinated, and that delays the approval."

Many stakeholders also gave examples of the positive reaction. Stakeholder from the Oregon DOE noted that "… when we created very detailed compliance forms … where we required the designer to indicate where on the construction documents (spec section and drawing #), several designers told me that that helped them make sure they were in compliance because they had to double check instead of just saying something complies." Figure 3 shows an excerpt from the Oregon compliance form illustrating the requirement.



**4. Recessed Light Fixtures (Section 1312.1.2.2)**

☐ **Complies**. The building plans do not show recessed light fixtures installed in ceilings separating conditioned spaces from unconditioned spaces.

☑ **Exception.** The building plans require that fixtures installed in direct contact with insulation be insulation coverage (IC) rated. The plans/specs show compliance in the following locations:

Drawing E-3, Luminaire Schedule and specifications section 16000.4.a

**Figure 3: Excerpt from the Oregon Compliance Form**

NYC DOB quoted a firm that "… commented that our reviews are more stringent than LEED® reviews, and while they felt it was time consuming, it was good for their business." Design team responder noted that GBCI reviews for LEED® have gotten more structured and thorough, and that NYC reviews became more rigorous in the last 2 years. "The submittal form for LEED® to document modeling assumptions is rigorous and carefully reviewed and compared to design drawings. This is great for the industry as it raises the bar for all. However, there are still too many loopholes in the modeling methodologies that make it easy to get very different results on certain projects. The review process is difficult because there is so much that must be known for certain building types. For complicated projects the best outcomes are the ones where there can be back and forth during the review process that allows for consensus to be developed on addressing "loopholes" or "grey areas" in the modeling methodologies. Much more education is needed around how to model and what the intent of modeling for code compliance is really about. Most code officials don't know anything about modeling and tend to trust the engineer. NYS could certify third party reviewers that are trained to review models that can serve as a neutral third party between code officials and designers."

## Performance Path Policy Recommendations

Availability of the compliance shell(s) has the greatest promise for improving consistency of results, and simplifying documentation and enforcement. However, this is not an attainable short term goal. California experience demonstrates that achieving it will require a fundamental market transformation and/or significant financial commitment by the adopting authority. Thus, in the short term, the policy should aim at creating favorable conditions for future development and adoption of the compliance shells, while improving and streamlining the current enforcement practices.

Stakeholders stressed similarities between LEED® and incentive program enforcement and code enforcement, pointing that the experience of these above-code programs may be used as a template for code. "…. LEED® Certification is just like code compliance, but even more complicated because it has to deal with more advanced strategies and technologies. …What the USGBC did was not to re-invent the wheel, i.e., develop a whole new certification tool, but to rely on established work like ASHRAE 90.1 Appendix G, etc., and then hire expert modeler to review the simulation results, while letting the market decide which tool to use. The bottom line is not to create a perfect tool, which doesn't exist and probably won't exist during our working lifetime, but to rely on an expert, or an expert body, as the gatekeepers. I would find that more dependable than relying on a computer program to be the gatekeeper." Recommendations below recognize these constraints, aiming at improving short term enforcement practices while providing the ground-work for greater engagement with the software vendors in the future.

1. Minimize the number of compliance options

   Existence of the three significantly different performance-based compliance options – IECC Section 407, 90.1 Section 11, and 90.1 Appendix G, complicates enforcement, because reviewers must be proficient with the three different rulesets, 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. In addition, this delays implementation of the compliance shells because vendors would have to implement multiple rulesets, and the certification procedures must be developed for each. IECC Section 407 is not an allowed compliance path in the current NYC code. 90.1 Appendix G protocol is used much more widely compared to Section 11, due to its ability to support both code and above code performance (e.g. both code compliance and LEED®). The most active current work to develop requirements for the future compliance shells is the DOE-funded PNNL's Performance Rating Method Reference Manual which focuses on 90.1 Appendix G. Thus, it is recommended to make 90.1 Appendix G the only performance path in the future code cycles.

2. Establish qualification requirements for the modelers and reviewers
   The requirements may be like those used in Oregon, and include three or more years of full-time equivalent modeling experience; or two years of modeling experience and ASHRAE certification as a Building Energy Modeling Professional (BEMP); and a minimum of one year full time equivalent experience with the specific building modeling tool, and a demonstrated ability to perform energy studies evaluating energy-efficient designs that have been implemented and successfully operated.

3. Engage Third Party Reviewers
   It may not be practical for smaller municipalities that see low volumes of performance-based submittals to have a reviewer with the appropriate qualifications on staff. Such municipalities may consider having third party reviewers perform the review. The state or municipalities may maintain a list of approved reviewers that meet the qualification requirements. Optionally, projects may be asked to carry the financial burden of reviews, similar to the practice used in Seattle.

4. Adopt a detailed, well-structured submittal template, to ensure consistency of modeling submittals and standardize reviews across different modelers and reviewers. The template must include the following:
   - detailed side-by-side list of inputs for the two models used to document compliance (the baseline and the proposed design)
   - specific references to design documents, connecting simulation inputs to the project drawings and specifications, to address the concern brought up by NYC DOB of the lack of coordination between the drawings and the model
   - list of simulation reports, depending on the simulation tool used

   The submittal template for code should be aligned to the greatest degree possible with the templates used for the other common New York compliance modeling applications, such as modeling-based incentive programs and LEED®. This will reduce compliance overhead for projects that must submit results to several rating authorities / jurisdictions, and improve quality of the template because resources of multiple adopting authorities can go toward improving it.

5. Develop and document the review process to support review of projects modeled in the various approved simulation tools.

   The proposed review process is based on the concept described in the paper by M Rosenberg et al. "An Approach to Assessing Potential Energy Cost Savings from Increased Energy Code Compliance in Commercial Buildings"[6] (PNNL 2016). The paper asserts that commercial code compliance verification is complicated and expensive, and it is unlikely that there will ever be enough resources available to fully judge compliance for all systems in every building. However, each project typically has only a handful of high impact measures, and the code verification efforts may be reduced by prioritizing the review to focus on these measures. The proposed approach involves determining a set of high-impact areas that should always be verified, with the remainder of the measures checked on a rotating or randomized basis, leading designers and contractors to focus on the most impactful requirements, while ignoring none.

   The proposed review manual to be developed under this contract will adopt this approach. It will include a comprehensive list of checks, and will describe the methodology that reviewers would use to identify the mandatory checks that must be performed on a given project. These checks may be

[6] http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24979.pdf

based on factors such as relative contribution of the individual end uses toward the total baseline and/or proposed design energy cost, end uses with the largest improvement between the baseline and proposed design, etc. The review process will rely on the information included in the submittal template, and some of the checks may be incorporated into the Excel version of the template to automatically flag inputs and/or outputs that appear erroneous. The methodology will be further refined in the next contract deliverable. The review checklist may be made available to the modelers and designers, to encourage that they self-check the submittals before submitting a project to code officials.

6. Provide trainings to the code officials and/or third party reviewers on the use of the submittal template and review process. NYSERDA may consider funding the development and delivery of such trainings, to promote adoption and improve enforcement.

## Performance Path Software Recommendations

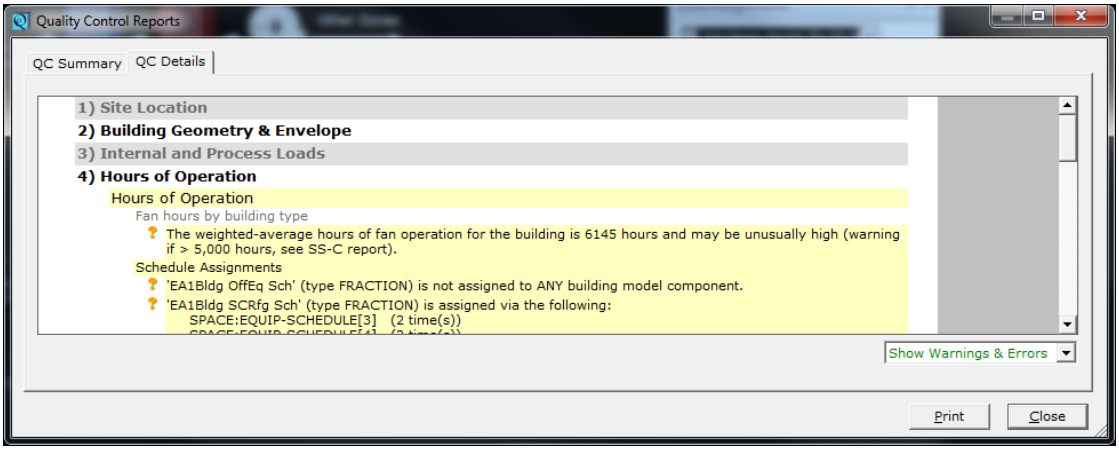
eQUEST is by far the preferred tool in the New York market, as described in the Commonly Used Simulation Tools section of the report. If New York software requirements are expanded beyond those in 90.1 and IECC, it is unlikely that software vendors will invest into adding the new features that are specific to New York, given the modest size of the New York compliance market described in this report. Thus, adding New York – specific requirements may result in no commercially available tools that can meet them, as was the case with IECC requirement for compliance shell. Recognizing this reality, the following is recommended:

Short Term:

1) Keep compliance software requirements aligned with 90.1
2) Engage with the vendors of the simulation tools popular in New York to obtain their input on the review checklist, and ask that they identify input and output reports needed to perform the checks included in the review manual.

Medium Term:

1) Request that simulation tool vendors expand the reporting capabilities of their tools to address the identified reporting deficiencies (if any) which prevent performing the mandatory checks formulated in the review manual.
2) Request that simulation tool vendors incorporate quality control module into their tools, to automate certain scope of QC checks identified in the review manual. Below is an example of a similar module in eQUEST. The functionality is applicable to both compliance and design support modeling, and thus will be valuable for a wider audience and is more likely to be implemented by the software vendors. Coordinate with the software vendors to allow sufficient grace period for implementation.




3) Incorporating automated QC checks and the compliance shell into the software tools popular in New York will improve the efficiency and technical integrity of code enforcement and above code programs in the state. NYSERDA may consider offering funding to vendors of the tools popular in New York, such as eQUEST, toward implementing this functionality.

Long Term

1) When the obstacles outlined in the Compliance Shell section of this report are addressed, require that vendors implement compliance shells in order for the software to be approved for documenting code compliance. The timing of this requirement should be aligned with the national effort, and requirements of other rating authorities (e.g. USGBC for LEED®) and states.

## Appendix A: Survey Questions

| Questions | NY Code Enforcement | Other Code Enforcement (Task 1.3) | Designers |
|---|---|---|---|
| What is an approximate percentage of projects that use energy modeling to document code compliance? | x | x | x |
| What is an approximate percentage of projects that use energy modeling to document above code performance (stretch code) | ? | x | x |
| For projects that use energy modeling, why do they select this approach versus a simpler prescriptive path? | x | x | x |
| Does the percentage of projects that use energy modeling increase overtime or stay about the same? E.g. did more projects use energy modeling this year compared to last year? | x | x | x |
| Did you notice changes in quality of modeling-based submittals? Is there trend to improvement (e.g. better this year than last year), do they stay about the same, or getting worse? | x | x | |
| Do you have staff that specializes in review / development of modeling-based submittals? | x | x | x |
| Does your organization have / use a written document or checklist with review steps for modeling-based submittals? | x | x | x |
| Are there requirements in addition to ASHRAE 90.1 and IECC related to modeling based compliance? | | | |
| List of approved software tools | x | x | |
| Mandatory use of a compliance shell | x | x | |
| Prescribed utility costs | x | x | |
| Prescribed weather files | x | x | |
| Other? | x | x | |
| Which software tools do you see most commonly used for modeling-based compliance? | x | x | x |
| Based on your experience, is review of modeling-based submittals becoming more structured / rigorous? | x | x | x |
| How did design professionals react to more rigorous enforcement? | x | x | x |
| [for administrative entities requiring compliance shell] How were software vendors brought on board to implement the required functionality? Are they reimbursed for maintaining their tools? | | x | |
| In your experience, which projects most commonly use energy modeling to document compliance | | | |
| Large commercial buildings (e.g. 100,000 SF+) | x | x | x |
| Buildings with large fenestration area | x | x | x |
| Projects that do energy modeling for LEED® or incentive programs | x | x | x |
| Other | x | x | x |