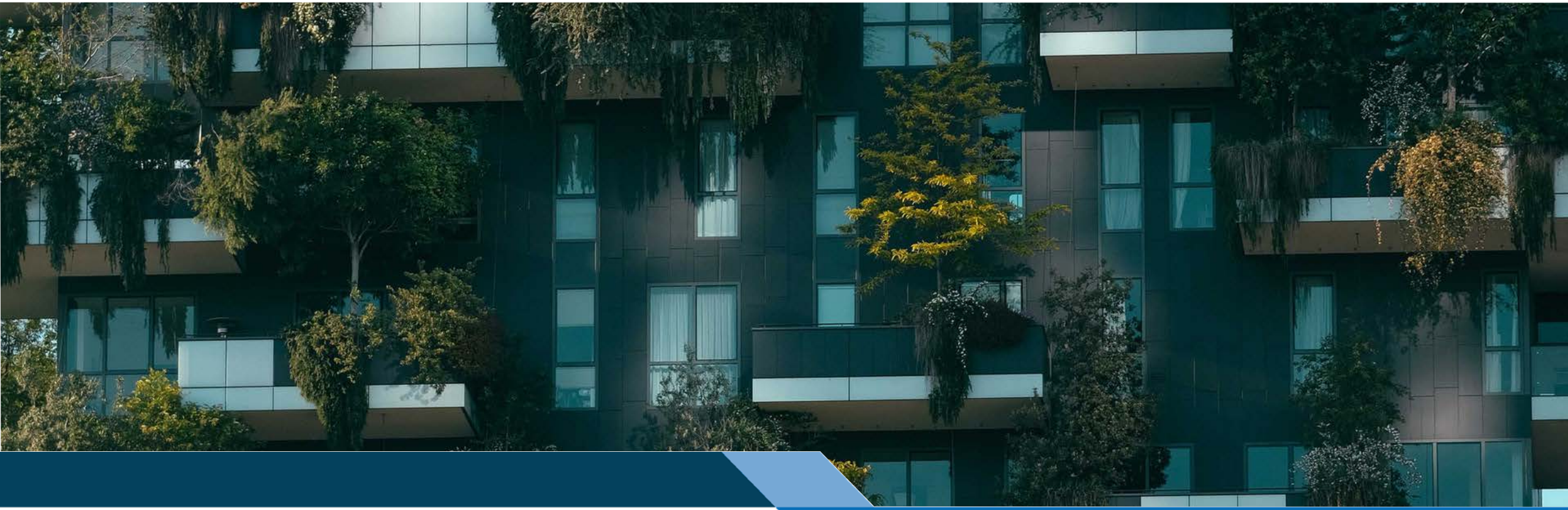

Lighting Integration and Interoperability: The Future of Building Codes and Standards

Alexi Miller, PE

Associate Technical Director
New Buildings Institute

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New Buildings Institute

Vision: We envision a transformed built environment that is carbon-free, sustainable, and energy-efficient and supports thriving economies that benefit all people and the planet.

Mission: We push for better buildings that achieve zero energy, zero carbon, and beyond – through research, policy, guidance, and market transformation – to protect people and the planet.

Lighting Controls – A Quick Overview of Types

- Local manual control (switches)
- Local occupancy & vacancy sensors
- Scheduled (time clocks)
- Daylighting (automatic dimmers)*
- Networked Controls*
- Luminaire level lighting control (LLLC)*
- Emerging: Wifi/IoT sensing*

***interoperability opportunity**

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Lighting Controls – Treatment in Codes ASHRAE 90.1-2019 (sample)

Table 9.6.1 ***Lighting Power Density*** **Allowances Using the Space-by-Space Method and Minimum** ***Control*** **Requirements Using Either Method**

Informative Note: This table is divided into two sections; this first section covers *space* types that can be commonly found in multiple *building* types. The second part of this table covers *space* types that are typically found in a single *building* type.			The *control* functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1 For each *space* type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.								
			Local *Control* (See Section 9.4.1.1[a])	Restricted to *Manual* ON (See Section 9.4.1.1[b])	Restricted to Partial *Automatic* ON (See Section 9.4.1.1[c])	Bilevel Lighting *Control* (See Section 9.4.1.1[d])	*Automatic* Daylight Responsive *Controls* for Sidelighting (See Section 9.4.1.1[e][6])	*Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section 9.4.1.1[f][6])	*Automatic* Partial OFF (See Section 9.4.1.1[g] [Full Off complies])	*Automatic* Full OFF (See Section 9.4.1.1[h])	Scheduled Shutoff (See Section 9.4.1.1[i])
Common *Space* Types[1]	*LPD* Allowances, W/ft^2	*RCR* Threshold	a	b	c	d	e	f	g	h	i
Atrium											
<20 ft in height	0.39	NA	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
≥20 ft and ≤40 ft in height	0.48	NA	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
>40 ft in height	0.60	11	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Audience Seating Area											
Auditorium	0.61	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Gymnasium	0.23	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Motion picture theater	0.27	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Penitentiary	0.67	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Performing arts theater	1.16	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Religious facility	0.72	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Sports arena	0.33	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
All other audience seating areas	0.23	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2

From: US DOE BECC Presentation "ANSI/ASHRAE/IES Standard 90.1-2019: Power and Lighting"
May 2020 – PNNL-SA-153216

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Lighting Controls in Codes
ASHRAE 90.1

- 70+ separate space types with various controls requirements
- No requirement for integration b/t HVAC and lighting

Control Function Types

- Local Control
- Restricted to *Manual*, *Partial Automatic* ON
- Bilevel Lighting Control
- Automatic Daylight Responsive Controls for *Sidelighting, Toplighting*
- Automatic *Partial, Full* OFF
- Scheduled Shutoff

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Lighting Controls in Codes
California Title 24 – Res: 150.0(k)2

- Res: Sec 150.0(k) lays out various control requirements
  - Mostly occupancy sensors; some MF/outdoor areas fall under the nonres code

Control Types	Requirements
LED Dimmers	All forward phase cut dimmers must comply with NEMA SSL 7A
Exhaust Fans & Lighting	Exhaust fans shall be switched separately from lighting systems
Manual ON/OFF	All lights must have readily accessible manual on/off control
No bypass	No control shall bypass a dimmer, occupant, or vacancy sensor
Under-cabinet lighting	Must be switched separately from other lighting

Lighting Control Type	What does it do?
Dimmer	• Varies luminous flux of electric lighting system by changing power delivered to the system
Occupant Sensor (indoor and outdoor)	• Auto-off after 20 minutes • Auto-on based on occupancy (motion)
Vacancy Sensor	• Auto-off after 20 minutes • Manual-on
Photo Control	• Auto-on/off based on available daylight
Astronomical Time-Switch Control (outdoor)	• Controls light based on time of day • Based on astronomical events like sunset, sunrise • Accounts for geographic location & calendar date

Credit: California Energy Commission

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Lighting Controls in Codes
California Title 24 - Nonres

- Nonres: Sec 130.1(a-f) lays out various control requirements
  - Manual area controls
  - Multilevel controls
  - Shut-off controls using occ sensors (partial and full-off)
  - Daylighting
  - Demand response (15% kW shed)
  - Control Interactions

130.1(f) Control Interactions

1. For general lighting, the **manual area control** shall permit the level or amount of light provided while the lighting is on to be set or adjusted by the controls specified in Section 130.1(b), (c), (d), and (e).

2. The manual **area control** shall permit the **shut-off control** to turn the lighting down or off.

3. The **multilevel lighting control** shall permit the automatic **daylighting control** to adjust the electric lighting level in response to changes in the amount of daylight in the daylit zone.

4. The **multilevel lighting control** shall permit the **demand responsive control** to adjust the lighting during a demand response event and to return it to the level set by the multilevel control after the event.

5. The **shut-off control** shall permit the manual area control to turn the lighting on. If the on request occurs while an **automatic time switch control** would turn the lighting off, then the on request shall be treated as an override request consistent with Section 130.1(c)3.

6. The automatic **daylighting control** shall permit the **multilevel lighting control** to adjust the level of lighting.

7. For lighting controlled by **multilevel lighting controls** and by **occupant sensing controls** that provide an automatic-on function, the controls shall provide a partial-on function that is capable of automatically activating between 50-70 percent of controlled lighting power.

Lighting Requirements in IECC 2019 Point-Based Tradeoff Approach, Section C406

- Must achieve enough credits/points to meet code: offers design flexibility
  - DOE/PNNL proposals (for ASHRAE & IECC) would adjust targets*

    (*by how much? Well … it's complicated)
- A few (~2) credits (varies by climate, building type) available if building lighting controls comply with section C406.4

TABLE C406.1(1)
ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP B OCCUPANCIES

SECTION	CLIMATE ZONE																
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
...																	
C406.4: Enhanced digital lighting controls	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1

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Lighting Requirements in IECC 2019 Tradeoff Approach in Section C406

C406.4 Enhanced digital lighting controls. Interior general lighting in the building shall have the following enhanced lighting controls that shall be located, scheduled and operated in accordance with Sections C405.2.1 through C405.2.3.

1. Luminaires shall be configured for continuous dimming.

2. Luminaires shall be addressed individually. Where individual addressability is not available for the luminaire class type, a controlled group of not more than four luminaries shall be allowed.

3. Not more than eight luminaires shall be controlled together in a daylight zone.

4. Fixtures shall be controlled through a digital control system that includes the following function:

    4.1. Control reconfiguration based on digital addressability.

    4.2. Load shedding.

    4.3. Occupancy sensors shall be capable of being reconfigured through the digital control system.

5. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions in Item 4.

6. Functional testing of lighting controls shall comply with Section C408.

Lighting Controls in Codes
Decarbonization Code (IECC Overlay)

C405 ELECTRICAL POWER AND LIGHTING SYSTEMS

Add new text as follows:

C405.2 Lighting controls. Lighting systems shall be provided with controls that comply with one of the following.

2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, C405.2.4 and C405.2.5. The LLLC luminaire shall be independently capable of:
   2.4 Reducing lighting power in a uniform manner by no less than 10 percent when signaled by a *demand responsive control*.

This approach to DR controls for lighting limits the requirement to LLLC lighting, which uses control technology that generally already includes DR functionality or for which DR functionality comes at a minimal additional cost. The threshold for lighting power reduction is drawn from California's T24 DR requirements.

demand responsive control: An automatic control device that can receive and automatically respond to demand response requests from a utility, electrical system operator, or third-party demand response program provider.

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Lighting Controls in Codes
Decarbonization Code (ASHRAE 90.1 Overlay)

9.4 MANDATORY PROVISIONS

Revise text as follows:

9.4.1 Lighting Control

Building lighting *controls* shall be installed to meet the provisions of Sections 9.4.1.1, 9.4.1.2, 9.4.1.3, ~~and~~ 9.4.1.4, and 9.4.1.5.

Add new text as follows:

9.4.1.5 Demand Responsive Lighting Controls

Building lighting *controls* shall be programmed to allow automated DR. The programming shall be capable of reducing the total connected lighting power in a uniform manner by no less than 15 percent but no more than 50% of the baseline power level when signaled by a *demand responsive control*. The baseline lighting power shall be determined in accordance with either Section 9.5 or 9.6.

Lighting DR language is modified from ASHRAE Standard 189.1. The built-in exception for lighting that is not connected to a central control point has been removed. To fully integrate lighting into the grid responsive infrastructure needed, lighting will need to be designed to meet these controls, which may require all systems be connected at a central control point.

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Lighting Controls in Codes
Decarbonization Code (ASHRAE 90.1 Overlay)

Add new definition as follows:

HORTICULTURAL LIGHTING. Electric lighting used for horticultural production, cultivation or maintenance.

PHOTOSYNTHETIC PHOTON EFFICACY (PPE). Photosynthetic photon flux emitted by a light source divided by its electrical input power in units of micromoles per second per watt, or micromoles per joule (µmol/J) between 400-700nm as defined by ANSI/ASABE S640.

Revise text as follows:

C405.4 ~~Lighting for plant growth and maintenance~~Horticultural Lighting. ~~Not less than 95 percent of the~~ pPermanently installed luminaires used ~~for plant growth and maintenance~~ shall have a ~~photon efficiency~~ *photosynthetic photon efficacy* of not less than 1.7 µmol/J for *horticultural lighting* in *greenhouses* and not less than ~~1.6~~ 1.9 µmol/J for all other *horticultural lighting*. Luminaires for *horticultural lighting* in *greenhouses* shall be controlled by a device that automatically turns off the luminaire when sufficient daylight is available. Luminaires for *horticultural lighting* shall be controlled by a device that automatically turns off the luminaire at specific programmed times.

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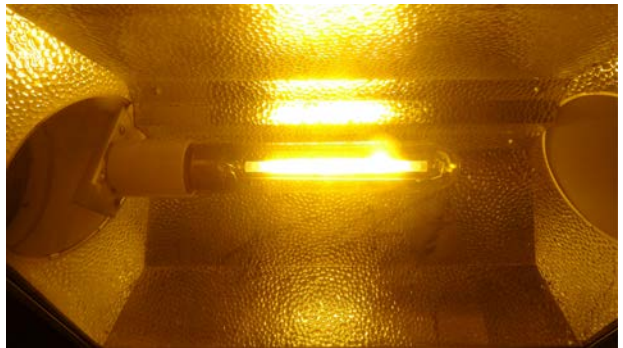
Tightening Efficacy Requirements

- Federal lamp standards moving forward
- Efficacy minimum values can be tighter in IECC 2021 than ASHRAE 90.1-2019 (where present)
  - MF dwelling unit exceptions may be reduced in future
- Horticultural Lighting: from 1.6 to 1.9 µmol/J
  - Moves away from HPS and toward decent-to-good LED



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Big Picture: Code Changes for Lighting Controls

- More requirements around smart digital controls
- Demand-responsive lighting controls
  - Proposals ~10-15% uniform power drop on DR signal
- More individual fixture addressability (ex: LLLC)
- Daylighting controls; smaller zones for daylighting
  - Ex: C406.4 says 8 luminaires per zone
- Including occupancy/vacancy sensors in central controls
- **Not a lot of movement** currently toward requiring or carefully defining integration between lighting and HVAC controls

BETTERBRICKS
Powerful Energy Ideas. Delivered by NEEA.

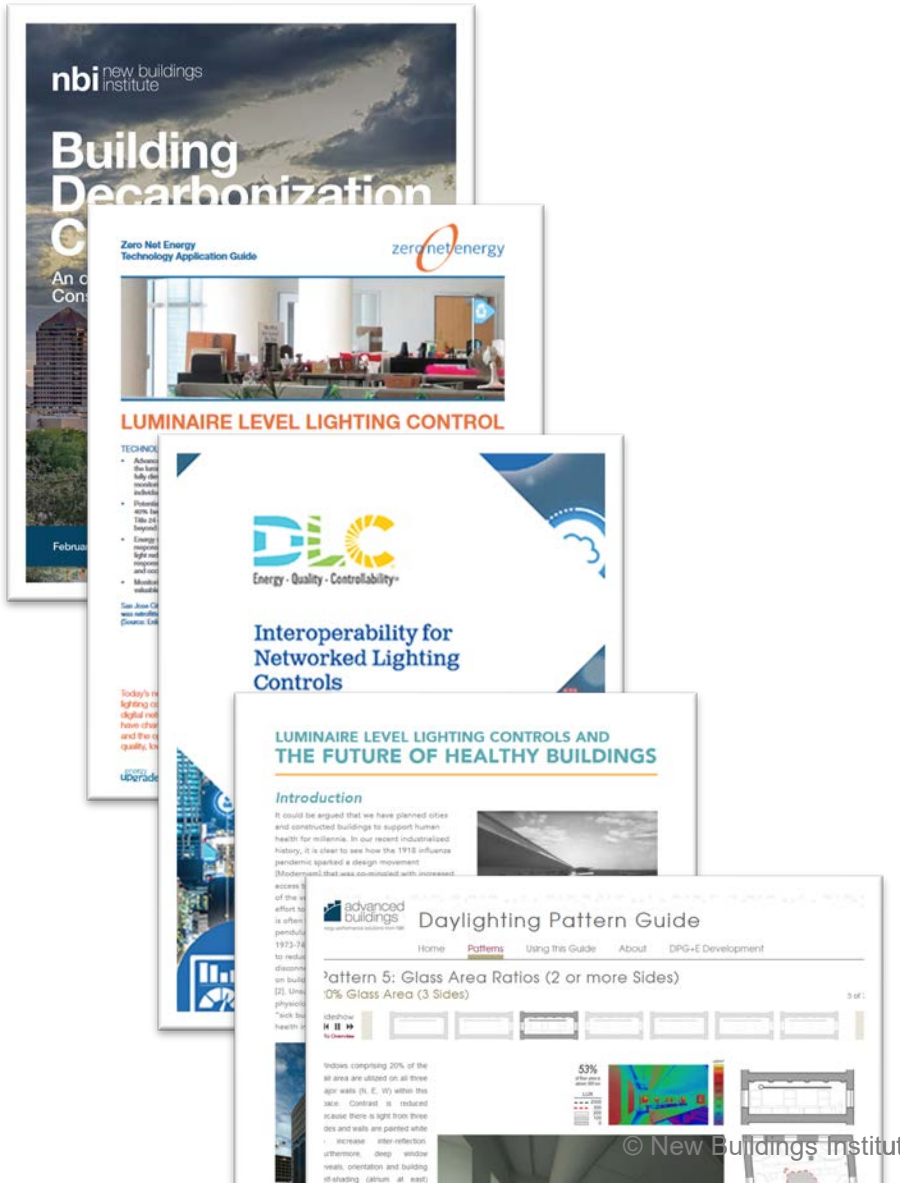
SUMMARY OF PRESENT AND POTENTIAL FUTURE USES OF LLLC DISTRIBUTED SENSORS IN BUILDINGS

CATEGORY	PRESENT LLLC USE CASE	FUTURE LLLC USE CASE
SPACE UTILIZATION & OPTIMIZATION	• Occupancy sensing and occupant density mapping.	• Scheduling and dynamic alerts for space availability and maintenance needs. • Personalized optimization of circadian exposure dosing.
ASSET TRACKING	• Management of equipment, spaces, and personnel. • Optimization of energy consumption via demand response.	• Plug load control optimization/ automation based on occupancy/ vacancy status, operation schedules, and/or demand response signal. • Equipment utilization rate and status.
SECURITY	• Motion/Infrared/Ultrasonic occupancy/ vacancy sensing.	• Motion/Infrared/Ultrasonic sensor(s) for security alerts and security systems.
SAFETY	• Automated switching lighting and equipment to prevent hazards in and around buildings. (Emergency lighting, path/circulation lighting to avoid tripping hazards and improve visibility)	• Camera-based motion sensing with frame-by-frame pattern recognition. (Fire/smoke detection) • AI-based pattern recognition of faces, figures, and objects for more complex environmental monitoring.
VENTILATION & THERMAL COMFORT	• LLLC not integrated with HVAC controls.	• Demand predictive and demand responsive ventilation. • Thermal mapping and dynamic setpoint control via distributed air temperature sensors.
VISUAL COMFORT & CIRCADIAN DOSING	• Illuminance sensors not utilized for visual comfort or circadian dose management. • Luminance cameras are not incorporated into LLLC fixtures/system.	• In-fixture camera-based sensors and integrate secondary devices with available cameras incorporated into sensor network. (Laptops and smartphones) • Monitoring of indoor glare and controlling dynamic blinds/shades. • Monitor light intensity and spectrum for circadian dose.

Table: Better Bricks

Some Resources: *www.newbuildings.org*, and …

- Decarbonization Code Overlay:
  https://newbuildings.org/resource/building-decarbonization-code/
- NBI's 2024 IECC Proposals:
  https://newbuildings.org/code_policy/2024-iecc-national-model-energy-code-base-codes/
- Daylighting Pattern Guide:
  https://patternguide.advancedbuildings.net/
- Interoperability for NLCs Report:
  https://www.designlights.org/resources/reports/report-interoperability-for-networked-lighting-controls/
- LLLC Tech Application Guide:
  https://newbuildings.org/sites/default/files/LLLC_ZNE_TAG.pdf
- LLLC and the Future of Healthy Buildings:
  https://betterbricks.com/resources/lllc-future-healthy-buildings



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Thank you!

alexi@newbuildings.org

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www.newbuildings.org