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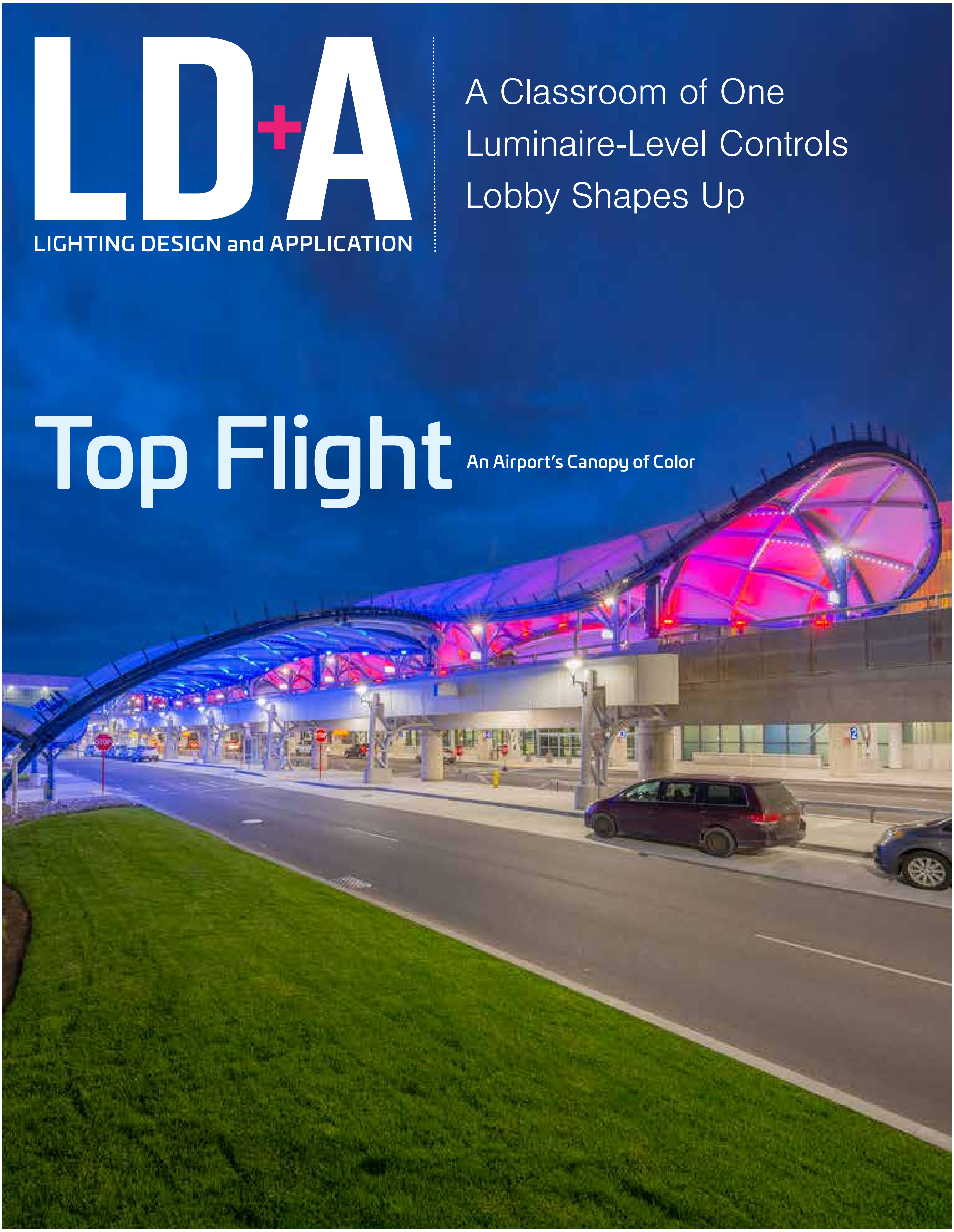

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Outcome-based Energy Codes Offer a New Path

Outcome-based energy codes are relatively new. They incorporate strategies that quantify a building's actual energy performance over time to demonstrate code compliance. The term *outcome-based* refers to the fact that compliance is linked with a building's actual energy "outcome," or energy use, which may be measured post-occupancy. Outcome-based compliance can be accomplished by establishing energy-use intensity (EUI) targets, which may vary based on the building type, its installed equipment, operational parameters and similar characteristics. Energy use, or similar metrics, are then measured periodically and reviewed by enforcement authorities to determine compliance with energy standards and requirements. Outcome-based codes can also include comprehensive energy allowances for safety equipment and emergency building systems.[1]

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Outcome-based codes differ substantially from traditional energy codes. Typically, traditional energy codes feature two compliance pathways using prescriptive and performance methods. Prescriptive methods are 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 to ensure a building complies with the energy code. The performance method uses comparative building energy modeling (BEM) to estimate the energy loads for a proposed building, using standardized assumptions for operation, among others. It is typically utilized for large, new construction or major renovation projects due to the complexity and cost of modeling a whole building and its systems.

The reach of traditional energy codes ceases at the certificate of occupancy. There is no post-occupancy mechanism to assess actual energy performance to determine if energy savings are actually realized. In addition, there is no way to determine if initial energy savings persist over the building's life. In most U.S. cities and states with adopted energy codes, compliance is only determined as part of a final inspection necessary for issuance of a building's certificate of occupancy. It may also be part of an inspection conducted for an alteration or addition to an existing building that requires a permit from the building department.

Traditional energy codes focus primarily on the energy needed for occupant comfort and productivity (e.g., power for lighting and HVAC systems). Process loads and miscellaneous electric equipment are largely unregulated while contributing significantly to overall building energy use. 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."[2]

Considering the building design and construction landscape, there are several market trends driving the desire and need for an outcome-based energy code. These trends include: 1) carbon neutrality and environmental stewardship; 2) increasing complexity and prescriptiveness within existing energy codes; 3) demonstrated gaps between claimed/designed energy savings and actual savings of code-compliant projects; 4) connected building system innovation; and 5) the importance of the occupant health and wellness (**Figure 1**). These drivers are intertwined and interdependent, and each can be addressed by migrating to an outcome-based energy code.

In California, the fifth 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 the state's greenhouse gas (GHG) emissions to 80% below 1990 levels by 2050 by Executive Order S-3-05 (2005).[4] This is a shift in focus from reducing energy consumption (e.g., zero net energy) and improving energy efficiency to reducing carbon emissions and ultimately becoming carbon neutral by eliminating fossil fuels and embracing electrification enabled by renewable sources.

California will leverage integrated distributed energy resources (IDERs) 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 and power in buildings, electric vehicles, electrical, thermal and battery storage.[5]

California has enacted a clean power and electrification pathway that includes de-carbonizing the electric power sector and electrifying transportation systems and buildings. Building electrification attempts to achieve net zero energy buildings by powering them using electricity from renewable energy 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 technologies largely known today if they are rapidly deployed at aggressive rates. The study identified key actions that can feasibly reduce California's GHG 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 code development:

- Aggressive efficiency measures for buildings will dra-

Figure 1. Market trends driving the need for an outcome-based energy code.

matically reduce per capita energy demand.
- Rapid electrification by renewable energy systems and avoiding fossil fuel use where technically feasible.
- Developing zero-emissions load balancing approaches to manage load variability.[7]

There is no doubt that many current energy codes are complex. For instance, under most existing energy codes, 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 sq ft. The resulting lighting power density (LPD) is often determined by a calculation incorporating the IES recommended light levels for the space type, the room geometry and surface conditions (e.g., reflectance), and other 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 designed in compliance with modern lighting energy codes may be allowed an LPD of 0.6 watts per sq ft and also be required to install lighting controls with numerous features and functionality. Mandatory controls could include:

- Manual area controls
- Multi-level and dimming controls
- Automatic shut-off controls
- Automatic daylighting controls[8]

Other controls may also be required, which can often be provided by the lighting control system:

- Demand responsive controls
- Plug-load control (circuit controls for 120-V receptacles)[9]

Once an energy code has been adopted, adding additional requirements each code cycle proved to be an effective strategy to improve energy efficiency outcomes over time. With respect to lighting, this approach coupled with efficacy improvements in LED technology 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 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 energy code is unable to accommodate new system-based strategies and innovations. Moreover, gaps persist between anticipated building performance and actual performance.

An outcome-based code approach supports building innovation by reframing building energy policies around robust energy budgets and migrating 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 Internet-of-Things (IoT) propositions.

OBC also creates an environment for new methodologies in which building professionals characterize energy use 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 potential due to the optimization of inputs and processes, and that losses can be mitigated. As the integration of sub-systems (i.e., lighting, HVAC, building services, etc.) into the whole building ecosystem continues to advance; OBCs, with their basis in realistic energy budgets that are measured post-occupancy, may accelerate this development.

Outcome-based code policies 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.[10]

Another driver of outcome-based energy codes and policy is the awareness and importance being placed on the health and wellness of building occupants—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 occupant 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, where health and wellness issues are just as important as energy usage considerations. Non-energy benefits (NEBs) such as human circadian system support, productivity, comfort, alertness, wellness and personalization are driving outcomes in sustainable design.

CEA'S OUTCOME-BASED INITIATIVE

In 2018, the California Energy Alliance (CEA) launched the Outcome-based Code Initiative to advance a new paradigm in building energy policy in California and support its ambition to decarbonize and electrify the economy's building sector. To further the state's mission of energy reduction and improvement of efficiency models, the CEA is advancing an outcome-based code to provide a means for realizing greater energy savings, achieving more robust development and future-proofing California's energy policies. Since then, CEA has been working closely with the California Energy Commission (CEC), investor-owned utilities (IOUs) and other interested stakeholders to drive development of a pragmatic, environmentally and economically sound OBC methodology for California.[3]

There are challenges to developing an outcome-based code. Some hinge on the existing regulatory structures which may eliminate the possibility of regulating energy use based on actual performance. Laws and regulations that created energy codes often include provisions that terminate regulatory action when the final certificate of occupancy is issued. Research is ongoing to determine the needed regulatory and legislative modifications to promulgate an energy code that extends compliance post-occupancy; to determine liability and responsibility for compliance; and develop mechanisms for recognizing changes in energy use over time that are not simply a factor of poor design or waste. Another challenge is related to energy modeling; currently comparative building energy modeling is used for code compliance, while OBC necessitates the need for predictive building energy modeling. Other challenges include how changes in occupancy impact OBC-based compliance, optimal smart energy use intensities, and their underpinning assumptions.

To develop a sustainable and future-proof OBC framework, initiatives must focus on foundational aspects, including a comprehensive review of adoption pathways, compliance and enforcement needs, and the exploration of the necessary steps needed to enable a practical OBC program. This includes supporting needed research, further outreach and collaboration with stakeholder organizations, engaging with jurisdictions already experienced in OBCs, and identifying the pathways toward marketplace consensus necessary for ultimate adoption and implementation.

There are also lessons to be learned from early adopters. The U.S. cities of Seattle and Boulder, CO, and the country of 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 the American Council for an Energy-Efficient Economy (ACEEE). NBI has published a guidance document for cities considering outcome-based code.[13]

Moreover, the California Energy Alliance has identified seven core components necessary for OBC. 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 ways of dealing with changes in occupancy; 5) retro-commissioning during the building lifecycle after initial compliance certification; 6) a system of incentives and penalties for compliance; and 7) an enhanced regulation of process and miscellaneous energy loads. Other considerations include metrics and assumptions underpinning EUIs; interest in decoupling OBC from the building code; and the inclusion of flexible load requirements and building response to dynamic utility pricing.

Outcome-based codes present a viable opportunity to help achieve ambitious decarbonization and climate goals while supporting the vision for an integrated, smart and resilient electricity grid. They have the potential to unlock renewed creativity for designers by focusing energy code requirements on actual building energy performance instead of prescriptive checklists that require significant compliance verification. OBCs will support new innovations in lighting, HVAC and other building systems by 1) focusing on whole-building energy metrics; and 2) removing the prescriptive requirements applicable to traditional design strategies that are difficult to navigate with system design and integration strategies.

Current initiatives underway across the U.S. are focused on developing a policy framework for an outcome-based code, including projects to understand the persistent gaps between modeled energy use in new buildings and measured energy use after occupancy. CEA and others are working to develop policy, code, standards and best practice recommendations, including exploring ways that outcome-based codes and policies can benefit citizens and the buildings in which they work, live and play. ◎

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