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EFFICIENT TECHNOLOGY ACCELERATOR

Luminaire-Level Lighting Controls 2025 State of the Market Report

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EXECUTIVE SUMMARY

Background and Methodology

Luminaire-Level Lighting Controls (LLLC) are an efficient lighting controls technology that provides energy savings, operational advantages, and building system integration opportunities for commercial building applications. In efforts to move Minnesota to adopt more LLLC systems, the LLLC Initiative was launched in 2023 as a program under Minnesota's Efficient Technology Accelerator (ETA). Through market engagement, the initiative strives to advance the adoption of LLLCs to bring lasting change in the lighting market and make LLLC systems standard practice for commercial building applications in Minnesota.

The ETA team conducts periodic market research to learn more about the current market and track trends over time. ETA undertook several primary data collection efforts in 2025 and early 2026 to gather up-to-date information about LLLC awareness, adoption, benefits, and barriers in Minnesota. The research was also designed to inform ETA's assessment of the initiative's Market Progress Indicators, the metrics used to monitor market transformation progress over time.

The primary data collection included:

- Phone interviews with manufacturers (N=4, representing four unique companies)[1] and manufacturers' representatives (reps; N=6, six unique agencies representing a total of 11 controls brands)
- Phone interviews with distributors (N=8, representing four unique companies)
- An online survey conducted with lighting and electrical contractors working in the commercial building market in Minnesota (N=98)
- Follow-up phone interviews with a subset of the contractor survey respondents (N=9)
- An online survey with building owners (N=89)[2]

As with all research, the data gathered in this study must be interpreted through its limitations. Specifically, the interviews with small numbers of respondents may not be representative of the full market. However, interview responses provide rich qualitative information, and the data reflects perspectives from active participants in the lighting and controls market with various specialties, which can be used in combination with other market intelligence to glean insights about the market as a whole. The surveys, which achieved larger sample sizes, provide better representativeness but also reflect biases resulting from the contact lists used. These limitations are discussed in greater detail in the report.

[1]The total number of respondents for each effort is represented by an uppercase N; later in the report, the subset of respondents for each individual question is represented by a lowercase n.

[2]For clarity, this report uses the term "building owner" to refer to all respondents to the survey, but respondents also included facility managers, engineers, and property managers.

Key Findings

While the body of the report is organized by market actor, the following section outlines key findings by major cross-cutting themes.

Awareness, perception, and use of LLLCs

Market actors show varying degrees of awareness and general approval of LLLC, yet actual installation rates remain low. LLLC is present in only a small, but growing, number of buildings.

- **Manufacturers and reps are very familiar with LLLC and have positive views of LLLC.** All ten respondents reported familiarity with LLLC, and eight out of ten shared favorable or very favorable opinions on LLLC. These results show that knowledge and approval of LLLC is high among interviewees at this top layer of the Minnesota supply chain.
- **Distributors have a favorable view of LLLC, and they see growth potential in controls in general and LLLC in particular, but today they are not using LLLC frequently.** Despite seven of eight distributors reporting favorable opinions of LLLC and reported expectations that LLLC sales will grow in the future, interviewees viewed LLLC as an emerging technology, not one they are commonly utilizing today.
- **Most contractors have at least some familiarity with LLLC, and 37% have installed LLLC in the past year.** Awareness remains mixed, with nearly half of contractors unfamiliar with the term LLLC. However, most contractors (55%) reported that they were at least somewhat familiar with the technology after reviewing a definition, and over a third (37%) had installed LLLC in the past year, indicating a meaningful amount of market activity.
- **Most building owners have never heard of LLLCs.** Before being provided with a definition of LLLC, only 11% of building owners had heard of the term. After reviewing a definition, 11% of building owners reported they were at least somewhat familiar with LLLC, an additional 33% said they were not very familiar, and 56% said they were not at all familiar with the technology.
- **LLLC is present in only a small minority of buildings, while traditional non-networked, non-integral controls are the most common type of lighting controls.** 67% of building owners reported they have traditional lighting controls in their buildings, while 6% reported having LLLC. This demonstrates how uncommon LLLC remains as a lighting controls solution in Minnesota.

Growing market trajectory

Manufacturers, reps and distributors expect integral control sales, including LLLC, to grow in the next few years, and are adjusting sales structures for that growth.

- **Manufacturers and reps see integral controls (including LLLC) as a growth segment.** Several respondents reported that integral controls (including LLLC) account for between 10% and 30% of controls sales. Respondents expect growth in the controls segment overall (estimated at 10%–20% year-over-year), as well as within integral controls (also estimated at 10%–20% year-over-year).

- **Distributors see integral controls (including LLLC) as a growth market and several distributors are investing in growing their outside sales teams for lighting and controls.** All eight distributors agreed that they expect growth in integral controls sales, with expected annual sales increases ranging from 10% to 40%. All eight interviewees also discussed growth in their companies' emphasis on lighting and controls outside sales teams, focusing on providing in-house design services for retrofit projects and design-build projects in some cases.

Market dynamics of influence for increasing LLLC adoption

Across the supply chain, market actors saw their roles as limited for increasing LLLC adoption, especially in projects requiring specification, which is seen as the domain of designers and engineers.

- **Manufacturers' reps do not have strong influence on specifications developed by lighting designers and engineers.** Reps view specified projects as the domain of designers and engineers and do not feel that they have opportunity to influence design decisions on these projects. Furthermore, they feel any such opportunity is hindered by the specifiers' preferences for proven, status quo solutions.
- **Retrofit contractors influence controls decisions and product selection, but in specified projects (such as a traditional design-bid-build new construction project), contractors have little influence over specifications.** Interviews revealed a distinct difference in contractor roles between these two project types, with retrofit projects being the clearest opportunity for contractors to promote a specific approach to controls or a specific product. In specified projects, contractors described specifications as typically sticking to the status quo.
- **Role ambiguity in lighting controls projects creates friction across the supply chain.** Distributors consistently flagged a lack of clarity around who owns key responsibilities in lighting controls projects, including developing the sequence of operations, programming the system, training end users, and providing ongoing support. While most agreed that long-term support should fall to the contractor, they also acknowledged that contractors frequently lack the technical depth or business model to provide these services effectively, so distributors can end up fielding support calls from end users.
- **There is no clear consensus on a best-practice approach for applying integral controls.** Some manufacturers and reps view limited network or room-based LLLC as a commonly applicable strategy and reported using this strategy more frequently than either non-networked standalone embedded controls or fully networked LLLC. This approach (defined as an LLLC system without a dedicated gateway) was reported as the most sold type of integral controls based on all participants' combined estimates of sales across the sub-types of integral controls. However, the mix of integral controls types varied greatly across participants, pointing to the diverse range of products and approaches available in the market.

Cost constraints and cost savings play a major role

Cost is a consistent barrier and motivator across the supply chain**.** However, utility rebates aimed at offsetting those costs have low awareness and usage. On the flip side, building owners described energy and bill savings as the most attractive benefit for LLLCs.

- **Manufacturers and reps prioritize making a sale over promoting a specific technology.** Eight out of 10 respondents (including manufacturers and reps) agreed that in the specification sales segment, their top priority is to make a sale rather than drive projects toward a specific solution. This means they view promoting LLLC over another solution provided by their brand as an unnecessary risk. If they can make the sale with a non-LLLC solution, they are satisfied.
- **Distributors avoid proposing high-end solutions when a lower-cost solution can meet project requirements, especially in specified projects.** Distributors explained that they do not often promote LLLC because their businesses operate on narrow margins in a highly competitive role in the market, and therefore they do not feel that they have the leeway to risk losing a job by promoting a higher-cost solution. They emphasized that being the low-cost bidder is critically important for many specified projects, and this limits their ability to influence or innovate on these jobs.
- **Contractors see upfront cost as the biggest barrier for LLLC.** Contractors view cost as the number one driver of decisions about lighting and controls and as the primary reason they do not use LLLC more often.
- **Concerns about callbacks can deter contractors from embracing LLLC.** The contractors with less favorable views of LLLC expressed that callbacks (i.e., a customer requesting follow-up service for which the contractor will not charge) can be a headache and cost to their business, and they view LLLC as raising the likelihood of callbacks. Contractors observed that customers can struggle to learn how to operate their controls systems, creating an ongoing need for support.
- **Contractors lack awareness of LLLC utility rebates, but most who are aware are actively promoting LLLC rebates.** Although contractors agreed that rebates are important to their getting selected for projects, only 39% of respondents were aware of utility rebates for LLLCs in their area. Among respondents who were aware of LLLC rebates, a majority (58%) of them reported promoting these rebates to their customers very often.
- **Building owners viewed utility rebates as important, but only 40% of them were aware that utility rebates were available for lighting controls.** Most building owners (74%) had pursued lighting rebates in the past, but less than half (40%) were aware of rebates being available for lighting controls specifically. However, 70% of building owners named utility rebates as an important factor that would be necessary for them to select LLLC in a future lighting upgrade.
- **Building owners want to maximize energy savings and lower energy bills, and they view these as the most valuable potential benefits of LLLC.** The survey provided information about some of the potential benefits of LLLC, and asked respondents to rate how

valuable each of these benefits would be. Eighty-one percent of respondents agreed maximizing energy savings was either “very valuable” or “essential.”

Training gaps

Training and preparedness gaps exist across multiple stakeholder groups. Contractors report low readiness to install and program LLLC systems. Most distributors provide little or no LLLC training. Building owners who have LLLC largely did not receive adequate system training.

- **Distributors may not be fully prepared to sell more LLLCs.** Despite favorable perceptions and a growing market, distributors indicated they do not frequently promote LLLC, and they report that their teams are not very prepared to sell LLLC.
- **Most distributors offer little to no training related to LLLC for contractors.** Despite recognizing that contractor skill gaps contribute to downstream support problems, six out of eight distributors reported offering little or no training themselves, largely deferring to reps to provide contractor training. Views were divided on whether this should change — some distributors saw an opportunity to engage more in contractor education, while others held that skill development is the contractor's own responsibility. Distributors agreed that hands-on, in-person training is the most effective approach.
- **Contractor preparedness to utilize LLLCs in their work is mixed.** Less than half (37%) of survey respondents felt well prepared to install LLLC systems, with only 22% feeling well prepared to program LLLC systems. Nearly half (44%) said they’re “not at all” or “slightly” prepared across all categories.
- **Contractors want more in-person training.** Contractors reported high interest in training on utility rebates, customer education, value engineering, and product selection. They strongly prefer in-person trainings held during winter mornings.
- **Among building owners with LLLC, all have experienced some drawbacks with LLLC, and most did not receive adequate training in system operation.** Six survey respondents reported having LLLC in their buildings, and of those, only one felt they had received adequate training on how to operate their system. Additionally, all six respondents with LLLC reported various drawbacks, including a lack of contractor follow-up and issues with the system’s features.

Conclusions

Overall, the research leads us to 10 overarching conclusions. These conclusions are explained in further detail in the Conclusions and Recommendations section of the report.

1. The Minnesota market **favors traditional non-networked, non-embedded, wired controls**.
2. Market actors see **norms shifting toward LLLC**.
3. Market actors **do not view LLLC as a clearly distinct product category** but rather see it as one of many related options for networked, wireless, and embedded controls.
4. **Project type and delivery process determines which market actors can influence lighting** and controls specifications.

5. Market actors **do not view energy code as strongly influential** on lighting and controls approaches.
6. **Utility rebates are important**, especially in retrofits, **but low awareness** and competition with cheap and easy TLEDs may be hindering the impact of LLLC incentives.
7. Manufacturer reps and distributors view **specifiers (i.e., lighting designers and engineers) as the key influencer of lighting and controls specifications** for specified projects.
8. **Distributors play a growing role in influencing lighting retrofit projects**, with several distributors investing in the growth of their lighting project sales teams.
9. **Contractors' technical skills for selling, installing, and supporting LLLC are limited**.
10. Despite valuing the LLLC's benefits, **most building owners never consider LLLCs** due to low awareness and contractor skill gaps in selling, installing, and support.

Recommendations

Based on the research findings and conclusions, the ETA team could consider the following recommendations. These recommendations are explained in detail in the Conclusions and Recommendations section of the report.

1. **Continue to offer in-person training workshops for contractors and distributor project sales staff.** This study revealed an ongoing need for training, especially among contractors. Distributor project sales staff may also benefit from LLLC education, given their growing role in the Minnesota market and their opportunity to influence projects. The ETA team already includes curriculum in workshops that addresses gaps identified in this study. Given the ongoing need for training in these subjects, the ETA team should review curriculum offerings and consider whether any topics need strengthening.
2. **Continue collaboration with utilities to encourage consistent and optimized rebates for LLLCs.** The ETA team recently worked with funder utilities and provided utilities with a set of recommended rebate definitions, requirements, and a consistent rebate structure for LLLC. Encouraging optimized and consistent rebates throughout Minnesota will enable contractors and other market actors to leverage them more effectively.
3. **Continue to work with utilities to support their trade ally networks and build awareness and adoption of utility rebate offerings.** This study indicated that contractor awareness of LLLC rebate opportunities remains lower than awareness of general lighting and controls rebates. The ETA team should continue providing resources and support to utilities to engage these networks and support them in leveraging utility rebate offerings for LLLC.
4. **To maximize the impact of engagement with the specifier community (i.e., lighting designers and engineers), the ETA team should continue in-depth engagement that respects specifiers' market role as experts.** As a brand-neutral third party, the ETA team may be able to reach specifiers more effectively than reps/manufacturers. However, because the specifier community is already highly knowledgeable about controls technologies, they may not be effectively reached through educational resources or trainings. Instead, the ETA team should continue to prioritize relationship building,

working through respected organizations, and forging ongoing partnerships with any existing LLLC champions in the specifier community to encourage peer-to-peer influence.

5. **Target engagement with distributors to reach their lighting project sales teams,** which are growing at several Minnesota distributors. These teams are leading lighting retrofit sales and leveraging utility rebates, and some of them report strategic growth. The ETA team has an opportunity to assist these distributor sales teams in embracing the benefits of LLLCs by equipping their sales professionals with the tools they need to sell LLLC. This could be achieved by using LLLC demo boards as a sales and training tool or through targeted trainings offered to distributor sales staff.
6. **Consider conducting an end-use customer awareness campaign.** This effort, if pursued, should not be prioritized over supply chain engagement or market actor education, which are higher-impact interventions and more critical to market transformation.
7. **In trainings and resources, continue prioritizing alignment with existing product definitions.** Despite challenges with the nuances of wireless and networked controls product categories, all groups of lighting professionals included in this research reported awareness of the term LLLC. The ETA team should maintain consistent terminology.

INTRODUCTION

LLLC Initiative

In efforts to move Minnesota toward the adoption of more luminaire-level lighting controls (LLLC) systems, the LLLC Initiative was launched in 2023 as a program under Minnesota's Efficient Technology Accelerator (ETA). ETA is a partnership funded by the state's participating investor-owned utilities and consumer owned utilities, administered by the Minnesota Department of Commerce, Division of Energy Resources, and implemented by Center for Energy and Environment (CEE).

The LLLC Initiative strives to advance the adoption of LLLCs to bring lasting change in the lighting market where LLLC systems become standard practice for commercial building applications in Minnesota. The initiative builds demand for LLLC by addressing adoption barriers through local market engagement, education, and partnerships. It supports building owners, designers, and installers with training, technical expertise, and resources to simplify decision-making, incentive opportunities, and installation.

LLLC Technology

LLLCs represent an advanced approach to lighting efficiency and present a cost-effective lighting solution that streamlines implementation of controls and can deliver substantial energy savings and mitigate peak demand. LLLCs are individually programmable luminaires (light fixtures) that contain embedded sensors and compact control components. Unlike traditional lighting control systems, LLLCs place control capabilities directly within each luminaire, allowing operators to maximize the benefits of multiple lighting control strategies. LLLC systems can save energy by optimizing light output through high-end trim (the ability to reduce maximum light output) and granular occupancy and daylight sensing. In addition to their energy-saving benefits, LLLC systems can also improve lighting quality and user experience.

LLLCs bridge the gap between light fixtures and controls components, simplifying design and installation by reducing the quantity of components installed onsite since they are contained within the fixture itself. They also simplify compliance with energy codes and offer labor savings over traditional lighting controls, making them an advantageous choice for retrofits and new construction projects. Additionally, LLLCs can provide the foundation for smart, connected buildings of the future, providing spatial data acquisition, integration with other building automation systems like occupancy-based control of HVAC, and value beyond energy savings.

While nuances of wireless and networked controls product categories exist, alignment around the term LLLC is progressing as national actors like IES, DLC, NEEA and even some manufacturers have adopted the DesignLights Consortium (DLC) definition. DLC defines LLLC as "the capability to have a networked occupancy sensor, ambient light sensor, and high-end trim installed for each luminaire/kit/lamp, and directly integrated or embedded into the form

factor during the manufacturing process."[3] LLLCs are a form of networked lighting controls (NLCs).

In this study, the ETA team sought greater insight into market perspectives on different variants of integral controls and approaches to LLLC:

- Non-networked standalone integral controls: luminaires with one or more integral sensor functions, without any networking capabilities.
- Room-based LLLC: a configuration of LLLC that includes limited networking, such as within a single room.
- Fully networked LLLC: a configuration of LLLC that connects to the internet and includes networking capability across the entire lighting and controls system.

To facilitate discussion of these variants, interviewees were provided with a document describing the definition of LLLC and the variations of controls products we wanted to learn about. This document is included as Appendix E: LLLC Definitions Document.

LLLC Market

LLLC systems have existed for approximately a decade, are widely applicable across building types, and can save on average 63% of the energy consumed by a traditional lighting system.[4] However, they still make up a very small proportion of lighting installations in Minnesota. Separately from this study, the ETA team collects and analyzes sales data to monitor LLLC adoption. The most recent analysis, reflected in the 2025 ETA Status Report filed with the Minnesota Department of Commerce, estimated 2,902 kW of LLLC systems were installed in 2025, corresponding to approximately 50,000 LLLC luminaires sold in Minnesota in 2025.[5]

LLLC systems are mainly used in commercial spaces like offices, warehouses, schools, and hospitals, where the largest energy savings can be achieved. Lighting installation processes can follow several different pathways. For new construction and major renovation scenarios, whether following the traditional design-bid-build project delivery method or the design-build method, LLLCs need to be included in some form of an initial electrical design to be installed. In retrofit scenarios, LLLC may be proposed by a contractor, a distributor, or even requested by the customer. Manufacturers and their sales representatives can influence any of these market actors through their sales, education, design assistance, and project support. Given the multiple possible pathways for LLLC to enter a project, a wide set of market actors can influence its

[3] Definition provided in DLC glossary: https://designlights.org/glossary#l

[4] Wen, Y., et al. 2020. Energy Savings from Networked Lighting Control (NLC) Systems with and without LLLC. Oakland. Energy Solutions – Northwest Energy Efficiency Alliance and the DesignLights Consortium. Pp 39. https://designlights.org/resources/reports/report-energy-savings-from-networked-lighting-control-nlc-systems-with-andwithout-lllc/.

[5] For context, a medium-sized (50,000 sq ft) office building would contain roughly 600 luminaires. This estimate is based on analysis performed by Steve Mesh for Ameren Illinois indicating lighting layouts for office spaces typically include approximately 83 sq ft per fixture. See Ameren Illinois, "Ameren Illinois Luminaire Level Lighting Controls (LLLC) Market Transformation Initiative Business Plan" (November 1, 2023). AIC-LLLC-MTI-Business-Plan-11.01.23-Final-Draft.pdf

adoption. Therefore, this research effort investigates the state of the LLLC market from multiple market actor perspectives up and down the supply chain: manufacturers and their representatives, distributors, contractors, and end-use customers. Lighting designers are another key stakeholder for this work, however they were not included in this effort as they were a focus of other recent research which can be found on the ETA website.

Research Goals and Scope

This report describes key market trends and insights around LLLC from a variety of primary data collection efforts. The overarching goal of this research was to build on what the ETA team has learned through recent work and further hone the ETA team's view of the market landscape, current perceptions, and changes in the market.[6] More specifically, the study sought to:

- Develop further understanding of LLLC market shares and other market intelligence.
- Better understand differences in preference and use for standalone embedded controls versus networked LLLC.
- Track market progress indicators (MPIs) and outcomes associated with LLLCs such as familiarity, use of LLLC systems, confidence in selling/installing, correct installation or programming, etc.[7]
- Identify areas to adjust deployment market strategies around training, outreach, etc.

Methodology Overview

Multiple primary data collection efforts were conducted to strengthen and expand market insights. These included:

- Phone interviews with manufacturers (N=4, representing four unique companies) and manufacturers' representatives (reps; N=6, six unique agencies representing a total of 11 controls brands)
- Phone interviews with distributors (N=8, representing four unique companies)
- An online survey conducted with lighting and electrical contractors working in the commercial building market in Minnesota (N=98)
- Follow-up phone interviews with a subset of the contractor survey respondents (N=9)
- An online survey with building owners (N=89)[8]

The surveys and interviews were designed to leverage the advantages of each approach. Interviews capture nuanced qualitative perspectives from market actors, which helps strengthen our understanding of market roles, relationships, and opinions. With fewer respondents, the interviews do not provide statistical representativeness, but they are the preferred method for gathering rich open-ended input from market participants. Surveys,

[6] Recent research includes the mentioned LLLC Market Insights Report: Lighting Designers and the 2023 LLLC Market Characterization.

[7] MPI results are reported in Appendix A: MPI Table and Appendix B: MPI Analysis.

[8] For clarity, this report uses the term "building owner" to refer to all respondents to the survey, but respondents also included facility managers, engineers, and property managers.

conversely, achieve larger sample sizes for improved representativeness and capture information in a standardized format that allows for comparisons.

More information about each of these efforts is included in its relevant section, and in Appendix C: Detailed Methodology.

The remaining sections of this report include detailed findings from each data collection effort, followed by conclusions and recommendations based on this research.

Manufacturer and Manufacturer's Rep Insights

Background

Manufacturers and manufacturers' representatives (also called reps or sales agencies) occupy a critical role in the market for LLLC as the top of the supply chain. Their decisions about product offerings, marketing and sales approaches, and priorities within their companies can greatly impact the adoption of new technologies. Within the lighting and lighting controls industry, large manufacturers offer thousands of products and serve many customer segments. Their views and strategies for LLLC, which is a narrow product category within their broad offerings, can drive or hinder market adoption.

To understand manufacturers' and reps' current perspectives on LLLC in Minnesota, we interviewed 10 people in roles related to lighting controls sales. These interviews sought to gather insight into larger lighting and controls manufacturers, to supplement previous research that focused on smaller companies. Topics included:

- LLLC familiarity, installation, and market trends
- Market composition and key players
- Market share for major manufacturers in Minnesota
- Role of standalone embedded controls (i.e., fixtures with non-networked integrated sensors and controls)
- Role of the Design Lights Consortium Qualified Product List for manufacturers

To facilitate discussion, we provided a document in advance of the interview that described the definition of LLLC and the variations of controls products we wanted to learn about. This document is included as Appendix E: LLLC Definitions Document.

Businesses Interviewed

Interviewees were recruited purposively, targeting manufacturers and reps who had not participated in another recent round of interviews performed by the ETA team. The recruitment list was developed by the ETA team in collaboration with its program contractors and included Minnesota based manufacturer representatives and manufacturer staff with territorial responsibility for Minnesota (e.g., Midwest sales managers).

We conducted interviews with four manufacturer staff members and six staff members from manufacturer representative agencies. To preserve interviewee anonymity, we will not list the names of companies interviewed. All interviewees represent companies that offer LLLC products, but the focus on LLLC ranged widely, from a minor niche offering to the majority of their business.

The four manufacturers ranged from large industry leaders to small niche controls companies. The roles of the individuals interviewed included two ESCO sales specialists (one national and one Midwest-focused), one national sales lead with a focus on the Midwest, and one Midwest sales manager with a focus on energy solutions. Where possible, the interviewees provided their

insights about Minnesota specifically, but they also shared general market perspectives. These perspectives provided insight into the specification sales (design-bid-build), design-build, and retrofit market segments.[9] These three segments differ in terms of decision-making parties, as well as in the opportunities for influence from other market actors.

The six rep agencies interviewed represented a total of 11 controls brands, including four of the largest manufacturers offering LLLC, as well as several smaller and niche brands. All six interviewees were based in the Twin Cities metropolitan area. Four of the individuals interviewed were controls specialists, and two had broader sales roles including lighting and controls. All six focused primarily on the specification sales market segment, with design-build as their second focus area. One rep mentioned retrofit sales as a third area of focus.

There was overlap in the brands represented by the interviewed manufacturer rep agencies and the interviewed manufacturers.

Opportunities for Influence

The reps we interviewed agreed that in the specification sales segment — that is, projects in which the lighting and controls specification is developed by a designer or engineer — reps do not view influencing product selection or design as part of their role. They explained that in this segment, which typically includes new construction and major renovations, the designer or engineer is responsible for the decision-making around lighting and controls. In these cases, the rep's role is to ensure that their brand's products are selected to meet the design.

> *"It's just about threading the needle between the existing spec and what the project budget can accommodate. It's not our job to redesign spaces that have already been designed. Our job is to respond to the specifications with the best quote we can put together." –Agency representative*

Eight out of 10 respondents (including manufacturers and reps) agreed that in the specification sales segment, their top priority is to make a sale. In other words, it is less important to drive projects toward a specific solution, and more important to ensure that their brand is the brand selected. Upselling is not an important part of their sales process. This indicates that given the current norms in the market, reps are not likely to promote LLLC as an alternative to other controls solutions that designers and engineers include in their specifications.

[9] Specification sales refer to projects in which the lighting and controls specification is written by a third party, typically an electrical engineer or lighting designer, and typically as part of a design-bid-build construction process (design-bid-build is the traditional construction project delivery method where design, bidding, and construction occur in separate, sequential phases). Specification sales tend to focus on design-bid-build projects, which are mostly new construction and major renovations. Design-build is a different approach to the construction process, in which specification decisions are made within the design-build team (typically led by a general contractor), rather than designed by a third party with the intention of seeking competitive bids. Lastly, retrofit sales focus on existing buildings seeking to update their lighting equipment. These projects are typically served by retrofit contractors.

Despite the limited influence on specified projects, reps and manufacturers have greater influence on other project types, particularly those led by contractors or distributors. Manufacturers play an important role in the market as the primary source of training for distributors and contractors. Reps offer formal proactive training specific to their products to both distributors and contractors (including design-build companies). They also offer *ad hoc* support to these groups, such as design support for projects, and support in system programming and setup in some cases. This role in providing training and support is particularly influential in the design-build and retrofit segments of the market. In these segments, contractors and distributors are typically in the decision-making role in determining lighting and controls specifications, and they may turn to reps for design support. More discussion of these roles and relationships is included in Contractor Insights.

Views on Controls Market

All interviewees noted that controls are a growing segment in their businesses. Three respondents were able to provide an estimate of the rate of growth, and their estimates ranged from 10% to 20% annual growth in controls sales. Despite these optimistic views on controls sales, most respondents also noted that controls make up a small portion of their overall lighting business. The exception to that statement was the two manufacturers interviewed whose product offerings focus exclusively on controls.

Within the controls segment, our interview focused on integral controls, i.e., those embedded in the light fixture, including LLLC.[10] This subsegment represents a minority of controls sales for all companies interviewed. Respondents found it difficult to estimate the portion of all controls projects that included integral controls, but among the five who were able to estimate, their approximations ranged from "small" to 30%. See additional discussion of integral controls and the sub-categories thereof below in the section Adoption and Application of Integral Controls.

LLLC Familiarity and Opinion

Nine of the 10 interviewees rated themselves as "very familiar" with LLLC, with the remaining one as "somewhat familiar."[11] Since these are mostly controls specialists, all representing companies that offer LLLC products, this high familiarity was expected. The one respondent that was only somewhat familiar with LLLC represented a brand that is less focused on LLLC and did not utilize LLLC often.

This group had a positive view of LLLC, which, again, is unsurprising given that they all offer and sell LLLC products. Eight of 10 described their opinion of LLLC as favorable or very favorable, with two reps having a neutral opinion on LLLC. Three respondents stood out as advocates for LLLC, readily discussing the benefits of the technology and its advantages over other alternative

[10] Integral controls are also referred to as embedded controls, and both terms are used interchangeably in this report. The DesignLights Consortium uses the term integral, but some manufacturers prefer the term embedded, and some survey and interview questions used the term embedded.

[11] Interviewees had been provided with the LLLC Definitions Document prior to the interview, see Appendix D.

approaches. The others with positive perspectives on LLLC viewed it as one of many tools in their toolkits: perhaps not appropriate for every situation, but a strong technology with clear benefits. The neutral respondents noted that they simply do not use LLLC very often and find that other products meet needs more often. One neutral respondent also viewed LLLC as complex and noted that complexity can lead to difficult experiences for installers and customers.

While manufacturer and rep interviewees expressed generally positive opinions of LLLC, most (all 6 reps and 2 manufacturers) agreed that they use LLLC infrequently in their work in Minnesota or nationally. This perspective reflects their experience and focus on the specification sales market, where manufacturers and reps agree that the chief barrier to broader adoption of LLLC is status quo inertia. There was a clear consensus that specifiers (engineers and lighting designers) tend to stick with what they know, which is zone-limited, non-integral, non-networked controls.

Several interviewees noted that specifiers can be resistant to change, and the Minnesota specifying community is viewed as "set in their ways." From the manufacturers' and reps' perspectives, specifiers tend to be risk averse and prefer to use proven solutions with which they have had past success. This results in slow adoption of new practices or technologies like LLLC. Interviewees explained that the aversion they see among specifiers is not specific to LLLC but rather encompasses anything outside the proven status quo. Two reps specifically mentioned that they rarely see wireless controls specifications from designers or engineers in Minnesota, with traditional wired approaches preferred among specifiers unless customers require wireless.

One rep pointed out that specifiers are highly educated on lighting and controls, and they do keep up with new technologies, but they may have learned about LLLC several years ago, when "the costs were still higher, and the technology wasn't as good." This may have dampened their willingness to use LLLC and created negative perceptions. Additionally, several reps mentioned the fact that they, as salespeople, are not in the best position to educate specifiers about new technologies: some reps feel that designers and engineers view them as biased toward their own brands. Six out of the 10 interviewees believed that ETA, as a neutral third party, may be in a better position to provide education to engineers and designers. However, several interviewees noted they believe this is a difficult group to influence because they are highly knowledgeable and risk averse.

Views on Market Leaders

We asked manufacturer reps for their perspective on which LLLC manufacturers are most prominent in Minnesota. Five of the six reps interviewed agreed that the Minnesota spec market prefers single-vendor or packaged lighting systems, i.e., systems in which the controls and fixtures are offered by the same manufacturer. Acuity was commonly mentioned as a market leader in Minnesota, followed by Cooper. (Note: these responses did not come exclusively from reps who represent those brands.) These companies are national leaders among single-vendor

providers of lighting and controls. A third provider in that space is Signify, which respondents did not mention as a market leader in Minnesota but does have agency representation.

While single-vendor solutions may be preferred in some cases, controls-only manufacturer Lutron is also viewed as a leading participant in the Minnesota market. Lutron and other dedicated controls providers tend to offer compatibility across many brands of lighting equipment, and some designers and engineers prefer the flexibility of being able to select fixtures from other brands.

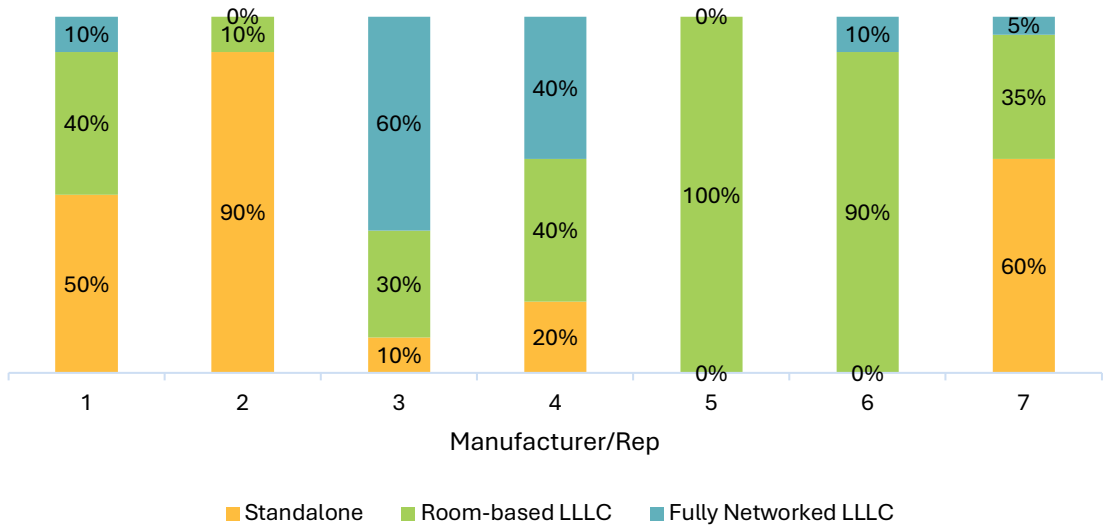
Adoption and Application of Integral Controls

As mentioned, interviewees considered LLLC an uncommon solution for controls. The interview attempted to gather more detail about controls approaches and applications, but interviewees had some trouble providing detailed responses. This is partly due to the granularity of the categories in which we asked for information. The questions were designed to solicit detailed information about sub-categories of integral controls, but most respondents were not tracking these sub-categories in as much detail as our questions presumed.

The interviewees were asked how often they use integral controls, including but not limited to LLLC. Only five of the 10 respondents were able to provide a response to this question, and two of the five gave qualitative estimates: “little,” “small amount.” The three respondents providing numeric responses said that out of all projects with controls, 10%, 20%, or 30% include integral controls. These values should not be considered representative of the total market, due to the limited and varied nature of the response data.

Within integral controls, the interviewees were asked to estimate the mix across three sub-types: non-networked standalone integral controls, room-based LLLC, and fully networked LLLC. Seven of the 10 respondents were able to estimate the mix within integral controls, and again, the responses varied widely. For this breakout as well, these values should be considered anecdotal and not representative of the total market due to the small sample, the difficulty respondents had in providing these estimates, and the high degree of variation in responses. As shown in Figure 1, across all respondents, the most frequently used sub-type was room-based LLLC, followed by standalone, then fully networked LLLC.

Figure 1. Manufacturers and Reps' Estimated Sales Mix of Sub-Types within Integral Controls (n=7)



Finally, interviewees were asked to describe the applications that were best suited for each sub-category of integral controls. For this question, five of 10 respondents were able to provide an answer. However, these responses, compiled in Table 1, showed greater consistency than the estimated sales figures. All five respondents gave a similar profile, with smaller and simpler applications as the best fit for standalone, and more complex and larger applications as best suited for fully networked LLLC. Room-based was cited as a middle ground that works well for many medium-sized spaces and common applications like office buildings and school classrooms.

Table 1. Applications Best Suited for Sub-Types of Integral Controls (n=5)

Sub-Type of Integral Controls	Ideal Applications suggested
Standalone/Non-networked	Small and medium warehouses, exterior, parking lots, janitor closets, light industrial, small office with one or two lights, "never – I don't recommend this"
Room-based LLLC	Classrooms, office buildings (including closed and open offices), parking garages, warehouses, "any medium-sized space"
Fully networked LLLC	Schools, campuses, multi-story/large office buildings, large commercial/industrial, multi-site, hospitals and healthcare, parking garages, larger projects, sites looking for a single system for interior and exterior

DesignLights Consortium QPL

We asked manufacturers about their use of the DesignLights Consortium's Qualified Product List (QPL) for Networked Lighting Controls. None of the four manufacturer respondents were deeply familiar with the DLC QPL, though they were aware that their company's products were listed. One respondent mentioned that he knew the QPL was valuable for ensuring utility incentive eligibility but did not know of other uses for the QPL.

DISTRIBUTOR INSIGHTS

Background

Distributors occupy a middle role in the lighting supply chain, stocking products and providing local availability that can reduce project lead times and financial risk for buyers. Their sales teams can actively recommend products, and they can also influence product selection through training, stocking commitments, and counter sales. Distributors tend to favor proven and readily available solutions, since they operate in a highly competitive business environment.

We interviewed distributors to understand their perspectives and roles regarding LLLC in Minnesota. We prioritized outreach to individuals with roles in lighting and lighting controls sales. Topics included:

- LLLC familiarity and use
- Distributor positioning and relationship in the market, including their role in recommending LLLCs and NLCs to contractors or customers and their interactions with manufacturer rep agencies
- LLLC applications, including differences in wired/wireless, standalone embedded controls and LLLC use, and HVAC integration possibilities
- Benefits and barriers for LLLCs
- LLLC preference for code compliance
- LLLC preparedness and appropriate installation techniques

To facilitate discussion, we provided a document prior to the interview that described the definition of LLLC and the variations of controls products we wanted to learn about. This document is included as Appendix E: LLLC Definitions Document.

Businesses Interviewed

Interviewees were recruited purposively. The recruitment list of 124 distributor staff was developed by the ETA team in collaboration with its program contractors. The list included Minnesota-based distributor staff, some of whom had participated in the ETA team's recent Distributor Jump Start Initiative. Recruitment targeted individuals in roles with involvement in lighting and lighting controls sales.

We performed eight in-depth interviews with distributor staff. To preserve interviewee anonymity, we will not list the names of companies interviewed. The eight interviews covered four companies. As shown in Table 2, seven interviews were with full-line electrical distribution companies, while one interview was with a specialty lighting-focused distributor. A full-line electrical distributor offers a wide range of electrical supplies, including wire and cable, conduit and fittings, panels, safety equipment, and other products. Lighting is a specialized department, often with dedicated staff with lighting expertise. Lighting controls, therefore, are a sub-

specialization within lighting. According to industry reporting, lighting tends to account for approximately 15% of a full-line electrical distributor's business.[12]

Table 2. Distributor Respondents and Company Types

Distributor	Company Type	Company Geographic Scope	Number of Respondents
Distributor A	Full-Line Electrical	Regional	3
Distributor B	Full-Line Electrical	Regional	3
Distributor C	Lighting Specialist	Minnesota	1
Distributor D	Full-Line Electrical	National	1

For the two companies with multiple respondents, the interviewees represented different focus areas, including specification sales, design-build, and retrofit. The interviewees held various roles within their companies, all with relevance to lighting and controls. Interviewee roles included outside project sales manager, lighting specialist, electrical or lighting sales manager, lighting business development manager, and lighting designer. Most respondents were based in the Twin Cities metropolitan areas, but many of their roles covered statewide or regional activities.

Users of this report should note that these distributor interviews reflect a small, non-representative sample, and it should not be assumed that these responses reflect the average sentiments of the overall market. Instead, these responses reflect a set of perspectives from active participants in the lighting and controls market with various specialties, which can be used in combination with other market intelligence to glean insights about the market as a whole.

Distributor Role and Influence

The role of the distributor and their opportunity to influence product selection or project design is highly variable, depending on the type and structure of the project. In specification sales, i.e., projects in which the specification is written by a designer or engineer (or in some cases a manufacturer rep providing design assistance), the role of the distributor is limited. For design-build and retrofit jobs, however, distributors have a greater opportunity to influence product selection and provide design input.

Interviewees described the distributor role in specification sales job as focused on providing a pricing quote for the materials specified. Interviewees emphasized that their goal with these projects is to win the job with the lowest bid, and that competitive advantage can be very slim. One distributor provided this example: "We had a school customer, an engineered job, and we lost the job because our bid came in $70 higher than the other guy." Given the tight competition distributors face on specified jobs, they do not have an opportunity to influence the

[12] Electrical Trends is an applied research and reporting group for the electrical industry. https://electricaltrends.com/2026/01/25/14-lighting-industry-trends-for-your-2026-business-planning/

specification and certainly would not be able to add higher-cost options to a bid. In fact, three respondents mentioned excluding controls equipment from their bids to gain a cost advantage over their competitors.

In the design-build and retrofit segments, distributors have more opportunities to influence product selection and project design. Distributors can influence design-build projects when contractors come to them for input on product selection to meet a project's requirements. They also influence retrofit projects in the same way, and in some cases, distributors lead these projects with their own sales teams. This typically includes sales and basic design support.

Outside sales teams work to develop relationships with key clients like school districts or local chains, and through those relationships they can lead the development of lighting and controls specifications. This process sidesteps the need for a third-party designer and allows distributors to service these clients and projects directly. Distributors are building their in-house design expertise to take on more of this work. Distributors (two interviewees) noted a preference for simpler-to-design projects in outside sales work, while still looking to manufacturer reps for help with complex design. One interviewee mentioned that distributors working in rural areas have more influence on a greater portion of projects because there are fewer spec-driven projects compared to urban markets.

Another key role that distributors play is in the logistics of fulfilling orders, by receiving shipments and stocking products. Distributors shared that they do not stock LLLC fixtures, but that they typically order LLLC fixtures on an as-needed basis, and most manufacturers are able to deliver LLLC fixtures in three to six weeks. Some manufacturers specialize in faster fulfillment, delivering most products in less than 30 days. Two distributors mentioned that they stock components and gateways for the Lutron Vive system, specifically those required for a non-integral wireless NLC configuration. One distributor mentioned that Lutron Vive is the system their contractors know the best and there are contractors who will only quote and install Lutron Vive, particularly for small and medium jobs.

Controls Market and Views on LLLC

Among the distributors interviewed, all respondents viewed controls as a growth market and all full-line distributors mentioned adding staff to invest in capturing this market. Distributors reported that their lighting outside sales teams, ranging in size between 5 and 20, were growing, and some companies have aggressive goals to capture more work in the retrofit/design-build market segments. This trend toward distributors developing outside sales teams that focus on lighting and controls retrofit and/or design-build projects was also corroborated by a comment from a manufacturer interviewee, who noted that distributors were a growing source of influence because several (though not all) are starting to build and develop their outside sales teams.

Distributors could not provide quantitative estimates of what portion of controls projects use integral controls, but they agreed it is a small but growing category. When asked about the annual growth of integral controls sales in Minnesota, five respondents were able to provide numeric estimates, which ranged from 10% (three respondents) to 40% (one respondent, who

indicated that this growth is a result of an intentional effort to increase sales of integral controls).

Distributors had at least some familiarity with LLLC: four respondents said they were "very familiar" with LLLC, three said "somewhat familiar," and one was not familiar with the term LLLC but was familiar with the concept once the interviewer explained the definition.[13] Distributors had favorable views of LLLC: seven of eight respondents said their opinion of LLLC was either "favorable" or "very favorable." The one remaining respondent reported a neutral opinion on LLLC.

LLLC Prevalence and Trends

Despite the growth opportunities and favorable outlook on LLLC, distributors agreed that LLLC is not a commonly applied solution for lighting controls in Minnesota today. Most of their controls projects are wired, non-networked, non-embedded, zone-limited controls. Particularly in the specification sales segment, distributors see inertia around the status quo, with designers and engineers "recycling the same specs they've used for a long time," according to one respondent. Another contributor to this status quo entrenchment is the highly cost-competitive environment in which distributors operate, discussed in more detail in the following section.

> *"Networked and LLLC are going to be the white goods of the future. All the advantages are there. It's not one thing, it's all the things. But they are up against the status quo and people chasing lowest cost sales and a huge resistance to learn anything new or do anything that would lose them a project based on cost." –Distributor*

However, distributors see clear advantages to LLLC, with seven of eight respondents recognizing energy savings as a key benefit of LLLC. Three respondents discussed the benefits for installers being able to "design in the field" — installers can use the same fixture for all locations with LLLC, and configure the system as needed by identifying the zones that make sense on site during the installation. This approach would be advantageous for jobs without detailed specifications and sequences of operations, which is more likely for some design-build and retrofit jobs.

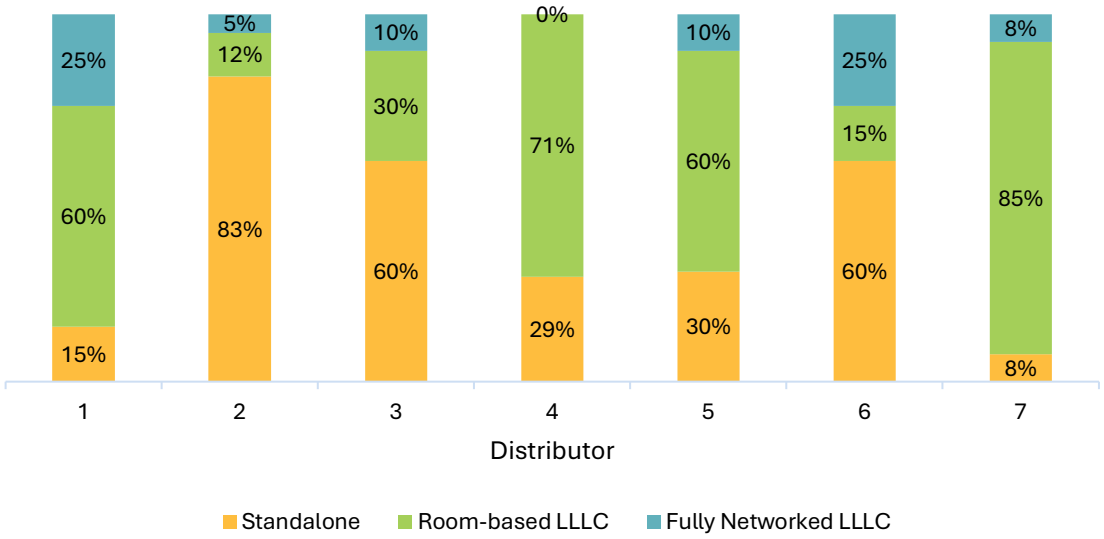
Adoption and Application of Integral Controls

All respondents agreed that integral controls are uncommon. Two respondents noted that some contractors and customers are becoming comfortable with wireless controls, and they have seen uptake of integral controls in retrofit and design-build. One respondent commented that their market is "still just catching on to the benefits of wireless and integrated controls," noting that these products are not frequently sold apart from some large, specified projects with advanced lighting controls. These responses illustrate a lack of consensus around which market segments are adopting integral controls.

[13] Interviewees had been provided with the LLLC Definitions Document prior to the interview, see Appendix D.

Within integral controls, the interviewees were asked to estimate the mix across three sub-types: non-networked standalone integral controls, room-based LLLC, and fully networked LLLC. Seven of the eight respondents were able to estimate the mix within integral and their responses were varied, as shown in Figure 2. Again, these values should be considered anecdotal and not representative of the total market due to the small sample, the difficulty respondents had in providing these estimates, and the high degree of variation in responses. For example, three responses were from three different representatives of the same company, and they vary significantly from one another, indicating that the respondents did not have a strong sense of these proportions.

Figure 2. Estimated Sales Mix of Sub-Types within Integral Controls (n=7)



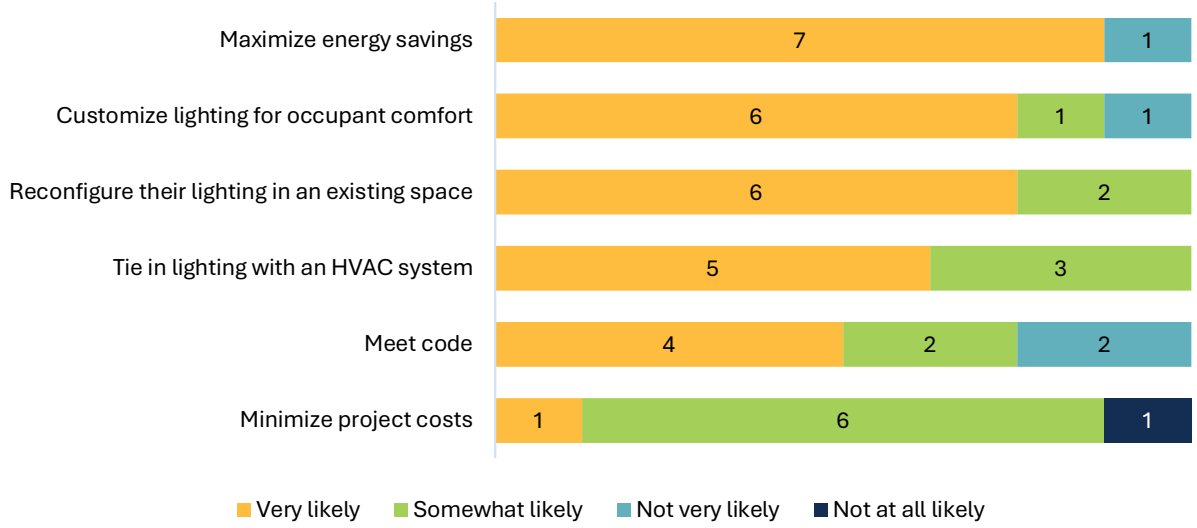
In commenting on their responses, five respondents agreed that room-based LLLC is the best approach for many projects. They shared a positive outlook on the benefits of room-based LLLC for ease of use, zoning, and flexibility. (Among those five respondents, one reported a low incidence of *using* room-based LLLC in the question above, while the other four used room-based LLLC between 30% and 85% of the time.) Most interviewees also agreed that standalone integral controls are not the best solution for most projects. They commented that standalone integral controls can make sense in limited applications like basic warehouses or small rooms, particularly in situations with constrained customer budgets. Once again, this opinion conflicted with a few of the responses provided in Figure 2. These conflicting responses illustrate the potential for lack of clarity around the detailed sub-categories of integral controls and point to the difficulty respondents had in quantifying their current practices.

Application of LLLC

Most distributors reported that they do not frequently recommend LLLC, with seven of eight respondents saying they recommend LLLC “sometimes” (n=3) or “not very often” (n=4). However, when we asked distributors how likely they were to recommend LLLC in various customer situations, their responses revealed that many customer situations could be

addressed with LLLC. As shown in Figure 3, energy savings were the top reason distributors would recommend LLLC, followed by customizability and reconfigurability.

Figure 3. How likely are you to recommend LLLCs for customers who are looking to…? (n=8)



The three lower-ranked customer situations were tying in lighting with an HVAC system, meeting code, and minimizing project costs. Distributors commented that HVAC system integration is rare and only occurs in certain building types including large college or corporate campuses and large manufacturing facilities.

Commenting on using LLLC as a means for meeting code, three distributors mentioned that they do not see code as a motivator for choosing lighting controls approaches, and they see a lack of code enforcement for lighting controls in Minnesota. They noted that in specified jobs, the engineer or designer does tend to design to meet code-minimum controls requirements. One distributor also mentioned schools as a building type/customer type that is more concerned with meeting code requirements. However, beyond those exceptions, the three respondents agreed that little attention is paid to code requirements for lighting controls, either by contractors or end-users.

Role of Utility Rebates

Six of the eight distributor respondents reported that they were familiar with utility lighting rebates in general, but only the retrofit-focused interviewees reported using the rebates frequently. One respondent with a greater focus on specification sales noted that he sees utility rebates used in only about 5% of his projects. He commented that the process can be confusing, and that it doesn't seem worth changing a project for a rebate. On the other hand, three retrofit-focused respondents reported using incentives in a higher percentage of projects, ranging from about 40% to 100%. Particularly for LLLC, one respondent viewed incentives as critical: "[For LLLC,] we use them every time. They are what pays for the adder. They are extremely important." Another respondent commented that while incentives are helpful for

LLLC, the current incentive offerings make TLEDs highly attractive from a cost perspective, and he views this as deterring customers from investing in LLLC: “As long as TLEDs are effectively free, it doesn’t matter what they pay for LLLC.”

Market Actor Roles in Customer Support

Distributors discussed a lack of clarity in the market around roles and responsibilities in the development and support of lighting controls projects. Practices vary around who is responsible for:

- Developing the sequence of operations (SOO) (designer/engineer, rep, distributor, contractor)
- Programming the system (rep, contractor)
- Educating the end user (rep, distributor, contractor)
- Supporting the system in the long run (rep, distributor, contractor)

Several distributor respondents agreed that there was room for improvement in standardizing and normalizing responsibility for these roles. Some distributors voiced concerns about callbacks and reported that they receive calls from end-use customers who are having trouble with their lighting controls system six months or a year after installation. In most cases, distributors agreed that long-term support should be handled by the contractor, but they also recognized that contractors may lack the expertise on all controls systems that they would need to effectively support and troubleshoot issues. Furthermore, they recognized that contractors often do not have service costs priced into their quotes, so callbacks can impact their business profitability.

Contractor Training

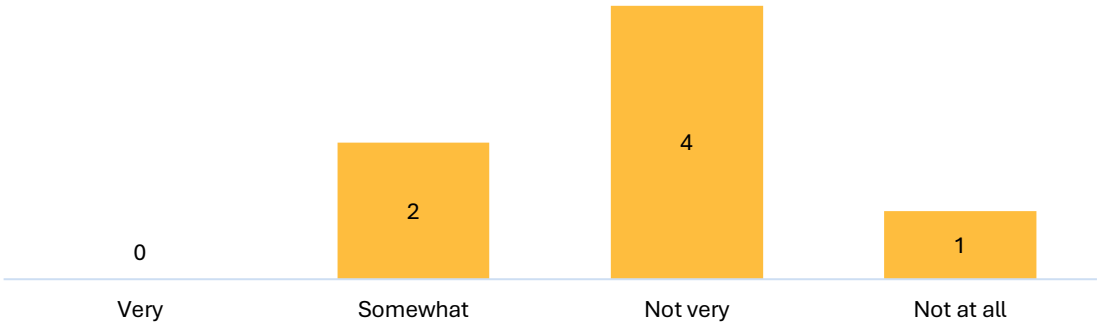
Despite acknowledging issues related to contractors lacking training, six out of eight distributor respondents said they offer little or no training for contractors. Most distributors reported that they rely on the reps for this function. A few distributors saw an opportunity to be more involved in contractor education, but others did not view this as part of their role in the market. Instead, those distributors felt that the contractors needed to be responsible for their own skill development.

When asked about the type of training that would be beneficial in the market, every respondent agreed that in-person and hands-on training is critical for contractors to learn new technologies. They emphasized that contractors learn best when they have a chance to try out new equipment themselves. They also pointed out the learning-curve challenge with the availability of many networked lighting controls systems — one distributor commented, “It's hard to know just one of these systems, let alone a dozen.” In addition to the strong support for in-person training, two respondents recommended *also* offering on-demand video/webinar resources as a secondary option to help reinforce learning.

LLLC Preparedness

When asked how prepared their sales staff are to sell LLLCs, distributors rated their preparedness fairly low, as shown in Figure 4. Among the seven distributors who were able to respond to this question, five rated their staff as “not at all” or “not very prepared” to sell LLLC.

Figure 4. How prepared would you say your sales staff are to sell LLLCs? (n=7)



While these responses point to low preparedness among distributor sales staff, distributors offered additional context, explaining that specialists carry out most of their lighting and controls sales efforts. This reflects an important nuance about the responses: not all distributor sales staff will be in a position to sell LLLC. This role will be specific to lighting and controls sales specialists, such as those working in outside sales teams, as retrofit specialists, or in roles with the opportunity to influence product selection. Even with that context, though, distributors agreed that their staff were at best somewhat prepared to sell LLLC.

> *“Our general sales staff are selling thousands of SKUs every day, and they don’t understand lighting or controls. You have to have somebody working just with lighting to make LLLC appealing. It’s not like selling a wire nut."*
> *–Distributor*

CONTRACTOR INSIGHTS

Background

This research effort sought perspectives from contractors who recommend, install, and set up lighting and controls equipment. These contractors play a critical role in delivering LLLC projects, including installing the fixtures, as well as often implementing the controls programming (e.g., defining zones, inputting the sequence of operations, etc.). Furthermore, contractors often hold ongoing responsibility for supporting the system over time, providing troubleshooting and maintenance services to end users. The role of the contractor, however, can vary greatly based on the type of project and the other market actors involved. Contractors themselves vary in their business approaches, ranging from broad-based electrical contractors (ECs) who serve all electrical needs in a construction project to highly specialized lighting and/or controls installers or retrofit specialists.[14] Due to their broad and varied responsibilities, contractors can influence lighting and controls outcomes at multiple project stages.

To gather insights from contractors, we fielded an online survey, then followed up with in-depth phone interviews with a sub-group of the survey respondents to gather more detailed perspectives.

Contractor Survey

The online survey sought better understanding about:

- Contractor awareness of LLLC
- Barriers to adoption or implementation of LLLC
- Why contractors install what they install
- What support contractors need for successful implementation of LLLC
- Contractor training or learning needs

Businesses Surveyed

The survey invitation was sent to a list of 900 Minnesota contractors, sourced largely from an energy efficiency utility program serving small and medium-sized businesses in the Twin Cities metro area. Thus, the contractors were largely concentrated in the Twin Cities metro area and may have more experience with energy efficiency and utility programs.

The survey received 98 responses from contractors who work on non-residential projects with lighting controls, reflecting a mix of business types focusing on both retrofit and new construction. About a quarter (23%) of respondents focused exclusively on retrofit work, while 5% performed exclusively new construction. The majority engaged in a mix of both types. The

[14] Another difference between EC firms and lighting firms is the type of credentials their staff are likely to hold. EC firms typically employ licensed electricians along with other workers, while lighting-specialist companies may instead focus on lighting expertise and employ lighting certified professionals (LCs).

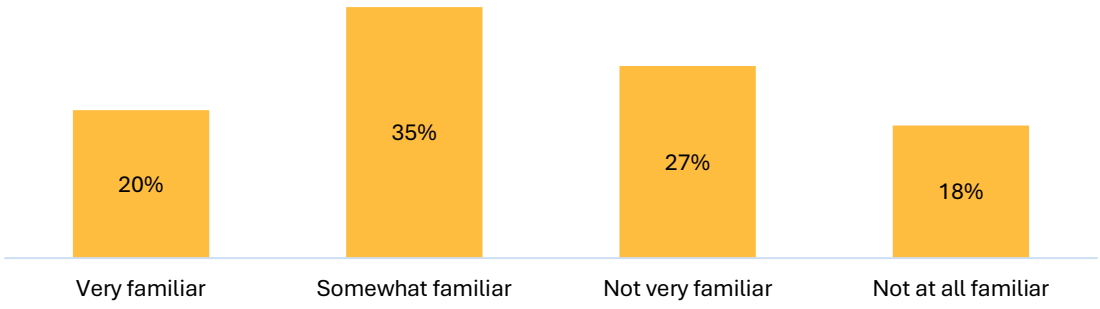
response data may reflect a bias toward the retrofit market, since a larger share of respondents represent retrofit-only firms.

Awareness and Use of LLLC

Most respondents had at least some familiarity with LLLC. The survey asked respondents whether they had heard of the term LLLC or luminaire-level lighting controls, without providing a definition. Fifty-five percent of respondents reported that they had heard of the term.[15]

After being provided with a definition of LLLC, 55% of respondents reported having some level of familiarity (either somewhat or very familiar), and only 18% described themselves as not at all familiar (Figure 5). After the definition was provided, more than a third of respondents reported having recent experience installing LLLC, with 37% having installed LLLC in the past year.[16] Four of those respondents had answered "no" to the prior question on whether they had heard of the term LLLC, signaling that while most contractors are familiar with the term, some may be familiar with the technology but use different language to describe it. We compared responses for businesses performing mostly retrofit against those performing mostly new construction, but we could not identify a meaningful difference in their rate of LLLC utilization.[17]

Figure 5. How familiar are you with LLLCs? (after reviewing definition, n=98)



When asked for their general opinion of LLLC (Figure 6), nearly half (49%) of respondents said they either "don't know" or had a "neither favorable nor unfavorable" opinion, with 44% reporting

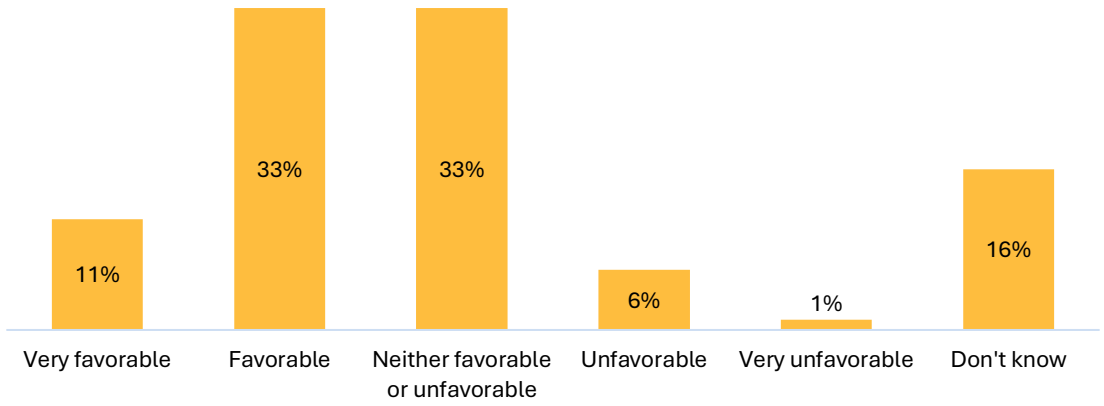
[15] For comparison, a study conducted by Northwest Energy Efficiency Alliance in 2024 found that (after 9 years of NEEA's LLLC initiative) 94% of installers were aware of LLLC. The question was asked differently and provided a definition of LLLC. Notably, Northwest states have a longer history of program intervention in the LLLC market, so this level of awareness would not be expected in Minnesota. However, the comparison with the NEEA finding indicates that it is possible for a high percentage of installers to be aware of LLLC. NEEA, Luminaire Level Lighting Controls: Market Progress Evaluation Report #3, available online: https://neea.org/resource/luminaire-level-lighting-controls-market-progress-evaluation-report-3/

[16] The definition provided in the survey was, "Luminaire-Level Lighting Controls are networked systems of light fixtures with embedded controls and a dedicated sensor per luminaire. Sensors are typically occupancy and/or daylight sensors and often use wireless communication. Since controls are housed within, additional relays/dimmers/control panels are not required like in other networked lighting control systems."

[17] The subsample groups were too small for statistical testing to be valid: 9 contractors performed 90+% new construction work, of which 4 had installed LLLC in the past year; 38 contractors performed 90+% retrofit work, of which 12 had installed LLLC in the past year.

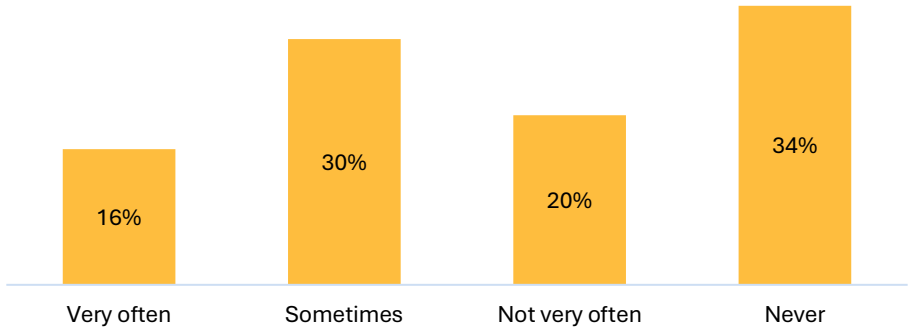
either a “favorable” or “very favorable” opinion of LLLC. The LLLC detractors were in the minority, with only 7% of respondents reporting an “unfavorable” or “very unfavorable” opinion.

Figure 6. In general, what is your opinion of LLLCs? (n=98)



Contractors were asked about their current practice when it comes to promoting or recommending LLLC. As shown in Figure 7, the most common response was “never,” with 34% of respondents. Another 30% of contractors reported recommending LLLCs “sometimes,” and a minority (16%) reported recommending LLLCs “very often.”

Figure 7. How often do you currently promote or recommend LLLCs, if at all? (n=98)



The survey asked about the projects that respondent contractors installed in 2025 to further characterize the type of work they perform. As shown in Table 3, 43% of projects these contractors engaged with do not include controls. This may indicate that some lighting retrofit projects leverage existing controls rather than adding new controls, or that some lighting projects exclude controls entirely. Among projects that do include controls, the clear leading strategy is traditional controls, in other words, non-networked, non-embedded, wired approaches to controls. This category accounted for 35% of lighting projects overall and 62% of reported projects including controls. LLLCs were included in 4% of lighting projects overall, and 8% of projects including controls. This survey was not designed to produce a representative

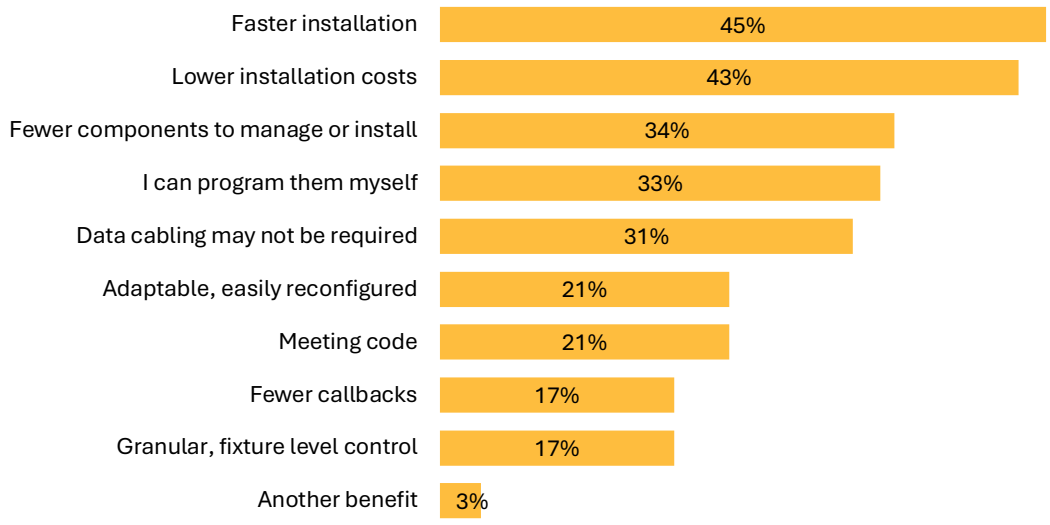
estimate of the mix of controls approaches in Minnesota, but this mix can be considered an approximate indicator of the relative prominence of each controls approach among the surveyed contractors.

Table 3. How many projects you installed in 2025 had the following types of controls? (n=98)

Controls Type	Number of Projects	Percent of Projects
Traditional occupancy sensors, photocells, or timeclocks (non-networked, non-embedded)	3,296	35%
Non-networked light fixtures with embedded sensors	841	9%
Luminaire-level lighting controls (LLLCs)	407	4%
Other networked lighting controls (NLCs)	792	8%
Something else	5	0%
No controls	4,043	43%

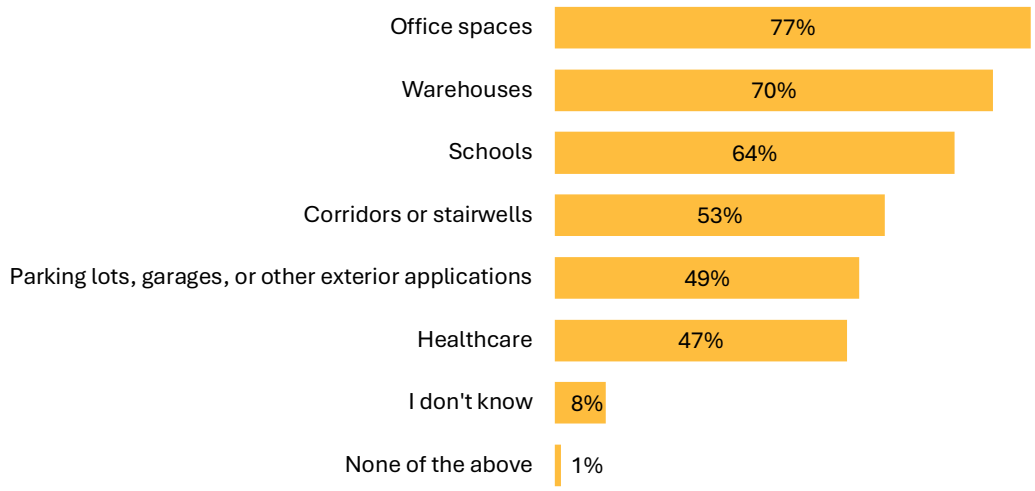
Contractors also reported on which benefits of LLLC they viewed as most attractive. As shown in Figure 8, the top benefits that appeal to contractors were faster installation, lower installation costs, and fewer components to manage or install. This cluster of benefits clearly indicates that contractor priorities are focused on the cost and time efficiency of their installation work.

Figure 8. What potential benefits of LLLCs are most attractive to you as the contractor? (n=98)



When asked which building types or spaces they considered a good fit for LLLC (Figure 9), most contractors identified office spaces (77%), warehouses (70%), schools (64%), and corridors or stairwells (53%). Only one respondent answered “none of the above.”

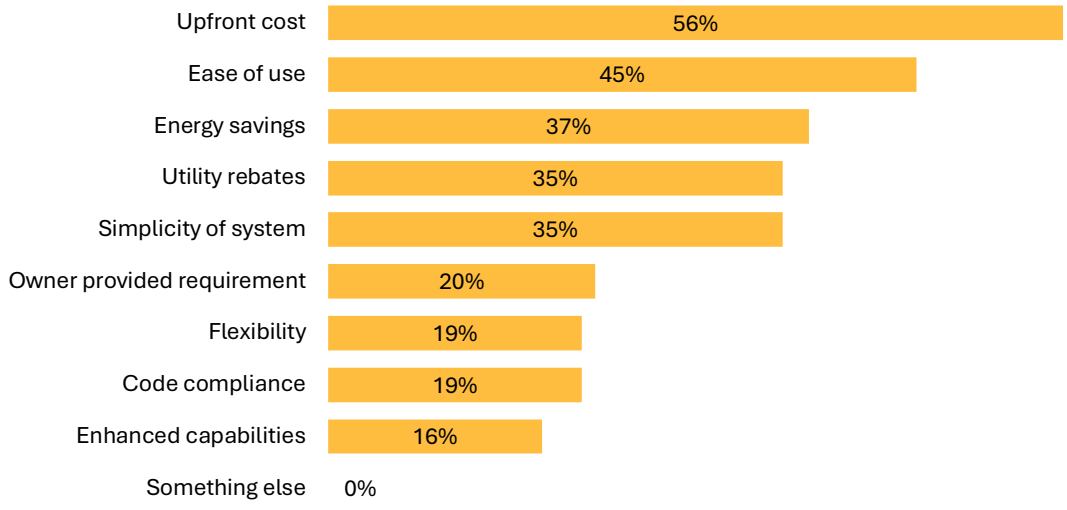
Figure 9. What types of buildings or spaces do you think would be a good fit for LLLCs? (n=98)



Barriers to Adoption of LLLC

The survey asked what the biggest factors are in selecting lighting system and controls options (Figure 10), and respondents identified the top factors as upfront cost (56%) and ease of use (45%), followed by energy savings (37%), utility rebates (35%), and simplicity of system (35%). (Respondents could provide up to three responses to this question.)

Figure 10. What are the biggest factors in selecting lighting system and controls options? (n=98)

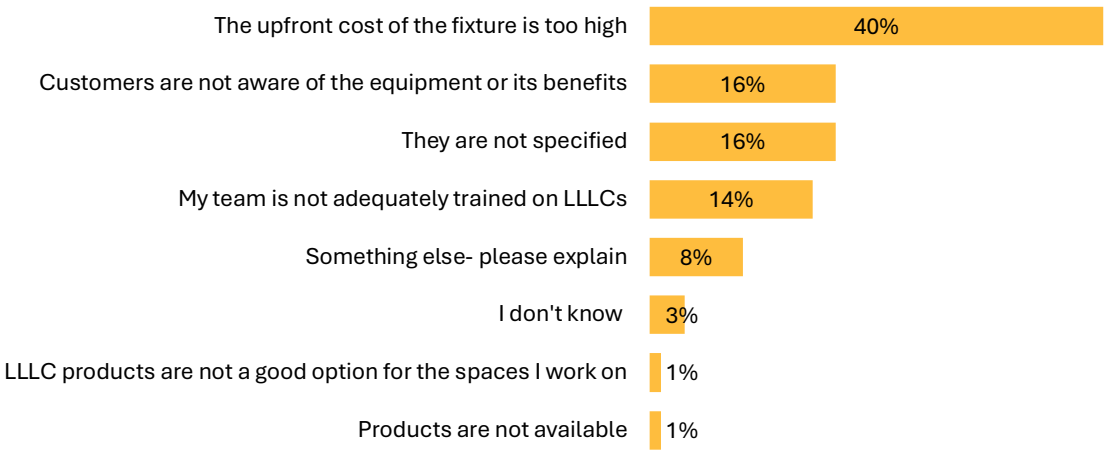


Note: Participants could select multiple responses (up to 3), so percentages do not sum to 100%.

When asked specifically why LLLCs are not used on more of their projects (Figure 11), 40% of respondents pointed to upfront fixture cost as the primary barrier followed by lack of customer

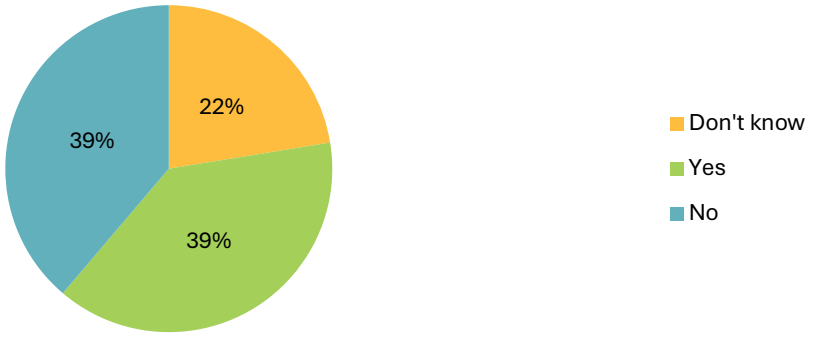
awareness (16%), LLLC not being specified (16%), and insufficient contractor training (14%). (This question did not allow multiple responses; respondents identified one top factor.)

Figure 11. Of these, which do you feel is the primary reason LLLCs are not used on more of your projects? (n=98)



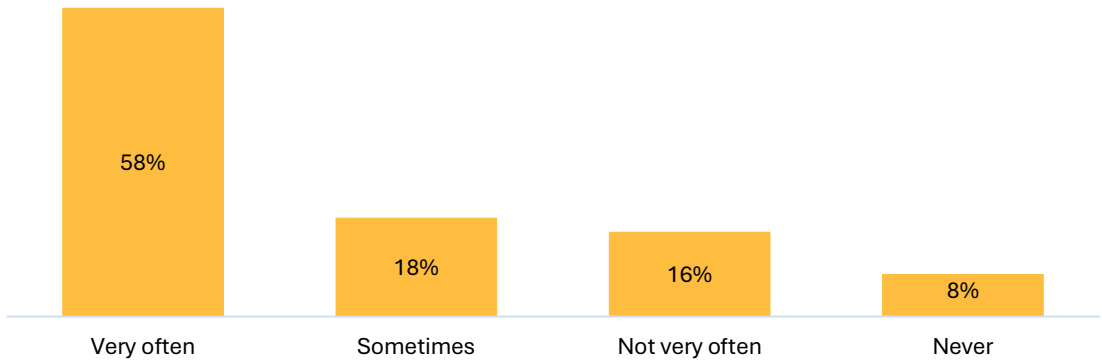
These two questions clearly indicate that upfront cost is a critical barrier for LLLC — it is viewed as the number one driver of decisions about lighting and controls and as the primary reason contractors do not use LLLC more often. This finding underlines the importance of utility rebates, which serve to reduce upfront costs. However, when asked about utility rebates, although 95% of respondents agreed that rebates are at least somewhat important to their getting selected for projects, only 39% of respondents were aware of utility rebates for LLLCs in their area, as shown in Figure 12.

Figure 12. Are you aware of any utility rebates for LLLCs in the area you work in? (n=98)



Among respondents who were aware of LLLC rebates, a majority (58%) reported promoting these rebates to their customers very often, as shown in Figure 13.

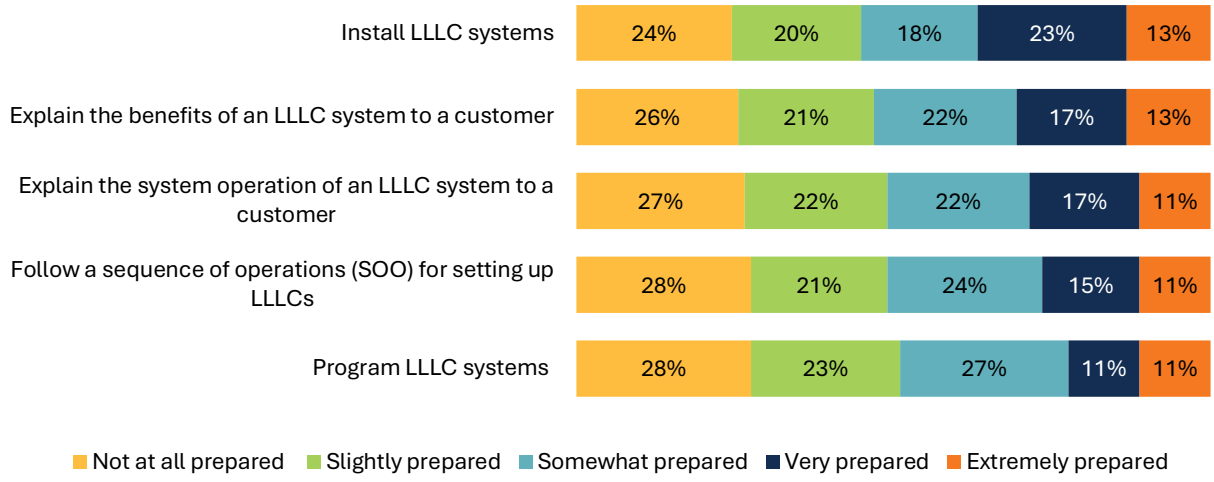
Figure 13. How often do you promote rebates for LLLCs? (n=38)



Preparedness and Support for LLLC

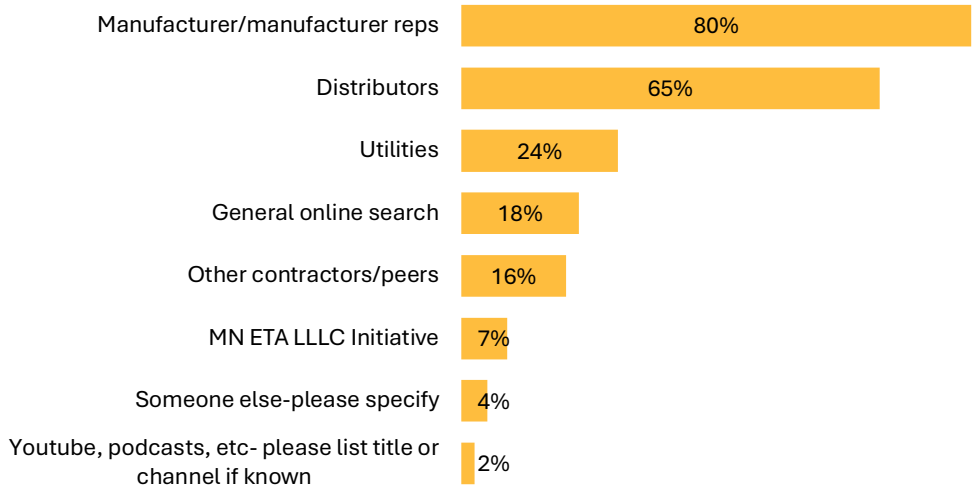
The survey asked contractors how prepared they felt in various skill areas needed for success with LLLC. As shown in Figure 14, at least 11% of respondents feel "extremely prepared" on all categories, but nearly half said they are "not at all" or "slightly" prepared across all categories. Readiness did not vary dramatically across categories, but programming LLLC systems had the lowest level of reported preparedness, with only 22% feeling "very" or "extremely prepared," and installing LLLC systems had the highest preparedness, with 37% feeling "very" or "extremely prepared."

Figure 14. How prepared do you feel to… (n=98)



When asked where they look for information about lighting controls (Figure 15), contractors said manufacturers and manufacturer reps were their top resources (80%), followed by distributors (65%). (Respondents could provide multiple responses to this question.)

Figure 15. Who would you look to for information about lighting controls like LLLCs? (n=98)



Note: Participants could select multiple responses, so percentages do not sum to 100%.

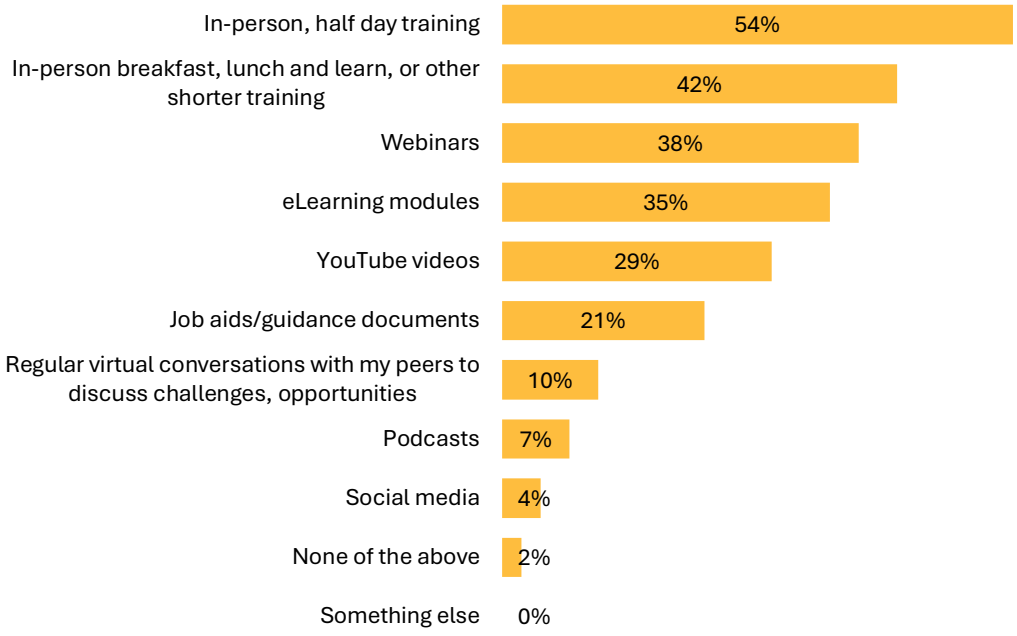
Contractor Training Needs

Some contractors have already received training on LLLC: 33% of respondents reported that they have received training on LLLC, a majority of which (81%) had received that training from a manufacturer. An additional 22% received training from distributors, and 9% received training through the MN ETA LLLC initiative.[18] As noted above, distributors reported they do not generally provide training for contractors. The interviews and survey did not collect additional detail to explore the disconnect between these two findings. However, we speculate that some distributors we did not interview do offer formal training. Additionally, it's possible that when distributors said they don't offer training, they were referring only to formal training (e.g., classroom setting), and that contractors considered project- or product-specific help they received from distributors to be training.

All contractors, regardless of whether they had previously received LLLC trainings, were asked about their preferences for receiving training. In-person options were clearly preferred over virtual options. As shown in Figure 16, half-day in-person trainings were the top response (54%), followed by shorter in-person trainings (42%), webinars (38%), and eLearning modules (35%).

[18] Due to self-selection bias, it is likely that this survey would overestimate the portion of contractors who had participated in ETA trainings.

Figure 16. What format(s) of training or resources do you find most valuable? (n=98)

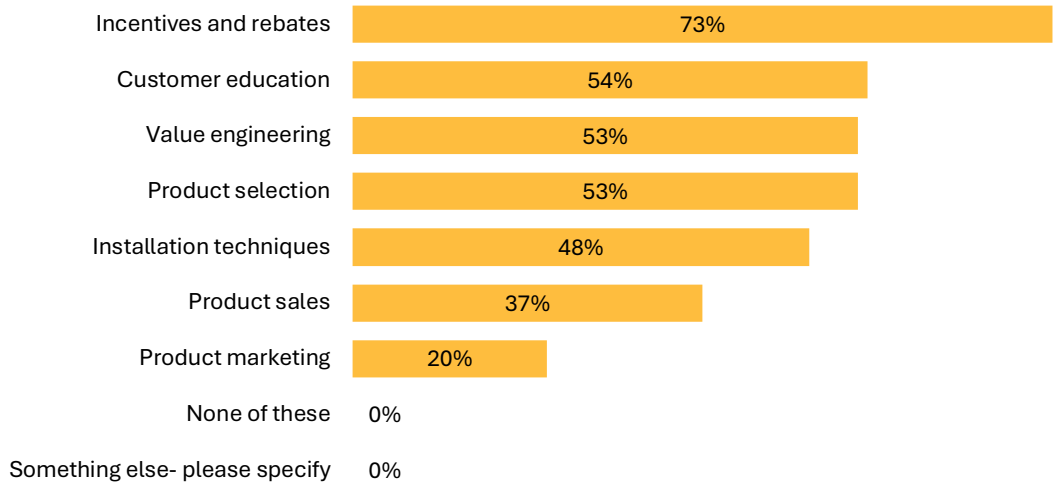


Note: Participants could select multiple responses, so percentages do not sum to 100%.

The survey went on to ask about specific preferences for timing: 82% preferred winter trainings over any other season, with summer coming in second with 14%. Mid-morning (49%) or early-morning (47%) were the preferred times.

When asked what topics for training or resources are worth contractors' time and energy (Figure 17), the most highly rated topic was incentives and rebates, preferred by 73% of contractors, as shown in Figure 17. Customer education, value engineering, and product selection followed, with 53–54% each. Notably, no respondents selected "none of these," or "something else," which indicates that this survey has identified a strongly relevant list of topics for contractor training: even the lowest-ranked topic, product marketing, was selected by 20% of contractors as a topic worth their time.

Figure 17. What training or resource topics are worth your time and energy? (n=98)



Note: Participants could select multiple responses, so percentages do not sum to 100%.

Contractor Phone Interviews

The follow-up phone interviews sought deeper insights into the following.

- Rebates and why/when contractors use or don't use them
- What is working well with LLLCs and where are roadblocks
- Benefits and drawbacks contractors see for themselves and for customers
- Contractor views on pricing and cost differentials
- How customer awareness or other processes drive product decision-making

Businesses Interviewed

The team performed follow-up interviews with nine contractors who had responded to the survey. The interviewees were selected by identifying survey respondents who stated they were willing to participate in a follow-up interview, then by prioritizing a mix of respondents with and without experience installing LLLC. Interviewees included three contractors who work for broad-based electrical contracting (EC) firms, five lighting contractors who specialize in lighting retrofit work, and one retired lighting professional with experience in many roles. Six interviewees had direct experience using LLLC, while three had not used LLLC.

Contractor Roles in Decision Making

Interviews highlighted the differences between business types and project processes. The contractors who worked for broad-based EC firms had distinctly different views and experiences from the lighting contractors who specialized in lighting retrofits. It was clear that EC firms are far less likely to influence the lighting and controls specifications for most of their projects, while retrofit firms do typically drive specification decisions on their projects.

EC firms focused more on design-bid-build projects, which they also referred to as specified jobs. In these projects, the specification is already set by the time the EC is involved, and ECs do not view influencing the specification as part of their role. In these projects, specification decisions are made by the engineer and/or lighting designer on the design team, sometimes with input from manufacturers' reps. The EC's role is to install the equipment as specified. Their top priorities are keeping costs down and getting jobs done quickly. One interviewee commented that large EC firms, especially, prioritize speed and that finishing jobs quickly is what drives their company profitability.

In some cases, interviewees noted that value engineering can occur. Value engineering is an industry term for the practice of changing project specifications to lower costs, or as a strategy for avoiding budget overruns. Contractors noted that when value engineering occurs with lighting and controls on their projects, it always goes in the direction of reducing and simplifying the originally designed specification to include fewer controls functions or a more basic approach to controls. None of the interviewees had encountered the concept of using LLLC to "value engineer" by lowering installation costs.

Contractors viewed specifiers (engineers and designers) as set in their ways and averse to change. They reported that specifiers tend to use the strategies that have worked for them in the past. Five of the nine contractors interviewed mentioned that specifiers use a standard approach that they repeat across projects, described as a "standard commercial package," a "legacy spec," or "sticking to the status quo."

In the retrofit segment, by contrast, contractors have much more influence over product decision-making. These contractors were also much more likely to embrace LLLC. In retrofit projects, the contractor leading the project typically drives decision-making around the lighting and controls specifications. They make recommendations on how to approach lighting and controls and which specific products to select. All five of the retrofit contractors interviewed had positive views on LLLC. They also all reported utilizing utility rebates on nearly all their jobs. Their business priorities are also different from those of the ECs discussed; they prioritize meeting customer needs, providing a high level of service, and achieving energy savings.

Some retrofit specialists and other lighting-specialist contractors, including those interviewed in this study, operate with a consulting business model. In this model, they provide recommendations to their customers (often based on an energy audit or lighting audit) then facilitate the installation and setup of the system. In many cases, the installation work is performed by subcontracted installers.

LLLC Perceptions, Benefits, and Drawbacks

The interviewees' views on LLLC were mixed, but cleanly divided along business type segments: the five retrofit specialists all reported a positive opinion of LLLC, while the EC firms were less favorable, with two neutral and one negative viewpoints on LLLC, and a negative view from the retired lighting professional. The two interviewees reporting a negative view on LLLC pointed to a perception of unnecessary complexity or over-engineering, concerns about the risk of callbacks, and a history of bad experiences with controls in general, networked controls in

particular, and wireless technologies. While this small sample size may not represent the overall population of contractors, it is clear from their responses that these retrofit firms have had greater opportunity and greater success with realizing the benefits of LLLC for their businesses and their customers.[19]

The contractors' confidence with LLLC products and installation was mixed. The interview asked whether contractors felt they had gained confidence with LLLC products and installations. Out of the seven contractors who were able to answer this question, four respondents said yes, one said no, and two additional respondents did not directly answer the question but had no experience with LLLC and had not yet learned about the technology. Some contractors expanded on their responses, with varying viewpoints. One noted that he does not have high confidence in LLLC technology itself, because in his experience, "networked solutions are always going to create more headaches than value." On the other hand, another contractor reported that he had gained confidence and that he feels LLLC "just keeps getting better. Multiple brands all have good products." Other contractors had more middle-of-the-road perspectives, saying they had gained confidence but still felt they needed more experience with LLLC.

Regarding the potential for LLLC to save labor due to reduced wiring needed, six out of nine interviewees noted that they are either not aware of the benefit of LLLC saving installation labor, or they do not believe the labor savings are meaningful. In expanding on these statements, contractors expressed strong views on the potential for callbacks. "Callbacks" is the industry term for customers calling the contractor with a problem after the installation is complete, a potentially burdensome aspect of their business. While some businesses can charge customers for service calls, most offer two-year or five-year warrantees for lighting and controls installations, which make callbacks an unpaid cost for their companies. With regards to LLLC, two contractors said that any installation labor savings would be offset by the increased risk of callbacks and problems later. They worried that customers would not be able to solve any programming issues that might arise after installation. The concern about callbacks was particularly strong from EC firms, reinforcing their business priorities to keep speed up and cost down. One contractor was an outlier on the topic of LLLC labor savings and enthusiastically embraced the savings his company has seen from avoiding unnecessary wiring, cabling, and set-up labor using LLLC. This outlier also noted that callbacks can serve to strengthen their relationship with the customer and ensure future

> *"Electricians don't have this sort of callback built into their budgets… this is why nobody wants to lean into [LLLC]…"*
>
> *(contractor)*

[19] As noted, the survey data did not validate this difference — the subsample sizes were too small to determine whether a statistically significant difference in rate of LLLC utilization existed between retrofit-focused and new-construction-focused contractors.[20] One additional respondent reported having LLLCs in their buildings, but in a later question reported the system had no networking capabilities. This means the system does not meet the definition of LLLC, so we recoded that response to "Non-networked light fixtures with embedded sensors."

business. But most contractors interviewed did not share that perspective: callbacks were viewed as a cost to be avoided, and LLLC viewed as increasing the risk for callbacks.

Role of the Customer

Contractors in all segments agreed that when a customer requests something specific (including LLLC), that is what will be installed. Several interviewees mentioned that higher customer demand would lead to greater adoption of LLLC. However, the consensus from interviewees was that most customers today are not knowledgeable about LLLC or about lighting controls in general.

In fact, the challenges contractors reported with LLLC tie back to a lack of customer knowledge about their systems. Many callbacks are related to customers not understanding their system's operation. Contractors had varied perspectives on this phenomenon.

- Some felt that customers simply don't want to learn how to use systems and would rather rely on contractors to troubleshoot issues that arise.
- Two respondents mentioned that facility manager roles tend to have high turnover, so even if one person gets trained, they may be gone by the time an issue arises. (An exception to this problem is with in-house/institutional facility managers such as those at universities, school districts, other municipal buildings, etc. Those roles are perceived by contractors as better able to handle the management of a lighting controls system.)
- Finally, one contractor felt that customer training is just part of the process, and providing training builds the customer relationship, even if they have to go back multiple times.

As discussed, the views of retrofit firms tended more toward the higher-touch customer service and training approach, while the EC firms tended to view lack of customer skill with their lighting system as a potential problem. An important caveat to this segmentation, though, is that most retrofit firms hire subcontracted installers, so while the retrofit firm may be happy to provide follow-up support to their customers, it's possible that those additional labor costs do not actually hit their bottom line but are rather absorbed by their subcontracted installation staff, who likely perform some of the callback labor.

Contractor Education Opportunities

The team noted that many of the contractor interviewees expressed interest in learning more about LLLC, utility rebate programs, and lighting and controls in general. Questions that contractors raised during the interviews included:

- What training is available on LLLC?
- What are the benefits of LLLC? Does it save energy?
- How do I access utility program information?
- What's going on with the fluorescent ban?
- What professional organizations would help them learn more?

This indicates a desire in the contractor community for additional learning and opportunities.

Crosscutting Contractor Insights

The contractor interviews supplemented the survey findings with more detailed and nuanced perspectives on the LLLC market. The following crosscutting themes emerged.

- **Upfront cost is a clear barrier for contractors.** Both the survey (with 40% citing fixture cost as the primary reason LLLC is not used more) and the interviews identified cost as a top obstacle. Interviewees added nuance, explaining that value engineering always moves toward simpler, lower-cost controls options.
- **Electrical contractors and lighting specialists reported differing views on LLLC.** While survey data could not distinguish between these groups, the interviews revealed a clear split between retrofit-focused lighting contractors and ECs. The retrofit specialists all held favorable views of LLLC and used LLLC in their work, while EC firms were less likely to embrace LLLC.
- **Perceived risk of callbacks dissuades some contractors from recommending LLLC.** The survey flagged upfront cost and lack of awareness as top barriers, but interviews surfaced a concern not fully captured in the survey: post-installation callbacks. Most contractors view LLLC as having an increased callback risk due to programming complexity and low customer literacy with controls, which offsets the labor savings benefit.
- **LLLC rebate awareness is low despite rebates being highly valued.** The survey found that 95% of contractors consider rebates at least somewhat important to winning projects, yet only 39% were aware of LLLC-specific rebates. Interviews reinforced that retrofit firms use rebates on nearly every job, while EC firms are less engaged.

BUILDING OWNER INSIGHTS

Background

Building owners and building decision-makers play an important role in selecting and operating lighting and controls systems. While roles can vary, these market actors are generally responsible for budgeting decisions that guide spending on lighting upgrades or installations, and drive decisions on how lighting and controls systems are best used to meet the needs of the businesses or tenants. This report uses the term "building owner" to refer collectively to the building representative role.

The study surveyed building owners in Minnesota, targeting individuals with responsibility for specifying, operating, maintaining, and interacting with lighting systems for their buildings. Additional detail on the methodology is included below and in Appendix C: Detailed Methodology. The online survey received 89 responses. The survey asked respondents about:

- The presence of controls in their buildings
- Their familiarity and experience with LLLC
- Recent lighting replacements
- Utility rebate awareness and experience

Individuals Surveyed

Survey recruitment leveraged ETA team-provided lists and partner newsletters. Building owner contact information largely comprised small to medium-sized businesses who previously participated in an energy efficiency utility program in the Twin Cities metro area. To broaden the reach and sample, a targeted ad was also placed in the ASHRAE Minnesota Chapter e-newsletter and the St. Paul BOMA Blast e-newsletter. However, the vast majority of respondents came from the utility program contacts and thus reflect small and medium-sized businesses, primarily within the Twin Cities metro area.

Respondents to the building owner survey reflected a mix of roles, with most respondents being facility managers (n=35) or building owners (n=30). Respondents predominantly worked with smaller portfolios of buildings: 59% of respondents manage one building, while 21% manage two to five buildings. However, two respondents represented large building portfolios: one with 100 buildings and one with 197 buildings.

The buildings respondents managed included a variety of building types; commercial offices were the most common (Table 4).

Table 4. What type of building(s) do you work with/manage? (n=89)

Building Type	Respondents (n=89)	Percent
Commercial office spaces	42	47%
Nonprofit offices and facilities	23	26%
Retail, including strip malls	20	22%
Public school buildings (classrooms, administrative offices, garages, athletic facilities)	7	8%
Medical, including hospitals	6	7%
City and county municipal buildings (fire, police, jails, offices, libraries, parks and recreation facilities, animal control facilities)	3	3%
Hospitality	3	3%
Large apartment or residential buildings	0	0%
Something else	24	27%

Note: Participants could select multiple responses, so percentages do not sum to 100%. Something else open-ended responses included: church (5), school/daycare (4), warehouse (4), manufacturing (3), residential (3), and mixed-use (3).

Presence of Controls

Survey respondents were asked what types of lighting controls were present in their buildings today, and 6% of respondents reported their buildings contain LLLCs, as shown in Table 5.[20] The majority of respondents (67%) reported that their buildings contain traditional non-networked, non-embedded controls. The second most frequently selected type of controls was non-networked light fixtures with embedded sensors (17%), followed by other networked lighting controls (16%). Finally, 15% of respondents said their buildings contained no controls.

[20] One additional respondent reported having LLLCs in their buildings, but in a later question reported the system had no networking capabilities. This means the system does not meet the definition of LLLC, so we recoded that response to "Non-networked light fixtures with embedded sensors."

Table 5. Which of the following lighting controls are in your building(s) now, if any? (n=89)

Controls Type	Respondents (n=89)	Percent
Traditional occupancy sensors, photocells, or timeclocks (non-networked, non-embedded)	60	67%
Non-networked light fixtures with embedded sensors	16	18%
Other networked lighting controls (NLCs) – lighting systems with a combination of sensors, network interfaces, and controllers that affect lighting changes in luminaires, retrofit kits, or lamps	14	16%
Luminaire-level lighting controls (LLLCs) – Networked systems of light fixtures with embedded controls and a dedicated sensor per luminaire. Unlike other NLCs, additional relays/dimmers/control panels are not required.	5	6%
Something else	6	7%
I don't know	4	4%
None of the above	13	15%

Note: Participants could select multiple responses, so percentages do not sum to 100%. Something else open-ended responses mentioned manual on/off switches (3), overhead lighting (1), and wireless motion sensors (1).

The survey asked respondents who do have controls in their buildings how they interact with those systems. Nearly half (44%) of the respondents reported they do not actively interact with the controls system, with 28% creating or adjusting light schedules, and 24% adjusting light levels. Additional interactions included monitoring energy use of lighting systems (19%) and remotely controlling lights (15%).

The 13 respondents without lighting controls were asked whether they had considered installing lighting controls, and why or why not. Eleven of these respondents said they had not considered adding controls, with common reasons including:

- Do not need controls (4)
- Already have another type of efficient lighting (3)
- Cost (2)
- Preference for older or manual technology (1)

Only one respondent reported actively considering controls and explained that they need more guidance on what solution is best for them and how to pursue it, as well as facing budget constraints.

Respondents were asked an open-ended question about where they thought LLLC might be a good fit within the buildings and spaces that they oversee (Table 6). The most common response was general common spaces (16%), followed by office spaces (7%). These responses provide a limited and potentially biased view of which applications are the best fit for LLLC, since they reflect the perspective of the building owner respondents, many of whom were not

previously aware of LLLC, and who also have purview only over their specific portfolio of buildings.

Table 6. Are there specific types of buildings or spaces in your building(s) where LLLCs are or would be a good fit? (n=73)

Response	Respondents (n=73)	Percent
Common spaces (general)	12	16%
Office spaces	10	14%
Warehouse/storage areas	8	11%
Restrooms	6	8%
Meeting/conference rooms	6	8%
Outdoor spaces	5	7%
Hallway	4	5%
Lunchroom/cafeteria	3	4%
Classrooms	3	4%
Retail spaces	3	4%
Side rooms	2	3%
Lobby	2	3%
Entrance	2	3%
Recreational spaces	2	3%
None	10	14%
Unsure	13	18%
Other	8	11%
Not specified	5	7%

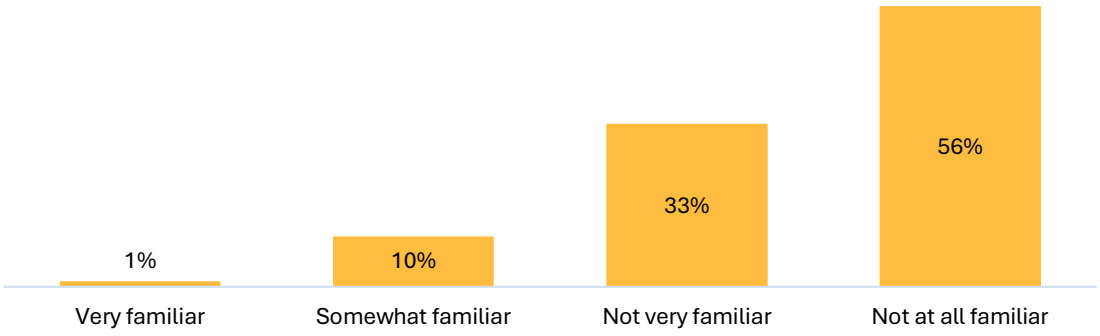
Note: Participants provided open-ended text responses, so percentages do not sum to 100%.

Familiarity and Experience with LLLC

When asked whether they have heard of LLLC, prior to being provided with a definition, 11% of respondents reported they had heard the term. After reading a definition of LLLC, respondents were asked about their familiarity with the technology.[21] As shown in Figure 18, over half of respondents still noted that they were "not at all familiar" with the technology.

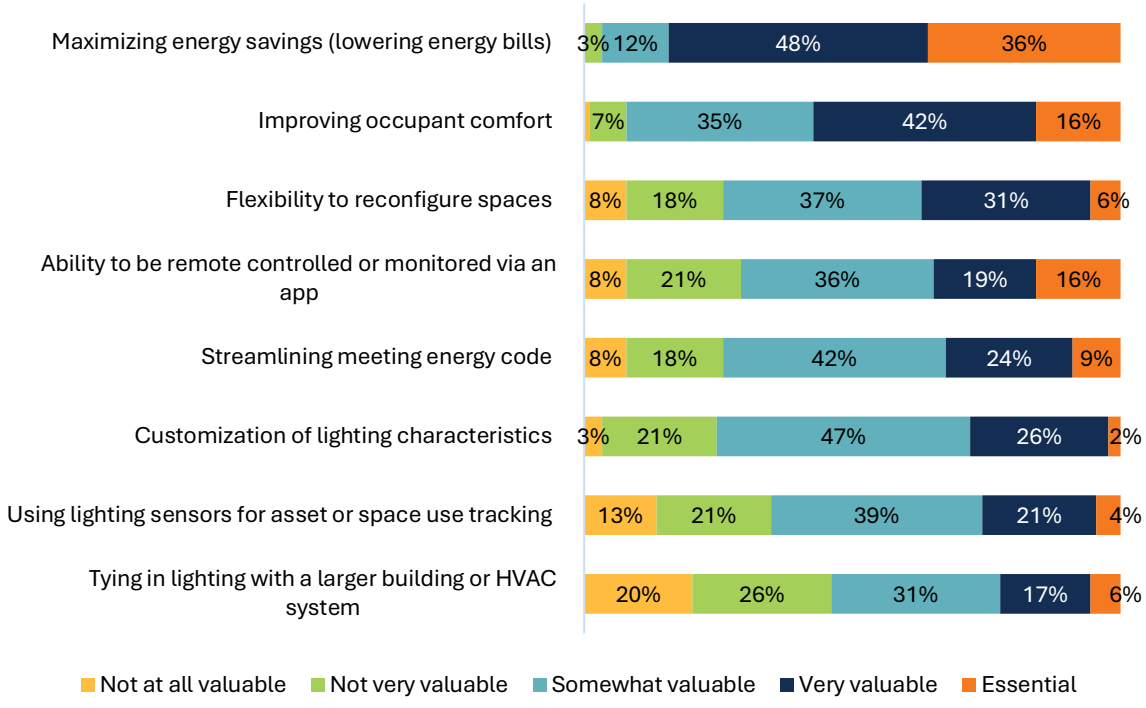
[21] The definition was provided as follows: "For the purposes of this survey, we are defining LLLCs as connected systems of light fixtures with embedded controls and a dedicated sensor per luminaire, which provide granular control over the lighting in a space. Sensors typically include motion and daylight, which allow for increased energy savings. The lights typically communicate with one another wirelessly, which allows for flexibility of design and reconfiguration of spaces."

Figure 18. How familiar are you with luminaire-level lighting controls (LLLCs)? (after reviewing definition, n=89)



The survey went on to provide information about some of the potential benefits of LLLC, and asked respondents to rate how valuable each of these benefits would be. These responses, displayed in Figure 19, clearly indicated the importance of maximizing energy savings and lowering energy bills, with 81% of respondents ranking it "very valuable" or "essential." The second-ranking benefit was improving occupant comfort, which over half of respondents rated as "very valuable" or "essential." Conversely, the more advanced capabilities of LLLC systems — tying into larger building or HVAC system and using lighting sensors for asset or space use tracking — ranked much lower, with only 22% and 26%, respectively, rating these benefits as highly valuable.

Figure 19. The following are potential benefits from LLLC systems. Please indicate how valuable each benefit would be for you. (n=89)



The survey asked the five respondents who currently have LLLC in their buildings several additional questions about their systems. Respondents were asked whether most of their LLLC systems were set up as fully networked systems (Table 7). Responses were mixed, with two reporting their systems were fully networked, and the remaining four offering varying responses, as shown below.

Table 7. Are most of your LLLC systems set up as fully networked systems (e.g. they communicate as a part of a connected system)? (n=5)

Networking Type	Respondents (n=5)
Yes – most are fully networked	2
Somewhat – a mixture of networked and non-networked	1
No – they are networked capable, but currently not networked	1
I don't know	1

Next, these respondents were asked whether they had established a sequence of operations when their LLLC systems were installed and configured (Table 8). Again, responses were mixed, with only one respondent saying yes.

Table 8. Did you have a sequence of operations established when the systems were installed and configured? (n=5)

Response	Respondents (n=5)
Yes – for all	1
No	1
I was not in charge of this process at installation	2
I don't know or remember	1

The survey asked the respondents with LLLC about their experience receiving training from the installer or manufacturer rep on system operation (Table 9). Again, responses were mixed, and only one respondent said yes. While this small sample may not be representative, these responses clearly point to inadequate education of building owners on system operation.

Table 9. Did you receive adequate training from the installer or manufacturer representative on system operation? (n=5)

Response	Respondents (n=5)
Yes	1
No, I received training but it was inadequate	1
No, I did not receive training	2
I was not in charge of this process at installation	1

The respondents with LLLC were asked about the benefits they have experienced from their LLLC systems (Table 10). The top reported benefits were energy savings (four respondents),

and customization of lighting characteristics (three respondents). One respondent reported experiencing no benefits from their LLLC system.

Table 10. What benefits have you or your occupants experienced specifically from your LLLC systems? (n=5)

Response	Respondents (n=5)
Energy/bill savings	4
Customization of lighting characteristics	3
Control over energy use	2
Occupant comfort	2
Flexibility with lighting configurations	2
Extended equipment life	1
Occupant safety	1
Ease of use (e.g., via remote control/app)	1
Integration with/providing data for building systems	1
Easy code compliance	0
Another benefit (please describe)	0
None of these/no benefits	1

Note: Participants could select multiple responses.

Correspondingly, the survey asked whether the respondents with LLLC had experienced any drawbacks from their LLLC systems. These responses revealed that all five respondents with LLLC systems reported having some drawbacks: three had issues with features malfunctioning or not working well and two had maintenance challenges.

Table 11. Have you encountered any drawbacks specifically with the LLLCs? (n=5)

Response	Respondents (n=5)
Features malfunctioning or not working well	3
Another type of challenge (please describe)	3
Maintenance challenges	2
Complicated settings or features	1
System integration challenges	1
None of these/no drawbacks	0

Note: Participants could select multiple responses.

The three respondents reporting another type of challenge provided additional detail:

- One reported issues with the lights but said the controls worked well.
- One said their system's software was no longer supported, the company no longer existed, and the system did not have integration as advertised.
- One reported a lack of follow-up from the contractor/installer.

Recent Lighting Replacements

All 89 respondents were asked about their recent experiences with replacing or installing lighting equipment. A large majority (93%) of respondents reported having performed lighting replacements or installations in the last 3 years. Those installations included individual fixture replacements (45%), space reconfigurations or room retrofits (43%), full building renovations (33%), and new construction (5%). Among these respondents, only 10% considered LLLCs as an option. When asked why or why not, the most common response (58%) was that they were not aware of LLLC. A few respondents also mentioned that their contractors never offered LLLC as an option. Four respondents reported that they did install LLLC, and provided varied explanations for why:

- *"Installation cost savings and consultant recommendation."*
- *"I was convinced of potential benefits."*
- *"We installed in a remodeled space to help meet company sustainability goals and help with energy costs."*
- *"[For] new construction it made a lot of sense to use wireless LLLCs as a way to reduce labor cost during installation. The avoidance of additional physical comms wiring gives us more flexibility for the future."*

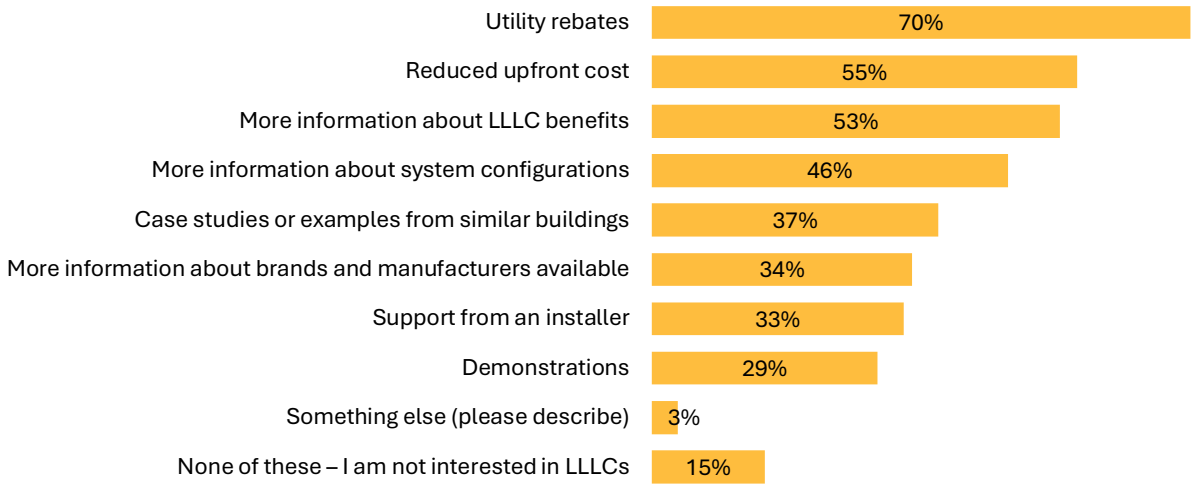
While these respondents were a minority, their responses illustrate the potential value of LLLC benefits to building owners.

Utility Rebate Awareness and Support Needs

Most respondents had experience using utility rebates for lighting: 74% reported pursuing utility rebates for "controls or lighting in general." However, only 40% were aware of rebates for lighting controls specifically. This indicates that awareness of controls rebates (and presumably their use) is less prevalent than awareness of lighting rebates in general. The 20 respondents who had never pursued lighting rebates were asked why not, and the most frequent explanations were not having any qualifying projects (40%), not knowing where to look for information (25%), the paperwork being too burdensome (15%), and having too many other priorities (15%).

70% of survey respondents also indicated that utility rebates would be a necessary form of support for adding LLLCs to their space. Other necessary forms of support respondents identified included reduced upfront cost (55%), more information about LLLC benefits (53%), and others as shown in Figure 20.

Figure 20. What types of support or information would you need to add LLLCs or add additional LLLCs to your spaces? (n=89)



Note: Participants could select multiple responses, so percentages do not sum to 100%.

LIMITATIONS

As with all research, there are limitations to this work. The research was designed to inform program strategy rather than to yield statistically representative estimates. Several groups had small sample sizes and self-reported data; results should be interpreted as directional indicators of market conditions.

Key limitations include:

- **Sample sizes.** All interviews conducted for this study (manufacturer, manufacturer rep, distributor, and contractor) included sample sizes of 10 or less. The data collected through these interviews may not represent the entire market. Instead, interview response data reflects perspectives from active participants in the lighting and controls market with various specialties, which can be combined with other market intelligence to glean insights about the market as a whole. Small sample sizes can impede comparability between studies, as sampling error and other biases are more likely to affect aggregated findings. This is discussed further in Appendix B: MPI Analysis.
- **Contact list limitations.** As described in greater detail in Appendix C: Detailed Methodology, the contact lists leveraged for the contractor and building owner surveys had a Twin Cities geographic focus and included market actors with prior engagement in energy efficiency programs. Despite the improved representativeness and comparability provided by the larger sample sizes achieved in these surveys, the contact list limitations introduce geographic and self-selection biases.

CONCLUSIONS AND RECOMMENDATIONS

When taken as a whole, this research indicates several key market trends and opportunities. Ten overarching conclusions and eight recommendations are discussed in the following.

Conclusions

1. **The Minnesota market favors traditional non-networked, non-embedded, wired controls.** Across all market actor groups, the research uncovered a theme of status quo inertia as a barrier to adoption of LLLC. Reluctance to diverge from known lighting and controls technology affects several groups: specifiers (i.e., designers and engineers) use the same proven strategies repeatedly; distributors strategically craft their bids to prioritize cost minimization rather than promoting specific products; contractors appreciate familiar installs they can complete quickly while avoiding perceived risk of problems or callbacks; and building owners are often content with basic lighting functionality. Furthermore, across all market actor groups, there is some degree of wariness of complexity and perceived wireless risks.
2. **Market actors see norms shifting toward LLLC.** While the status quo looms large, there is a broad acknowledgement of change, and pockets of enthusiasm for LLLC as an emerging norm. Across market actor groups, most respondents expressed a positive view of LLLC. Building owners expressed a strong priority around pursuing energy savings when choosing lighting equipment. Supply chain market actors agreed that everyone involved in project delivery can learn new technologies when forced. Most manufacturers and reps, and some distributors and contractors have embraced the notion of LLLC as the future status quo. While LLLC remains a rare choice for lighting installations in Minnesota today, the more innovative market actors believed that this technology will be more broadly adopted soon.
3. **Market actors do not view LLLC as a clearly distinct product category but rather see it as one of many related options for networked, wireless, and embedded controls.** Most research participants, including those representing manufacturers and manufacturer reps, had some trouble drilling down into the detailed variations of networked and embedded controls products. The research attempted to ask questions segmenting the embedded controls category into non-networked (standalone embedded controls), limited network (room-based controls), and fully networked LLLC. While market actors were easily able to understand these distinctions, they did not, for the most part, have separate detailed insights about each category.
4. **Project type and delivery process determines which market actors can influence lighting and controls specifications.** Designers and engineers tend to drive specification decisions on design-bid-build jobs, while other market actors have greater opportunity to influence other project/delivery types.
   - Design-bid-build/specified projects nearly always include controls in the design, though rarely LLLC, and specifications are determined by the lighting designer

and/or engineer. Reps, distributors, and contractors have very little opportunity to influence those projects once the spec exists.
   - Design-build projects are more varied, and some reportedly do not include controls. In this delivery process, there are more opportunities for influence — reps, distributors, and contractors can recommend products and controls approaches in some design-build projects.
   - Retrofit projects, whether contractor-led, distributor-led, or ESCO-led, represent the segment in which market actors reported the greatest success with LLLC. In this segment, the market actor leading the sales process had a clear opportunity to influence the lighting and controls specifications.
5. **Market actors do not view energy code as strongly influencing lighting and controls approaches.** Most contractors and distributors indicated that meeting code was not an influential factor in selecting lighting system and controls options. Distributors commented that they do not see code as a motivator, in part because they see a lack of code enforcement for lighting controls. As it stands, LLLC is not required by code, but it does offer a means for meeting the code requirements for lighting controls.
6. **Utility rebates are important, especially in retrofits, but low awareness and competition with cheap and easy TLEDs may be hindering the impact of LLLC incentives.** All groups had good levels of awareness of utility rebates for lighting and controls in general, but awareness of LLLC rebates was lower. Utility rebates are viewed as very important, and some retrofit-focused contractors and distributors stated that rebates are critical to successfully sell LLLC. However, LLLC retrofits compete with cheaper TLED retrofits, and one respondent mentioned that ongoing utility rebates for TLEDs make it more difficult to sell the value of LLLC. Contractors also selected utility rebates as the highest priority topic for training.
7. **Manufacturer reps and distributors view specifiers (lighting designers and engineers) as the key influencer of lighting and controls specifications for specified projects**, especially those following the traditional design-bid-build project delivery process. This group is viewed as resistant to change, and they are highly educated experts who prefer to use their own proven best practices. Multiple reps and manufacturers interviewed for this study expressed that they would like to see the ETA team build relationships with specifiers and inform them of the potential advantages of adopting new technologies like LLLC. This is a strategy the ETA team is actively pursuing, and this finding confirms that market actors support this approach.
8. **Distributors play a growing role in influencing lighting retrofit projects, with several distributors investing in the growth of their lighting project sales teams.** Both manufacturers and distributors observed a growing influence of distributors in their expansion of outside sales teams that focus on lighting projects. These teams are attempting to capture market share for retrofit and design-build projects especially, where distributors' in-house design support can drive product selection. This trend, occurring across multiple distributor companies in Minnesota, represents an opportunity for a greater influence in the lighting and controls market.

9. **Contractors' technical skills for selling, installing, and supporting LLLC are limited.** Distributors agree that contractors sometimes lack the technical skills to troubleshoot LLLC installations, and contractors themselves reported low levels of familiarity with LLLC and low preparedness for installing and programming LLLCs. This points to a knowledge gap in the Minnesota market and a need for additional education for contractors. Lack of contractor skills can not only hinder the adoption of LLLC, it can also create negative experiences with LLLC for customers and other market actors when unskilled contractors install program systems incorrectly or fail to adequately educate their customers on system operation.
10. **Despite valuing LLLC's benefits, most building owners never consider it due to low awareness and contractor skill gaps in selling, installing, and support.** Building owners value energy savings and occupant comfort, but most of them have not considered LLLC as an option because they were not aware of the technology. Building owners also report that their contractors/consultants did not offer LLLC as an option. Additionally, among the few building owners who do have LLLC systems, most did not receive adequate education on system operation, highlighting the risk for poor customer experiences.

Recommendations

1. **Continue to offer in-person training workshops for contractors and distributor project sales staff.** Market actor education is critical and this study revealed an ongoing need for training, especially among contractors. Distributor project sales staff may also benefit from LLLC education, given their growing role in the Minnesota market and their opportunity to influence projects. The ETA team already includes curriculum in workshops that addresses knowledge gaps identified in this study. Given the ongoing need for training in these subjects, the ETA team should continue offering this curriculum, as well as periodically reviewing and considering whether any topics need strengthening. This may include the following.
   - Offer real-world examples of cost comparison between wired vs. wireless LLLC systems.
   - Teach the benefits of LLLC, especially highlighting proven energy savings through examples and comparisons. This study indicated that many contractors lack understanding of the energy savings benefits of LLLC.
   - Provide detailed, step-by-step guidance on how contractors and other market actors can leverage utility rebates.
   - Clarify the concept of sequences of operations (SOOs) and provide best practice guidance for how to develop and implement SOOs to meet customer needs. (This topic emerged as an area of difficulty in distributor interviews, and continuing to educate contractors on this topic will also be valuable.)
   - Teach best practices for system handover and customer education to set up customers for success and minimize callbacks.
2. **Continue collaboration with utilities to encourage consistent and optimized rebates for LLLCs.** The ETA team has recently worked with funder utilities and provided utilities with

a set of recommended rebate definitions, requirements, and a consistent rebate structure for LLLC. Continuing this collaborative approach, encouraging optimized and consistent rebates throughout Minnesota will enable contractors and other market actors to leverage LLLC rebates more effectively.

3. **Continue to work with utilities to support their trade ally networks and build awareness and adoption of utility rebate offerings.** This study indicated that contractor awareness of LLLC rebate opportunities remains lower than awareness of general lighting and controls rebates. The ETA team should continue providing resources and support to utilities to engage these networks and help them leverage utility rebate offerings for LLLC. Additionally, if utilities are willing to provide the ETA team with access to trade ally or program participant contact information to leverage for future research, this collaboration will yield greater statewide insights.
4. **To maximize the impact of engagement with the specifier community (lighting designers & engineers), the ETA team should continue in-depth engagement that respects specifiers' market role as experts.** As a brand-neutral third party, the ETA team may be able to reach specifiers more effectively than reps/manufacturers. However, because the specifier community is already highly knowledgeable about controls technologies, they may not be effectively reached through educational resources or trainings. Instead, the ETA should continue to prioritize relationship building, working through respected organizations, and forging ongoing partnerships with any existing LLLC champions in the specifier community to encourage peer-to-peer influence. CEE should continue leveraging professional organizations in Minnesota such as IES, as well as utilizing existing guidelines like ANSI/IES LP-6-25 Lighting Control Systems – Properties, Selection and Specification[22] and the Federal Government's General Services Administration's guidance on LED Lighting and Controls[23] to encourage industry consensus about when and how to apply LLLC.
5. **Target engagement with distributors to reach their lighting project sales teams,** which are growing at several Minnesota distributors. These teams are leading lighting retrofit sales and leveraging utility rebates, and some report that they are strategically growing. The ETA team has an opportunity to assist these distributor sales teams in embracing the benefits of LLLC by equipping their sales professionals with the best tools to sell LLLC. This could be achieved through use of the LLLC demo boards as a sales and training tool or through targeted trainings offered to distributor sales staff. While distributors are important actors in the lighting controls market, CEE must focus

[22] IES LP-6 is a national standard intended to help designers, users, commissioning providers, and other interested parties understand fundamental characteristics and purposes of lighting control systems. Available for purchase via IES: https://store.ies.org/product/lighting-practice-lighting-control-systems-properties-selection-and-specification/?v=0b3b97fa6688

[23] The GSA guidance on lighting and controls includes a detailed guide and a decision tree for determining when to apply LLLC or other controls approaches in government buildings. These resources are freely available online: https://www.gsa.gov/governmentwide-initiatives/federal-highperformance-buildings/highperformance-building-clearinghouse/emerging-technology-evaluations/lighting/led-and-controls-guidance

engagement on lighting and controls sales specialists and avoid wasted effort training general sales staff who will not be involved in controls project decision-making.

6. **Consider conducting an end-use customer awareness campaign.** This effort, if pursued, should not be prioritized over supply chain engagement or market actor education, which are higher-impact interventions and more critical to market transformation. However, if the ETA team wishes to pursue end-user engagement strategies, the team may consider the following.
   - Engage decision makers via professional organizations such as BOMA and IFMA, ideally with collaboration from utilities, to offer awareness-building events around the benefits of LLLC and the availability of utility rebates.
   - Direct outreach to property management firms, ideally in coordination with utility Key Account Managers, to provide informational resources about LLLC and utility rebate opportunities. Regional property management firms like Frauenshuh have a large footprint and drive decisions for large portfolios of buildings. Thus, educating these decision-makers on the benefits of LLLC and the availability of utility rebates could disproportionately impact market adoption. This strategy has a low probability of success but could have a high impact.[24]
7. **In trainings and resources, continue prioritizing alignment with existing product definitions.** Despite challenges with the nuances of wireless and networked controls product categories, all groups of lighting professionals included in this research reported awareness of the term LLLC. This indicates that industry alignment around this term is progressing. Additionally, there is existing alignment around the term LLLC from national actors like IES, DLC, and even manufacturers such as Acuity, one of the identified market leaders and an influential manufacturer on the national level. To continue this progress, the ETA team should continue to maintain consistent terminology.

[24] This recommendation focuses on regional/local entities rather than large national-scale property management firms like JLL, Cushman & Wakefield, and Colliers. These larger companies tend to apply policies nationally, and influence is unlikely, barring a larger national collaboration.

APPENDIX A: MPI TABLE

The table below summarizes results from this study and prior research that relate to the LLLC Initiative's Market Progress Indicators (MPIs). MPIs are defined metrics for tracking the progress of a market transformation initiative. Appendix B: MPI Analysis includes further discussion on the MPIs assessed in this study, and how results compare to previously collected data.

Logic Model Outcome	MPI	Pre 2024 Baseline	Baseline reference	2024 data	2024 data source	2024 reference	2025 data	2025 data source	2025 reference
OC1. Awareness of product and value proposition among key stakeholders increases	A. Increasing % of stakeholders reporting familiarity with LLLC	**Specifiers:** "All six specifiers understood LLLC technology and concepts. Four of six specifiers were familiar with the term 'LLLC,' but all were familiar with the concept and had previously used LLLCs on projects." (p. 33)	LLLC MC	**Specifiers:** "When asked if they were familiar with the term LLLC, six said they were familiar with the term, another three were familiar with the concept, but not necessarily the term, and one said they were not aware." (p. 3)	Specifier survey	LLLC MI	Not included in this study	Specifier survey	LLLC MI
		Contractors: "Slightly more than half of contractors (62%) reported having heard of LLLCs." (p. 20)	LLLC MC	Not planned for 2024	Installer/ programmer survey	N/A	**Contractors:** "The survey asked respondents whether they had heard of the term LLLC or luminaire-level lighting controls, without providing a definition. 55% of respondents reported that they had heard of the term." Additionally, "After being provided with a definition of LLLC, 55% of contractors reported at least some familiarity with the technology (very or somewhat familiar) and more than a third of respondents reported having recent experience installing LLLC, with 37% having installed LLLC in the past year. Four of those respondents had answered "no" to the prior question of whether they had heard of the term LLLC, signaling that while most contractors are familiar with the term, some may be familiar with the technology but use different language to describe it."	Contractor survey	LLLC SoM

		Building Decision-Makers: "Only 30% of our participants had heard of LLLCs prior to the interview, and none had any experience with them." (p. 38)	LLLC MC	Not planned for 2024	Building owner survey	N/A	**Building owners:** "When asked whether they have heard of LLLC, prior to being provided with a definition, 11% of respondents reported they had heard of the term." Additionally, "Survey respondents were asked what types of lighting controls were present in their buildings today, and 7% of respondents reported their buildings contain LLLCs."	Building owner survey	LLLC SoM
	B. Increasing % of stakeholders reporting agreement that LLLCs are appropriate for different applications	**Specifiers:** "Specifiers report classrooms and open office spaces are ideal applications for LLLC installation because schools and offices see value in LLLCs' ease of reconfiguration… multiple specifiers said warehouses are an ideal fit for LLLCs and can improve safety... Specifiers mentioned that projects in existing buildings can be more challenging than new construction projects." (p. 35)	LLLC MC	**Specifiers:** "When asked where LLLCs may be most appropriate. Interviewees mentioned several different spaces. At least two people [out of 11 firms] mentioned the following: Schools (4), Offices (3), Exterior lighting or parking garages (3), Corridors or stairwells (3), Warehouses (2), Retail (2), Healthcare (2), Anywhere you need controls (2)" (p. 13) "Half of respondents noted that wireless systems were particularly good for retrofits." (pg 9)	Specifier survey	LLLC MI	Not included in this study	Specifier survey	LLLC MI
		Installers: "Contractors with LLLC experience report the most common applications for LLLCs are office spaces (8) and warehouses (8), followed closely by schools (6). Three respondents also mentioned industrial and manufacturing areas. Three participants also reported installing LLLCs in parking lots and garages." (pg. 30)	N/A	Not planned for 2024	Installer/ programmer survey	N/A	**Contractors:** "When asked which building types or spaces they considered a good fit for LLLC, a majority of contractors identified office spaces (77%), warehouses (70%), schools (64%), and corridors or stairwells (53%). Only one respondent answered with 'none of the above.'"	Contractor survey	LLLC SoM

		Building Decision Makers: "Three participants thought that common spaces, like hallways, stairwells, and parking garages, would be great candidates for LLLCs. Another two participants thought that office spaces would be a good fit while two others thought that hospitals or doctors' offices would benefit. Two participants who worked in school systems thought that LLLCs would be a good fit for classrooms. And another participant who worked as property manager for a county thought that 24-hr facilities and jails would be good applications for LLLCs, especially because they would allow for easy changes to light settings and would be minimally disruptive." (p. 47)	LLLC MC	Not planned for 2024	Building owner survey	N/A	**Building owners:** "Respondents were asked where they thought LLLC might be a good fit within the buildings and spaces that they oversee. The most common response was common spaces (16%), followed by office spaces (7%)." However, these results have limited applicability, because most building owners were unaware of LLLC and therefore could not provide an informed perspective, and because their perspectives would naturally skew toward the building types for which they are responsible, therefore not reflecting the overall best applications of LLLC.	Building owner survey	LLLC SoM
OC2. Coordinated efforts occur across regional and national stakeholders	C. Product definitions and resources aligned; unified input to manufacturers and other market actors (memos, specs, etc.)	**Program partners:** Alignment with broad program partners (NEEA, DLC, etc.)	Program partner conversations and documentation	**Program Partners:** Alignment with broad program partners (NEEA, DLC, etc.)	Program partner conversations and documentation	N/A	Not included in this study	Program partner conversations and documentation	N/A
		Specifiers: "Specifiers indicated a lack of consistency in the terminology surrounding LLLCs. While the four focus group participants were familiar with the term "LLLC," they agreed this is not the most commonly used term. Specifiers reported that "embedded controls" is used most often, but other terms like 'individual controls' are	LLLC MC	**Specifiers:** "When asked if they were familiar with the term LLLC, six said they were familiar with the term, another three were familiar with the concept, but not necessarily the term, and one said they were not aware" (pp. 12) "Some interviewees were asked to describe what the term meant to them, with the most common responses being individual light fixture control and general	Specifier survey	LLLC MI	Not included in this study	Specifier survey	LLLC MI

		also prevalent. They indicated the terminology is unspecific and leads to confusion: 'Do they mean individually addressable fixtures, or personal ability to control the lighting in one person's workspace?' A few respondents mentioned hearing 'embedded sensors in each luminaire' or 'embedded fixture with integral controls.' All indicated some level of confusion and frustration with the inconsistent language used to describe LLLC." (p. 33)		advanced controls... it was clear that several interviewees are using luminaire-level control technology as standalone controls rather than networked systems, citing particular applications where this is more useful. The use of standalone controls should be considered in following insights regarding LLLCs." (p. 12-13)					
		Market actors: 14/19 market actors (mfr., dst, mfrrep) familiar with LLLC, and "embedded controls" was the most common alternative, though moving more toward LLLC. (pg. 10)	LLLC MC	**Additional market actors:** not planned for 2024	Supply chain survey (manufacturer, manufacturer reps, and distributors)	LLLC MI	**Market actors:** 17/18 market actors (mfr., dst, mfrrep) familiar with LLLC. **Manufacturers and manufacturers' reps:** "Nine out of the 10 interviewees rated themselves as "very familiar" with LLLC, with the remaining one "somewhat familiar."" **Distributors:** "Distributors had at least some familiarity with LLLC: four respondents said they were "very familiar" with LLLC, three said "somewhat familiar," and one was not familiar with the term LLLC, but was familiar with the concept once the interviewer explained the definition."	Manufacturer, manufacturer's rep, and distributor interviews	LLLC SoM
	D. # of national or regional stakeholders participating in coordinating efforts	Added in 2025					Not included in this study	N/A	N/A

OC3. LLLC incentives are differentiated from other controls and promoted to consumers and market actors	E. Increasing # of utility programs with aligned LLLC incentives	LLLC qualified for rebates under custom and other controls or LED rebate programs	Utility data	Xcel Energy and Otter Tail Power have rebates available through prescriptive paths, MN Power has a rebate available through a custom path. Several COUs also offer custom rebates. Rebates do not align with our specifications, but utilities are open to adjusting for the next triennial. (2027)	Utility program definitions	N/A	Not included in this study	Utility program definitions	N/A
	F. Increasing promotional efforts around rebates by utilities and market actors	Added in 2025	Utility conversations Supply chain survey				**Contractors:** Among respondents who were aware of LLLC rebates, a majority (58%) of them reported promoting these rebates to their customers very often.	Contractor survey	LLLC SoM
OC4. Market actors feel more prepared to utilize LLLCs	G. Increasing % of market actors feel prepared to utilize LLLCs	**Installers**: "An even smaller percentage feel very prepared to install (15%) or program (12%) LLLC systems" (p. 24) "Supply chain actors reported that while some contractors already have the technical skills to successfully implement LLLCs, as a group, contractors need more exposure and experience to gain confidence." (p. 16)	LLLC MC	**Installer training survey:** Of the 23 participants who completed a pre-training survey, 7 (30%) indicated they were very or somewhat prepared to utilize LLLCs. Of the 21 participants who completed a post-training survey, 18 (86%) indicated they were very or somewhat prepared to utilize LLLCs, growth of 50+ percentage points.	Installer/ programmer survey	N/A	**Contractors:** 37% of contractors said they were very or extremely prepared to install LLLC systems, with 22% being very or extremely prepared to program LLLC systems. **Distributors:** 5/7 distributors rated their staff as "not very" or "not at all" prepared to sell LLLC.	Contractor survey Distributor interviews	LLLC SoM
OC5. Market actors gain experience and confidence, and promote LLLCs	H. Increasing # of installers report installing an LLLC system	"Less than half [37% of contractors] installed LLLCs (Table 4)." (p. 21)	LLLC MC	Not planned for 2024	Installer/ programmer survey	N/A	**Contractors:** "more than a third of respondents reported having recent experience installing LLLC, with 37% having installed LLLC in the past year."	Contractor survey	LLLC SoM
	I. Increasing # and % of projects where LLLC is used	"Only 124 projects included LLLCs, accounting for 1% of total installations." (p. 21)	LLLC MC	Not planned for 2024	Installer/ programmer survey	N/A	**Contractors:** "LLLCs were included in 4% of lighting projects" (407 reported projects during 2025, from 98 respondents).	Contractor survey	LLLC SoM

	J. Increasing % of market actors report increased confidence with LLLCs	Added in 2025					**Contractors:** 4 of 7 interviewees report having gained confidence with LLLC. "The interview asked whether contractors felt they had gained confidence with LLLC products and installations. Out of the seven contractors who were able to answer this question, four respondents said yes, one said no, and two additional respondents did not directly answer the question but had no experience with LLLC and had not yet learned about the technology."	Contractor interviews	LLLC SoM
	K. Increasing % of market actors report recommending or promoting LLLCs	Added in 2025					**Distributors:** Most distributors reported that they do not frequently recommend LLLC, with 7 out of 8 respondents saying they recommend LLLC "sometimes" (3) or "not very often" (4). **Contractors:** A minority (16%) reported recommending LLLCs "very often." 30% reported recommending LLLCs "sometimes." 34% said they "never" recommend or promote LLLC.	Distributor interviews	N/A
OC6. Increase in specifier interest and use, especially for code compliance	L. Increasing % of specifiers who report interest in LLLC products	"All respondents [6] said they are likely to specify systems with LLLCs and expect the number of LLLC projects to increase" (p. 35) "Twelve of the 13 contractors with experience installing LLLCs reported they 'liked' (2) or 'somewhat liked' (10) working with LLLCs." (p. 29)	LLLC MC	"Interviewees noted varying experiences with LLLCs, with two mentioning they, or their company, have done 50-60 projects with LLLCs in the past year, and one mentioning they do not use them at all. Most had only a handful of projects in which LLLCs were used...Several interviewees mentioned LLLC popularity is growing." (10/11 use them) (p. 13)	Specifier survey	LLLC MI	Not included in this study	Specifier survey	LLLC MI

	M. Increasing % of stakeholders indicate LLLCs are their preferred system to meet code	**Specifiers:** "Specifiers typically incorporate LLLCs into projects to fulfill code requirements" (p. 33) "Specifiers report that code is pushing them toward LLLCs more often and code requirements make highly granular sensing logical in some spaces. LLLCs provide a means to achieve compliance with these code requirements. Codes drive nearly all specifiers' design decisions." (p. 36) "According to specifiers, LLLCs offer the flexibility necessary to meet code, particularly in areas where multiple lighting control strategies and plug load controls are required. Respondents viewed LLLCs as superior to traditional control systems for this reason." (p. 37)	LLLC MC	**Specifiers:** This was not explicitly asked, but rather around preference for code minimum or advanced control systems. "A code minimum approach is more common. 6 of 11 said they start with code-minimum approaches, as they generate energy savings and functionality while minimizing costs. However, more advanced controls are specified based on customer need." (p. 4) "Additionally, when discussing advantages of LLLCs, two interviewees mentioned energy code compliance as one pro for LLLCs, though they are not the only system available to meet code." (p. 10)	Specifier survey	LLLC MI	**Specifiers:** Not included in this study **Contractors:** 21% of contractors identified "meeting code" as one of their top three most attractive potential benefits of LLLC.	Specifier survey Contractor survey	LLLC SoM
	N. Increasing % of projects where specifiers use LLLC	Do not know number of projects, but all 6 indicated they would use them. (p. 35)	LLLC MC	"Interviewees noted varying experiences with LLLCs, with two mentioning they, or their company, have done 50-60 projects with LLLCs in the past year, and one mentioning they do not use them at all. Most had only a handful of projects in which LLLCs were used. It should be noted these numbers may not reflect Minnesota projects specifically." (p. 13)	Specifier survey	LLLC MI	Not included in this study	Specifier survey	LLLC MI
OC7. Incentives claimed for LLLCs increases	O. Increasing # of projects claim incentives	To be retroactively included once data for energy savings are available and reported.	N/A	To be retroactively included once data for energy savings are available and reported.	Utility data, potentially new construction implementers	N/A	Not included in this study	Utility data, potentially new construction implementers	N/A

OC8. Market share of LLLCs increases	P. Increasing % of market share	To be retroactively included once data for energy savings are available and reported. Installers: See Table 5 – LLLCs account for 1% of total installations. (p. 22)	N/A	To be retroactively included once data for energy savings are available and reported.	N/A, eventually Encentiv; installer/ programmer survey	N/A	**Contractors:** "LLLCs were included in 4% of lighting projects." **Building owners:** "Survey respondents were asked what types of lighting controls were present in their buildings today, and 6% of respondents reported their buildings contain LLLCs."	Contractor survey, Building owner survey	LLLC SoM
OC9. Codes and standards encourage LLLCs where appropriate	Q. Codes or standards include measures that encourage LLLC adoption	Code does not require this.	N/A	Code does not require this.	Code language	N/A	Not included in this study	Code language	N/A
OC10. Energy savings and non-energy benefits realized	R. Market actors report energy savings and non-energy benefits	No baseline available	N/A	Not planned for 2024	Customer survey Installer/ programmer survey Specifier survey Building owner survey Supply chain survey	N/A	**Contractors:** The top potential benefits that appeal to contractors were faster installation (45%), lower installation costs (43%), and fewer components to manage or install (34%). Note: contractors were not stating that they had experienced these benefits, but rather that they find them attractive in theory. **Building owners:** Among 5 respondents with LLLCs in their buildings, the top reported benefits were energy savings (4 respondents), and customization of lighting characteristics (3 respondents). One respondent reported experiencing no benefits from their LLLC system.	Contractor survey Building owner survey	LLLC SoM

APPENDIX B: MPI ANALYSIS

OC1. Awareness of product and value proposition among key stakeholders increases

MPI A. Increasing % of stakeholders reporting familiarity with LLLC

Verdict: No increase

This study asked contractors and building owners about their awareness of LLLC, without providing them with a definition of the term. Fifty-five percent of contractors and 11% of building owners reported that they had heard of the term LLLC. The 2023 baseline study showed 62% of contractors and 30% of building owners had heard of LLLC. Compared with the baseline study, in which similar questions were asked, these percentages are lower. Contractors were also asked about their level of familiarity after reviewing a definition of LLLC, and 55% reported at least some familiarity (very or somewhat familiar) with LLLC in response to that question. (A similar question was not asked in the baseline study.)

While the reported familiarity with LLLC is lower in the 2025 data than in the 2023 data, it is unlikely that this represents a real decrease in familiarity in the market; once a stakeholder becomes aware of a technology, it is unlikely that they will lose that awareness. Rather, there is potential for sampling error or other sources of bias that could drive differences between the two studies. The baseline study had small sample sizes (39 contractors and 17 building owners), while the 2025 study achieved higher sample sizes (98 contractors and 89 building owners). However, with the small sample sizes for the baseline study, the differences observed would fall within the statistical margin of error. Another potentially confounding source of bias is the different methods used in the baseline study and the 2025 study. For building owners, the baseline study used phone interviews, while the 2025 study used a web survey. Interviews are more susceptible than web surveys to social desirability bias and courtesy bias (i.e., with a human interviewer, respondents feel the need to portray themselves in a positive light and/or be agreeable).[25] Furthermore, many other indicators show movement in a direction that would indicate awareness of LLLC in increasing: a higher portion of contractors feel prepared to utilize LLLC (see MPI G) and a higher portion of building owners reported having LLLC in their buildings (see MPI P).

MPI B. Increasing % of stakeholders reporting agreement that LLLCs are appropriate for different applications

Verdict: Increase among contractors based on stated opinions on LLLC applications

[25] This article from Pew Research discusses this phenomenon in polling: https://www.pewresearch.org/?p=13477

The percentage of contractors in 2025 reporting LLLC as a good fit for different applications was higher than in the 2023 baseline study. In 2025, contractors (N=98) reported LLLC to be a good fit for office spaces (77%), warehouses (70%), and schools (64%). Those same applications were the top responses to a parallel question in the 2023 study, where the percentages (out of N=17) were office 47%, warehouse 47%, schools 35%.

The building owner survey also included a question about which buildings or spaces in their portfolio would be a good fit for LLLC. The top two categories, common areas and office spaces, remained consistent between the 2023 baseline study and the 2025 study. However, these results have limited applicability to inform this MPI, because most building owners were unaware of LLLC, so could not provide an informed perspective, and because their perspectives would naturally skew toward the building types for which they are responsible, it may not reflecting the overall best applications of LLLC. It is recommended to remove the building owner portion of this MPI in the future.

OC2. Coordinated efforts occur across regional and national stakeholders

MPI C. Product definitions and resources aligned; unified input to manufacturers and other market actors (memos, specs, etc.)

Verdict: Increasing alignment among market actors on definition of LLLC

The 2025 percentage of market actors (manufacturers, manufacturers' reps, and distributors) reporting familiarity with the term LLLC (94%) is higher than the 2023 baseline level (74%). This is indicative of greater awareness and acceptance of the industry's preferred terminology for this technology. While a high percentage of respondents were aware of the term, not all respondents reported *using* this term in their own business.

OC3. LLLC incentives are differentiated from other controls and promoted to consumers and market actors

MPI F. Increasing promotional efforts around rebates by utilities and market actors

Verdict: None – first year of data collection

The 2025 contractor survey asked about awareness and promotion of utility rebates. Among respondents who were aware of LLLC rebates, a majority (58%) of them reported promoting these rebates to their customers very often.

OC4. Market actors feel more prepared to utilize LLLCs

MPI G. Increasing % of market actors feel prepared to utilize LLLCs

Verdict: Increase in percentage of contractors based on reported preparedness to install and program LLLC

In 2025, 37% of contractors said they were very or extremely prepared to install LLLC systems, with 22% being very or extremely prepared to program LLLC systems. This was an increase over the reported preparedness in the 2023 baseline study, in which 15% felt very or extremely prepared to install and 12% to program. The comparison between baseline and 2025 levels of preparedness shows a clear increase.

OC5. Market actors gain experience and confidence, and promote LLLCs

MPI H. Increasing # of installers report installing an LLLC system

Verdict: Likely small increase in percentage of installers based on contractor reported installations including LLLC in 2025

The comparison between the 2023 baseline study and the 2025 contractor survey shows a likely increase in the percent of installers reporting installing an LLLC system; however, changes in methodology prevent a direct comparison. The 2023 study asked contractors about installations in the prior three years, while the 2025 study asked about the past year only. The same percentage of contractors (37%) reported installing LLLC in those time periods. However, the 2025 study reflects only one year of activity. Therefore, it is very likely that these responses indicate an increase in the portion of contractors who have installed LLLC. This is also borne out by comparing the average number of LLLC projects reported per contractor per year in the two sets of survey results:

- In 2025, 407 projects were reported in one year by 98 respondents = 4.15 projects per contractor per year
- In 2023, 124 projects were reported across 3 years by 39 respondents = 1.06 projects per contractor per year

Future studies should ask these questions in the same format as the 2025 study to allow for direct comparison.

MPI I. Increasing # and % of projects where LLLC is used

Verdict: Increased percentage of projects based on contractor reported project activity in 2025

Based on contractor survey responses, the percentage of reported projects including LLLC increased from the 2023 baseline (1%) to 2025 (4%). As described in the previous MPI, the comparison is not perfectly aligned because the baseline study asked about the prior three years, while the 2025 study asked about the past year. However, the directional indication is that the share of projects including LLLC has increased.

MPI J. Increasing % of market actors report increased confidence with LLLCs

Verdict: None – first year of data collection

The 2025 contractor interview (N=9, of which 7 answered this question) asked whether respondents felt they had gained confidence with LLLC products and installations. Four of seven contractors reported that they had gained confidence with the technology. Future studies should consider including this question in a survey format, rather than in interviews, so respondents are required to provide definitive answers.

MPI K. Increasing % of market actors report recommending or promoting LLLCs

Verdict: None – first year of data collection

The 2025 distributor interviews (N=8) asked how often distributors recommend LLLC. Seven of eight respondents said they recommend LLLC “sometimes” (3) or “not very often” (4).

The 2025 contractor survey (N=98) also asked about this topic. A minority (16%) reported recommending LLLCs “very often.” Thirty percent reported recommending LLLCs “sometimes.” Thirty-four percent said they “never” recommend or promote LLLC.

MPI P. Increasing % of market share

Verdict: Likely increase based on contractor and building owner survey data, but additional verification needed when empirical sales data become available

As discussed above for MPI I, the percentage of contractor-reported projects including LLLC increased from the 2023 baseline (1%) to 2025 (4%). Additionally, 6% of 2025 building owner survey respondents reported their buildings contain LLLCs, compared to 0% in the 2023 baseline survey. These small increases likely correspond to increasing market share of LLLC, but this MPI should be verified when empirical sales data are available for more detailed analysis of market share.

OC6. Increase in specifier interest and use, especially for code compliance

M. Increasing % of stakeholders indicate LLLCs are their preferred system to meet code

Verdict: None – no comparable data from prior studies

The 2025 contractor survey asked respondents to select the top three potential benefits of LLLC that are most attractive to the respondent as a contractor. Twenty-one percent of contractors included "meeting code" in their top three selections. This does not directly compare to prior data collected related to this MPI.

OC10. Energy savings and non-energy benefits realized

MPI R. Market actors report energy savings and non-energy benefits

Verdict: None – first year of data collection

The 2025 contractor survey asked which potential benefits of LLLC are most attractive to contractors. The top responses were faster installation (45%), lower installation costs (43%), and fewer components to manage or install (34%). Note: contractors were not stating that they had *experienced* these benefits, but rather that they find them attractive in theory.

Additionally, the 2025 building owner survey asked respondents who reported having LLLC systems in their buildings today (n=5) what benefits they had experienced. The top reported benefits were energy savings (4 respondents) and customization of lighting characteristics (3 respondents). One respondent reported experiencing no benefits from their LLLC system.

APPENDIX C: DETAILED METHODOLOGY

Manufacturer and Manufacturer's Rep Phone Interviews

Purpose and scope. Phone interviews with manufacturers and manufacturers' representatives sought insights from both large and smaller manufacturers and their sales representative agencies to understand their perceptions of LLLC, as well as to track MPIs as appropriate. Fernhill Shopworks conducted recruitment and interviews with this market actor group. Participants were offered a $200 gift card via Tango.

Sample and recruitment. Recruitment was purposive, targeting manufacturers and reps who had not participated in another recent round of interviews performed by the ETA team. The recruitment list was developed by the ETA team in collaboration with its program contractors and included Minnesota-based manufacturer representatives and manufacturer staff with territorial responsibility for Minnesota (e.g., Midwest sales managers). Four manufacturers and six manufacturer representatives completed interviews.

Question domains. The interviews asked questions about LLLC familiarity, installation, and market trends; sales estimates that would inform the ETAs team understanding of market share for LLLC manufacturers; trajectory of standalone embedded controls vs networked LLLCs; market composition of key players and relationships; and DLC QPL participation.

Analysis approach. Interview results were systematically reviewed and coded according to expected and emergent themes. This qualitative analysis included two stages: an initial summary of themes provided by Fernhill Shopworks and a comprehensive analysis including detailed coding and identification of additional themes conducted by Kate Bushman Advising.

Distributor Phone Interviews

Purpose and scope. Phone interviews with distributor staff sought to gather insights from these market actors on their roles, perspectives, and experiences with LLLC, as well as to track MPIs as appropriate. Fernhill Shopworks conducted recruitment and interviews with this market actor group. Participants were offered a $200 gift card via Tango.

Sample and recruitment. Recruitment was purposive, targeting distributors who had not participated in another recent round of interviews performed by Fernhill Shopworks on behalf of the ETA team. The recruitment list of 124 distributor staff was developed by the ETA team in collaboration with its program contractors. The list included Minnesota-based distributor staff, some of whom had participated in the ETA team's recent Distributor Jump Start Initiative. Thirty-eight individuals on the list had contact information, while the remainder had only branch- or company-level contact information. Recruitment targeted individuals in roles with involvement in lighting and lighting controls sales, such as lighting specialists, branch

managers, quotations specialists, outside sales managers, and directors of sales. Eight distributors completed interviews.

Question domains. The interviews asked questions about distributor roles and relationships regarding LLLC; LLLC familiarity and usage; LLLC applications, including differences in wired/wireless, standalone embedded controls and LLLC usage, and HVAC integration possibilities; benefits and barriers for LLLCs; LLLC preference for code compliance; and LLLC preparedness and appropriate installation techniques.

Analysis approach. Interview results were systematically reviewed and coded according to expected and emergent themes. This qualitative analysis included two stages: an initial summary of themes provided by Fernhill Shopworks, and a comprehensive analysis including detailed coding and identification of additional themes conducted by Kate Bushman Advising.

Contractor Online Survey and Phone Interviews

Purpose and scope. The key goal for this research activity was to better understand differences in different installer types and track MPIs and market perceptions that can inform program strategy. The ETA team fielded a web-based survey, and Fernhill Shopworks conducted follow-up phone interviews with a subset of survey respondents. Survey respondents were offered a $50 gift card via Tango. Interview respondents were offered an additional $100 gift card.

Sample and recruitment. Ninety-eight lighting and controls contractors responded to the survey. The survey invitation was sent to a list of 900 Minnesota contractors, sourced largely from an energy efficiency utility program serving small and medium-sized businesses in the Twin Cities metro area. Thus, the contractors were largely concentrated in the Twin Cities metro area and may have more experience with energy efficiency and utility programs.

The participation of 98 respondents yielded a 10.9% response rate. The high response rate reflects the existing relationship between recruited contractors and the utility program. This relationship also likely introduces bias, with respondents more likely to be knowledgeable about energy efficiency and utility programs compared to the general population of contractors.

Follow-up interviews were recruited by identifying survey respondents who stated they were willing to participate in a follow-up interview then prioritizing a mix of respondents both with and without experience installing LLLC.

Question domains. The survey asked questions about contractor roles and strategies, familiarity and usage of LLLC, LLLC benefits and barriers, LLLC preparedness, LLLC applications, and utility rebate awareness and utilization. The follow-up interview sought deeper insights about contractors' use of utility rebates, LLLC benefits and barriers, contractor views on pricing, and drivers of product decision-making.

Analysis approach. Survey results were summarized as descriptive statistics with figures throughout the Contractor Insights section. Several figures report total n alongside percentages to aid interpretation where item non-response or skip logic applied. Qualitative responses were organized thematically to reveal insights. Interview results were systematically reviewed and coded according to expected and emergent themes. This qualitative analysis included two

stages: an initial summary of themes provided by Fernhill Shopworks and a comprehensive analysis including detailed coding and identification of additional themes conducted by Kate Bushman Advising.

Building Owner Online Survey

Purpose and scope. A downstream online survey captured decision-maker perspectives on LLLC. The survey was hosted on Qualtrics and managed by Cadmus. Participants received a $100 Tango gift card for completing the survey.

Sample and recruitment. We received 89 responses from building owners, facility managers, and related roles across Minnesota. Recruitment leveraged ETA team-provided lists and partner newsletters; respondents were involved with operation and maintenance of lighting and controls equipment in their properties. Building owner contact information largely comprised small to medium-sized businesses that previously participated in an energy efficiency utility program in the Twin Cities metro area. To broaden the reach and sample, a targeted ad was also placed in the ASHRAE Minnesota Chapter e-newsletter and the St. Paul BOMA Blast e-newsletter. The vast majority of respondents, however, came from the utility program contacts, and thus reflect small and medium-sized businesses, primarily within the Twin Cities metro area.

The term “building owners” is used throughout the report and collectively refers to all survey respondents including building owners, facility managers, engineers, and property managers who participate in decision-making around lighting and controls matters. 2,600 building owners who had previously participated in the utility program were contacted and sent a personalized link to complete the Qualtrics survey. An additional 1,500 building owners were reached via newsletter blast. In total, 89 respondents completed the survey for a response rate of 2%.

Question domains. Key modules included responsibility for lighting systems, respondent role, presence of controls, familiarity and experience with LLLC, recent lighting replacements, and utility rebate awareness and experience.

Analysis approach. Descriptive statistics for survey results were provided by Cadmus. Results were summarized as descriptive statistics with figures throughout the Building owner insights section; several figures report total n alongside percentages to aid interpretation where item non-response or skip logic applied. Qualitative responses were organized thematically to reveal insights and to provide downstream context for manufacturer, distributor, and contractor findings.

Integration and Study Period

Data collection occurred in late 2025 and early 2026 to provide an updated snapshot of Minnesota’s lighting controls market for the LLLC initiative. Findings were synthesized in 2026 to inform conclusions, recommendations, and interpretation of market progress indicators.

APPENDIX D: DATA COLLECTION INSTRUMENTS

The following data collection instruments were developed and deployed in this study:

- Manufacturer and Manufacturer's Representative Interview Guide
- Distributor Interview Guide
- Contractor Survey Instrument
- Contractor Interview Guide
- Building Owner Survey Instrument

Manufacturers & Rep Agencies

Name - Company

Interview Date

Introduction & Background

Intro: Thanks for taking the time to talk with me. I'm John Arthur Wilson and I'm working with CEE, a Minnesota nonprofit that implements the Efficient Technology Accelerator Program. As a part of that program, they focus on lighting controls and specifically LLLCs, which we will plan to spend the majority of our conversation on. We will also talk about market share, key players and relationships, and benefits and challenges for lighting controls.

Just a few reminders before we dive in.

- The interview will take about 30 - 45 minutes, but it will depend on how much you have to say
- Participation is voluntary and if you don't know an answer or don't want to talk about a topic, that's fine.
- Responses will be viewed by the project team and compiled into a public report, We will not attach your name or business name to any public reporting. However, we may use quotes for the report and our program materials (without names attached). We anticipate using the report to help us better shape our programs and better serve the lighting market and its customers.
- Finally, I'd like to record our interview for notetaking purposes. Is it ok with you if I record? This will only be for our research team to fill in notes.

The overarching goal of this research is to better understand

1. General awareness of integral lighting controls

2. Sales estimates by unit in the state of Minnesota (or at the branch level)

3. Preference for the different categories of integral controls by building type and application

4. Existing drivers and barriers for integral lighting controls

5. The unique role of electrical distributors.

The topics we will explore in this interview include:

1. Interviewee & Organization
2. Definitions
3. Estimating Market Share
4. Key Players & Relationships
5. Integral Controls and Their Applications
6. Specification Drivers
7. Additional Capabilities
8. Installers
9. Existing and Potential Resources
10. Design Lights Consortium's NLC Qualified Products List

Manufacturers and Rep Agencies Interview Guide

Section 1: Interviewee & Organization

1. Interviewee Information:

Interview Date:	
Interviewee Name:	
Job Title & Role:	
Company Name and Brands Represented:	

- response

2. Which market segments do you work with most directly?

Market Segment	Response Notes
Spec Sales	
Design Build	
Lighting Retrofit	

ESCO	
Discretionary	
National Accounts	
Maintenance	
Other	
Other	

Response

Section 2: Definitions

3. How familiar would you say you are with LLLC?
    a. Very familiar
    b. Somewhat familiar
    c. Not familiar

4. Before this interview, we provided you with a graphic which describes three versions of integral controls. For convenience's sake, I can pull that graphic back up for you to look at now.

    The three categories of integral controls described are: (A) standalone embedded controls (B) room based LLLC, and (C) fully networked LLLC.

    Looking at the definitions we've provided – do you agree with those, or would you suggest any edits for clarity's sake?

    Response

5. Does your company offer all or some of these products?
    Probe for specific brands and systems

Type	Interviewee Response
Standalone embedded controls	*Brands / Systems:*
Room-based LLLC	*Brands / Systems:*
Fully Networked LLLC	*Brands / Systems:*

- response

Section 3: Estimating Market Share

6. Can you provide an estimate for the annual (2024) number of units / fixtures sold in the state of Minnesota in each category?

   If you are unable to provide a numerical estimate, can you estimate what percentage of your total fixtures sales include integral controls?

Type	Interviewee Response
Standalone Embedded Controls	***Est. #*** ***Est. % of total sales is SEC***
Room-based LLLC	***Est. #*** ***Est. % of total sales is room-based LLLC***
Fully Networked LLLC	***Est. #*** ***Est. % of total sales is Fully Networked LLLC***

response

7. In terms of percentage increase or decrease, how would you estimate sales trajectory of Integral Controls between 2024 and 2025?

Type	Interviewee Response
Standalone Embedded Controls *(estimated percentage difference between 2024 and 2025)*	
Room-based LLLC *(estimated percentage difference between 2024 and 2025)*	
Fully Networked LLLC *(estimated percentage difference between 2024 and 2025)*	

Response

Section 4: Key Players & Relationships

8. Thinking about integral controls in general, who are the top 3 -5 players / relationships you work with when it comes to product specification in the Minnesota market?

Type	Interviewee Response
Lighting design companies	
MEP / Design Build Firms	
Electrical distributors	
Electrical contractors / installers	
ESCOs	
Others	

Response

Section 5: Integral Controls and Their Applications

9. For each category, what building types / applications do you think are best suited for integral controls?

Type	Interviewee Response
Standalone Embedded Controls	
Room-based LLLC	
Fully Networked LLLC	

- response

10. For each category, when do you think integral controls *are not* the right customer solution?

Type	Interviewee Response
Standalone Embedded Controls	
Room-based LLLC	
Fully Networked LLLC	

response

11. For each category, what do you believe are the advantages of integral controls?

Type	Interviewee Response
Standalone Embedded Controls	
Room-based LLLC	
Fully Networked LLLC	

response

12. When thinking about integral controls in general, what do you think are the main barriers slowing market adoption?

Potential Barriers for integral controls	#	Interviewee Response *Notes*
Lack of customer demand		
Value engineering		
Upfront cost		
Lack of installer knowledge		
Other		
Other		

Response

13. Following up on the barriers you just identified, can you expand on who the barrier effects most? (i.e. contactors or building owners, or facility operators, etc.)

Potential Barriers for integral controls	**Who is Effected *Notes***
Lack of customer demand	
Value engineering	
Upfront cost	
Lack of installer knowledge	
Other (reliability)	
Other	

Response

LLLC specific section (MPIs)

14. In general, what is your opinion of LLLCs specifically? Would you say it is…
    a. Very favorable
    b. Favorable
    c. Neither favorable nor unfavorable
    d. Unfavorable
    e. Very unfavorable?

Response

15. [if they sell LLLCs] How often do you promote or recommend LLLCs, if at all?
    a. Very often
    b. Sometimes
    c. Not very often
    d. Never

response

16. How prepared would you say your sales staff are to sell LLLCs?
    a. Very prepared
    b. Somewhat prepared
    c. Not very prepared

d. Not at all prepared

response

17. I'm going to read a list of customer situations and let me know how likely you would be to recommend LLLCs for customers in each of the following situations. Would you say you would be very likely, somewhat likely, not very likely or not at all likely to recommend LLLCs for customers who are looking to:

	Very likely	**Somewhat likely**	**Not very likely**	**Not at all likely**
a. Maximize energy savings				
b. Customize lighting for occupant comfort				
c. Meet code				
d. Reconfigure their lighting in an existing space				
e. Tie in lighting with an HVAC system				
f. Minimize project costs				

Response

Section 6: Product Specification Drivers

18. Thinking about controls in general, what are the top 3-5 primary decision factors that influence product specification:

Possible Drivers for Controls Spec Language	#	Interviewee Response *Notes*
Energy Savings		
Code Compliance		
Flexibility		
Upfront Cost		
Ease of Use		
Enhanced Capabilities		
Owner Provided Requirement		
Utility Rebates		
Other		
Other		

- Response

19. In your opinion, what are the top 3 – 5 barriers that keep *integral controls specific language* out of current specification language?

Possible Responses to Barriers to Integral Controls in Spec Language	#	Interviewee Response *Notes*
Status quo inertia (current practice)		
Lack of specifier familiarity with LLLC		
Perceived upfront cost		
Lack of customer input (OPR)		
Access to utility incentives		
Systems are actually not easy to use		
Enhanced capabilities = complexity		
Cyber security related concerns		
Wireless reliability concerns		
Other		
Other		

response

Section 8: Additional Capabilities

20. How often do you estimate LLLC systems are integrated with other building systems?

    Note: This is the fully networked variety

    a. *Less than 10%*
    b. *Between 10 – 25%*
    c. *Between 25-50%*
    d. *More than 50%*

response

21. What types of buildings / applications are most common for lighting / systems integration?

    response

22. In your experience, which additional capabilities are most popular?

Potential Responses to Advanced Capabilities	#	Interviewee Response
Asset Tracking		
Space utilization tracking		
Demand Response		
HVAC integration		
Other		

response

23. Are you noticing a trend or increased trajectory in any of the additional capabilities you mentioned in the last question?

Section 9: Installers

24. With regards to installers, do you think there are installation advantages for integral controls?

Type	Interviewee Response
Integral Controls *(catch-all)*	
Standalone Embedded Controls	
Room-based LLLC	
Fully Networked LLLC	

Response

25. Specific to installers – in your opinion, what are the primary barriers for integral controls?

Potential Barriers for Installers	#	Interviewee Response *Notes*
Lack of integral controls familiarity		
Uncomfortable with wireless		
Lack of awareness with utility incentives		
Upfront Cost		
Other		
Other		

Response

Section 10: Potential & Existing Resources

26. In terms of value and likelihood of being used, what resources do you think are most valuable and which stakeholders do you think they would be most helpful for?

Examples of Resources	#	Interviewee Response
In person controls workshops		
Case Studies		
1 Page Technical Guides		
Controls Demo Boards		

Other	1	

- Response

27. Thinking about integral controls in general, what percentage of lighting projects do you estimate take advantage of / apply for utility incentives?

- Response

Section 11: Design Lights Consortium

28. How does your organization utilize the Design Lights Consortiums Qualified Products List for Networked Lighting Controls?

Potential Responses	#	Interviewee Response Notes
To be eligible for utility incentives		
To verify product performance / features		
For comparing between products		
Other		
Other		

Response

Electrical Distributors
Name – Company
Interview Date

Introduction & Background

Intro: Thanks for taking the time to talk with me. I'm John Arthur Wilson and I'm working with CEE, a Minnesota nonprofit that implements the Efficient Technology Accelerator Program. As a part of that program, they focus on lighting controls and specifically LLLCs, which we will plan to spend the majority of our conversation on. We will also talk about market share, key players and relationships, and benefits and challenges for lighting controls.

Just a few reminders before we dive in.

- The interview will take about 45-60 minutes, but it will depend on how much you have to say
- Participation is voluntary and if you don't know an answer or don't want to talk about a topic, that's fine.
- Responses will be viewed by the project team and compiled into a public report, We will not attach your name or business name to any public reporting. However, we may use quotes for the report and our program materials (without names attached). We anticipate using the report to help us better shape our programs and better serve the lighting market and its customers.
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2. Sales estimates by unit in the state of Minnesota (or at the branch level)

3. Preference for the different categories of integral controls by building type and application

4. Existing drivers and barriers for integral lighting controls

5. The unique role of electrical distributors.

Electrical Distributors

Name – Company

Interview Date

The topics we will explore in this interview include:

1. Interviewee & Organization
2. Definitions
3. Estimating Market Share
4. Key Players & Relationships
5. Integral Controls and Their Applications
6. Specification Drivers
7. Additional Capabilities
8. Installers
9. Existing & Potential Resources
10. Design Lights Consortium's NLC Qualified Products List

Section 1: Interviewee & Organization

1. Interviewee Information:

   Interview Date:
   Interviewee Name:

   Job Title & Role:

   Company Name:

2. What type of electrical distributor are you?

(e.g. brick and mortar, project house, pipe and wire, independent, etc.)

response

3. Which market segments do you work with most directly?

Market Segment	Response
Spec Sales	
Design Build	
Lighting Retrofit	
ESCO	
Discretionary	
National Accounts	
Maintenance	
Other	
Other	

response

4. Does your organization have an outside sales team?

   If so – how many people?

   response

5. How does your organization train or work with electrical contractors / installers to support emerging technologies like integral LLLC?

   response

6. How would you describe your organization's strategic partnerships or allegiance to current lighting controls brands?

   response

Section 2: Definitions

7. How familiar would you say you are with LLLC?
   a. Very familiar
   b. Somewhat familiar
   c. Not familiar

8. Before this interview, we provided you with a graphic which describes three versions of integral controls. For convenience's sake, I can pull that graphic back up for you to look at now.

   The three categories of integral controls described are: (A) standalone embedded controls (B) room based LLLC, and (C) fully networked LLLC.

   Looking at the definitions we've provided – do you agree with those, or would you suggest any edits for clarity's sake?

   response

9. Does your company offer all or some of these products?
   Probe for specific brands and systems

Type	Interviewee Response
Standalone embedded controls	*Brands / Systems:*
Room-based LLLC	*Brands / Systems:*
Fully Networked LLLC	*Brands / Systems:*

   response

10. Does your company stock the following types of integral controls?

Type	Interviewee Response
Standalone embedded controls	
Room-based LLLC	
Fully Networked LLLC	

Section 3: Estimating Market Share

11. Specific to your company (or branch) can you provide an estimate for the annual (2024) number of units / fixtures sold in the state of Minnesota in each category?

    You can estimate annual fixture sales for the state of Minnesota or annual fixture sales at the branch level

    If you are unable to provide a numerical estimate, can you estimate what percentage of your total fixtures sales include integral controls?

    response

Type	Interviewee Response
Standalone	***Est. #***
Embedded Controls	***Est. % of total sales is SEC***
Room-based LLLC	***Est. #*** ***Est. % of total sales is room-based LLLC***
Fully Networked LLLC	***Est. #*** ***Est. % of total sales is Fully Networked LLLC***

12. In terms of percentage increase or decrease, how would you estimate sales trajectory of Integral Controls between 2024 and 2025?

Type	Interviewee Response
Standalone Embedded Controls *(estimated percentage difference between 2024 and 2025)*	
Room-based LLLC *(estimated percentage difference between 2024 and 2025)*	
Fully Networked LLLC *(estimated percentage difference between 2024 and 2025)*	

    response

13. Specific to your company, what percentage of sales in the state of Minnesota do you estimate are from online sales channels?

    response

14. Specific to your company, what percentage of online sales do you estimate are integral controls?

    response

Section 4: Key Players & Relationships

15. Thinking about integral controls in general, who are the top 3 -5 players / relationships you work with when it comes to product specification in the Minnesota market?

Type	Interviewee Response
Lighting design companies	
MEP / Design Build Firms	
Lighting Rep Agencies	
Electrical contractors / installers	
ESCOs	
Others	

16. Does your distribution shop have its own lighting and controls designers, or do you leverage those services from rep agencies or others?

response

Section 5: Integral Controls & Their Applications

17. For each category, what building types / applications do you think are best suited for integral controls and why?

Type	Interviewee Response
Standalone Embedded Controls	
Room-based LLLC	
Fully Networked LLLC	

response

18. For each category, when do you think integral controls *are not* the right customer solution?

Type	Interviewee Response
Standalone Embedded Controls	
Room-based LLLC	
Fully Networked LLLC	

response

19. For each category, what do you believe are the advantages of integral controls?

Type	Interviewee Response
Standalone Embedded Controls	
Room-based LLLC	

Fully Networked
LLLC
response

20. When thinking about integral controls in general what do you think are the main barriers slowing market adoption?

Potential Barriers for integral controls	**#**	**Interviewee Response *Notes***
Lack of customer demand		
Value engineering		
Upfront cost		
Lack of installer knowledge		
Other		
Other		
response		

21. Following up on the barriers you just identified, can you expand on who the barriers effect most? (i.e. contactors or building owners, or facility operators, etc.)

Potential Barriers for integral controls	**Who is Effected *Notes***
Lack of customer demand	
Value engineering	
Upfront cost	
Lack of installer knowledge	
Other	
Other	
response	

LLLC specific section (MPIs)

22. In general, what is your opinion of LLLCs specifically? Would you say it is…
    a. Very favorable
    b. Favorable
    c. Neither favorable nor unfavorable
    d. Unfavorable
    e. Very unfavorable?

response

23. [if they sell LLLCs] How often do you promote or recommend LLLCs, if at all?
    a. Very often
    b. Sometimes
    c. Not very often
    d. Never

response

24. How prepared would you say your sales staff are to sell LLLCs?
    a. Very prepared
    b. Somewhat prepared
    c. Not very prepared
    d. Not at all prepared

response

25. I'm going to read a list of customer situations and let me know how likely you would be to recommend LLLCs for customers in each of the following situations. Would you say you would be very likely, somewhat likely, not very likely or not at all likely to recommend LLLCs for customers who are looking to:

	Very likely	**Somewhat likely**	**Not very likely**	**Not at all likely**
a. Maximize energy savings				
b. Customize lighting for occupant comfort				
c. Meet code				
d. Reconfigure their lighting in an existing space				
e. Tie in lighting with an HVAC system				
f. Minimize project costs				

response

Section 6: Product Specification Decision Factors

26. Thinking about controls in general, what are the top 3-5 primary decision factors that influence product specification:

Possible Drivers for Controls Spec Language	#	Interviewee Response *Notes*
Energy Savings		
Code Compliance		
Flexibility		
Upfront Cost		
Ease of Use		
Enhanced Capabilities		
Owner Provided Requirement		
Utility Rebates		
Other		

response

27. In your opinion, what are the top 3 – 5 barriers that keep *integral controls specific language* out of current specification language?

Possible Responses to Barriers to Integral Controls in Spec Language	#	Interviewee Response *Notes*
Status quo inertia (current practice)		
Lack of specifier familiarity with LLLC		
Perceived upfront cost		
Lack of customer input (OPR)		
Access to utility incentives		
Systems are actually not easy to use		
Enhanced capabilities = complexity		
Cyber security related concerns		
Wireless reliability concerns		
Other		
Other		

response

Section 8: Additional Capabilities

28. How often do you estimate LLLC systems are integrated with other building systems?

    Note: This is the fully networked variety

    a. *Less than 10%*
    b. *Between 10 – 25%*
    c. *Between 25-50%*
    d. *More than 50%*

    response

29. What types of buildings / applications are most common for lighting / systems integration?

    response

30. Which additional capabilities are most popular?

Potential Responses to Advanced Capabilities	#	Interviewee Response
Asset Tracking		
Space utilization tracking		
Demand Response		
HVAC integration		
Other		
Other		

    response

31. Are you noticing a trend or increased trajectory in any of the additional capabilities you mentioned in the last question?

    response

32. As a distributor – what is your role in supporting integration?

response

Section 9: Installers

33. With regards to installers, do you think there are installation advantages for integral controls?

Type	Interviewee Response
Integral Controls *(catch-all)*	
Standalone Embedded Controls	
Room-based LLLC	
Fully Networked LLLC	

response

34. Specific to installers – in your opinion, what are the primary barriers for integral controls?

Potential Barriers for Installers	#	Interviewee Response *Notes*
Lack of integral controls familiarity		
Uncomfortable with wireless		
Lack of awareness with utility incentives		
Upfront Cost		
Other		
Other		

response

Section 10: Potential & Existing Resources

35. In terms of value and likelihood of being used, what resources do you think are most valuable and which stakeholders do you think they would be most helpful for?

Examples of Resources	#	Interviewee Response
In person controls workshops		
Case Studies		
1 Page Technical Guides		
Controls Demo Boards		
Other		
Other		

response

36. Thinking about integral controls in general, what percentage of lighting projects do you estimate take advantage of / apply for utility incentives?

response

37. How important are utility incentives for lighting projects with integral controls?
    a. Extremely important
    b. Very important
    c. Somewhat important
    d. Not very important
    e. Not at all important
    f. Don't know

response

38. [if they sell LLLCs] How often do you promote utility rebates, if at all, when selling LLLCs?
    a. Very often
    b. Sometimes
    c. Not very often
    d. Never

response

Section 11: Design Lights Consortium

39. How does your organization utilize the Design Lights Consortiums Qualified Products List for Networked Lighting Controls?

Potential Responses	#	Interviewee Response Notes
To be eligible for utility incentives		
To verify product performance / features		
For comparing between products		
Other		
Other		

response

2025 LLLC CONTRACTOR SURVEY

Research goals

i. Track/update MPIs (table below)
ii. Better understand:
    1. Awareness
    2. Barriers
    3. Why they install what they install
    4. What support is needed
iii. Training or learning needs

MPI	Associated questions
A. Increasing % of stakeholders reporting familiarity with LLLC	Q3, Q8
B. Increasing % of stakeholders reporting agreement that LLLCs are appropriate for different applications	Q13, Q14
F. Increasing promotional efforts around rebates by utilities and market actors	Q21
G. Increasing % of market actors feel prepared to utilize LLLCs	Q9
H. Increasing # of installers report installing an LLLC system	Q4
I. Increasing # and % of projects where LLLC is used	Q5
J. Increasing % of market actors report increased confidence with LLLCs	Q9, Q10?, Q11, Q17
K. Increasing % of market actors report recommending or promoting LLLCs	Q11
P. Increasing % of market share	N/A

Email:

Email subject: Lighting contractor perspectives needed!

Hello,

I'm from CEE, a nonprofit based in Minnesota, and we are working with Minnesota's electric utilities to better understand perspectives on lighting controls. We are particularly interested in hearing from commercial lighting contractors, including installers, programmers, and others who work on setting up lighting controls. Would you be willing to help us learn more by participating in a short survey? Your insights are incredibly valuable and will help us shape energy efficiency programs to support your business.

Please click on the survey link below.

[survey link]

The survey should take about 10-15 minutes, and we are offering a $50 gift card through Tango, an online gift card provider, to say thank you for your time. The survey will ask questions about your experience with lighting controls, barriers and opportunities with them, and needed support. If you feel someone else in your organization would be a better fit for this survey, please feel free to pass the survey on to them.

Please let me know if you have any questions or technical difficulties.

Thanks so much in advance,

Maddie

This research is being conducted on behalf of the Efficient Technology Accelerator, a program funded by the state's investor-owned utilities, administered by the Minnesota Department of Commerce, Division of Energy Resources, and implemented by Center for Energy and Environment (CEE). Your participation is completely voluntary and will not affect any services you receive or relationships you have with any of these entities.

Survey intro:

Hello! Thank you so much for taking the time to complete this survey. The survey should take about 10-15 minutes and will ask about your perspectives around lighting controls. Your participation is voluntary and we will not attach your name to any responses for public reporting - however CEE may follow up with you to connect you with opportunities if you'd like.

Screeners

1. Do you work on commercial or other non-residential projects with lighting controls?
    a. Yes
    b. No [thank and term]
        i. Unfortunately this is only for contractors who work with commercial lighting controls, and you do not qualify. Thank you for your interest!

Market experience

2. Thinking back to all of the lighting projects you worked on in 2025, what percentage of lighting installation projects were:
    a. New Construction/Major renovation (code compliance required)____
    b. Retrofit_____
    [must sum to 100%]
3. Have you heard of the term "LLLCs" which stands for Luminaire Level Lighting Controls? It's ok if you have not heard of them!
    a. Yes
    b. No
    c. Unsure
4. Please select each lighting controls strategy you have installed in the last year (2025):
    a. **Traditional** occupancy sensors, photocells, or timeclocks (non-networked, non-embedded)
    b. **Non-networked light fixtures with embedded sensors**
    c. Luminaire level lighting controls (LLLCs) – Networked systems of light fixtures with embedded controls and a dedicated sensor per luminaire. Unlike other NLCs, additional relays/dimmers/control panels are not required.
    d. **Other networked lighting controls (NLCs) –** lighting systems with a combination of sensors, network interfaces, and controllers that affect lighting changes in luminaires, retrofit kits or lamps
    e. Something else – Please explain _____
    f. None of the above

5. [FOR EACH SELECTED, all should get a] How many projects have you installed in the last year (2025) that were associated with the following types of controls? Your best guess is fine.
    a. No controls/manual switch only _____
    b. Traditional Non-networked, non-embedded sensors/photocells/timeclocks _____
    c. Non-networked light fixtures with embedded sensors _____
    d. Luminaire Level Lighting Controls (LLLCs) _____
    e. Other Networked Lighting Control Systems (NLCs) _____
6. [If Q4=c-d] How often are sequences of operation (SOOs) included with advanced lighting controls (NLCs or LLLCs)?
    a. Always
    b. Very often
    c. Some of the time
    d. Not very often
    e. Never
    f. I don't know
7. What are the biggest factors in selecting lighting system and controls options? Please select up to three.
    a. Energy savings
    b. Code compliance
    c. Flexibility
    d. Upfront cost

e. Ease of use
f. Enhanced capabilities
g. Owner provided requirement
h. Utility rebates
i. Simplicity of system

Q1. Something else - Please explain

LLLC-specific Questions

The next set of questions ask about your opinions about and experience with LLLCs specifically – again our definition is that Luminaire Level Lighting Controls are networked systems of light fixtures with embedded controls and a dedicated sensor per luminaire. Sensors are typically occupancy and/or daylight sensors, and often use wireless communication. Since controls are housed within, additional relays/dimmers/control panels are not required like in other networked lighting control systems.

8. How familiar are you with LLLCs?
    a. Very familiar
    b. Somewhat familiar
    c. Not very familiar
    d. Not at all familiar
9. For the next few questions, please indicate how prepared you feel to do the following:

	Extremely prepared	Very prepared	Somewhat prepared	Slightly Prepared	Not at all prepared
a. I**nstall** LLLC systems?					
b. P**rogram** LLLC systems?					
c. E**xplain the benefits** of an LLLC system to a customer?					
d. E**xplain the system operation** of an LLLC system to a customer?					
e. **Follow a sequence of operations** (SOO) for setting up LLLCs?					

10. In general, what is your opinion of LLLCs?
    a. Very favorable
    b. Favorable
    c. Neither favorable nor unfavorable
    d. Unfavorable
    e. Very unfavorable
    f. Don't know
11. What potential benefits of LLLCs are most attractive to you as the contractor? Please select **up to 3** of the following options:
    a. Faster installation
    b. Fewer components to manage or install

c. Lower installation costs
d. Granular, fixture level control
e. Adaptable, easily reconfigured
f. I can program them myself
g. Data cabling may not be required
h. Fewer callbacks
i. Meeting code
j. Another benefit (please describe_____)

12. How often do you currently promote or recommend LLLCs, if at all?
    a. Very often
    b. Sometimes
    c. Not very often
    d. Never
13. Would you recommend or use LLLCs if customers expressed interest in the following?

	Yes	Maybe	No	Don't know
a. Maximizing energy savings				
b. Customizing lighting for occupant comfort				
c. Meeting code				
d. Having the flexibility to reconfigure spaces				
e. Tying in lighting with a larger building or HVAC system				
f. Tracking asset or space use via lighting sensors				

14. What types of buildings or spaces do you think would be a good fit for LLLCs? Please select all that apply.
    a. Schools
    b. Healthcare (e.g. clinics, hospitals, etc.)
    c. Warehouses
    d. Office spaces
    e. Corridors or stairwells
    f. Parking lots, garages, or other exterior applications
    g. Something else – Please explain
    h. None of the above
    i. I don't know
15. What are the reasons that LLLCs are not used on more of your projects today? Please select all that apply:
    a. The upfront cost of the fixture is too high

b. Products are not available
c. Customers are not aware of the equipment or its benefits
d. My team is not adequately trained on LLLCs
e. LLLC products are not a good option for the spaces I work on
f. They are not specified
g. Something else – Please explain
h. I don't know

16. Of these, which do you feel is the primary reason LLLCs are not used on more of your projects?
    a. **[pipe in responses selected]**

17. **[Only if Q4 includes c]** Do you like working with LLLC equipment?
    a. Yes
    b. Somewhat
    c. No
    d. I don't know
18. **[Only if Q4 includes c]** Have you had any challenges with LLLC systems? If so, please describe.
    a. No
    b. Yes _____
19. What additional support or market conditions would you need to install more LLLCs? **[OE]**

Rebate awareness

20. Are you aware of any utility rebates for LLLCs in the area you work in?
    a. Yes
    b. No
    c. Don't know
21. [If yes] How often do you promote rebates for LLLCs?
    a. Very often
    b. Sometimes
    c. Not very often
    d. Never
22. In general, how important are rebates in getting selected for projects?
    a. Extremely important
    b. Very important
    c. Somewhat important
    d. Not very important
    e. Not at all important
    f. I don't know

Information and Training

23. Who would you look to for information about lighting controls like LLLCs? (Select all that apply)
    a. Manufacturer/manufacturer reps

b. Distributors
c. Utilities
d. Other contractors/peers
e. General online search
f. MN ETA LLLC Initiative
g. YouTube, podcasts, etc. - Please list title or channel if known_____
h. Other – Please specify_____

24. Have you received any training on LLLC equipment?
    a. Yes
    b. No
    c. Do not know
25. If yes: Who did you receive training from? (Select all that apply)
    a. Manufacturer
    b. Distributor
    c. MN ETA LLLC Initiative
    d. Someone else - Please specify _____
26. What format(s) of training or resources do you find most valuable? (Please select all that apply)
    a. In-person, half day training
    b. In-person breakfast, lunch and learn, or other shorter training
    c. eLearning modules
    d. Webinars
    e. Podcasts
    f. YouTube videos
    g. Job aids/guidance documents
    h. Regular virtual conversations with my peers to discuss challenges, opportunities
    i. Social media
    j. Other - Please specify_____
    k. None of the above
27. What time of year do you prefer to have training? (Select all that apply)
    a. Winter
    b. Spring
    c. Summer
    d. Fall
28. What time of day do you prefer to have training? (Select all that apply)
    a. Early morning
    b. Mid-morning
    c. Lunchtime
    d. Afternoon
    e. Evening
29. What training or resource topics are worth your time and energy? (Select all that apply)
    a. Installation techniques
    b. Product selection

c. Product marketing
d. Product sales
e. Value engineering
f. Customer education
g. Incentives and rebates
h. Other - Please specify_____
i. None of these

30. What types of resources would be most helpful? (Select all that apply)
    a. Case studies demonstrating successful projects
    b. Sales guides making the case for LLLCs
    c. Technical guides with best practices and guidance on LLLC installation and operation
    d. Customer testimonials
    e. Visuals or videos demonstrating LLLCs installed in different spaces
    f. Other (please specify_____)
    g. None of these
31. Finally, are there any other thoughts you would like to share? **[optional OE]**

    _____

    _____

    _____

Thank you so much for sharing your thoughts and experiences! This information will help us better understand contractor opinions and experiences and will influence programming and offerings.

32. Please enter your contact information to receive your $50 gift card. This information will not be attached to your responses.
    a. Name_____
    b. Email _____
    c. Email confirmation_____
    d. Phone_____
    e. I do not want a gift card

Please note, gift cards are not sent automatically – you should receive them in 1-2 weeks. Feel free to email Katie Wilson at kwilson@mncee.org if you have not heard from us.

33. Would you be interested in doing a follow-up interview about your responses and LLLCs? Please note that selecting “yes” does not guarantee you will be contacted.
    a. Yes
    b. No
34. If yes, please include the best contact information to reach you.
    a. Same as provided above
    b. Different
        i. Name_____
        ii. Email _____
        iii. Email confirmation_____
        iv. Phone_____

Please check here if you would like to be contacted with resources, trainings, or other program offerings, including a copy of the final report related to this research. [checkbox].

[add contact info if they have not done so already]

If you are interested in learning more about LLLCs, please visit the [insert website link].
Thank you!

Contractor Interviews

Name – Company

Interview Date

Contractor Interview

Introduction

Intro: Thanks for taking the time to talk with us. I'm JAW and I am working with the Efficient Technology Accelerator Program, which is a program funded by the MN utilities, administered by the state, and implemented by CEE. As a part of that program, we focus on lighting controls and specifically LLLCs, which we will plan to spend the majority of our conversation on.

Just a few reminders before we dive in.

- The interview will take about an hour, but it will depend on how much you have to say
- Participation is voluntary and if you don't know an answer or don't want to talk about a topic, that's fine. Participating or not participating will not affect any services or relationships you have.
- We will not attach your name or business name to public reporting unless you'd like us to.
- Responses will be compiled into a public report, and while we won't attach your name, we may use quotes to illustrate points in the report. We anticipate using the report to help us better shape our programs and better serve the lighting market and its customers.
- Finally, I'd like to record our interview for notetaking purposes. Is it ok with you if I record? This will only be for our research team to fill in notes.

Questions:

To set the stage: Our definition is that Luminaire Level Lighting Controls are networked systems of light fixtures with embedded controls and a dedicated sensor per luminaire. Sensors are typically occupancy and/or daylight sensors, and often use wireless communication. Since controls are housed

within, additional relays/dimmers/control panels are not required like in other networked lighting control systems.

Section 1: Intro & Project Selection

First, we'd like to know a little bit more about your business specifically…

1. **Could you tell us what type of lighting controls projects or sectors you primarily work on?** (For example, retrofit vs new construction vs major replacement, MUSH market, etc.)
    a. Do you have any niche markets or focus?

    response

2. How big is your organization? (Total employees, # of lighting installers)
    a. Within your organization, how many employees would you say use LLLCs in any of their projects?

    response

3. **How do you get lighting and lighting controls projects?**
    a. Once you have a project, who decides what actual lighting and controls products are installed? Is this set by the time it comes to you?
    b. Is product selection more driven by the specifier, the customer, or something else?
    c. Are there key points in the process where products change, such as with value engineering?

    response

Contractor Interviews

Name – Company

Interview Date

Section 2: LLLC projects

Switching gears a bit to talk about LLLCs, you mentioned you have installed some products with LLLCs.

4. **Tell me more about what building types or spaces those projects went into and why LLLCs were chosen.**

   response

5. **Do you feel like you have gained confidence with LLLC products and installation?**
   a. Yes, a lot, yes somewhat, no

   response

6. **Did those projects have a sequences of operations document?**
   a. If yes, how were those developed?

   response

Contractor Interviews

Name – Company

Interview Date

7. **Did you apply for utility rebates for those projects, either for LLLCs specifically or for lighting controls generally? Why or why not?**
   a. For which types of projects do you consider lighting rebates?
   b. Do you promote them to customers?
   c. At what point in the process are rebates factored in?
   d. Do you feel like the rebates influence product selection, or are they a nice perk for projects that would be installed anyway?

response

8. **What price points have you been seeing recently for LLLCs?**
   a. How do total project costs compare to those without LLLCs?
   b. Are you seeing any savings with reduced labor or cabling costs for LLLCs

response

9. **If a customer has a problem or question with an LLLC system after installation, who do they typically call?**
   a. Does your organization do onsite training with customers once the LLLCs systems are installed?
   b. How do you think this should work?

response

Contractor Interviews

Name – Company

Interview Date

Section 3: LLLC Benefits & Drawbacks

10. For your LLLC projects, are your customers seeing energy savings?

a. If so, how much are they saving? (e.g., percentage reduction, kWh savings, bill savings, other anecdotes)

response

11. What other benefits have customers reported seeing from LLLC, if any?

response

12. What types of benefits have you seen as the contractor, if any?

a. What have you liked about working with LLLCs?

response

13. What challenges have you faced with LLLCs?

a. What have you not liked about working with LLLCs?

b. Are there any challenges your customers have reported?

response

Contractor Interviews

Name – Company

Interview Date

Section 4: Barriers & Resources

14. **Why do you think other contractors are not working with LLLCs?**

    response

15. **From our survey, we found that lack of customer awareness and LLLCs not being specified were two main barriers preventing LLLC adoption. Which do you feel is a bigger barrier for LLLC?**

    response

16. **What types of support or resources do you think would help get more people on board with LLLCs?**

    response

17. **What types of support or resources would be most valuable to your business to increase your use of LLLCs?**

    response

Thank you so much for your time!

2025 Building Owner Survey – LLLC Focus

Introduction

Hello! Thank you for your willingness to complete this survey. The survey should take about 20 minutes and will ask your perspectives around lighting systems, including lighting controls, and Heating Ventilation Air Conditioning (HVAC) equipment, especially Rooftop Units (RTU), in commercial or other non-residential buildings in Minnesota. Responses will be aggregated and compiled into a public report, and will help us better shape programs to help buildings like yours.

As a thank you for completing both the lighting and HVAC sections of the survey, you may be eligible to receive a **$100 gift card through Tango, an online gift card provider where you can select a $100 voucher to a store of your choosing.** Gift card availability is limited and offered while supplies last. The administrator reserves the right to withhold incentives for incomplete, duplicate, or ineligible responses.

This research is being conducted on behalf of the Efficient Technology Accelerator, a program funded by the state's investor-owned utilities, administered by the Minnesota Department of Commerce, Division of Energy Resources, and implemented by Center for Energy and Environment (CEE). Your participation is completely voluntary and will not affect any services you receive from any of these entities. Responses will remain anonymous - we will not attach your name to any responses for public reporting. However, you may opt-in to be contacted in the future with additional resources, trainings, and other program offerings.

Screeners (Section S)

1. Are you responsible for the operations or equipment specification decisions in a commercial or other non-residential facility in Minnesota? [Force response]
    a. Yes
    b. No [If Q1=b, thank and term]
        i. Term: Unfortunately, this survey is only for those who are responsible for operations or equipment specification decisions for non-residential buildings in Minnesota and you do not qualify. Thank you for your willingness to participate.

2. Are you involved with specifying, operating, maintaining, or interacting with lighting systems or HVAC equipment for your building? [Force response]
    a. Yes, lighting systems only
    b. Yes, HVAC equipment only
    c. Yes, lighting systems and HVAC equipment
    d. No, I am not involved with either of these [If Q2=d, thank and term]
        i. Term: Unfortunately, this survey is only for those responsible for these technologies and you do not qualify. Thank you for your willingness to participate.
3. [If Q2=b or c] Do any of the buildings in your portfolio have rooftop units (RTUs)? [Force response]
    a. Yes [continue to Q4]
    b. No [if Q2=b AND Q3=b or c, thank and term]
    c. I don't know [if Q2=b AND Q3=b or c, thank and term]
        i. Term: Unfortunately, it will be difficult to answer the survey questions without having RTUs on buildings in your portfolio. Thank you for your willingness to participate.
4. When considering lighting systems and HVAC equipment, which of the following do you work on? Please select all that apply. [RANDOMIZE A-E] [Force response]
    a. Specifying or selecting new, upgraded, or replacement equipment
    b. Operation & Maintenance
    c. Building automation/controls
    d. Pursuing utility rebates
    e. Reducing energy consumption or corporate sustainability
    f. Something else – Please explain _____
    g. None of the above [thank and term]
        i. If NONE OF THE ABOVE: Unfortunately, this survey is only for those responsible for lighting and HVAC equipment and you do not qualify. Thank you for your willingness to participate.

Role (for both – Section B)

5. What is your role? Please select all that apply.
    a. Building owner
    b. Third-party property manager
    c. Facility manager
    d. Building engineer
    e. Something else – Please explain _____

6. Do you work with or manage one building or a portfolio?
    a. One building
    b. Portfolio of buildings
        i. If portfolio: how many buildings do you work with or manage?
7. What type of building(s) do you work with/manage? Please select all that apply. [RANDOMIZE A-H]
    a. Commercial office spaces
    b. Non-profit offices and facilities
    c. Retail, including strip malls
    d. Medical, including hospitals
    e. Public school buildings (classrooms, administrative offices, garages, athletic facilities)
    f. City and county municipal buildings (fire, police, jails, office, libraries, parks and recreation facilities, animal control facilities)
    g. Hospitality
    h. Large apartment or residential buildings
    i. Something else – Please explain _____

Lighting only (Section L)

[NOTE: program only for people whose response to S2 = a or c.]

Controls

The next section will ask questions about lighting controls.

8. Have you heard of the term "LLLCs" which stands for Luminaire Level Lighting Controls? It's ok if you have not heard of them!
    a. Yes
    b. No
    c. Unsure

9. Which of the following lighting controls are in your building(s) now, if any? Please select all that apply.
    a. **Traditional** occupancy sensors, photocells, or timeclocks (non-networked, non-embedded)
    b. **Non-networked light fixtures with embedded sensors**
    c. **Luminaire level lighting controls (LLLCs) –** Networked systems of light fixtures with embedded controls and a dedicated sensor per luminaire.

Unlike other NLCs, additional relays/dimmers/control panels are not required.

d. **Other networked lighting controls (NLCs)** – lighting systems with a combination of sensors, network interfaces, and controllers that affect lighting changes in luminaires, retrofit kits or lamps
e. Something else – Please explain _____
f. I don't know
g. None of the above [EXCLUSIVE RESPONSE]
    i. If NONE OF THE ABOVE: Have you considered installing lighting controls in your building(s)? Why or why not? [open-end]
    ii. If I DON'T KNOW OR NONE OF THE ABOVE: SKIP TO Q10

10. How do you actively interact with your controls system(s)? Please select all that apply. [RANDOMIZE A-D]
    a. Adjust light levels
    b. Remotely control lights
    c. Monitor energy usage of lighting systems
    d. Create and/or adjust light schedules
    e. Something else – Please explain _____
    f. I do not actively interact with the controls systems(s) [EXCLUSIVE RESPONSE]

LLLCs

The next few questions will ask about your perceptions of luminaire level lighting controls (LLLCs). For the purposes of this survey, **we are defining LLLCs as connected systems of light fixtures with embedded controls and a dedicated sensor per luminaire, which provide granular control over the lighting in a space. Sensors typically include motion and daylight, which allow for increased energy savings. The lights typically communicate with one another wirelessly, which allows for flexibility of design and reconfiguration of spaces.**

11. How familiar are you with luminaire level lighting controls (LLLCs)?
    a. Very familiar
    b. Somewhat familiar
    c. Not very familiar
    d. Not at all familiar
12. The following are potential benefits from LLLC systems. Please indicate how valuable each benefit would be for you.

	Essential	Very valuable	Somewhat valuable	Not very valuable	Not at all valuable
Maximizing energy savings (lowering energy bills)					
Customization of lighting characteristics					
Flexibility to reconfigure spaces					
Improving occupant comfort					
Ability to be remote controlled or monitored via an app					
Streamlining meeting energy code					
Tying in lighting with a larger building or HVAC system					
Using lighting sensors for asset or space use tracking					

13. [Pipe in based on essential or very valuable options] Thinking about these potential benefits, which do you think would be most valuable for you or your occupants?
    a. Maximizing energy savings (lowering energy bills)
    b. Customization of lighting characteristics
    c. Flexibility to reconfigure spaces
    d. Improving occupant comfort
    e. Ability to be remote controlled or monitored via an app
    f. Streamlining meeting energy code
    g. Tying in lighting with other building systems
    h. Using lighting sensors for asset or space use tracking
    i. Something else – Please explain _____
    j. None of the above

For those with LLLCS

[This section, Q14-Q19, is only for those with LLLCs where Q9=c]

The next few questions ask specifically about LLLCs in your building(s).

14. [If Q9=d and Q6=b] How many of your buildings include LLLCs?
    a. All of them
    b. Most of them
    c. Some of them
    d. A few of them

e. Just one
f. None of them [skip to Q20]

15. [If Q9=c]: Are most of your LLLC systems set up as fully networked systems (e.g. they communicate as a part of a connected system)?
    a. Yes – most are fully networked
    b. Somewhat – a mixture of networked and non-networked
    c. No – they are networked capable, but currently not networked
    d. No – they have no networking capabilities
    e. I don't know
16. [If Q9=c]: Did you have a sequence of operations established when the systems were installed and configured?
    a. Yes – for all
    b. Yes – for some
    c. No
    d. I was not in charge of this process at installation
    e. I don't know or remember
17. [If Q9=c]: Did you receive adequate training from the installer or manufacturer representative on system operation?
    a. Yes
    b. No, I received training but it was inadequate
    c. No, I did not receive training
    d. I was not in charge of this process at installation
    e. I don't know or remember
18. [If Q9=c]: What benefits have you or your occupants experienced specifically from your LLLC systems? Please select all that apply. [RANDOMIZE A-I]
    a. Extended equipment life
    b. Energy/bill savings
    c. Control over energy use
    d. Occupant comfort
    e. Occupant safety
    f. Customization of lighting characteristics
    g. Flexibility with lighting configurations
    h. Ease of use (e.g. via remote control/app)
    i. Integration with/providing data for building systems
    j. Easy code compliance
    k. Another benefit (please describe_____)
    l. None of these/no benefits [EXCLUSIVE RESPONSE]

19. [If Q9=c]: Have you encountered any drawbacks specifically with the LLLCs? Please select all that apply. [RANDOMIZE A-D[
    a. Complicated settings or features
    b. Maintenance challenges
    c. Features malfunctioning or not working well
    d. System integration challenges
    e. Another type of challenge (please describe_____)
    f. None of these/no drawbacks [EXCLUSIVE RESPONSE]

LLLC support

20. Are there specific types of spaces in your building(s) where LLLCs are or would be a good fit? Please describe. [open-end]
21. What types of support or information would you need to add LLLCs or add additional LLLCs to your spaces? Select all that apply. [RANDOMIZE A-H]
    a. More information about LLLC benefits
    b. More information about system configurations
    c. More information about brands and manufacturers available
    d. Reduced upfront cost
    e. Utility rebates
    f. Support from an installer
    g. Case studies or examples from similar buildings
    h. Demonstrations
    i. Something else (please describe_____)
    j. None of these – I am not interested in LLLCs
        i. If H: why are you not interested in LLLCs? [Open end]

Recent replacement

The next few questions ask about lighting replacements or installations in general in the last 3 years.

22. Have you done any lighting replacements or installations in the last 3 years?
    a. Yes
    b. No
    c. I don't know
23. [If Q 22=a] Were those installations for any of the following situations? (select all that apply)
    a. A new construction building
    b. A full building renovation

c. A space reconfiguration or room retrofit
d. Individual one-off fixture replacements
e. Something else (Please describe_____)

24. [If Q 22=a] Did you consider LLLCs as an option for any of those lighting installations?
    a. Yes
    b. No
    c. I don't know
25. [If Q 22=a] Why or why not? [OE]
26. [if Q24=a] Did you select LLLCs for any lighting installations?
    a. Yes
    b. No
    c. I don't know
27. [If Q 24=a] Why or why not? [OE]

Rebates

28. Are you aware of any utility rebates for lighting controls equipment?
    a. Yes
    b. No
29. Have you pursued any rebates for controls or lighting in general?
    a. Yes
    b. No
    c. I don't know
30. [If 29=b] Why did you not apply for utility rebates? (select all that apply) [Randomize A-F]
    a. I don't know where to look for information
    b. The paperwork is too burdensome
    c. Too many equipment requirements
    d. The dollar amount is not worth it
    e. I don't like using utility rebates
    f. I have too many other priorities on my plate
    g. Another reason (please describe_____)
    h. None of these – I would likely apply [EXCLUSIVE RESPONSE]

[Go to Conclusion if S2 was a; continue if S2 was c.]

HVAC only (Section R)

[Removed for brevity – not used in this report]

Conclusion

Thank you so much for sharing your thoughts! This information will help us better understand building owner and operator opinions and experiences and shape programming and offerings to support others like you.

31. Would you like to enter your contact information to receive your $100 Tango gift card?
    a. Yes
    b. I do not want a gift card

IF YES: Please enter your contact information to receive your gift card. We will not share or sell your information, and it will not be attached to your responses.

Gift cards will be sent to you via Tango, an online gift card provider where you can select a $100 voucher to a store of your choosing. Please note, gift cards will be processed manually – you should receive an email from Tango in 1-2 weeks. **Please contact Katie Spillenkothen at katie.spillenkothen@cadmusgroup.com if you do not receive anything after this time frame.**

First Name_____

Last Name _____

Email _____

Email Confirmation_____

Phone_____

32. Would you be interested in participating in a follow-up interview about your responses? Please note that selecting "yes" does not guarantee you will be contacted.
    a. Yes
    b. No

IF YES AND DID NOT SUBMIT CONTACT INFO FOR GIFT CARD:

Please enter your contact information. We will not share or sell your information, and it will not be attached to your responses.

First Name_____

Last Name _____

Email _____

Email Confirmation_____

Phone_____

33. Would you like to be contacted with additional resources, trainings, and other program offerings?
    a. Yes
    b. No

IF YES AND DID NOT SUBMIT CONTACT INFO FOR GIFT CARD OR FOLLOW-UP:

Please enter your contact information. We will not share or sell your information, and it will not be attached to your responses.

First Name_____

Last Name _____

Email _____

Email Confirmation_____

Phone_____

If you are interested in learning more about luminaire level lighting controls or RTUs, please visit our webpages for LLLC or Next Gen Rooftop Units initiatives, two programs that are implemented by CEE. Thank you!

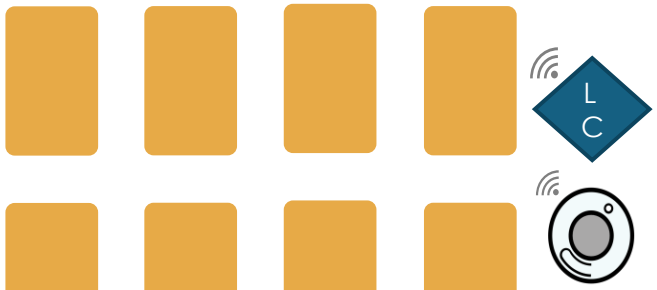
APPENDIX E: LLLC DEFINITIONS DOCUMENT

This document was provided to manufacturer, manufacturer representative, and distributor interviewees to clarify terminology and facilitate discussion.

Three Levels of Luminaire Integration

A. Zone Limited

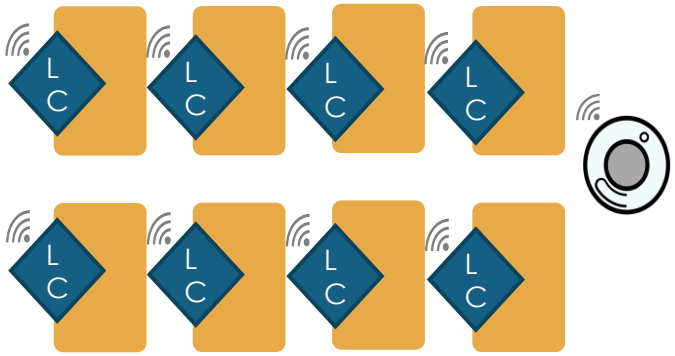
1 sensor : many fixtures



1 load controller : many fixtures

B. Individually Addressable

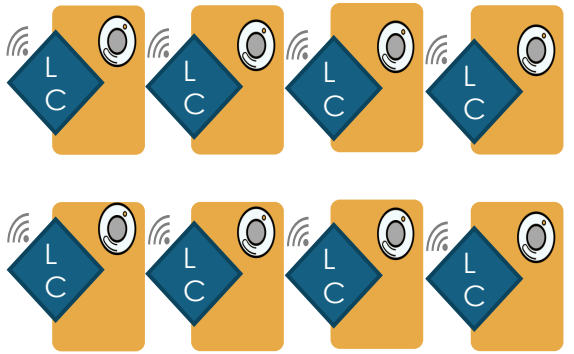
1 sensor : many fixtures



1 load controller : 1 fixture

C. Luminaire Level

1 sensor : 1 fixture

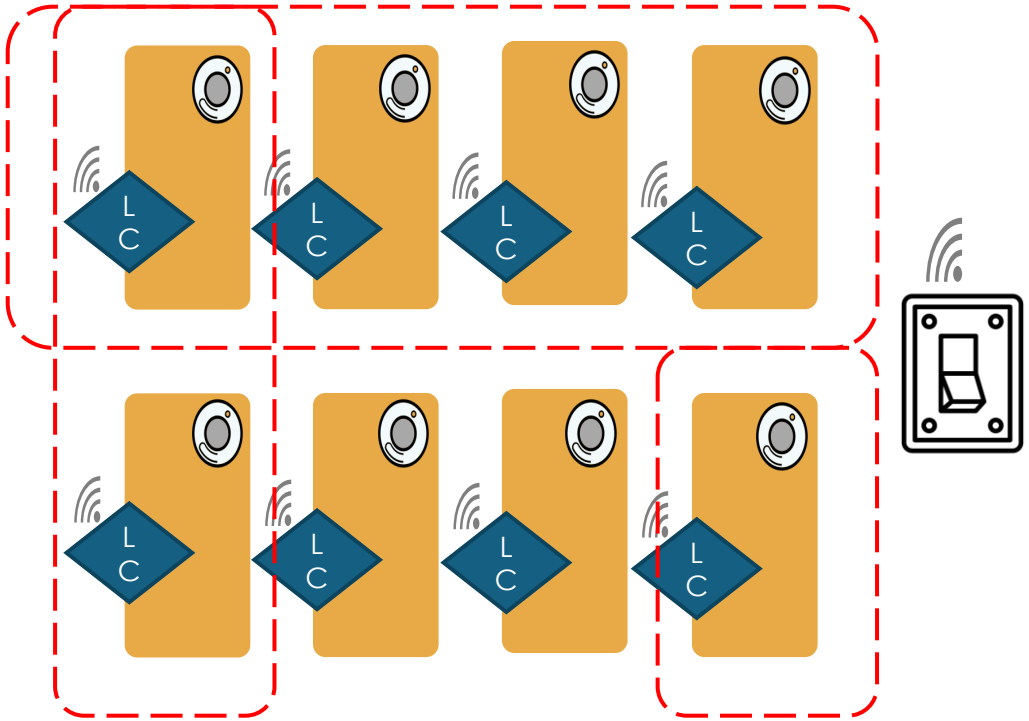


1 load controller : 1 fixture

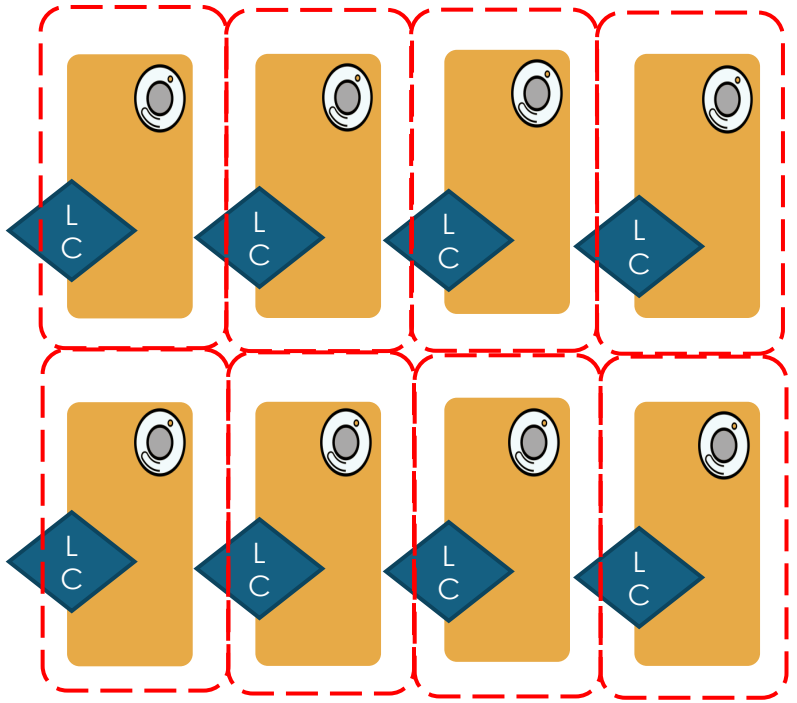
Difference between LLLC vs. Non-Networked Embedded Controls

LLLC is Networked

Networked capabilities include:
Zoning – Wireless Controllers– App Based Configuration, and more.



Non-Networked embedded controls limitations include:
No zoning, limited configuration methods, no wireless wall stations



When We Say…	
When we say…	**We mean…**
Standalone	Non-networked
Networked	At any level – (e.g. locally with mesh or wide with dedicated gateway)
Embedded	Sensors or nodes integrated into fixtures
Node	Addressable component. Can be integrated into any type of device (e.g. sensor, load controller, wall station) Can be wired or wireless.
Wireless	Wireless communication between devices. Most devices are still wired for power + low voltage wires between sensors and load controllers.

Terms I'm going to avoid…	
Terms	**Why…**
Advanced	Ambiguous, can refer to networked level or specific features. No industry standard for what is *advanced* vs. not.
Controls Ready	Ambiguous, can refer to fixture form factor, driver type, or the ability to scale capabilities with additional networking hardware (e.g. gateway)

Luminaire Integration & Networked Spectrum Matrix

Level of Luminaire Integration	<======== Networked Spectrum ========>		
	Non-Networked (standalone)	**Limited Network** (room-based)	**Fully Networked** (dedicated gateway)
Luminaire Only *no fixture integration*	Luminaire Only Fixtures	Luminaire Only Fixtures	Luminaire Only Fixtures
Luminaire + Load Controller & Sensor *no nodes*	Standalone Embedded Controls	NA	NA
Luminaire + Load Controller & Node *no sensors*	NA	Individually Addressable Fixtures *in limited or mesh network*	Individually Addressable Fixtures *with dedicated gateway*
Luminaire + Load Controller & Node & Sensor	NA	LLLC *in limited or mesh network*	LLLC *with dedicated gateway*