



FINAL REPORT

Performance Testing and Networking for C&I Lighting Controls

MA23C03-E-LGTCTRLC

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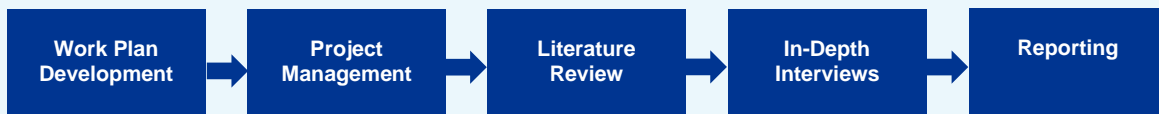
List of acronyms used in this report

ALC	advanced lighting control
C&I	commercial and industrial
Cx	commissioning
CxA	commissioning authority
DLC	Design Lights Consortium
EEAC	Energy Efficiency Advisory Council
LED	light-emitting diode
LLLC	luminaire-level lighting controls
NLC	networked lighting controls
PA	Program Administrators
RCx	retro-commissioning
PT	performance testing

Executive Summary

The Lighting Controls Performance Testing Study leveraged existing literature and interviews with lighting experts, market actors, and program implementers to clarify the criteria to verify if advanced lighting control systems are being properly set up and tested for the Program Administrators (PAs). These criteria will ease the decision-making around the appropriate savings factors and incentive levels that projects can claim. DNV collected responses and insight to inform a list of important criteria that will serve as an adequate verification tool and not present undue barriers to implementation. Additionally, DNV collected and is sharing relevant learnings as to the market for commissioning, retro-commissioning, performance testing and the prevalence of lighting controls in general.

Methodology and Approach



There were two **key learning phases** in this study. The tasks and their associated subtasks were:

Literature Review



- Review of relevant regional studies on Advanced Lighting Controls (ALCs)
- Review of national sources on ALCs, their networking, and commissioning
- Review of five PA custom ALC project files

In-Depth Interviews



- Interview 5 lighting controls experts
- Interview 5 lighting controls market actor
- Host a MA PA implementer panel discussion

Study Purpose

The purpose of the Performance Testing and Networking for C&I Lighting Controls study was to provide uniform definitions of lighting controls Performance Testing and lighting controls networking to be used by the Massachusetts PAs.

“As much as possible I think this needs to be kept easy. I am very hesitant to throw up additional burdens and obstacles for a measure that is having a hard time gaining traction.” - Market Expert

“I do not think lights need to be networked to attain higher savings or a higher incentive, but without networking, you cannot prove the savings and address changes into the future.” - Market Expert

Key Findings

- 1) The population of market actors and experts interviewed confirmed the differing opinions on commissioning and performance testing found in the literature. Despite this, there was consensus about the key criteria needed to ensure a lighting system is appropriately set to design intent after installation.
- 2) Because programs around the country have seen dissatisfaction with the time and process for performance testing, setting early customer expectations is important.
- 3) Market actors were not surprised by the current percentages of lighting controls being added to lighting projects through MA downstream. Reasoning varied but cost, incentives, and paperwork, in comparison to midstream, was highlighted.
- 4) Retro-commissioning intrigued many respondents, though they saw little of it in the field. Opinions mixed on savings potential.
- 5) A fixture simply being network-capable was generally not considered savings beneficial by respondents. Verification and savings measurement benefits are seen from the connectivity.
- 6) Respondents noted costs of performance testing can be different between who provides the service with third-party testers often being more expensive.

Conclusions and Recommendations

Recommendation 1: DNV recommends that the PAs adopt the following criteria into an easy-to-scale, fillable form, for performance testing delivery staff to provide at completion. This form should include the following:

- An area to describe the defined design intent for each distinct space/zone
- Characterization of different space/zones in facility (e.g., Lobby, Stairwell, Office 1, Office 2...)
For each zone:
 - Quantity of each zone with similar configuration and settings
 - Number of fixtures networked and controlled and how many are LLLC in each zone
 - Defined illumination levels in each zone
 - High end trim settings
 - Occupancy sensor timeout and characterization of time out trim level
 - Is daylight harvesting switched on and what is the illumination (max and min)
 - Description box highlighting closed or open loop, Location of sensor.
 - Box to describe testing performed
 - Box to describe owner/designer signoff
 - Box for description of owner/operator training and operation manuals delivery

Recommendation 2: DNV recommends the PAs change the naming of Advanced Lighting Controls (ALC) as follows:

- Networked lighting control (NLC) **changed to** Networked lighting control (NLC) – Performance Tested (PT)
- Luminaire-level Lighting Controls (LLLC) – Networked and Commissioned **changed to** Luminaire-level Lighting Controls (LLLC) – Networked and Performance tested (PT)
- Non-Commissioned LLLCs **changed to** Non-Performance Tested LLLCs

Considerations

Consideration 1: The MA PAs should examine what level of training is appropriate for those commissioning and/or programming advanced lighting control systems. This could be training from the manufacturer with a certificate, training from a manufacturer rep, or others. The responses to interviews showed that the range of training levels among contractors and those programming systems can be large.

Consideration 2: The recommendations provided above do little to impact the ability for programs to verify the installation of ALCs through the midstream program. DNV suggests the PAs consider understanding how the existing midstream QC process could be used to verify ALC installations to confirm performance testing, and therefore, be better able to estimate appropriate savings factors. Perhaps in creating a sampling plan, projects with ALCs can be targeted to understand how they were installed and if performance testing was done.

Consideration 3: The PAs should consider requiring LLLCs to not only be capable of networking, but also be networked to ensure that the systems can report on energy savings and provide easier verification. This would involve networking beyond the room level, as discussed prior in the report.



2 INTRODUCTION

2.1 Study purpose and objectives

DNV carried out the Performance Testing and Networking for C&I Lighting Controls Study (MA23C03-E-LGTCTRLC) for the Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) Consultants from April 2023 to September 2023. The study's overall purpose was to provide uniform definitions of lighting controls performance testing and lighting controls networking to be used by the MA PAs. Its objectives were as follows:

1. Define an appropriate and usable definition for C&I lighting controls networking and performance testing, to be used by both evaluation and implementation.
2. Understand the current practices of program implementers and market actors when installing lighting controls requiring performance testing and the effectiveness of the currently used interim definition.
3. Understand the opportunities for further performance testing and retro-commissioning.

2.2 Study background

"Commissioning" is well-defined by entities such as ASHRAE, the Building Commissioning Agency, and other national groups. It also is defined by contractor groups, trade organizations, and other entities. These latter organizations often provide a definition less robust and that omits certain steps from those provided by ASHRAE and others. This research effort found that the market, especially in Massachusetts, conflates the definition of commissioning with the definition of performance testing and programming. In fact, many industry practitioners did not know of any distinction between the two.

Therefore, this study is careful as to how it characterizes commissioning and will refer to the majority of activities as performance testing, to not introduce greater confusion into an already muddled discussion. The Connecticut PSD study that recommended this research referred to the requirement of lighting controls commissioning when performance testing was ultimately the desired outcome, thus this study will characterize these activities as such. The reader may notice questions from the interviews and respondent answers discuss commissioning in an unclear or incorrect manner. This is due to the decision to limit the use of commissioning being made after these research activities were completed.

To be classified as a Luminaire-Level Lighting Control (LLLC) or a Networked Lighting Control (NLC) and to claim the associated savings factors, implementation must demonstrate that the fixture is networked and performance tested – which requires a standard definition of what that means. For ease, LLLCs and NLCs are also referred to as Advanced Lighting Controls (ALC) in this paper. Additionally, the entire industry lacks a consistent existing definition for programs to use. This study produced a set of criteria to be used by programs and evaluators to appropriately allocate savings factors to measures and sought to define performance testing and networking of lighting controls to provide clarity going forward.¹ Additionally, to better understand the market for these advanced controls, the study looked at *how* performance testing is being performed and how the interim definition decided on by MA PAs is being applied, and incorporated those findings into its recommendations and considerations.

Performance testing is a key step in the commissioning process and was found to be the best match with the level of verification needed to ensure lighting control systems are operating in accordance with design intent. ASHRAE 90.1 defines commissioning as "a quality-focused process for enhancing the delivery of a project for verifying and documenting that the building and its systems, controls, and building envelope are planned, designed, installed, tested, and include plans for operation and maintenance to meet specified requirements."² ASHRAE goes further to define key elements required within commissioning, some of which may go beyond the needs of lighting. Additionally, lighting controls networking can involve a

¹ This study did not intend to update the control savings factors.

² ASHRAE 90.1, 2019

great amount of nuance, so setting the appropriate definition for programs and evaluators to appropriately classify controls measures is important for program success. In industry accepted practice is for an independent third-party (not associated with the design or construction of the project) to perform commissioning. While independent third-party commissioning is a valuable service, it is costly and time intensive and is not necessary to ensure the performance of the control systems. The Design Lights Consortium definition of networking has typically been used in MA, and this study confirmed that this definition is appropriate.³ However, through conversations with industry experts and the MA stakeholder group, it has generally been understood that these definitions are not universally followed or agreed upon.

To provide program staff with interim guidance until the criteria for performance testing was defined, the PAs and EEAC consultants agreed upon the following guidelines:

1. To receive incentive/ savings from lighting controls measures codes 63A/ 65A, they must be listed on DLC NLC qualified product list.
2. A commissioning report (a PDF or screenshot) that: details settings around high-end trim and dual sensors with motion and photocell/ ambient light sensors; documents schedule setting, as well as the setting and operation of occupancy sensors; details how the system can control motion response and illumination levels; details on how the fixtures and/or control devices interacts and communicates with other fixtures and/or control devices.
3. A screenshot of the commissioning application.

Table 2-1 shows the current controls categories in Massachusetts and their associated savings factors. The significant savings bump between Non-Commissioned LLLCs and LLLCs is due to the increase in savings associated with performance testing and networking requirements.

Table 2-1. Controls categories and associated savings factors

Control Function Category (Newly Adopted)	Control Savings Factor
Networked Lighting Controls (NLC)	49%
Luminaire-Level Lighting Controls (LLLC) – Networked & Commissioned	49%
Non-Commissioned LLLCs	38%
Dual Occupancy and Daylight Sensors	38%
Combination High-End Trim and Daylight Dimming	35%
Combination High-End Trim and Occupancy Sensors	33%
High-End Trim	27%
Daylight Dimming	28%
Occupancy Sensors	24%

In a recent Connecticut study,⁴ industry experts and market actors indicated that the savings potential of lighting controls relies heavily on the set-up and/or commissioning of the system. *As stated earlier, the recommendation really was ultimately more interested in performance testing than commissioning.* The savings rely on the effectiveness of the set up at meeting the design intent and effective set up is dependent on the level of performance testing and/or commissioning. In light of this

³ DLC definition for “Networking of Luminaires and Devices” in “Networked Lighting Controls Technical Requirements (Version NLC5, Released June 23, 2020, Updated December 22, 2021):” “The capability of individual luminaires/lamps and control devices to exchange digital data with other luminaires/lamps and control devices on the system. This capability is required at the room, space, or area level, but not at the whole building level or beyond (e.g. non-lighting systems, or the internet).”

⁴ <https://energizect.com/sites/default/files/2022-07/CT%20X1931-4%20ALC%20PSD%20Phase%202%20Memo%20Final060822.pdf>



and other corroborating findings, the MA stakeholder group agreed that this a study was needed to clarify how performance testing should be defined for the programs.⁵

⁵ This understands the CT study assumed this need was commissioning, although performance testing has been found adequate.



3 METHODOLOGY AND APPROACH

This study had two main methodological components: a literature review of relevant studies and project files, and a series of in-depth interviews with lighting experts and market actors.

3.1 Literature review

The team performed a literature review of other jurisdictions' evaluation reports on lighting controls, networking, and commissioning, and PA project files for custom projects involving advanced lighting controls.

As part of this work, the team sought to understand the use of commissioning and networking for lighting controls and how they are defined in different areas. We reviewed the DLC standards alongside other market or evaluation research that examines commissioning. Additionally, the team reviewed prior research conducted in Massachusetts and Connecticut, including the Lighting Controls Market Study (MA20C11-E-LCR), Upstream Lighting Impact Study (MA19C06-E-UPLGHT), and PY2017-18 Custom Electric Impact Study (MA19C07-E-CUSTELEC) in Massachusetts, and CT X1931-4 ALC Phases 1 & 2 in Connecticut.

The team reviewed findings from those studies and compiled relevant learnings helpful to this study effort. We also reviewed these materials to derive insights into what can increase the rate of commissioning. Such findings not only informed how to recommend the appropriate definition for commissioning and networking but may inform program efficiency and effectiveness.

Finally, the team reviewed relevant C&I custom projects that had advanced lighting controls measures included and identified those with commissioning. DNV requested custom projects of the PAs that involved the installation or retrofitting of advanced controls and selected five for review (three from National Grid and two from Eversource). These reviews incorporated as much project variety as possible by considering project size, whether it was an all-lighting project, building type, and PA.

3.2 In-depth interviews

The DNV team conducted interviews with lighting control experts, contractors, and program staff to gain a better understanding of how the market views lighting controls networking and commissioning and current practices.

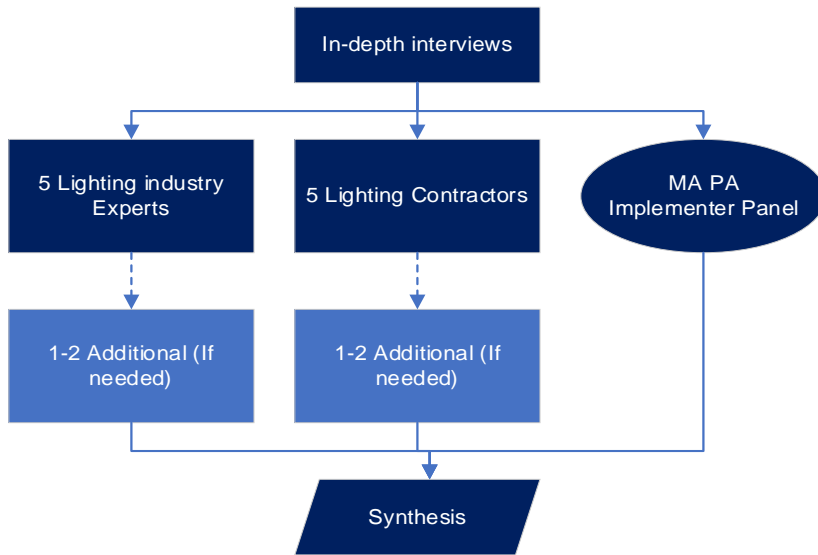
The team spoke with five lighting market experts to understand how commissioning and networking is performed in different types of projects and how they have understood it broadly. The objective of these interviews was to understand the prevalence of commissioning and the experts' perspective on how it happens or barriers to it happening. We asked for the experts' insights and perspectives on the general industry trends around advanced lighting controls, networking, its commissioning, and its promotion by market actors. These interviews also collected some information to inform the market opportunity for generating additional savings through retro-commissioning. After reviewing the results of the first five interviews, DNV felt appropriate levels of information was collected, negating the need for additional IDs that were included as in the scope of work should more insights be needed. The interview guide for this set of interviews can be found in APPENDIX B.

The DNV team also conducted interviews with five lighting contractors who have installed advanced lighting systems in Massachusetts. The goals of these interviews were to gather more insight into how controls are being commissioned and networked in the field and to tighten the definition of commissioning. Additionally, in these interviews, we asked the contractors if they had any insights on process improvements that would increase customers' interest in proper commissioning. After reviewing the results of the first five interviews, DNV felt appropriate levels of information were

collected, negating the need for any additional IDIs. The interview guide for this set of interviews can be found in APPENDIX A.

Finally, on September 19, 2023, DNV facilitated a panel discussion with PA implementers, discussing their perspectives on C&I lighting controls, how they are being deployed in practice, if and how they are being networked and commissioned, and where they see challenges, opportunities, or revisions to the existing process. These interviews were partially informed by learnings and questions from the PA evaluators, EEAC Consultants, and literature and desk review findings. Figure 3-1 illustrates the relationship between the interviews conducted and the study analysis.

Figure 3-1. Flowchart of in-depth interview workflow and analysis



4 ANALYSIS AND RESULTS

4.1 Literature review

4.1.1 Lighting controls performance testing

Performance testing is a core component of the commissioning process, as defined by ASHRAE.⁶ The definition of commissioning among ASHRAE, the Building Commissioning Association, and other national groups is fairly consistent, yet the definitions provided by many industry groups can deviate. According to the DOE, commissioning is “a systematic process of ensuring that a building performs in accordance with the design intent, contract documents, and the owner’s operational needs.”⁷ More specifically, the Lighting Design Lab notes that it is a process ensuring that all building systems “perform interactively according to documents, design intent and the owner’s operational needs.”⁸ Although similar, the National Electrical Contractors Association (NECA) provides that this process can include “...factory start-up, sensor calibration, and owner notification of the operation and intent of the control systems.”⁹ Typical commissioning will tune the initial angular placement, sensitivity and time delay of sensors, auto-shut off (“sweep”) schedule, and dimming limits and troubleshoot false switching.¹⁰ These focus on the standard setup protocols and end of the process, excluding much of the advance work done typically done in a full commissioning process. .

Despite including similar components in their definitions, industry practitioners differ in opinion as to who should carry out this process and the level of effort that is required. NECA defines the commissioning team as a “working group made up of representatives from the architect/engineer, general contractor, sub-contractors, specialty manufacturers, and the owner as required for implementation of the commissioning plan.”¹¹ What is notable about that definition is the inclusion of contractors and manufacturers as market actors who can perform commissioning while other groups and experts in the field maintain that commissioning should be done by an independent third-party commissioning agent. The rationale here is that the third party does not have biases that can occur when commissioning the products of the company one works for. Additionally, independent commissioning providers are typically engaged in helping to ensure the design intent is clear, is followed in the design, the bid and the installed project. An example of the complexities surrounding how and who does commissioning can be seen in this description:¹²

“A common misconception is that factory start-up is commissioning. In reality it is just a small part of the commissioning process. Factory start-up of a lighting system is performed at the end of construction and typically involves the lighting control system manufacturer or representative, lighting designer, and contractor verifying the system performs per the manufacturer’s instructions and the lighting designer’s intent, sequences of operations, plans, and specifications. This includes properly locating the daylight sensor in the room, setting the dimming curves, and addressing all of the components in the lighting control system. Unlike factory start-up, commissioning is a quality assurance process that starts prior to design and doesn’t end until months after the building is occupied.”

⁶ ASHRAE 90.1, 2019

⁷ US DOE. *Los Alamos National Laboratory Sustainable Design Guide, Chapter 9: Commissioning the Building.* <https://www.energy.gov/eere/buildings/articles/chapter-9-commissioning-building>

⁸ Lighting Design Lab. *Lighting Commissioning: Lighting Maintenance*, 2003. <https://www.lightingdesignlab.com/resources/articles/articles-lighting-maintenance/lighting-commissioning>

⁹ National Electrical Contractors Association’s Guide to Commissioning Lighting Controls, p.1. <http://apps.necanet.org/files/ACF363E.pdf>

¹⁰ Ibid

¹¹ National Electrical Contractors Association. *Commissioning Building Electrical Systems*, 2015. P.3. <https://necanet.org/wp-content/uploads/2021/10/Education-NEIS-Commissioning-Building-Electrical-Systems-90-2015.pdf>

¹² Baumgartle, B., *Lighting commissioning guidelines and standards*, 2012. <https://www.csemag.com/articles/lighting-commissioning-guidelines-and-standards/>

Many prominent organizations and agencies note the benefits of an independent commissioning agent. ASHRAE 90.1, 2019 requires independent commissioning.¹³ The DOE notes that it is beneficial to have a third-party commissioning authority, although it is “acceptable for a project to use a qualified member of the design team as the commissioning agent.”¹⁴ Further, the US Green Building Council has strict rules around the qualifications of the commissioning authority, including:

- *“The CxA must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy;*
- *The CxA may be a qualified employee of the owner, an independent consultant, or an employee of the design or construction firm who is not part of the project’s design or construction team, or a disinterested subcontractor of the design or construction team.*
 - *For projects smaller than 20,000 square feet (1 860 square meters), the CxA may be a qualified member of the design or construction team. In all cases, the CxA must report his or her findings directly to the owner.”¹⁵*

Regardless of who performs commissioning or performance testing, the process and customer satisfaction must be taken into consideration. A PG&E study found that customer satisfaction was low for lighting controls commissioning, saying it was “tedious” and “time consuming.” Further, all of the facilities managers said the commissioning process took longer than expected.¹⁶ This draws a natural parallel to the training of the persons doing lighting controls performance testing and the expectations being set from the start.

The Lighting Design Lab notes some key elements to be involved when performance testing:

- Calibration of occupancy/daylight sensors
- Calibrate lumen maintenance levels
- Program time of day scheduling
- Program preset dimming schemes
- Interface with BMS system
- Interface with AV system
- Program user PC controls
- Demo system for owner¹⁷

Puget Sound Energy (PSE) created a document to help verify advanced lighting controls (ALC) projects in order to define savings and incentive levels.¹⁸ Within this document, the performance testing individual must denote the trim settings, the occupancy sensor timeouts, and also if daylight harvesting is turned on. There are other sections to input other relevant information that the programs require. This document is a simple and straightforward way for the documenting of key steps within a performance testing process.

NEEA’s 2016 LLLC market characterization study identified barriers to adoption of advanced controls including first cost, contractor training, and market fragmentation. The study identified the most critical barrier to address is the lack of training on installation and performance testing of LLLCs. The study found that manufacturer requirements for training vary widely. Of the ten manufacturers surveyed in the NEEA study, eight used their own staff of certified representatives to performance

¹³ ASHRAE 90.1, 2019

¹⁴ US DOE. *Los Alamos National Laboratory Sustainable Design Guide, Chapter 9: Commissioning the Building.* <https://www.energy.gov/eere/buildings/articles/chapter-9-commissioning-building>

¹⁵ US Green Buildings Council. *Fundamental commissioning and verification.* <https://www.usgbc.org/credits/new-construction-commercial-interiors-core-and-shell-schools-new-construction-retail-new-c-6>

¹⁶ Kraft, J.; EMI Consulting. *PG&E Advanced Lighting Controls System Tool Trial Evaluation*, 2019. https://www.calmac.org/publications/PGE_ALCS_Final_Report.pdf

¹⁷ Lighting Design Lab. *Lighting Commissioning: Lighting Maintenance*, 2003. <https://www.lightingdesignlab.com/resources/articles/articles-lighting-maintenance/lighting-commissioning>

¹⁸ Puget Sound Energy. *Business Lighting Incentive Program: LLLC, NLC & Exterior NLC*, 2023. https://www.pse.com/-/media/PDFs/REBATES/Business-Lighting/PSE_BLI_STANDARD_Application.xlsx?sc_lang=en&modified=20230816033607&hash=A5A582E24899F51002EA44A637A61B2C



test LLLC systems, while four of those eight also permitted third parties to perform performance testing. One of the manufacturers requires third-party commissioners to participate in a two-day training. Some of those who do not allow third-party commissioners claim it is because ease of performance testing is a central tenet of their design, and therefore it is not worth training outside staff. Three of the ten manufacturers only estimated performance testing being a 15- to 20-minute effort, highlighting the differing industry perspectives.¹⁹

Massachusetts programs currently do not define who must perform performance testing in any recent studies or in program documentation. At present, the MA programs allow for trained distributors, installers, and/or manufacturers and manufacturer's representatives to perform the performance testing, and that is deemed appropriate for lighting system performance testing. This study does not make a recommendation as to which entity or type of individual should perform the performance testing.

4.1.2 Networking

The DLC defines networking as “the capability of individual luminaires/lamps and control devices to exchange digital data with other luminaires/lamps and control devices on the system. This capability is required at the room, space, or area level, but not at the whole-building level or beyond (e.g., non-lighting systems, or the internet).” This definition was found to be widely adopted in the reviewed literature and is the standing definition used in Massachusetts and Connecticut in relation to their advanced lighting controls.

In their definition of advanced lighting control systems, a PG&E study noted that they “provide networked control and monitoring capabilities of connected luminaires that include software configurable zoning and lighting settings, data exchange with building management or heating and cooling systems, and historical and real-time reporting capabilities.”²⁰ This is notably more comprehensive than the DLC definition above, as it calls for the data exchange with a building management system.

The DLC definition states that a measure must have networking capability in order to qualify as part of their qualified product list. They do not specify the controls have to be networked. The PG&E definition notes that ALCs provide networked control, suggesting the networking is set up and functioning in ALCs. When discussing similar lighting technologies, the DOE uses the term “Connected Lighting,” which they define as “an LED-based lighting system with integrated sensors and controllers that are networked (either wired or wireless), enabling lighting products within the system to communicate and exchange data with other devices.”²¹ It is unclear to what extent customers are utilizing the capabilities of ALC systems and the networking aspect of them.²²

Understanding these, we make no recommendation to deviate from the existing definition used by the DLC.

4.1.3 Custom study project review

The team conducted an in-depth review of a sample of custom projects with advanced lighting controls to assess performance verification practices that occur as part of the project implementation process. The team pulled a representative sample of five projects, three of which were from National Grid and two of which were from Eversource. The project files provided included applications, analysis files, BCR screening tools, and inspection memos. We found that a performance testing-specific memo is not a standard submittal for projects that include the installation and performance testing of lighting

¹⁹ Research Into Action, Inc; Energy 350. Luminaire Level Lighting Controls (LLLC) Market Characterization and Baseline Report, 2016. <https://neea.org/img/uploads/luminaire-level-lighting-controls-lllc-market-characterization-and-baseline-report.pdf>

²⁰ Kraft, J.; EMI Consulting. PG&E Advanced Lighting Controls System Tool Trial Evaluation, 2019. https://www.calmac.org/publications/PGE_ALCS_Final_Report.pdf

²¹ [DOE] Department of Energy. 2019. Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. Prepared by Navigant Consulting. Retrieved from <https://www.energy.gov/eere/ssl/downloads/2019-ssl-forecast-report>

²² DNV. C&I Lighting Controls Market Study, 2021. https://ma-eeac.org/wp-content/uploads/MA20C11-E-LCR_Lighting-Controls-Final-Report_20210630.pdf

controls systems and post-inspection memos provide a description of fixtures, controls, and settings, similar to a typical lighting controls project.

One application provided feedback on the use of a phone app for verification of all control types as part of the project. Through the app, the team was able to confirm that high-level trim and dimming were installed and operational per the scope. None of the other applications in the sample provide this level of feedback. Several applications do, however, provide building management system (BMS) screenshots that show system and controls end settings. This indicates that system performance testing occurred as the settings were verified to match the scope. Table 4-1 provides project-specific details on the information regarding performance testing found through the custom project desk review.

Table 4-1. Custom project specific findings

PA	Sample	Project-specific commissioning findings
National Grid	1	The project included a screenshot of the performance testing app called “Easy Sense IR” within the post-inspection documentation. Through the app, the team was able to verify the control settings for fixtures as part of the project.
National Grid	2	This project didn’t include any specific documentation confirming the performance testing of the control types stated in the project.
National Grid	3	This project didn’t include any specific documentation confirming the performance testing of the control types stated in the project.
Eversource	4	This project includes screenshots of the BMS (Building Management System) which portrays the system being tested but does not include any details on the process of testing and what that entailed.
Eversource	5	This project includes screenshots of the BMS (Building Management System) which portrays the system being tested but does not include any details on the process of testing and what it entailed.

4.2 In-depth interviews

4.2.1 Performance testing criteria

Experts and market actors had differing opinions about who can do performance testing, and two experts questioned if the scope of this study is looking more toward defining the criteria for performance testing rather than commissioning. Further highlighting the industry friction discussed in the literature review. Two experts noted that understanding performance testing is important, as true commissioning starts with design and ends with occupancy and owner sign-off. Still, there is a general consensus that the performance testing that is being considered for ALCs does not need to be conducted by an independent, third-party commissioning agent. For the sake of consistency, these findings will refer to the process by which this study verifies appropriate set up and confirms installation to design intent at performance testing.

The main concern among the market actor and expert respondents is the need for proper and comprehensive training for any individual that completes the performance testing of an advanced lighting control system. The implementation staff did note that distributors often have experts who do performance testing. Others have manufacturers or somebody trained by the manufacturer do the performance testing. They note the process is and should be an iterative process, involving constant communication with customers to ensure the building is set to the design intent.

What was clear among respondents is that certain criteria need to be included in proper performance testing. Most respondents noted confirmation of zoning the system to design intent, setting trim settings, occupancy settings, and daylight harvesting settings as necessary components of commissioning, as well as what the dim levels move to when these functions are engaged. Experts also noted that, through the design intent, there must be a detailed and documented sequence of operations that becomes the guidebook for performance testing of the system to follow. Other market actors were not familiar with sequence of operations.

A few respondents highlighted the need to also train the end user on system operation, in the event that they need to make adjustments. This involves a walkthrough of the application and discussion of the system interface. One contractor noted that they include an iPad in each project, which is left with the building manager after a system/application walkthrough so they can make system adjustments as needed. Table 4-2 and Table 4-3 provide summary responses from market actors and experts for three questions related to what they believe commissioning²³ to be, how to document it, and who should do it.

Table 4-2. Key market actor themes around commissioning/performance testing

Question	Respondent	Answer
How do you define commissioning for advanced lighting controls?	Respondent 1	-Cx comes after install to check against needs of client/design -Confirm networking, trim, occupancy timeouts -Confirm groupings and zones
	Respondent 2	-Post install, confirming installation happened to design -Adjust control settings -Train end user
	Respondent 3	-ID Fixtures -Group them for occupant -Set trim -Set daylighting -Set occupancy timeouts
	Respondent 4	-Verify fixtures found on system -Fixtures identified -Programmed -Brought onto back-end software for final Cx -Iterate with owner to confirm proper operation
	Respondent 5	-Cx required to make sure system is communicating and doing the design intent
How should this commissioning be documented?	Respondent 1	-Any high level ALC should/will have its own platform -Interface can be shared with PA
	Respondent 2	-Depends on System -Some produce back-end report that can be exported -Others would require snapshot of commissioning app
	Respondent 3	-Trouble is manufacturers and proprietary systems, applications, and processes. -Some applications allow export of a Cx report while others have no report function
	Respondent 4	-Respondent's company would turn over as-built paperwork highlighting room by room, location by location details. -What was replaced? With what? -Control behaviors -This is given to customer but could be given to PA
	Respondent 5	-Most systems now have a reporting function. They like quarterly or annual reports indicating performance.

²³ The questions were phrased as commissioning to the experts and market actors. They responded as such, prior to the decision to characterize this process as performance testing.

Question	Respondent	Answer
In your opinion, who should perform lighting commissioning? If anybody?	Respondent 1	-Most vendors and lighting reps who sell product do Cx -You can purchase a line item for vendor to perform Cx
	Respondent 2	-Contractor, supplier, or rep should do Cx -Tough thing with manufacturers rep is addition of substantial cost
	Respondent 3	-Doesn't know if it matters who does Cx
	Respondent 4	-Varies. Really comes down to proper training. -Few people contract manufacturers or third-party agents due to high cost
	Respondent 5	-Rarely see third party individuals. Believe it is a function of training.

Table 4-3. Key expert themes around commissioning

Question	Respondent	Answer
How do you define commissioning for advanced lighting controls?	Respondent 1	-Does not consider this Cx. Major difference between Cx and programming -He considers this exercise programming
	Respondent 2	-Act of establishing and confirming settings & sequence of operations for system -Somebody needs to define the intended groups and zones and along with them, the relevant signals and settings. -This can be done when installation is done
	Respondent 3	-The most important piece is design intent. -Sequence of operation should be a contractual agreement as to how controls will work within space -Programmer must know intent to set up space.
	Respondent 4	-Mostly a digital exercise these days -Most companies have proprietary solutions -Should put the onus on contractor to prove
	Respondent 5	-The process to confirm setup goes to owners' intent. -Build network, organize devices, apply strategies.
How should this commissioning be documented?	Respondent 1	-Are there required settings? -Confirm trim, daylight, timeout, occupancy, etc. -Feels every fixture at minimum should be 80% trim -Pointed to PSE LLLC requirements
	Respondent 2	-Important components that could be reported in checklist. -Occupancy timeout, which luminaires respond to occupancy/daylight. Task tuning
	Respondent 3	-Show sequence of operation for various spaces -Proof these have been tested
	Respondent 4	N/A – <i>did not respond</i>
	Respondent 5	-Sequence of operations. Maybe a sample table to fill out.

Question	Respondent	Answer
In your opinion, who should perform lighting commissioning? If anybody?	Respondent 1	-Manufacturers and distributors are fine for programming as long as meets design intent -Many retrofits are missing control narrative
	Respondent 2	-Comfortable with installation contractor as long as trained -Third party Cx would only impose additional cost to a measure already having trouble gaining traction -Preference for rep to do it
	Respondent 3	-Main concern is whoever does Cx/programming must understand how system works and are properly trained by manufacturer
	Respondent 4	-Should be installing contractor or installing entity -Must only be allowed in a way where they are held accountable. This respondent desired better accountability to the individual's performance testing the system. -Confirm testing is done and show to owner or PA it functions
	Respondent 5	Varies from small to large projects. Small and medium projects should be installers trained, as there is not budget for Cx. Large projects could be integrator or manufacturer tech or rep.

When discussing the requirements for commissioning²⁴ with program implementation staff, they noted that the interim guidance defined by the PAs and EEAC consultants was a good start, but they wanted more clarity. One individual identified a need for more guidance on pre-defined setting levels while another implementer pushed back on this idea, stating that the nuance required for various building and space types would open the PAs up to liability if they were to define blanket settings that may not be appropriate for certain space types.

Others asked questions about the guidance, such as “what does a screenshot mean?” and “what if customers ask for unrealistic standards [that do not promote enough savings]?” One also noted that a screenshot of a lighting app may not capture what the light is programmed to do, which is an important part of verification.

Understanding how to document and verify that any defined performance criteria is met is also important. Implementers, experts, and market actors all noted that the various software applications used for lighting systems and controls installation and performance testing are proprietary and do not all act the same way. While some have the capability to export reports, one market actor noted that the application they used would only export some of the control function settings, but not all. Other ALC systems do not have an export capability.

Further, two experts noted that there needs to be a level of accountability placed on the whoever completes the performance testing, and one market actor noted that having a checklist or document to fill in while doing the performance testing would not be burdensome, as the testing already follows a natural step process. With regards to being burdensome, one lighting industry expert finished their interview by saying, *“As much as possible I think this needs to be kept easy. I am very hesitant to throw up additional burdens and obstacles for a measure that is having a hard time gaining traction.”*

²⁴ Again, this was framed to implementers as commissioning although we now consider it performance testing.

4.2.2 Opportunities and barriers to customer use of performance testing and controls

The respondents were asked various questions to better understand their perception of barriers to customers choosing to performance test ALCs, market opportunity for more performance testing or retro-commissioning, and why more lighting projects through downstream pathways are not being installed with lighting controls. Experts noted some issues with the performance testing process that really centered on time and the awareness of the process. As their understanding of performance testing comes at the end of a project, the pressure to complete the project and skip steps in that testing can be higher. Similarly, if a customer has not had the benefits of the performance testing process appropriately explained, they may view it as a burden and barrier to concluding the project.

“It comes at the end of the project. The timeline is pressured. Everybody expects [performance testing] to be instantaneous.”
- Market Expert

When asked about the prevalence of and customer interest in retro-commissioning, responses varied. There also appeared to be continued conflation between the customer’s perception of performance testing and commissioning. Of the market actors, four of five say they rarely see it happen. The other respondent reported that they see it happening frequently in retail spaces where layouts and tenants can change, though this description is indicative of redesign, not RCx. Regarding whether or not retro-commissioning can be a feasible opportunity for future program savings, Table 4-4 highlights the responses of market actors and experts. Note that some of the responses do suggest confusion about the true meaning of RCx, further showing the disconnect in the market.

Table 4-4. Perceptions of retro-commissioning savings opportunity

Respondent	Do you see RCx as an opportunity to generate more savings through EE programs for ALCs?
Market Actor	
Respondent 1	Does believe opportunities are out there. Unsure if opportunity is worth the cost. With so many LEDs, controlled wattages are so low so changes will be small.
Respondent 2	No. More of an adjustment to layout functionality.
Respondent 3	N/A
Respondent 4	He thinks there is opportunity, but unsure who makes sense to perform RCx. Would probably need a contractor with closer ties to PA.
Respondent 5	They find this idea intriguing. Potential as an add-on service for projects.
Expert	

Respondent 1	Depends on how PA account for savings. There is probably something there.
Respondent 2	Do think there is opportunity, but the yield will be limited. Largest benefits may come from customer satisfaction.
Respondent 3	Does think there is an opportunity. Plenty of documented studies about RCx improving savings
Respondent 4	N/A
Respondent 5	Potentially, it could more be a way to extend measure lives.

Market actors were also asked about the prevalence of lighting controls included in downstream lighting projects. A review of second quarter, 2023 PA tracking data found that less than half of downstream lighting projects included controls. Market actors agreed that this finding was reflective of what they are seeing in the market. One respondent noted that they believe energy savings claimed did not justify the cost of adding controls as the controlled wattage of LEDs was too small. We will note this maybe be an opinion, but DNV does not have measurable data to support the claim. Another market actor shared that “There are less hurdles making it easier to move projects through midstream.” This market actor also noted that they recently lost a customer after having comprehensive discussions about a custom lighting approach, as going through the midstream program was easier. They went on to estimate their project would have created roughly \$200,000 in incentives, but with merely an email and almost no paperwork, the customer was able to attain roughly \$125,000 in incentives through midstream.

I also had a project that could’ve had a lot more LLC controls incorporated into it for the strip lighting, but it was rejected because the only program-eligible strip fixture was selectable wattage and we could not get the program to do an engineering review at a lower wattage setting. Understanding how to properly calculate the wattage savings for a selectable wattage fixture is an important barrier to address, since the products incorporating selectability are becoming so prevalent. – Market Actor, paraphrased.

Though the incentives were not quite as large, the speed, minimal documentation, and ease of navigating the midstream program led the customer towards pursuing the midstream option. This market actor concluded by noting they do not performance test midstream projects and do not know anybody who does or know how it would be done properly.²⁵ To better target those opportunities, the PAs could consider a way to leverage existing midstream QC to include ALC performance testing.

A different market actor noted expertise is a barrier. They feel many market actors are hesitant to promote ALCs

because they are either unfamiliar with them or more comfortable with traditional lighting controls. They also noted they think stronger rebates can always help grow the programs and hosting or promoting events and product showcases can help educate customers and market actors.

4.2.3 Networking

The Design Lights Consortium’s definition for “Networking of Luminaires and Devices” is “The capability of individual luminaires/lamps and control devices to exchange digital data with other luminaires/lamps and control devices on the system. This capability is required at the room, space, or area level, but not at the whole-building level or beyond (e.g., non-lighting systems, or the internet).” Market actors interviewed for this study agreed with this definition. Some expressed

²⁵ In MA19C06-E-UPLIGHT, a review of the midstream QC process was done. Yearly, 10% of sites are QC’d by the verification vendor

curiosity as to why the DLC definition makes a point about whole building and noted that it can be the whole building level but does not need to be.

The responding experts had more to add. One expert did not agree with the inclusion of room-based controls, stating that “Room-based controls lose many of the non-energy advantages of LLLCs and NLCs. Room-based would not allow for demand response.” Another expert noted the increasing prevalence of systems being installed without networking, and thus the luminaires operate independently and autonomously. They also stated that, increasingly, contractors are going to the room level, and they should be included in the definition. On the other hand, another expert indicated that LLLCs with no networked control sequence can lose their effectiveness if they are only responding to the ones closest to them and do not operate to a defined order of operation.

One expert noted that LLLCs are often purchased but ultimately not networked. To satisfy many codes, the fixtures need to be controlled but those codes do not require installers to completely network the lighting control system.

In the implementer panel, the respondents noted that the DLC definition only designates that networking be a capability, but does not specify how networking should be utilized and whether it is being used for energy savings. As stated by a market actor, “I do not think lights need to be networked to attain higher savings or a higher incentive, but without networking, you cannot prove the savings and address changes into the future.” Although the DLC definition only requires the capability to be networked, the requirement to network may allow for better reporting and verification of savings. DNV recommends the PAs continue to use the DLC definition of networking, but consider the benefits of networking beyond room-level, as it opens up more doors to tracking, adjustment, and DR.

4.2.4 Performance testing assessments

Based on the insights gathered from the literature review and interviews, the effective training of performance testers is more important than specifying who should be responsible for or allowed to do the testing. As a result of these findings, the DNV team is not advocating for the PAs to specify what type of contractor or individual can do testing.

Additionally, the implementers expressed a desire for further clarification and guidance around how to verify appropriate performance testing. Emphasis was placed on needing to accomplish key steps and verify fixtures, programming, and settings. Compiling the various commissioning steps brought forward from the literature, interviews, and the panels, DNV proposes that the PAs design an easy to fill, scalable form that allows for the performance testing individual to fill in the following information:

- An area to describe the defined design intent for each distinct space/zone
- Characterization of different space/zones in facility (e.g., Lobby, Stairwell, Office 1, Office 2...)

For each zone:

- Quantity of each zone with similar configuration and settings
- Number of fixtures networked and controlled and how many are LLLC in each zone
- Defined illumination levels in each space
- High end trim settings
- Occupancy sensor timeout and characterization of time out trim level
- Is daylight harvesting switched on and what is the illumination (max and min)
 - Description box highlighting closed or open loop, Location of sensor
- Box to describe testing done
- Box to describe owner/designer signoff
- Box for description of owner/operator training and operation manuals delivery

This form can replace the second criteria of the interim guidance for a “commissioning report.”

5 CONCLUSIONS, RECOMMENDATIONS, AND CONSIDERATIONS

5.1 Conclusions

The market definitions and interim guidance provided by the PAs to implementation staff was a decent starting point for the conversation. Defining performance testing criteria required more in-depth and specific, actionable guidance. Existing DLC definitions of networking are accepted by the market but may not provide the requirements needed for understanding savings and easing verification. Further, incentive structures between different delivery pathways are moving customers towards these controls, but potentially not in the way or at the magnitude program staff want. Finally, there was not evidence for us to recommend the PAs to build out more retro-commissioning efforts in the state for lighting and advanced lighting controls. With that said, the lack of performance testing found in the custom project review suggests the PAs may look into after-the-fact performance testing of projects that did not receive it.

5.2 Recommendations

DNV recommends the following:

Recommendation 1: DNV recommends that the PAs adopt the following criteria into an easy-to-scale, fillable form, for performance testing individuals to provide at completion. This can replace the second interim guidance documentation requirement. This form should include the following:

- An area to describe the defined design intent for each distinct space/zone
- Characterization of different space/zones in facility (e.g., Lobby, Stairwell, Office 1, Office 2...)

For each zone:

- Quantity of each zone with similar configuration and settings
- Number of fixtures networked and controlled and how many are LLLC in each zone
- Defined illumination levels in each space
- High end trim settings
- Occupancy sensor timeout and characterization of time out trim level
- Is daylight harvesting switched on and what is the illumination (max and min)
 - Description box highlighting closed or open loop, Location of sensor
- Box to describe testing done
- Box to describe owner/designer signoff
- Box for description of owner/operator training and operation manuals delivery

Recommendation 2: DNV recommends the PAs change the naming of Advanced Lighting Controls (ALC) as follows:

- Networked lighting control (NLC) **changed to** Networked lighting control (NLC) – Performance Tested (PT)
- Luminaire-level Lighting Controls (LLLC) – Networked and Commissioned **changed to** Luminaire-level Lighting Controls (LLLC) – Networked and Performance tested (PT)
- Non-Commissioned LLLCs **changed to** Non-Performance Tested LLLCs

5.3 Considerations

DNV offers up the following considerations to the PAs:

Consideration 1: The MA PAs should examine what level of training is appropriate for those performance testing lighting control systems. This could be training from the manufacturer with a certificate, training from a manufacturer rep, or others. The responses to interviews showed that the range of training levels among contractors and those programming systems can be large and some base level of demonstrated competency may be needed.



Consideration 2: The recommendations provided above do little to impact the ability for programs to verify the installation of ALCs through the midstream program. DNV suggests the PAs consider understanding how the existing midstream QC process could be used to verify ALC installations to confirm commissioning, and therefore, be better able to estimate appropriate savings factors. Perhaps in creating a sampling plan, projects with ALCs can be targeted to understand how they were installed and if performance testing was done.

Consideration 3: The PAs should consider requiring LLLCs to not only be capable of networking, but also be networked to ensure that the systems can report on energy savings and provide easier verification. This would involve networking beyond the room level, as discussed prior in the report.



APPENDIX A. MARKET ACTOR INTERVIEW GUIDE

Memo to: MA PAs & EEAC Consultants

From: Ben Crosby, DNV

Date:

Massachusetts Commissioning and Networking for C&I Lighting Controls – Market Actor Interview Guide

STUDY OBJECTIVE

The purpose of the Commissioning and Networking for C&I Lighting Controls study is to provide actionable definitions of lighting controls commissioning and lighting controls networking to be used by the Massachusetts Program Administrators (MA PAs). This study seeks to:

1. Define an appropriate and usable definition for both C&I lighting controls networking and C&I lighting controls commissioning to be used by both evaluation and implementation. This definition would contain the necessary criteria indicating if a project has met the requirements to get the higher savings factors associated with commissioned and networked LLLCs and NLCs.
2. Understand the current practices of program implementers and market actors for lighting controls projects that are using the current interim definition agreed upon by EEAC consultants and PAs.
3. Understand the opportunity for further promoting commissioning and retro commissioning.

INTERVIEW OBJECTIVE

The DNV team will conduct interviews with five lighting contractors who have installed advanced lighting systems in Massachusetts. If possible, some of these contractors will have been involved with the customer projects reviewed in the previous task so we can ask questions about the decisions made for that specific lighting controls project as well. The goals of these interviews are to gather more insight into how controls are being commissioned and networked in the field and to tighten the definition of commissioning. Additionally, these interviews will ask the contractors if they have any insights on process improvements that would increase customer desires for proper commissioning. After reviewing the results of the first five interviews, if any gaps in our understanding of the commissioning and networking processes remain, DNV will interview one to two additional lighting contractors who work in Massachusetts.

Research Questions	Question number
Intro and background	1-3
Project Specific Questions (If applicable)	4-7
Commissioning Questions	8-20
Networking & Close	21-26

INSTRUMENT AND DATA COLLECTION INFORMATION

The research team **will do the following:**



Table 1: Overview of Data Collection Approach

Data Collection	Description
Population Description	Lighting market actors, particularly installers
Population Size/Sample Frame	5
Type of Sampling	None
Target Sample – Survey Completion	All
Instrument Type	Phone Interview
Survey/Interview Length	Approximately 30-45 minutes
Description of Contact Sought	Market Actors in Lighting and Lighting controls with specific knowledge to the sales, design, installation, and functionality of systems.

INSTRUMENT: INTERVIEW SCRIPT

Interviewee		Interviewer	
Interviewee Company		Interview Date	
Interviewee Phone #		Interviewee email	

Introduction

Thank you for taking the time to talk with me today. My name is _____ of DNV. On behalf of the Massachusetts Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC), we are trying to better understand how commissioning and networking for commercial and industrial (C&I) advanced lighting controls is done and applied in practice. The outcome of this research effort will be clarified definitions and criteria for what constitutes a lighting control being commissioned and networked. Additionally, we will look into ways to improve the adoption of these practices.

We will begin by reviewing the C&I controls that are currently offered by the MA PAs and note some key distinctions in how the program administrators can offer these controls. From there we will go into some questions about your understanding and experience as well as any suggestions you have.

Measure	Control Category	Control Type	Description
Commercial and Industrial Interior Lighting Controls	Basic Lighting Controls	Occupancy Sensors	Reduces lighting operation hours by switching off lighting in unoccupied spaces.
		Daylight Dimming	Reduces lighting output to a set level or reduces lighting operating hours in response to natural daylighting using continuous, stepped, or on/off dimming capabilities.
		High-End Trim	Reduces lighting output of individual lights or groups of lights to a set level continuously.
	Hybrid Lighting Controls	Combination high-End Trim and Occupancy Sensors	Combines the capabilities of high-end trim and occupancy sensors
		Combination High-End Trim and Daylight Dimming	Combines the capabilities of high-end trim, reducing the lighting output to a set level continuously, and daylight sensors, allowing lighting fixtures to reduce output to respond to daylight.
		Dual Occupancy and Daylight Sensors	Combines the capabilities of occupancy and daylight sensors, allowing lighting fixtures to respond to occupancy and daylight.
		Non-Commissioned LLLCs ²⁶	An LLLC that is not verified commissioned or networked
	Advanced Lighting Controls	Luminaire Level Lighting Controls (LLLC)	Integrates high-end trim, occupancy and daylight sensors into the LED fixture
		Networked Lighting Controls (NLC)	An intelligent network of individually addressable luminaires and control devices for remote access by the user. NLC have fixture networking capabilities, individual addressability, occupancy sensing, daylight harvesting, high-end trim, flexible zoning, continuous dimming, scheduling, and cybersecurity.

First, we have a few background questions.

1. What is your job title?
2. How many years have you been involved with lighting controls systems?
 - a. How many years has your company been involved with lighting control systems?
3. I want to understand what lighting controls products and services your company offers. I am going to name a few. For each one, please tell me if you company offers that service.

²⁶ Non-Residential Technical Reference Manual Review. P.39. https://ma-eeac.org/wp-content/uploads/MA22C01-B_TRM-Review_FINAL_31OCT2022.pdf



Lighting Control System Services	Have you specified or installed in the last year? (Select all that apply)
a. Which lighting control services do you provide?	Design Installation Programming Commissioning Repair
b. Which sectors do you serve?	Residential, including multifamily Commercial
c. Which applications do you work on?	New, including major renovations Retrofits
d. Which Advanced control technologies do you specify/sell/install?	LLLC NLCs Combination Controls Other?

Project Specific questions

If we are able to identify a participating contractor that was involved with a custom project identified through our literature/project review, we will ask them these questions.

4. We understand you were involved with [insert relevant project information]. Would you please describe the nature of the advanced lighting controls being installed in the facility?
5. Please indicate how the performance requirements were defined?
 - a. How were they documents and used?
6. Can you describe the nature of the process used to confirm performance of the lighting system and controls?
 - a. List criteria for commissioning/confirmation
7. Please describe the nature of how this lighting design was networked?
 - a. Fixture to fixture, room level, building level?

Next, we have some questions about the commissioning of advanced lighting controls in commercial and industrial facilities.

8. How do you define commissioning for advanced lighting controls?
9. How should this commissioning be documented?

The Massachusetts PAs currently require the following criteria to document that a lighting control was commissioned:

- a. To receive incentive/ savings from code 63A/ 65A, must be listed on DLC NLC qualified product list

- b. A commissioning report (a PDF or screenshot – see below) that: details settings around high-end trim and dual sensors with motion and photocell/ ambient light sensors; documents schedule setting, as well as the setting and operation of occupancy sensors; details how the system can control motion response and illumination levels; details on how the fixtures and/or control devices interacts and communicates with other fixtures and/or control devices.
 - c. A screenshot of the commissioning app – I believe someone brought this up on the call that many of the DLC products have an app that show the commissioning settings, and can serve as a commissioning report

- 10. Please let me know how you react to these criterial?
 - a. Are they stringent enough, not stringent enough, just right?
 - b. Should anything else be considered?

- 11. Do you perform commissioning on lighting control projects?

- 12. In your opinion, who should perform lighting commissioning? If anybody?
 - a. **[Pause. Suggest the following, if necessary]** Installing contractor, independent third party, other?
 - b. Do you have any experience dealing with a third party commissioning agent? If so, please elaborate on the interaction and your experience.

- 13. From your experience, is there a pre-defined commissioning process installers or contractors use when setting up networked lighting controls (NLC) and luminaire level lighting controls (LLLC)?
 - a. If so, please elaborate.
 - b. If not, what value, if any, do you see value in a more standardized set of criteria for commissioning specific to advanced lighting control technologies?

- 14. When you install an NLC or LLLC, what do you do to confirm performance is in accordance with design?
 - a. Is your practice of commissioning similar to others?

- 15. In your experience, are there best practices for commissioning of advanced lighting controls?

- 16. After projects are completed and buildings are occupied, are further adjustments done to the lighting controls systems?
 - a. Who does those?
 - b. How is it confirmed the setup effectively serves the needs of the site?

- 17. What do you consider to be the important steps or criteria that need to be involved in commissioning NLCs and LLLCs?

- 18. Before we move on from talking about commissioning, I'd like to ask a few questions about retro-commissioning. From your experience, can you estimate the percentage of advanced lighting controls projects that receive retro-commissioning within three years? More than 3 years? **[If necessary, provide definition of retro-commissioning]**
 - a. How long after commissioning do you estimate this RCx to happen?
 - b. **[If needed]** Does this vary by building type, use type, or other project attributes?



19. Do you see RCx as an opportunity to generate more savings through energy efficiency programs for advanced lighting controls?
 - a. Please expand on your answer.

20. Are there any improvements that could be done to programs to help promote customers' interest in the commissioning or RCx of their advanced lighting controls system?

Now I would like us to further discuss your thoughts on networking of lighting controls.

21. How do you define networking in the context of LLLCs and NLCs?

22. What level of networking do you most commonly see?
 - a. Room, space, area, building level?

23. Are there any specific components that must be present for a widget to be an LLLC or an NLC?

24. Is it common for people to purchase LLLCs for attributes other than networking and choose not to network them?

25. The Design Lights consortium's definition for "Networking of Luminaires and Devices" is *"The capability of individual luminaires/lamps and control devices to exchange digital data with other luminaires/lamps and control devices on the system. This capability is required at the room, space, or area level, but not at the whole building level or beyond (e.g. non-lighting systems, or the internet)."*²⁷ Do you agree with this definition?
 - a. Does this definition capture how you are seeing NLCs and LLLCs being deployed in the market?
 - b. What if anything would you change to this definition so it better reflects how NLCs and LLLCs are being deployed in the market?

Lastly,

26. Do you have any final thoughts to share with me about networking and commissioning for lighting controls.

Closing

Thank you very much for your time today. It was a pleasure speaking with you. Have a wonderful day.

End Call

²⁷ DLC definition for "Networking of Luminaires and Devices" in "Networked Lighting Controls Technical Requirements (Version NLC5, Released June 23, 2020, Updated December 22, 2021):" "The capability of individual luminaires/lamps and control devices to exchange digital data with other luminaires/lamps and control devices on the system. This capability is required at the room, space, or area level, but not at the whole building level or beyond (e.g. non-lighting systems, or the internet)."



APPENDIX B. EXPERT INTERVIEW GUIDE

Memo to: MA PAs & EEAC Consultants

From: Ben Crosby, DNV

Date:

Massachusetts Commissioning and Networking for C&I Lighting Controls – Market Expert Interview Guide

STUDY OBJECTIVE

The purpose of the Commissioning and Networking for C&I Lighting Controls study is to provide actionable definitions of lighting controls commissioning and lighting controls networking to be used by the Massachusetts Program Administrators (MA PAs). This study seeks to:

1. Define an appropriate and usable definition for both C&I lighting controls networking and C&I lighting controls commissioning to be used by both evaluation and implementation. This definition would contain the necessary criteria indicating if a project has met the requirements to get the higher savings factors associated with commissioned and networked LLLCs and NLCs.
2. Understand the current practices of program implementers and market actors for lighting controls projects that are using the current interim definition agreed upon by EEAC consultants and PAs.
3. Understand the opportunity for further promoting commissioning and retro commissioning.

INTERVIEW OBJECTIVE

The DNV team will conduct interviews with five lighting market experts, such as leaders at DLC, to understand how commissioning and networking is performed in different types of projects and how products are installed through different points of sale. We will target at least two of the experts having expertise in the northeast. The objective of these interviews is to understand the prevalence of commissioning and the experts' perspective on how it happens or barriers to it happening. Experts' insights and perspectives on the general industry trends around advanced lighting, networking, its commissioning, and its promotion by market actors will be asked. These interviews will also collect information to inform the market opportunity for generating additional savings through retro commissioning. After reviewing the results of the first five interviews, if any gaps in our understanding of the commissioning and networking processes remain, DNV will interview one to two additional lighting market experts.

Research Questions	Question number
Intro and background	1-3
Commissioning and RCx	4-16
Networking	16-20
End	21

INSTRUMENT AND DATA COLLECTION INFORMATION

The research team will do the following:



Table 1: Overview of Data Collection Approach

Data Collection	Description
Population Description	Lighting market experts, particularly designers/specifiers and suppliers
Population Size/Sample Frame	5
Type of Sampling	None
Target Sample – Survey Completion	All
Instrument Type	Phone Interview
Survey/Interview Length	Approximately 45 minutes
Description of Contact Sought	Experts in Lighting and Lighting controls with specific knowledge to the sales, design, commissioning, networking, and functionality of systems.

INSTRUMENT: INTERVIEW SCRIPT

Interviewee		Interviewer	
Interviewee Company		Interview Date	
Interviewee Phone #		Interviewee email	

Introduction

Thank you for taking the time to talk with me today. My name is _____ of DNV. On behalf of the Massachusetts Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC), we are trying to better understand how commissioning and networking for commercial and industrial (C&I) advanced lighting controls is done and applied in practice. The outcome of this research effort will be a clarification of the definitions and criteria for what constitutes a lighting control being commissioned and networked. Additionally, we will look into ways to improve the adoption of these practices.

We will begin by reviewing the C&I controls that are currently offered by the MA PAs and note some nuances found in those measure categories. From there we will talk about your understanding and experience as well as any suggestions you have.

Measure	Control Category	Control Type	Description
Commercial and Industrial Interior Lighting Controls	Basic Lighting Controls	Occupancy Sensors	Reduces lighting operation hours by switching off lighting in unoccupied spaces.
		Daylight Dimming	Reduces lighting output to a set level or reduces lighting operating hours in response to natural daylighting using continuous, stepped, or on/off dimming capabilities.
		High-End Trim	Reduces lighting output of individual lights or groups of lights to a set level continuously.
	Hybrid Lighting Controls	Combination high-End Trim and Occupancy Sensors	Combines the capabilities of high-end trim and occupancy sensors
		Combination High-End Trim and Daylight Dimming	Combines the capabilities of high-end trim, reducing the lighting output to a set level continuously, and daylight sensors, allowing lighting fixtures to reduce output to respond to daylight.
		Dual Occupancy and Daylight Sensors	Combines the capabilities of occupancy and daylight sensors, allowing lighting fixtures to respond to occupancy and daylight.
		Non-Commissioned LLLCs ²⁸	An LLLC that is not verified commissioned or networked
	Advanced Lighting Controls	Luminaire Level Lighting Controls (LLLC)	Integrates high-end trim, occupancy and daylight sensors into the LED fixture
		Networked Lighting Controls (NLC)	An intelligent network of individually addressable luminaires and control devices for remote access by the user. NLC have fixture networking capabilities, individual addressability, occupancy sensing, daylight harvesting, high-end trim, flexible zoning, continuous dimming, scheduling, and cybersecurity.

First, we have a few background questions.

1. What is your job title?
2. How many years have you been involved with lighting control systems in commercial and industrial applications?
 - a. How many years has your company been involved with lighting control systems?
3. Please explain your experience with lighting controls and advanced lighting controls?

Next, we have some questions about the commissioning of advanced lighting controls in commercial and industrial facilities.

4. How do you define commissioning for advanced lighting controls?

²⁸ Non-Residential Technical Reference Manual Review. P.39. https://ma-eeac.org/wp-content/uploads/MA22C01-B_TRM-Review_FINAL_31OCT2022.pdf



5. How should this commissioning be documented?

The Massachusetts PAs currently require the following criteria to document that a lighting control was commissioned:

- a. *To receive incentive/ savings from code 63A/ 65A, must be listed on DLC NLC qualified product list*
 - b. *A commissioning report (a PDF or screenshot – see below) that: details settings around high-end trim and dual sensors with motion and photocell/ ambient light sensors; documents schedule setting, as well as the setting and operation of occupancy sensors; details how the system can control motion response and illumination levels; details on how the fixtures and/or control devices interact and communicates with other fixtures and/or control devices.*
 - c. *A screenshot of the commissioning app – I believe someone brought this up on the call that many of the DLC products have an app that show the commissioning settings, and can serve as a commissioning report*
6. Please let me know how you react to these criterial?
- a. Are they stringent enough, not stringent enough, just right?
 - b. Should anything else be considered?
7. Do you perform commissioning on lighting control projects?
8. In your opinion, who should perform lighting commissioning? If anybody?
- a. **[Pause. Suggest the following, if necessary]** Installing contractor, independent third party, other?
 - b. Do you have any experience dealing with a third party commissioning agent? If so, please elaborate on the interaction and your experience.
9. From your experience, is there a pre-defined commissioning process used when setting up networked lighting controls (NLC) and luminaire level lighting controls (LLLC)?
- a. If so, please elaborate.
 - b. If not, what value, if any, do you see value in a more standardized set of criteria for commissioning specific to advanced lighting control technologies?
 - c. Can you elaborate on who defines the settings? Does this work?
10. After projects are completed and buildings are occupied, are further adjustments done to the lighting controls systems?
- a. Who does those?
 - b. How is it confirmed the setup effectively serves the needs of the site?
11. What barriers do you see in the market that prevent effective commissioning?
12. What do you consider to be the important steps or criteria that need to be involved in commissioning NLCs and LLLCs?
13. Before we move on from talking about commissioning, I'd like to ask a few questions about retro-commissioning. From your experience, can you estimate the percentage of advanced lighting controls projects that receive retro-commissioning within three years? More than 3 years? **[If necessary, provide definition of retro-commissioning]**
- a. How long after commissioning do you estimate this RCx to happen?
 - b. **[If needed]** Does this vary by building type, use type, or other project attributes?



14. Do you see RCx as an opportunity to generate more savings through energy efficiency programs for advanced lighting controls?
 - a. Please expand on your answer.

15. Are there any improvements that could be done to programs to help promote customers' interest in the commissioning or RCx of their advanced lighting controls system?

Now I would like us to further discuss your thoughts on networking of lighting controls.

16. How do you define networking in the context of LLLCs and NLCs?

17. What level of networking do you most commonly see?
 - a. Room, space, area, building level, wired v. wifi?

18. Are there any specific components that must be present for a widget to be an LLLC or an NLC?

19. The Design Lights consortium's definition for "Networking of Luminaires and Devices" is *"The capability of individual luminaires/lamps and control devices to exchange digital data with other luminaires/lamps and control devices on the system. This capability is required at the room, space, or area level, but not at the whole building level or beyond (e.g. non-lighting systems, or the internet)."*²⁹
 - a. Does this definition capture how you are seeing NLCs and LLLCs being deployed in the market?
 - b. Do you think it is common for people to install LLLCs for their attributes other than networking and fail to network them?
 - c. What if anything would you change to this definition so it better reflects how NLCs and LLLCs are being deployed in the market?

Lastly

20. Do you have any final thoughts to share with me about networking and commissioning for lighting controls.

Closing

Thank you very much for your time today. It was a pleasure speaking with you. Have a wonderful day.

End Call

²⁹ DLC definition for "Networking of Luminaires and Devices" in "Networked Lighting Controls Technical Requirements (Version NLC5, Released June 23, 2020, Updated December 22, 2021):" "The capability of individual luminaires/lamps and control devices to exchange digital data with other luminaires/lamps and control devices on the system. This capability is required at the room, space, or area level, but not at the whole building level or beyond (e.g. non-lighting systems, or the internet)."



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