DEVELOPING A DETAILED RULESET FOR USE IN AUTOMATING THE PERFORMANCE RATING METHOD OF ASHRAE STANDARD 90.1-2010

Supriya Goel¹, Michael Rosenberg¹, Bing Liu¹, Dimitri Contoyannis² and Noah Czech²
¹Pacific Northwest National Laboratory, Richland, WA
²Noreesco, Boulder, CO

ABSTRACT
California Building Energy Code Compliance tool for commercial buildings (CBECC-Com) was developed by the California Energy Commission. CBECC-Com is used to demonstrate compliance with the California Energy Code, Title-24, through the Nonresidential Alternative Compliance Method (NACM). A preliminary step in developing CBECC-Com was the creation of a ruleset that provides a standardized approach for performing energy modeling as required by the NACM in Title 24. A similar ruleset for analyzing performance compared to ASHRAE 90.1-2010 using the Appendix G Performance Rating Method (PRM) has been developed by the Pacific Northwest National Laboratory (PNNL) through funding support from the Department of Energy (DOE). The Performance Rating Method Reference Manual (PRM-RM) and tools like CBECC-Com are intended to significantly reduce effort to generate a baseline model, remove the ambiguity involved in the interpretation of performance based ruleset requirements and provide a standardized approach for the development of a baseline model. This paper discusses the technical approach used for the development of the PRM-RM following the model used in CBECC-Com.

INTRODUCTION
ASHRAE Standard 90.1-2010 provides two simulation based procedures for determining building performance (ASHRAE 2010). The first, the energy cost budget approach (ECB) is used to determine compliance with the Standard. The second, the Performance Rating Method (PRM), commonly referred to by its location in the Standard, “Appendix G,” is used for rating the performance of buildings that exceed the minimum requirements of the Standard. The two approaches are similar in the sense that a proposed building is compared against a baseline which meets the prescriptive code requirements, however the scope of prescriptive requirements addressed as well as the design features that can be credited for the proposed differ between the two approaches. The ECB baseline building tracks the proposed design with each element in the baseline defined to the same as the proposed, however meeting the prescriptive code requirements. The PRM approach significantly differs from the ECB approach in that the baseline characteristics are defined and to a certain extent, are independent of the proposed building characteristics. The intent of the Appendix G approach is to credit beyond-code design strategies and not necessary verify code compliance.

The PRM method is used much more than the ECB method, because of its reference by the Leadership in Energy Efficiency in Design (LEED) rating system. LEED requires building design teams to demonstrate a percentage improvement in the proposed building performance rating compared with the baseline building performance rating, following the modeling rules identified in Appendix G (USGBC 2005, 2009, 2014). The PRM is also cited by a number of standards and programs including ASHRAE/ USGBC/IES Standard 189.1-2011, the International Green Construction Code (IGCC), the Federal Energy Efficiency Standards, and the recently expired Commercial Building Federal Tax...
Deductions (ASHRAE 2011), (10 CFR 433), (Deru 2007).

The PRM-RM provides a methodology for standardizing building energy modeling for such programs that require compliance with Appendix G by defining the methodology for creating consistent baselines relative to an energy code or standard (Goel et al. 2016). Its purpose is to increase the accuracy and confidence in energy modeling when using ASHRAE Standard 90.1-2010 Appendix G. It was developed from a variety of sources including the Commercial Energy Service Network (COMnet) Modeling Guidelines and Procedures (MGP), the California Nonresidential Alternative Calculation Manual (NACM) and the Energy Cost Budget (ECB) Compliance Supplement developed by Standing Standard Projects Committee (SSPC) 90.1 ECB Subcommittee (COMnet 2014), (CEC 2013), (ECB 1999). It includes default operational characteristics and rules for translating code requirements to energy model inputs for purposes such as green building ratings. It defines rules that can be used by an energy modeler for creating the baseline model or by a simulation program automating the generation of a baseline model for streamlining the compliance process.

CBECC-Com is a software tool that implements the rules defined in the NACM (CEC 2013) and automates the process of performance-based code compliance analysis. The software allows a user to define the proposed building and automatically creates the code baseline building, using OpenStudio to perform simulations for the proposed and baseline buildings through EnergyPlus. CBECC-Com uses the methodology defined in the NACM for creating a ruleset that can interpret the proposed building design, defined by the user to automatically create the baseline building following the code requirements. Having a standard set of rules provided by manuals like the NACM and PRM-RMcoupled with a simulation program that implements the rules to automatically generate the baseline ensures that authorities approving energy models only need to verify and approve the design model and are assured about the accuracy of the baseline model.

CBECC-COM

CBECC-Com is an open source software program that may be used by code jurisdictions, rating authorities, or utility programs in the development of energy codes, standards, or efficiency programs. Architects, engineers, and energy consultants may also use these tools to demonstrate compliance with energy codes or beyond-code programs. CBECC-Com was originally developed for analysis of California’s energy code, Title 24. However, one of the primary design goals from the start was to develop a tool that could be expanded to encompass other energy codes and performance based rulesets. The ruleset for 90.1-2010 Appendix G can be added to the CBECC-Com framework, and similar efforts could be undertaken to expand its application for other applications(state-specific codes, local jurisdictions, international codes).

Architecture

CBECC-Com’s flexibility is due to its modular architecture. It can be functionally separated into five components, each of which serves a key purpose, but many of which are essentially independent of the particular performance ruleset being analyzed.

The software’s key components are shown in Figure 1 and defined below:

- **Graphical User Interface (GUI)** - The GUI allows users to enter details about a proposed building’s design (Proposed Design). Users enter information describing the building’s geometry, envelope, lighting and other internal gains, HVAC systems, and DHW systems. The input requirements are designed to represent information that is generally available to design teams (no abstract energy modeling inputs), and directly relevant to energy consumption analysis (using similar terminology and units of measure). The input data is represented in an XML file format based on the Standards Data Dictionary (SDD), described in more detail in the next section, and called SDXML. A public-domain GUI was developed and is freely available. Additionally, an application programming interface (API) and supporting documentation is available for third-party software developers to connect alternate GUIs to CBECC-Com’s ruleset implementation functions.

- **Ruleset** - The ruleset is a computer-processable form of the performance based modeling requirements. It can be thought of as a series of logical if/then statements and lookup tables that define those requirements. It is used to build the baseline building energy model against which the proposed building’s energy consumption or energy cost is compared. The ruleset’s function is to compare every input stored in the proposed building’s SDXML file against the baseline energy modeling requirements and determine whether that value is to remain consistent between both models, or whether the baseline model’s value must be changed to a code-minimum or other value. The ruleset also checks to ensure that the mandatory code requirements are being
followed. The structure and details of the ruleset are described in detail (in plain-english) in the NACM for Title 24, and the PRM-RM for ASHRAE 90.1.

- **Compliance Manager**: The Compliance Manager is the core of CBECC-Com. It handles communication between all of the software modules. It stores the SDDXML model representing the proposed building, processes the ruleset to generate the baseline building, initiates energy simulations in EnergyPlus, analyzes the results to determine how a proposed building compares to the baseline building, and produces reports via the Report Generator.

- **Connection to the U.S. Department of Energy's EnergyPlus Simulation Engine**: The Compliance Manager performs energy simulations using EnergyPlus to compare the proposed building energy cost to the baseline building’s energy cost. As noted above, the input file format for describing the proposed design is SDDXML. After the Compliance Manager processes the ruleset, a baseline building model is also generated in SDDXML format. In order to run the simulations in EnergyPlus, these files must first be converted to EnergyPlus’s IDF file format. This is done via an intermediate translator built into the OpenStudio platform. After the file translation is completed, EnergyPlus simulations are initiated to calculate predicted annual energy consumption for the proposed building, perform HVAC system sizing calculations for the baseline building, and calculate predicted energy consumption for the baseline building. Simulation results are returned to the Compliance Manager and a compliance assessment can be performed.

- **Report Generator**: The Report Generator generates reports to summarize the building's characteristics including all relevant inputs, simulation results, and a pass/fail assessment. For Title 24, “Official” compliance forms are generated following the energy code requirements for content and format and they may be submitted for building permits, or as documentation for other programs (e.g. incentive programs, LEED). The compliance forms are secure - the Report Generator provides checks to ensure that a valid ruleset was used, and produces a non-editable PDF form to ensure that the reported data is legitimate. The Report Generator is also capable of producing highly detailed spreadsheets (CSV files) that summarize the model inputs for performing QA/QC activities.

**SDDXML**

The Standards Data Dictionary (SDD) Data Model is a library of building objects and properties organized hierarchically based on the relation of objects and properties to one another. The structure of the data model is analogous to a tree, where the main trunk (Project) splits into smaller branches (Building and FluidSystem), and then continues to split as needed. The main trunk and each subsequent branch is called an object, and each object has the ability to retain further levels of detail called object properties. Properties typically hold the actual input data for each model (Project:ClimateZone, Building:Azimuth and FluidSystem:Control Type). This organization gives the data model a clear structure with capabilities for an infinite amount of detail that can be added with additional objects and properties.

The SDD Data Model was developed by the State of California to unify compliance simulation modeling into a standard file format. California has detailed requirements for compliance modeling and the SDD Data Model gives a clear, hierarchical list of all components and properties available for use in compliance.

![Figure 1: CBECC-Com Tool Architecture](image)

Standardization of simulation data structure simplifies the data exchange between different applications like Building Information Modeling (BIM) and keeps the information from being specific to a particular simulation application. Modularity and expandability are the data model’s strongest characteristics. Expandability allows new properties to be added to existing features and new features to be added without modifying the existing structure. The modular structure of the data model allows common properties (like efficiency) to have multiple meanings throughout the data model depending on object relation.
Testing and Validation
The Ruleset Implementation (RI) tests are intended to verify that the software correctly constructs the baseline model and applies rules of the reference manual appropriately to both the proposed and baseline models. The RI tests cover representative portions of the rules for building envelope, lighting, daylighting, space use data and HVAC systems. For each RI test there is a set of three models defined:

- **User Model** - the user model contains the user inputs for the as-designed building. In most cases, the values for the proposed model will be taken from user inputs with no modifications. However, there are some cases where the user model may be modified to the proposed model to reflect inputs that may be prescribed for the proposed model, or constrained by mandatory minimums.

- **Proposed Model** - the proposed model is defined by the rules in the reference manual, created by the vendor software, and is the building modeled for analyzing performance. This model takes user inputs for building geometry, building envelope, lighting and HVAC systems and is used in the compliance simulation.

- **Baseline Model** - this is the baseline model defined by the reference manual modeling rules, and forms the basis of comparison for determining the proposed building performance.

These RI tests do not require simulation results to be verified, but do require the simulation input files for the proposed model and baseline model to be constructed in accordance to the rules in the reference manual. For the testing process, multiple RI tests are typically grouped within one test model.

The entire suite of RI tests are documented to catalogues the intent of individual tests, explain the characteristics of each model as well as the final results.

**PERFORMANCE RATING METHOD REFERENCE MANUAL**

PRM-RM is a methodology document for standardizing building energy modeling by creating consistent baselines according to the requirements of ASHRAE Standard 90.1 Appendix G’s Performance Rating Method. It comprises of a set of rules and guidelines that provides the standardization for specific modeling inputs in the baseline building as well as the restrictions for the corresponding input for the proposed building. It provides default values for basic modelling assumptions such as schedules of operation, plug loads, ventilation loads etc., providing a reliable and consistent default value for designs where actual values are not available.

Through the defined rules, guidelines and default values, it provides a more accurate basis for comparing performance results for project submittals, ensuring a more practical, cost-effective and streamlined compliance review.

**PRM-RM Structure**

The PRM-RM follows the structure defined by COMnet and has been segregated into five broad chapters.

- Chapter one gives an overview of the document and its purpose as well as the types of projects it can be used for.
- Chapter two provides general modeling procedures. It defines a space, thermal zone and thermal block as well as the guidelines for classifying a building into these three components. It defines the rules for baseline equipment sizing as well as rules related to unmet load hours for baseline and proposed building. It addresses some of the ambiguous requirements in Standard 90.1-2010 with regards to dealing with unconditioned spaces, handling of semi-heated spaces and well as modeling requirements for special space types including parking garages, crawlspaces and attics.
- Chapter three documents all the building descriptors where each building descriptor corresponds to a value that is required to be defined for the baseline and/or proposed building model. It addresses all descriptors related to spaces and thermal zones, building envelope, primary and secondary systems as well as miscellaneous energy uses such as water heating and exterior lighting.
- Chapter four of the document summarizes the process used for defining energy cost data, including default values for annual state average energy costs as well as the guidelines for defining custom utility data using tariffs, energy, demand charges and ratchets.
- Chapter five provides the requisite content and format of the standard output reports required by PRM-RM, following requirements specified by the Standard 90.1-2010 Appendix G as well as LEED V4. The standard output reports provide a means for the rating authorities to view building information written out by the software tool, eliminating human errors or inconsistent interpretation of requirements.

**PRM-RM Purpose**

The PRM-RM provides clarification to the rules defined in Appendix G as well as the process for converting these rules into energy modeling inputs. While the Appendix G provides a fair amount of detail,
it is not possible for a 14 page document to provide all the rules necessary to ensure implementation will be consistent between different energy modelers using different simulation softwares. The much greater level of detail provided by the PRM-RM is meant to ensure that consistency. Clarifications to Appendix G rules have been made in consultation with energy modelers, the ECB subcommittee and LEED reviewers. Some clarifications have also paved way for code change proposals for future version of Appendix G. One example of the clarifications provided by the PRM-RM includes the rules related to baseline building orientation and sizing. In accordance to Standard 90.1-2010 Table G3.1, the baseline building is required to be rotated and simulated for all four orientations, however the rules do not explicitly state the orientation requirement for baseline equipment sizing. The equipment sizes might differ significantly based on the building orientation, resulting in varying requirements for equipment efficiency, energy recovery ventilation or economizer control. Hence, the PRM-RM clarifies this rule to require sizing runs for all four orientations and the baseline equipment size is based on the equipment capacity determined through the corresponding sizing run. Another example of clarification provided by the PRM-RM addresses the requirements related to the baseline building window-to-wall ratio (WWR). Standard 90.1-2010 defines the baseline requirements for window to wall ratio (WWR) as a maximum of 40% of above grade wall area for all orientations. However, It's not reasonable to do the calculation of fenestration area as a percentage of gross wall area for the entire building where there is a mix of different types of conditioned space and semi-heated space. This is because the prescriptive criteria for envelope performance in Standard 90.1-2010 are different for different space conditioning categories. For instance, there is no solar heat gain coefficient (SHGC) requirement for fenestration in semi-heated space. Hence, the PRM-RM requires that the window-to-wall ratio be calculated for each space conditioning category which shouldn’t exceed 40% of the total above grade exterior wall area for the corresponding space conditioning category for the baseline building. One of the bigger challenges of automatically generating the baseline model is modeling requirements that are not explicitly specified by the user. A few examples of these include determination of the baseline HVAC system definition and modeling for mandatory requirements such as daylighting for primary and secondary daylight areas. Automating the process for determining the baseline HVAC system is challenging, especially for a building with a mix of occupancy types, heating fuel types, or spaces that have significantly varying internal loads or schedules, triggering special rules in Standard 90.1-2010 G3.1.1 Exception (b). The PRM-RM simplifies this entire process by defining specific steps for determining the baseline HVAC system, which can be easily translated to rules for a software program. For determination of daylighting setpoints for the baseline building, the PRM-RM references the 2013 NACM, using the the Relative Daylight Potential (RDP) approach developed for the NACM.

In addition to the clarifications provided to Appendix G requirements, the PRM-RM provides defaults values that can be used if design values are not available. Curves for equipment performance are referenced from COMnet-MGP, default schedules of operation and internal loads are provided, referenced from the 2013 NACM (CEC, 2013).

The PRM-RM incorporates specific requirements for programs using the Performance Rating Method. For instance, the reporting requirements have been developed based on specifications present in Appendix G as well as LEED V4. It provides standard output formats that would be populated by software programs based on rules defined by the manual which facilitates submittals for projects applying for certification through these programs as well as simplifies the verification process the projects need to go through.

Performance Reference Manual Integration with CBECC-Com

Detailed performance reference manuals such as the NACM and the PRM-RM use building descriptors to define each user input as well as the corresponding behavior for the automated baseline building model. The building descriptors guide the development of a user interface such as CBECC-Com and provide the rules governing the validity of user input for the proposed building model. With CBECC-COM, the building descriptor set is translated by the software to native simulation input through the SDDXML data model. The ruleset engine evaluates the proposed building model, applies a ruleset and generates the SDDXML data model for the baseline simulation. Some of the user inputs may be translated directly into the simulation input file or might require processing to form an input for the simulation program. For instance, user input for fan motor brake horsepower is translated to give the total static pressure drop and fan efficiency, which are required by the energy model. Similarly, user-input rated efficiency for packaged equipment is broken down into cooling efficiency and fan power so that they can be modeled separately, as required by the NACM and PRM rulesets.
Verification of Code Requirements

A building, before being submitted for simulation, is verified for compliance with all applicable mandatory code requirements. For instance, for roofs rated by the Cool Roof Rating Council (CRRC), the NACM specifies default values for roof solar reflectance based on the roof type. These value can be overridden by the user but are flagged by the tool and the user is required to submit documentation supporting the value used. These inputs, flagged by the tool, are reported in the standard output reports as inputs that require additional documentation. Similarly, some mandatory requirements for Standard 90.1-2010 require specific user inputs, such as optimal start controls for air distribution systems with design supply air exceeding 10,000 cfm or demand control ventilation requirements for spaces greater than 500 ft² and design occupancy larger than 40 people per 1000ft². A software tool, implementing the Standard 90.1-2010 ruleset should prompt the user if any of these mandatory requirements aren’t addressed and require the user is to make revisions before a building can be simulated.

The automatically generated baseline building model for T-24, accounts for all applicable mandatory and prescriptive code requirements. Some of the baseline modeling rules are straightforward, such as calculation of the interior lighting power allowance for the baseline building, using the lighting specification method (complete building method or area category method) as defined for the proposed building input. The baseline interior lighting power allowance accounts for special allowances for precision work, display or ornamental lighting etc., hence accurately reflecting the prescriptive requirements. Whenever any of the special allowance exceptions are claimed, software tools are required to flag these inputs and report the same for verification. Some of the baseline modeling rules require additional user input, such as calculation of the baseline fan power allowance using the additional pressure drop credits specified for the proposed system. A pressure drop credit greater than 1” w.g. in the proposed building, is flagged by the tool and reported in the standard output reports. A user is required to provide additional documentation to justify this input. Baseline system is subject to a maximum of 1” w.g. additional credit for pressure drop. Assigning these credits for the baseline HVAC systems can be complicated if there isn’t a one-to-one mapping between the proposed and the baseline HVAC systems. For this purpose the ruleset engine has developed a series of rules where the baseline fan power allowance is split between all zones served by the system in the proposed building, in the ratio of the design airflows to each zone. The fan power allowance for the baseline system is the sum of the calculated fan power allowances for each zone served by the baseline system. This approach accounts for the possibility of a varying relationship between thermal zones and HVAC systems between the proposed and baseline systems.

The Compliance Manager, along with verifying mandatory requirements through the tool GUI, also addresses NACM requirements specific to the proposed building. For instance, if the unmet load hours for the proposed building exceed 150 of the total 8760 hours simulated, the tool can check for the same and require the user to modify the equipment capacity or design supply airflow to reduce the unmet load hours within permissible limits. Minimum ventilation requirements for the proposed building are also verified, when designed in accordance toT-24-2013. The tool compares the design ventilation rates against the minimum ventilation requirements in accordance to the standard and an error is displayed if the design ventilation is less than the code minimum required ventilation.

The Report Generator, for Title-24, generates standard output reports, summarizing building inputs as well as simulation outputs. The establishment of these reports would standardize the way energy modeling output data is presented to various rating authorities. By standardizing the reports, all rating authorities would be able to view building information reported at a fixed level of detail and evaluate the project for certification, labeling, or tax credit. The standard reports generated by the tool could incorporate all ruleset requirements. The GUI can flag inputs which special documentation and reporting requirements and report the same in the output reports, providing a checklist for the reviewer to verify. In addition to reporting requirements specified by the ruleset, the tool could also produce standard outputs useful to programs such as LEED, including a summary of model inputs for the baseline and proposed buildings, such as the exterior wall and window areas by orientation for the baseline and proposed, equivalent full load hours of operation for all internal loads and HVAC systems, a summary of the energy features for the baseline and proposed building model etc.

APPLICATIONS

The intent of the PRM-RM is to provide a technically credible procedure to energy modelers, software developers and program administrators for evaluating the energy performance of nonresidential and high-rise residential buildings. The PRM-RM is intended to provide the technical basis to support beyond-code programs such as green building ratings and government and utility programs. Through its detailed specifications for automated baseline building generation, modeling the as-designed building and
generation of the standard output reports, it provides a means to reduce the level of investment and effort involved in developing energy models as well as increase the confidence in energy modeling results and energy savings.

**Energy Modelers**

The PRM-RM provides a standard approach to interpretation of 90.1 requirements, development of the proposed building models as well as the baseline building model. Along with clarifying requirements, it also helps translate the same into energy modeling inputs, providing model based solutions for implementation of the requirements. It provides guidelines for development of software tools which can automate baseline model generation. Hence, the repetitive and uncreative aspect of baseline model generated is automated, providing more time for innovative integrated design.

**Software Developers**

Software tools developed to be in line with such reference manuals are intrinsically more reliable in terms of the automated baseline models generated. The modeling rules defined in such reference manuals are validated through multiple rounds of review and address ambiguous requirements that might be open to interpretation. CBECC-Com has been developed as an open source software that can be very easily integrated with other software tools, providing a more stable approach for creating baseline buildings and has already been integrated with software tools such as IES-VE, EnergyPro and Simergy for compliance analysis using T-24-2013 (CEC 2013b)

**Program Administrators**

Both the PRM-RM as well as CBECC-Com significantly reduce the review time associated with verification of baseline building models. They eliminate ways people can game the system to inflate savings. Standard reports generated by software tool can be customized to provide outputs specific to the program requirements, which can streamline the implementation of a program and not require an extensive verification for the same purpose.

**FUTURE OF AUTOMATED BASELINE MODELING FOR PERFORMANCE BASED CODES**

The intent of Appendix G is to give credit to building designs exceeding minimum code requirements through better design. Many of the characteristics of the baseline building are defined independent of the proposed building to reflect typical design choices in the baseline building and give credit to energy-reducing design strategies, such as optimized orientation, selection and sizing of mechanical systems, use of thermal mass, optimized window area, etc. in the proposed building. It also allows credit for reductions in unregulated plug and process loads when in addition to the mandatory code requirements. Hence, Appendix G provides a flexible approach for evaluating beyond code performance in buildings and forms the basis for green ratings systems, tax credits, utility rebates etc. Standard 90.1 is published every 3 years with revisions to the prescriptive requirements as well as the performance rating method. This creates additional complications for energy modelers who now have to familiarize themselves with a completely new set of code requirements, for program administrators who now have to re-write the program requirements to keep up with the new code as well as for software developers who want to automate the process of baseline creation and have several versions of the standard to deal with a new one being published every 3 years. With prescriptive requirements getting more stringent with every code cycle, reflecting the same for the automated baseline is also a complicated process. These issues have been addressed by ASHRAE Standard 90.1-2016 that provides a new approach to performance based code compliance, where the baseline building is held constant at an efficiency level approximately equal to that in Standard 90.1-2004 (Rosenberg 2013). The intent is that future versions of the standard will specify increasing levels of improvement over the baseline required for compliance. Beyond code programs can also specify levels of improvement beyond the fixed baseline to meet their program needs. This encourages the development of more robust software tools, which need not be periodically re-invented to keep up with the latest codes. The PRM-RM has been developed for the purpose of Standard 90.1-2010, which is presently used for LEED V4 and other programs. The PRM-RM document would need to be updated to be applicable to Standard 90.1-2016 so that it can be used for energy modelers and software programs looking to comply with the new fixed baseline approach.

**CONCLUSION**

Automatically generated baseline building models, based on a standard set of rules defined through a thoroughly vetted and reviewed document like the PRM-RM, can help standardize and streamline the compliance process. Software tools like CBECC-Com developed using such standard reference manuals facilitate quality control and increase the quality assurance associated with both the proposed and baseline building models. However, since there might
be multiple ways of interpreting specific code requirements as well as modeling the same in an energy modeling software, development of such a standard document requires an extensive review and vetting process. COMnet has undergone an extensive vetting and review process and PRM-RM builds on the same. Industry wide adoption of the additional details provided by the document will pave the way for more consistent energy modeling including the automation of consistent baseline building generation. This will lead to more cost effective and accurate modeling. Review periods will be significantly reduced. With the adoption of the fixed baseline approach in Standard 90.1-2016, it will be more conducive for software tools to invest in the automated baseline process, as a single model will be useful for many different purposes.

Furthermore, with the development of automated ruleset functionality into the open source software platform CBECC-Com, software tool developers can now integrate these features into their tools with minimal effort. Several software vendors have already completed this integration for demonstrating compliance with California’s Title 24 and, with minimal added development time and cost, could also encapsulate the Appendix G automation functionality via the CBECC-Com API. As this ruleset functionality becomes integrated into more design and energy analysis software tools and supported by more energy codes and efficiency programs, energy analysts will have the opportunity to use the tool of their choice and follow a truly integrated workflow; one where they may perform design analysis and optimization as their core focus but with code compliance analysis, beyond-code program analysis, and utility incentive calculations automatically calculated with no added effort.

REFERENCES
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