



Understanding and Implementing Lighting-HVAC Control Integration



summary

According to the US Energy Information Administration's 2018 Commercial Buildings Energy Consumption Survey (CBECS), buildings of 25,000 ft² or less make up about 87% of all US commercial buildings and about 35% of commercial floorspace. And more than half of the commercial buildings in the US were built between 1960-1999. The HVAC and lighting loads combined represent a significant percentage of overall energy usage in those buildings (between 60-70%), with rooftop units (RTUs) serving more than 60% of all commercial floorspace¹. These buildings frequently have owners or operators with significant budget constraints as well as significant lack of technical knowledge to undertake complicated technological control system upgrades. As a result, millions of kilowatt hours of lighting and HVAC system operation go to waste annually when an integrated system approach could bring combined energy savings of 50% or more. For instance, DLC research has shown that NLC systems can generate, on average, 48 percent lighting energy savings. By integrating the lighting control system with the HVAC system, up to 30 percent HVAC energy can be saved².

Technology advances in the past few years have expanded the range of integration solutions available; no longer does the owner/operator have to choose between a basic on/off approach or a highly complex approach that is overkill for their needs.

This paper will explore some of the challenges and benefits of lighting-HVAC integration, offer an overview of the current and emerging solution approaches available in the marketplace, and present an implementation roadmap.



Background

The largest energy loads in buildings have traditionally been lighting and HVAC. Combined, these account for nearly two-thirds of total building energy consumption:

- Space heating 32%
- Ventilation 11%
- Cooling 9%
- Lighting 10%

Optimal building energy performance could be achieved if there was coordinated control of these loads, a goal that has been pursued with limited success for decades.

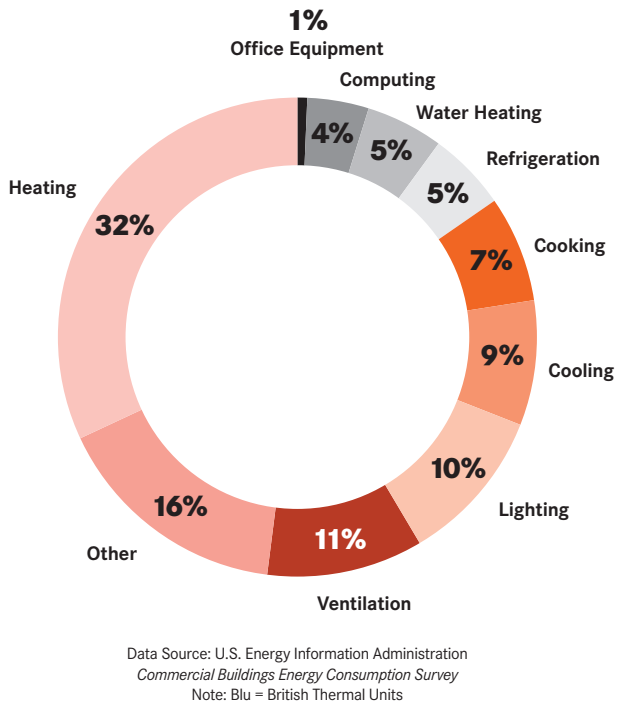


Figure 1. Total energy consumption by load type in commercial buildings.

Integrating control of these loads depends on extending the control signal from one building system to the other; for instance, using a lighting cue such as occupancy or non-occupancy to trigger an action in the HVAC network (on, off, increase or decrease in setpoints), or to use a scheduling cue such as time in an HVAC system to trigger an action throughout the lighting system (such as an HVAC setpoint increase at 8 am to turn general lighting on).

Integration Challenges

While the process sounds simple, it has presented challenges for years. These can fall into different categories, such as technological challenges, design/construction process challenges and operational or organizational challenges.

Technological Challenges

Lighting is controlled per fixture or in discrete zones or groups, usually based on proximity or function (open office areas, hallways, etc) while HVAC control is defined by ductwork, VAV boxes, and thermal loads, often much larger than a typical lighting zone. Another obstacle has been incompatible protocols and vendor ecosystems. Lighting networks typically use communication protocols such as Bluetooth mesh, Zigbee, DALI or other proprietary protocols. HVAC controls, on the other hand, typically run on BACnet, LonWorks, or Modbus. Creating a bridge between these different systems can add cost, complexity and increased risk of failure.

Often, available solutions (which will be discussed in detail in the Integration Approaches

section) have been either too simple for a wide range of applications, or too complex and costly to be applicable in all but the largest settings.

Design and Construction Process Challenges

Design professionals are often 'siloed' with electrical engineers responsible for lighting specification and mechanical engineers responsible for HVAC system design. Rarely is there a single party responsible for the integrated system during the design phase. Similarly, there can be issues during the contracting and procurement process, since lighting controls are typically in the electrical contractor's scope (Division 26) while HVAC controls reside in the mechanical/controls scope (Division 23/25). Integration falls into the gap between them, with each side assuming the other will handle it. Specifications may be vague without adequately defining aspects such as sequences of operation or protocols. System commissioning may occur at different times, while testing of integrated sequences of operation may be overlooked.

Operational and Organizational Challenges

Challenges may continue throughout the operational phase as well. Facilities personnel may be more comfortable with one system than the other, so when an integration function issue arises, they lack the knowledge to troubleshoot. Likewise, software upgrades may not occur at the same time, and system operators need to be prepared for integration issues as a result. Finally, perhaps the biggest challenge is space reconfiguration, with tenant turnover or improvements causing building layout changes. System administrators need to be prepared for updating integration plans accordingly.

Integration Benefits

In spite of these very real challenges, the benefits resulting from successful lighting-HVAC integration are substantial:

- **Energy savings**

Research from DesignLights Consortium has shown that networked lighting control (NLC) systems can generate, on average, 48 percent lighting energy savings. By integrating the lighting control system with the HVAC system, up to 30 percent HVAC energy can be saved³

- **Simplified controls and management**

A single interface/schedule can simplify facility operations, instead of juggling separate lighting panels and HVAC controllers. Furthermore, centralized data

makes it easier to spot anomalies (e.g., a conflict between lighting and HVAC zones, such as a zone that is “occupied” per the lighting controls network but operating a weekend setback on the HVAC system), as well as swiftly identify maintenance needs from a single dashboard.

- **Data and analytics benefits**

Utilizing lighting control signals such as occupancy to drive both lighting and HVAC can clarify how spaces are actually used, information useful for space planning, right-sizing HVAC zones, and more. Facilities can also participate more fully in local demand response programs with the ability to perform real-time load shedding across both building systems

- **Improved occupant comfort**

Coordinating lighting and HVAC systems optimizes temperature control based on actual real-time occupancy via shared occupancy sensor data, eliminating hot and cold spots and dynamically adjusting space setpoints for occupant comfort.

- **Compliance and certification**

Combining control of both building systems helps meet high performance building certifications such as LEED or Energy Star that reward integrated, demand-responsive building systems. In addition, energy codes are beginning to require occupied-standby mode operation in certain space types that can benefit from lighting occupancy sensors sharing space occupancy information with the BAS or HVAC system⁴.

- **Faster ROI on smart building investment**

Integrating control of both building systems rather than implementing parallel control systems reduces first cost of investment in new construction, while deploying an integrated solution in retrofit applications can qualify for rebates and other financial incentives.

Integration Approaches

There are three current approaches to achieving lighting-HVAC integration:

- Contact closure
- BACnet-based Building Management System
- Standards-based Approach with smart thermostat and open-standard NLC

In this section, we'll explore each of these approaches, how it works and what some of the pros and cons are with each approach.

Contact Closure

Contact closure is the simplest way to coordinate control of lighting and HVAC. This approach uses a basic dry contact (relay) signal. It typically works using a signal from an occupancy sensor (but could also use a scheduling signal) from the lighting network. The signaling device has a relay output which then opens or closes a circuit based on occupancy or vacancy. The relay switches the lighting while the HVAC controller receives that signal as an input and responds based on how the contact is defined (i.e., closed = occupied so the HVAC turns on or runs an 'occupied' setpoint; open = vacant so the HVAC turns off or runs a 'vacant setpoint').

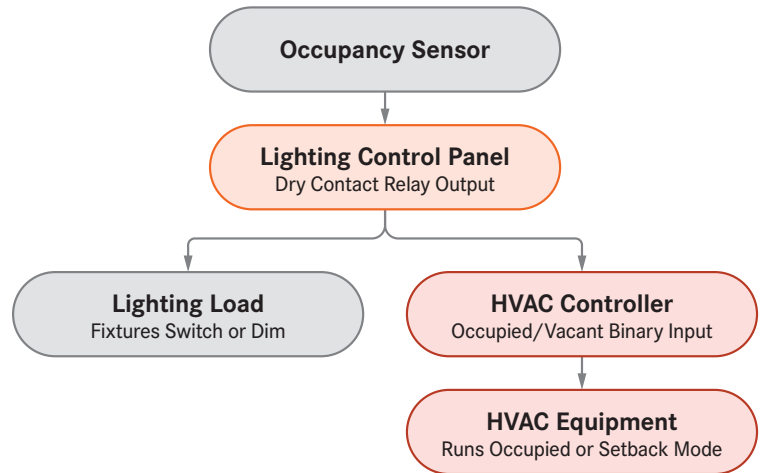


Figure 2. Contact closure approach to lighting-HVAC integration.

While the contact closure approach is simple and vendor-agnostic, it is also binary and one-directional (occupied/vacant or open/closed delivers on/off or occupied/unoccupied setpoint with no additional capabilities). It can be an ideal approach for small or medium-sized buildings where budget constraints and facility staff bandwidth are concerns.

BACnet-Based BMS

This approach is at the opposite end of the spectrum from the contact closure approach. Instead of the lighting relay signaling directly to the HVAC controller, in this approach both systems expose relevant points as BACnet objects accessible to the building automation system. Each BACnet device produces 'object' data which is defined in standardized terms according to the BACnet protocol. The BMS dashboard/supervisor operates the entire system, reading the object data from each BMS device, determining actions, and writing commands back. In a sense, the BMS becomes the central manager that coordinates lighting and HVAC—often alongside other building systems—as a unified single entity rather than individual independently wired ones.

This approach offers a wide range of capabilities, including monitoring and visualization of data from a single dashboard, including occupancy status, light levels, temperatures and setpoints, trends, energy use, occupancy analytics, and more. In addition, it can perform centralized scheduling and create custom rules for sequences of operation across both lighting and HVAC systems, participate in demand response activities, and detect and report faults. Typically, these capabilities can be performed onsite or conducted remotely via web-based cloud access. For portfolio management, the approach can also be used to manage multiple facilities from a single enterprise dashboard.

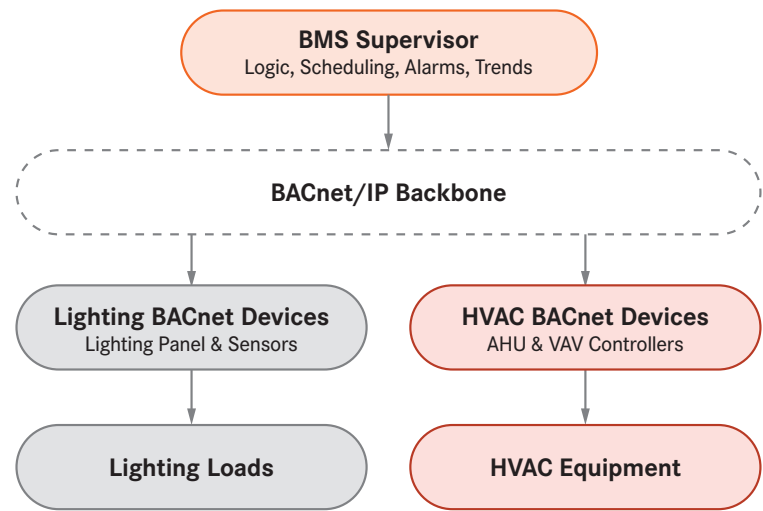


Figure 3. BACnet-based BMS approach to lighting-HVAC integration.

This level of sophistication and capabilities set is accompanied by higher front-end cost and complexity. Skilled commissioning is required as well as ongoing skill in system administration. And while BACnet is an open standard, not every device exposes everything at the BACnet layer so that additional proprietary equipment may still be needed to fully integrate the two systems. Often, this approach is ideal for large enterprise applications where the balance between cost and benefit can be fully realized and the amount of data provided by the BMS can drive space utilization and energy performance goals.

Standards-based Approach: Smart thermostat with Open Standard NLC

Recently available in the marketplace is a third approach, using open standards-based network lighting controls and smart wireless thermostats. This provides some of the capabilities of the BACnet-based BMS approach with far less complexity.

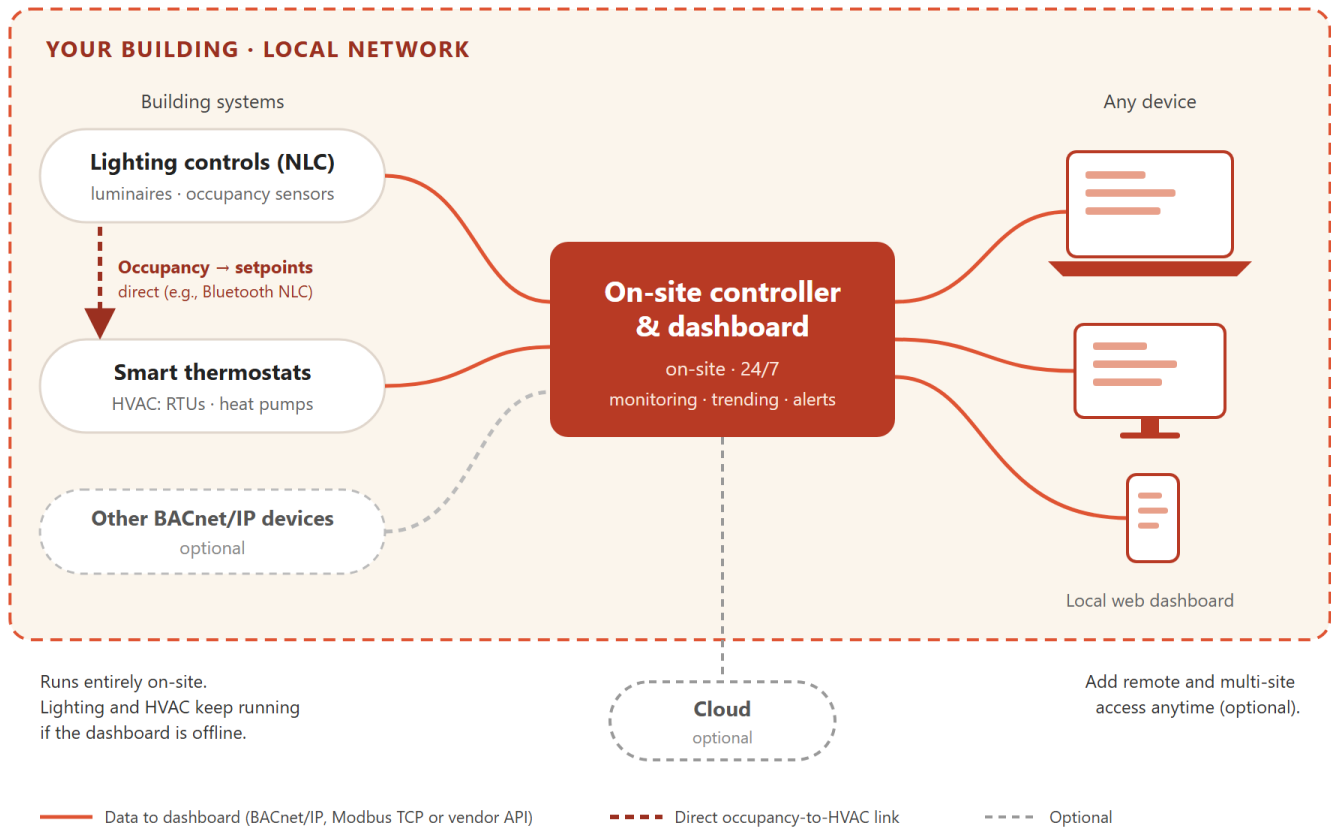
This method utilizes open standards such as Bluetooth NLC to define device profiles for both lighting and HVAC devices. The Bluetooth HVAC Integration NLC Profile enables a conforming wall thermostat to subscribe to occupancy information from occupancy sensors within a Bluetooth NLC system. This allows occupancy information already used by the lighting-control system to also influence HVAC operation without requiring a separate occupancy-sensing infrastructure. An integrated lighting-HVAC system can then utilize the occupancy sensor data to signal the thermostat directly to switch between its occupied and unoccupied setpoints.



Emerging Approach: 'Mini' BMS Control

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Figure 5. Mini BMS System



Roadmap for Implementation

This section will focus on some best practices and considerations once a decision has been made to implement lighting-HVAC integration. The biggest decision at the outset will be what approach to use. The table below lays out some key considerations and the Quick Guide following the table summarizes these in an ‘at-a-glance’ format.

Criteria	Contact Closure	Open Standards Approach	Full BACnet BMS	Mini-BMS
Building size	Single zone to small building (1-10 zones)	Small to mid-sized buildings (up to 50,000 ft ²)	Mid-to-large / multi-building portfolios	Mid- to large, single facility
Budget	Lowest (\$ hundreds-thousands per point)	Medium (some software/apps, commissioning)	Highest (software, licensing, engineering, commissioning)	Medium (software licensing, commissioning)
Data richness needed	Binary only (occupied/vacant)	Occupancy shared from lighting to HVAC; analytics limited to each system's own platform	Full analytics, trending, cross-system data	Combined lighting and HVAC data and trending for a single facility
Number of integration points	Few (1-5 point-to-point links)	Moderate (tens; each thermostat links wirelessly to one or more lighting zones)	Many (hundreds+ across multiple systems)	Moderate (tens to low hundreds within one facility)
Vendor mix	Works across any vendor (dry contact is universal)	Vendor agnostic within the Bluetooth NLC certified ecosystem	Requires BACnet compliance + BMS platform expertise	Vendor agnostic within the Bluetooth NLC certified ecosystem ¹
In-house technical skill	Low – any teletricician/controls tech can wire it	Medium (experience with lighting & HVAC desirable)	High – needs BACnet + specific BMS platform expertise	Medium (experience with lighting & HVAC desirable)
Commissioning time	Hours to days	Hours to days	Weeks to months	Hours to days
Scalability	Poor – new wire run per point	Excellent: interoperable ecosystem simplifies future expansion	Excellent – centralized logic scales building-wide	Excellent within single facility scope
Central monitoring/dashboard	None	Optional (separate lighting and thermostat dashboards, not combined)	Full building-wide graphics and dashboards	Full building-wide graphics and dashboards
Remote access	No	Yes, if cloud-connected, through each system's own app (lighting and thermostat)	Yes, built-in	Optional (through a cloud connection)
Alarming/fault detection	None (no visibility into failures)	Separate: lighting faults in the NLC platform; HVAC alerts from the thermostat platform	Cross-system alarms, fault trending	Alarms, fault detection for lighting & HVAC systems (device health and fault status; not cross-system fault trending)
Reporting (LEED/Energy Star/audits)	Not supported	Limited (lighting energy reports; thermostat runtime logs kept separately)	Built-in trend logs and reports	Trending and reporting for single facility
Cybersecurity exposure	Very limited (isolated hardwired signal)	Moderate (wireless network security, commissioning and access control)	Broader attack surface; needs segmentation, patching	Depends on the local or cloud architecture
Maintenance burden	Very low	Ongoing (software updates)	Ongoing (software updates, licenses, recommissioning)	Ongoing (software updates)
Single point of failure risk	None (each link independent)	Low (decentralized mesh; no central controller)	Moderate (supervisor/backbone outage, though local controllers usually keep running on fallback logic)	Low to moderate (a dashboard outage stops monitoring, but lighting and thermostat control continue)
Best fit	Single-tenant office, retail, small commercial	Retrofit small- mid-sized buildings	Large commercial, campus, hospital, multi-building portfolio, or anywhere occupancy/energy analytics matter	Mid- to large size single building

Table 1: Solution selection matrix compares a range of factors and variables relevant to decision making when identifying the ideal integration approach for a specific project.

¹ If system uses Bluetooth module and not BACnet

Quick Decision At a Glance:

Choose contact closure if:

- Small to mid-sized facility
- Limited budget
- Only occupied/vacant setback coordination is needed
- No need for dashboard or remote visibility

Choose Open Standards NLC with Smart Thermostat if:

- Richer data (light levels, multiple zones) is desired
- Future scalability and network flexibility is needed
- Avoidance of proprietary systems and vendor lock is important
- No need for centralized building-wide logic or reporting — a middle-ground retrofit

Choose full BACnet BMS if:

- Facility involves multiple zones/floors/buildings
- Project wants/requires energy reporting for compliance or cost tracking
- Anticipated future expansion involving multiple building systems and cross-system alarming (elevators, metering, access control)
- Participation in demand management/response programs is desired for both lighting and HVAC systems

Choose mini-BMS if:

- Rich data similar to a full BACnet BMS but only for a single facility
- Concerns over cybersecurity or intent to avoid cloud-based solutions
- No in-house BMS staff, but one dashboard for lighting and HVAC is wanted
- Monitoring is needed for existing networked lighting and thermostats without the cost of a full BMS

Some other key aspects that will contribute to the success of a lighting-HVAC integration project include:

1. Create a project team that includes all stakeholders

This should include the lighting professionals, the HVAC professionals, their controls contractors or consultants, and facility owner/operator representatives. Identify a single 'owner' for the project; the party who will assume responsibility for the project outcome as well as the party responsible for creating consensus among all the stakeholders for project decision making. Create and commit to a **common set** of project goals: is it energy savings? Occupant comfort? High performance building rating system? What is the budget, not just for implementation but for the operational cycle of the building?

2. Understand the existing systems already in place as well as the way the building currently functions before selecting an integration approach

If the project is new construction, this step is not necessary but in an existing building project, this step is critical. Know what the current lighting and HVAC systems include, document their current sequences of operation. Understand how the facility currently functions: what occupancy patterns are like, what the HVAC zones are, what existing wiring is.

3. Determine the best integration approach based on the inputs from steps 1 and 2 above.

It's easy to be seduced by technology and while it may make sense to select an approach that can more easily expand over time in the event needs change, the most important consideration is what the best approach is for the team in place, the needs of the facility and the budget available to support it.

4. Create a commissioning plan

Ensure that all contractor teams participate in the development of a unified commissioning plan with agreed-upon conventions, sequences of operation, and testing.

5. Create an operations plan for ongoing operation, not just installation

Train the entire facilities staff on the entire integrated system, not simply each subsystem. If selecting an approach with monitoring and alarming capabilities, create alarms for specific integration faults (where lighting settings may not be aligned with HVAC settings). Create a cybersecurity plan if the selected

approach includes cloud-based capabilities. Finally, remember to recommission after any equipment replacement.

6. Track system performance after implementation

Measure performance to identify actual energy savings and other non-energy benefits.



conclusion

While the challenges of integrating major building systems like lighting and HVAC are very real, the benefits are substantial. Combining system operations can compound energy savings, create a functional environment that enhances occupant comfort based on actual occupancy patterns and flows, and takes a big step toward better building performance.

And today's technology advances in lighting controls mean that the integration options are no longer simply contact closure or full-blown BACnet-based BMS. There are real advantages to integrating performance of these building systems and increasingly, more choices for how to achieve it in smaller or mid-sized buildings without requiring high-cost and high-complexity teams and solutions.

The biggest beneficiary of lighting-HVAC integration are the thousands of small and mid-sized existing buildings with budget and staffing constraints. Now more than ever, capturing meaningful energy savings of 50% and more is within reach of virtually every building owner/operator.



endnotes

¹ [Pacific Northwest National Laboratory, Advanced Rooftop Control \(ARC\) Retrofit: Field-Test Results](#), PNNL-22656, 2013).

² [Guidance for Lighting-HVAC Integration](#), Craig diLouie, LinkedIn, June 25,2025

³ [Making Sense of Lighting-HVAC Integration in Buildings](#), Inside Lighting July 15, 2025.

⁴ [Guidance for Lighting-HVAC Integration](#), Craig diLouie, LinkedIn, June 25,2025



resources

[Lighting Systems Save More Energy Through HVAC Integration](#), LightNOW Blog, June 22, 2026

[What To Know About Bluetooth HVAC Integration NLC Profile](#), David Shiller, LightNOW Blog, December 25, 2025

[Dialogue Between Lighting and HVAC Systems: Improving Building System Integration](#), Michael Poplawski, LD+A Magazine, August 2024.

[Best Practices for HVAC and Lighting Controls Integration](#). Consulting Specifying Engineer Magazine, March 16, 2018.

Design Lights Consortium, [Connected Lighting and HVAC Integration](#) including a free NLC-HVAC Integration Toolkit.

[Bluetooth SIG](#): a range of resources related to lighting-HVAC integration including articles and the HVAC Integration NLC Profile 1.0

[Lighting Controls Academy \(LCA\)](#) — various articles on this topic.

[Illuminating Engineering Society \(IES\)](#)—various articles on this topic in its monthly magazine, LD+A.

[Whole Building Design Guide](#): offers several online, on-demand courses related to lighting-HVAC integration.

[ANSI/ASHRAE/IES Standard 90.1 Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings](#)



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