OUTCOME-BASED ENERGY CODES: CALIFORNIA BEGINS ADVANCING A NEW PATH TOWARD GRID OPTIMIZATION AND DECARBONIZATION

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ABSTRACT
California's Building Energy Efficiency Standards, Title 24 Part 6, have been an integral part of the state's energy efficiency landscape, contributing to a stable energy-efficient supply-demand contour that has helped California weather market disruptions and changing load profiles.

These standards have also been extremely influential in the development of other energy efficiency code frameworks. Today is an ideal time for continued standards evolution as a means of helping achieve California's ambitious climate and decarbonization goals, as well as its vision for a smarter, more integrated, and more resilient electricity grid.

An outcome-based code (OBC) relies on realistic, agreed-upon energy use intensity (EUI) budgets instead of connected load calculations, overly prescriptive requirements, and project-by-project complex modeling, *and* also measures compliance through the reporting of actual energy performance outcomes of the building post-occupancy. An OBC approach offers great promise to close the gap between claimed or anticipated energy savings and actual realized savings.

Further, OBC offers building design, construction and operation professionals more flexibility to adopt technologies and solutions that meet functional and aesthetic goals, rather than expending large amounts of creative capital "designing to code."

This session explores the need for outcome-based codes as well as collaborative efforts underway to develop a pragmatic, sustainable, "future-proof" OBC framework. The session also examines learnings from "early adopting" jurisdictions and explores how these combined efforts may shape the energy management marketplace for the foreseeable future. Finally, the session explores how design and energy management professionals may find emerging opportunities beyond their traditional spheres of influence related to building performance and integrated grid operations.

WHY AN OUTCOME-BASED CODE FOR CALIFORNIA?

California Energy Alliance and the Outcome-based Code (OBC) Initiative

In 2018, the California Energy Alliance (CEA) launched the Outcome-based Code Initiative to advance a paradigm shift in building energy policy in California and support the State's ambition to decarbonize and electrify the buildings sector of the economy. Since then, CEA has been working closely with the California Energy Commission (CEC), the Investor-owned Utilities (IOUs), and other interested stakeholders to drive development of a pragmatic, environmentally and economically sound outcome-based code methodology for California. [1]

CEA is a member-based, non-profit organization committed to smart, sustainable energy use in the built environment. Uniting representatives of many varied organizations to address concerns and affect change, CEA actively participates in code change proposal development for the CA Building Energy Efficiency Standards, Part 6 of Title 24, the State Building Code whose regulations govern the design, construction, and operation of buildings in California.

CEA works to improve California's energy future by focusing on the promotion and realization of the deep energy savings possible with new strategies and methodologies, sustainable energy generation, and building to grid integration.

To further the State's mission of energy reduction and improvement of efficiency models, CEA is looking to outcome-based code to provide a means for realizing deeper energy savings and achieving more robust and future-proof energy policy in California.

What is an Outcome-based Energy Code?

Outcome-based codes are a new breed of code that incorporate compliance strategies which measure the actual energy usage of a building over a period of time. The term "outcome-based" refers to the fact that compliance is linked with the actual energy outcomes for a building, and energy usage must be measured post-occupancy and commissioning for a period of time, perhaps a year. Outcome-based compliance could be accomplished by setting energy use intensity (EUI) targets for buildings according to agreed-upon characteristics, such as putting smart meters on all building circuits to measure energy consumption in real time, and reporting out to an entity that would determine if the number (i.e., perhaps in kBtu/sf/yr) meets the performance requirements for that building type and complies with the standard. Outcome-based codes could also be more comprehensive and include energy allowance packages for safety or emergency building system operation. [2]

Outcome-based codes differ significantly from traditional energy codes. Typically, traditional energy codes feature two compliance pathways: a prescriptive method and a performance method. The former is typically used for smaller buildings and retrofits, levying numerous functional requirements with which each building system (e.g. lighting, HVAC, building envelope, etc.) must comply. The building inspector of an Authority Having Jurisdiction (AHJ) must confirm in the field that each requirement is met and that the building complies with code. The performance method uses comparative building energy modeling (BEM) to anticipate the energy loads for a proposed building. It is typically utilized for large projects due to the cost of the energy modeling and expertise needed to provide the energy simulation of the whole building and its systems.

Second, the reach of traditional energy codes ceases at the certificate of occupancy as there is no post-occupancy mechanism to assess energy performance for the remainder of the building lifecycle. In California and other states with energy codes, compliance is measured as part of the final inspection that results in issuance of the certificate of occupancy for a new building, or as part of the inspection conducted against a permit for an alteration or addition to an existing building.

Third, traditional energy codes focus primarily on the energy needed for occupant comfort and productivity (e.g., power for lighting and HVAC systems). Process loads are largely unregulated and contribute significantly to overall building loads. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) defines 'process energy' as "manufacturing, industrial or commercial processes not related to the comfort and amenities of the building's occupants." [3]

DRIVERS OF OUTCOME-BASED POLICY

In considering the California Building Energy Efficiency Standards and the building design and construction landscape, CEA believes there are at least four market trends driving the desire and need for an outcome-based energy code in California. These trends are: (1) California's ambition to be carbon neutral; (2) complexity and prescriptiveness in the current code; (3) the gap between claimed energy savings and actual savings given current code structure and compliance; (4) connected building system innovation; and (5) the increasing importance of the health and wellness of building occupants. All these drivers interact with each other and can be addressed and/or mitigated by migrating to an outcome-based energy code in California.

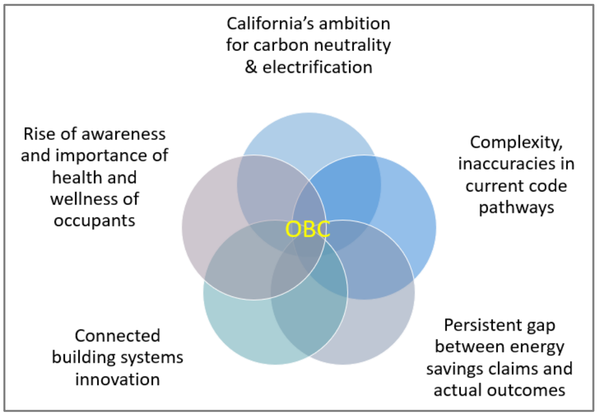

FIGURE 1: DRIVERS OF OUTCOME-BASED CODE

California's Ambition to be Carbon Neutral

In California, the 5th largest economy in the world, there is a unified vision to reduce carbon across all three sectors of the economy – buildings, transportation, and power. All sectors are charged with reducing greenhouse gas (GHG) emissions in the State to 80% below 1990 levels by 2050 by Executive Order S-3-05 (2005). [4]

This is a shift in focus from energy consumption (e.g., zero net energy) and energy efficiency to reducing carbon and becoming carbon neutral by eliminating fossil fuels and embracing electrification by renewable sources.

California will leverage Integrated Distributed Energy Resources (IDER) as part of its economic plan to accomplish carbon reduction. IDERs include energy strategies such as community solar, rooftop solar, microgrids, demand response, combined heat + power in buildings, electric vehicles, electrical and thermal storage, and battery storage. [5]

California has enacted a clean power and electrification pathway with three pillars: 1) de-carbonize the electric power sector, 2) Electrify transportation, and 3) electrify buildings. Electrification of buildings means achieving net zero energy buildings powered by electricity from renewable sources. [6]

A study by the California Council on Science and Technology, "California's Energy Future – The View to 2050" found that California can achieve emissions roughly 60% below 1990 levels with technology largely known today if it is rapidly deployed at aggressive rates. The Study identified key actions that can feasibly reduce California's greenhouse gas emissions to roughly 150 metric tons of carbon dioxide equivalent per year by 2050. Several of the key findings and recommendations were especially relevant for building energy codes development:

- Aggressive efficiency measures for buildings will dramatically reduce per capita energy demand

- Aggressive electrification by renewables and avoiding fossil fuel use where technically feasible
- Developing zero-emissions load balancing approaches to manage load variability [7]

Complexity and Inaccuracies in Current Code

There is no doubt that California's current energy code is indeed complex. The 2019 Energy Efficiency Standards adopted last year, and which become effective January 1, 2020 include:

- 325 pages of Standards (Title 24, Part 6, and associated administrative Regulations in Part 1) for residential and nonresidential buildings
- 39 separate compliance forms for nonresidential new construction
- 746 - page Compliance Manual for nonresidential construction
- 514 - page Compliance Manual for residential construction

The complexity stems, in large part, from the strategy employed since the 1970s to garner energy savings: layer new energy saving requirements over the previous code cycle's requirements while increasing the stringency of existing code requirements.

For instance, there are two primary facets of prescriptive requirements for the installation and operation of lighting systems in commercial buildings: (1) installed lighting power and (2) lighting controls. The power allowed for lighting installed in each space type is regulated in watts per square foot. The resulting lighting power density (LPD) is determined by a calculation incorporating the Illuminating Engineering Society (IES) recommended light levels for the space type, the room geometry and surface conditions (reflectances), and several assumptions including source efficacy, light loss factors, and room surface dirt depreciation factors. In addition to complying with installed lighting power, the lighting design must also incorporate all mandated controls and their required functionality.

An open plan office design in compliance with the 2019 Building Energy Efficiency Standards requires:

LPD = 0.6 w/sf AND

These lighting controls with numerous functional aspects:

- Manual Area Controls
- Multi-level (dimming) Controls
- Automatic Shut-Off Controls
- Automatic Daylighting Controls [8]

And other controls required (this control is often provided by the lighting system):

- Demand Responsive Controls
- Plug Load Control (Circuit Controls for 120-Volt Receptacles) [9]

On the performance side, the required energy modeling is complex and expensive, as the performance path requires modeling of all the above-described requirements of the prescriptive path.

Connected Building System Innovation

California was the first state to implement minimum energy efficiency standards in 1974. For many subsequent code cycles, adding additional requirements independently proved an effective strategy to improve energy efficiency outcomes. This approach coupled with significant efficacy improvements in LED technology (more light for less watts) resulted in major boosts in efficiency and energy savings. Layered, prescriptive code requirements worked well when building systems were simple and straightforward, solutions were predominantly room-based (stand-alone), and components lacked embedded intelligence.

Now, as the digital revolution enables interconnected, intelligent systems and devices, this legacy code approach poses a significant burden. The disruption to design and practice encompasses technology delivery as well as implementation because the digital revolution is about connecting devices together, leveraging synergies, and creating ecosystems.

Current code is unable to accommodate new system-based strategies and innovations. For instance, the controls mentioned earlier in the 2019-compliant open office design might also include functionality such as wayfinding, asset tracking, color tuning, and other capabilities that contribute to energy consumption but are difficult to model. Moreover, the gap persists between anticipated building performance and actual performance.

An OBC approach supports building innovation by reframing building energy policies around robust energy budgets and away from complex, functional requirements. OBC supports the development of the next wave of systems – systems that balance automated behavior with personalization – which deliver on new IoT propositions.

OBC also creates an environment for new methodologies in which building professionals can characterize energy usage within a comprehensive integrated system, where component or sub-system functionality is harmonized and optimized. A key assumption of holistic system design is the inherent energy savings possible due to the optimization of inputs and processes and that losses can be mitigated. Integration of sub-systems (lighting, HVAC, building services, etc.) into the whole building ecosystem continues to advance; OBC, with its basis in realistic energy budgets that are measured post occupancy, may accelerate this development.

Outcome-based code policy can also accommodate new technology/IoT models, such as the shift from preventive to predictive maintenance (e.g. automated fault detection and diagnostics) in building automation and HVAC controls that is on the horizon [10].

Increasing Importance of the Health and Wellness of Building Occupants

Another driver of outcome-based energy policy is the awareness and importance being placed on health and

wellness of occupants of buildings – from offices to schools to healthcare settings. [11] Forty-nine percent of building owners are willing to pay more for buildings demonstrated to have a positive impact on health. [12]
Responsible investing is on the rise, with today's investors increasingly looking to environmental, social, and governance (ESG) performance when making investment decisions. Health and wellness is becoming just as important as energy usage considerations. Non-energy benefits (NEBs) such as human circadian system support, productivity, comfort, alertness, wellness, and personalization are beginning to drive outcomes in sustainable design. More real estate developers, more building owners, and more designers are considering building labeling programs such as the WELL building standard and Fitwel to achieve health and wellness outcomes for buildings alongside sustainability and energy efficiency outcomes.

DEFINING AN OUTCOME-BASED CODE IN CALIFORNIA

Challenges

Some of the challenges involved with developing an OBC in California hinge on the existing regulatory structure in the state – the Warren Alquist Act and the fact that energy code policy concludes with the final certificate of occupancy. Research is ongoing to determine the needed regulatory and legislative modifications to promulgate an energy code that extends compliance post-occupancy. Another challenge is related to energy modeling; currently comparative building energy modeling is used for code compliance; OBC necessitates the need for predictive building energy modeling. Other challenges include how changes in occupancy impact OBC-based compliance as well as the optimal smart energy use intensities and determine underpinning assumptions.

DEVELOPING A SUSTAINABLE, "FUTURE-PROOF" OBC FRAMEWORK

CEA Approach

To develop a sustainable and 'future-proof' OBC framework, CEA's Initiative has initially focused on foundational aspects, including a comprehensive review of adoption pathways, compliance and enforcement needs, and exploration of the necessary steps needed to enable a practical, statewide OBC program. Recent activities have resulted in an initial roadmap toward next steps, including necessary research, further outreach and collaboration with stakeholder organizations, engagement with jurisdictions already experienced in OBC, and identifying the pathways toward marketplace consensus necessary for ultimate adoption and implementation.

CEA Initiative: Working Groups and Topics

The CEA Initiative's volunteer base is organized into four workstreams each covering a broad aspect of the development and research needed to successfully implement an OBC in California. Timelines and deliverables have been established for the working groups which center around four key aspects: external research; technical analysis, methodologies, and implementation; validation projects and demonstrations; and policy, legal, liability, and enforcement analysis.

CEA Initiative: Learnings from Early Adopters

Two U.S. cities, Seattle and Boulder, and one international city, Singapore, have implemented outcome-based pathways in their energy regulations. Other valuable sources of expertise on energy codes include The National Institute of Building Sciences (NIBS), New Buildings Institute (NBI), and American Council for an Energy-Efficient Economy (ACEEE). NBI has published a guidance document for cities considering outcome-based code. [13]

CEA Initiative: Identifying Core Values of an OBC Approach for California

Over the past year, the CEA Initiative has conducted numerous workshops and webinars to develop consensus among its stakeholders and subject matter experts on core values or aspects of an OBC approach for California. These include: (1) metering of circuits; (2) actual measurement and reporting of energy usage post-occupancy; (3) predictive building energy modeling to develop EUI budgets by building application type; (4) formalized way of dealing with change in occupancy; (5) retro-commissioning during the building lifecycle after initial compliance certification; (6) system of incentives and penalties for compliance; and (7) enhanced regulation of process and miscellaneous energy loads.

CEA Initiative: Achieving Consensus on Remaining Characteristics

While the CEA Initiative has achieved consensus on a number of topics, others are still being discussed and debated, and some will likely be tested as part of validation projects. Characteristics in this group include: (1) smart metering of all circuits; (2) metrics; (3) assumptions underpinning EUIs; (4) decoupling the OBC from the building code; and (5) flexible loads / building response to dynamic utility pricing.

CEA Initiative: Code Adoption Proposed Timeline

The CEA recognizes that successful implementation of an outcome-based code in California is a long-term, massive effort. CEA favors a "glide path" approach to adoption in three stages that would take place over three code cycles, 2022, 2025, and 2028 respectively.

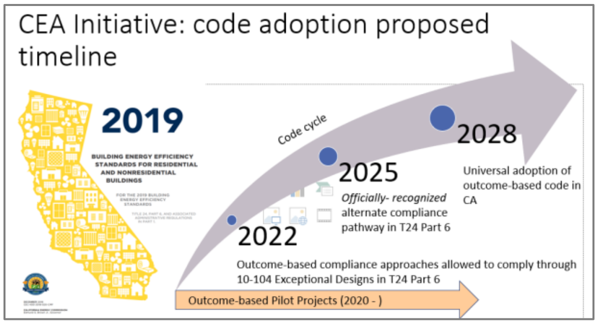

FIGURE 2: GLIDE PATH FOR OUTCOME-BASED CODE IMPLEMENTATION

CEA is preparing a code change proposal for Title 24-2022 that would allow outcome-based compliance approaches through §10-104 Exceptional Designs. In the 2025 cycle, CEA would propose an officially implemented alternate outcome-based compliance approach in Title 24, and in the 2028 cycle, would propose universal adoption of an outcome-based code, the result of a thoroughly vetted approach pilot projects, replacing both the current prescriptive and performance compliance pathway to become the sole compliance mechanism allowed in the State.

In addition to establishing a plan and goals, this CEA approach offers two key benefits. It allows time to validate the effectiveness of OBC approaches, metrics, and methods, and it allows time and opportunity for building industry stakeholders to participate in policy development and become proficient in its application for the most effective OBC deployment.

CEA Initiative: Deploying Pilot Projects to Validate Outcome-based Methodologies and Assumptions

CEA believes that it is imperative for an outcome-based code to govern both new construction and existing buildings in equal measure. Implementing an OBC provides an opportunity to improve energy efficiency of the existing building stock which is immense. This opportunity would likely enable California to extend energy efficiency practices to a significant number of structures currently outside the code.

To this effect, CEA is researching how to leverage building performance benchmarking policies as part of an OBC and seeking input from jurisdictions in California with building energy benchmarking and transparency laws in effect. [14]

ENVISIONING AN OBC-DRIVEN MARKETPLACE

Part of the mission of the CEA Initiative Working Group 4 explores market transformation, education, and outreach. CEA believes that evolving building energy policy to an outcome-based code would benefit California's economy in terms of jobs and growth. Early thinking on this topic includes three emerging areas that would be positively impacted by an OBC: (1) creating an integrated design/build approach; (2) nurturing "as-a-service" models for optimizing built environments; and (3) cultivating microgrid entities and other decentralized energy delivery systems as market catalysts.

BIOGRAPHY

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Kelly is Technical Policy Director for Signify where she leads building and energy code standardization activities for North America, advising company business groups, market teams, and researchers on implications for lighting products and systems from pre-development through installation. She is subject matter expert for the high-performance buildings domain including topics such as LEED, WELL building standard, building benchmarking and transparency, green codes and standards, and building energy efficiency.
She serves as Lighting Subcommittee Chair of ASHRAE SSPC 90.1 and leads development of Sections 8 and 9 of ANSI/ASHRAE/IES Standard 90.1, the national model energy code for commercial buildings. She is an active member of the California Energy Alliance where she leads the Outcome-based Code Initiative and contributes to code change proposals for California Title 24.

Kelly also participates in NEMA proposal development for the IECC and is involved with key organizations relevant to building efficiency, green building standards & codes, energy rating and benchmarking, and smart buildings. Kelly has worked in lighting and energy efficiency in the U.S. for nearly twenty years; her experience includes lighting design and application, strategic planning and market analysis, presentation and training, and energy efficiency and transformative market consulting.

She holds M.S. Lighting and B.S. Building Sciences degrees from Rensselaer Polytechnic Institute in New York, USA and is a member of the Illuminating Engineering Society (IES) and ASHRAE. She is a LEED Accredited Professional, Lighting Certified by the NCQLP, and is Past President of the New York City Section of IES.

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Cori Jackson is Program Director for the California Lighting Technology Center at UC-Davis, where she is responsible for effectively planning, budgeting, scheduling, and monitoring CLTC research projects. For several years, Cori managed CLTC's demonstrations program, facilitating the installation of leading-edge lighting technologies in more than 100 sites throughout California and in other areas of the U.S.

Cori also serves as Secretary and Co-Chair of the California Energy Alliance. She provides Program Development direction to the organization. In that role, she actively leads policy initiative activities, including key work on the OBC Initiative.

She is a graduate of the University of California, Davis, with degrees in Optical Engineering and Mathematics. Cori is currently pursuing her master's degree in Operations Research with a focus on building design and operations optimization.

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