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Future-Proofing Energy Efficiency with Networked Lighting Controls

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DesignLights Consortium®
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Introduction

Commercial lighting has transformed multiple times over the past few decades, all in pursuit of greater energy savings. Moving first from reliance on incandescent fixtures and then through various iterations of fluorescent products, the commercial lighting market is now dominated by super-efficient and long-lived light-emitting diode (LED) technology. But now LEDs are at a turning point because first-generation products are starting to be replaced and lighting controls technology is maturing. Simultaneously, research shows that efficiency programs and practices are not capturing the maximum energy and cost savings that LED technologies can deliver.

In light of this, the DesignLights Consortium (DLC) commissioned a study titled "Economic Potential of Networked Lighting Controls in Commercial Buildings: Tapping the Added Value of HVAC Connections", summarized in this resource. This study explores how to capture the full potential of LEDs and companion lighting controls technologies to maximize energy savings for commercial and industrial facilities while meeting the ambitious decarbonization and electrification targets of states and cities across the U.S.

What are NLCs?

The DLC defines networked lighting controls (NLCs) as the combination of sensors, network interfaces, and controllers that effect lighting changes to luminaires, but do not include the luminaires themselves.

Often, these control devices may be embedded in luminaires during the manufacturing process.

NLCs may be wireless (radios embedded in each network device that wirelessly connect with each other) or wired (physical wires connect the network control components).

A good example is a platform containing occupancy sensors, switches, photosensors, and control modules that all work together across an application to provide interrelated and coordinated control.

The DLC's mission is to make a positive climate impact through the adoption of new technologies that save energy. Our previous research illustrates that pairing LED lighting projects with networked lighting controls (NLC) can increase potential energy savings by an average of about 50 percent – and nearly 70 percent for some building types. Yet, despite the benefits NLCs offer, they comprise less than one percent of all luminaires in the U.S.

Moreover, while the U.S. Department of Energy projects that LEDs will represent 88 percent of all installed lighting systems in commercial buildings nationwide by 2030 (up from about 26 percent in 2017), the same forecast projects that only 14 percent of installed lighting systems will be controlled, connected systems, and even this projection may be optimistic. Previous DLC research has shown that, while NLC savings are expected to total 34 terawatt hours (TWh) by 2035, aggressive promotion of NLCs could double that number.

Aggressive utility promotion of NLCs could save over 60 TWh of energy by 2035.

With a new cohort of LED installations underway in offices, industrial buildings, and other commercial facilities nationwide, the time is ripe to calculate the potential energy savings that would result from updated policies and incentives for NLCs, which also offer an array of non-energy benefits including occupant comfort, security, and wellbeing.

Reasons for the lagging uptake of NLCs are varied, but one key barrier to wider adoption is continued apprehension about the initial cost of installing NLCs and the eventual return on investment. Further obscuring the true economic of value NLCs is the fact that, while some efficiency programs do accurately value the energy saved by NLCs themselves, almost none consider the energy savings possible by incentivizing the integration of connected lighting with other building systems such as HVAC. Recent energy codes require HVAC occupancy controls when the same space has lighting occupancy controls, but the savings potential of combined lighting and HVAC control integration remains untapped in many existing buildings.

The DLC launched the study outlined below to quantify the value NLCs hold in future energy efficiency programs. Conducted by NV5 (a provider of technology, conformity assessment, and consulting solutions), it explores the economics of NLC investment under current policy frameworks and energy system characteristics in two states typical of the U.S. Northeast and Southwest – Connecticut and Arizona. It presents the technical and economic potential of NLCs through 2030 and explores how utilities and/or state programs should incentivize NLCs and at what levels.

The analysis found significant energy savings for connected lighting systems in both scenarios we modeled:

1. NLC Replacement scenario - LED luminaires are coupled with network controls at the time of originally planned LED installations.
2. Controls-Ready Replacement scenario - Assumes LED luminaires are designed to accommodate the future addition of NLCs.

Most of these savings would be realized by using lighting-system-based occupancy sensors to reduce HVAC energy usage in unoccupied spaces.

Quantifying the technical and economic energy efficiency and demand reduction potential for NLCs through 2030 in these two states, the research addressed an overarching question: “Are incentives for NLCs good investments for electric energy efficiency programs?” Findings indicate the short answer is “yes” – particularly in cases where lighting controls are integrated with HVAC systems, for a Utility Cost Test BCR (Benefit/Cost Ratio) in the range of 3:1 to 6:1 (i.e., valuable benefits for low cost).

The study assesses the incremental energy efficiency potential for NLCs and controls-ready systems in existing buildings compared with the installation of standard LED luminaires. It also quantifies:

- Additional energy efficiency and demand reduction potential that can be unlocked when integrating NLCs with other building systems to better manage HVAC, and
- Additional demand reduction potential when NLCs are leveraged to reduce peak loads via demand response.

The analysis found that these capabilities, when considered together, can yield substantial energy and demand savings, greenhouse gas emissions reductions, and societal benefits.

Findings regarding integration with HVAC systems were especially compelling, with the study concluding these measures are generally cost effective in both jurisdictions assessed. Importantly, the research found that the HVAC savings effectively unlock the significant technical potential for lighting end-use energy savings, with the most potential value in large offices, retail, healthcare, and other high energy use buildings. Without the savings from HVAC, lighting savings alone would not be cost effective.

Significant energy savings are achieved for large offices, retail, healthcare, and other high energy use buildings when NLCs are paired with HVAC systems.

A key focus of the study was how to better design energy efficiency policies and programs to incentivize these savings. The study showed that, while “midstream” and “downstream” energy efficiency programs do already promote NLC lighting equipment, the current approach is not conducive to achieving integration with other building systems. In addition, the structure of many current programs forces less expensive non-NLC lighting fixtures to compete with NLCs, since the former are less costly in the near-term timeframes these programs employ. Continuing to rely on paradigms that incentivize first-year savings and short-term goals will sacrifice energy savings – exactly the opposite of what energy efficiency policies and programs are meant to achieve.

To achieve maximum long-term energy savings, programs need to shift the paradigms that incentivize first-year savings and short-term goals. Supporting NLC systems and integrations effectively will also require custom and turnkey incentive programs coupled with technical assistance and trade ally and customer education.

What’s the best way for utilities to invest in NLCs?

Good	Better	Best
LEDs + NLC in some building types	LEDs + NLC + demand response in more building types	LED + NLC + occupancy/ scheduling for HVAC in most large buildings

In two model states, NLCs were most cost-effective when integrated with HVAC systems in large buildings.

Methodology

The study's computer model used Connecticut and Arizona as examples of variable local and regional conditions in two parts of the U.S. While the term "networked lighting controls (NLC)" is used throughout the report, the precise control system assumptions and capabilities vary by building size. For small buildings (less than 25,000 square feet), the analysis assumed use of room-level lighting controls that can only be operated by occupants of a given space. For larger facilities, it assumed the installation of comprehensive NLC systems that can be manipulated remotely from an internet location. Plug load integration with NLC systems was also explored for larger buildings but found to be not cost effective in most applications.

To characterize end-use energy, equipment saturation, and key building characteristics by building type, the study relied on the recently released National Renewable Energy Laboratory ComStock data. These data indicate that only about 60 percent of large (over 50,000 square feet) buildings have building automation systems to control heating and cooling. For these buildings, the analysis also considered integration for HVAC control and assumed a 30 percent reduction in HVAC energy consumption due to integration with NLCs, based on recent studies by the Pacific Northwest National Laboratory. (Note that because ComStock only covers primary building types that comprise 62 percent of commercial floor space nationally, the study created a more complete picture of all the commercial floor space in CT and AZ by mapping a more extensive set of building types from the US Energy Information Administration's [Commercial Buildings Energy Consumption Survey (CBECS)] onto the ComStock data. This mapping was based on estimated interior lighting end-use energy density and qualitative consideration of primary building activities.)

Finally, the study considered participation in demand response programs to reduce lighting loads during summer peak demand periods and assumed that non-critical lighting loads could be decreased by a maximum of 40 percent during peak periods, provided that passive lighting controls aren't already reducing light levels beyond this point.

Presuming that lighting is retrofitted about once a decade, the study drew from several datasets to model energy usage in all commercial and industrial buildings in each state and considered two main scenarios:

1. Adding controls at the time of a scheduled lighting upgrade and assessing how much energy the NLCs would save by controlling illumination, through demand response capability, with plug load control, and – for larger buildings – by offering occupancy signals for HVAC.
2. In cases in which controls are not added at the time of planned lighting upgrades, specifying that those upgrades require installation of controls-ready luminaires, and assessing levels of savings if NLCs are added five years later (given a five-year delay, this scenario goes out to 2035 to capture the eventual savings).

In both scenarios, researchers assumed the baseline measure to be an LED luminaire without NLCs.

Results

The energy efficiency potential associated with NLCs is significant - in the most optimistic scenario, the study found reductions of 2030 commercial building electric energy consumption by nearly 10 percent in Connecticut and 5 percent in Arizona. In addition, the study found that NLCs can reduce 2030 peak demand by approximately 1.8 percent in Connecticut and 0.7 percent in Arizona, while integration with HVAC systems can reduce 2030 natural gas consumption by 1.3 percent and 0.5 percent in Connecticut and Arizona, respectively. The maximum cumulative potential for savings is similar in both the NLC Replacement and Controls-Ready Replacement scenarios except that maximum savings are reached five years later in the Controls-Ready Replacement case.

Importantly, the study found that, in both regions assessed, NLC measures integrated with HVAC systems generally passed the Societal Cost Test (a cost-effectiveness test that includes utility system impacts, as well as host customer impacts and societal impacts such as environmental and economic development). The economics are particularly favorable in buildings with high lighting power density and variable occupancy.

	Energy consumption through 2030	Net Benefits (6 years)
Arizona	Reduced 5%	$217 million
Connecticut	Reduced 10%	$1.2 billion

In addition, using Arizona and Connecticut as models, the benefits of acquiring all cost-effective savings from NLCs would be significant enough to make a noticeable impact. Businesses in CT could receive almost $1.2 billion in net benefits by 2030, while businesses in AZ could receive benefits of $217 million. Based on these findings, these are the recommended Action Items for Energy Regulators and Energy Efficiency Programs.

What Regulators and Energy Efficiency Programs Can Do

- **Future-proof investments in energy efficient lighting by only offering lighting incentives for luminaires that include NLCs or are controls-ready.** Programs should discontinue incentives for lighting equipment that does not include integration of controls now or in the future. While this might increase the cost of first-year energy savings, it will support significantly higher cumulative long-term savings.
- **Revise program metrics with appropriate, updated timescales.** Programs that emphasize first-year savings and three- to five-year efficiency plans will leave significant potential savings stranded as we near 2030. In places with 2030 decarbonization and electrification goals, investing more today to incentivize controls, or to ensure that lighting systems are at least

controls-ready, is the most cost-effective way to capture additional savings five to ten years from now.

- **Make room in program budgets to incentivize NLC-HVAC integration.** Integrating HVAC control with networked lighting systems, particularly in large buildings, offers the best opportunity for energy savings. Without high energy savings from NLC-HVAC integration to support high incentives, NLC uptake may be low in some regions and some building types.
- **Design programs to support NLC-HVAC integration**, such as requiring a pathway for occupancy communication from lighting to HVAC, specifying communications protocols to enable building systems to integrate and communicate, and offering incentives for master system integrators to review designs before installation and help solve problems afterward.

> **In places with 2030 decarbonization and electrification goals, investing more today to incentivize controls (or to ensure that lighting systems are at least controls-ready), is the most cost-effective way to capture additional savings 5-10 years from now.**

Future Work

While this study estimates NLC savings potential under a variety of scenarios, configurations, and geographic areas, some data underpinning the research are based on a limited number of case studies. Future refinements could consider not only updated cost and savings estimates, but also more granular assumptions of existing lighting and HVAC equipment saturations, historical energy efficiency program participation, variability of occupancy by building type, and the feasibility of various NLC applications in specific jurisdictions, especially in places with critical peak demand.

Conclusion

This study demonstrated the economic wisdom and substantial demand reduction benefits of adding NLCs to planned and future LED lighting upgrades, especially the value of pairing networked LED lighting with HVAC systems. Inherent in these findings is the imprudence of installing new LEDs today that don't either include NLCs or are equipped for the addition of future controls. Further, for energy efficiency programs in regions with 2030 electrification and decarbonization targets, continuing to focus on first-year energy savings or three- to five-year efficiency plans does not make sense. A different regulatory framework is needed to meet those targets – one that distinctly incentivizes commercial lighting projects to either pair LED luminaires with NLC systems now or install controls-ready fixtures that can be easily integrated with NLCs later.

Capturing the full potential of NLCs will require changing energy efficiency programs and policies to support and prioritize NLCs over uncontrolled lighting solutions that provide short-term benefits but lose the long-term savings needed to meet our decarbonization goals. Further, state and utility programs must focus on breaking down the technical and cost barriers associated with effective NLC installation. As first-generation LEDs are now reaching the end of their useful lives and lighting replacements and upgrades are underway, efforts should focus on strategies to unlock the potential of NLCs and incentivize them to increase their availability and desirability in the commercial lighting market.

For more information or to access the full potential study, contact info@designlights.org. Additional studies and resources can be found on our website.

About the DesignLights Consortium: The DLC is a non-profit organization improving energy efficiency, lighting quality, and the human experience in the built environment. We collaborate with utilities, energy efficiency programs, manufacturers, lighting designers, building owners, and government entities to create rigorous criteria for lighting performance that keeps up with the pace of technology. Together, we're creating solutions for a better future with better lighting.