Advancing Outcomes through Certified Prescriptive Packages

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ABSTRACT

Interest in outcome-based codes and related policies are expanding to meet the desire for actual measured improvements in energy use. To date, such policies are only feasible for highly engineered structures with sophisticated owners where modeling and systems interactions are well understood. However, with a majority of the building stock and a significant proportion of energy use being in small buildings, the opportunity for realization of energy goals is extremely hampered. A mechanism to focus on achievement of outcomes, but still meet the challenges of designing small structures with limited budgets, satisfying the project owner that a design will help them meet outcome-based requirements and supporting the code department's compliance mission is necessary.

This paper will examine the opportunity for development of prescriptive packages designed to meet the outcome-based requirements. Such an approach will open up new avenues for standards development and require new conformity assessment, modeling and testing methodologies. Code officials would be presented with certified prescriptive requirements to be inspected against. Manufacturers or trade associations could develop specific packages based on their products, moving beyond a component-by-component approach to incorporate systems-based synergies. Linking prescriptive packages with emerging off-site construction technologies and practices could lead to the creation of a "Zero Energy Building in Box." This effort will contribute to a shift from the current prescriptive-based approaches that may or may not yield the anticipated energy savings to a regulatory system based on the desired end-state (how much energy is used).

Introduction

Across the building industry there is increasing interest in building performance—actual, measured verification of project goals. Cities, counties and states across the country are implementing benchmarking and transparency ordinances.[1] The U.S. General Services Administration Public Buildings Service has transitioned P100—its facility design criteria—to be more performance focused with identification of targets and standards for measurement and verification (GSA 2015). The National Institute of Building Sciences has developed the National Performance Based Design Guide as a private sector tool similar to the new GSA criteria (NIBS 2014).

To date, this focus on facility energy performance has been largely disconnected from the design and construction criteria contained within energy codes. While energy code provisions provide an important foundation for the realization of long-term energy performance, they only address a fraction of the influences of total energy use (Heller, Heater, and Frankel 2011).

With the exception of the benchmarking and disclosure requirements, a community's willingness or ability to tackle the ongoing energy performance of buildings has been limited to

[1] See http://buildingrating.org/ for the latest information on adoption of such policies.

incentive programs (either by government or utilities) or through awareness programs (Kilowatt Crackdowns, etc.).[2] Projects are underway to help identify mechanisms for a coordinated approach to address the energy performance of buildings from design and construction through operations.[3]

While this interest in actual, measured performance of buildings is expanding, the predominant baseline energy codes (International Energy Conservation Code and ANSI/ASHRAE/IES Standard 90.1) have not yet caught up. Only recently have they incorporated provisions focused on energy performance in operations—albeit in a very limited way (e.g., planning for operations, submission of commissioning plans, etc.). The provisions still stop at the issuance of a certificate of occupancy which many in the codes and standards community see as the limit of scope for codes.

The traditional understanding of energy codes as strictly design and construction requirements may be shifting. Seattle's 2012 energy code included a target-based compliance option which focused on the achievement of a specific energy use intensity (EUI) as the basis of compliance with the energy code (Seattle 2012). A coalition of representatives from the design, construction, owner, manufacturer, advocate and regulatory community were successful in proposing an outcome-based compliance path in the 2015 International Green Construction Code (ICC 2015). A similar coalition has proposed an outcome-based compliance path for the 2018 International Energy Conservation Code (ICC 2016).[4]

Unlike prescriptive and performance approaches that dominate current codes, an outcome-based code establishes an energy use target where compliance largely relies on demonstrating achievement of that target through actual, measured results. Besides the desire to address energy performance across the life-cycle of a building and influence the ability of a community to achieve energy use or greenhouse gas emission reduction goals, an outcome-based approach aims to address several other challenges before the building industry.

It is becoming increasingly obvious that the current component-by-component strategies for reducing energy use in both code and incentive programs are reaching maximum effectiveness. The energy efficiency of individual building components is reaching its maximum technical and cost effectiveness limits (ASE 2016). This constraint forces consideration of a new approach to advancing energy performance—one focused on the interactions of building components. This focus on system-level or even whole building efficiency adds a level of complexity. Prescriptive or check-list based equipment selection is no longer effective in delivering desired energy performance results.

Additionally, departments charged with the enforcement of building codes are under increasing pressure due to limited resources. Increased complexity in the code and the need for energy modeling to prove out the ability to achieve required targets can exacerbate these pressures.[5]

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[2] New York City's audit and retrofit requirements is one of a very limited number of examples of a regulatory mechanism to address energy performance in existing buildings. See http://www.nyc.gov/html/gbee/html/plan/ll87.shtml and http://www.nyc.gov/html/gbee/html/plan/ll88.shtml.

[3] The National Institute of Building Sciences and the New Buildings Institute are working with the Department of Energy to develop a framework for communities to implement life-cycle based energy performance programs.

[4] For an introduction to outcome-based codes including the opportunities and challenges associated with development, adoption and enforcement, see Colker 2012, NBI 2016, WBDG 2016 and papers presented at past ACEEE Summer studies.

[5] A recent study commissioned by the Department of Energy looked at the energy code compliance rate for residential construction and found a significant level of compliance. While this is good news, it is unclear what it

While outcome-based provisions in code will help address some of the current challenges including a focus on life-cycle energy performance, addressing approaching limits on component-based efficiency, and limited resources within code departments, their widespread adoption as a preferred mechanism for regulating energy use requires addressing specific challenges.

Expanding the Utilization of Outcome-Based Policies

As with any new technology or technique, the adoption rate starts small but expands as experience and results are widely shared. Early adopters are those best able to contain the risk of such a new approach and/or those with the most to gain from success. While outcome-based code provisions are relatively new, several strategies can be considered as proxies for such an approach. The growing number of zero energy buildings illustrates the expansion of building owners with an eye towards actual, measured energy performance.[6]

Performance-based contracting provides insight into what is possible at an individual project level. GSA's Federal Center South project in Seattle tied a percentage of the design fee to realization of energy performance targets one year post-occupancy.[7] The State of Washington is also developing a facility in Olympia with a five-year performance guarantee (Washington 2016). While these projects involve savvy owner-occupiers and design teams, the application of outcome-based requirements will need to expand to address goals to reduce actual, measured energy use. This includes implementation in small buildings and in projects without sophisticated engineering teams.

As identified in the Energy Information Administration's Commercial Buildings Energy Consumption Survey, almost 94 percent of commercial buildings are under 50,000 square feet and account for roughly half of commercial square footage (EIA 2014). A strategy to reduce overall energy use that does not include mechanisms for addressing the energy use of small commercial buildings is destined to have limited effectiveness.

For outcome-based policies to be effective, they must eventually include tools that support utilization by small buildings, buildings with limited budgets or owners with portfolios of similar buildings. Currently, many of these types of projects rely on the prescriptive requirements contained in code or other guidance.[8] Developing tools that look like the prescriptive methods this segment of the industry is familiar with may help drive the widespread adoption of outcome-based policies.

The prescriptive paths in today's codes are largely developed at the individual component level based on the cost effectiveness of higher levels of efficiency of the particular component (which as indicated above is approaching a point of diminishing returns) and not through whole building modeling to support achievement of a particular use level. Other building codes identify

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means for compliance with more performance focused criteria. In general, both the design and construction process and the compliance study process focused on meeting prescriptive criteria. These findings may provide support for the need for prescriptive requirements as discussed in this paper. See https://www.energycodes.gov/compliance/residential-energy-code-field-study.

[6] The New Buildings Institute has been tracking zero energy buildings since 2012 and found a tripling in number of projects between 2012 and 2015. See http://newbuildings.org/resource/names-numbers-2015-interim-getting-zero-status-update/.

[7] See the case study on the Whole Building Design Guide at http://www.wbdg.org/references/cs_fcsb1202.php.

[8] Other prescriptive guidance includes ASHRAE's Advanced Energy Design Guides, https://ashrae.org/aedg and New Building Institute's Advanced Buildings Program, http://newbuildings.org/hubs/advanced-buildings/.

the necessary load values a structure must obtain (regardless of building material chosen) and then develop the prescriptive requirements for each material that would meet that load. Energy codes are developed using almost the completely opposite approach—the capabilities and cost effectiveness of individual components are determined and then specified in the code—without a desired end goal in mind. This results in a wide variation of actual energy use based on the specific components selected. An outcomes approach with prescriptive packages avoids this issue by bundling individual components into packages specifically modeled to meet an energy target. All the components in the package must be implemented to comply.[9] The approach outlined in Appendix A of "Roadmap for the Future of Commercial Energy Codes" may be a methodology for development of such prescriptive packages (Rosenberg et.al. 2015).

As currently conceived, outcome-based codes and policies rely on establishment of a target and then a demonstration that a project met that target at some defined point post-occupancy. Demonstration of meeting the target would be based on utility or metering data. While ultimate compliance relies on meeting the target, the community and the building owner may require a demonstration during the design and construction process that the finished product has the capability of meeting the target.[10]

Achieving Outcomes through Prescriptive Packages

As discussed above, owner-occupied and highly engineered buildings are the most likely to choose an outcome-based compliance path. Expanding the audience for use of such an approach to all building types will help drive achievement of energy use or greenhouse gas reduction goals. Based on the flexible nature of the outcome-based approach, there are likely multiple design, construction and operations strategies that will result in compliant buildings. Small building projects in particular may have trouble identifying an effective strategy given limited expertise or budget.

A prescriptive package "designed to meet" the target accompanied by an effective operations plan could help ease owner and design team concern about meeting an outcome-based target. Of course, these prescriptive packages must be developed with the specific target in mind and with sufficient rigor to satisfy project stakeholders including owners, financiers, insurers, and regulators. This section outlines a potential pathway for development and acceptance of prescriptive packages "designed to meet" the outcome-based targets. A visualization of the parties and processes involved in development and approval of prescriptive packages is provided in Figure 1.

An outcome-based process will take material interests out of the code development process. Such interests would then be reflected in the prescriptive packages where users are more likely to recognize such biases and choose the path to follow accordingly. In addition, the interests would have to be shown to be effective to succeed. With a myriad of compliant designs, prescriptive pathways can be developed by a variety of different organizations. Naturally the organization developing the prescriptive pathway will have its own biases or priorities, but the

[9] Rosenberg et.al. identify the opportunities to advance energy codes through the development of a series of prescriptive packages. This concept is expanded here to couple such packages with an outcome-based target identified in code and a means for verifying the effectiveness of the packages in meeting the target levels.
[10] The current proposal for inclusion in the 2018 International Energy Conservation Code includes such a requirement.

need to meet a defined target will provide a level of fairness and consistency. Potential developers of prescriptive packages include:

- Professional and scientific groups: Groups like ASHRAE have a long history of developing guidance for their members and the industry. Publications like the Advanced Energy Design Guides could be easily transitioned to meet an energy use target.
- Codes and standards developers: ICC and ASHRAE as developers of the IECC and IgCC and Standards 90.1 and 189.1 respectively already have prescriptive content within these documents. As these codes and standards transition to a strictly outcome-based code, the prescriptive provisions could be offered as an appendix or other guidance. The considerable effort put into development of the current code pathways would not be lost.
- Advocacy groups: Within the energy efficiency space, there is a well-developed network of advocacy organizations at the national and regional level. Such groups include the New Buildings Institute, American Council for an Energy Efficient Economy and Alliance to Save Energy and a network of regional energy efficiency organizations. These groups could develop and market prescriptive packages that meet the targets and go beyond the targets. Packages developed by the regional efficiency groups could be specifically focused on unique characteristics of the region.
- Manufacturers or trade groups: To accompany their efforts to promote their products and the potential benefits of a coordinated and integrated approach, an individual manufacturer or trade group could develop prescriptive packages that highlight the effective use of their products.[11] Multiple manufacturers may also team up to develop packages where systems effects and interdependencies are researched and addressed.[12] Even energy suppliers could develop packages based on their specific energy source (electric, gas, renewables, geothermal). This could dampen some of the debate on the metrics ultimately chosen to set targets (site energy, primary/source energy and/or CO_2e).
- Building operations contractors: Building operations contractors understand life-cycle costs and the design choices that lead to efficient building operations. They can translate this information into prescriptive packages as a service for future clients. If they are able to bundle the prescriptive packages with their operational expertise, they can offer guaranteed performance packages which would relieve small building owners from the potential risks under outcome-based requirements. Such an approach could be a precursor to expanded use of design-build-operate-maintain type contracts.

[11] For example, an insulation trade group could develop a prescriptive package that makes extensive use of insulation with corresponding reductions in HVAC equipment requirements.
[12] Manufacturers of HVAC, lighting, fenestration and building management systems could provide a prescriptive package.

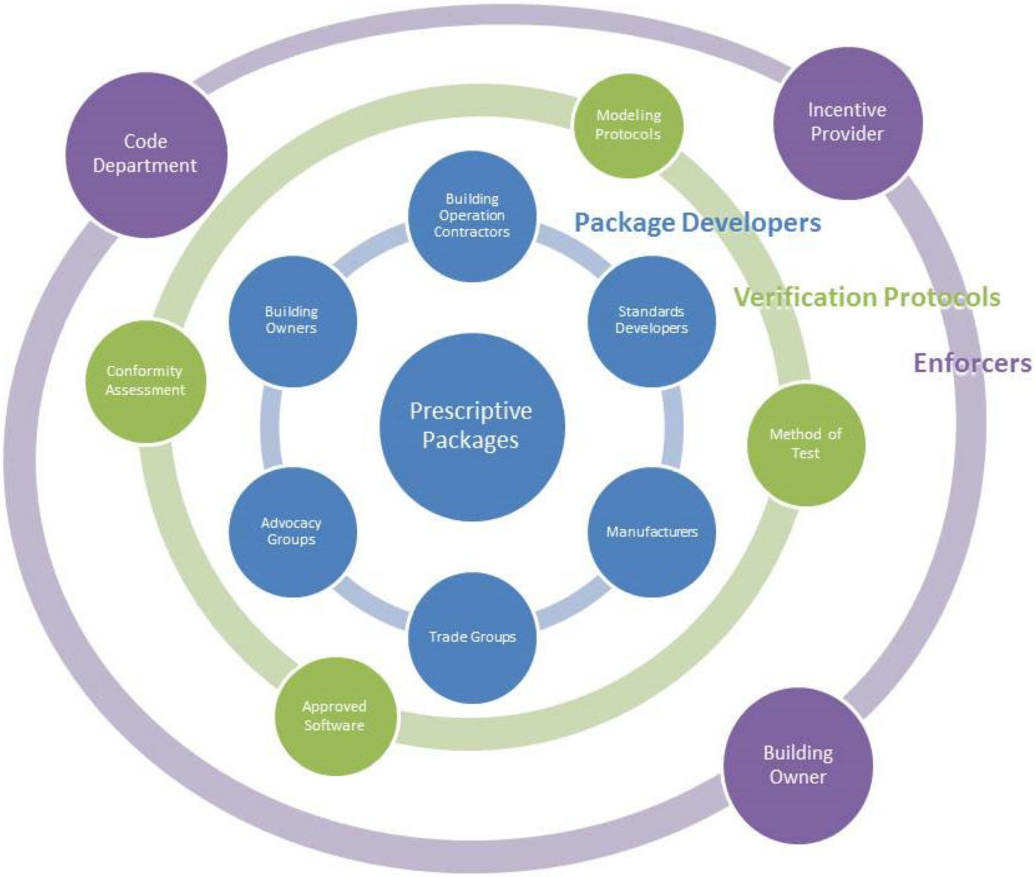

Figure 1: Parties and Processes for Prescriptive Packages

Naturally, any prescriptive package developed will need to be cognizant of required variations across climate zones and building types. The documentation accompanying the prescriptive package must include the assumptions made relative to occupancy and plug loads. This could result in a significant number of packages. A mechanism for tracking the availability and acceptance of such packages will be required. Presumably, the prescriptive package developers will monitor the use of such packages and have the opportunity to track whether projects that have implemented the packages have met the targets. This would be a valuable feedback loop and encourage improvements to the packages over time based on lessons learned.

The prescriptive packages developed under this methodology would not be incorporated into the codes themselves, but the methodology for acceptance would be provided.[13] For example, as an alternative to providing results of a model, the proposed outcome-based compliance path for the 2018 International Energy Conservation Code indicates "the design team shall provide the code official with design documents containing prescriptive requirements for all building systems impacting energy use that are published or certified by an entity acceptable to the code official to meet the relevant [target energy use intensity] requirements (ICC 2016)."

[13] While not covered here, this approach may provide some opportunities to address challenges presented by preemption of certain building equipment under the Energy Conservation and Production Act as amended by the Energy Policy Act of 1992 (42 USC 6297).

While the prescriptive paths will be valuable for the transition to outcome-based codes and policies, their existence alone is not sufficient. Building owners, regulators and even the designers and prescriptive package providers will need some assurance that the prescriptive packages actually have the potential to meet the targets when implemented.

As the transition to outcome-based performance occurs, designers have expressed concerns about their liability when they have little control on how the building is ultimately operated. The availability of prescriptive packages may help alleviate some of this concern as the design is now certified as capable of meeting the target. When accompanied by commissioning and regulatory inspections, the design and construction process will receive some level of assurance that the pieces are in place for a building that can perform as required.

Such assurance will require the development of a new suite of standards and conformity assessment[14] processes. Standards will need to be developed for two specific audiences: the prescriptive package developer and the conformity assessment organization.

Standards for the Prescriptive Package Developer

Presumably, the prescriptive package will be developed through the use of building energy modeling. The modeling process must be well defined to assure consistency, replicability and verification. Unlike current modeling requirements contained in code, the proposed prescriptive package will not be modeled against a baseline building, but rather to determine the ability of the package to meet a target. The modeling process including the defined and variable parameters within the model should be well defined in a standard. This modeling process standard would build off the existing ASHRAE standard on "Standard Method of Test for the Evaluation of Building Energy Analysis Systems" (ANSI/ASHRAE Standard 140-2011) and the current work to develop standards on "Standard Representation of Performance Simulation Data for HVAC&R and Other Facility Equipment" (SPC 205P) and "Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings" (SPC 209P).

The package developer would select a modeling program that meets requirements of Standard 140 and then apply the design for target-based energy performance parameters requirements. The "Design for Target-Based Energy Performance Parameters" requirements could be established within the code or in a separate standard (maybe SPC 209P). Existing work by the Commercial Buildings Energy Modeling Guidelines and Procedures (COMnet) may also be a starting point (COMnet 2011).

Third-party software developers may wish to develop modeling programs (or plug-ins to existing programs) designed specifically for the development of designs for target-based energy performance. Such programs would have the required parameters pre-loaded and only allow input of variable design parameters. As identified by Rosenberg, current tools to verify modeling results for predictive performance have been sparse as the lack of standardization makes it difficult for software developers to keep up (Rosenberg et.al. 2015).

While outside the scope of this paper, improvements in the modeling process including addressing differences between modeling results and actual performance are required. The "Getting to Outcome-Based Building Performance" report discusses the need in greater detail (Frankel, Edelson, and Colker 2015).

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[14] ISO/IEC 17000:2004, *Conformity assessment—Vocabulary and general principles*, defines conformity assessment as "demonstration that specified requirements relating to a product, process, system, person or body are fulfilled."

The code official would use the parameters within the pre-approved prescriptive package as the basis for inspection followed by the verification of energy use relative to the target post-occupancy. Limiting the analytical need by the code department will allow greater focus on the quality of installation of the specified components and the actual energy use in operations.

Standards for Conformity Assessment

The standards for conformity assessment and those utilized by the package developers will need to be well coordinated to assure that the assessment process is smooth and reliable.

Conformity assessment would ideally be conducted by established organizations that perform similar functions relative to building-related codes and standards. Such organizations include Underwriters Laboratories (UL) and the International Code Council Evaluation Service (ICC-ES). The evaluating organizations should be well recognized by designers, owners, manufacturers and code officials to facilitate the utilization of prescriptive packages receiving their approval. These organizations should also provide a means for easily verifying the packages approved by them.

Following verification of the acceptability of the modeling platform used to develop the prescriptive package, the evaluating organization will need to apply a "Method of Test for Verifying Modeling of Designs for Target-Based Energy Use." This method of test must focus on verifying both the acceptance of the model itself (including parameters utilized) and the outputs vis-à-vis the established targets.

Additional Utility of Standards and Conformity Assessment Process

In addition to the ability to establish prescriptive packages, development of a standards and conformity assessment process will provide significant benefit for the expansion of outcome-based performance requirements.

For example, if a designer or owner wishes to assure that a design not based on the prescriptive packages has the capacity to meet the targets, they too can elect to have the design subjected to the standards and conformity assessment process. This could help ameliorate concerns of designers around liability for not meeting the targets.

A methodology for demonstrating compliance or achievement of target energy goals that allows designs to be utilized across multiple facilities could be incredible valuable for owners that construct multiple facilities. Big-box retailers and fast food restaurants could be particularly interested in such an approach. ICC's *Guideline for Replicable Buildings* could be utilized to support such an approach (ICC 2010).

Beyond the targets established in regulation, the process may also be used for targets established by the owner or by incentive programs. Beyond code programs, green building rating systems and efforts to achieve zero energy buildings could incorporate these tools as prerequisites to help advance the linkages between design and construction and operations.

Utilization to meet zero energy building (ZEB) goals may be particularly valuable. As defined by the U.S. Department of Energy, a zero energy building is "an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy (DOE 2015)." If an owner or design team is pursuing a zero energy building, they are likely highly motivated by achievement of the goal and wish to monitor progress during design in meeting such a well-defined target.

Following development of either a prescriptive package or a beyond-code verified design, additional opportunities to achieve building industry goals may also be realized. Off-site construction has been identified as a potential opportunity to address challenges on the availability of a skilled workforce, worksite safety, and sustainability (OSCC 2016). The developer of a prescriptive package may wish to provide additional services including delivering the specified products to the site as a package—this could involve pre-assembly of many of the components. This approach could lead to development of a “ZEB in a Box” where owners could essentially specify specific criteria and then receive a “kit of pieces” to be assembled on-site.

Conclusion

As policymakers, building owners and designers increase their focus on the actual, measured performance of buildings, the availability of guidance to transition to an outcome- or target-based approach for the regulation of building energy use is underway. Expanded guidance will be necessary to help facilitate the transition and address current concerns around liability for the design and construction team and the applicability to small buildings or other facilities where extensive engineering is not possible. Pre-approved prescriptive packages and a mechanism to verify other designs for their ability to meet performance targets will be important.

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