The NLC App-Based Configuration Tool User Experience
Findings Report
Submitted, January 27, 2021

Contents

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Acknowledgements:
The Lighting Design Lab (LDL) would like to recognize and thank the following individuals for their contributions to this project: Jesse Collier, Acuity Brands; RB Evans, Osram; Luz Garcia, Crestron; Bill Schaefer, Crestron; Rob Holler, Lutron; Mike Hopkins, Cooper Lighting; Mark Lachman, Ideal Audacy; Ravi Parikh, RAB; Dixon Soracco, ETC Echoflex; Shaun Darragh, LDL; Armando Berdiel, LDL; John Arthur Wilson, LDL.

Section 1: Introduction

Over the past several years, nearly every major lighting and controls manufacturer has launched a Networked Lighting Control (NLC) system featuring a simplified smart device app based programming or fine-tuning tool. NLC systems are proliferating in the new construction and major renovation markets. However, they have failed to gain similar traction in the existing buildings (design-build/retrofit) market segment.

Correspondingly, utility programs across the country recognize that NLC systems offer significant savings potential, and many provide generous incentives to support market uptake via their C&I existing building lighting programs. Specific to the Pacific Northwest (PNW), many utilities have also invested in the development and delivery of education and publicly available tools and resources.

Despite product availability, incentives from utilities, training, and a host of non-energy related benefits, NLC systems are not being adopted and installed in the existing buildings market as expected. This conclusion is supported by PNW utilities' NLC measure activity for their existing buildings lighting programs.

LDL's Market Position

Lighting Design Lab (LDL) is a workgroup within Seattle City Light's (SCL) Electrification & Strategic Technologies Division. A unique charter allows LDL to partner with utilities outside SCL's service territory. LDL has more than 30 years' experience engaging with the lighting market supply chain and is an objective resource for the industry and utility program partners.

Since 2017, LDL has delivered dozens of virtual and in-person courses supporting NLC market adoption. LDL works with multiple manufacturers and has unique insights into market trends, market actors, and pain points.

Section 2: The NLC User Experience

In 2019, LDL identified the NLC user experience as a key obstacle to market acceptance**.** The NLC user experience (or UX) consists of two focus areas. The first is the modern NLC wall station which allows building occupants to operate the lighting system. The second is the modern NLC configuration tool. These application-based (app-based) configuration tools are how installers initially program and setup most of the systems, and how facility professionals typically maintain them.

The two NLC user experience focus areas and their respective user groups:

NLC User Experience:	User Group
Wall Stations	Occupants and facility professionals
App-Based Configuration Tools	Installers and facility professionals

In 2020, LDL implemented a multi-phased approach to better understanding both areas of the NLC user experience. <u>This report focuses on the approach and findings specific to app-based configuration tools.</u>

Findings from the NLC wall station survey project can be found on LDL's website resource page. : https://www.lightingdesignlab.com/resources

App-Based Configuration Tool

App-based configuration tools represent a significant market trend for NLC systems. Observing dozens of systems available on the market, a majority utilize app-based configuration tools as a primary method for setup and programming. The trend by lighting manufactures to leverage app-based tools is itself part of a broader trend by manufacturers (of all types of products) seeking to take advantage of app-based platform benefits including a) the ability to maintain a familiar platform for customers, b) accessibility on multiple devices, c) relatively low cost to develop and maintain, d) ability to update, and e) potential for wider systems integration.

Despite inherent advantages to the app-based configuration tool approach, not all apps are equal, and a scan of the market reveals the array of approaches affecting user experience in different ways.

Focus on Mid-Tier Systems

Unlike LDL's NLC wall station UX project, which was not market-segment specific, the products identified and catalogued for the NLC configuration tool UX project are focused on medium-tier systems which are applicable to both major renovation and existing building retrofits, in addition to new construction. This was done to a) provide some practical limits on the scope of work, b) focus on the area of the market where utilities are requesting support and c) support a rapidly expanding market segment that LDL views as critical to the overall connected building eco-system.

Section 3: Configuration Tool Study Overview

Introduction:

NLC systems yield significant energy savings potential and have been identified as a critical pathway for the future generation of connected building systems and devices. Observing the NLC market at large, app-based configuration tools are currently the most prevalent method used by manufacturers for completing initial system setup and programming.

Frequently repeated discussion comments from many workshops suggest that, in the context of installing and programming NLC systems, most users prefer app-based configuration tools over the click-and-pair or remote-control methods. While users generally prefer app-based configuration tools over other setup methods, LDL also observed key differences in app-based approaches which may significantly affect the user experience for better or for worse.

Process:
Informed by the experience of delivering dozens of workshops with multiple systems over the past three years, LDL collaborated with industry partners and PNW regional stakeholders including the Northwest Energy Efficiency Alliance (NEEA) and determined to catalogue the app-based configuration tool user experience for leading NLC systems and to report on its findings.

During Q3-Q4 2020, LDL completed interviews with nine manufacturers. A list of the systems reviewed, and complete synthesized findings can be found in this report.

Summary Conclusion:
LDL's primary conclusion is that app-based configuration tools have been established as a dominant user-interface method for mid-tier NLC systems. Manufacturers should commit to long term planning including both expanding existing system capabilities and improving the current user-experience. As system features proliferate, the value of a quality user experience on the configuration tool will increase. Additionally, manufacturers should recognize that the path to an expanded market requires a better user experience for all users, not just trained professionals.

Macro Trends Aligning:
Increasingly, NLC systems have more in common than ever before. Technology integration is driving alignment in hardware. Utility incentives are driving an emphasis on the four primary control strategies (scheduling, high-end trim, occupancy / vacancy, and daylight harvesting), and competition is driving increased process streamlining. Taken as a whole, modern NLC systems are more capable, less complicated, and less costly than they ever have been.

Select Differences & Recommendations:
Strictly observing app-based configuration tools, LDL identified and prioritized a total of eight areas of setup and programming. As described in Section 5, emphasis was placed on points of divergence that reflect an opportunity to increase efficiency (*time savings)* or that significantly impact the user experience. This summary contains select examples of divergence points and recommendations for improvement. A complete list of system differences and recommendations can be found in sections 8 and 10. *Note: this report does not address divergent approaches to wireless protocols.*

- **Adopt Standard Language**
  The most surprising (and perhaps significant) finding of this study is that despite decades of collective investment and experience, even veteran lighting professionals can get confused because of the lack of standard terms and definitions. Industry jargon and nomenclature is so diversified that LDL observed multiple ways in which miscommunications can happen between competent system operators. Exacerbating this issue is the competitive nature of product development, which often propels manufacturers to apply and promulgate novel (or recycled) phrases in the hope of making their product stand out. *LDL recommends that NLC system*

manufacturers use their clout to work through existing channels to prioritize and drive standard definitions.

- **Kick the Ladder**
  A second significant point of divergence in the NLC user-experience is between systems which allow maximum functionality via the app-based configuration tool and those that require system operators to physically access devices. For instance, some systems allow full app-based control of programing sensors or can perform a complete system reset through the app. *LDL recommends that NLC system manufacturers incorporate full programming functionality into app-based tools, thus eliminating the need to physically access remote devices unless it is for a battery replacement.*

- **Make *Help* Readily Available**
  Among the systems observed by LDL, less than half included an in-app help menu. Feedback from workshop participants aligns with anecdotal evidence provided by manufacturers' representatives: even if somebody has been trained on the system, they are still likely to have a question. When that question arises, where should they look for support? In total, LDL observed four different flavors of in-app help. These are a) the basic help menu, b) a context- driven help menu, c) links to external resources such as videos or wiring diagrams and d) links to helplines or text support. *LDL recommends that NLC system manufacturers seek to incorporate multiple forms of in-app help into future versions of their configuration tools.*

Setup Time – LLLC vs. NLC:
Half of the systems reviewed by LDL were LLLC capable and at least two manufacturers with strictly NLC systems reported that LLLC systems were in development. Contemplating the continual growth of LLLC system availability relative to NLC as a whole, LDL focused attention towards the question, *which method is faster and simpler for operators to setup and program?*

LDL observed that for most standard lighting projects, LLLC systems offered the potential for fewer steps during initial system setup. Furthermore, LDL noted that advances in default pre-programming (out-of-the-box functionality) has the potential to save installers additional time during the programming phase depending on the system requirements and sequence of operations. For more complex projects that require greater degrees of granular control, the level of effort between NLC and LLLC systems during the programming phase is likely comparable.

Sharing the Findings:
In response to these findings, LDL plans to incorporate key learnings into existing market-facing tools and resources that will be publicly available. LDL will work with regional stakeholders to share findings that may support utility programs. LDL also plans to share its findings with industry partners and will work through industry associations to make its findings available.

Section 4: How LDL's Workshops Informed This Study

Since 2017, LDL has delivered dozens of in-person courses supporting NLC market adoption. During these one- and two-day workshops, participants receive hands-on training with multiple NLC systems. Simulating a real project, workshop attendees use system-specific configuration tools to create spaces and implement key lighting control strategies. During this process, manufacturers' representatives from each of the systems being showcased are present to assist with instruction and provide market insights.

The systems featured at these workshops use three different methods of networking functionality and programming: the click-and-pair method, the remote-control method, and the app-based method.

Conclusive findings from multiple workshops revealed that in the context of installing and programming NLC systems, a majority of users significantly prefer app-based configuration tools over the click-and-pair or remote-control methods. Specific to app-based configuration tools, LDL also observed key differences in approaches which, on the surface level, appear to significantly affect user preference. This was one of the primary reasons' LDL prioritized research for the app-based NLC configuration tools.

Section 5: Cataloguing the User Experience

Working first from the NLC systems that rotate through its workshops, LDL set about documenting both unique and shared experiences for app-based configuration tools. The documentation process was informed by direct observation as well as by reviewing relevant product information available on the internet. Through this process, LDL identified 17 distinct stages and 104 likely decision nodes which apply to most systems observed.

The following table lists the 17 distinct stages specific to the NLC configuration tool user experience with the number of common decision nodes associated with each stage.

Common Stages and # of decision nodes in the NLC User Experience					
Stage	**NLC UX Stage**	# of decision nodes	**Stage**	**NLC UX Stage**	# of decision nodes
1	Downloading App	8	**10**	Scene Programming	8
2	Networking	4	**11**	Wall Station Programming	6
3	Device Discovery	7	**12**	Demand Response	3
4	Area/Room Setup	2	**13**	Setup Streamlining	5
5	Loads/Zones	3	**14**	Help & App Documentation	5
6	Sensor Hardware	9	**15**	Reporting & Dashboarding	16

7	OS/VS Setup	8	**16**	Offline Programming & Functionality	3
8	Daylight Harvesting	9	**17**	Reprogramming	4
9	High-End Trim	4			

The table above presents the 17 stages in a logical and ordinal order *(i.e. starts with 1, downloading the app, progresses through creating spaces, adding devices, etc., and culminates with post project offline capabilities.)* With the exception of where you start, LDL recognizes the validity of multiple approaches and the sequential order provided here is for demonstrative purposes only.

Ultimately, the number of decision nodes is project specific. To streamline system setup, many app-based configuration tools have assigned default values which allow operators to skip a decision point. An example of this is an occupancy sensor which defaults to: occupancy mode, 15-minute delay, medium sensitivity, with reduce to 0%. *Note: Appendix A, provides further details specific to the common decision nodes identified within each stage*.

App-Based Configuration Tool Focus Areas:
Using the table above as a reference, LDL reviewed and documented the app-based configuration tool approach for multiple NLC systems. To refine the list, LDL focused on the areas within the user experience that have the greatest potential to either positively or negatively impact the user experience. The following focus areas also reflect feedback from NLC workshop participants and industry partners sharing field experience. LDL's focus areas can be divided into two categories.

Time Savings:
LDL identified three specific areas within the user experience that tend to either save or add time to system programing.

Key Areas of Time Savings	Examples
Saves time by consolidating steps within the app	Preprogrammed default settings
	Consolidated steps
Saves time by providing project specific shortcuts	Room and scene templates
	Key words
Specifically removes the need to make physical contact with related system devices	No need to toggle a button
	No need to get a ladder to reach a device

Critical User Experience Considerations:
In addition to areas of quantifiable time savings, LDL focused on the specific features and approaches within the apps which are most likely to lead to a positive outcome.

Critical User Experience Considerations	Examples
How is the user guided?	Guided experience vs. power user experience

	Ease of access to scheduling, high-end trim, occupancy / vacancy, and daylight harvesting control strategies
How is help offered?	In-app help menu
	Links to task specific videos or related content

Identifying and documenting the user experience focus areas was the final step in preparing LDL for interviews with industry partners.

Section 6: Interviews with Industry & Analysis

To solicit participation, LDL provided a memo (Appendix B) to industry partners highlighting project objectives and pledging to share lessons learned. The following manufacturers and systems were interviewed for the purposes of LDL's NLC configuration tool UX project.

NLC Systems	
LLLC Capable Systems	**Non or limited LLLC Capable Systems**
Acuity – nLight Air	OSRAM Encellium – Edge
Cooper – Wavelinx	Crestron – Zum
Hubbell – NX	Ideal – Audacy
Lutron – Vive	ETC - Echoflex
RAB – Light Cloud	

Interviews were conducted via a virtual platform and were recorded for the sake of review. Participants received a copy of LDL's NLC configuration tool user experience matrix and questions in advance of the interview. Typical interviews were around 90 minutes.

Findings from the interviews were documented, reviewed by the LDL team, and then assigned into one of two categories: A) general trends towards commonality or B) points of divergence. LDL reserved the bulk of its analytical review for the latter category seeking to understand how divergent areas affect the user experience.

Section 7: Key Findings - Commonality

Increasingly, NLC systems have more in common than ever before. Rather than introducing new concepts or control methods, app-based configuration tools provide a simplified user-interface for implementing existing control and design methods.

In general, all NLC configuration tools are trying to accomplish the same basic tasks, and, taken as a whole, they are improving. The systems observed by LDL feature a wide range of capabilities and are simple to operate when compared to many systems that predate the app-based configuration approach.

In total, LDL observed three primary areas of commonality.

A. Hardware:

Increasingly, modern NLC systems have aligned around basic hardware approaches such as 0-10v load controllers and integrated photo and occupancy sensors. Additionally, it is common for systems to offer both wired and wireless devices such as sensors and wall stations. All NLC systems reviewed for this project offered single-scene and multi-scene wall stations and all manufacturers offered some form of custom labeling.

A final commonality to the hardware trend is the proliferation of LLLC as an option. The combined result of component integration is that systems are easier for designers to specify and less complicated for distributors to stock.

B. Simplifying Setup:

Increasingly, systems are simplifying the process of detecting devices and offering more in the way of pre-configuration. An example is the trend for modern NLC systems to not only detect devices, but also to automatically identify specific device types, hardware configurations, and related programming options. This automation removes tedious repetitive steps for the user and further streamlines the overall experience.

Example:

Basic Device Discovery	Advanced Device Discovery
Step 1 New wall station identified	**Step 1:** New wall station identified; hardware configuration is automatically detected.
Step 2: Identify wall station type and button configuration *(e.g. 4 button vs. 7 button)*	
Step 3: Pair with room and controlled zones	**Step 2:** Pair with room and controlled zones
Step 4: Assign Scenes or program	**Step 3:** Assign Scenes or Program

The proliferation of logical scene programming, that is not specific to each control station, is another major trend that simplifies system setup. Increasingly, many NLC systems are promoting a top-down, scene-based control approach, which allows for rapid assignment of pre-programmed scenes to one or more wall stations or wall station buttons. The practical benefit is that users can take advantage of single-button scene selection, and programmers are freed from tedious repetitious tasks associated with programming scenes specific to each wall station button.

C. Configuring Controls:

All systems reviewed by LDL included the four primary control strategies (scheduling, high-end trim, occupancy / vacancy, and daylight harvesting). While specific approaches to implementing the control strategies still exist, basic functionality like setting the timeout for sensors is commonplace. Additional app-based functionality like sensitivity selection, vacancy/occupancy selection, and daylight calibration are becoming much more prevalent. Furthermore, it is common for modern app-based devices to offer multiple pathways for users to configure control settings. The practical result is that it is easier for system operators to both perform the initial system setup and fine-tune the system to meet occupant needs.

Section 8: Key Findings – Differences

Despite numerous macro level trends, LDL observed several notable divergences in system setup approaches. While myriad nuanced differences were observed, LDL concentrated on the following eight areas because of their relevance to the user experience, as described in section 5.

A. Lack of Standard Industry Nomenclature

One of the key differences that stands out when reviewing multiple NLC system configuration tools is the lack of standard industry nomenclature. Through the interview process, LDL realized that even experienced industry professionals (ostensibly on the phone to talk about the same thing), can still miscommunicate as a result of inconsistent technical jargon. Because miscommunication can lead to disruptions on a project or less-than-stellar customer experiences, LDL deemed the finding as significant.

In the process of working through the system interviews LDL identified two distinct types of nomenclature inconsistency. These are a) inconsistencies that agree, and b) inconsistencies that do not agree.

a. Inconsistencies that <u>agree</u> occur when two people are using different words or phrases to describe the same thing (like high-end trim and task tuning or load shed and demand management).

b. Inconsistencies that <u>do not agree</u> occur when *Person A* uses common terms interchangeably, and a margin of error exists for *Person B* to think they are talking about something else. (e.g. zone vs. group or room vs. area).

Exacerbating both examples is the competitive and often proprietary nature of the lighting industry. Seeking to stand out and highlight innovation, manufacturers are sometimes motivated to apply novel names to standard practices. LDL recommends manufacturers strive to adopt common technical jargon and eschew novel naming methods for existing common practices.

B. Approach to Device Discovery

All the systems observed share the requirement that individual parts and pieces (*i.e.* load controllers, sensors, wall stations, etc.) need to be discovered (detected) by either other devices or by a central hub or gateway for programming. This step is necessary for devices to be associated with each other, and with corresponding rooms, groups, zones, etc.

The way in which systems optimize this experience for operators performing initial system setup is a point of divergence, with systems generally following one of two methods. For the purposes of this report, LDL refers to these as the *Automatic Device Detection Method* and the *ID-Scan Method*.

The Automatic Device Detection Method:

The *Automatic Device Detection Method* uses a wireless radio signal, or wired digital link, to search for devices which are powered. In the case of wireless systems, the signal frequently emanates from a central gateway or hub to detect the devices closest to it first. It then continues to add devices within range. Some systems accomplish automatic device detection using a mesh network between multiple devices rather than a central hub. Once devices are detected and added to the project in the app, they can be individually identified (typically by *blinking* the luminaire) before being paired and programmed.

Earlier generations of this technology required operators to physically enable the devices into “discover mode” via a button on the device (like connecting to a new Bluetooth device). Many NLC systems which use the *Automatic Device Detection Method* can detect devices without this step.

The ID-Scan Method:

The *ID-Scan Method* is generally characterized by systems that utilize either a QR code or a bar code label. This ID label is applied (commonly as a sticker) to individual system components (or in the case of LLLC, a single integrated fixture) and requires the operator to scan each device to detect it during initial system setup. During the initial setup phase, duplicate ID stickers may be placed on *as-built* plans to designate exact fixture location, groupings, and zones.

In addition to requiring a physical scan, the *ID-Scan Method* is distinguished from *the Automatic Device Detection Method* by its common use of pre-programming. Pre-programming (sometimes referred to as off-site or remote programming) allows factory certified reps to configure a wide range of design and configuration specifications prior to installation. System components are then packaged and labeled for specific spaces identified via building plans. It is during the pre-programming phase that devices are first assigned the ID code, which will later be scanned by the operator during system setup to detect the device.

Hybrid Method:

LDL did observe that some systems allow for pre-programming and leverage au*tomatic device detection* but this hybrid approach was not commonly available.

Device Discovery Findings:
LDL originally hypothesized that app-based configuration systems that deploy the *Automatic Device Detection Method* would save time when compared to the *ID-Scan Method* and thus would be preferred by users. Further observation, however, revealed that both approaches take comparable time and effort.

The two varying approaches likely work just as well, and the primary practical difference appears to be whether or not the initial setup process is completed on-site by the initial operator or split between the off-site factory technicians or contractor preplanning teams, and on-site electrical contractors.

	Automatic Device Discovery Method	**ID-Scan Method**
Pre-install	Project-specific *Sequence of Operations* is developed.	Project-specific *Sequence of Operations* is developed, and initial system programming is completed offsite by a contractor or factory technician.
Project install	System operator uses automatic device detection to rapidly detect multiple devices. Blinking to identify each device detected can be time consuming.	Scanning individual devices may take time up front, but there may be less time required onsite to identify all devices.

C. Approaches to Guiding the User

LDL observed that most NLC app-based configuration tools can broadly be categorized as offering their users either a *Guided Process* or a *Power Menu Approach*. Both approaches have pros and cons and preference is likely dependent on how often a user accesses the system or sets up similar projects.

The Guided Process:
The *Guided Process* is generally characterized by systems that provide a logical, step-by-step approach to system configuration while channeling user input. These systems tend to offer a structured process intended to educate the user and guide the process. The *Guided Process* commonly features the use of graphics and icons to highlight options and next steps. Used together with helpful text, this method provides visual queues and a sense of context to the lay user.

The Power User Menu Approach:
The *Power User Menu* approach is generally characterized by systems which do not rely on graphic images or structured pathways to guide the user. Instead, these systems typically offer a sleek menu offering rapid access to myriad features.

Guiding the User Findings:
LDL recognizes the merits of both approaches to guiding users. The *Guided Process* is likely preferred by facility operators and industry professionals who do not work regularly with specific NLC systems. The *Power User Menu* approach allows for quicker movement throughout an application but also necessitates a higher level of system training and lighting knowledge.

With the goal of bringing networked lighting controls to an expanded market, LDL recommends manufactures pursue the *Guided User* approach. While the *Power User Menu* approach may work well for a trained elite, the general user requires (and will appreciate) the structure and context driven approach offered by the *Guided User* method (think *TurboTax)*.

LDL also recommends manufacturers consider a toggle feature that could be configured as part of an individual's accounts that would allow operators to navigate through the UX approach that suits them best.

D. Approaches to Sensor Configuration

The approaches to sensor configuration are divided between systems that allow the user to complete all stages of discovery, pairing, and programming via the app, versus systems that require hardware to be physically touched. In practical terms, the difference comes down to both time and convenience, with the second type potentially including a ladder.

LDL recommends that full functionality for sensor configuration should managed via the app-based configuration tool. This would mean system operators would not have to physically click on devices to change settings.

E. Approaches to Setup Streamlining

LDL noted a growing trend towards app-based configuration tools offering some level streamlining features to reduce programming time but observed that different systems offer widely varying approaches. Most common among the system streamlining approaches observed by LDL were templates for spaces, scenes, and behavior groups; e.g. sensor configuration styles. Given the repetitive nature of many projects (e.g. spaces, schedules, scenes, etc.), systems offering streamlined short cuts, which can eliminate duplicate actions and save time, will likely gain favor with installation professionals.

Another key streamlining method observed has been the use of pre or user defined keywords that may be applied to iterative tasks such as defining room names or types. LDL recommends that manufacturers seek to include all forms of streamlining into app-based configuration tools (space templates, scene templates, copy and paste, and keywords).

F. Approaches to Energy Use and Dashboarding

LDL noted a general trend among most towards app-based configuration tools for providing some level of dashboard for energy use tracking but observed that different systems offer widely varying approaches and data collection.

Increasingly common among the systems observed by LDL is real-time energy use reporting. Most systems offered some variation of energy use per device, energy use per gateway/hub, and energy saved over a specific time period. Less common was the ability for users to customize the dashboard metrics and report method.

LDL also observed that less than half of the systems reported remaining battery life for wireless devices. This is a significant potential barrier for facility staff or capital project managers wary of wireless devices. LDL recommends that manufactures include battery-life metrics and continue to develop energy use and system reporting capabilities for all mid-range NLC systems.

Also absent from all systems observed was the capability to easily export an *as-built* system configuration report. An *as-built* report would be beneficial to installers, facility professionals, commissioning agents, and for purposes of utility program oversight. For these reasons, LDL recommends manufacturers consider developing the capability to export *as-built* configuration reports. LDL also recommends that manufacturers collaborate on an industry wide standardized reporting format to simplify system implementation, verification, and maintenance.

G. Approaches to In-App Help

Among the NLC systems observed, most did not offer in-app help menus or resources. Where they existed, LDL noted a varying degree of approaches. Systems that included in-app help menus typically offered them in one of four flavors: a) general help menu b) context-driven help options c) links to external resources and d) reference to helplines or text message assistance.

While a few systems offered multiple in-app help features, notably, more than half did not include any. LDL recommends that manufacturers provide multiple in-app help pathways for customers and system operators. In particular, LDL sees value in links to short, focused videos.

H. Approaches to Reprogramming

The inherent ability of simple reconfiguration is a primary selling point for NLC and LLLC systems. However, before a system can be fully reprogrammed, it typically should be fully reset to prevent confusion in reconfiguration and reprogramming. Among the systems observed, the primary point of divergence for reprogramming hinged around whether the task could be performed solely through the app-based configuration tool or if physical access to a specific device is needed (e.g. gateway or hub).

Similar to configuring sensors, LDL recommends that manufacturers seek to incorporate full system reset capabilities into the app-based configuration tool, thus eliminating the need to access hardware that may be in a ceiling.

Section 9: LLLC vs. NLC for Setup

Approximately 50% of the systems featured in LDL's NLC workshops are LLLC. With regard to *which is faster and easier to setup, an LLLC configured system or a NLC configured system*, observation revealed two predictable schools of thought.

The first camp posits that NLC configured systems are faster and easier because there are fewer parts and pieces to detect and program (e.g. fewer sensors, fewer zones). Fewer parts and pieces equals less work. *QED.*

The second camp posits that LLLC fixtures with integrated sensors and load controllers do not constitute *additional devices* in the same way that discrete components do. This camp also posits that additional system programming is project-specific and the level of effort is specific to the design specifications of the project.

LLLC vs. NLC for Setup Findings:
Strictly focusing on the initial stages of system setup listed in the table below, LDL observed that LLLC configured systems typically result in fewer devices to discover, pair, and add to a space.

Task comparison between LLLC and NLC systems for a single zone		
Stages of Initial System Setup:	**LLLC**	**NLC**
Discovery & Pairing	Integral components result in one device to discover	Multiple devices to discover
Adding to Rooms	1 device to add to a room	Multiple devices to add to a room
Sensor Configuration	Typically some level of pre-programming	No pre-programming
Full Programming	Similar	Similar

Focusing on the system programming steps that follow detecting and pairing, LDL further observed that the variability in system setup effort required is most likely a result of project-specific design. <u>For projects that do not require significant levels of granularity or fine-tuning, LLLC configured systems that are frequently feature significant pre-programming upon installation will likely provide the fastest and simplest solution.</u> For projects specifying increased zone control, with complex Sequence of Operations, or specific requirements, optimization between the two system type approaches is comparable.

Project Specific Design Approach			
Project with more design specifications *(more rigorous code requirements, higher number of fixture zones/groups, or seeking maximum energy savings)*		**Project with fewer design considerations** *(basic design-build or retrofit project, spaces that don't require granular lighting controls)*	
LLLC	**NLC**	**LLLC**	**NLC**
Overall, LDL observed that the programming time required between NLC and LLLC systems is very similar for projects with more specific design specifications. (*i.e.* lighting systems are finely tuned).		LLLC systems that are ~70% programmed out of the box will likely be faster.	NLC systems that seek to effectively deploy the four primary lighting control strategies will likely take longer.

Additional benefits of LLLC:
LDL also recognizes that not all lighting projects have a lighting designer or lighting engineer involved in the specification process. At an increased equipment cost, LLLC systems allow lighting projects to move forward without the expense of professional lighting design. As app-based configuration tools become more adept, migrating final system setup downstream to electrical contractors and facility professionals may yield both financial savings and increased ownership and control of the system.

Section 10: Recommendations to Industry & Next Steps

Summary of recommendations to LLLC / NLC system manufacturers:

1. **Align on standard language:** LDL recommends that manufacturers strive to adopt common technical vocabulary and avoid novel naming methods for existing common practices.

2. **Guide the user:** With the goal of bringing networked lighting controls to the masses, LDL recommends that manufactures pursue the *Guided User* approach as described in Section 8b. LDL also recommends that manufacturers consider a toggle feature which could be configured as part of an individual's system accounts and would allow operators to experience the app-based configuration tool in which ever mode best fits their background and skill level.

3. **Remove remote device dependence:** LDL recommends that full functionality for tasks such as sensor configuration or system reset be managed via the app-based configuration tool. This would mean that system operators would not have to physically click on devices to change settings or use a ladder to access devices that may be in a ceiling.

4. **Offer multiple streamlining tools:** LDL recommends that manufacturers seek to include all forms of streamlining into app-based configuration tools (space templates, scene templates, copy and paste, and key words).

5. **Increase Dashboarding Capabilities:** LDL recommends that manufactures include battery-life metrics and continue to develop energy use and system-reporting capabilities for mid-range systems. LDL also recommends that manufacturers consider developing the capability to export standardized *as-built* configuration reports.

6. **Provide multiple forms of in-app help:** LDL recommends that manufacturers provide multiple in-app help pathways for customers and system operators. In particular, LDL sees value in links to short, focused videos.

7. **Make a point to experience other apps:** LDL recommends that manufacturers and their representatives make a point to experience other systems to help exercise market awareness and avoid tunnel vision.

Next Steps:
In response to these findings, LDL plans to incorporate key learnings into existing market-facing tools and resources that will be publicly available. LDL will work with regional stakeholders to share findings that may support utility programs. LDL also plans to share its findings with industry partners and will work through industry associations to make its findings available.

Appendix A: Common NLC app-based setup stages with decision nodes:

1. **Programming Apps**
   a. Confirm NLC system uses an application (app)-based platform available on either Android or iOS? (or both)
   b. Are there alternative means of programming such as PC software?
   c. Is the app available from Apple and Google Stores?
   d. How does the end-user download and install the app?
   e. Is there a cost for the app?
   f. Does the app require an account or login registered with the manufacturer?
   g. Please describe the steps a user must follow to gain full access to the app
   h. Can more than one user access the app program in a specific area at the same time?

2. **Networking / Hardware**
   a. Does your system require a hub or gateway for system programming?
   b. Does your system require a hub or gateway for system operation?
   c. Is network access required for system programming or operation?
   d. How is cloud access commonly achieved?

3. **Device Discovery**
    a. Does your system automatically discover load controllers / or digital driver controllers in the system area?
    b. Does your system automatically discover sensors, including LLLC luminaire mounted sensors in the system area?
    c. Does your system automatically discover wall stations within the system area?
    d. Does it automatically determine wall station type and configuration?
    e. Does your system have a method to simplify confirmation of automatically discovered devices other than blinking each one? (please describe)
    f. Does your system use an alternative preprogramming step such as QR codes or any devices mounted in locations that may require a ladder?
    g. Can your system come pre-configured (from the factory or rep agency) according to plans, specifications, and Sequence of Operations?

4. **Area / Room Setup**
    a. In many systems, creating rooms or areas are among the most basic steps. Please describe the steps required to create a room in your system.
    b. Can the system run nested sub areas or are all areas always separate rooms?

5. **Loads / Zones**
    a. If the system automatically discovers load controllers or digital driver controllers, please describe the method of determining which loads should be assigned to which zones, groups, or areas?
    b. Since your system does not automatically discover load controllers, please describe how you determine which loads should be assigned to which zones, groups, or areas?
    c. Please describe the process of assigning zones to specific rooms or areas.

6. **Sensor Hardware**
    a. Does your system have integrated sensors with DS / OS / VS capabilities?
    b. Does your system incorporate other sensor types such as CO2, temperature, or humidity?
    c. Does your system have LLLC capabilities with
        i. 0-10v load controllers,
        ii. digital driver controllers,
        iii. or some other option?
    d. Does your company plan to introduce an LLLC system within the next 12 months?
    e. Does your system feature OS / VS sensors that can change function based solely on app programming?
    f. Does your system feature OS / VS sensors that can change function based on dip switches or other settings on the sensor itself?
    g. Does your system allow the use of active sensors such as ultrasonic or dual technology?

h. Does your system support both open loop and closed loop daylight sensors? If not, which is preferred.
i. Does your system support both wired and wireless sensors? Which mode is preferred?

7. OS / VS Setup

a. Does your system feature sensors that can be either OS or VS?
b. Can the sensor be toggled between OS and VS via app programming or are dip switch settings required?
c. Does your programming app allow for dynamic changes to device configuration, such as OS/VS, timeout, or enable/disable based on time of day or other variables?
d. Can the sensitivity of the sensor be adjusted by the programming app?
e. Can the system be programmed to provide scene control or for minimum light level rather than 100% off when vacancy is determined?
f. Can sensors be programmed to operate in groups with shared or overlapping control zones?
g. Please describe the process of assigning sensors to specific areas.
h. Please describe the process of pairing zones to sensors.

8. Daylight Harvesting

a. Is your sensor self-calibrating? If so, please describe the method and algorithm.
b. Is calibration accomplished through the CT or is it necessary to physically access the sensor?
c. Is a light meter required to calibrate the sensor?
d. Is there a time of day requirement for sensor calibration?
e. Does your app support easy assignment of primary and secondary daylight zones from a single sensor?
f. How does your system accommodate primary and secondary daylight zones?
g. Can your system be programmed in the app to aggregate DS input from multiple sensors in one area as from LLLC sensors?
h. Please describe the process of assigning sensors to specific areas.
i. Please describe the process of pairing zones to sensors.

9. High End Trim

a. Does your system allow for a global imposition of HET for all areas and zones?
b. Does your system allow for wide areas imposition of HET for rooms or areas?
c. If global or wide area setup is possible, can individual zones be adjusted later?)for example, most zones may be set at 70% output while 2 or 4 might be set to 85% output.
d. Does your system also allow for minimum light level by project, areas, or individual zone?

10. Scene Programming

a. Please describe the process of scene creation in your system.
b. Is the scene fade rate adjustable by the app programming?
c. Are scenes programmed and mapped to each specific wall station?

d. Are scenes programmed within each areas and then able to be mapped to a wall station / wall station button in that area?
e. Can the button mapping be changed?
f. Can a scene programmed within any area then be mapped to a wall station in any other area?
g. Can a list or group of scenes be created and copy / pasted to other specific areas or wall stations in the project?
h. Can scene be additive / subtractive / toggled in your system or is it always "last touch," in each area?

11. Wall Station Hardware

a. Does your system offer battery operated wall stations, convenience powered wall stations or both? (Is there a preferred option?)
b. Does your system offer single scene and multi-scene wall stations?
c. Does your system offer wall stations with additional potential functionality, e.g. scene or zone toggle, sensor over-ride, etc. ?
d. Does your system offer touch screen wall stations? (if so, are they customizable?)
e. Does your system allow for custom engraving or silk screening of the buttons for scene or functionality?
f. Can those names be generated from the programming app?

12. Wall Station Programming

a. Please describe the process of adding wall stations to each area.
b. Please describe the process of mapping / pairing scenes or functionality to each wall station button.
c. Does your system allow each button to be reconfigured from the programming app?
d. Can your touch screen wall stations be programmed / customized within the program app or is a different tool required?

13. Demand Response

a. Does Your system have wide area demand response capabilities?
b. Please describe how your programming app enables or disables demand response and how individual zones are added or made unaffected.
c. Does the programming app allow for configuration of automated demand response via Open ADR or similar?

14. Setup Streamlining

a. Does your app allow any copy and paste functionality of any kind?
b. Does your app allow room copy and paste functionality?
c. Does your app allow typical scheduling copy and paste functionality including time of day sensor changes?

d. Does your app allow typical wall station copy and paste functionality?
e. Does your app allow for use of keywords to simplify naming of rooms, zones, or devices, *(e.g. conference, office, or corridor?)*

15. Help and App Documentation

a. Does your system off in help functionality?
b. Is it contextually based help or is it a separate meu driven system?
c. Does the app itself intuitively guide users through the various programming steps? (*describe how this works)*
d. Does the app provide links to external media content such as setup guides or videos to assist installers?
e. Does the app provide direct contact information such as phone numbers or online chat centers to provide live assistance when problems arise?

16. Reporting & Dashboarding

a. If your system uses batteries in sensors or wall stations, does your app provide diagnostic or battery life reporting?
b. Does your app offer any reporting capabilities for device or luminaire diagnostic issues?
c. Does the app provide any programmable dashboarding capabilities for energy use and trending? (please describe)

17. Offline Programming and Functionality

a. In absence of a network or hub communication, is the user able to use the app to make programming changes to be uploaded to the system later, such as after hours?
b. Can the system function without a programming hub, gateway, or cloud connection?
c. If hub, gateway, or cloud connection are lost, what functionality is lost and is there a way to program around this in the app?

18. Reprogramming

a. Can load controllers / zones be reprogrammed in the app without physically touching the devices?
b. Can sensors be reprogrammed in the app without physically touching the devices?
c. Can wall stations be reprogrammed in the app without physically touching the devices?
d. Can you please describe the steps necessary to factory reset the major components of your system?

Appendix B: Invitation to participate in the app-based interview process

NETWORKED LIGHTING CONTROLS (NLC) USER EXPERIENCE:
App-Based Configuration Tools

HELP US, HELP YOU!
IMPROVE USER EXPERIENCE

WE NEED YOUR HELP!

LDL IS SEEKING PARTICIPATION FROM INDUSTRY-LEADING NLC MANUFACTURERS. THE ESTIMATED TIME COMMITMENT IS 2-3 HOURS OVER AN ANTICIPATED 2-3 TELECONFERENCES.

LDL is working with industry partners to catalogue NLC app-based configuration tool approaches and is planning on publishing a best practice memo in Q4 2020.

REASONS TO PARTICIPATE

- LEARN ABOUT THE INTERFACE TRENDS YOUR CUSTOMERS ARE EXPECTING.
- IDENTIFY AREAS YOUR SYSTEM CAN IMPROVE TO MEET CUSTOMER DEMANDS.

This research project is limited to NLC systems that use an application-based configuration tool for programming and primarily focuses on products easily implemented in the existing buildings/retrofit market.

QUESTIONS?

TO PARTICIPATE OR FOR MORE INFORMATION
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lighting design lab
POWERED BY
Seattle City Light