2030 Goals Require Long Term Efficiency Plans that Specify Networked Lighting Controls

Levin F. Nock, DesignLights Consortium (DLC)
Kyle Hemmi, CLEAResult
Lauren Morlino, Evergreen Consulting Group
Matthew Socks, NV5
Stuart Berjansky, DesignLights Consortium (DLC)

ABSTRACT

Most incentivized commercial lighting upgrades could save half of the new lighting load by using networked lighting controls (NLC). More importantly, NLC integrated with HVAC can save 30% of the HVAC load through occupancy control, at a small fraction of the cost of HVAC replacement. Incentives for uncontrolled LED lights destroy opportunities for these deep, cost-effective energy savings, because each new LED locks out these opportunities over the 10+ year product lifetime. Regulators and policymakers with 2030 decarbonization goals could unlock these opportunities by regulating energy saving incentives within the same 20-year perspective as generation, transmission, and distribution.

We will present common challenges for utilities in implementing integration rebates, as well as program design solutions that can overcome these challenges. These solutions focus on equity while satisfying the immediate and longer-term needs of the different stakeholders involved. We will also present preliminary versions of tools to help incentive programs support NLC-HVAC integration, recommended by a 2023 working group. These tools will help choose appropriate projects, help lighting and HVAC specialists communicate, and identify case studies.

The paper will discuss energy, non-energy, and decarbonization benefits for utilities and their customers. Our analysis showed that in buildings where NLC-HVAC integration is feasible, it is considerably more cost-effective than NLC alone. For example in Connecticut, the Benefit-to-Cost Ratio (BCR) for integration was between 3 and 6, depending on building type. In Arizona, with lower electricity prices, BCR for integration was between 1 and 3.

Introduction

To Double Efficiency, Policy Updates are Needed

To address the climate crisis, we need to double the global pace of energy efficiency (EE) progress by 2030 by tripling investments (IEA 2023). Meanwhile, we need to meet legislated energy and decarbonization goals at a reasonable cost to society. By 2050, energy efficiency could cut energy use and greenhouse gas emissions in half (Nadel and Ungar 2019). However, the current regulatory framework for efficiency programs will not get us there.

This paper explores how EE policy needs to evolve; and then explores networked lighting controls (NLC) and NLC-HVAC integration in commercial and industrial (C&I) buildings as examples of significant, cost-effective energy savings potential that are largely ignored today.

Many efficiency programs allocate incentives based on efficiency plans of 5 years or less. From that perspective, incentives delivering the least expensive first-year savings are prioritized—even when this precludes deeper savings over a 5 to 10-year timeline. For example, most lighting incentives today are used to lower the net cost of new uncontrolled LED lighting, which competes directly with more expensive NLC lighting systems that would have delivered more energy savings over the entire lifetime of the LED products.[1] Each new uncontrolled LED locks out these larger energy savings that would have been available over the 10+ year product lifetime. Adding new controls to luminaires post-installation is usually prohibitively expensive, so adding NLCs during the initial installation is key. Most incentivized commercial lighting upgrades could have saved half of the new lighting load by adding networked lighting controls at the time of installation (Wen et al. 2020).

More importantly, NLC integrated with HVAC in appropriate buildings could have saved roughly 30% of the HVAC load through occupancy control, at a small fraction of the cost of HVAC replacement (Graeber, Harper, and Erberich 2023; Hinkle, Mead, and Kirlin 2022; NBI 2021; PNNL 2021 and 2022; Zhang, Lutes, and Brambley 2013; also see Table 6 below). Integration of NLC with HVAC control is one aspect of a Grid-Interactive Efficient Building (GEB). “GEBs can play a key role in promoting greater affordability, resilience, environmental performance, and reliability across the U.S. electric power system.” (Satchwell et al. 2021).

While deeper energy savings are attractive, any implementation of new policies and processes requires effort to overcome obstacles. The goals of this paper are to raise awareness of these potential savings, address some of the challenges to realizing these savings, encourage more incentives and programs for NLC and NLC-HVAC integrations—and above all, to promote a long-term perspective on the value of energy efficiency in policy.

Typical Energy Savings from Lighting Retrofits

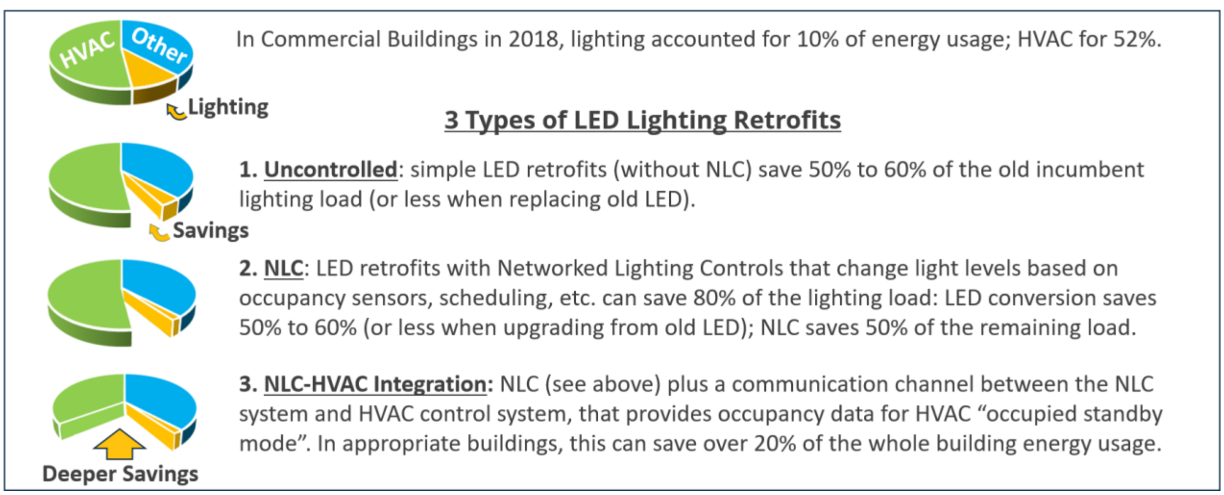

Figure 1. Energy usage in commercial buildings, and typical portfolio-level energy savings from lighting retrofits. Savings in individual buildings will vary. *Source*: EIA 2022, Wen et al 2020, and Table 4 below.

[1] While a few efficiency programs in the northeastern US have recently focused retrofit incentives on lighting with NLC, data from a sample of efficiency programs representing 5 TWh of savings shows that more than 70% of lighting incentives outside the Northeast currently support uncontrolled lighting—more than 90% in many states. (Kyle Hemmi, pers. comm., May 2024).

Figure 1 above illustrates that in 2018, lighting accounted for 10% of the total energy usage of a typical commercial building. As shown, implementing NLC can save 50% of the lighting load which equates to 5% of the building load. Additionally, HVAC comprised 52% of the energy load of the same building (US EIA 2022), so saving 30% of that (~15%), plus half of the lighting load, could have saved over 20% of the building's total energy load. Short-sighted incentives for uncontrolled lighting tend to discourage NLC installations.

Thankfully, a few states have begun to eliminate incentives for uncontrolled LED retrofits, including NY and MA; but program goals with an emphasis on first-year savings and short-term efficiency plans preclude many regions from following suit.

Policy

Performance Incentives Can Unlock the Long-Term Value of Deep Energy Savings

Regulators and policymakers with 2030 decarbonization goals could unlock deeper energy savings from NLCs and integration with other building systems by establishing performance incentive mechanisms that support NLCs. These mechanisms could regulate EE more along the lines of the 20-year perspective of generation, transmission, and distribution. While progress has been made to consider demand-side management (DSM) on an even footing with supply-side resources in the development of integrated resource plans (IRP), most jurisdictions with energy efficiency resource standards (EERS) still use three-year or five-year periods for EE program planning. Further, savings goals are primarily established in terms of annual savings. This combination of relatively near-term planning horizons and a focus on current-year annual savings achievement can lead to myopic program design decisions. Even when longer-term EE program requirements can be anticipated—for example, in jurisdictions with longstanding legislation supporting DSM and/or long-term goals in statute—programs may still aim to maximize near-term annual savings. This commonly leads to "cream skimming," whereby programs focus on opportunities that are easiest and cheapest to capture (such as uncontrolled lighting retrofits), even when those opportunities preclude opportunities for deeper but more expensive savings (such as lighting retrofits with NLC or NLC-HVAC integration).

NLCs generally produce higher annual and lifetime energy savings and have lower free ridership than uncontrolled lighting measures. However, in most programs, NLCs directly compete with cheaper and easier-to-implement uncontrolled or minimally controlled luminaires. Promotion of "controls-ready" luminaires may help achieve longer-term savings goals by enabling future control retrofits for already-installed luminaires, but they will not contribute any control savings without additional program engagement in the future. These factors present considerable headwinds to NLCs in program portfolios.

Extending EE program planning periods to ten years or more could minimize stranded savings. However, given volatility and uncertainty in the energy market, federal policies, and the DSM space, program administrators and regulators are unlikely to support longer planning horizons for program goals and budgets. Even if longer-term planning periods were feasible, programs could still be pressured to achieve annual savings targets, which would continue the tendency to focus on near-term least-cost measures. Fortunately, regulators have additional tools at their disposal to guide program design efforts.

Performance incentive (PI) mechanisms can be designed to support NLCs and reduce the potential for stranded savings in lighting projects. Performance incentives enable utility shareholders to share in the value of energy efficiency and to earn a return on investments similar to the return utilities typically earn on supply-side investments. While the exact structure of PI mechanisms varies from jurisdiction to jurisdiction, most use a multivariate approach whereby the magnitude of the PI is determined by program achievement relative to multiple metrics. The key metrics are typically designed to support policy goals such as program comprehensiveness and reaching underserved segments of the market. For example, the PI mechanism currently in use in Massachusetts for the MassSave programs requires that certain portions of total program benefits are achieved in targeted communities and through electrification efforts and are intended to support equity and decarbonization policy goals, respectively (MA DPU 2022). Selecting primary PI metrics that value deep lifetime savings will encourage the promotion of NLC measures relative to simpler lighting measures with shallower savings. Further, secondary metrics that specifically support NLCs could be established. For example, a PI metric could require that a percentage of total rebated lighting luminaires must incorporate NLCs. Even a small amount of funds tied to such secondary objectives can raise awareness of those objectives in utility program planning and implementation. In this case, the secondary metric supporting NLC would be justified in terms of the opportunities for deeper energy savings that are lost over the LED product lifetime with every uncontrolled LED lighting retrofit.

NLC-HVAC Integration Could Deliver Substantial Cost-Effective Energy Savings and Demand Reduction

A recent analysis of the energy savings potential of NLC in the commercial building stock of Connecticut (CT) and Arizona (AZ) showed that in large buildings where NLC-HVAC integration is feasible, it is considerably more cost-effective than NLC alone (Socks and Mohan 2023; DLC 2023b; Nock 2023), as shown by the charts of Benefit-to-Cost Ratio (BCR) in Figure 2 below. In CT, NLC alone was only cost-effective (BCR>1) in buildings where lighting power densities are relatively high—retail and hospital. On the other hand, NLC-HVAC was cost-effective in all large building types. In AZ, where low electricity prices make cost-effectiveness more challenging, NLC was not cost-effective in any large building types—but NLC-HVAC integration was cost-effective in all of the large building types analyzed except for warehouses.

To select building types with a BCR greater than one, the results were very similar between the Utility Cost Test (shown) and the Societal Cost Test (not shown). In both states analyzed, the trend was similar: efficiency programs can serve more utility customers in more types of buildings with NLC-HVAC integration, compared to NLC alone which can only serve a smaller number of customers in a few building types with high lighting power density. A robust program to support NLC-HVAC integration in large buildings (50,000 s.f. and above), from 2024 to 2030, could deliver over $1 billion net benefits in Connecticut, and over $200 million net benefits in Arizona. These benefits would include annual energy savings, reduction in demand,

and reduction in GHG emissions. Occupancy-based demand reduction in C&I buildings is likely to provide well-timed grid benefits, in the morning and evening hours when these buildings are sparsely occupied and grid-level demand is sometimes at peak.

Buildings under 50,000 s.f. (square feet) were not considered in the analysis as NLC-HVAC integration is less mature. However, as plug-and-play technology develops to address these smaller buildings, they could see similar benefits with NLC-HVAC integration.

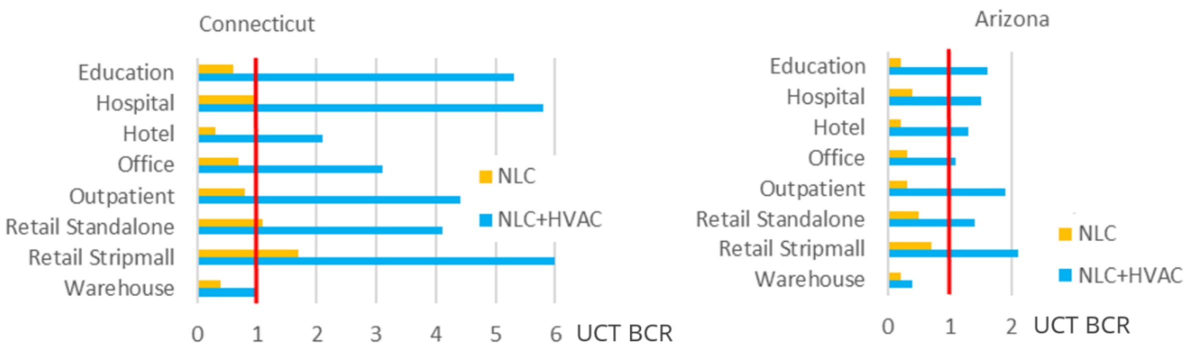

Figure 2. Utility Cost Test Benefit-to-Cost Ratio in large buildings in CT and AZ. *Source:* Socks and Mohan 2023

Challenges Faced by Efficiency Programs in Lighting, NLC and Integration

EE programs face the following challenges in implementing rebates and incentives for lighting, NLC and integration of multiple building control systems.

LEDs are Now the Baseline, Reducing Claimable Savings

General service lamps have been removed from many EE programs because federal standards with a minimum of 45 lumens/watt (US DOE EERE 2022) have increased baselines and reduced claimable savings. Additionally, some states have passed fluorescent bans (McClenney 2023) due to mercury content as well as the broad availability of LED products. Thus, LEDs have become the baseline for interior commercial lighting applications. Even in regions without fluorescent bans, the combination of lighting program success and LED market adoption has diminished lighting savings opportunities, now that lighting end-use energy consumption has dropped to 10% for C&I buildings (US EIA 2022). With reduced savings ahead from uncontrolled lighting retrofits, efficiency programs need to find new ways to meet their savings goals by exploring new measures.

Electrification and Decarbonization Policies

In addition to filling energy efficiency portfolio gaps, programs and their trade allies are also being asked to address building electrification and decarbonization in their short- and long-term plans. Four states and nine municipalities have passed Building Performance Standards (BPS) that require buildings to meet carbon or energy performance targets by specific deadlines, and become stricter over time. More than thirty municipalities plus a state have committed to passing similar policies, as members of the National BPS Coalition (IMT 2023).

At the federal level, electrification strategies are being pursued across all sectors from commercial to residential to transportation (White House 2022). These policies add pressure on utilities and their customers to achieve deeper levels of energy efficiency, demand reduction, and load shifting. For efficiency programs, states, and end users, the inability to control multiple items in their space could cost them energy, carbon, and money.

Unfamiliarity for Trade Allies and TRMs

Many EE trade allies are unfamiliar with NLC and NLC-HVAC integration. Decarbonization and the broader energy transition are changing workforce needs. Many lighting trade allies stay in their comfort zone: quick and simple lamp and fixture retrofits. These trade allies are ill-equipped to deal with the changes coming to EE programs, in terms of capacity and expertise. While training has always been an important aspect of programs, it has fallen short of preparing trade and supply chain partners for the level of change that is needed. With an already tight labor market for electricians, and pressures to increase the implementation of solar, EVs, and other electrification measures, this gap in labor supply and demand promises to widen.

In addition, some Technical Resource Manuals (TRMs) do not yet recognize the energy savings potential of NLC-HVAC integration for occupied-standby HVAC mode.

Silos in Utilities and Supply Chain

Utilities often face structural silos within their organizations that can thwart innovation. Each section of the organization has its own employees, tools, metrics, and reporting mechanism. Lighting specialists may not be located in the same department or under the same manager as the HVAC or Controls Specialists. Lighting savings come from the lighting portfolio and are reported by the responsible lighting program managers, just as HVAC savings are reported by HVAC program managers. Rarely do these groups intermingle, join other groups' meetings, or develop future measures together. Program managers at utilities or their implementation firms may not be set up to specialize in more than one technology or break down these silos to collaborate. Beyond programs within EE, internal structural silos often separate EE from distribution, in terms of staff and resources. While control solutions can deliver both energy savings and demand reduction, these two areas of expertise are often located in different parts of an organization. This makes it difficult to attribute appropriate benefits to a control measure.

Similar challenges for successful integration exist in the market. The lighting (electrical) and HVAC (mechanical) design communities operate in their own silos with unique systems, sensors, protocols, terminology, construction specification divisions, etc., that greatly hinder collaborative planning, communication and understanding between these two communities.

Slow Market in Commercial Building Occupancy, Upgrades, Supply Chain

All of this is occurring in a broader market environment that is still suffering from the impacts of the pandemic. Commercial building vacancy levels are now near 30%, a thirty-year high (CFO Dive 2024), on top of reduced average occupancy levels that remain around 50% nationwide (Kisi 2024; Kastle 2024). Supply chain issues for new energy efficient equipment appear to be improving but are still longer than previous lead times. Collectively this has investors, particularly property management companies and owners, hesitant or unable to perform significant upgrades and investments in their buildings. Non-residential building starts are down 5% in early 2024 (Dodge Construction Network 2024), and architectural billings are down for the ninth consecutive month (AIA/Deltek Architecture Billings Index (ABI) 2024). Lighting manufacturers and distributors finished 2023 relatively flat and slowing. While they had significant concerns over the next six months, there was some optimism for anticipated interest rate decreases to begin to filter down (Gordon 2024). The labor market remains relatively tight, with growth in the energy sector fueled by recent Inflation Reduction Act (IRA) and Bipartisan Infrastructure Law (BIL) legislation and a related push towards electrification likely to exacerbate problems within the energy efficiency space (Newton 2024).

NLC-HVAC Integration Solutions

The following program design solutions can address the challenges mentioned above, by focusing on equity while meeting the needs of various stakeholders.

LLLC Offers a Low-Cost, Low-Risk Point of Entry

Luminaire-Level Lighting Control (LLLC) systems are a type of NLC system that offers a relatively low-cost, low-risk, first step for customers interested in NLC. LLLC-based incentives enable efficiency programs to incentivize a version of NLC using a simple, conventional, widget-based incentive per luminaire that can be easily administered in downstream and midstream programs. LLLC offers users a cost-effective, flexible system that can be easily reconfigured as space usage changes over time (Betterbricks 2023) and saves over 60% of the energy used by new LED lighting (Wen 2020). The systems use intuitive apps to set or edit zones and light levels; and are appropriate for buildings of all sizes.

At any time during or after installation, LLLC can be connected to a centralized gateway device that supports more sophisticated functions such as energy monitoring, remote diagnostics, and asset tracking. An LLLC system connected to a gateway can also be integrated with an HVAC control system, providing occupancy sensing data back to the centralized system. This gives utilities a useful technology to promote to customers with limited budget or interest in controls at present, without closing the door to deeper energy savings from whole building integration later down the road.

Replace Incentives for Uncontrolled Lighting with Incentives for NLC Lighting Systems

EE Programs can avoid stranding future energy savings from NLC by signaling to the marketplace that NLC retrofits are preferable to uncontrolled lighting retrofits. Ideally, if feasible, incentives for uncontrolled lighting can be phased out. Or, at a minimum, incentives for uncontrolled versus controlled (NLC) lighting can be structured to encourage trade allies and customers to pursue the NLC option.

Because the market views these products as system solutions, programs should build out control measures as systems (as opposed to separate fixture and control components) in TRMs and in cost-effectiveness testing. This helps with realization rates and cost-effectiveness, and signals both internally and externally that program design, program support, and trade allies need to view projects through this systems lens. This mentality lends itself well to subsequent enhanced measure offerings for intelligent platforms that can facilitate not only lighting end-use savings but also additional energy savings and demand reduction from integration with HVAC and other building systems.

Speak the Customer's Language with Structured Custom Rebates

NLC and HVAC integration measures are perfect candidates for an effective rebate design called "structured custom," as shown in Table 1. Structured custom rebates reduce potential issues with Evaluation, Measurement and Verification (EM&V) for risk-averse EE programs, while still promoting a tangible rebate amount to the customer. An example of a traditional incentive design is "$/kWh saved." However, the typical building operator cannot easily estimate the kWh savings from replacing T8 with LED in their space or including NLC with LED. Therefore, rebates defined as "$/kWh" effectively mean nothing to a customer making purchase decisions. Alternatively, a structured custom incentive can be designed to discount dollars or percent of a purchase price that is known to the customer. On the back end, the program calculates the rebate using custom methodology to maximize savings and minimize incorrect assumptions.

Table 1. Risk Levels of Rebates and Incentives

	Utility Risk	Volume/Promotion	Rebate Example
Custom Rebate	Low	Low	$/kWh saved
Structured Custom	Medium	Better	% of project cost
Prescriptive	High	Best	$ off project cost

One utility in the Northeast U.S. launched a structured custom rebate program for NLC and HVAC integration. The objective was to bring down the cost of the NLC-HVAC controls integration service by promoting a 50% incentive on the total cost of programming labor, troubleshooting, installation, and setting up safe overrides. This way, when the building operator or owner received the quote for integration labor from the integrator, they knew exactly the amount due from the business's budget, and the amount they could expect in a rebate check.

Programs can limit their risk even further with a structured custom incentive by using a "hold back" amount. In the example of a 50% discount in labor, the program could opt to provide the customer with a 40% reimbursement paid when the project is completed, and hold back the rest of the incentive (10% of the total labor cost) until after the customer has provided the program with a report documenting nine months of operational control savings.

Conduct Research to Support More Prescriptive Approaches and Measures

To simplify custom offerings and move toward a more prescriptive approach, pilot programs and limited field testing for targeted integration and related data analytics for measure offerings are an increasingly important part of any successful EE program portfolio. Areas in need of this research include:

- occupancy-based HVAC control using LLLCs,
- simplified Application Programming Interfaces (API) integration to expand opportunities for Small to Medium Businesses,
- lighting Automated Demand Response (ADR),
- quantification of lighting and lighting controls-based non-energy impacts (NEIs) or benefits (NEBs) (DLC 2023a).

As LEDs slowly saturate the market and early-generation and less efficient LEDs age, another area that requires development is the inclusion of LED-to-new-LED-with-NLC measures in prescriptive offerings. Progress on these research fronts is critical to ensure the longer-term viability of EE programs.

Educate and Expand the Workforce with Trade Ally Training and Engagement

There is an urgent need for greatly expanded workforce development efforts that go deeper and are sustained longer than conventional training efforts to date. In the USA, a college student with loans graduates from a 4-year program with an average of more than $40,000 of debt (NCES 2023). One of the main qualifications for working with NLC and building controls is familiarity with phone apps and networking software. From these perspectives, subsidized education in LED/NLC/HVAC installation and integration could be an attractive alternative for college-age students. IRA/BIL funding can assist with these efforts. We cannot deliver on bigger broader goals without a significantly larger, better-informed and more highly-skilled workforce.

EE programs often engage the supply chain through trade ally networks for electrical and HVAC contractors. Control contractors should also be recruited for these programs and highlighted on utility websites, search features, and case studies, since they are in extremely high demand across the country. Working closely with these contractors can help programs learn about their perspectives, challenges and needs:

- whether they represent several brands or are exclusive to one,
- their sales or service territory location,
- their NLC and HVAC integrations completed and lessons learned,
- their estimate of the typical cost of integrations,
- how to incentivize them to complete more integrations and save more energy on each job.

Think Outside the Box (or Silo) with Cross-Functional Teams

Silos exist within efficiency programs because the organizations have successfully met their obligations and goals without making radical changes to their internal structures. As EE program goals progress in size and scope, many programs will need to strategically implement NLC and HVAC integration programs to fulfill goals and gaps. Programs that foster an environment where employees can challenge structural norms and typical meeting attendance lists will be better suited to provide integration rebates and services to their customers. A lighting program manager should be able to join the controls or HVAC working groups. An HVAC engineer should be able to join the lighting controls committee. Programs need to think more wholistically about their whole portfolios, and less in unilateral technology categories. Change can be more impactful and long-lasting if employees bridge that gap by joining cross-functional groups in the short-term, rather than waiting for a top-down structural reorganization. Sometimes hiring an external consultant can offer an advantageous perspective and neutral facilitator to help break through a utility's historically rigid structural silos. While a variety of tools, technologies, and standardization efforts such as ASHRAE 223P will help break down barriers between silos, there is still a great deal of work to be done on this front. EE programs should seek ways to better facilitate greater collaboration—within their own programs, across utility functions such as distribution and demand response, and throughout the supply chain (McGonegle 2018).

Meet Decarbonization Goals with New Measures

While utility organizations are still siloed internally as discussed above, the movement toward decarbonization is clear. Utilities would benefit from actively identifying and building new measures, in addition to securing projects with existing measures. Currently, decarbonization and electrification are major drivers of industry changes. Utilities should leverage measures like NLC-HVAC integration to meet current energy efficiency program goals, manage creeping baselines, and support future decarbonization needs.

Develop New Tools to Support NLC-HVAC Integration

In the summer of 2023, the DesignLights Consortium (DLC) convened a working group to explore promotion of NLC-HVAC integration. Recommendations from the group were further developed in a DLC Controls Summit in September 2023. Based on this stakeholder input, the DLC is developing tools to help EE programs support NLC-HVAC integration by addressing the silos between NLC and HVAC at many levels, from manufacturers and efficiency program staff to salespeople and installers. These tools (handbook, templates, decision tree and database of case studies) will be available in 24Q4 to help lighting and HVAC specialists communicate with each other and identify appropriate integration case studies and projects.

NLC-HVAC Integration Handbook and Templates. The handbook will describe basic information that each side needs to know about the other side, with references to relevant standards, along with blank templates to share data specific to programs and projects. For example, the project-specific template will include topics such as those shown in Table 2.

Table 2. Example Topics for Project-Specific NLC-HVAC Integration Template

Topic	Details
How a project will flow	Who is responsible for success in key steps, key contacts
Control points	Number of points for each side, naming/mapping convention, definitions of points, master for overriding each point
Protocols to be used	Are protocols open? Cybersecurity concerns?
Input and output of each system	With sufficient technical detail, for example: what should a Dry Contact interface look like?
Latency requirements	On all signals between systems

Decision tree to determine project feasibility. The energy that can be saved by using NLC occupancy signals for occupied-standby HVAC control has been documented in several case studies, but the savings from each project is highly variable. Certain project attributes can strongly influence the difficulty of integration and the magnitude of energy savings. A decision tree will show whether a particular project is a good candidate for NLC-HVAC integration—and if so, the range of energy savings that is likely to be realized. Table 3 shows a sample of some project attributes that are likely to make NLC-HVAC integration more feasible.

Table 3. Example project attributes that affect NLC-HVAC integration feasibility

Topic	**Explanation**
Building type	Does this type of building tend to have a variable occupancy pattern?
Operations	Do the operations of this particular space suggest a variable occupancy pattern?
Size	Is the project large enough to justify customized software development?
HVAC zone size	Are the HVAC zones small enough so that each zone is sometimes unoccupied?
VAV	Does the HVAC system support Variable Air Volume?
BMS or HVAC unit input	Does the building have a Building Management System (BMS), or else an input to each HVAC unit for digital remote control or dry contact?

While this list favors large buildings where NLC-HVAC integration is currently more common, development work will increase feasibility in smaller spaces where occupancy sensors integrated in LLLC luminaires can provide more robust occupancy data compared to a single occupancy sensor on a residential-style smart thermostat (C. Wolgamott, Senior Product Manager, NEEA, pers. comm., February 29, 2024). The decision tree can be updated in the future as work on this topic progresses.

Case study database. The DLC is compiling a database of case studies of NLC-HVAC integration in North America. A few fields from the draft database are shown in Table 4. While the amount of data varies between case studies, each project offers useful information. This list will be expanded and integrated with the decision tree, so that when a project is deemed feasible by the decision tree, any case studies of similar projects will be readily available.

Find the Silver Linings and Synergies to Seize Opportunities

Implementing these changes in the face of the challenges discussed is a daunting task. While it is easy to focus on those difficulties, programs can and should seek out the silver linings and opportunities posed by those very challenges. For example, market conditions have brought many new construction and large retrofit projects to a halt. So, programs can focus their efforts and energies on smaller to medium-sized projects, as well as tenant improvements and core and shell projects to repurpose vacant commercial spaces, many of which are found in traditionally underserved communities. Downward pressures on energy savings from lighting coincide with unprecedented public spending through IRA, BIL, green banks and related federal, state, and local initiatives. Programs should capitalize on synergies with current and future program offerings while that funding exists (EPA 2024), opening a window of opportunity to explore, research, and reinvent program offerings to better fit a transitioned, decarbonized and largely

Table 4. Case Studies of NLC-HVAC Integration

State/ Prov.	Site	Building Type & Number	Internet URL
MN	Hennepin County	Clinic & Fitness	https://integratedlightingcampaign.energy.gov/sites/default/files/2023-07/EED_2406_FLYER_Hennepin-FieldVal_FINAL2.pdf
CA	Cal State Dominguez Hills	University	https://newbuildings.org/wp-content/uploads/2021/05/Retrofit-Tech-Case-Study_CSU_FINALv5.pdf
CA	Cal State Long Beach	Univ., 110	https://www.enlightedinc.com/wp-content/uploads/2023/02/Enlighted_Case-Study_CSU-Long-Beach_r4.pdf
CA	UC Davis	Univ., 4	https://www.energy.ca.gov/sites/default/files/2023-06/CEC-500-2023-039.pdf
MN	University of MN	University	https://integratedlightingcampaign.energy.gov/sites/default/files/2023-07/EED_1581_FLYER_UM-FieldVal_FINAL2.pdf
MN	CentraCare Becker	Health-care	https://integratedlightingcampaign.energy.gov/sites/default/files/2023-07/EED_2282_FLYER_CentraCare-FieldVal_FINAL2.pdf
CA	Kaiser San Diego	Health-care, 10	https://www.willdan.com/casestudies/Kaiser-Permanente-HVAC-Case-Study.pdf
TX	Sinclair Hotel	Hotel	https://www.mncee.org/sites/default/files/report-files/EE0008191_PoE_Case_Study_SinclairHotel.pdf
WA	Enatai Elementary	K-12	https://atspnw.com/projects/integrated-lighting-hvac/
WA DC	KIPP DC	K-12, 20	https://www.nexuslabs.online/content/case-study-kipp-dc-schools-wants-autonomy-deploys-idl-supervisory-control-fdd-and-cmms
ON	Cisco Toronto	Office	https://www.panduit.com/content/dam/panduit/en/solutions/solution-pdf/NI-ENT-CiscoCaseStudy_CPCS64.pdf
MN	City of St Paul	Office	https://integratedlightingcampaign.energy.gov/sites/default/files/2023-07/EED_2407_FLYER_StPaul-FieldVal_FINAL2.pdf
CO	Denver Water Admin	Office	https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/ILC-Case%20Study-DenverWater.pdf
NY	Empire State Bldg.	Office	https://www.lutron.com/CaseStudyLibrary/ESB_English.pdf
CA	Intuit San Diego	Office	https://www.ibismsi.com/occupancy-enabled-hvac-optimization-case-study/
NY	Penn 1 Plaza	Office	https://www.cisco.com/c/en/us/solutions/collateral/enterprise-networks/dna-spaces/cisco-penn1-case-study.pdf
WA DC	Theodore Roosevelt Federal Building	Office	https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/ILC-Case%20Study-OPM.pdf
CA	Menlo Business Park	Office & Lab	https://www.enlightedinc.com/wp-content/uploads/2022/09/Enlighted_Casestudy_Menlo-Rev01.pdf
OK	Tinker AFB	Open ofc. & Indus.	https://integratedlightingcampaign.energy.gov/sites/default/files/2021-02/EED_1063_BROCH_ESTCPbrand.pdf
MN	MN DOT Cedar Ave, Better Bldgs.	Open office	https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/ILC_Case_Studies_MnDOT.pdf
MN	MN DOT Cedar Ave, Slipstream	Open office	https://slipstreaminc.org/publications/case-study-state-minnesota-department-transportation
NC	Crate & Barrel	Retail	https://www.shareddocs.com/hvac/docs/1001/Public/09/CASESTUDY63.pdf
-	ECOMT	Retail, 3400	https://www.intesis.com/docs/librariesprovider11/case-studies/ecomt_success-story_2020.pdf
-	ATT	Various, 240	https://www.enlightedinc.com/wp-content/uploads/2022/09/Enlighted_Casestudy_ATT_p1r2.pdf
MN	Cadmus	Various, 5	https://aceee2022.conferencespot.org/event-data/pdf/catalyst_activity_32392/catalyst_activity_paper_20220810190501262_6e1bd41a_890c_4fc8_87ab_e353845d0cba

Some case studies describe energy savings, payback and/or square footage; others do not. This table provides a preview of the larger database to be published. If you know of additional NLC-HVAC integration case studies sited in the USA or Canada, please notify info@designlights.org to augment future versions of this list.

electrified future. With an increased focus on equity and Justice40 targets attached to federal funding (White House 2023), many of the suggestions provided here can inform optimized offerings to reach businesses in underserved communities. Figure 3 provides an example of this through a pilot program supported by the DOE's Buildings Upgrade Prize (Buildings UP). The pilot will leverage energy concierge services with data analytics from lighting and HVAC systems to deliver comprehensive efficiency, demand response, and conservation solutions to underserved equity-eligible businesses.

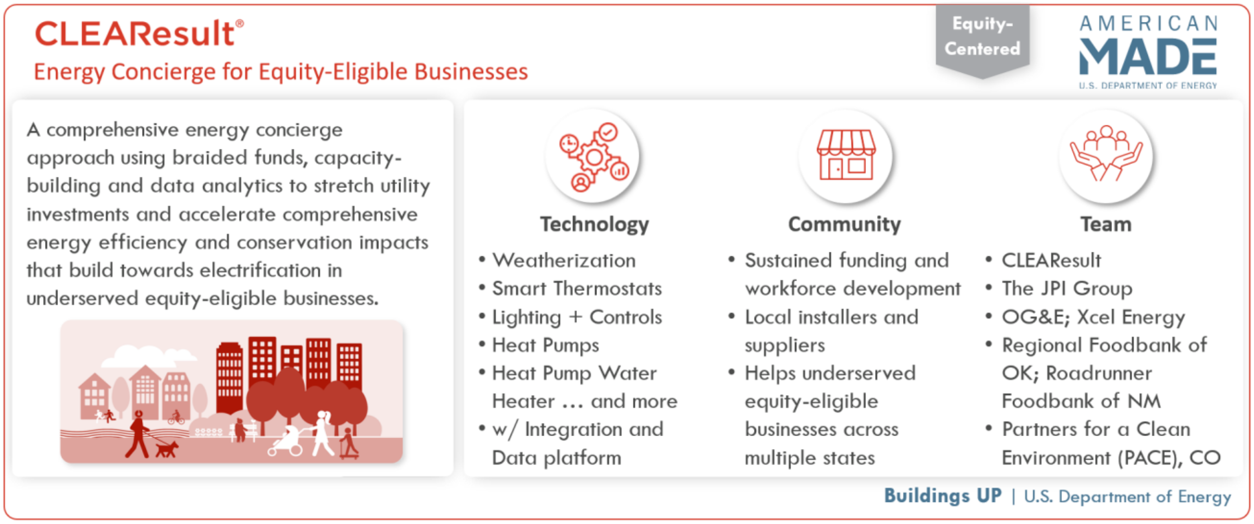

Figure 3: Program Synergy Example

Conclusion

The world is in a climate crisis! We are not on track to meet necessary energy efficiency improvements by 2030 by tripling investments in energy efficiency (IEA 2023). To address this urgency, EE planning timelines of three to five years should be reconsidered on the longer 20-year timeframes associated with electric utility upgrades to generation, transmission and distribution. Short timelines create a focus on short term paybacks, devaluing technologies such as Networked Lighting Controls that have longer paybacks but offer deeper savings in both energy and demand. Performance incentive mechanisms can address this issue by valuing lifetime savings and/or requiring that a percentage of total rebated lighting luminaires incorporate NLC. In order for this to happen by 2030, regulators need to align performance incentives more closely with decarbonization goals.

NLC-HVAC integration offers substantial and cost-effective energy savings and demand reduction in appropriate buildings. Such integration uses occupied standby mode to save 30% of the HVAC load in appropriate buildings, without costly HVAC equipment replacement. Considering that many case studies are pre-pandemic, savings may be even higher in buildings with lower post-pandemic occupancy.

Our hope is that more regulators will use performance incentive mechanisms to align efficiency program goals more closely with decarbonization goals; and that the affected efficiency programs will then be able to use the solutions outlined here, to meet those new goals.

References

ASHRAE Standard 223P. "Designation and Classification of Semantic Tags for Building Data." in development. https://www.ashrae.org/news/esociety/ashrae-bacnet-committee-works-with-other-organizations-on-new-standard

AIA/Deltek Architecture Billings Index (ABI). 2024. "Architectural Billings Decline for Ninth Consecutive Month." https://inside.lighting/lighting-industry-market-info/architecture-billings-index

Betterbricks. 2023. "Luminaire Level Lighting Controls for Decision-Makers." Lighting Handout. betterbricks.com/uploads/resources/NEEA_LLLC_Overview-for-Decision-Makers_Utility.pdf

CFO Dive. 2024, "Tenants retain upper hand as US office vacancy hits fresh high: CBRE." https://www.facilitiesdive.com/news/tenants-retain-upper-hand-us-office-vacancy-rate-hits-fresh-high-cbre/715498/?

DLC. 2023a. "Evaluating the Non-Energy Benefits of Advanced Networked Lighting Controls." www.designlights.org/resources/reports/evaluating-the-non-energy-benefits-of-advanced-networked-lighting-controls/

DLC. 2023b. "Future-Proofing Energy Efficiency with Networked Lighting Controls." www.designlights.org/resources/reports/future-proofing-energy-efficiency-with-networked-lighting-controls/

Dodge Construction Network. February 22, 2024. "C&I Building Starts Dip Slightly to Begin 2024." Inside Lighting news. inside.lighting/news/24-02/ci-building-starts-dip-slightly-begin-2024

EPA. 2024. "Greenhouse Gas Reduction Fund." www.epa.gov/greenhouse-gas-reduction-fund

Gordon, D. January 8, 2024. "Pulse of Lighting: The Latest Report." Inside Lighting. inside.lighting/news/24-01/pulse-lighting-latest-report

Graeber, K., A. Harper, P. von Erberich. 2023. "Pilot-Scale Evaluation of Integrated Building Control System for Commercial Buildings." CEC-500-2023-039. www.energy.ca.gov/sites/default/files/2023-06/CEC-500-2023-039.pdf

Hinkle, N., R. Mead, B. Kirlin, 2022. "Hot Mess or Cool Tech? Secrets to Success for Advanced Building Controls Integration." In Proceedings of the 2022 ACEEE Summer Study on Energy Efficiency in Buildings Panel 3. Asilomar, CA: ACEEE. https://www.aceee.org/sites/default/files/summerstudy/2022/event-data/pdf/catalyst_activity_32392/catalyst_activity_paper_20220810190501262_6e1bd41a_890c_4fc8_87ab_e353845d0cba

IEA. 2023. “Energy Efficiency – The Decade for Action.” www.iea.org/reports/energy-efficiency-the-decade-for-action#downloads

IMT. 2023. “Map: National BPS Coalition Participating Jurisdictions.” https://imt.org/resources/map-national-bps-coalition-participating-jurisdictions/

Kastle. 2024. “Kastle Back to Work Barometer.” https://www.kastle.com/safety-wellness/getting-america-back-to-work

Kisi. 2024. “Return to office trends: Occupancy data.” https://www.getkisi.com/office-occupancy-index 2024.

MA DPU (Massachusetts Department of Public Utilities). 2022. “2022-2024 Three Year Energy Efficiency Plans Order.” https://www.mass.gov/doc/2022-2024-three-year-energy-efficiency-plans-order/download

McClenney, J. 2023. “Five More States Are Phasing Out Fluorescent Bulbs”. ACEEE Blog Post. www.aceee.org/blog-post/2023/08/five-more-states-are-phasing-out-fluorescent-bulbs

McGonegle, J. July 31, 2018. “Enhancing integration of electric and HVAC design.” CSEMAG. www.csemag.com/articles/enhancing-integration-of-electric-and-hvac-design/

Nadel, S. and L. Ungar. September 2019. “Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050.” Report U1907. www.aceee.org/research-report/u1907

NBI. 2021. “Retrofit Technology Case Study: CSUDH James L. Welch Hall.” newbuildings.org/wp-content/uploads/2021/05/Retrofit-Tech-Case-Study_CSU_FINALv5.pdf

NCES. 2023. “Fast Facts.” National Center for Education Statistics. nces.ed.gov/fastfacts/display.asp?id=900

Newton, E. 2024. “How a Potential Labor Shortage Could Slow Down the Clean Energy Transition.” EnergyCentral Post. energycentral.com/c/hr/how-potential-labor-shortage-could-slow-down-clean-energy-transition

Nock, L. 2023. “Future Proofing Energy Efficiency with Networked Lighting Controls”. DLC webinar recording. www.designlights.org/news-events/events/future-proofing-energy-efficiency-with-networked-lighting-controls/

NYC Local Law 97. www.nyc.gov/site/sustainablebuildings/ll97/local-law-97.page

PNNL. 2021. “Lighting System Integration with HVAC and Plug Loads: Tinker Air Force Base.” PNNL-SA-158737. integratedlightingcampaign.energy.gov/sites/default/files/2021-02/EED_1063_BROCH_ESTCPbrand.pdf

PNNL. 2022. “Field Validation of Lighting Retrofit with HVAC Integration and Plug Load Controls at the University of Minnesota.” PNNL-SA-186337. integratedlightingcampaign.energy.gov/sites/default/files/2023-07/EED_2406_FLYER_Hennepin-FieldVal_FINAL2.pdf

Satchwell, A., M. Piette, A. Khandekar, J. Granderson, N. Frick, R. Hledik, A. Faruqui, L. Lam, S. Ross, J. Cohen, K. Wang, D. Urigwe, D. Delurey, M. Neukomm, D. Nemtzow. 2021. “A National Roadmap for GEB.” gebroadmap.lbl.gov/

Socks, M. and S. Mohan. 2023. “Economic Potential of Networked Lighting Controls in Commercial Buildings: Tapping the Added Value of HVAC Connections”. Prepared for DLC, available to regulators, policymakers, and DLC member efficiency programs by request at info@designlights.org.

US DOE EERE. 2022. “Appliance and Equipment Standards Rulemakings and Notices, General Service Lamps.” https://www.energy.gov/eere/buildings/standards-and-test-procedures

US EIA. 2022. “2018 Commercial Buildings Energy Consumption Survey, Consumption and Expenditures Highlights.” www.eia.gov/consumption/commercial/data/2018/pdf/CBECS%202018%20CE%20Release%202%20Flipbook.pdf

Wen, Y-J., E. Kehmeier, T. Kisch, A. Springfield, B. Luntz, M. Frey. 2020. ”Energy Savings from Networked Lighting Control (NLC) Systems with and without LLLC.” Report for NEEA and DLC. www.designlights.org/resources/reports/report-energy-savings-from-networked-lighting-control-nlc-systems-with-and-without-lllc/

White House. December 14 2022. “Fact Sheet: New Innovation Agenda Will Electrify Homes, Businesses, and Transportation to Lower Energy Bills and Achieve Climate Goals.” www.whitehouse.gov/ostp/news-updates/2022/12/14/fact-sheet-new-innovation-agenda-will-electrify-homes-businesses-and-transportation-to-lower-energy-bills-and-achieve-climate-goals/

White House. 2023. “Justice40: a Whole-of-Government Initiative.” www.whitehouse.gov/environmentaljustice/justice40/

Zhang, J., G. Liu, R.G. Lutes, M.R. Brambley. 2013. “Energy Savings for Occupancy-Based Control (OBC) of Variable-Air-Volume (VAV) Systems.” PNNL- 22072. www.pnnl.gov/main/publications/external/technical_reports/PNNL-22072.pdf?bcsi_scan_C429A8BD0F8CBB7E=0&bcsi_scan_filename=PNNL-22072.pdf