A Radical Proposal: Simplify Codes by Relying on Professional Competence and Outcomes

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ABSTRACT

Energy codes are becoming increasingly complex as they reach toward "net-zero" energy use. However, more complexity does not lead to better results. Over-complexity leads to frustration, increased expense, lack of compliance, and reduced building performance. The construction process is stuck in "design-build" when it must move to "design-build-operate" to learn both how to optimize energy use post-occupancy and how to apply "lessons learned" from actual building operations.

The authors propose a two-part approach to help move toward "design-build-operate." First, replace complex codes with simple codes specifying energy budgets or outcomes. Second, ensure designers, builders, and operators possess the skills necessary to meet the code established targets. The authors focus on one building function, lighting, at the design stage of the building process. Data on building performance post-occupancy are also required to measure both compliance and provide feedback for improvements.

The target established in outcome-based codes and the integrity of the certification system for competency-based certifications are the key issues addressed, on the building- and human performance sides, respectively. The tools required are readily available, at least in lighting. A competency-based global lighting design certification system is in operation, and outcome-based lighting codes are being introduced around the world.

Benefits of such an approach to energy codes include: (1) reduced economic overhead, (2) increased latitude for creative solutions, (3) increased opportunity for systems approaches, (4) achievement of actual rather than theoretical energy use goals, (5) increased feedback loops to support design of high-performance buildings, and (6) adjustments to changes in technology.

I. Introduction

The proposal advanced in this paper is straightforward: huge progress toward optimizing building energy use after occupancy could be made by substituting the competence of design professionals for the detail of prescriptive energy code requirements at the design phase. Assign a building an energy budget (in this case, for lighting), design and build to meet that budget, then measure energy use in the finished building. The energy budget comes from an outcome-based energy code which is detailed in Section II. Disconnects among design, construction and operations lead to uneven results in actual buildings. In addition, data from building operations are not readily available to inform the process of designing, constructing and operating future buildings. We are explicitly not addressing enforcement or implementation, as those are huge separate issues deserving a paper of their own. The combination of how local governments are organized (building departments don't speak to health departments or tax authorities), how utilities are governed, and related issues must be explored and changed to give outcome-based codes a real chance. Instead, our focus is on the question of what could substitute for the increasing levels of detail in today's energy codes?

Increasingly Complex Energy Codes Do Not Lead to Increased Energy Efficiency

To date, most regulatory programs, green building rating systems, utility and government energy efficiency programs and other efforts to advance energy efficiency have focused on design and construction. While criteria influencing building design are important for setting up the long-term performance of a project, they do not automatically assure that the intended performance is achieved. This is illustrated in a study conducted by the New Buildings Institute of buildings designed to achieve certification under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program. (Turner, 2008; Turner 2011) The study found that the measured energy use intensity (EUI) was often not well correlated with expected savings based on design and pre-construction modeling. Figure 1 illustrates the findings from that study. The discrepancies between observed results and expected performance may mean that the modeling done to predict the projects' performance was inaccurate, they may mean that the projects were not constructed according to the plans used in the predictive models, or they may have other causes. The one clear conclusion from the graphic in Figure 1 is that predictive models often are not very predictive of actual performance.

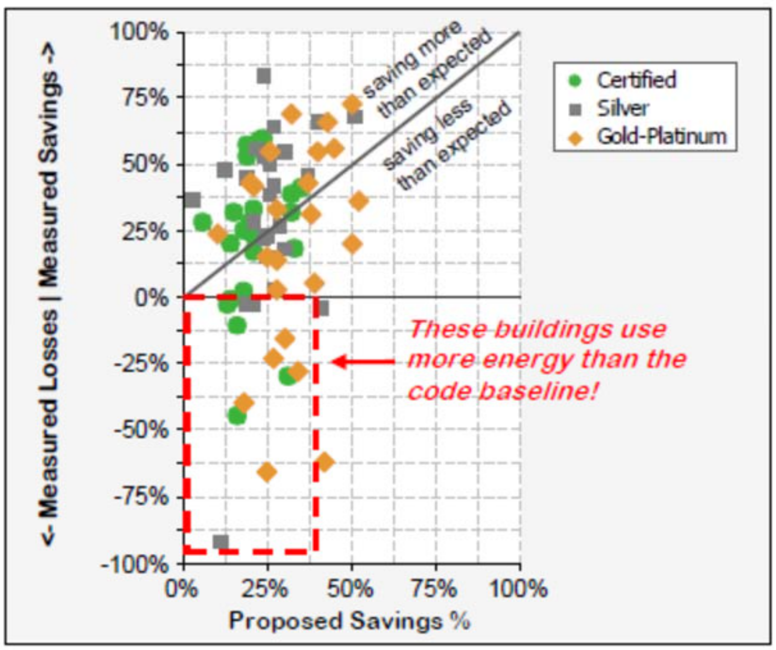

Figure 1: Measured versus Expected Savings Percentages (NBI 2008)

Energy codes are becoming increasingly complex as policymakers and others continue to utilize prescriptive methods and add new requirements to make them more stringent. The fact that most energy codes have only included a select set of criteria[1]—and leave out several of the components contributing to overall energy use—places undue focus on increasing the efficiency

[1] For example, prescriptive-based codes generally do not address building massing, shape and orientation.

of this limited subset of parameters. The current approach also tends to discount the impacts of system level effects due to interactions among components and systems (ASE 2016).

High Performance Buildings Require a Coordinated Approach to Design, Construction and Operation

Coordinated new efforts are needed to realize energy efficiency goals for buildings. There are disconnects at all stages of the building process, and among the most severe are the disconnects between the energy efficiency goals of design and the actual performance of buildings after occupancy. Buildings have a life-cycle—from initial concept through demolition or deconstruction. To date, discrete points in a building's life have been shepherded by specialized disciplines with specific requirements for each stage, with little requirement or incentive to look at the whole building throughout its life cycle.

The concept of looking holistically at a building's performance across its life-cycle is encapsulated in the concept of a high-performance building.[2] This high-performance building concept has been identified as a transformational opportunity for the design, construction and operation of buildings by Congress and groups like the National Institute of Building Sciences and the High-Performance Building Congressional Caucus Coalition.[3] However, efforts to optimize have been confined to individual disciplines and discrete segments of the building life-cycle.

Realization of Sustainability Requires Performance Measurement—Data Speak

Building performance benchmarking and disclosure ordinances are being established in communities across the country to expand access to building performance data and drive improvements in energy use through market forces or other tools.[4] Communities could also use such data to support verification of progress under initiatives to reduce greenhouse gas emissions through a climate action plan, the state's response to the Environmental Protection Agency's Clean Power Plan under section 111(d) of the Clean Air Act or for "80-by-50" initiatives.[5]

Communities and building owners have also identified goals to achieve zero energy buildings (ZEBs) throughout the building stock or their portfolio by a defined date. However, as identified by the U.S. Department of Energy (DOE), achievement of a ZEB relies on the building's ongoing operation—which is not effectively captured in today's codes. DOE defined a ZEB as, "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 (U.S. DOE, 2015)."

Interest in connecting performance data to code requirements is also growing. Seattle implemented a target performance path in its Energy Code in 2012 (Seattle, 2012). An outcome-

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[2] The U.S. Congress defined a high-performance building in the Energy Independence and Security Act of 2007 as, "a building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations." (U.S. Congress, 2007)

[3] A coalition of over 200 building industry organizations who support policy and advocacy activities to advance achievement of high-performance buildings. See http://www.hpbccc.org.

[4] See BuildingRating.org, http://buildingrating.org/.

[5] See "Regional leaders from around world sign pledge to reduce carbon pollution," *Washington Post*, https://www.washingtonpost.com/national/health-science/2015/09/24/8a766b50-6317-11e5-b38e-06883aacba64_story.html.

based compliance path was accepted into the 2015 International Green Construction Code (IgCC) (ICC 2015). A proposal is pending for inclusion in the 2018 International Energy Conservation Code, and the project committee developing ANSI/ASHRAE/USGBC/IES Standard 189.1-2017 is considering including an outcome-based compliance path.

Work is also underway by the National Institute of Building Sciences and the New Buildings Institute (NBI), with support from the U.S. Department of Energy, to map a coordinated process that cities can use to implement a comprehensive program to address energy use across the entire life-cycle of a building. Such an approach will require programs that address both pre- and post-occupancy requirements including building codes, commissioning, benchmarking and disclosure.

II. Traditional And Outcome-Based Building Energy Codes

Traditional building energy codes offer two main paths for compliance: the *prescriptive* and the *performance* paths. Outcome codes incorporate post-occupancy measurement of actual energy use. The traditional prescriptive path involves compliance with specific requirements at the level of building components and systems, such as electric lighting at the luminaire or lighting circuit level, occupancy and photo sensors and operation specification of controls in terms of timing and energy reduction. The performance path allows deviation from the prescriptive requirements as long as the resultant energy requirements meet or are less than those of a building that has the same arrangement and geometry of spaces, with all covered systems (envelope, electric lighting and HVAC) meeting the minimum prescriptive requirements. Both prescriptive and performance paths rest solely in the realm of design and construction with no mandated data collection or feedback system.

Outcome-based building energy codes are similar to the performance path of traditional energy codes, with one significant difference. Just like the performance path of traditional codes, they are free of any prescriptive requirements, giving complete freedom to building designers. Compliance, however, is shown by meeting or beating an *annual energy budget*, in the building's actual (i.e. measured) operation. The energy budget can be for individual spaces, zones or the whole building, for individual energy consuming systems, such as lighting and HVAC, or the building as a whole. The key difference is that in outcome-based codes, compliance is shown through measured performance of the building after it is built, rather than the theoretical potential of the performance path of traditional codes, which does not guarantee that the expected energy performance will be realized.[6] As noted in the Introduction above, predictive modeling results frequently differ, sometimes dramatically, from actual performance.

Considering lighting as an example, traditional codes are based on lighting power density standards for different space types, and may require controls that adjust lighting levels based on occupancy and daylight availability. Envelope requirements focus on window and skylight requirements and characteristics, such as window-to-wall ratio and visible and solar transmittance. The performance path uses an approved computer simulation software that simulates the energy performance of the proposed building, as well as the "base building", i.e., the same spaces and geometry, but modified to meet all minimum prescriptive requirements.

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[6] http://h-m-g.com/Projects/Photocontrols/Final%20Report%20Sidelit%20Photocontrols%20including%20Errata%20031406.pdf

Unlike the performance path in existing codes, outcome-based codes do not use a "base building." Rather, they use lighting energy budgets for each space type within the building. These budgets are also based on installed power density and also account for energy savings from controls based on occupancy, daylight availability and good operations. The savings are expressed in the form of adjustment factors, which take into consideration expected occupancy patterns for different spaces, as well as daylight availability for different geographic locations.

Outcome Codes Account for All Energy Use

Outcome-based codes account for all energy associated with the building and its systems, including additional energy consumed by control systems such as sensors, processors and actuators, as well as energy consumed by emergency lighting, such as charging of batteries. Outcome-based approaches, such as the U.K.'s Lighting Energy Numeric Indicator (LENI)[7], also account for controls for lumen maintenance, as well as institutional and personal lighting tuning, which makes them suitable for application in remodeling and retrofit projects, where one-to-one luminaire replacement usually results in higher light levels, which can be tuned down.

Determining the maximum energy budget for different spaces, buildings and locations is at the heart of outcome-based codes. It can be done either based on statistical information about existing buildings (e.g., Commercial Buildings Energy Consumption Survey (CBECS)[8]) or through computer modeling, as in the performance path of existing codes, considering different combinations of design and context parameters. The latter approach involves assumptions, which are equivalent to the prescriptive requirements or traditional codes for the determination of the base case building in the performance path of traditional codes. Most of the required work however, is performed by the code developers rather than the building designers, which makes the life of the latter much easier and leaves them with plenty of time to focus on innovative design approaches.

Outcome Codes Provide Data for Compliance, Operation and Continuous Code Improvements

Outcome-based codes are simpler to understand and can be easily adjusted to better reflect changes in strategies and technologies over time, through simple adjustment of the energy budgets. Verification of compliance is also very straightforward, which is a very significant advantage of the outcome-based codes compared to traditional codes. While traditional codes assume that the predicted energy savings will happen, outcome-based codes focus on realizing them.

The success of outcome-based codes relies on accounting for energy use during building operation. While energy consumption at the building level is effectively measured by utilities, today's digital systems and controls allow submetering of energy consumption for individual systems, such as lighting, cooling, heating and even plug loads, which can also be effectively considered in outcome-based codes. Since the determination of energy budgets is a function of location, energy budgets can be fine-tuned to match the reality of different countries, states and even cities for localized energy codes. This customization of energy budgets based on the same

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[7] http://www.iar.unicamp.br/lab/luz/ld/normas%20e%20relat%F3rios/en_15193-1_energy_requirements_for_lighting.pdf

[8] http://www.eia.gov/consumption/commercial/

conceptual model makes outcome-based codes much easier to shape to meet the reality of different locations and also of different projects, such as construction of new buildings and retrofit of existing buildings.

Outcome-based codes have the potential to improve performance over time, as the actual performance of buildings will continuously inform effective adjustment of energy budgets based on real data as opposed to assumptions, which traditional codes rely on. Outcome-based codes are also very compatible for use in codes requiring ZEBs, as they focus on the actual annual building energy consumption. To reiterate a key theme of this paper: use outcome-based codes to eliminate prescriptive detail and allow creative solutions to complex problems in building design and operation.

III. The Role of Human Competence in Producing Optimum Buildings

Of course, removing prescriptive detail from energy codes increases reliance on the competence of the humans who are responsible for conceiving, designing, constructing and operating buildings.

To realize potential energy savings, it is necessary to take an integrated approach during building design. In the transition to include such approaches in energy codes, building owners and communities are likely to have concerns about the ability to actually deliver on energy budgets with a decreased level of regulatory-level guidance. Competency-based credentialing involves an appropriate third-party mechanism that provides a level of assurance that the design team will deliver on such requirements. Outcome-based approaches provide multiple benefits that cannot readily be incorporated into traditional codes through allowing flexibility to achieve compliance most cost effectively. Achieving outcome-based targets rests on the ability of the design team to develop multi-factor strategies that optimize building systems' performance. At the same time, these systems must be installed as conceived and commissioned and operated according to the design. Each step requires a high and verifiable level of human competence.

At present, we generally define a complex rule-set (prescriptive or performance paths), expect individuals (designers) to utilize that set, and ask different individuals (plan checkers and inspectors) to determine whether the rules have been followed. Still another set of individuals (construction team) must turn the plans into the actual building. Finally, additional sets of individuals (commissioning agents and building operators) must attempt to calibrate and maintain complex systems to make them work as expected. The training, certifications, and skill levels of all the individuals involved are often not matched to the requirements of ever-changing codes. The result is uncertainty about compliance rates and continuing efforts to improve training and skills of designers, code officials, and builders (Bartlett 2016). As an alternative, individuals' overall competence can be certified through a well-designed credentialing system at lower overall economic cost while also taking qualitative aspects of each profession into account.

Note that for an outcome-based code system to be effective and use minimum necessary resources, each phase of design, construction, operation, and measurement of a building and its performance should be directed by competent professionals. The separate tasks of the different disciplines produce data that inform the work of other disciplines, extending the "design-build" paradigm to a more effective "design-build-operate" paradigm.

Certification programs also bring requirements for continuous learning and re-certification. With competency focused certifications and their re-certification requirements, professionals will be encouraged to learn from the successes and failures of past projects—thus establishing important feedback loops on life-cycle building performance that are largely lacking in today's design community as fee structures and contracts limit connections with a project post-occupancy. Long-term involvement in building operations post-occupancy is important to supporting a shift to a design community focused on delivering high-performance facilities. Certified professionals will also need to keep apprised of changes in technology and practice to maintain their ability to demonstrate competence. These expected benefits correspond to items 2, 3, 4, 5, and 6 in the enumeration of benefits outlined at the beginning of this paper.

Among professions concerned with the built environment, competency-based certifications are becoming increasingly common. At the commissioning and operating end of the building process, the CCP (Certified Commissioning Professional) designation created by the Building Commissioning Association and the CFM (Certified Facility Manager) credential created by IFMA (International Facility Management Association) are prime examples. Site-level professions including project managers (CPM designation) and most construction trades include competency-based designations of proficiency. In recent years, such sub-specialties as lighting controls installation have also been advanced and made more reliable through competency-based certifications, such as the California Advanced Lighting Controls Training Program (CALCTP). In the design arena, the experience requirements of most licensed professions (e.g., architecture, engineering) ensure some degree of performance proficiency.

Example: Certified Lighting Designer (CLD)

The CLD (Certified Lighting Designer) credential extends the idea of competency-based credentialing to architectural lighting design, and is presented here as an example of the development and operation of a competency-based credentialing system.

The CLD, introduced in 2015, was developed by a task force assembled by the International Association of Lighting Designers (IALD) that included lighting designers and architects from around the world. The task force followed established and approved best practices (ANSI and ISO 17024) for the development of certification systems. The result is a performance-based certification encompassing seven "Domains of Practice" verified through "the implementation of an online application system that allows practitioners across the world to submit artifacts and attestations of authenticity."[9] The practice domains constitute a set of universal standards for the practice of lighting design. They are:

- Goals and Outcomes–Create a lighting concept that satisfies project requirements and design intent so the solution performs as predicted.
- Collaboration–Interact with other disciplines by serving as an integral member of the team.
- Ingenuity–Contribute ideas that demonstrate innovation, creativity, originality, imagination, or resourcefulness to foster the goals of the project.
- Synthesis–Integrate technical and aesthetic elements of lighting with space and form.
- Science–Apply principles of light to meet project relevant technical criteria.

[9] Dr. Judith Hale, Hale Associates, personal communication. Dr. Hale, a psychometrician with a practice focused on human performance improvement and development of certification systems, was lead consultant to the CLD task force throughout the development of the CLD.

- Stewardship–Insure that lighting responds to known and potential environmental impacts (including energy efficiency).
- Human Experience–Design lighting solutions that positively affect people.[10]

In a field with an ambiguous body of knowledge and practice boundary, such standards help clarify the value added by practitioners, as well as verifying the proficiency levels of individuals in the domains. Extensive testing and validation efforts proved the reliability and validity of the CLD before its public release.

CLD candidates must prove eligibility: at least three years' experience as a lead architectural lighting designer, where "lead" is carefully defined.[11] CLD candidates complete an online application that specifies exhibits of appropriate evidence of proficiency for each domain of practice. The evidence, depending on the domain in question, may include attestations from clients or project managers, along with plans, sketches, photographs and compliance documentation. Applicants must submit evidence from at least two unique project types (e.g., commercial, cultural, hospitality, etc.). Applications are anonymized and reviewed by trained, recognized experts. Reliability and consistency are maintained through extensive training of these judges using rubrics and markers that characterize successful exhibition of the skills required in each practice domain. Successful candidates must re-certify every five years.

The CLD exemplifies several trends in credentialing: it is evidence-based, it is global, it was developed by practitioners, and it includes a set of broad competencies related to the practice of the profession. "Evidence-based" means that no particular training or academic curriculum is required to earn the credential; it is based on actual professional achievement. "Global" means that the CLD will be recognized across national boundaries, important in an almost borderless profession. "Practitioner-developed" means that the CLD includes the highest standard of current practice in the profession. The set of broad competencies included in the CLD helps ensure that practitioners have demonstrated that they are able to apply knowledge and see projects through to completion.

A competency-based credentialing system can incorporate qualitative as well as quantitative aspects of practice. In the case of lighting designers, certified practitioners are more likely to meet net-zero targets than other types of practitioners, while also maintaining quality, architectural value, and meeting human needs. In lighting, this balance can be expressed as an optimum point maximizing important considerations in all three areas as illustrated in Figure 2.

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[10] CLD Candidate Handbook, 2015

[11] "Lead Lighting Designer" is defined in the CLD Candidate Handbook (see Appendix) as one who is responsible for:
• Creating the lighting design strategy and crafting the lighting design concepts for client projects
• Documentation related to the design solutions of the project
• Conveying and exchanging ideas with the client and the project team
• Meeting project design deadlines
• Providing advice throughout the implementation process
• Guiding the outcome of the developed and documented design

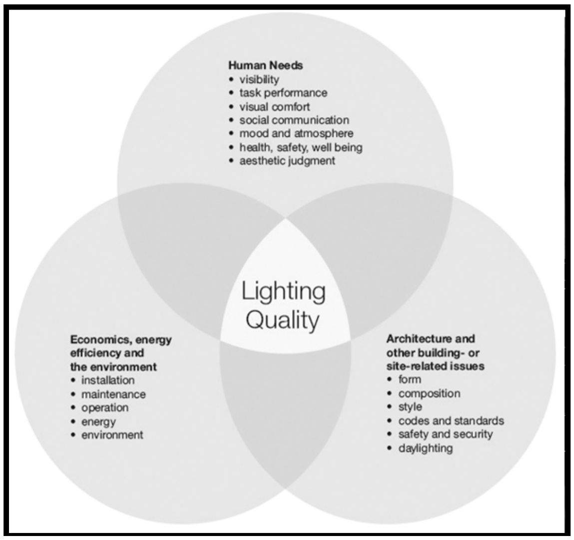

Figure 2: Three Dimensions of Lighting Quality (IALD 2010)

In short, CLD holders know what they are doing, which is associated with superior performance (Mellinger and Samla, 2013). In addition, the CLD removes "information asymmetry" (World Bank, 2010); it provides clients, employers, owners and code reviewers with assurance that the holder knows what he or she is doing. Other competency-based certification programs incorporate similar mechanisms to remove information asymmetry and verify performance capability. Providing assurance of competence is vital because most fields include knowledge and practices that are not accessible to non-practitioners. Just as medical doctors use skills that most of us cannot personally judge, design and engineering professionals generally must apply skills that most of us—even professionals in other design fields—cannot personally judge.

IV. Conclusions

Outcome-based codes together with reliance on the competence of individual practitioners at each stage of the "design-build-operate" building life-cycle offer the most effective path towards realizing the net-zero energy vision for buildings in the U.S. and elsewhere.

Outcome-based codes offer much more latitude to practitioners than common prescriptive code paths in order to facilitate solving unique problems of unique buildings and spaces. They are tied to actual energy use rather than likely use based on assumptions and expectations for the building construction and operation. The most important issue in establishing outcome-based codes is setting benchmarks and energy budgets for space types or other comparative factors. Experience from national and international efforts suggests that these parameters can be readily established.

Competency-based certification systems offer a straightforward way to ensure practitioners have the required knowledge and experience to be effective in realizing the expected outcome. Certification systems are becoming more common among fields at all stages of creating and maintaining the built environment. The challenge is in verifying the level of proficiency and the relevance of demonstrated competencies offered by practitioners. The CLD (Certified Lighting Designer) credential is offered as a model of a certification system that ensures a high level of proficiency by its holders in truly relevant skills. A competent practitioner will be able to design to an energy-use budget or similar outcome measure of energy use while maintaining a balance of energy considerations with considerations of occupant comfort and productivity as well as esthetic, architectural and economic considerations.

The benefits of this emerging approach to energy codes include: (1) reduction of the economic overhead associated with complex rule-sets, (2) increased latitude for creative and integrative solutions to design problems, (3) increased opportunity for systems approaches to meet user needs, (4) actual rather than theoretical achievement of owner and community energy use goals, (5) increased feedback loops to support design and operation of high-performing buildings, and (6) rapid and simple adjustments to changes in technology.

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