TECHNOLOGY

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Dialogue Between Lighting and HVAC Systems: Improving building system integration

Lighting systems have long been capable of sensing when someone enters or exits a room and using that knowledge to turn lights On or Off. More recently, connected lighting systems with sensors integrated into every luminaire have become broadly available, facilitating highly granular occupancy detection.

Similarly, HVAC systems have long been able to use an understanding of building occupancy to adjust temperature setpoints and reduce energy use without significant impacts to occupant comfort. Energy codes (e.g., ANSI/ASHRAE/IES Standard 9.1-2022 *Energy Standard for Buildings Except Low-Rise Residential Buildings*, IECC [International Energy Conservation Code] and Title 24) now require "occupied standby HVAC control," whereby systems adjust both temperature and ventilation setpoints in zones that are determined to be unoccupied during normal occupancy hours.

Here we have two building systems, each employing sensors to detect people—or the absence of people—to aid in energy reduction. Naturally, these systems should be capable of engaging in dialogue, right? Although today's lighting and HVAC systems are capable of such dialogue via BACnet communication networks or application programming interfaces, their interoperability—i.e., the sharing of actionable information—is limited by a number of practical issues.

Resolving these issues is an important focus for energy efficiency organizations, standards bodies and the U.S. Department of Energy (DOE), where we are working with stakeholders to light the path toward broader building-system interoperability, deeper energy savings and reduced emissions from buildings. These efforts are motivated by the opportunity to reduce up-front material and labor costs and the many advantages lighting systems offer as sensing platforms.

Lighting control zones are typically smaller than HVAC zones, making their zone-level sensors more than capable of detecting occupancy in typical HVAC zones. Lighting systems with sensors integrated into every luminaire can serve even the smallest HVAC zone sizes. In principle, such systems can even be configured to support reduced HVAC zone sizes that might result from retrofits targeting the greater energy savings that temperature setpoint-widening control schemes can deliver with smaller zones.

> "For the third and final phase of the L-Prize competition, DOE is asking entrants specifically to address lighting/HVAC system interoperability

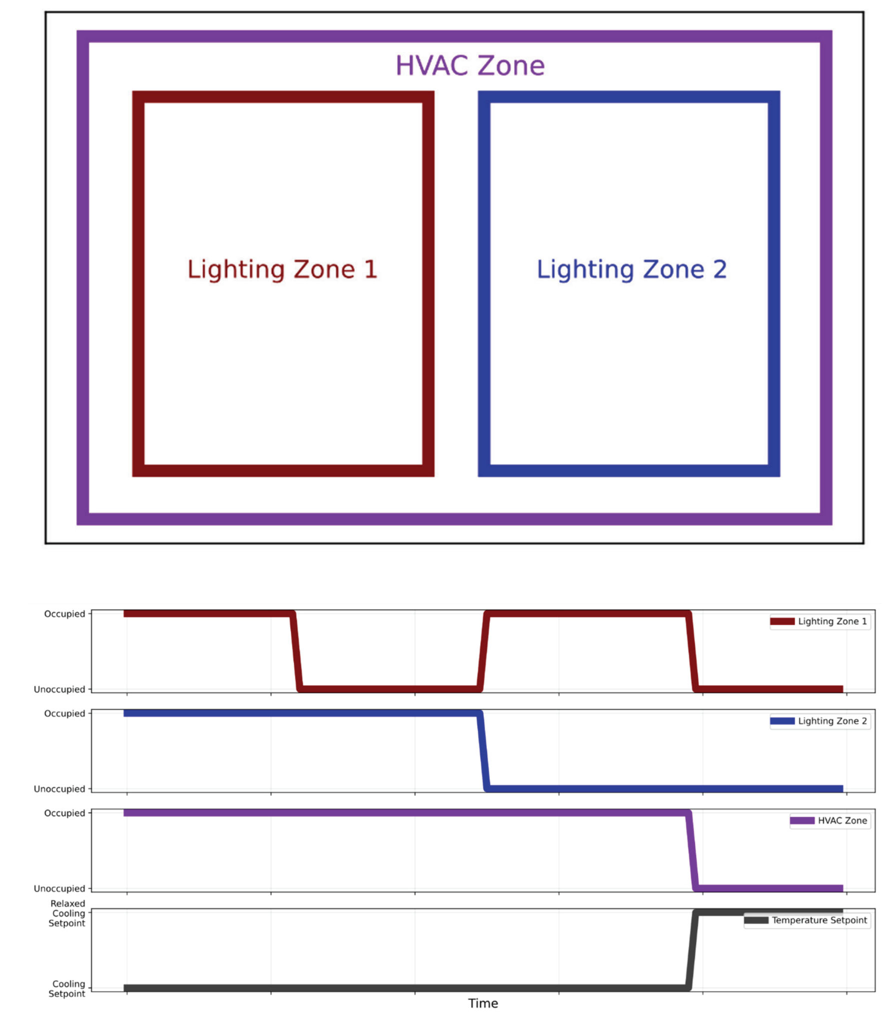
"The single biggest problem in communication is the illusion that it has taken place." George Bernard Shaw was talking about human communication when he made this oft-repeated observation, but it applies to the issues that often stymie lighting/HVAC integration in real-world projects. Although some of the first versions of connected lighting systems with BACnet interfaces had issues that resulted from not implementing the latest version of the BACnet standard, many of today's incarnations can reliably make lighting sensor or zone occupancy data available via a BACnet interface. However, the availability of this data is a necessary, but not sufficient, criteria for effective integration with the HVAC system. While the exposed occupancy data is associated with a lighting zone or luminaire, the HVAC contractor or system integrator needs to know which sensors are measuring occupancy in an HVAC zone. In an ideal world, the location of a lighting sensor relative to HVAC zones would be well-documented in the final project construction drawings and verified by a single engineer-of-record. However, this is often not the case. Separate engineering firms may have designed the lighting and HVAC systems, and their final designs may have been correlated with different versions of the architectural design. Furthermore, once the project goes into construction, and the engineer drawings are transferred to separate electrical and mechanical contractors, one or both of the designs may have been altered to resolve issues and/or installation conflicts or as the result of value engineering.

In cases where the HVAC contractor or system integrator is able to accurately identify the occupancy data points in the lighting system that correspond to a given HVAC zone, they may find that in many (if not most) cases, there are multiple corresponding points. This scenario begs answers to many questions. Should all the available data be used to determine HVAC zone occupancy, only some of the data or just one of the data points? If only one data point, which one? If more than one, which ones, and how should the many data points be algorithmically processed to determine a single HVAC zone occupancy value?

Ideally, these details were decided and documented in design, but in practice, this is not often the case, and decisions are made during integration without an understanding of how they impact the HVAC control strategy and the associated energy savings expectations. In addition, strategies to use all available data may be compromised by cost considerations, as the current labor-intensive practice of "mapping" data points from a BACnet object (e.g., the lighting system) into the BACnet network is typically priced on a per data point basis, making the integration of all available data cost-intensive.

Multiple DOE efforts are targeting these barriers to success. Chief among them is support for the development and adoption of emerging semantic interoperability standards (e.g., ASHRAE Standard 223). These standards enable the creation of semantic models of building systems that allow the systematic digital documentation of, for example, the zone that is being observed by a specific occupancy sensor, the relationship between that zone and building rooms as well as the BACnet object identifier that is associated with the data that the sensor is sending to the BACnet network.

The creation and integration of standardized semantic models of lighting and HVAC systems enable the creation of software tools that transform the human-centric lighting sensor-to-HVAC zone mapping



Representative example of the use of occupancy data from multiple lighting zones to determine HVAC-zone occupancy and trigger a temperature setpoint-widening control scheme.

process into one that is semi or fully automated. Another effort involves developing a digital design workflow that simulates occupancy and reveals the impact of, for example, using data from one, all or a subset of the available lighting sensors in a given HVAC zone to determine HVAC-zone occupancy.

A third DOE effort is driving lighting innovators to develop new functionality in pursuit of the latest L-Prize. For the third and final phase of the competition, the Manufacturing and Installation Phase, DOE is asking entrants specifically to address lighting/HVAC system interoperability. In particular, the competition will award 10 bonus points to entries that can share lighting energy use and zone occupancy data over a BACnet interface; five bonus points for systems that can calculate and share customized HVAC zone occupancy data from available lighting zone occupancy data; and 15 bonus points for entries that successfully demonstrate this capability in a real-world installation. Finally, DOE's Integrated Lighting Campaign has added a recognition category for lighting and HVAC integration in 2024 to give a shout-out to innovators that are making interoperability breakthroughs.

The adoption of semantic interoperability standards will require the development and deployment of new digital tools and workflows. Changing existing practice is always hard, and new approaches need to deliver value to soften the initial resistance to change. If the adoption of semantic interoperability standards and related new tools and workflows can reduce the barriers to effective integration of lighting and HVAC systems to deliver code-required energy savings, then perhaps that success can ease the path for other use cases, including the automated configuration of advanced control schemes, automated commissioning and automated fault detection and diagnostics. The creation of standardized semantic models of lighting and other building systems provides a lifetime benefit to new and existing systems, enabling a paradigm we see in other technology ecosystems where improved performance and new features are only a software install away, as opposed to requiring the time and cost of deploying new hardware. This paradigm shift can greatly accelerate the ability of buildings to realize their energy efficiency potential and thereby support the nation's decarbonization goals.

Michael Poplawski, Member IES, IEEE and ASHRAE, is a chief engineer and team lead at the Pacific Northwest National Laboratory. His research efforts develop digital tools, workflows and semantic models that facilitate building system integration and the use of software applications that support system configuration, operational energy management and maintenance, electric grid interaction and other data-driven use cases.