Connected Lighting
Lessons from a Living Lab

Twelve systems in 12 classrooms at The New School were evaluated

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One of the hottest topics in lighting today is the tremendous potential of intelligent, connected lighting systems to provide substantial energy savings, responsive lighting performance and a wealth of value-added data to improve safety, business outcomes and much more. These systems range from interoperable and information-rich networks that can play a role in the emerging Internet of Things, to simpler, energy-focused systems of luminaires, sensors and controls.

To assist lighting manufacturers and users in assessing and applying this new technology, the Next Generation Lighting Systems (NGLS) program has embarked on a new series of evaluations of connected lighting systems. This article reports on the first of these evaluations.

As a first step, NGLS decided to start at the simpler end of connected lighting by evaluating systems of luminaires and controls marketed as "easy to install and configure." Beginning in July 2017, two sets of evaluations were conducted at The New School in New York City, in collaboration with the School of Constructed Environments, Parsons School of Design. A total of 12 connected lighting systems—representing a range of controls and luminaire types, including linear pendants, troffers and retrofit kits—were installed in functioning classrooms at The New School, with each system lighting its own classroom to a common lighting and control specification. Participants are listed below.

EVALUATION 1 PARTICIPANTS

Control System Manufacturer	Control System	Luminaire Manufacturer	Luminaire
Magnum Energy Solutions	Magnum	LumenWerx	Reven SIB
Philips	Easy Sense	Selux	M36 D-1
Crestron Electronics	Zum	Starfire	Versalux D-I
Philips Lighting	SpacewiseDT	Philips Lighting	Sona
RAB Lighting	RAB LightCloud	RAB Lighting	Swish 2x2
Cree	Smartcast	Cree	CR22
Nextek Power Systems	Sky Control	Independence	iLED R Series

EVALUATION 2 PARTICIPANTS

Control System Manufacturer	Control System	Retrofit Manufacturer	Retrofit Kit
Eaton	Wavelinx	Eaton	Metalux Cruze
LG Electronics	Sensor Connect	LG Electronics	Simple Choice
Philips Lighting	Spacewise	Philips Lighting	EvoKit LED
Lutron Electronics	Vive	Orion	Orion ISON
Acuity Brands Lighting	nLIGHT AIR	Lithonia	BLT Relight Series

THE DESIGN PROCESS

Following documentary prequalification, each manufacturer submitted a complete system of luminaires, integrated controls and supplemental equipment, based on room layout (ranging from 300 to 650 sq ft), lighting-performance requirements and control-performance specification (see details below). Photometric analysis based on the manufacturers' proposals was used to refine the luminaire choice and layout. The manufacturers' control systems and layout were used without modification.

Each system was installed and configured by a team of electrical contractors in a similar working space, following a typical design and construction process.

NGLS LIGHTING PERFORMANCE TARGETS

Task Plane Illumination	Illuminance Uniformity	Maximum Luminance Ratio	
Average initial at full power work plane	Average to minimum across background surfaces	Between task and immediate (ceiling, walls, floor)	Between task and distant background surfaces
45 – 55 fc	2:1	3:1	10:1 or 1:10

Installation documents varied widely in terms of clarity and usefulness.

Control Performance Specification

1. System shall provide for **vacancy control** (manual on/auto off) of two zones, with a time-out period of five minutes.
2. System shall provide **manual continuous dimming** of the same two zones indicated in item 1. Minimum dimming level of each zone shall be ≤ 10% of lumen output.
3. System shall provide **daylight harvesting** to maintain task-plane illumination at the current level provided by the electric lighting (whether full output, task-tuned or manual-dimmed). When daylight contribution exceeds task-plane illumination, luminaires shall operate at lowest dimmed level (and stay illuminated until switched off manually or by presence-detection control).
4. System shall provide **field-adjustable high-end trim** to lower maximum system light output. System shall be delivered with high-end trim set at 100%.
5. Manual dimming control takes precedence to establish the specified task-plane illumination. **Daylight harvesting should not override to raise light levels** to the maximum task-plane illumination if the manual dim setting is not at full.
6. **Control settings shall be adjustable** by the user without factory assistance.

THE EVALUATION PROCESS

To evaluate installation and configuration, NGLS used two-person teams drawn from a wide range of lighting practitioners, facilities professionals, and utility personnel. The evaluators observed, timed and assessed in three separate stages: 1) the installation of the luminaires or retrofit kits, 2) the installation and startup of the controls and 3) the adjustment of the control settings.

The installers (a lead and a helper) were licensed electrical contractors who had limited experience with connected lighting systems, and who had been selected by The New School. Installer feedback, both during and immediately after the process, played an important role in the evaluation. Although manufacturer representatives were invited to observe the installation and configuration of their products, they were not permitted to interact with the installation contractors during the installation process.

LESSONS LEARNED

System Architecture. Lighting control systems are typically comprised of a variety of physical components, including relays, occupancy sensors, photocells, local area controllers and wall switches. Connection of these components can be achieved by hardwire, wirelessly or via power over Ethernet (PoE). The control systems submitted to NGLS varied significantly in the number, placement and connection of components and can be grouped into three broad categories, based on the degree of installation complexity.

SYSTEM ARCHITECTURE COMPLEXITY

	Least Complex	Moderately Complex	Most Complex
Components	• Luminaire-integrated sensor and control • Wall switch	• Luminaire-integrated sensor and control • Wall switch • Local area network device	• Remote-mounted sensor and control • Wall switch
Connection	• Wireless	• Wireless	• Wired • Wireless • PoE
Systems	• Cree • Philips • Selux (Philips) • Acuity • LG • Lumenwerx	• Eaton • Lutron	• RAB • Crestron • Nextek

Not surprisingly, the least complex systems were the easiest to install. Since occupancy and daylight sensors were factory-integrated, no additional field installation was required, and the wireless wall switches typically were installed easily. The moderately complex systems also tended to be easy and quick to install, similarly benefiting from the luminaire-integrated sensors and controls and the wireless wall switch. The additional wireless area network devices added some additional time for installation, mainly related to providing electrical power to the device. The most complex systems required significantly longer times for installation of the control components. The contractors first had to identify and understand the sensors and other components, which required them to consult printed instructions; then those devices had to be mounted and connected using a variety of methods.

Operational Complexity. As was previously noted, NGLS required the control systems to provide a minimum set of capabilities established as appropriate for “easy” systems. All of the submitted systems had at least the minimum required control capabilities. Several systems provided additional functionality, such as energy moni-

INITIAL STARTUP APPROACH

Pre configured Out of the Box Operation	On site pairing of luminaires to wall switches, factory set default operational settings	On site pairing of luminaires to wall switches, various additional steps, factory-set default operational settings	On site pairing of luminaires to wall switches, on site configuration of external daylight ing and occupancy sensors
Lumenwerx	Cree	Eaton	Crestron
Nextek	Acuity	LG	RAB
	Philips	Lutron	
	Selux (Philips)		

toring and building-system integration, with access to control settings for adjustment through a computer front end. In general, the installers found these latter systems to be more challenging to use and understand when trying to adjust control settings. Simpler systems used either an app or a handheld tool for ongoing system operation and to change control settings, which installers generally found easier to use.

In addition, the systems used a number of different approaches to initial startup, from completely preconfigured for out-of-the-box operation, to requiring onsite configuration of external daylighting and occupancy sensors.

The variety of approaches to initial startup and variation in system capabilities presented different benefits and drawbacks. Systems that arrived preconfigured were generally easy to set up, but this advantage was more than offset by a complicated computer front end that caused difficulty when changing the settings.

Systems that provided relatively fewer control capabilities and included default operational settings were generally easier for the installers to understand and configure, leading to a higher success rate for system operation.

The NGLS evaluations identified a clear relationship between system capabilities and ease of operation; the larger the set of control capabilities, the more complex the system was to operate. Specifiers need to find the appropriate balance between simplicity and functionality for each application. It's important to consider whether these additional features will be clearly understood and implemented, or whether they'll create complexity, cause frustration and eventually be disabled.

CONFIGURATION TOOLS

Handheld Tool	Phone App	Computer Front end
Cree	Eaton	RAB
	Lutron	Nextek
	Philips	Lumenwerx
	Selux (Philips)	
	Acuity	
	LG	
	Crestron	

Configuration Tools. NGLS entrants used three different approaches to system configuration: a dedicated hand-held tool, a phone app and a computer front-end. The hand-held tool proved simple and straightforward to use, but allowed relatively fewer control function adjustments compared to the other approaches. The phone apps allowed adjustment of numerous control settings and, if well-designed, offered intuitive operation. But some of the phone apps were confusing rather than intuitive, and some had limited phone compatibility. Using Internet-based software on a computer front end typically provided a robust user interface and adjustment of a large suite of control settings. Overall, however, the software was the most complicated method to use and the most difficult to access, requiring a laptop or desktop computer and sometimes an additional communications device (dongle). All configuration methods raised issues of access and function after the system was set up and turned over to the facility manager.

The phone apps allowed control settings to be adjusted and, if well-designed, offered intuitive operation. Some, however, were confusing.

Wall Controls. Wall controls provide a user interface that allows room occupants to adjust the lighting. There was very little consistency in the physical format and operation of the user interfaces provided for the NGLS evaluation, with each manufacturer taking a different approach. Based on the entries submitted, NGLS grouped the user interfaces into four general categories, although within each category there were additional differences in operation.

WALL CONTROLS

Factory-Configured Rocker Switch	Factory Configured Multi Button Switch	Site Configurable Rocker Switch	Site Configurable Multi Button Switch
Cree	Lutron	RAB	Eaton
Philips	LG	Nextek	Crestron
Selux (Philips)	Acuity		
Lumenwerx			

With *factory-configured switches*, operation of the switch is set by the manufacturer and can't be changed onsite. With *site-configurable switches*, each switch has to be programmed onsite to provide various means of operation of the lights, such as setting a different lighting scene in the room (some typical programmed scenes were "all on," "presentation mode," and "all dimmed 50%"). Entrants also took different approaches to powering switches; some were hard-wired, while others were battery- or kinetic-powered.

As with system operation, simpler wall controls were easy to set up, especially those that were factory-configured, but they offered limited functionality. Rocker-type controls generally required more "real estate" to handle multiple zones and scenes. Site-configurable controls and multi-button controls offered more flexibility but required more configuration.

Documentation. There was a wide variation in the format and content of the various control-system installation documents, with a correspondingly wide variation in clarity and usefulness. Many of the documents relied mainly on text, with word-dense instructions and sometimes unfamiliar language. The contractors generally found that

Why Use 'Virgin' Installers?

For consistency in the installation and configuration, NGLS used installers who weren't familiar with any of the control systems. What's more, manufacturer assistance was not permitted unless problems proved too difficult to resolve without it. While this approach may not be typical for new products, it does serve to identify what it means to be "easy" to install—if not today, then as a target for tomorrow. Meanwhile, it's good practice to be sure that installers are familiar with the systems they're handling and have ready access to technical support.

these documents weren't as helpful as they could have been, and often did not read the detailed text thoroughly, particularly when small font sizes made reading difficult. Other documents were much more graphical, using numerous screenshots, sketches and diagrams. Installation instructions that included clear and clean drawings and diagrams were the most useful to the contractors.

Similarly, the most successful startup and configuration documentation used quick-start guides or screenshots, or located instructions directly in the app or computer program. Lengthy, detailed instructions were the most frustrating and, often, confusing to the installers. Installation videos, especially for the retrofit kits, were particularly helpful to the contractors, provided the links were readily accessible. Lastly, most of us are creatures of habit. That is, when something looks familiar, we tend to treat it according to previous experience, without reviewing the documentation that's provided. This can lead to problems if the equipment needs to be treated differently from the familiar item.

THE BIG PICTURE

Based on the NGLS site evaluations of the installed systems:

- All 12 luminaires satisfied the lighting performance specifications
- Four control installations were considered satisfactory in terms of setup and operation for the "easy" market
- Five control installations were considered close
- Three control installations failed to set up easily or operate to the NGLS specification

Systems that proved least successful may simply not be suitable for the "easy-to-configure" market, but might effectively serve applications requiring more capability. Clearly, manufacturers have more work to do to match systems to applications and then deliver fully on their promise of "easy to use." But given the fact that most of these systems have been on the market for less than a year, and the lack of standards for connected lighting, the results of the NGLS to date are actually quite impressive. It's telling that the manufacturers have enthusiastically embraced the feedback from their NGLS evaluations—and from the installers themselves—and are using it to refine and improve their systems.

The NGLS is not a competition that pits one manufacturer against another; rather, it's a "living lab" to identify all issues that need attention, so that the technology fulfills its potential.

The evaluations of the 12 systems installed to date are continuing at Parsons, with both user evaluation of lighting and control performance and manufacturer participation to facilitate further product development. NGLS expects to install and evaluate additional systems later this year. ☐

THE AUTHORS

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