



Estes Park | Fort Collins | Longmont | Loveland

Welcome to the Efficiency Works Business

LEDs – the right, bright and controllable way to provide light

25 February 2021

We will get started soon.

David Suckling

Fort Collins Utilities

Energy Services Program Manager



Upcoming events

- **Service provider feedback sessions**
Throughout the year – sign up now
- **June 10** – Water efficiency
Virtual event 8:30-10 a.m.
- **November** – Service provider social and awards
In-person event, Loveland

Register for Efficiency Works events:

<https://efficiencyworks.org/resources/events/>

Efficiency Works™

Estes Park Power
& Communications

Fort Collins
Utilities

Longmont Power
& Communications

Loveland Water
and Power

Platte River
Power Authority



Efficiency Works Business – programs for all needs



Resources

Works with staff to have access to professional resources or get facilities assessments completed.



Service providers

Be listed on a searchable list for customers to find efficiency upgrade professionals.



Incentives

Offset the cost of the efficiency upgrade through rebates and direct install opportunities.



Building tune-ups

Get those existing facilities optimized through retrocommissioning and enhanced maintenance efforts.

*Relaunching
spring 2021!*

A word about Exterior Lighting Code

The City of Fort Collins regulates:

Lighting levels by use area

Design Standards for lighting plans:

3 - “Light sources shall be concealed and fully shielded and shall feature sharp cut-off.....”

11 - “All lighting shall have a nominal....CCT no greater than three thousand (3,000) Kelvin.”

All cities in the Platte River territory have similar requirements

Resources for Lighting Code

Estes Park:

https://library.municode.com/co/estes_valley/codes/development_code?nodeId=CH7GEDEST_S7.9EXLI

Fort Collins:

https://library.municode.com/co/fort_collins/codes/land_use?nodeId=ART3GEDEST_IV3.2SIPLDEST_3.2.4SILI

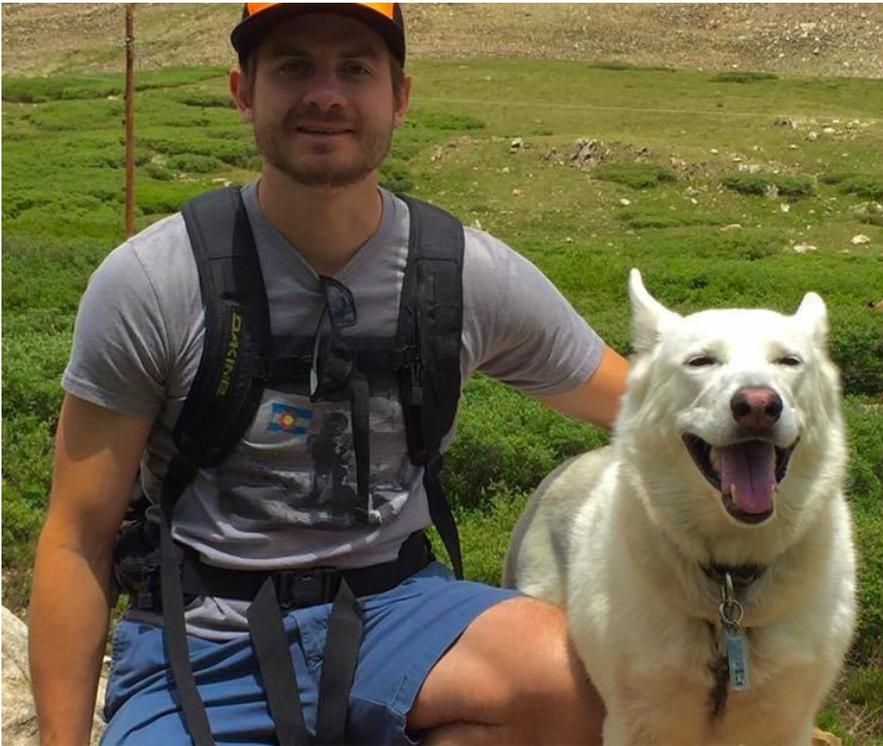
Longmont:

https://library.municode.com/co/longmont/codes/code_of_ordinances?nodeId=PTIICOR_TIT15LADECO_CH15.05DEST_15.05.140OULI

Loveland: <http://online.encodeplus.com/regs/loveland-co/doc-viewer.aspx#secid-4191>

To have this slide emailed to you send request to: dsuckling@fcgov.com

LEDs – the right, bright and controllable way to provide light



Nick Berry

- Nick has been in the lighting industry since 2010 – silly enough to have specialized in Lighting Control that entire time.
- Graduate from the University of Colorado Boulder with a BS in Architectural Engineering.
- Lifelong Colorado Native – Loves all sports (playing or viewing) and loves all that the Colorado outdoors has to offer.



Advancement / Integration

We are here

1960s Initial commercialization of LED light source

1980s Signs and signals

1990s Decorative and accent

2000s White Light LEDs

2000s LED "lamps," "fixtures"

2010s Optimized LED luminaires

2010s Digital Lighting / Control Systems

2020s Intelligence-driven Solutions



Why Implement Controls??

- 1) REBATES!
- 2) Energy Savings
- 3) Code!
- 4) Occupant Comfort and Experience
- 5) Ease of Implementation
- 6) Future Expandability



Rebates

OVER 53 DLC LISTED NETWORKED LIGHTING CONTROL SYSTEMS!

Measure	Incentive (\$/Watt _{Reduced})	Criteria	Examples
Prescriptive Lighting Rebates	Varies	Varies. See Prescriptive Lighting Rebate table at the top of this page	Grocery case lighting, exit signs, and the following ENERGY STAR fixtures: can lights, wrap lights, strip lights, bath vanities, ceiling mount lights, and decorative pendants.
LED fixture (replacing fluorescent)	\$1.00	New Hardwired LED fixture must: <ul style="list-style-type: none"> • Be listed on the DLC Qualified Products List (QPL) or ENERGY STAR Certified • Replace an existing fluorescent fixture (T5, T8, T12, CFL, induction, etc) • Have integral LEDs (i.e. not lamps or tubes) Additional rebate of \$0.25 per watt is available if new fixture has DLC integrated advanced controls as defined below. Examples: Troffers, wraps, fluorescent high bays	This category does not include LED emergency lights (frog eyes) or any other upgrade that utilizes the existing housing or socket. See LED Retrofit below.
LED fixture (replacing HID/incandescent)	\$1.00	New Hardwired LED fixture must: <ul style="list-style-type: none"> • Be listed on the DLC Qualified Products List (QPL) or ENERGY STAR Certified • Replace any non-fluorescent fixture (such as HID, incandescent, or LED) • Have integral LEDs (i.e. not lamps or tubes) Additional rebate of \$0.25 per watt is available if new fixture has DLC integrated advanced controls as defined below. Examples: Area lights, wall packs, HID high bays	This category does not include LED emergency lights (frog eyes) or any other upgrade that utilizes the existing housing or socket. See LED Retrofit below.
LED Retrofit (replacing fluorescent)	\$0.50	Hardwired Retrofit or Retrofit Kit must: <ul style="list-style-type: none"> • Be listed on the DLC Qualified Products List (QPL) or ENERGY STAR Certified • Retrofit an existing fluorescent fixture (T5, T8, T12, CFL, induction, etc) • Be hardwired (i.e. not use the existing socket for power) Examples: Type C LED tubes with external driver, area light retrofits, monument and backlit signs	This category does not include any LED lamps that use the existing socket for power, including Type A or Type B LED tube lights. This category does not include LED emergency lights (frog eyes).
LED Retrofit (replacing HID/incandescent)	\$0.50	Hardwired Retrofit or Retrofit Kit must: <ul style="list-style-type: none"> • Be listed on the DLC Qualified Products List (QPL) or ENERGY STAR Certified • Retrofit any non-fluorescent fixture (such as HID, incandescent, or LED) • Be hardwired (i.e. not use the existing socket for power) Examples: Area light retrofits, monument and backlit signs	This category does not include any LED lamps that use the existing socket for power, including LED corn cobs. This category does not include LED emergency lights (frog eyes).
LED Lamp/Other	\$0.10	Lamp must be on either the DLC QPL or ENERGY STAR Certified. This category includes any LED lamp with an internal driver. Other 'specialty' products may be considered in this rebate category on a case-by-case basis. Examples: A19 or BR/R Flood bulbs, Type A or Type B LED tubes, LED tape light, "corn cobs"	This category does not include LED emergency lights (frog eyes).
Fixture removal only	\$0.10	Permanent removal of existing fixtures	This category does not include reduction of fixtures due to lighting redesign.
Bonus Rebates for Automatic Controls¹			
Multi-level controls	\$0.25	Add automatic controls to new LED fixtures/retrofits/lamps such that each fixture is controlled by at least two means. This may include a combination of two of the following: occupancy/motion sensor, photocell/daylighting sensor, or scheduled timer.	This category does not apply to new controls replacing identically functioning existing controls. At least one additional control must be added to the existing conditions to meet the multi-level control requirement. Manual dimmers are not eligible.
DLC networked controls	\$0.50	DLC Networked Lighting Control System (NLCS). If the controls are integral to the fixture, the full fixture model number indicating the controls must be shown on the invoice to be eligible	This category does not apply to controls integral to - or added on to - LED retrofits or lamps. 

Existing: (3) Lamp T8 @ ~85W

New LED: 32W Fixture

\$1.00/W_{reduced} for fixture = \$53

\$0.50/W_{reduced} for controls = \$26.50

TOTAL REBATE = \$79.50

Energy Savings

Figure 1. Distribution of NLC savings across all buildings analyzed (n=194).

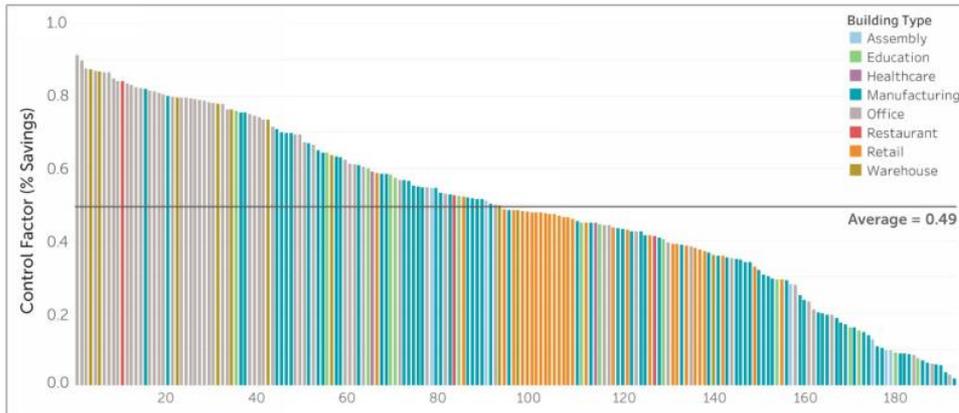


Table 1. Summary of estimated control factors by building types.

Building Type	Total Buildings	Unique Manufacturers	Control Factor* (% Savings)			
			Average	25th-75th Percentile**	High-End Trim Contribution	Other Control Strategies***
Assembly	6	2	0.28	0.11 - 0.45	0.07	0.23
Education	14	5	0.41	0.19 - 0.58	0.19	0.32
Healthcare	2	1	0.52	0.48 - 0.56	0.33	0.24
Manufacturing	73	4	0.40	0.20 - 0.55	0.16	0.29
Office	57	8	0.64	0.53 - 0.81	0.46	0.36
Restaurant	3	2	0.59	0.47 - 0.68	0.27	0.30
Retail	29	1	0.44	0.39 - 0.48	0.22	0.27
Warehouse	10	2	0.68	0.53 - 0.79	0.38	0.48
Overall	194	12	0.49	0.35 - 0.69	0.27	0.32

* A control factor is a number between 0 and 1, representing the fraction of the energy saved through controls. 0 represents no savings, and 1 means all energy is saved. Control factor is equivalent to percent savings (% savings) when presented in percentage. For example, a control factor of 0.49 is equivalent to 49 percent savings (49% savings).

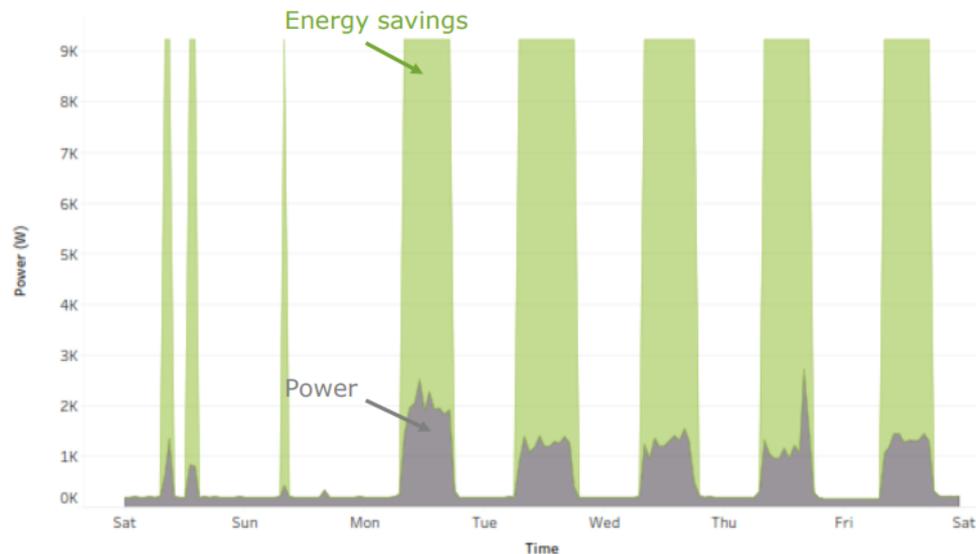
** The range for the middle 50% is displayed instead of the full range between the minimum and the maximum to provide a more representative range of savings one can generalize and expect.

*** In this report, the control factors for control strategies other than high-end trim, unless otherwise noted, are in comparison to an inferred baseline with savings from high-end trim removed. Therefore, the control factors for high-end trim and other control strategies will not add up to the overall control factor. See Page 33 for a more detailed discussion.

Source: DLC ENERGY SAVINGS FROM NETWORKED LIGHTING CONTROL (NLC) SYSTEMS WITH AND WITHOUT LCCC. SEPT. 24, 2020

Energy Savings

What Site Characteristics Result in High NLC Savings?



Major factors that enable high savings:

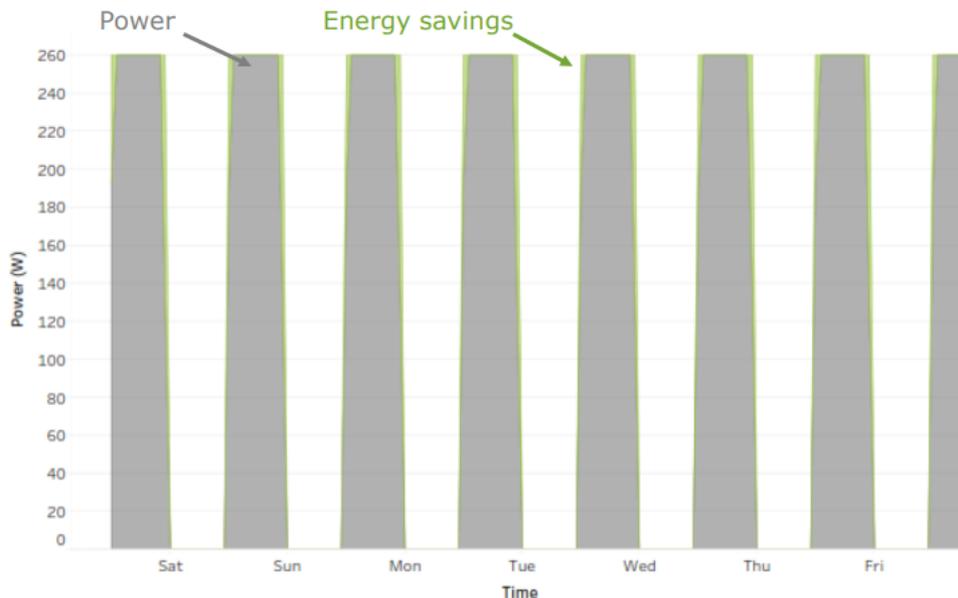
- Significant high-end trim (up to 60%)
- Aggressive occupancy controls

Other factors may include (but are more difficult to attribute savings to):

- Daylight harvesting
- High swings in occupancy
- Scheduling controls

Energy Savings

What Site Characteristics Result in Low NLC Savings?



Sample zone within a manufacturing facility

NLC system used primarily as a scheduling control:

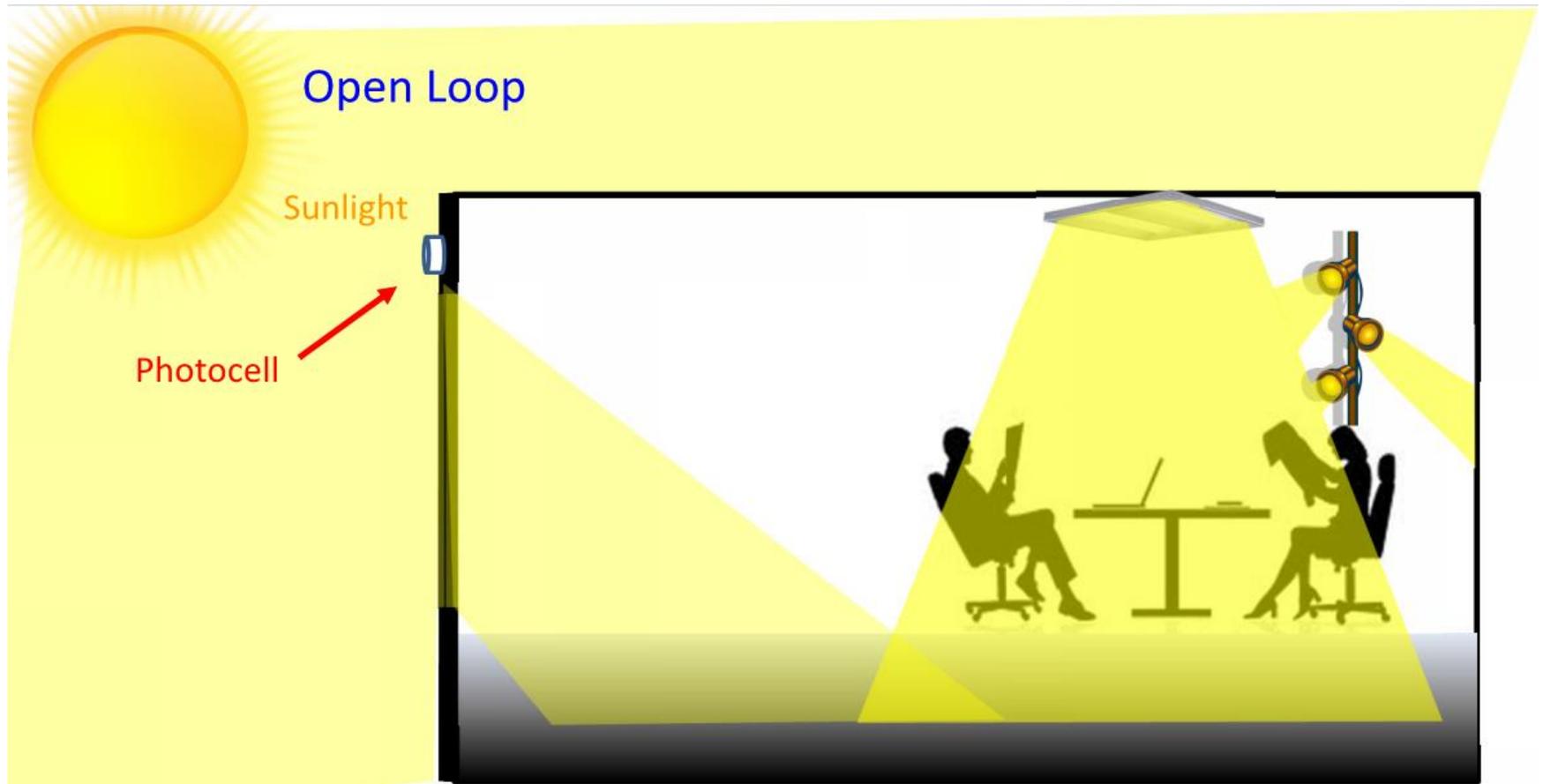
- No high end trim
- Lights appear to be at 100% full-time
- Occupancy controls not enabled or building does not have occupancy shifts

Common Strategies

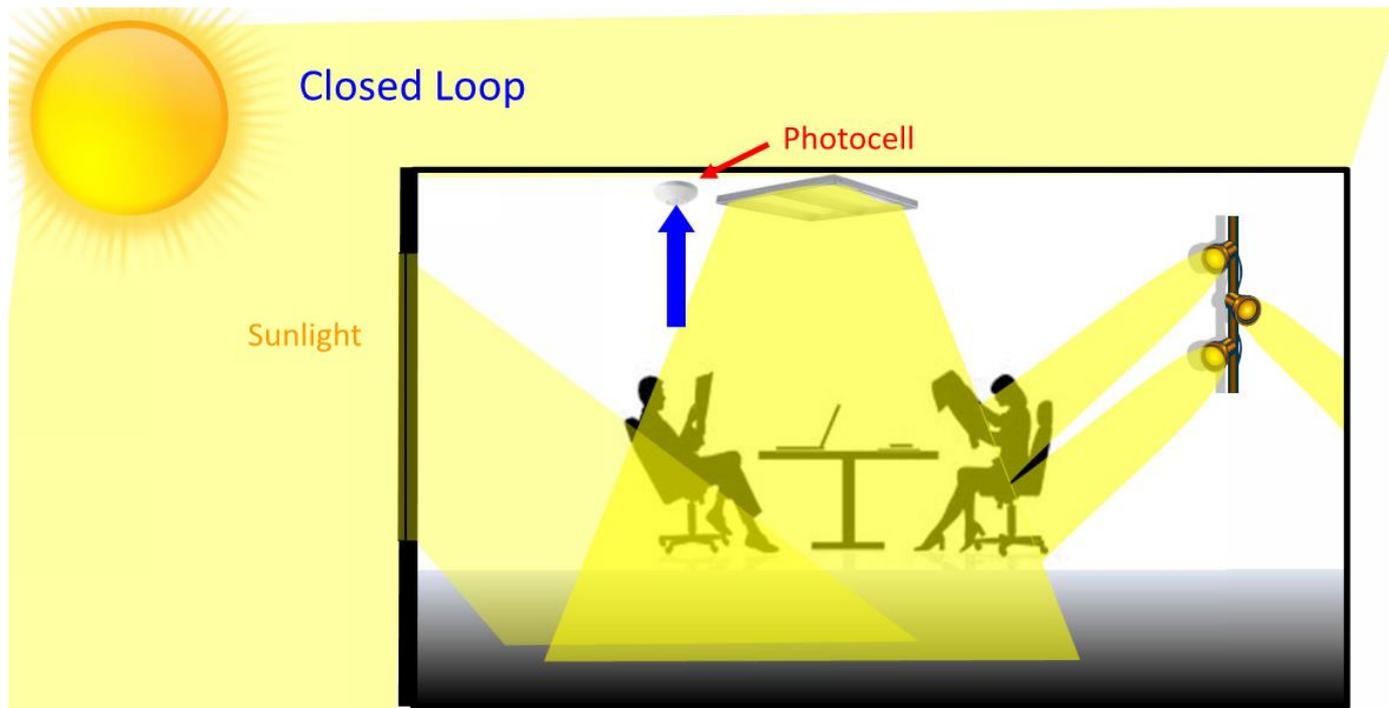
CONTROL CAPABILITY	DLC DEFINITION
 Daylight harvesting	The capability to automatically affect the operation of lighting or other equipment based on the amount of daylight and/or ambient light present in a space, area, or exterior environment.
 Occupancy sensing	The capability to automatically affect the operation of lighting equipment based on the detection of the presence or absence of people in a space or exterior environment.
 High-end trim	The capability to set the maximum light output to a less-than maximum state of an individual or group of luminaires at the time of installation or commissioning.
 Scheduling <small>(reported, not required)</small>	The capability to automatically affect the operation of lighting equipment based on time of day, week, month, or year.
 Personal control <small>(reported, not required)</small>	The capability for individual users to adjust the illuminated environment of a light fixture or group of light fixtures in a specific task area to their personal preferences, via networked means.
 Luminaire level lighting control <small>(reported, not required)</small>	The capability to have a networked occupancy sensor and ambient light sensor installed for each luminaire or kit, and directly integrated or embedded into the form factor during the luminaire or kit manufacturing process.



Daylight Harvesting

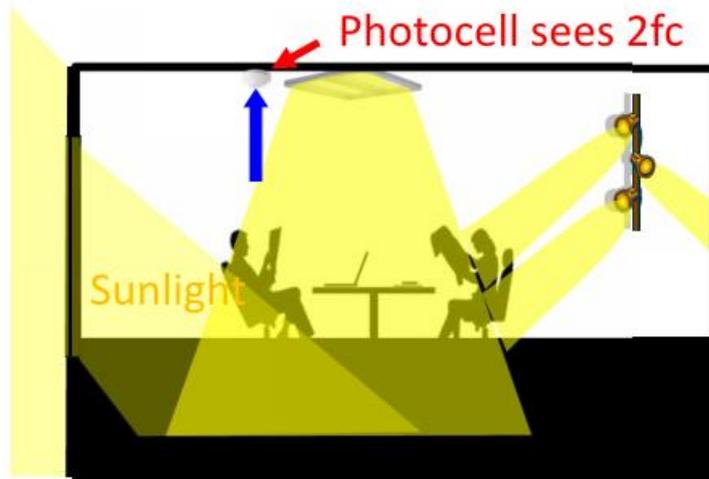


Daylight Harvesting

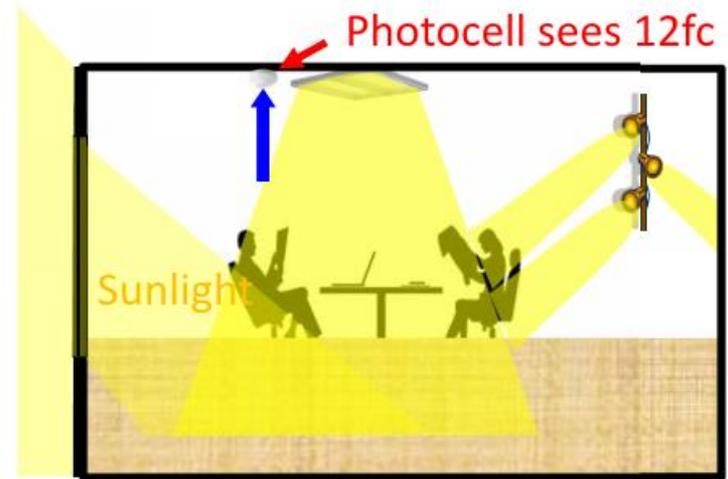


Typically uses a set point expressed in foot-candles (fc)

Daylight Harvesting



Black floor



Beige floor

Occupancy / Vacancy Sensors

Why Sensors?



Occupancy / Vacancy Sensors

Why Sensors?

IECC 2018

C405.2.1 Occupant sensor controls.

Occupant sensor controls shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms.
2. Conference/meeting/multipurpose rooms.
3. Copy/print rooms.
4. Lounges/breakrooms.
5. Enclosed offices.
6. Open plan office areas.
7. Restrooms.
8. Storage rooms.
9. Locker rooms.
10. Other spaces 300 square feet (28 m²) or less that are enclosed by floor-to-ceiling height partitions.
11. Warehouse storage areas.

RECENT AMENDMENTS (applicable to Fort Collins)

Section C405.2.1 Occupant sensor controls is hereby retained in its entirety with the following amendments:

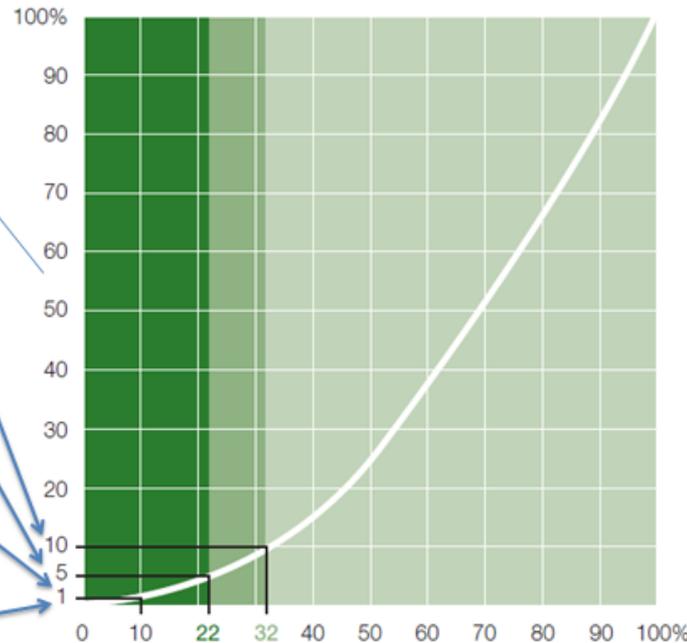
In new construction and additions that require a building permit, occupant sensor controls shall be provided to automatically reduce connected lighting power by not less than 50 percent during periods when no occupants are present in the following locations:

1. corridors and enclosed stairwells;
2. storage stack areas not open to the public;
3. library stack areas; and
4. parking garages.

High End Trim



Measured Light



Commodity - Dim to 10%,
32% Perceived
Load shedding

Industry Standard - Dim to 5%,
22% Perceived
Energy management dimming

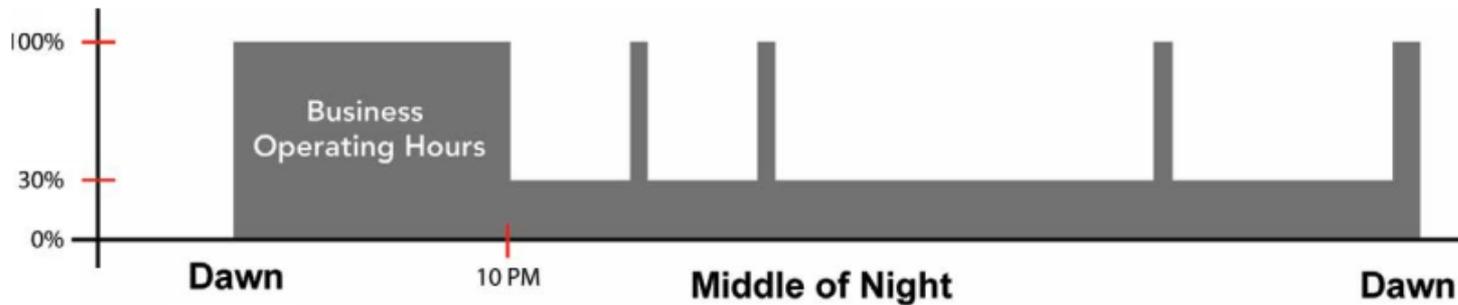
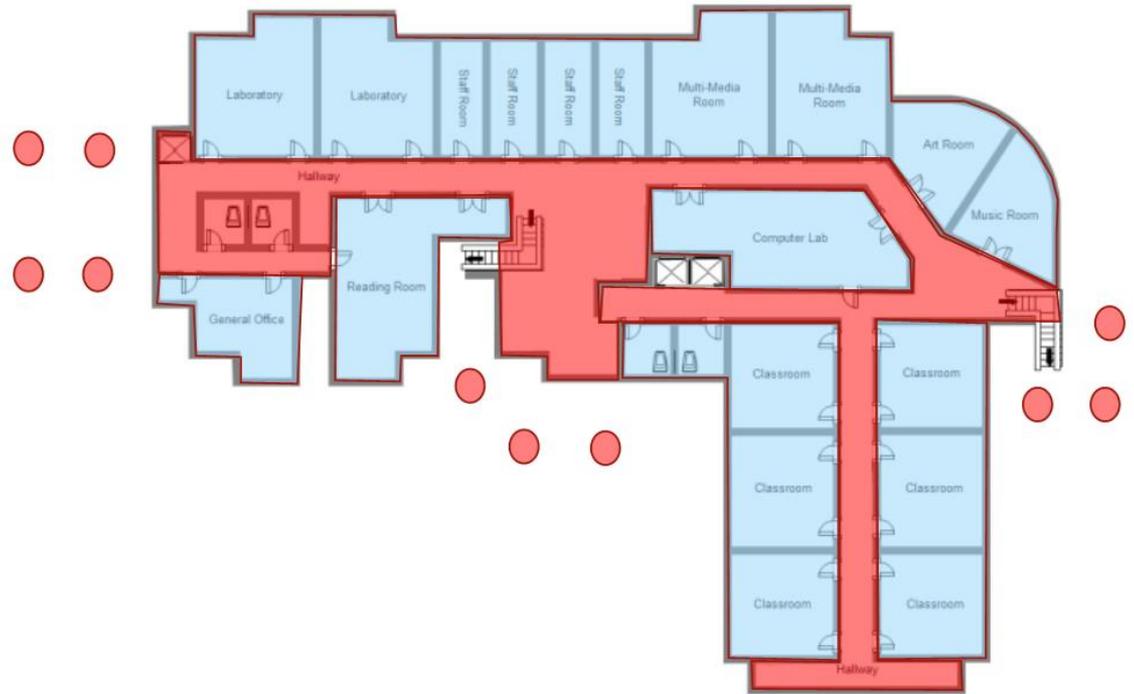
New Standard EZ1 - Dim to 1%,
10% Perceived
Daylight & Conference Rooms

OPTION EZB 0.1% Dim to black
(eldoLED only) 3% Perceived
Highest-Performance spaces



Perceived Light

Scheduling



Manual Control

MAKE IT PERMANENT



Install a Dimmer Switch >

Luminaire Level Lighting Control (LLLC)



C405.2 Lighting controls (Mandatory).

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

1. Lighting controls as specified in Sections C405.2.1 through C405.2.6.
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:
 - 2.1. Monitoring occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.
 - 2.2. Monitoring ambient light, both electric light and daylight, and brighten or dim artificial light to maintain desired light level.
 - 2.3. For each control strategy, configuration and reconfiguration of performance parameters including; bright and dim setpoints, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configurations.

Luminaire Level Lighting Control (LLLC)

Figure 16. Control factors of NLCs with and without LLLC across all buildings analyzed.

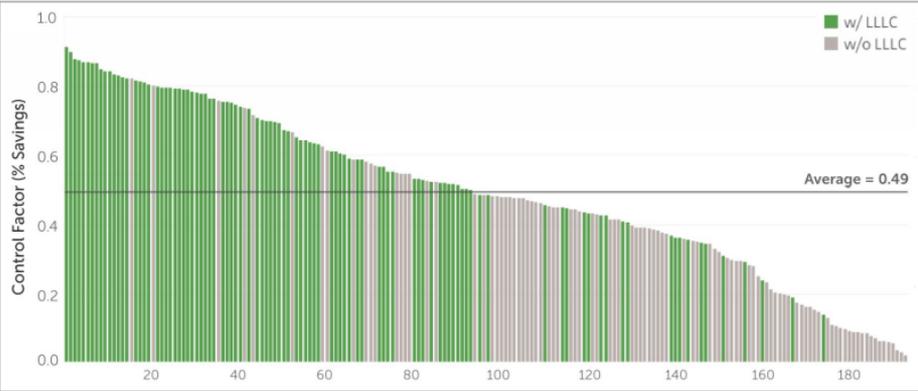


Table 6. Summary of estimated control factors by LLLC and control strategies.

LLLC Presence	Total Buildings	Control Factor (% Savings)			
		Average	25th-75th Percentile	High-End Trim Contributions	Other Control Strategies
NLCs w/ LLLC	98	0.63	0.50 - 0.79	0.37	0.41
NLCs w/o LLLC	96	0.35	0.17 - 0.48	0.17	0.22
All NLCs	194	0.49	0.35 - 0.69	0.27	0.32

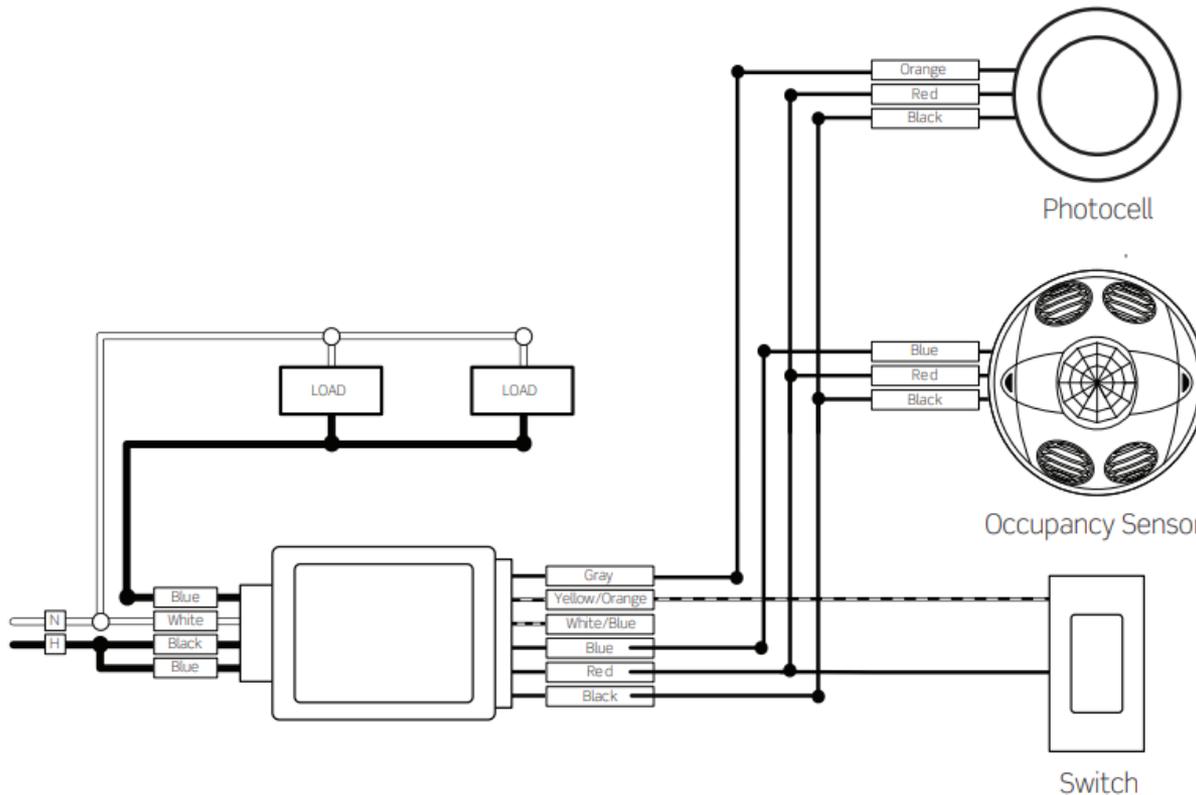
Note: The numbers in this table are meant to provide a high-level overview of average savings trends. Additional study is needed to control for potentially confounding variables. At this time, the data does not imply that LLLC is universally superior or applicable to all building types.

Table 7. Summary of estimated control factors by building type and LLLC.

Building Type	Total Buildings	Unique Manufacturers	Average Control Factor (% Savings)		
			NLCs w/ LLLC	NLC w/o LLLC	All NLCs
Education	14	5	0.52	0.35	0.41
Manufacturing	73	4	0.51	0.26	0.40
Office	57	8	0.77	0.40	0.64
Overall	194	5	0.63	0.35	0.49

Note: The building types included in this analysis are those where there was sufficient diversity across NLCs with and without LLLC and across different manufacturers. The "overall" row includes all building types and all NLCs.

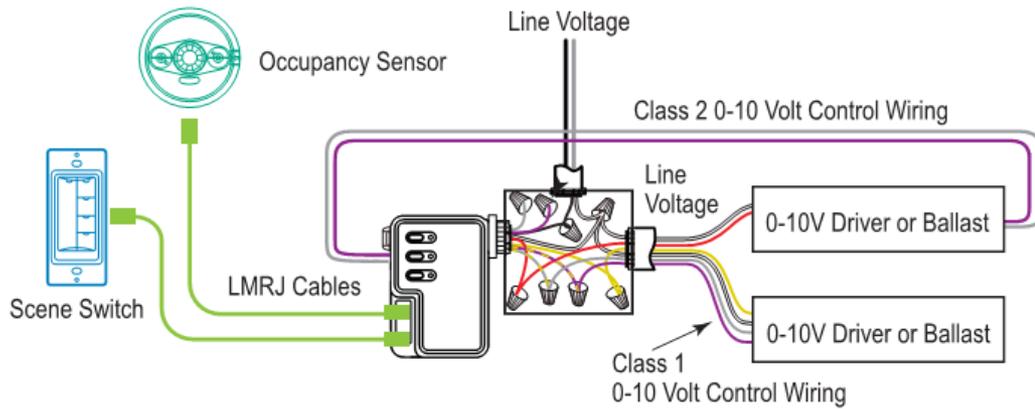
Implementation - Analog



Dimming?
3-way?
Multiple Zones?
Adjustments?

So many wires
And
Wirenuts!

Implementation - Digital

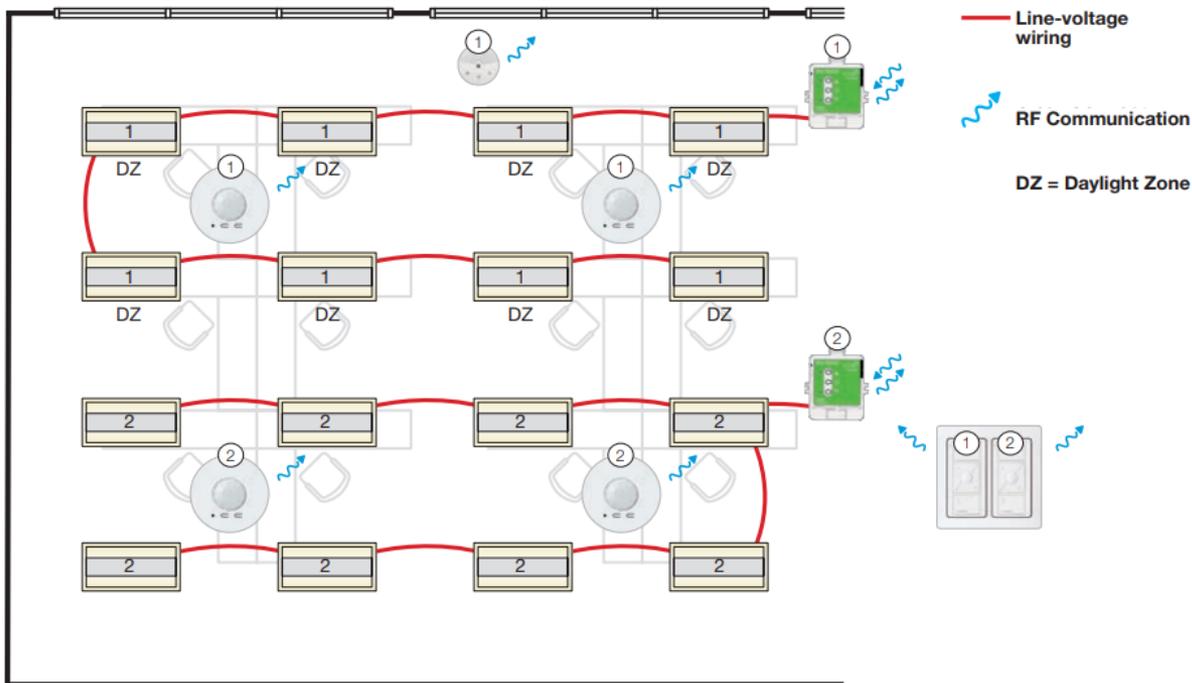


Better, More Flexible.

Still a hardware and Labor investment For control wiring (e.g. CAT5)

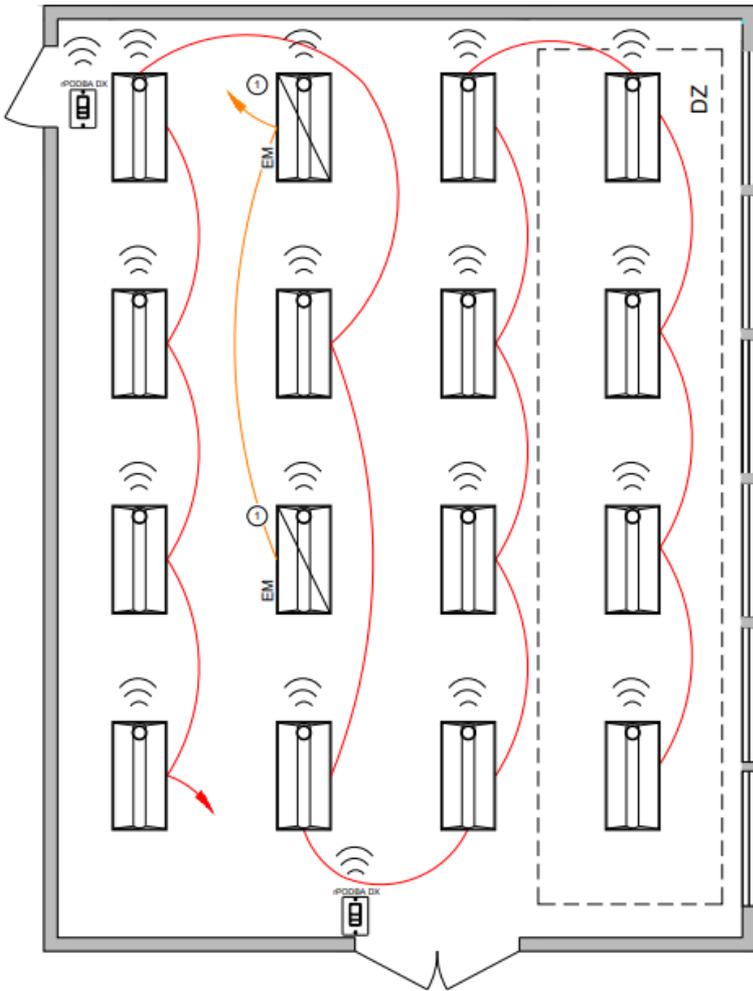
Wire Color	Function
Black	Line in
White	Neutral
Red	Load A switched hot
Yellow	Load B switched hot
Violet	Load A 0-10V (+)
Gray	Load A 0-10V (-)
Violet/Yellow	Load B 0-10V (+)
Gray/Yellow	Load B 0-10V (-)

Implementation – Wireless, Loose Devices

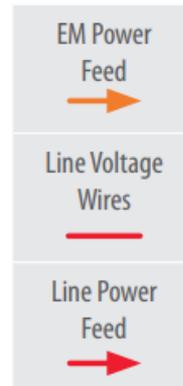


**Eliminates a lot
Of hurdles,
But not
Truly Wireless!**

Implementation – LCCC



① Fixture(s) assumed to include power interruption detection emergency option. For battery backup option, no dedicated EM circuit necessary.



Bill of Materials

Symbol	Qty	Product #	Description
	14	See Note	Enabled Troffer with Sensor Option
	2	See Note	Enabled Troffer with Sensor and EM Option
	2	rPODBA DX G2	Battery Powered, On/Off, Raise/Lower WallPod

/ OPERATIONAL DETAILS:

Light Fixtures:

- All fixtures are dimmable
- All fixtures are controlled together or independently
- Maximum level can be task tuned to any percentage via programming

Occupancy Control:

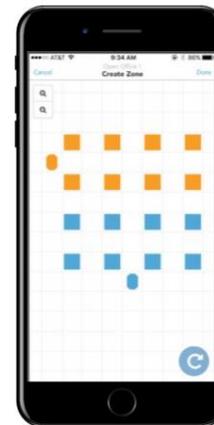
- Fixtures must be turned on manually (or optionally can be configured to come on automatically to 50%)
- Fixtures turn off automatically when room becomes vacant
- General lighting must be controlled in zones not greater than 600 sq. ft.

Daylight Control:

- Smooth continuous dimming
- Custom grouping of fixtures into separate daylight zones (max. number zones = number of fixtures)
- Not required for offices without windows or that have loads <150W in sidelit zones

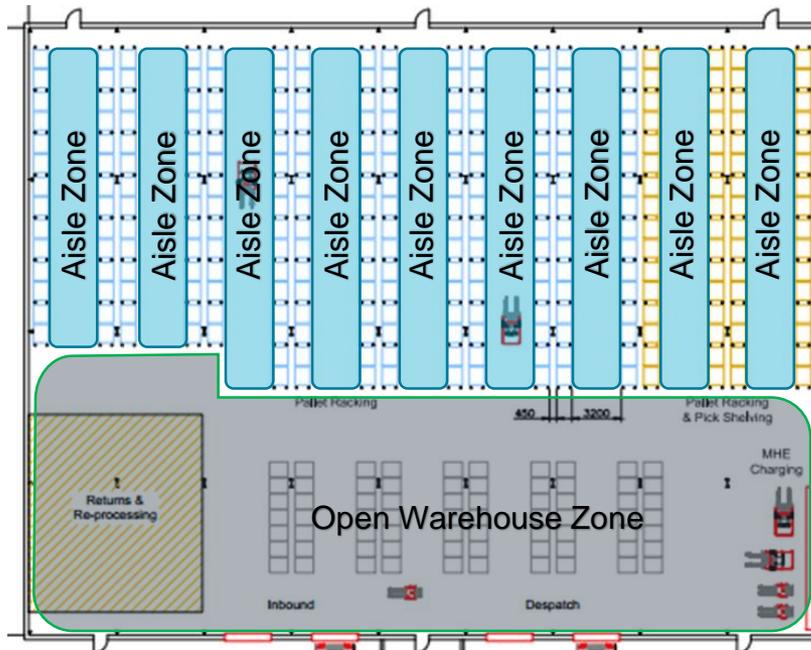
Manual Control:

- On/off & raise/lower control of fixtures



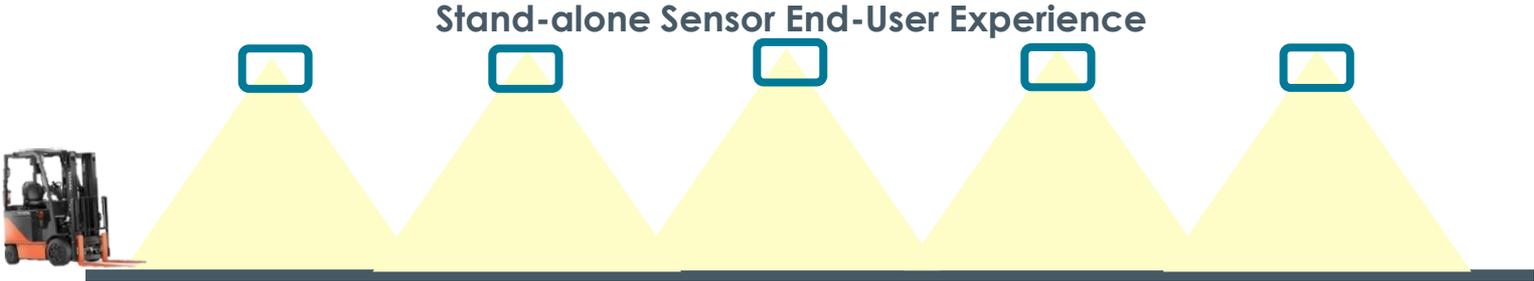
Implementation – IECC 2018 Warehouses

Control Functionality

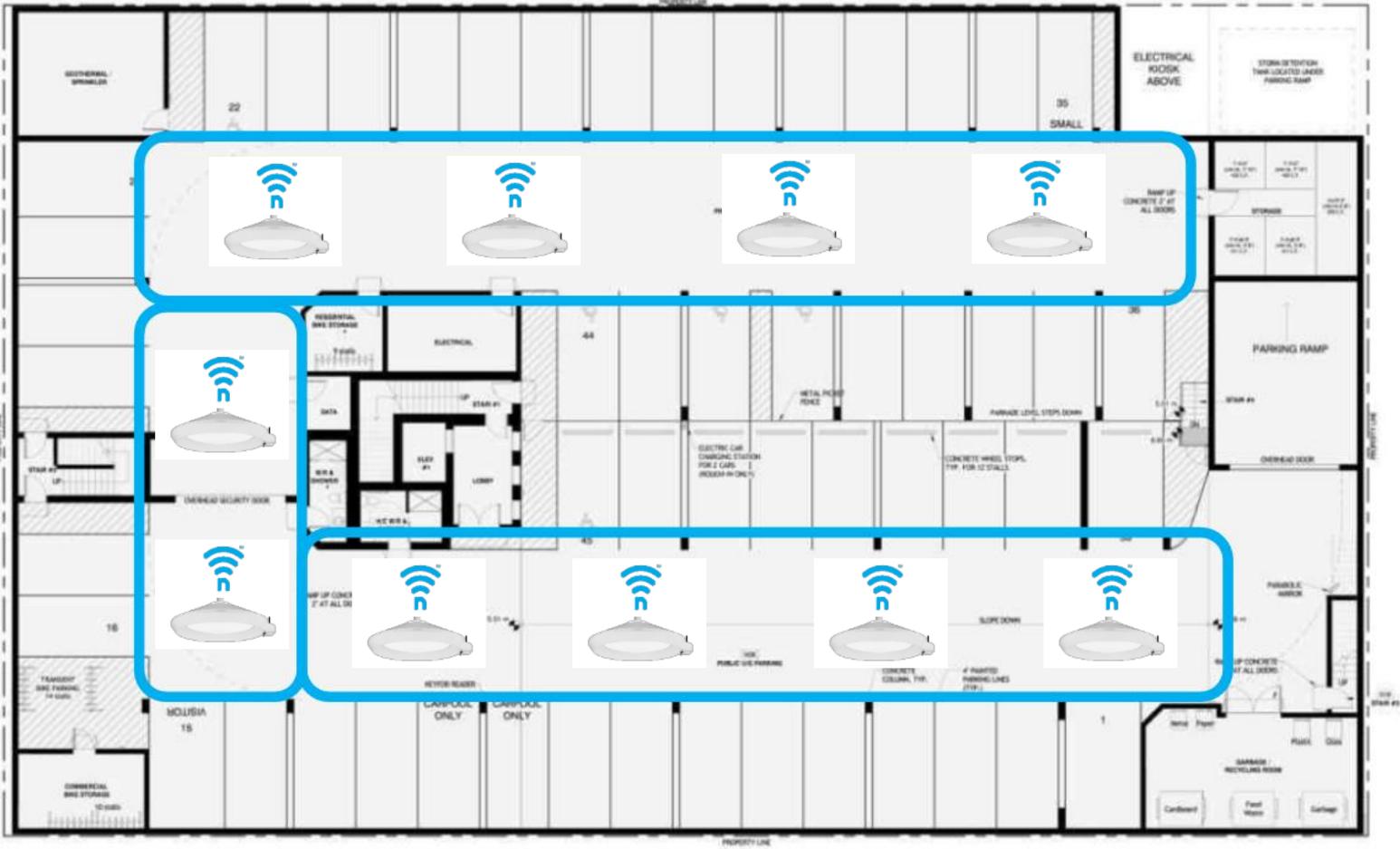


- reduce lighting power by at least 50% when unoccupied... (dim or turn off)
- Aisleways must be controlled independently and not grouped with lighting beyond the aisleway

Implementation – IECC 2018 Warehouses



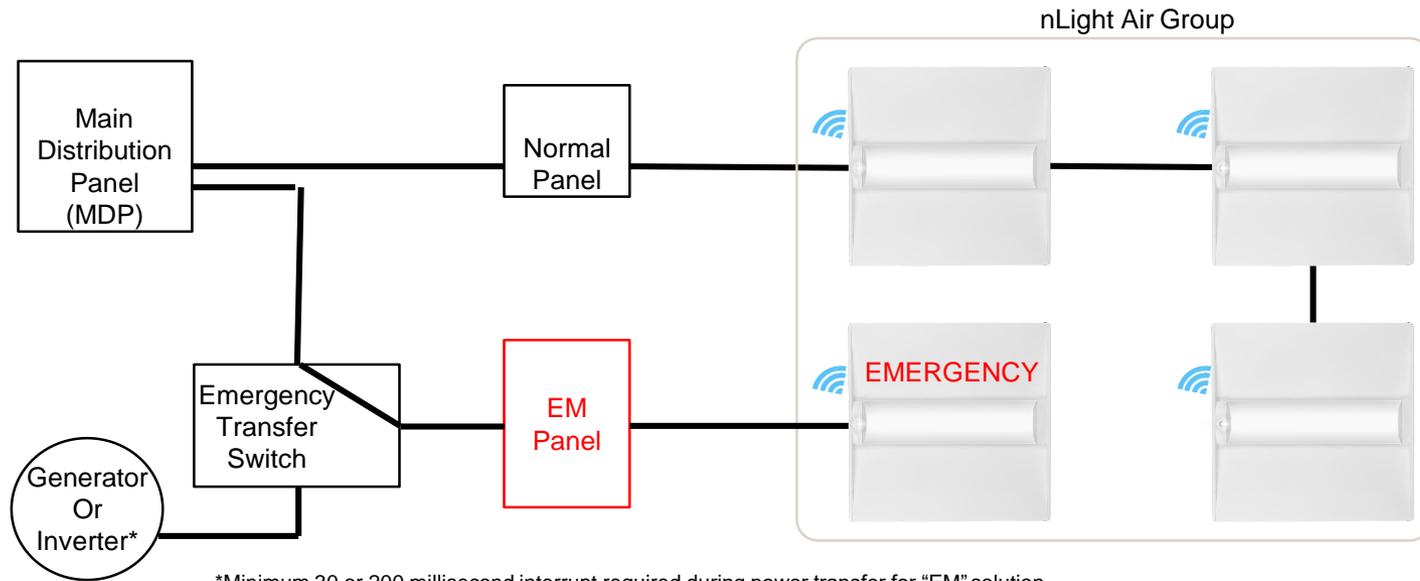
Implementation – IECC 2018 Parking Garage



Implementation – LCCC

Emergency UL-924

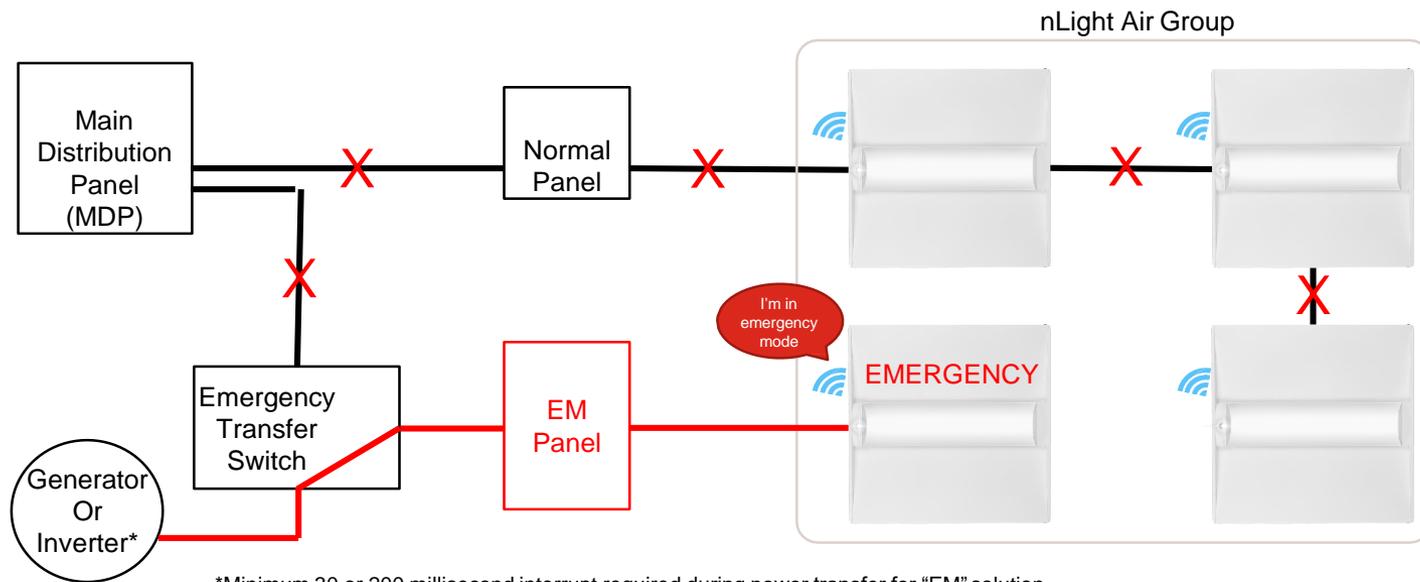
Under Normal Power



Implementation – LCCC

nLight Air “EM” Solution

Under Backup Power

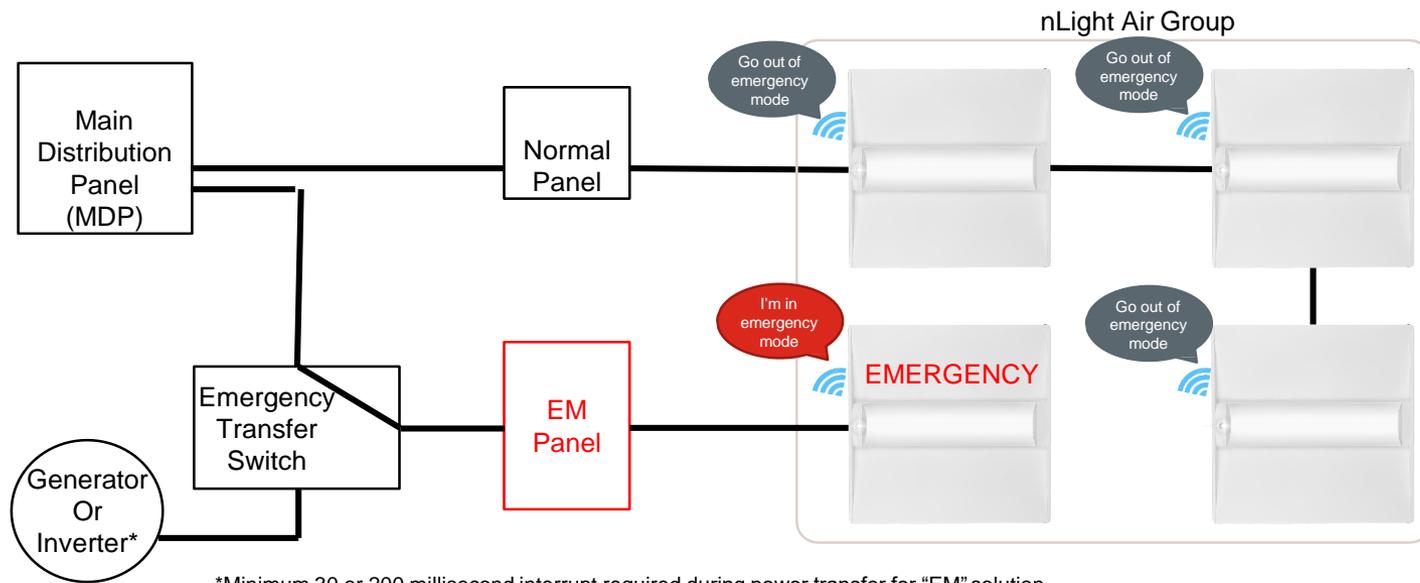


*Minimum 30 or 200 millisecond interrupt required during power transfer for “EM” solution

Implementation – LCCC

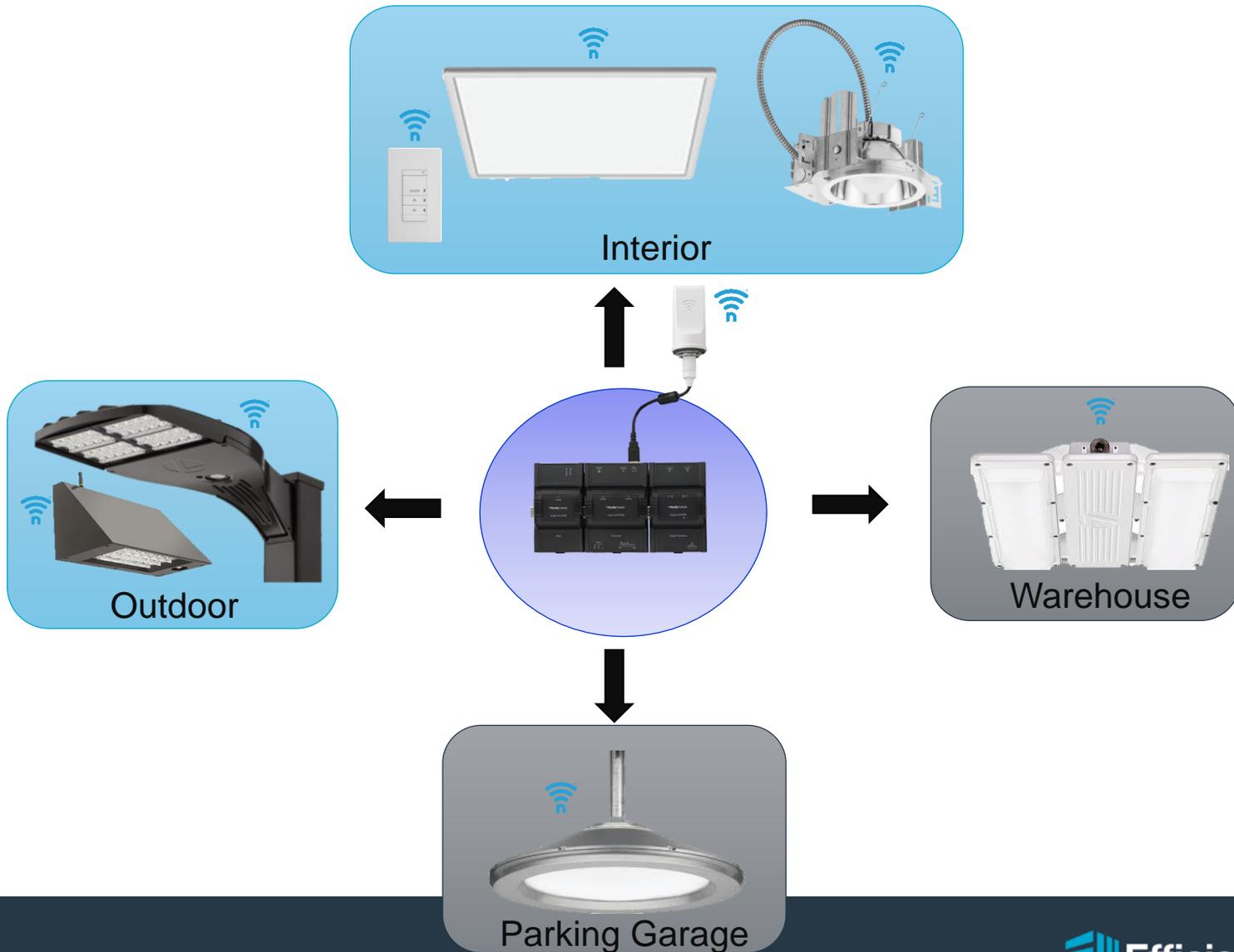
nLight Air “EM” Solution

Power is Restored



*Minimum 30 or 200 millisecond interrupt required during power transfer for “EM” solution

Implementation – Networking



Networking - Software

STRATEGY	DESCRIPTION	SAVINGS
 Scheduling	Automated control based on time of day, or relative to sunrise and sunset. Temporary timers and blink warnings ensure easy occupant override.	10-40%
 Occupancy Sensing	Turn off lights and set-back HVAC in unoccupied areas. Share occupancy information with BMS or security systems.	10-30%
 Daylight Harvesting	Seamlessly dim or switch artificial lighting in response to available daylight.	5-15%
 Task Tuning	Reduce eye strain and save additional energy by presetting light levels below 100% (full output).	5-15%
 Occupant Controls	Intuitive controls allow adjustment of lighting or temperature to maximize occupant comfort and productivity.	5-25%
 Load Shedding	Minimize peak demand charges and reduce real time energy usages through automated curtailment of various building electrical loads.	5-15%
 HVAC	Leverage lighting system scheduling, sensors, and wall stations to integrate HVAC control.	Situational
 Plug Load Control	Turn off plug loads based on time, occupancy or for load shedding.	Situational
 PC-Based Control	Remote control and monitoring of lighting and sensors simplifies building operations for facility managers and security staff.	Situational

Mike B-OSPC (nCM PDT 9 ADC)

Occupancy, Relay & Dimming

 Occupied: No

 Follow Photocell Level: 80%

 Unscaled Dim Level: 80.0%

 Dim Level: 80%

 Pole State Reason: Not controlled by sensor

 Actual Voltage Output: 8.18 V

PIR & PDT

 Time Delay Timer: 00:09:59

 PIR Activity: Motion Detected

 Tracked Occupancy Timer: 00:00:00

 Mic Activity: No Activity

Photocell

 Transition Time: 00:10:00

 Measured Light Level: 25.9 fc

Scenes & Profiles

 Scene Active: No

 Profile Active: No

Single Management Interface
Complete Configurability
Optimized Operation
Remote Connectivity

Networking - BAS Integration



Unified HVAC and Lighting Graphics



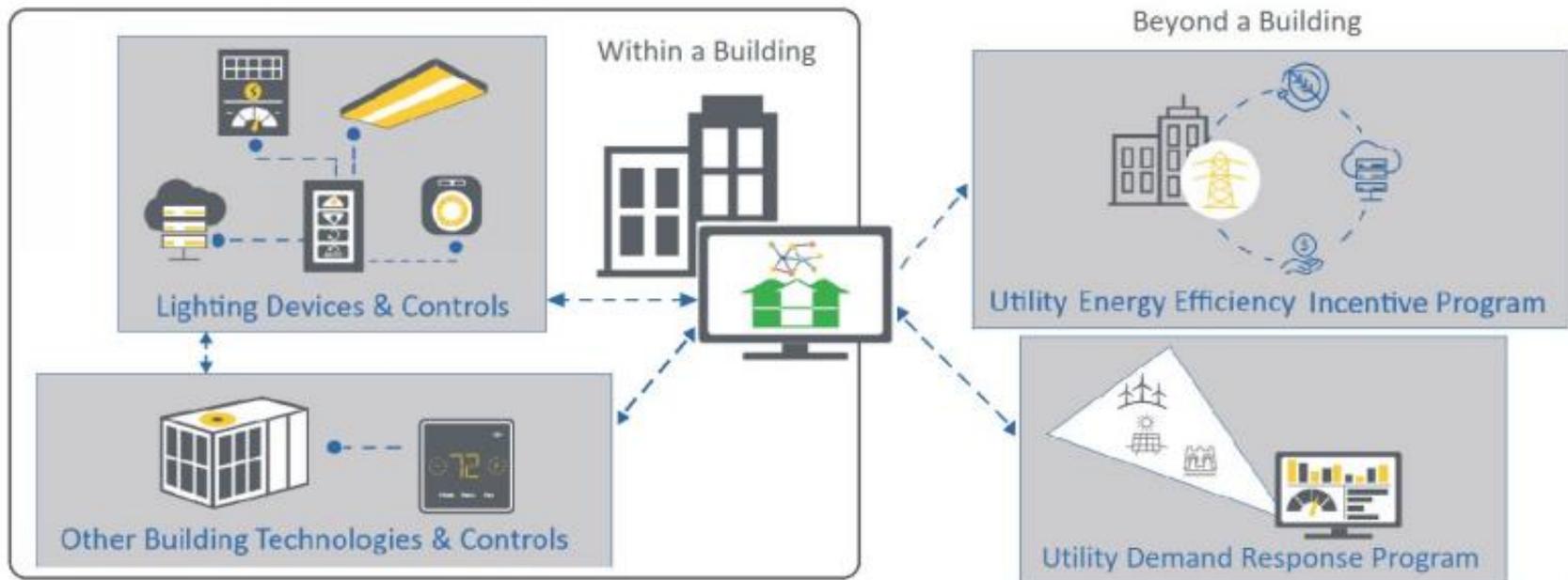
BMS/HVAC Controller

Lighting Controller



Wireless Controls

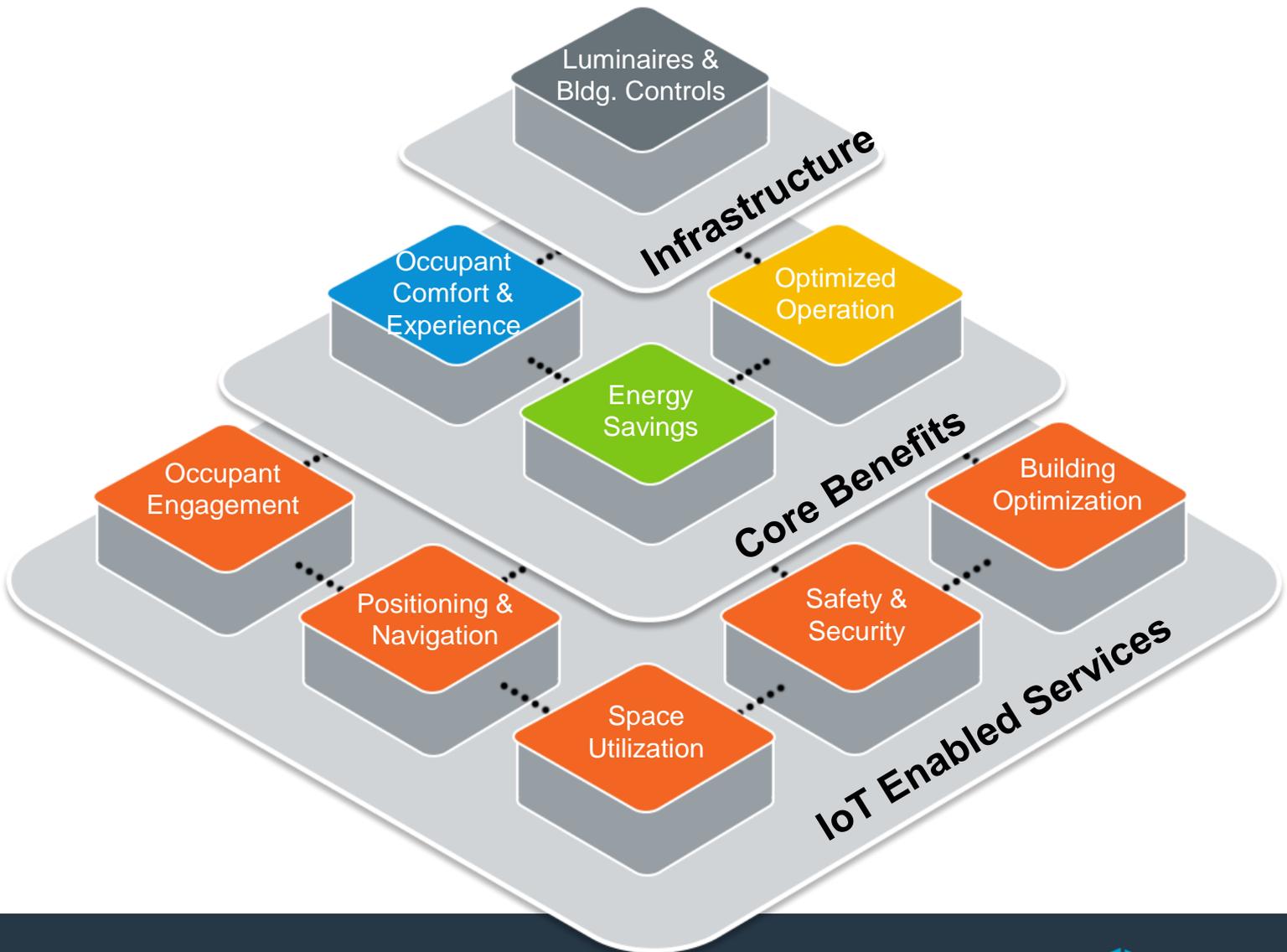
Networking – Demand Response





Energy & Maintenance optimization are just the tip of the iceberg...

Future Expandability - IoT



THANK YOU

Reminder: Upcoming events

2021 JUNE						
SUN	MON	TUE	WED	THU	FRI	SAT
		1	2	3	4	5
		Water efficiency				
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

2021 training events

Efficiency Works Business:

Water efficiency

June 10th – virtual event

Register at:

EfficiencyWorks.org

Thank you for participating in Efficiency Works Business

Email: Business@EfficiencyWorks.org
EfficiencyWorks.org



Estes Park | Fort Collins | Longmont | Loveland