

# Jump Starting Networked Lighting Controls Projects in Schools (NLC in Schools!)

Presented by

**Armando Berdiel Chavez, LC, M.Eng.**

**Technical Development Supervisor**

**May 4<sup>th</sup>, 2021**



I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom  
I will not mess with the Lighting System in the Classroom



l i g h t i n g   d e s i g n   l a b

# Before we begin...

## During the Webinar

- Attendees will be muted
- Please use the chat feature in the control panel to submit questions to LDL staff
- The presenter will pause to address questions every ~10 minutes
- Please participate in the online polls.

## Following the Webinar

- Please take the short survey
- A recording and the slide deck will be posted on LDL's webpage
- Reach out to [LightingDesignLab@seattle.gov](mailto:LightingDesignLab@seattle.gov) with comments or questions.



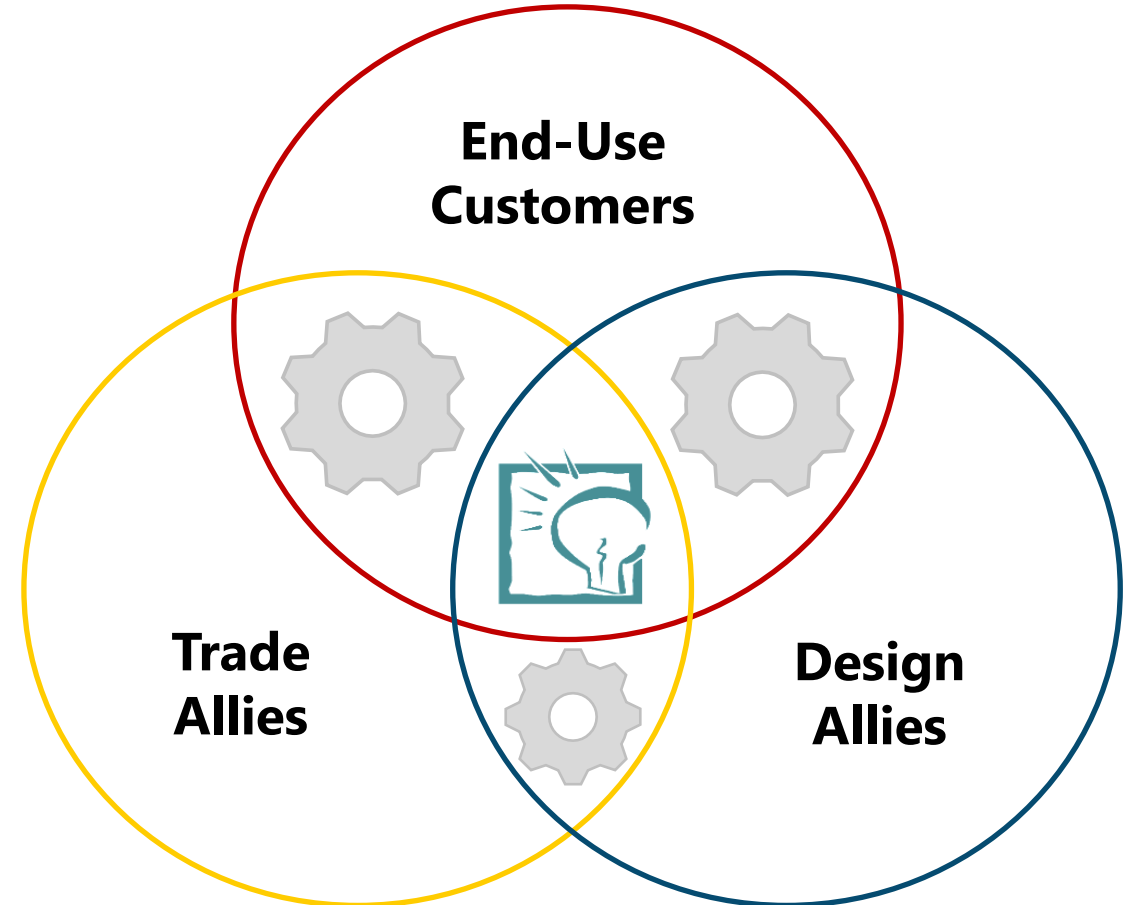
*Powered by*

**Seattle City Light**

# Who We Work With



*It takes a village...*



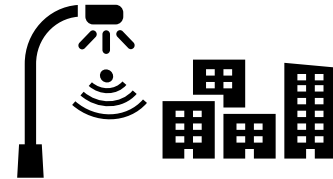


# LDL's Four Core Service Areas

## EDUCATION & TRAINING



## TECHNOLOGY EVALUATION



## TOOLS & RESOURCES



## INFORMATION AGGREGATION



# Quick Instructor Background



**Armando Berdiel Chavez, M.Eng., LC**  
*Technical Development Supervisor*



- Lehigh University, B.S.
  - Computer Science & Business
- Penn State University, Meng.
  - Engineering Management
- Lutron Electronics (PA)
  - Systems Support (Commercial & Resi)
  - Sr. Project Coordinator – Commercial Inside Sales (Spec to Close)
- Pearl Street LED Systems (NJ, NY, PA)
  - Controls & Project Development Engineer (Retrofit Market)



# Learning Objectives

- Understand and apply NLC hardware and features
- Gain knowledge to ask the right questions to implement common control strategies in schools
- Leverage utility resources
- Navigate financial & operational conversations for NLC projects



Time for a Quick Poll...

Enough about me...

Let's talk about you...





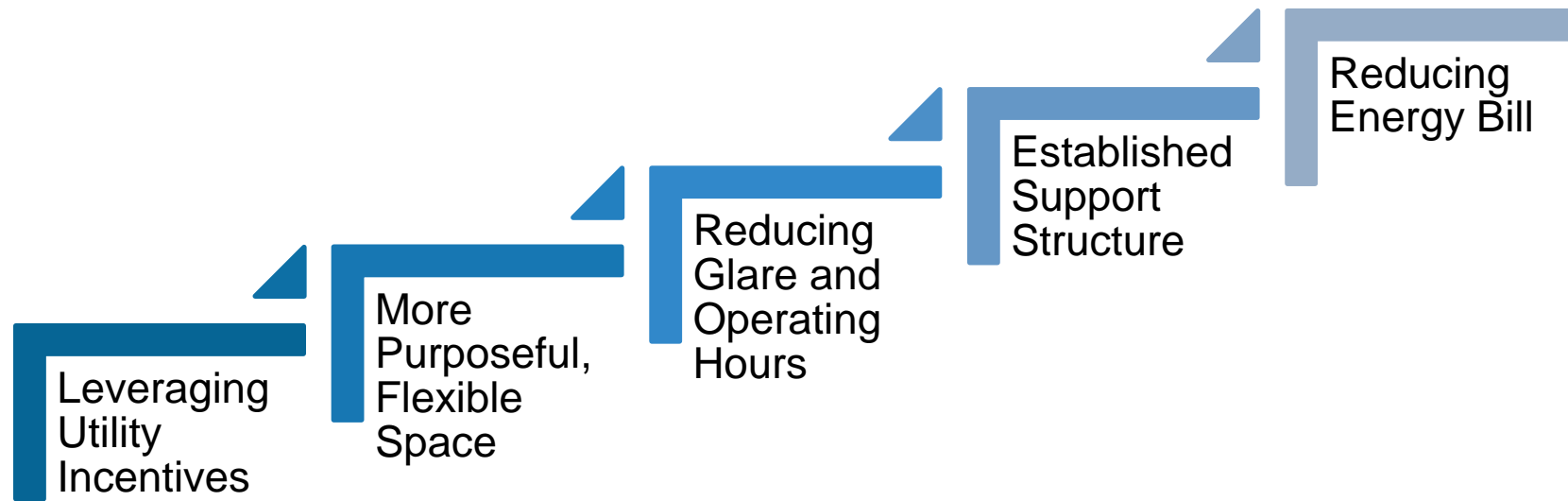
# The Why



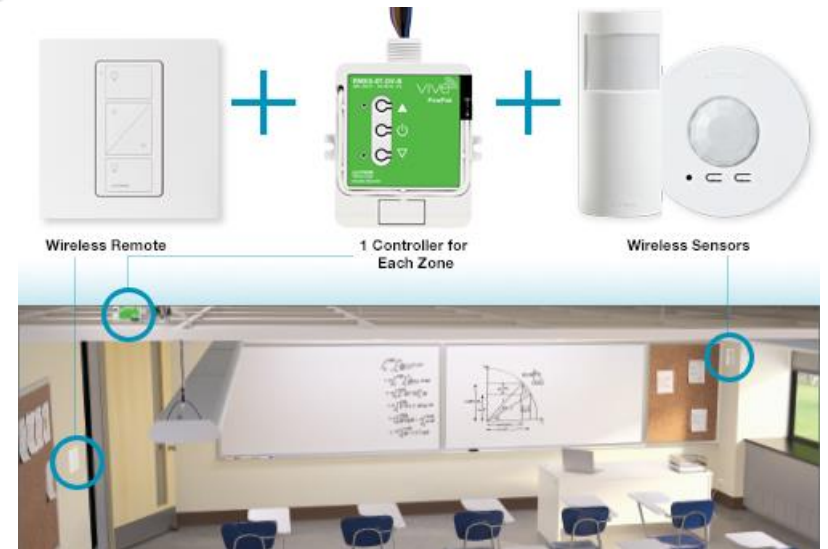
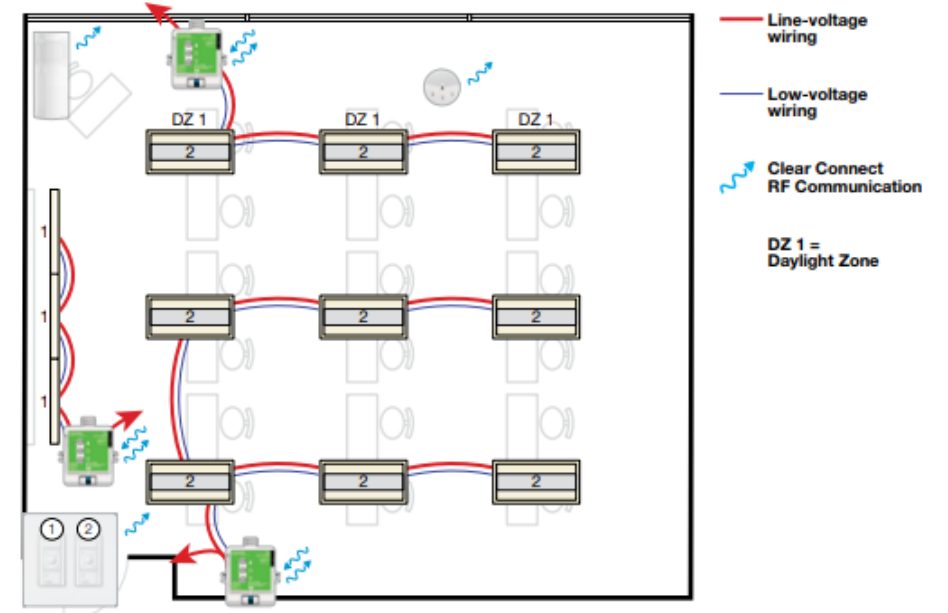
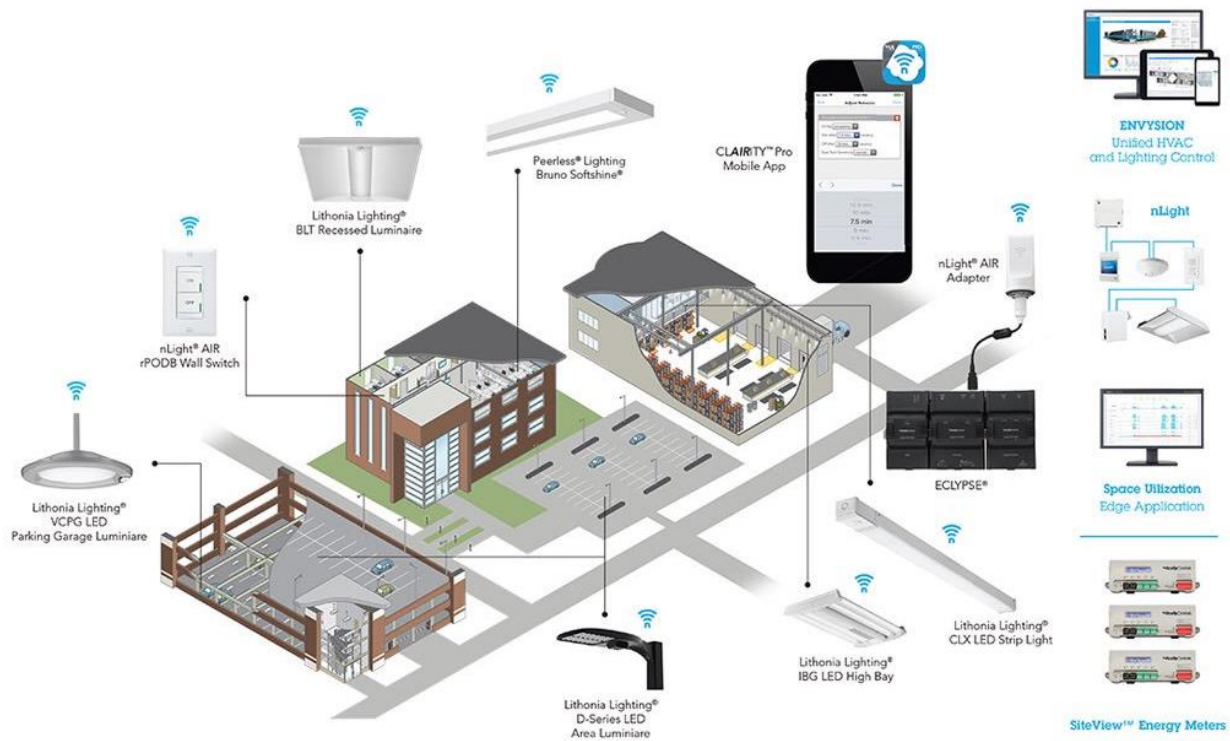
- Those smiles
- Some good ol' Learnin!
- Improving quality of life
- Enhancing the purpose of the space



# The How



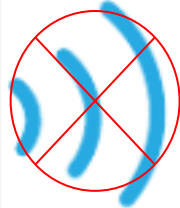
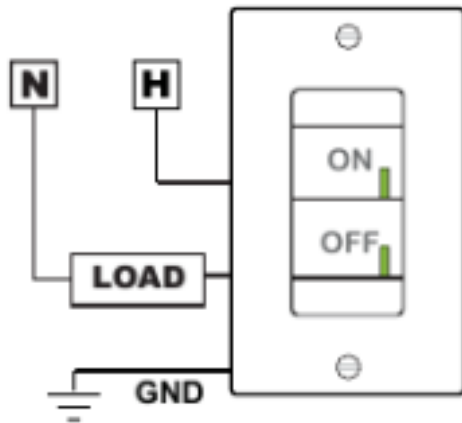
# The What



# The Odds Have Been Stacked Against NLC



Desired Timeout (Minutes)	Number of Flashes from Light/Motion Sensor
1 Minute	2 Flashes
5 Minutes	3 Flashes
15 Minutes	4 Flashes
30 Minutes	5 Flashes



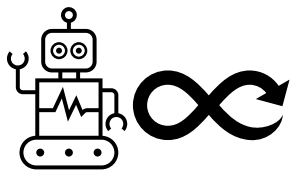


# NLCs Today are Smoother and Leverage NEBs

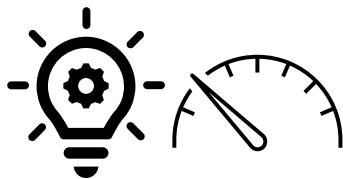
Even though there is still a long way to go...



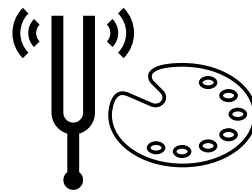
## The Proliferation of *FEATURES*...



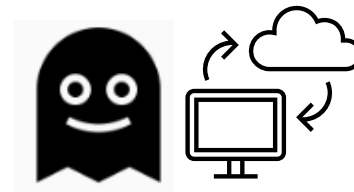
*Controls  
Persistence*



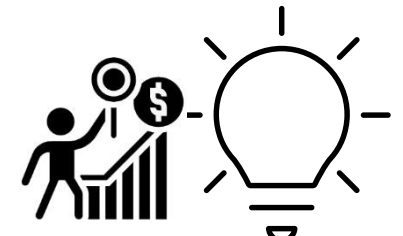
*Energy  
monitoring*



*Color tuning*



*Cyber security*



*Demand  
Response*

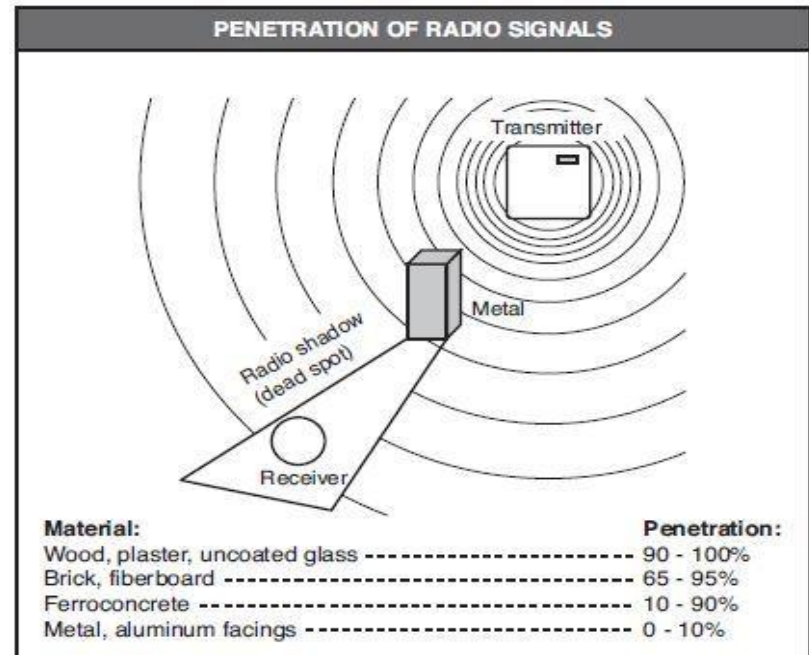
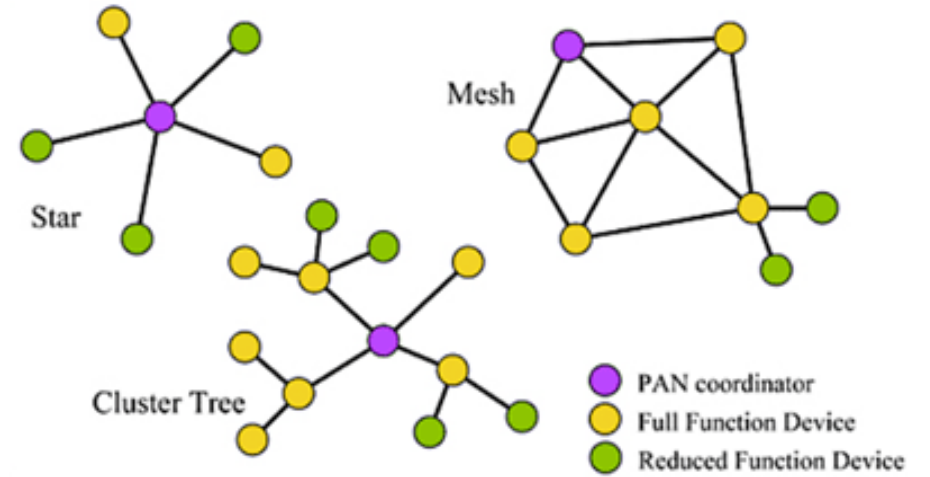
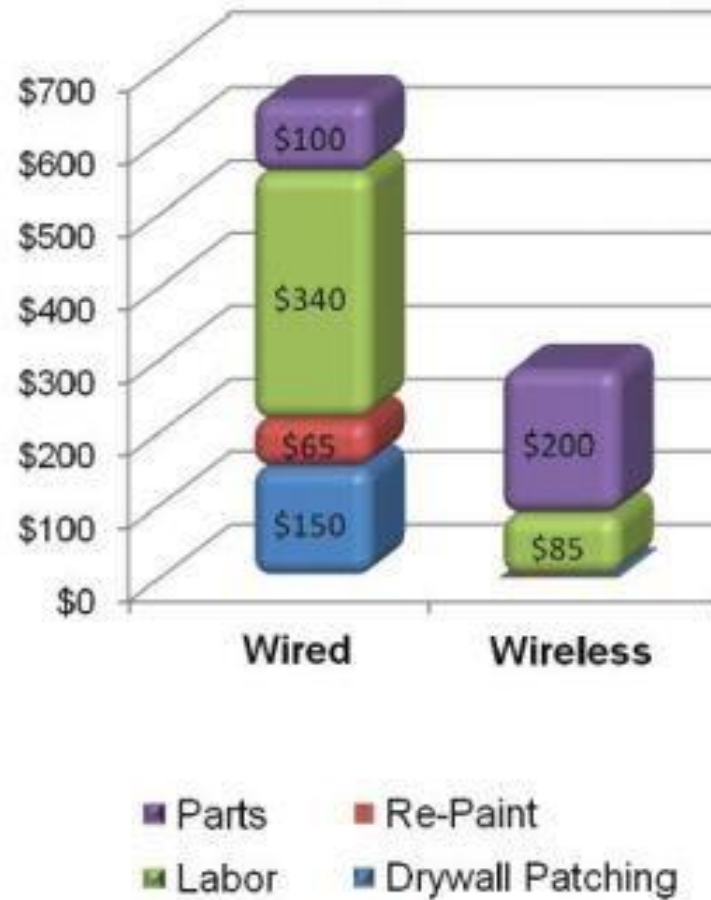
*... and so many more*



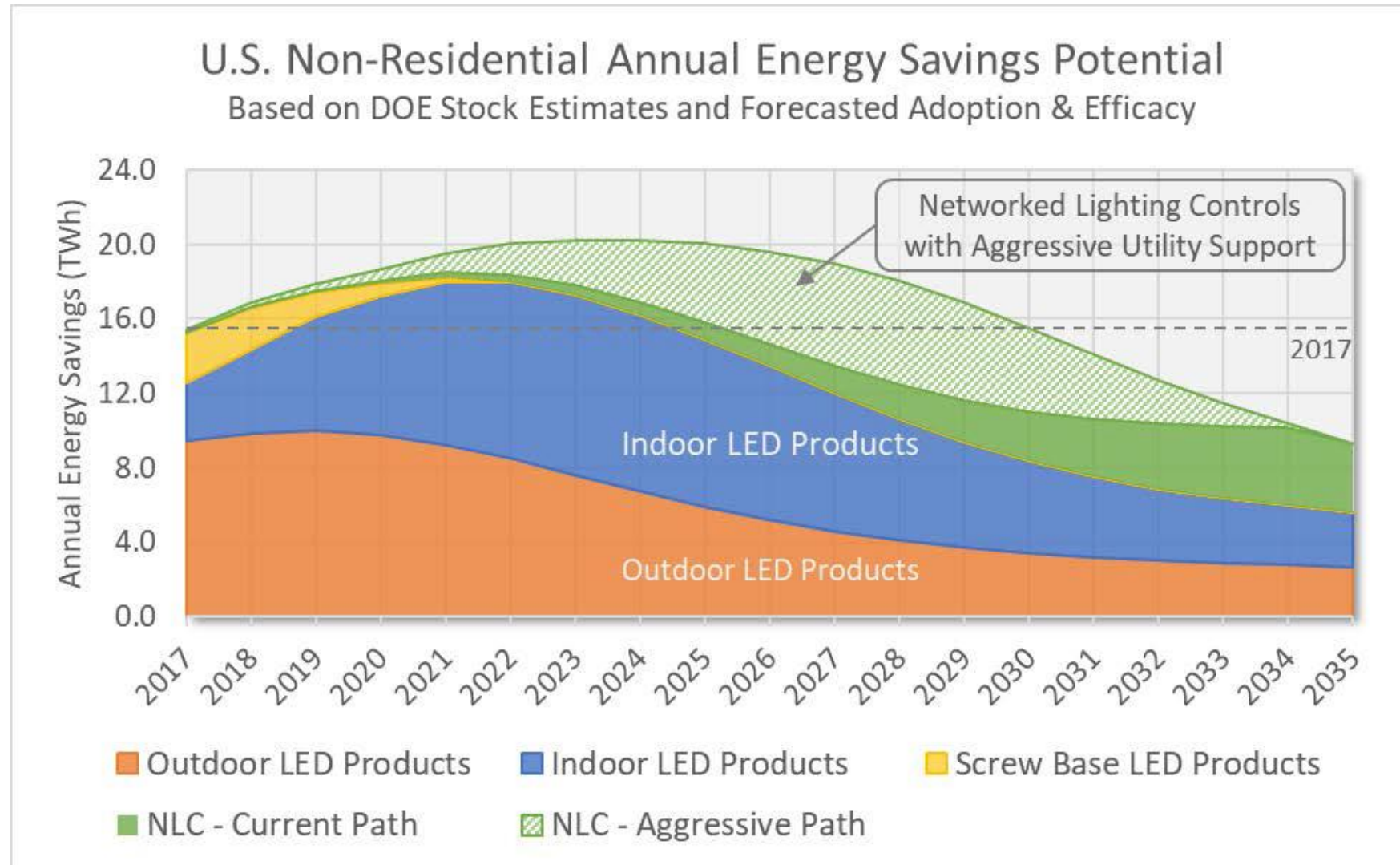
# Wireless Protocols with NLC Today

- Zigbee
- Bluetooth
- BLE
- EnOcean
- Zwave
- WiFi
- IEEE 802
- Proprietary
- Others

**WIRED VS. WIRELESS COSTS**

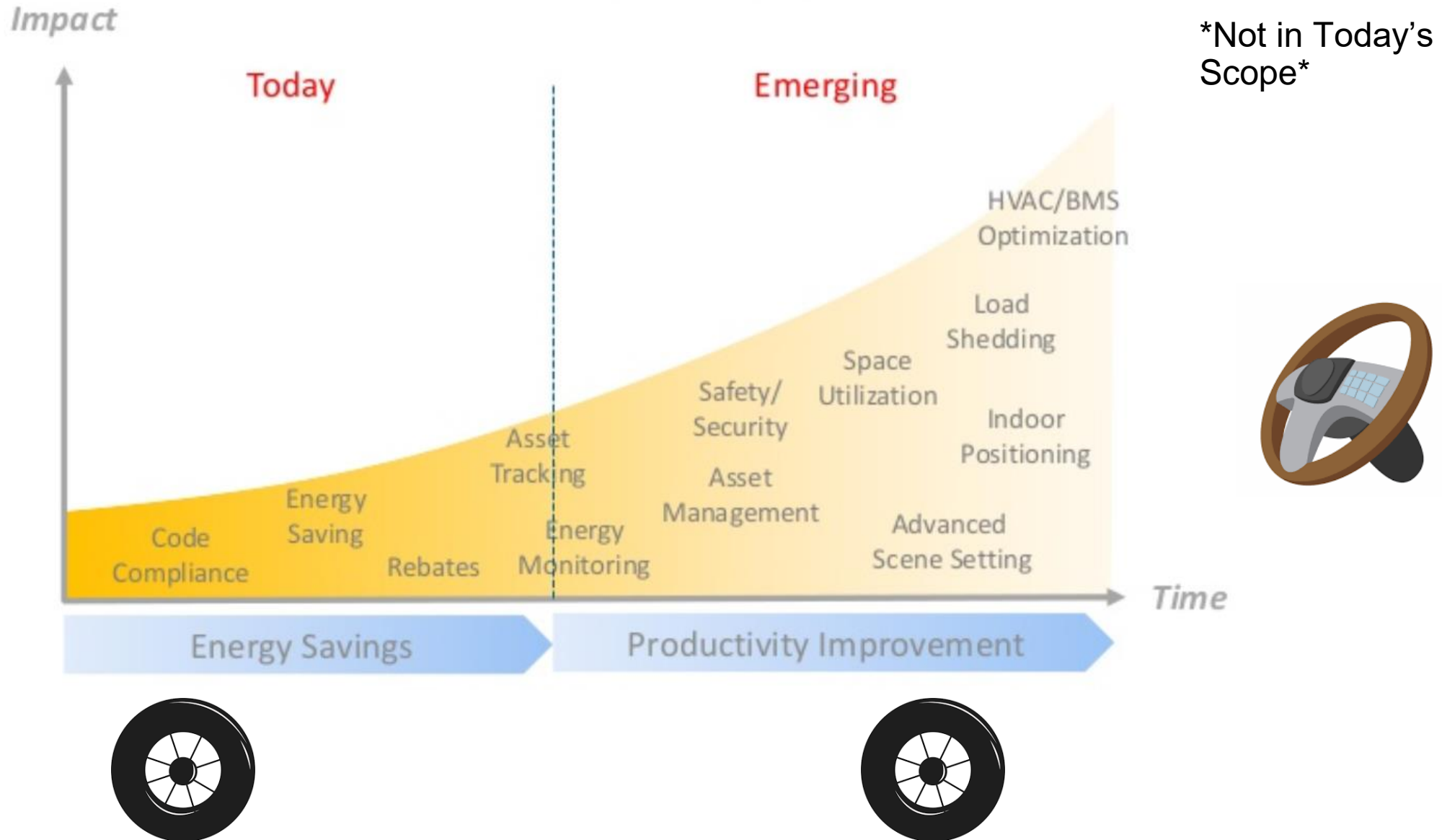


# The Savings Prospects



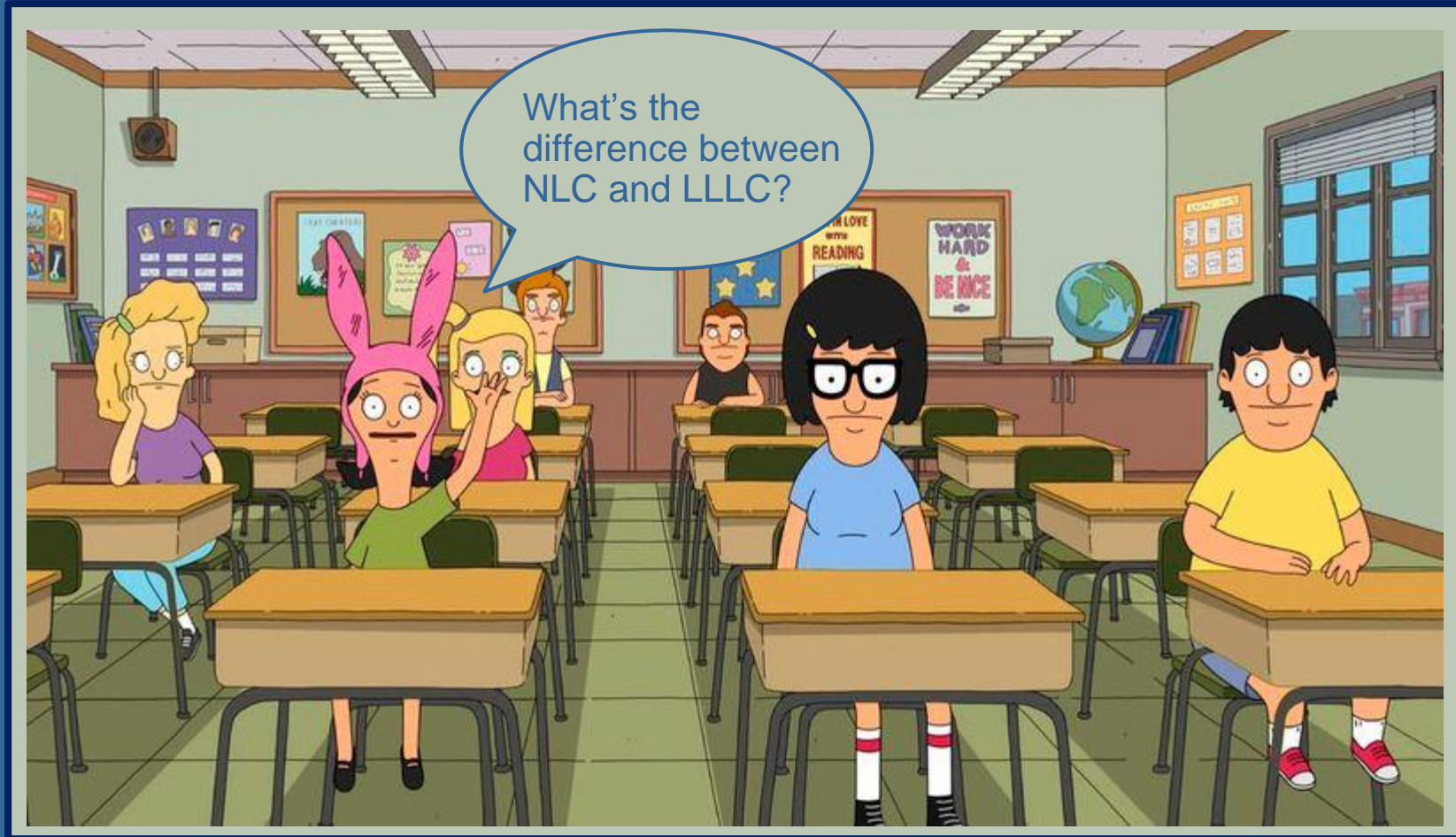
ENERGY SAVINGS POTENTIAL OF DLC COMMERCIAL LIGHTING  
AND NETWORKED LIGHTING CONTROLS

# Emerging Tech Non-Energy Benefit Drivers





# NLC Terms, Control Strategies, and Other Fun Stuff



# TomAto – Tom<sub>A</sub>to

- Advanced Lighting Controls
- Networked Lighting Controls

→ ALC = NLC

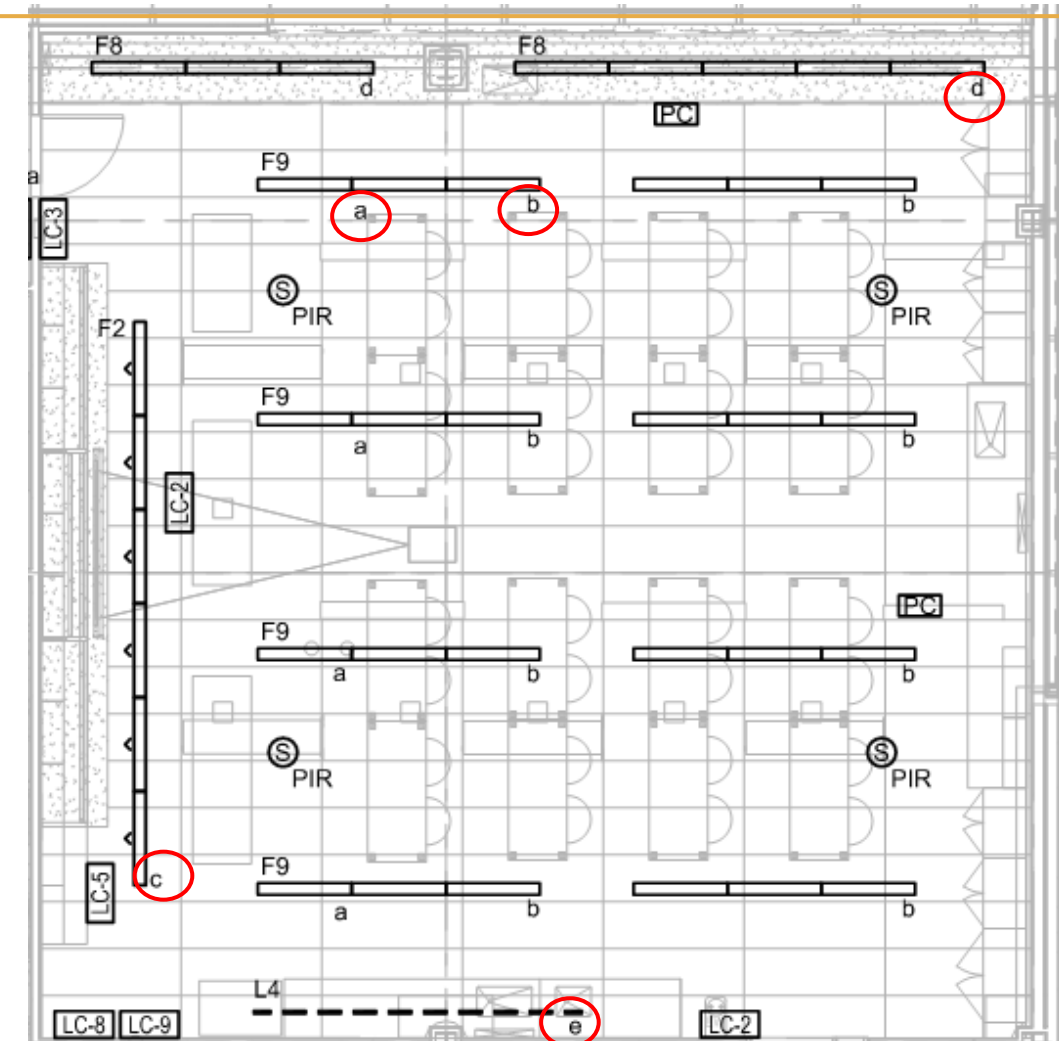


Think about the sensor switch, or analog motion sensor with a relay.



# Control Zone / Channel

- A Control Zone is a logical grouping of luminaires that are controlled together.
- Generally, the more control zones, the more flexible the system will be.
- Poor zoning is the most common error in controls.



North Seattle College Allied Health Building

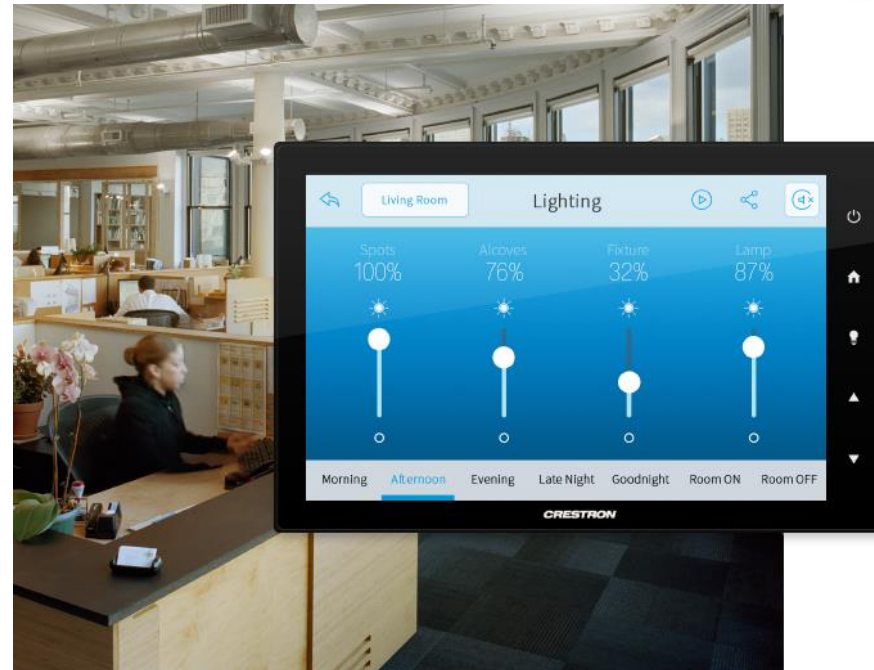
# Load Controllers

- Controls a Zone of Lighting
- Dimming or Relay
- 1A-20A
- Usually 0-10V Flavors for dimming



# Zone Controller / Wall Station

- Line voltage
- Low voltage remote dimming
- Networked System
- Zones or groups
- Simple to design
- Easy to understand
- Users like personal control



Courtesy: Lutron, Leviton, Crestron

# Scene / Preset Control (More Complex Wall Station)

- Grouping of zones at specific levels
- More complicated
- Simply Repeatable
- May be confusing
- Consider engraving



Courtesy: Lutron, Leviton, Pharos

# High End Trim or Task Tuning

IES Lighting Level Guidelines		
IES Lighting Level Guidelines	Average Maintained Footcandles (Horiz)	Location (AFF = Above finished Floor)
<b>Bank</b>		
ATM - walk up (indoor)	20 fc	at 3' AFF
Lobby	10 fc	at 0' AFF
Teller Window/Writing Table	30 fc	at 0' AFF/Writing Surface
<b>Bar</b>		
General Seating	5 fc	at 2' AFF
Lounge/Work Surfaces	10 fc	at 2' AFF or work surface
<b>Corporate Office</b>		
Workspace	30 fc	at 2.5' AFF
<b>Dining (Non-Hospitality)</b>		
Cafeteria	15 fc	at Tabletop
Coffee Shop	10 fc	at Tabletop
<b>Library</b>		
Stacks	20 fc	at 0' AFF
Reading	50 fc	at 2.5' AFF
General	15 fc	at 2.5' AFF
<b>Reading &amp; Writing</b>		
Graphite Pencil	30 fc	at 2.5' AFF
Red Pencil	50 fc	at 2.5' AFF
Black Pen	30 fc	at 2.5' AFF
Other Pen	40 fc	at 2.5' AFF

Lighting professionals specify conservative lumen packages

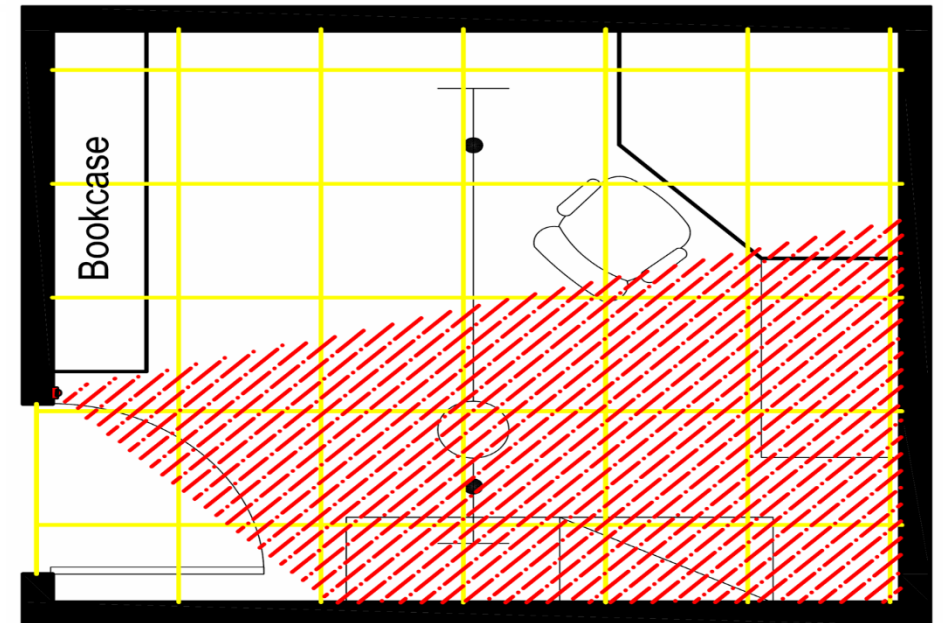
- Deliver the target illuminance level
- Reduce glare
- Extend the Life of the fixture
- Save as much as 20-30% of the energy in a typical system



# Motion Sensors -

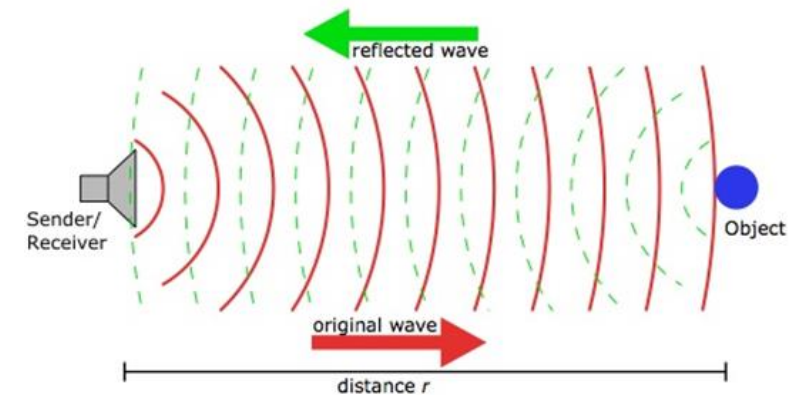
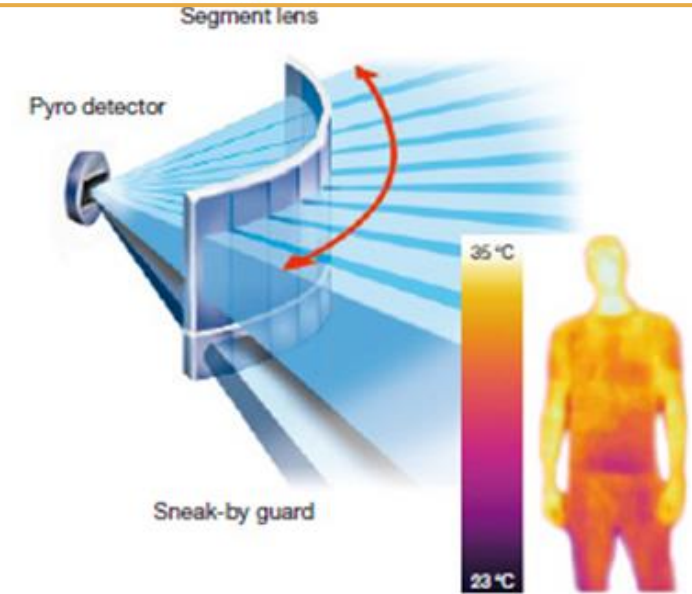
## Occupancy and Vacancy

- Auto on
- Auto off
- May control load
- Mounting
  - Wall
  - Ceiling
  - Fixture
- May have some residual angst over older systems



# Sensor Types

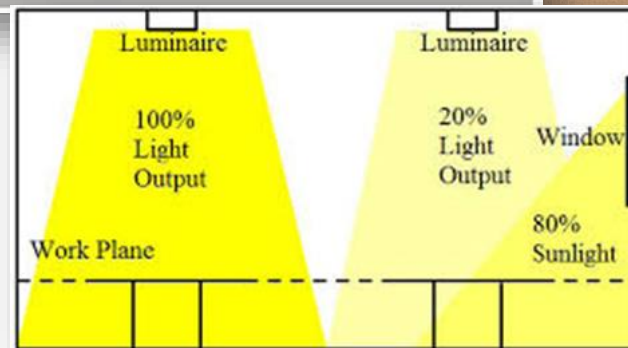
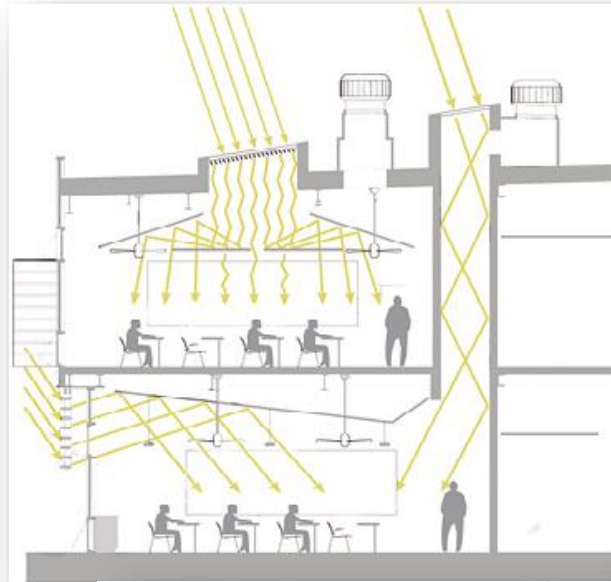
- Passive Infrared
  - Needs line of sight to work
  - Can be wireless -> battery
- Ultrasonic
  - Does not need line of sight to function
  - Only wired -> constant power
- Dual Tech
  - Little bit of both



Courtesy: Wattstopper, Echoflex, Leviton, Steinel

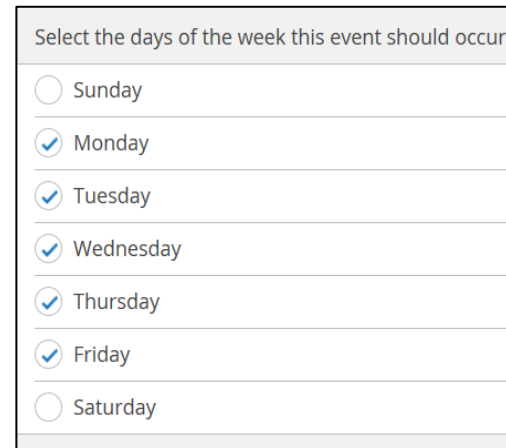
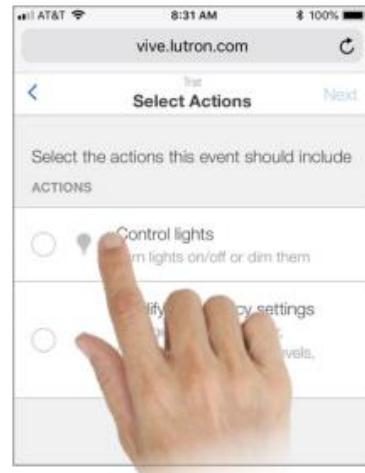
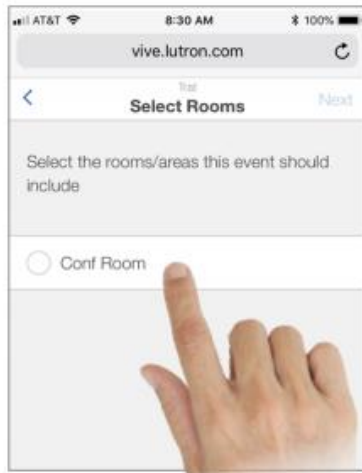
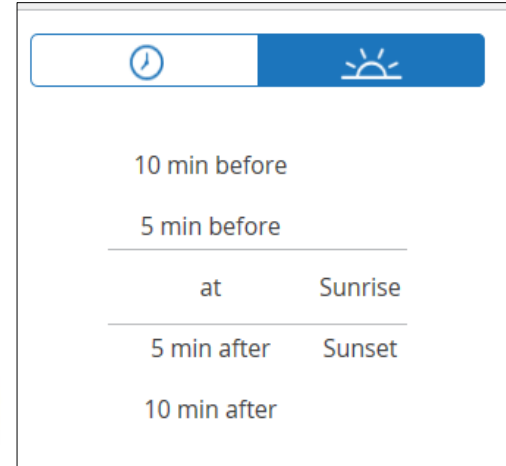
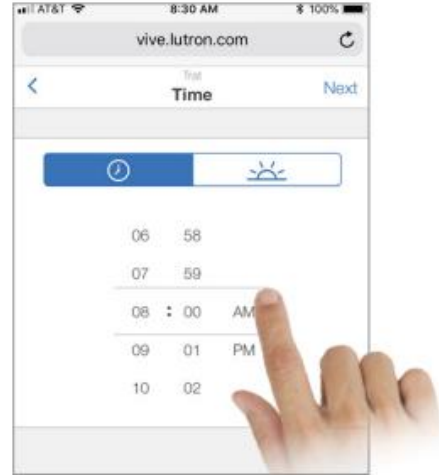
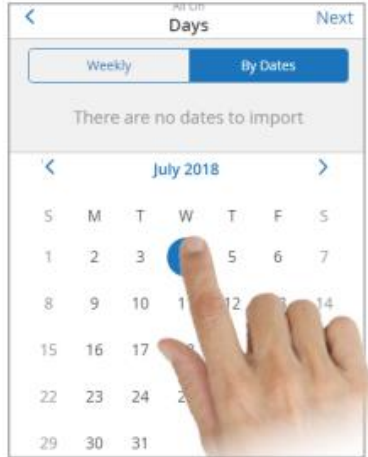
# Daylight Harvesting

- Leverage available daylight availability
- Dim artificial Light
  - Comfort in maintaining appropriate light level
  - Reduce Glare
  - Save Energy
- Commissioning
  - Pair with motion sensors
  - Rows
  - Calibration



Chemeketa Community College Health Sciences Building  
SRG

# Timeclock Programming



Status Enable ☒

Behavior  
☒ Occ/Vac ☐ Vac Only

When Occupied ^

Dimmable Lights

When Unoccupied ^

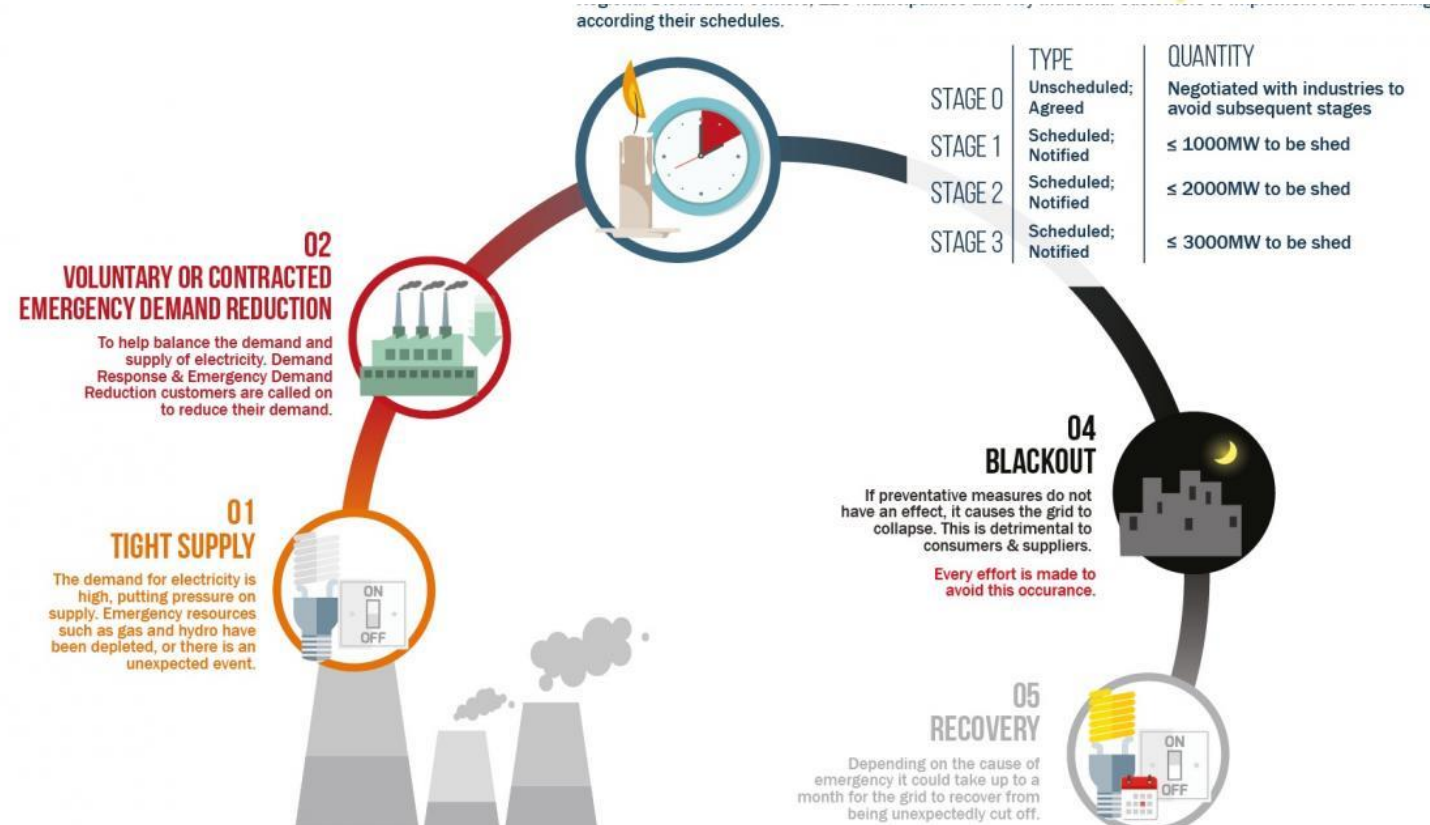
Dimmable Lights

Timeout  
☐ 1 min ☐ 5 min  
☒ 15 min ☐ 30 min



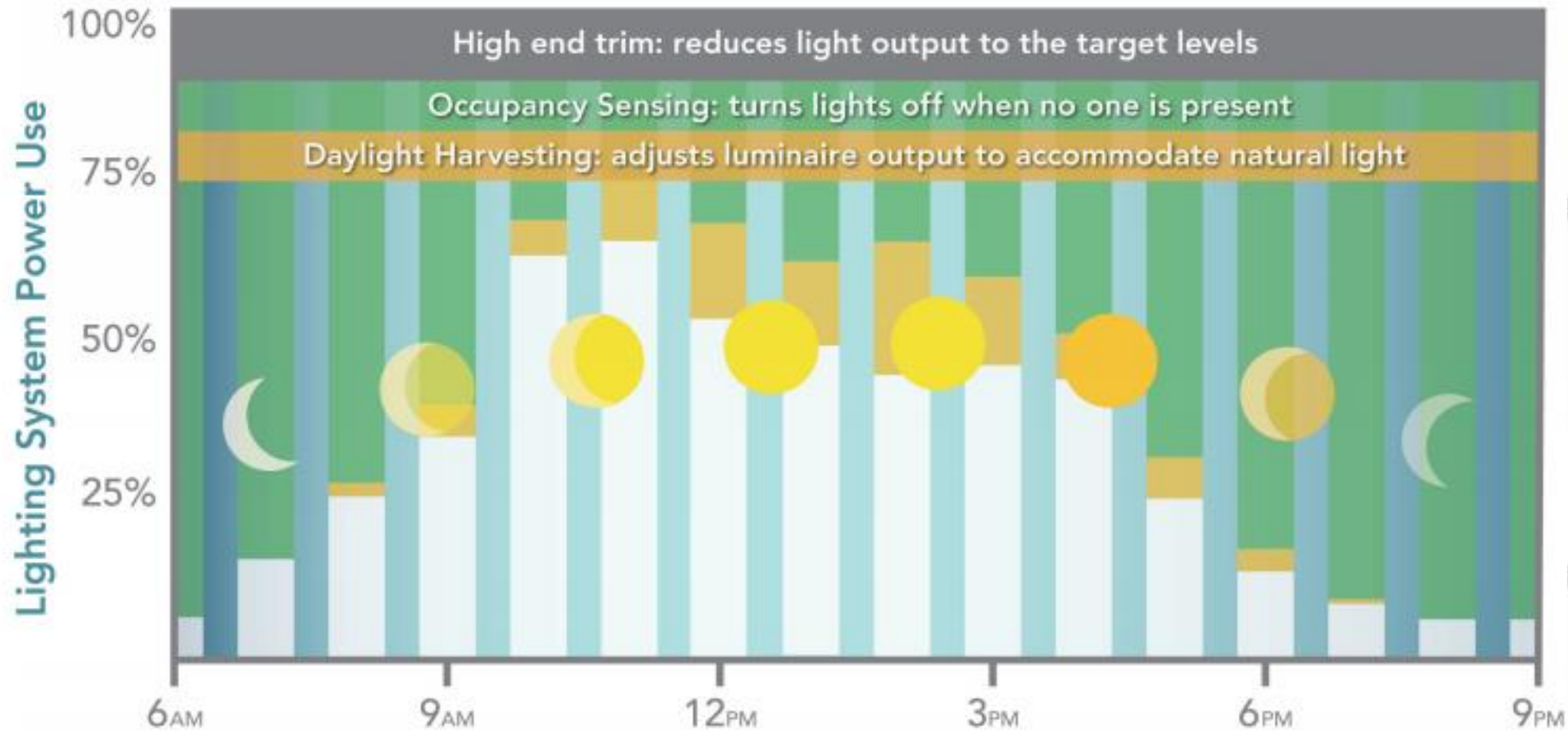
# Load Shed / Demand Response

- The ability to reduce lighting load by a set amount when signaled to do so by others.
- Most NLC Systems have a DR/ADR setting

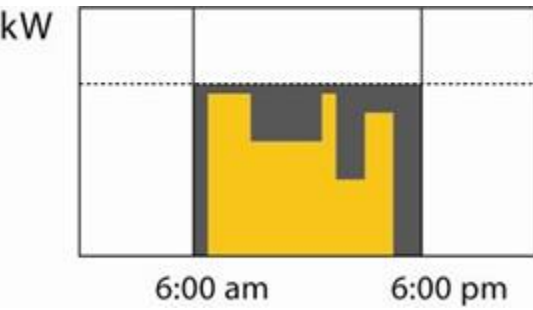




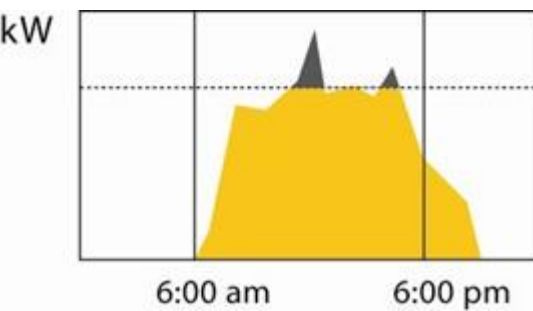
# Critical NLC Strategies Compounded



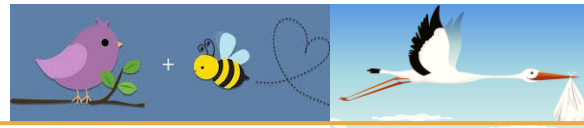
Personal Control



Demand Response



# Where do Savings Come From?



- Converting to LEDs
- Adding NLC/LLLC Systems
- Whole Building System Management

## What is a Kilowatt-Hour?

$$\text{Energy} = \text{Power} \cdot \text{Time}$$

$$\text{kWh} = \text{kW} \cdot \text{hr}$$

$$1 \text{ kW} = 1000 \text{ W}$$

$$1 \text{ hr} = 3600 \text{ s}$$

Medium General Service Downtown Network (MDD)

	Jan 2019	Nov 2019	Jan 2020
Per kWh	\$ 0.0925	\$ 0.0919	\$ 0.0987

# Did You Know... NLC & LLLC

- Luminaire Level Lighting Control
  - Individually Addressable
  - Integrated occupancy and daylight sensors
  - Continuous dimming
  - Networkable
- Benefits
  - Less Components
  - Labor Savings
  - Simple Configuration
  - Future Expandability
  - Reconfigurable

NLC

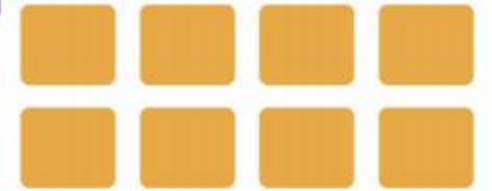


LLLC



**1 :  
Many**

BASIC NLC CONFIGURATION



*1-8 zones possible with  
additional sensors*

**1 : 1**

LLLC CONFIGURATION



*1-8 zone capable  
out of the box*

**BONUS: Automatically Meets Code**

# 2018 Washington State & Seattle Comm Energy Code\*

**C405.2 Lighting controls.** Lighting systems shall be provided with controls that comply with ~~((one))~~ item 1 or item 2 of the following.

1. Lighting controls as specified in Sections C405.2.1 through C405.2.7. In addition, any contiguous open office area larger than 5,000 square feet shall have its general lighting controlled by either:
  - 1.1. An enhanced digital lighting control system conforming to the requirements of Section C406.4; or
  - 1.2. Luminaire-level lighting controls (LLC) conforming to the requirements in Item 2 of this subsection.
2. Luminaire level lighting controls (LLC) for all areas and lighting controls as specified in Sections C405.2.1, C405.2.3 and C405.2.5. The LLC luminaires shall be independently configured to:
  - 2.1. Monitor occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.
  - 2.2. Monitor ambient light, both electric and daylight, and brighten or dim artificial light to maintain desired light level. A maximum of 8 fixtures are permitted to be controlled together to maintain uniform light levels within a single day-light zone.
  - 2.3. For each control strategy, be capable of configuration and re-configuration of performance parameters including: bright and dim set points, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configuration.



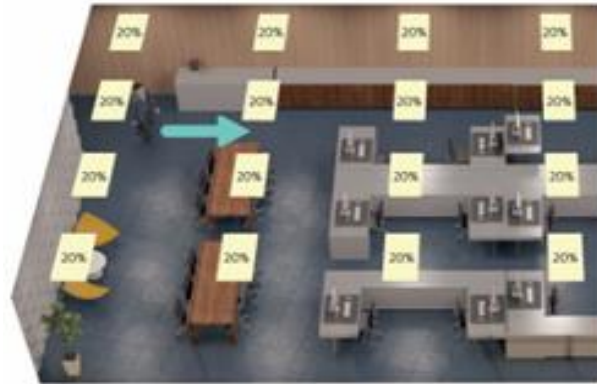
# How These LLL Control Methods Work Together

## At the room level – Open Office

7:00am

*Initial walk-in*

Lights on to  
background or  
daylight level



9:00am

*Half Occupied*

Lights brighter  
on occupied  
desks, not on  
vacant spaces



5:00pm

*Leaving*

Lights go to set  
level as people  
leave, brighter  
if occupied



7:00pm

*Vacant Space*

Lights go off



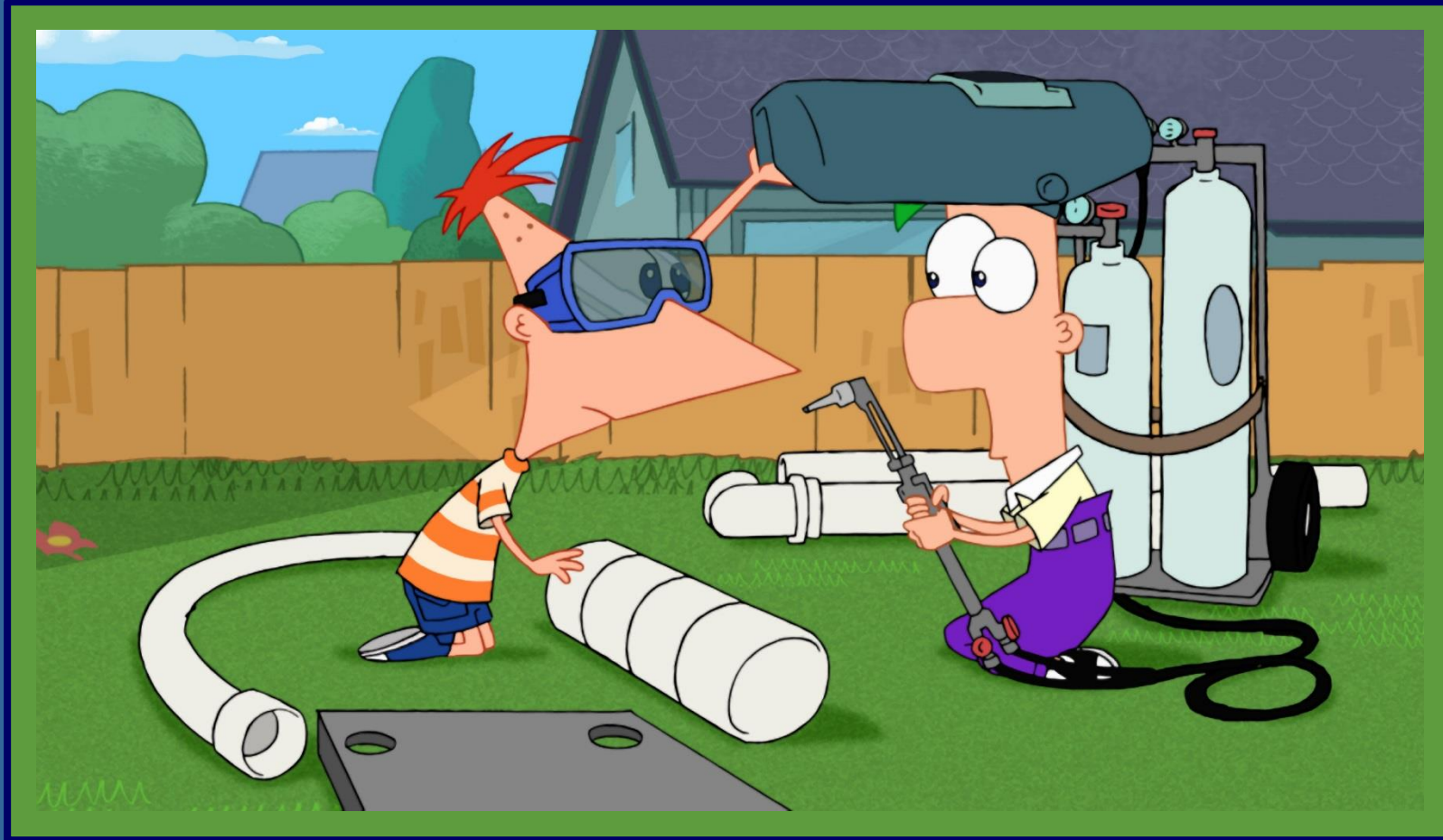
Images Courtesy of Signify

Poll: What is your take on LLC Technology?

# Pause for Questions



# Before Getting These Project Started





# Relatively Nearby Regional Resources

- In field / Development Support:

- SCL Energy Specific Questions:

Connect with an Energy Advisor to help you better understand energy options, navigate your choices, and create a plan that helps your home or business save energy and money. Conservation, energy efficiency and smart energy choices are within reach.

Call 206.684.3800

Email [SCLEnergyAdvisor@seattle.gov](mailto:SCLEnergyAdvisor@seattle.gov)

- Best Practices, Mockup, Tools, Resources, Network

- Your Utility
  - Lighting Design Lab
  - Integrated Design Lab
  - Trade Ally Network NW
  - Many Others!

Regional Contacts

## LIGHTING SPECIALIST CONTACT INFORMATION

The NWTAN team of lighting specialists is here to support the Northwest lighting community. Please contact the specialist serving your geographic region if you have any questions or need information.

### WASHINGTON



**JEFF ANDERSON**  
Western Washington  
360.707.8950  
[jeff.anderson@northwest-lighting.org](mailto:jeff.anderson@northwest-lighting.org)



**JOHN WILMOTH**  
Northeast Washington  
509.342.5217  
[john.wilmoth@northwest-lighting.org](mailto:john.wilmoth@northwest-lighting.org)



TRAINING & RESOURCES ▾ PROGRAM OFFERINGS ▾ ABOUT [BECOME A TRADE ALLY](#)

## TRAINING & RESOURCES

Search here for training opportunities and other resources to help streamline your next commercial **HVAC** or **lighting** project. From this page you can find workshops, link to the online training portal, read case studies, brush up on sales skills, and download technical documents and product lists.

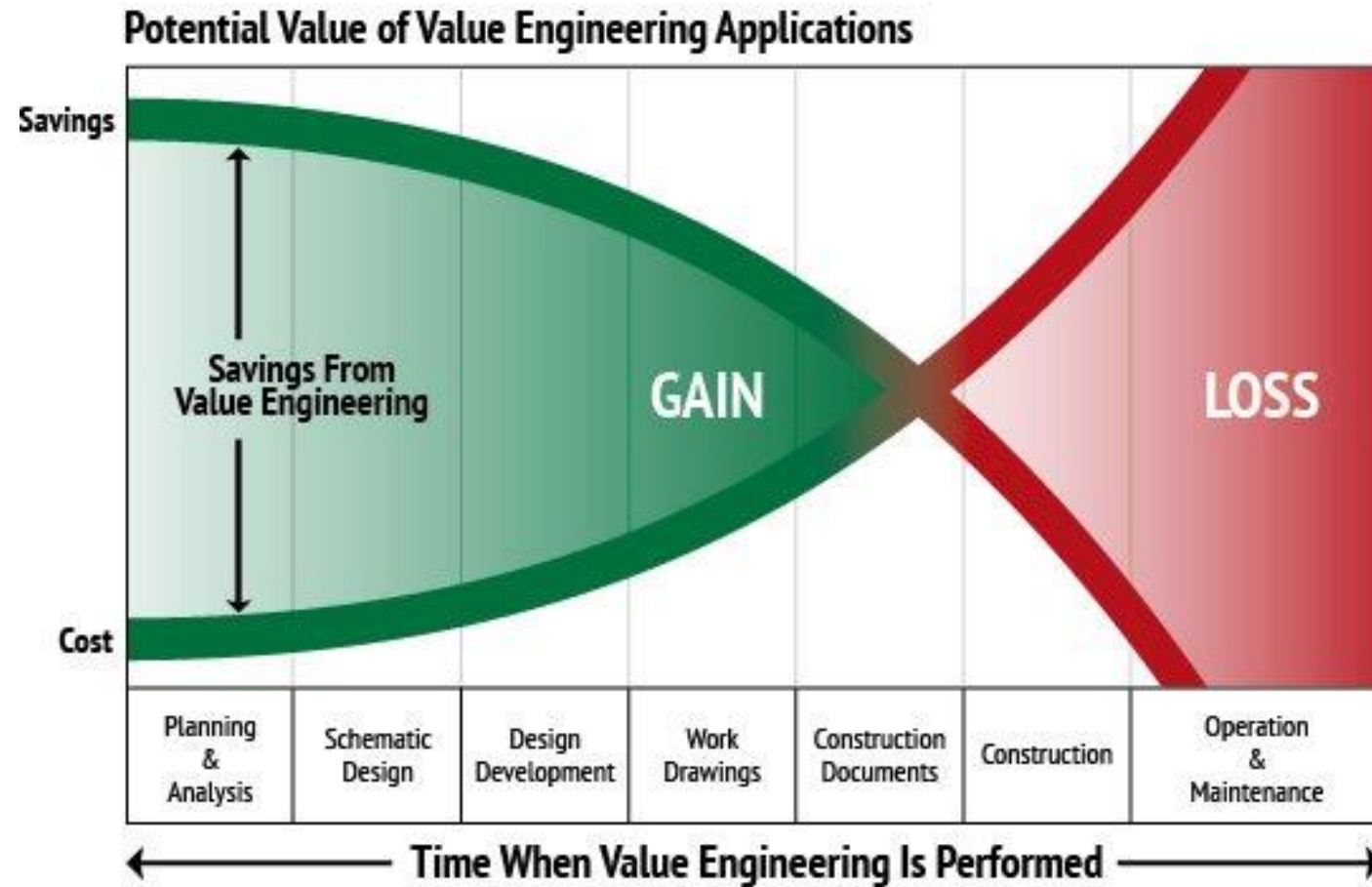
# Lighting Audit: Make a First Impression

- Attend LDL Audit & Retrofit Class ;)
- Benchmark Existing Conditions
- Estimate Energy, Labor, Rebate Savings
- Propose Multiple Solutions, Model kWh Savings
- Lead to Life Cycle Analysis and Non-Energy Benefits
- Tell a Story from Audit to Proposal

				LED
Annual kWh Reduction:				19,783
% kWh Reduction (of existing lighting):				78%
Annual Utility Electric Savings:				\$2,461
Annual Lamp/Ballast Maintenance Savings:				\$2,619
Rebate Savings:				\$3,500
Total Savings:				\$8,580
Upgrade Cost:				\$20,000
			Estimated Labor Cost	\$5,000
Net Project Cost:				\$25,000
Simple Payback (years):				2.91

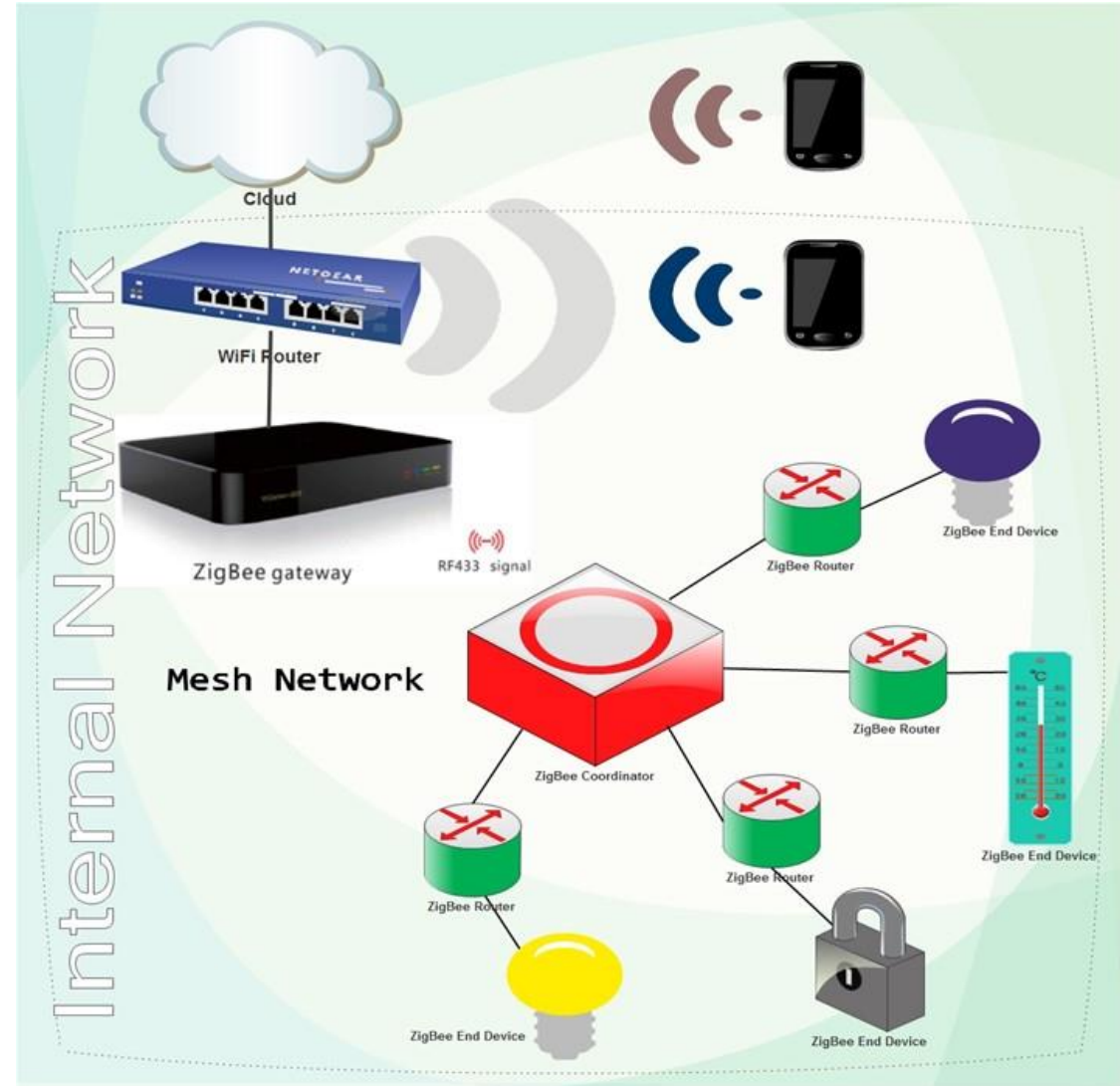
# Not “Value” and not “Engineering”

- Removes hardware / features last minute to reduce cost
- Other Building contractors up-sell
  - EC typically down-sell
- True value engineering “adds” to up-front cost to reduce life-cycle cost



# Cybersecurity Considerations

- Get IT involved ASAP!
- Smart lighting may be a gateway to attack just like other building systems.
- Becoming a greater issue & consideration.
- Recommend having system-specific network
- Design Lights Consortium
  - DLC NLC QPL
  - UL-2900





DLC_NLC-QPL-v3-0_08-17-18.xlsm - Excel																										
File Home Insert Draw Page Layout Formulas Data Review View Help BLUEBEAM Power Pivot Tell me what you want to do																										
C1	System																									
	A	B	C	D	E	O	AL	AW	AZ	BI	BM	BR	BU	CC	CG	CI	CJ	CK	CQ	CV	DE	DH	EB	EW	EZ	FE
	Show All				Sho	Sho	Sho	Sho	Show	Show	Sho	Sho	Sho	Sho	Show		Individual Luminaire Addressability	Sho	Sho	Sho	Sho	Sho	Sho	Sho	Sho	Sho
	Company	Brand	System	Interior / Exterior	Summary	Network	Occupancy Sensing	Traffic Sensing	Daylight Harvest / Photocell	High-End Trim	Scheduling	Personal Control	Demand Response	Plug Load Control	Color Changing / Tuning	Zoning		LLLC Luminaire Level Lighting Control	Continuous Dimming	User Interface	Control Persistence	Energy Monitor	External Systems Integration	Remote Diagnostics	Emergency Lighting Documentation	Cyber-security
1																										
4	Acuity Brands	Acuity Controls	XPoint Wireless	Interior		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Acuity Brands	Acuity Controls	nLight AIR	Interior		Yes	Yes	No	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
6	Acuity Brands	Acuity Controls	nLight	Interior		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	Autani, LLC	Energy Center	Energy Center	Interior		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
8	Autani, LLC	Energy Center	Energy Center	Exterior		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
9	Avi-on Labs, Inc.	Avi-on Proline	Avi-on Proline	Interior		Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
10	California Eastern Laboratories	Cortet	Cortet	Interior		Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	No	No
11	Cree, Inc.	SmartCast Wireless	SmartCast Wireless	Interior		Yes	Yes	No	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No
12	Crestron Electronics	Crestron DALI	Crestron DALI	Interior		Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
13	Crestron Electronics	Crestron Züm™	Crestron Züm™	Interior		Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No
14	Current by GE	Daintree Enterprise	ControlScope	Interior		Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
15	Digital Lumens	Digital Lumens	SiteWorx Tune	Interior		Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
16	Eaton	LumaWatt Pro	IoT System	Exterior		Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No

# Understand Code Requirements

- When does Code Apply?
- LPD pushes LED Savings
- Control Implementation Requirements
  - Motion Control
  - Daylight
  - Lighting Reduction (Dimming)
  - Local Control
  - Time Clock Control
- kWh Savings 10% below Code Impact Incentive

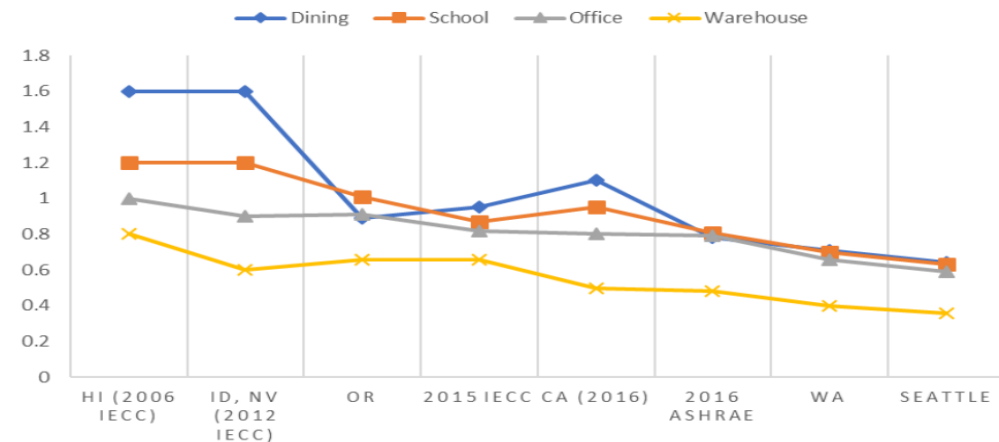
**TABLE C405.4.2(1)**  
**INTERIOR LIGHTING POWER ALLOWANCES:**  
**BUILDING AREA METHOD**

Building Area Type	LPD (w/ft <sup>2</sup> ) Before Jan 1 2018	LPD (w/ft <sup>2</sup> ) After Jan 1 2018
Automotive facility	0.64	<u>0.58</u>
Convention center	0.81	<u>0.73</u>
Court house	0.81	<u>0.73</u>
Dining: Bar lounge/ leisure	0.79	<u>0.71</u>
Dining: Cafeteria/fast food	0.72	<u>0.65</u>
Dining: Family	0.71	<u>0.64</u>
Dormitory	0.46	<u>0.41</u>
Exercise center	0.67	<u>0.60</u>
Fire station	0.54	<u>0.49</u>
Gymnasium	0.75	<u>0.68</u>
Health care clinic	0.70	<u>0.70</u>
Hospital	0.84	<u>0.84</u>
Hotel	0.70	<u>0.63</u>
Library	0.94	<u>0.85</u>

**TABLE C405.4.2(2)**  
**INTERIOR LIGHTING POWER ALLOWANCES:**  
**SPACE-BY-SPACE METHOD**

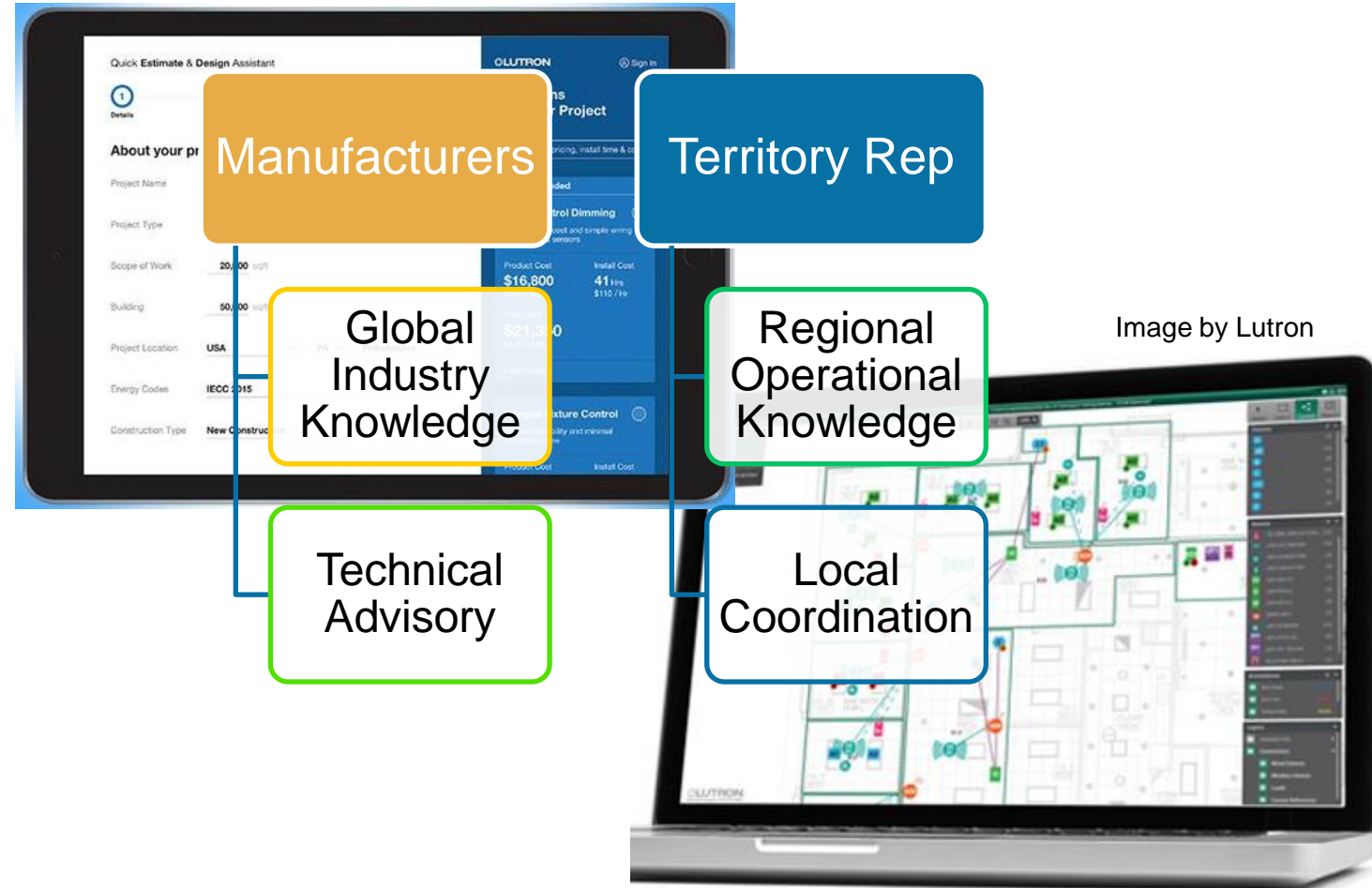
COMMON SPACE-BY-SPACE TYPES <sup>a</sup>	LPD (w/ft <sup>2</sup> ) <sup>d</sup> Before Jan 1 2018	LPD (w/ft <sup>2</sup> ) <sup>d</sup> After Jan 1 2018
Computer room	1.37	<u>1.23</u>
Dining area		
In a penitentiary	0.77	<u>0.69</u>
In a facility for the visually impaired (and not used primarily by the staff) <sup>b</sup>	1.52	<u>1.52</u>
In a bar/lounge or leisure dining	0.86	<u>0.77</u>
In a family dining area	0.71	<u>0.64</u>
Otherwise	0.52	<u>0.47</u>
Electrical/mechanical	0.76	<u>0.68</u>
Emergency vehicle garage	0.45	<u>0.41</u>
Food preparation	0.79	<u>0.71</u>
Guest room	0.38	
Laboratory		
In or as a classrooms	1.02	<u>0.92</u>
Otherwise	1.45	<u>1.31</u>

**LIGHTING POWER ALLOWANCES**



# Implementers – Leverage Partner's Procedural Efficiency

- Quoting tools
- Project Development tools
- One lines with Packaging
- Room Packaging
- Pre-Pairing
- Pre-Commissioning



# Benefits of plugging in to your Territory Utility

- Investment on innovation and energy efficiency
- Customer and technical support on specific projects
  - Or access to resources for these
- Access to tools and resources
- Access to programming





# Program Design Considerations: Savings & Incentives

## Example of prescriptive savings in City Light's lighting program

Space Use Type	Networked Lighting Controls	Luminaire Level Lighting Controls
Break Room	40%	60%
Classroom	25%	25%
Hallway	40%	60%
Lobby	40%	60%
The Loo	40%	60%
Warehouse	40%	60%

*And so on and so forth...*

## Regional Technical Forums: Non-Residential Lighting Retrofits protocol

Dictionary

Search for a word



pro·vi·sion·al  
/prəˈviːZHənəl/

1. Arranged or existing for the present, *possible to be changed later*

### **Simplify Approach:**

- prescriptive savings
- prescriptive incentives



### **Right-Sized Incentive**

- \$50-75 incentive bonus –  
*In addition to performance savings!*



# Seattle City Light NLC \$50/Fixture Incentive Requirements



- DLC NLC QPL System
- Programmed HET, Occupancy, Daylight Harvesting
- Min (2) Zones per 300sqft
- Pre-Install
  - SOO
  - Floor Plan
- Post-Install
  - As Builts
  - Site Visit



- TLEDs
- Fixtures under 20W
  - HET under 20W = prorated \$50 incentive
  - 10W Fixture will provide \$25 of incentive
- **Otherwise: \$0.15 / kWh on fixture and control savings**



**Seattle City Light**

CUSTOMER ENERGY SOLUTIONS  
PROGRAM REQUIREMENTS

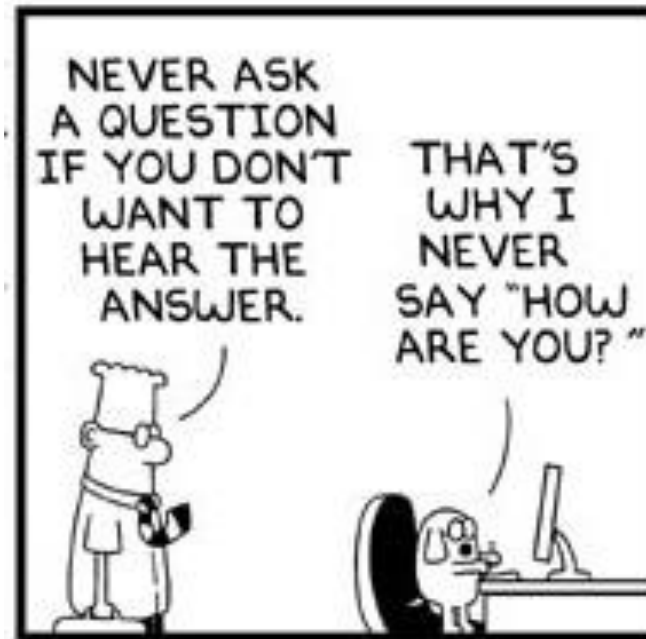
[Commercial and Industrial Retrofit Program](#)



lighting design lab

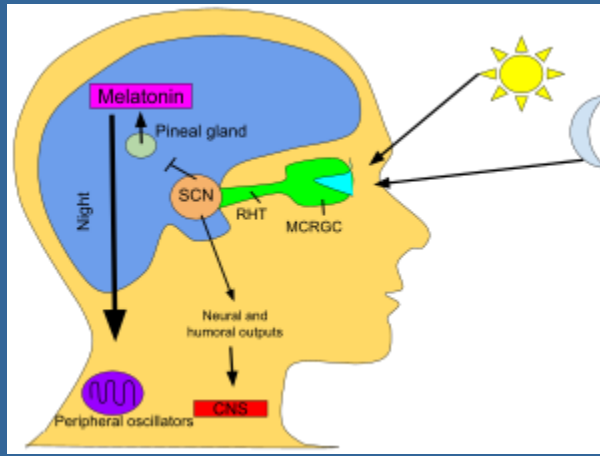
# Select all benefits of a Lighting Audit

# Pause for Questions





# Light & Health 101



# Tunable White, Circadian Lighting

- Specific color tuning adjusting the correlated color temperature / SPD along the black body radiator curve.
- Meant to affect mood or alertness.
- Circadian lighting
- Light & health ongoing research





# Key Light Stimulus Variables for Circadian Entrainment

- Circadian Entrainment
  - Intensity
  - Distribution
  - Spectral Power Distribution
  - Duration – Dose
  - Timing
  - Photobiological History



# Intensity

- How much light is incident on the eye
- Lux
- Typically measure at seated eye height for most environments

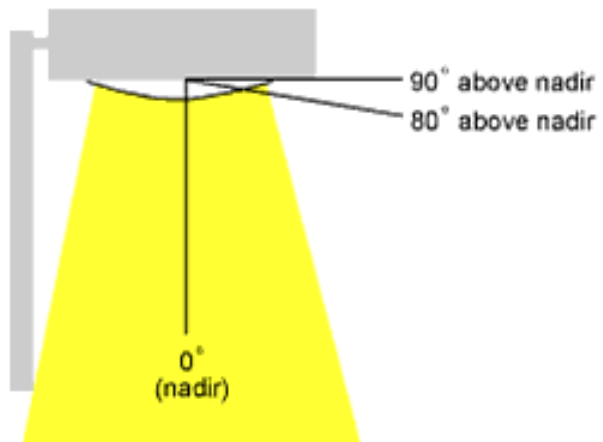


St John's Hospital



# Distribution

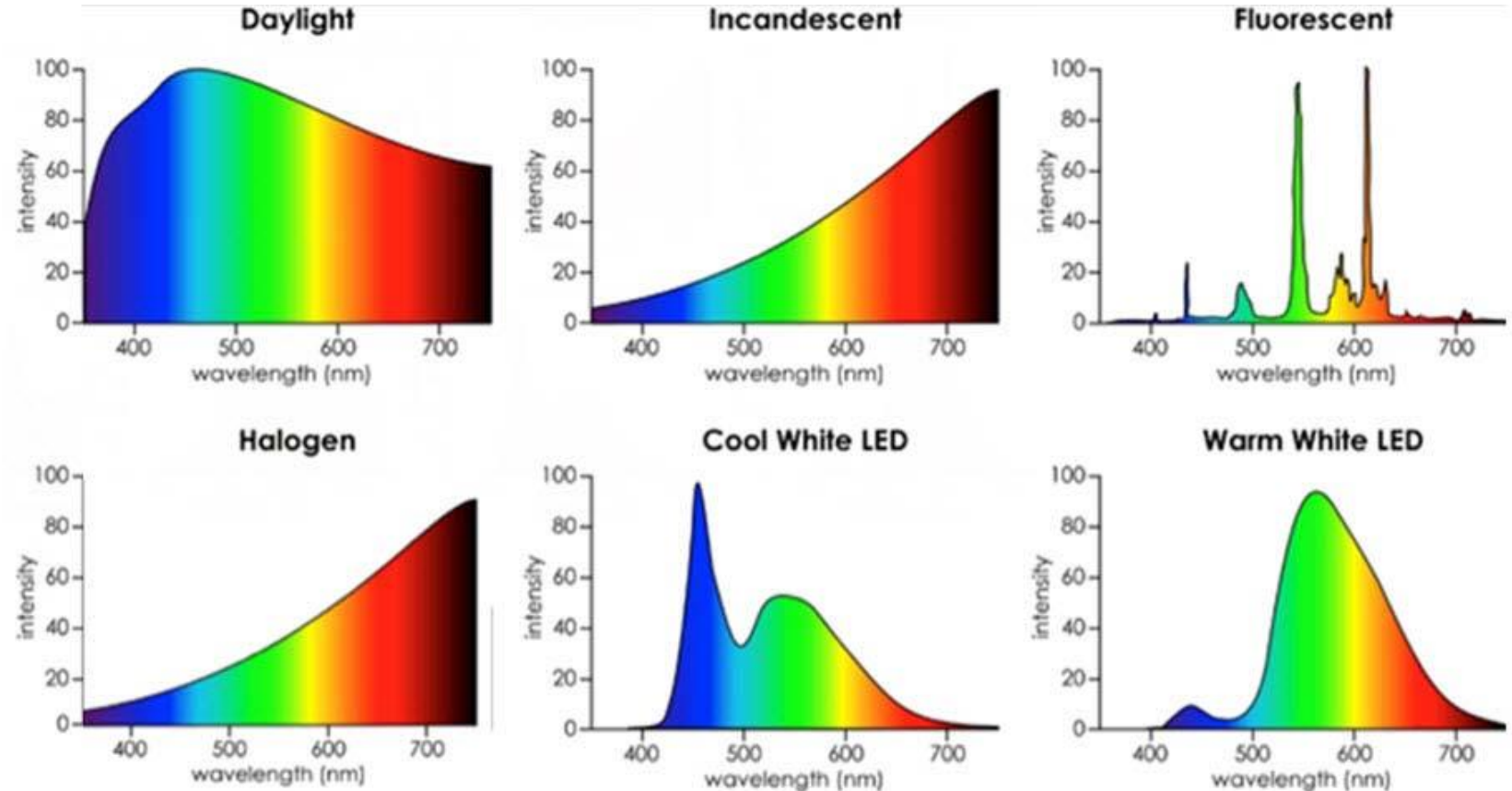
- Direction of light matters
- 90 degrees from nadir and higher
- Think about blues sky light



Cook Hospital

# Spectral Power Distribution

- What wavelengths are present in the light source
- Heavy reliance on blue wavelengths
- Research is showing this may not be as important as thought
- Non-visual photoreceptors (ipRGC) benefit from SPD



# Duration - Dose

- How long are you subjected to the light stimulus?
- At what intensity was the light stimulus?
  - Both matter



Courtesy of Signify



# Timing

- What time are you subjected to the stimulus?
- Resetting the circadian clock at 5:30 pm may not be the best choice for day active workers.
- What about for students?
  - ~8am – ~3pm





# Photobiological History

- The patterns of light exposure during the day and over time matter
- Intensity ranges may be critical over time
- How does this affect shift workers?



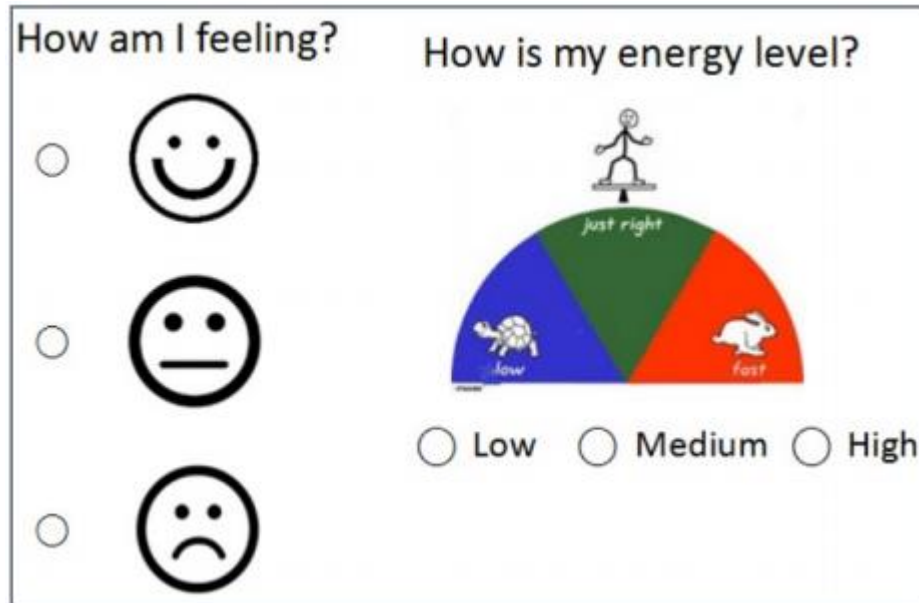
# Tunable White in Classrooms – PNNL & DOE 2018-2019 Study

## ■ Study Conclusions

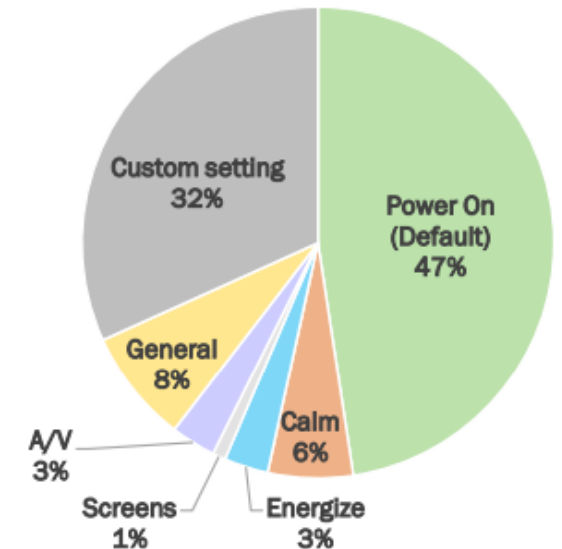
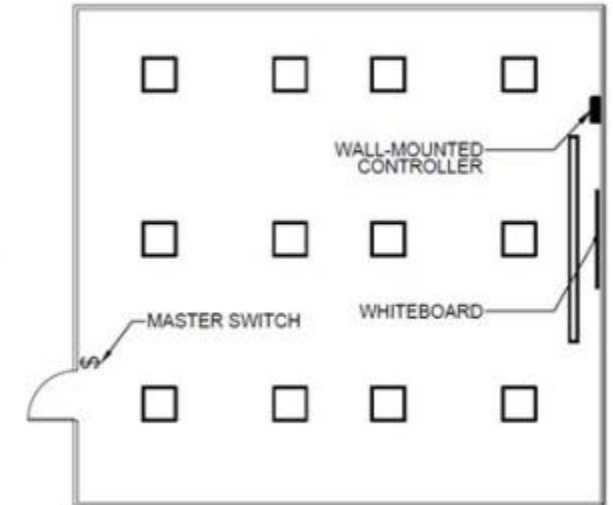
How am I feeling?

How is my energy level?

Low Medium High

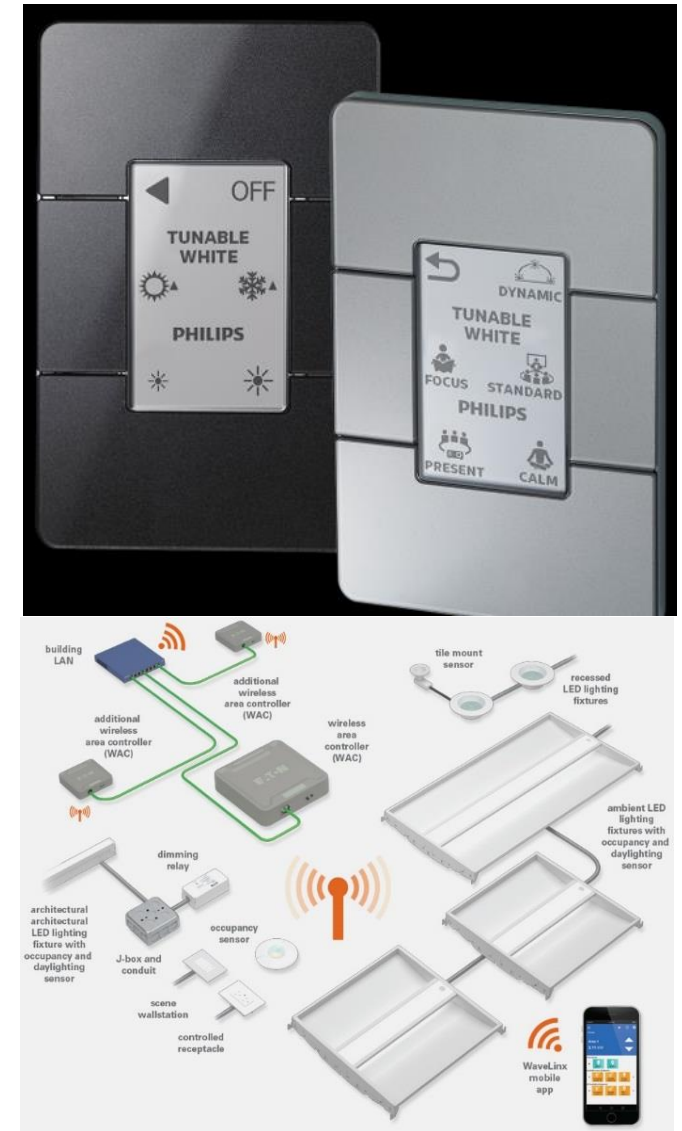


- improved working conditions and learning environment for teachers and students



# Lighting Controls to the Rescue

- Intensity
- Distribution
- Spectral Power Distribution
- Duration – Dose
- Timing
- Photobiological History
- If only we had a convenient means of manipulating most of these variables....



Courtesy: Signify, Eaton

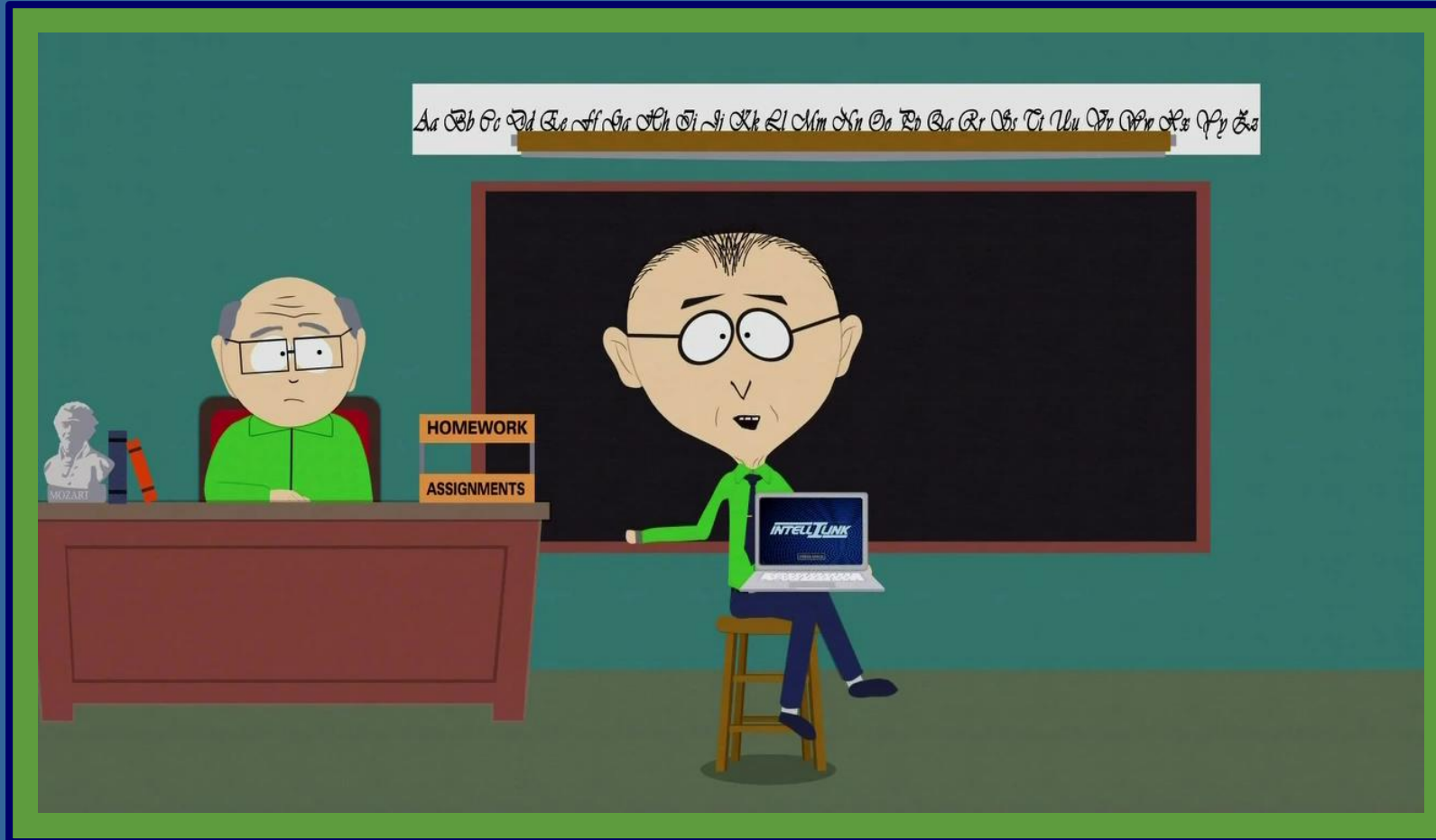
# Select variables that affect Circadian Entrainment

# Pause for Questions





# NLC Implementation & Applications

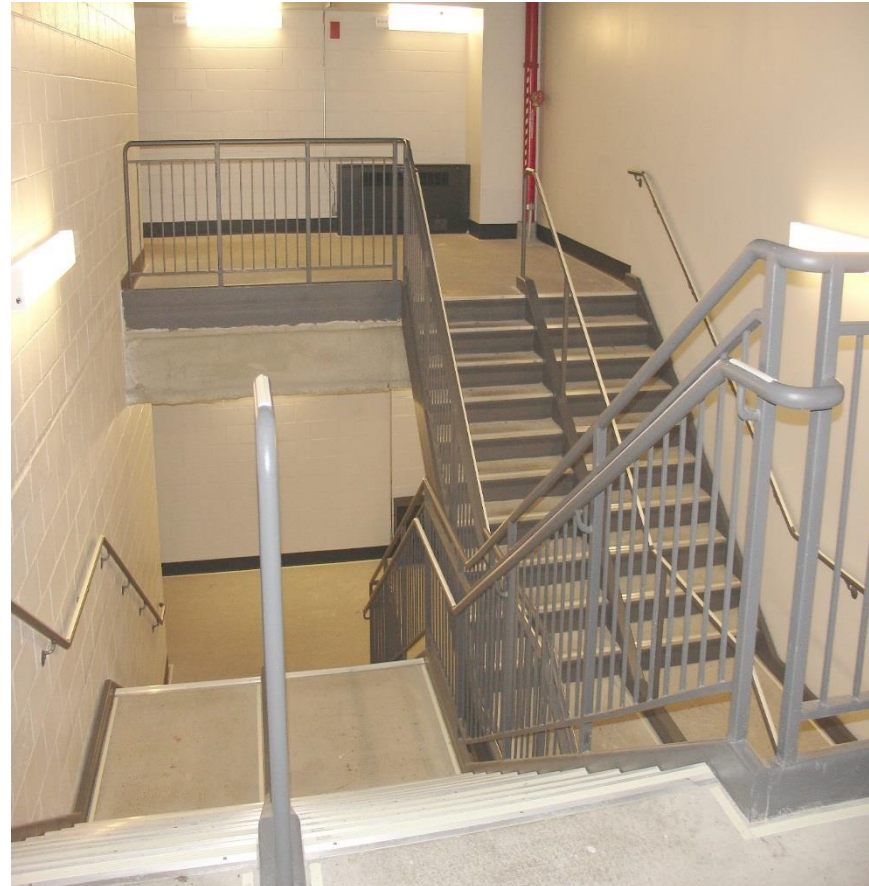
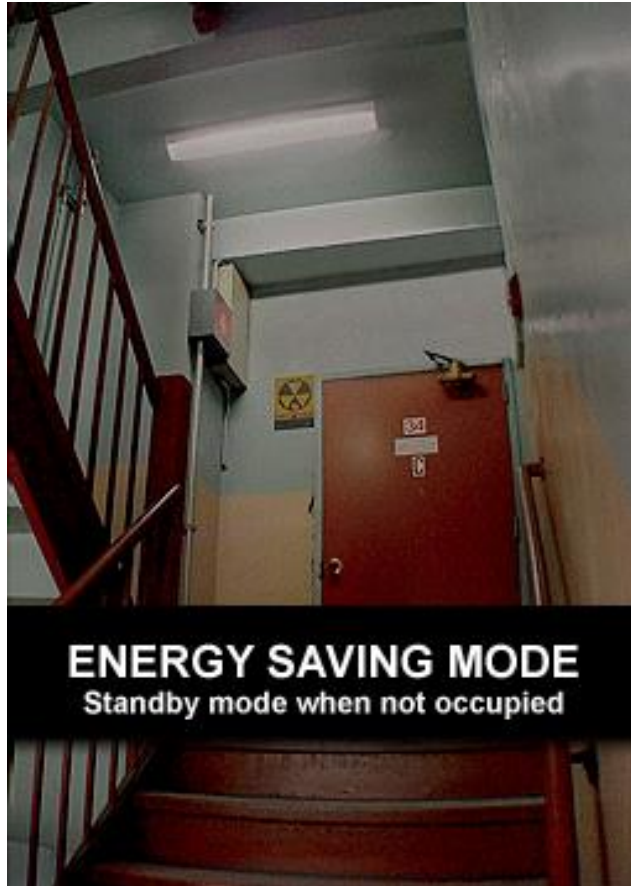


# Stairwells and Corridors and Garages

- Each space could have one or few more Load Controller and Sensor
- Automatically reduce lighting power by not less than 50% when vacant for 15 minutes (30 for Garages... or refer to code)
- Restore lighting to full or a higher level (50%+) when occupants enter the stairway.

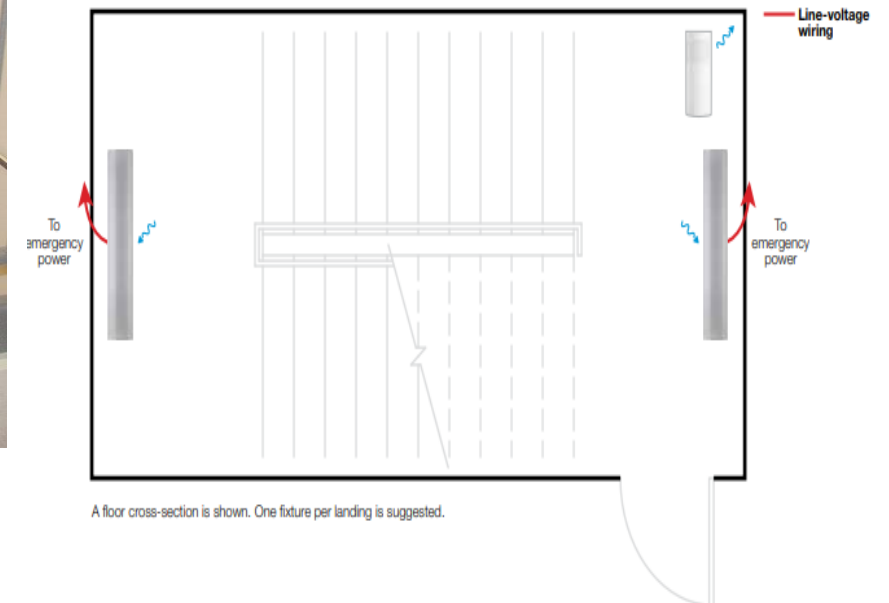


# Stairwells and Bi-Level Dimming

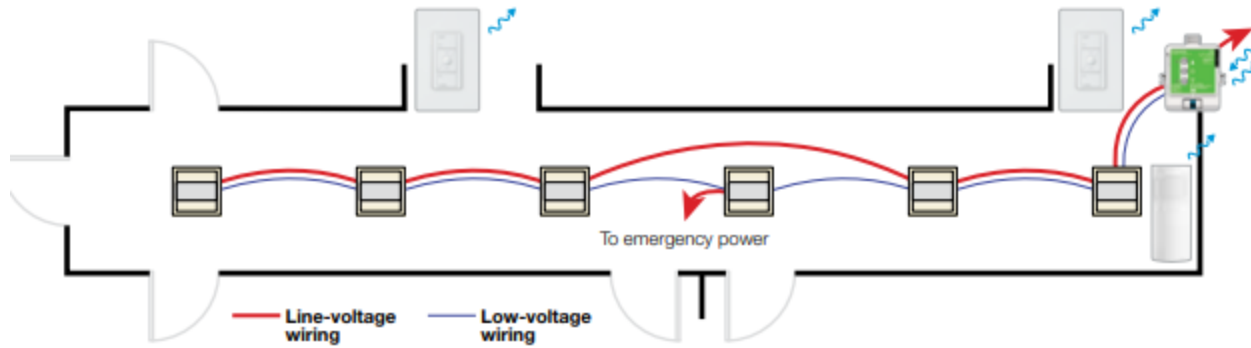


NLC + LLLC  
Approaches

Separate Corner Mount  
Sensors

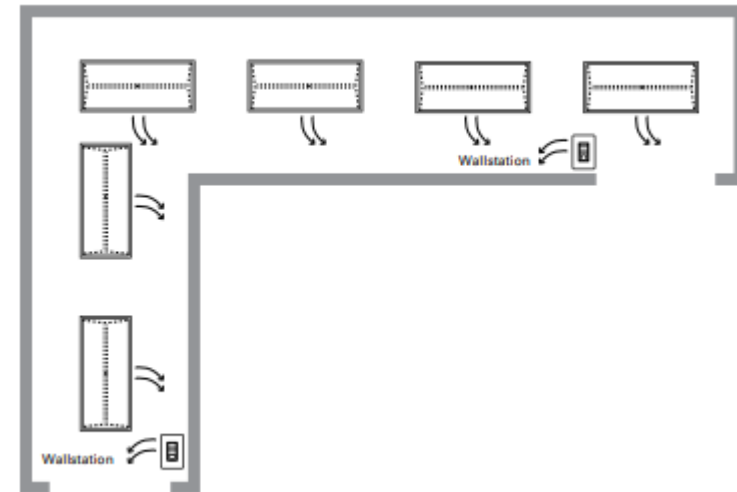


# Corridors



- Some hallway sensors can have coverage beam of 1500 ft
- Hi-Low
- Manual control optional

## LLLC Benefits in L-Shapes!



# Restrooms

## Single Stall

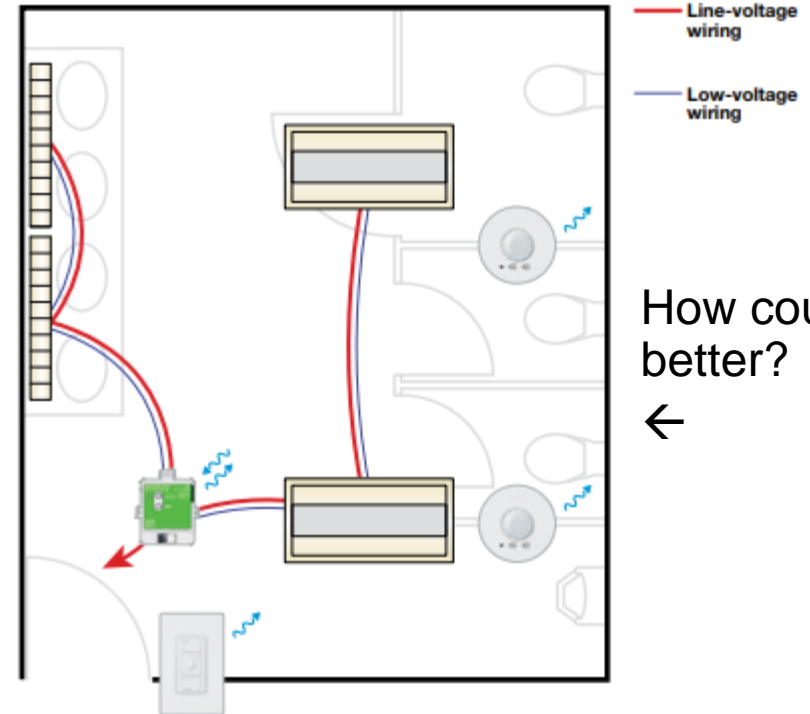


What's the difference here?



Can also implement connected sensors, load controllers, and wall station (optional)

## Multi-Stall



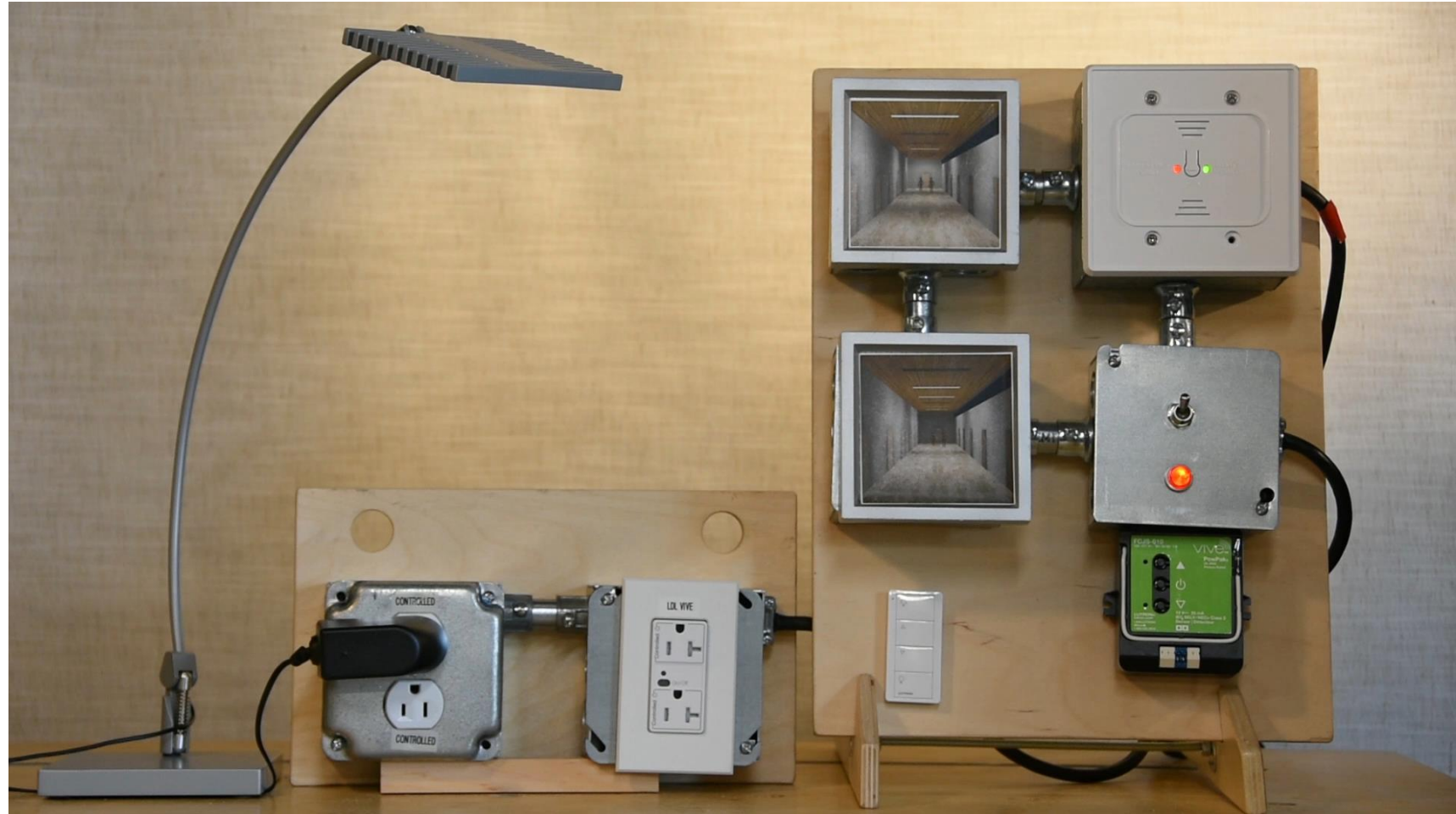
How could this be better?





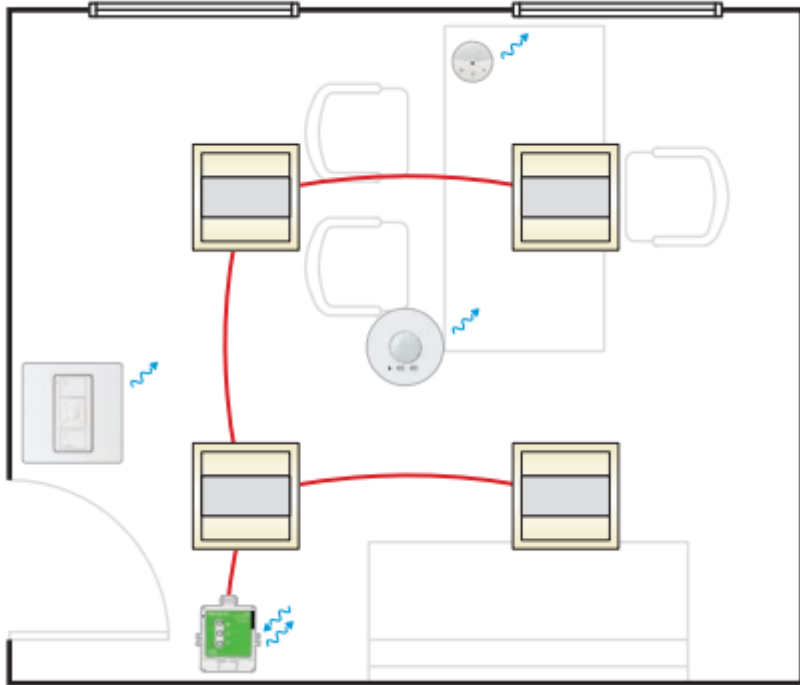
# Emergency – 24-hour lighting?

- Emergency lighting was frequently provided by a 24-hour constant hot circuit in the past.
- That is no longer allowed in most cases and codes!
- UL924

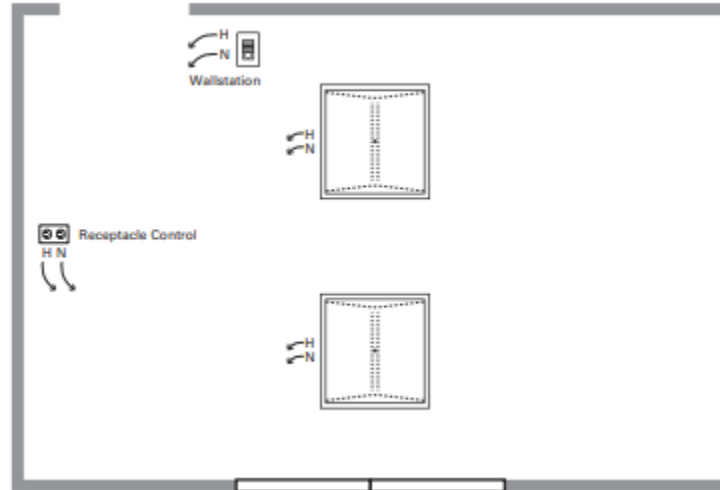


# Private Office

NLC Design



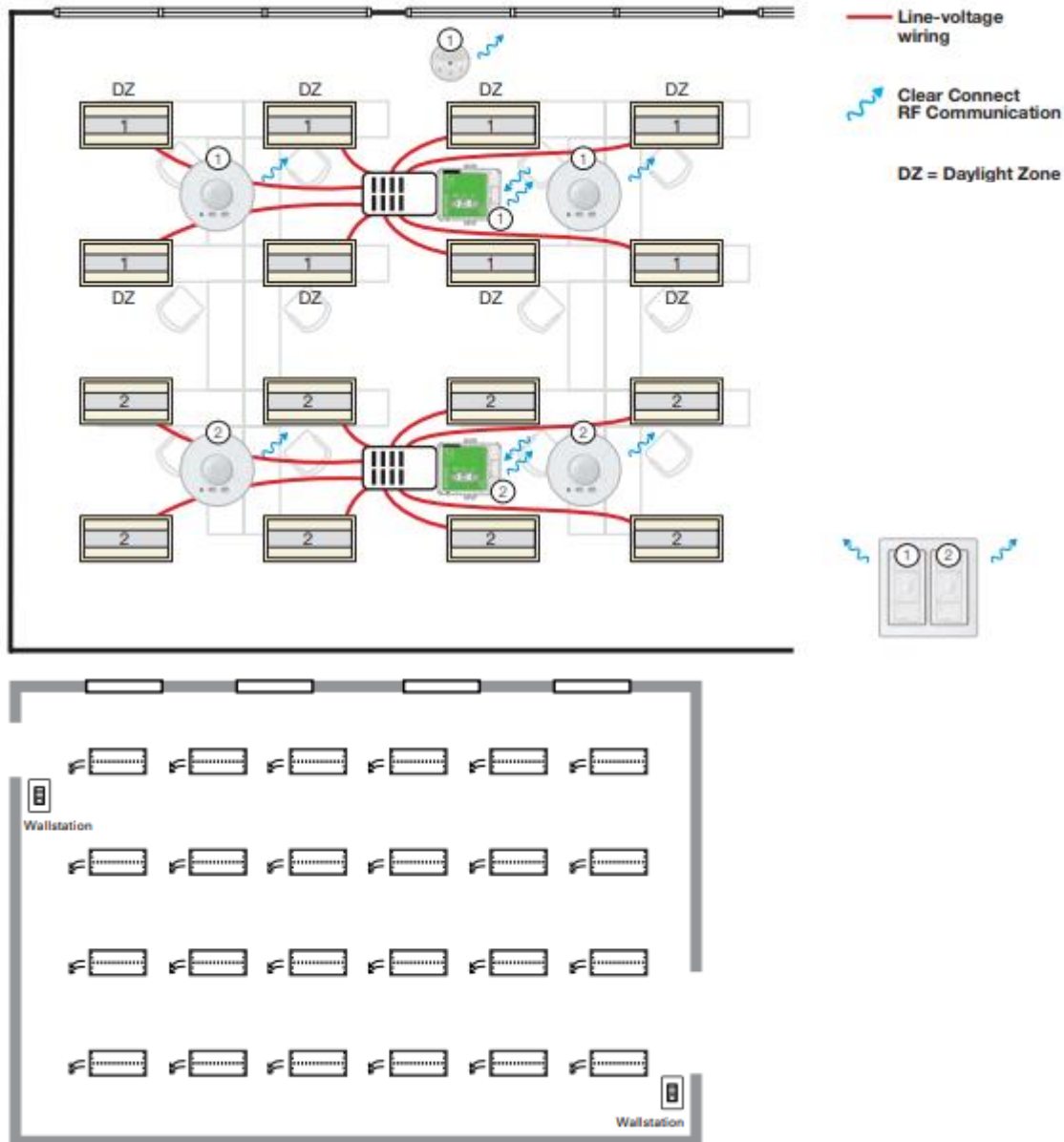
LLLC Design



Receptacle Control!



# Open Office



## Sequence of operations

### Lighting

- 0-10V lighting loads
- Up to 3 dimmable zones
- Out of the box 75% high end trim

### Occupancy

- Automatic on to 50%
- Optional vacancy mode
- Optional auto on to scene
- Optional plug load turns on/off with occupancy
- Automatic off of lighting and plug load on vacancy

### Daylighting

- Continuous dimming to off
- Individual luminaire daylight dimming to approximately 500 lux
- Daylighting not required for indoor space without windows
- Not required in spaces without windows or that are less than 150W

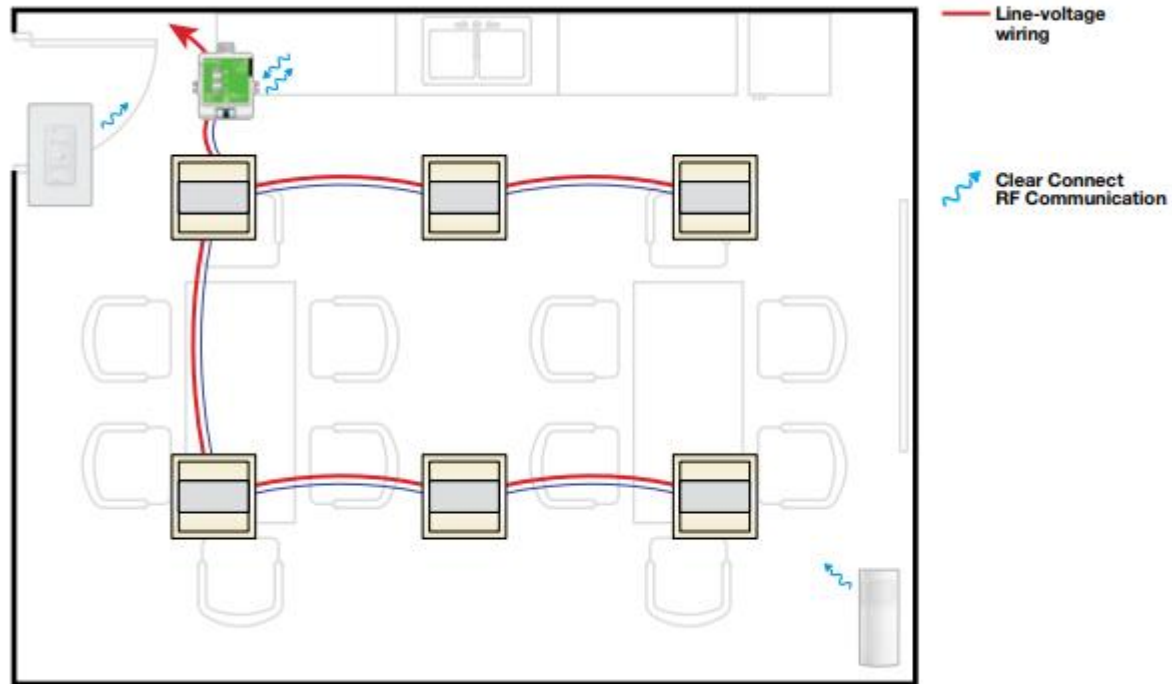
### Manual Controls

- Top or dominant button half lights (sets lights to 50% or less)
- Remaining buttons trigger scenes
- Raise
- Lower
- All off

### Additional Features

- Power measurement reporting through mobile application
- Automatic demand response available from wireless area controller
- Scheduling of partial off light levels and times from wireless area controller
- UL924 emergency control capabilities available via luminaire battery backup

# Break Room



## Control Functionality

### Occupant Enters:

Lights do not automatically turn on when an occupant enters the space; lights must be turned on manually. Maximum light level is set to 80%.

### When Occupied:

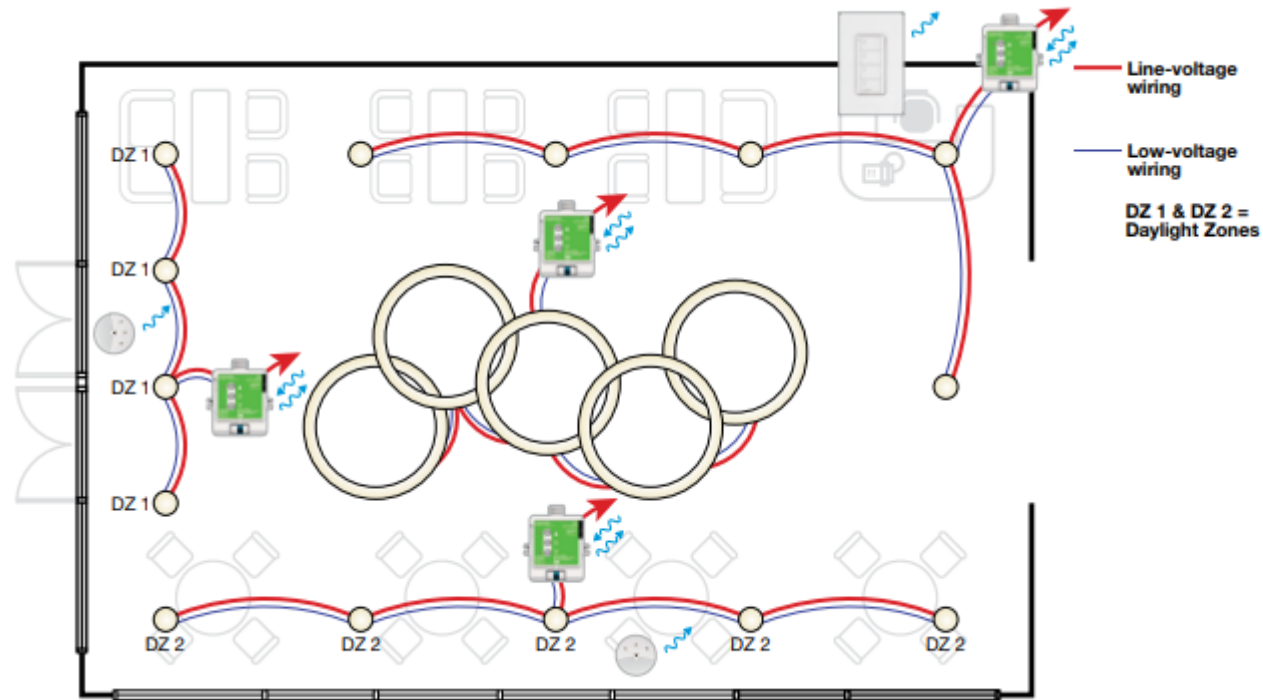
Manual: Occupant uses wall dimmer to set desired light levels for all lights.

### Occupant Exits:

All lights automatically turn off 15 minutes after all occupants exit.

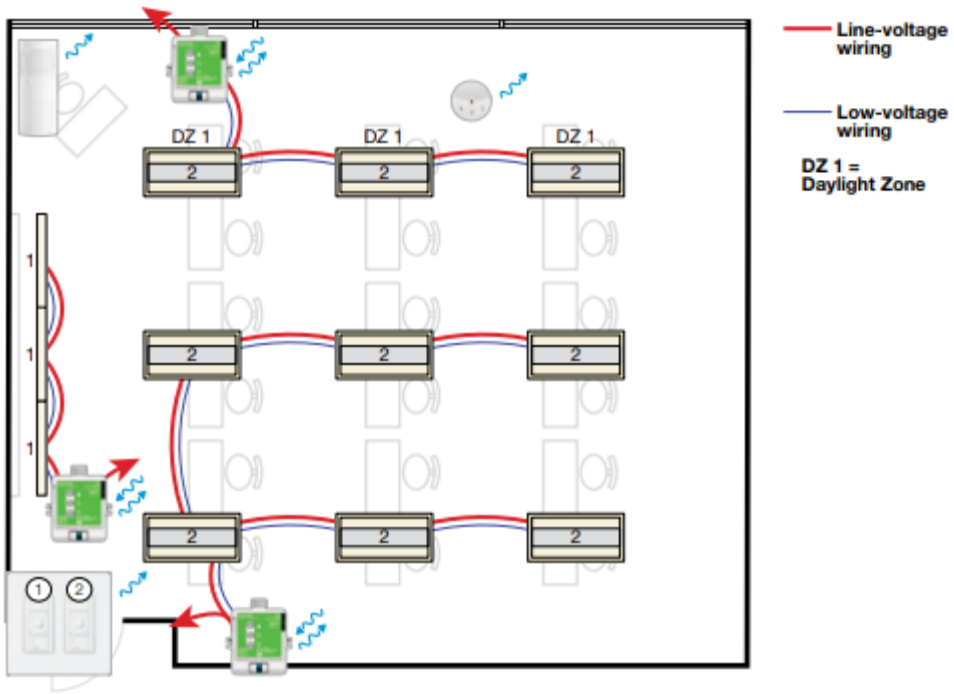


# Atrium

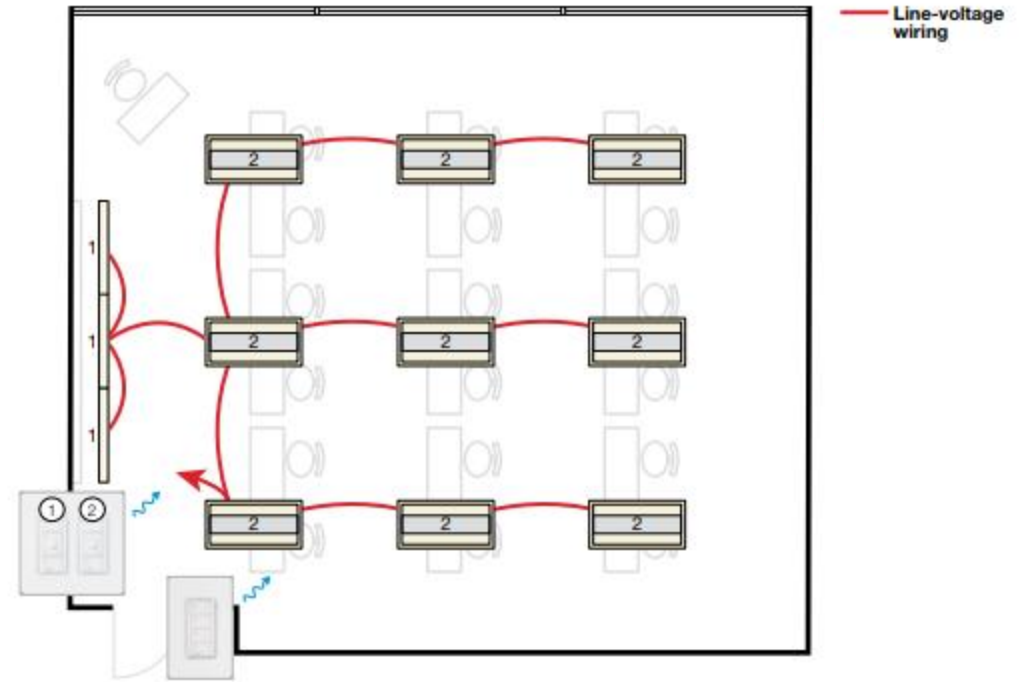


# Classroom

## NLC Design

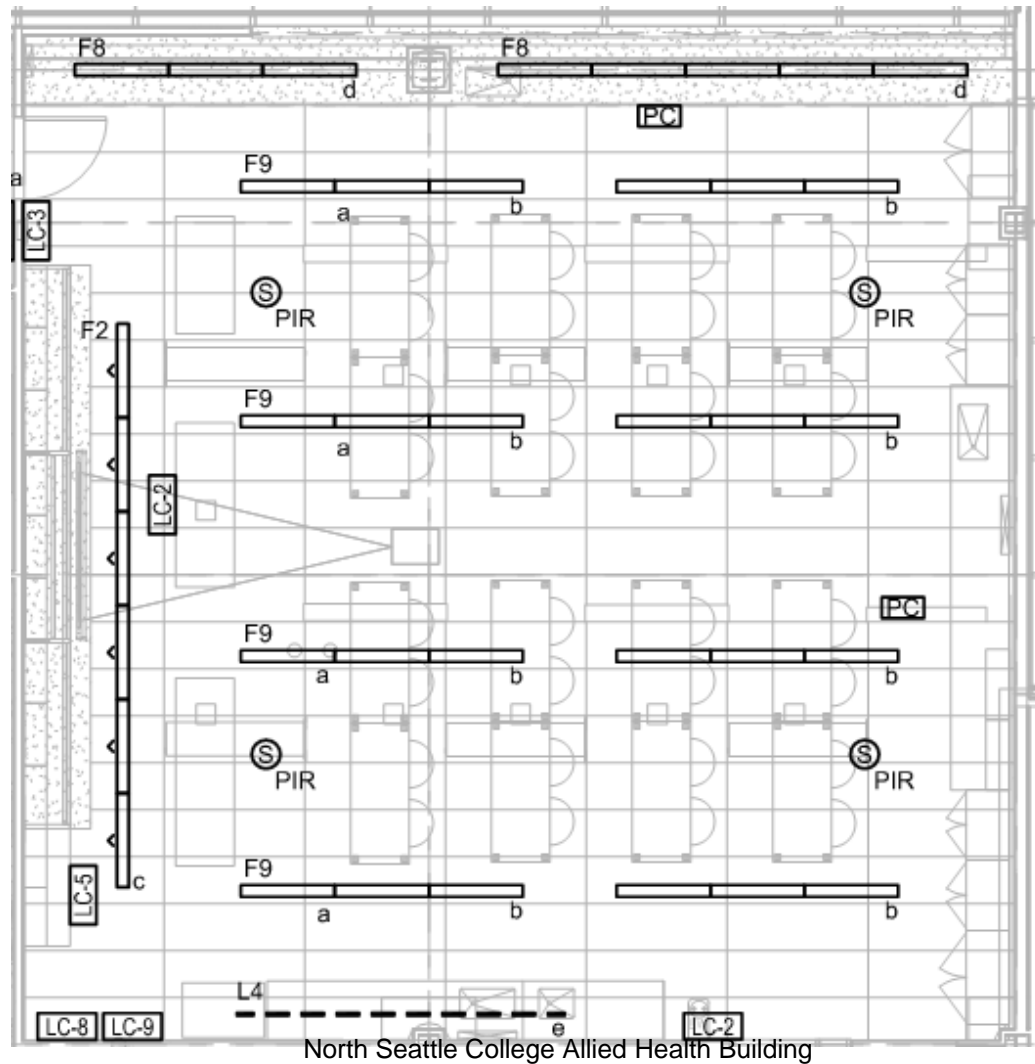


## LLLC Design



- Can also use ceiling sensors
- Quantity depends on sqft

# Classroom with many zones



Similar to a Lab

Difference:

- Use wall sensors between vertical obstructions in a Lab!

# Rep/Manufacturer Should be Involved – They Know Their Stuff!

IECC 2015 Commercial Energy Code Application Guide

## Suggested Code Compliant Solutions

Diagram key:

● = New construction

⚙ = Lighting retrofit<sup>1</sup>

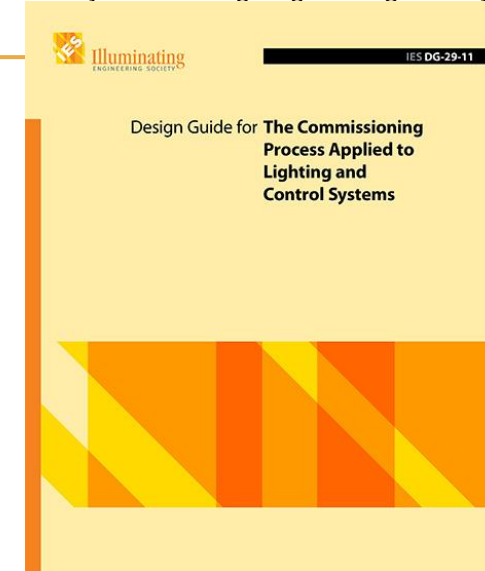
⚙ = New construction and retrofit<sup>1</sup>

		Atrium	Classroom, Lecture Hall, Training Room	Conference, Break Room	Corridor <sup>2</sup>	Lobby	Open Office (>300 sq. ft.)
Manual Control	Switch		⚙	⚙			
	Dimmer or scene control	⚙			⚙	⚙	⚙
Automatic ON/OFF Control	Timeclock	⚙					
	Occupancy sensor		⚙	⚙	⚙	⚙	⚙
	Settings	Full ON			⚙	⚙	
		Partial ON	⚙				⚙
		Manual ON	⚙	⚙			
		Full OFF	⚙	⚙		⚙	⚙
		Partial OFF			⚙ <sup>5</sup>		
Other	Daylight responsive control	⚙	⚙ <sup>6</sup>	⚙	⚙	⚙	⚙ <sup>6</sup>
	Receptacle control						
	Demand response						



# Commissioning vs. Startup

Courtesy: Illuminating Engineering Society



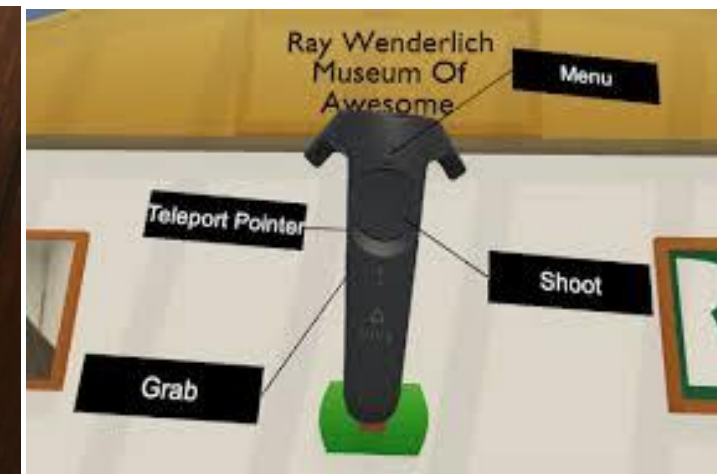
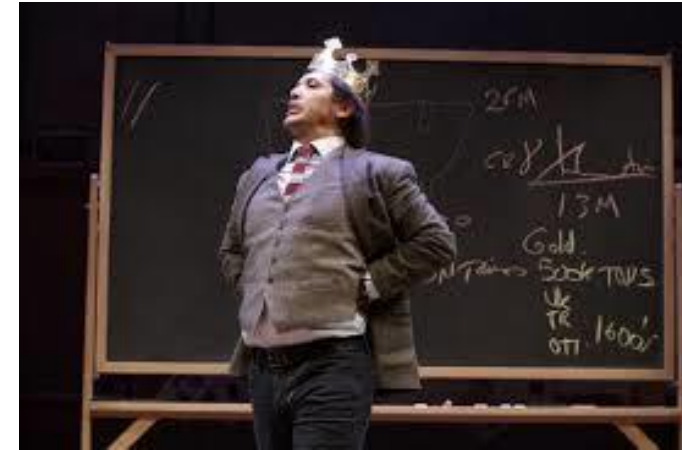
- Third Party Commissioning may be required
  - Commissioning Plan
    - Includes Optimization
  - Certified Commissioning Professional
    - Ie Title 24 / LEED / WELL
  - Functional Testing/Adjusting
  - Final Report (Docs required)
- Startup:
  - Initial programming of a system and its components



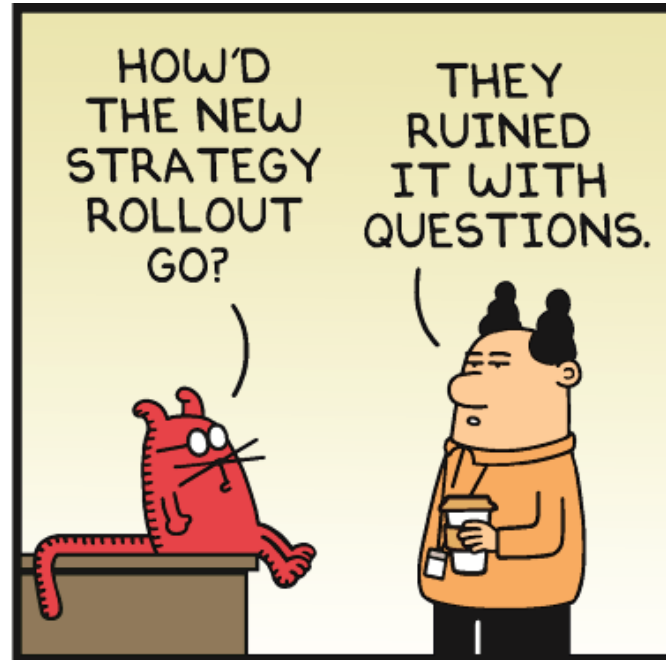
# Important & Overlooked Commissioning

## Commission the occupants....

- Let them know what to expect from the system and how it operates....and why....
- Teachers can be kings in their domain
- Empower tenants to interact with the space for their needs



# Pause for Questions



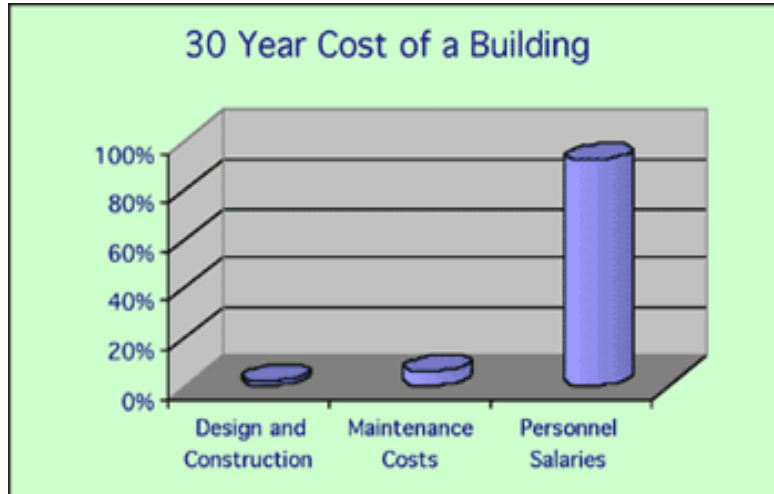
# Finance, Budgeting, Overcoming Some Barriers





# Connected Lighting Prospectus for Buildings

## The 1-9-90 Rule



1% Energy & Resources

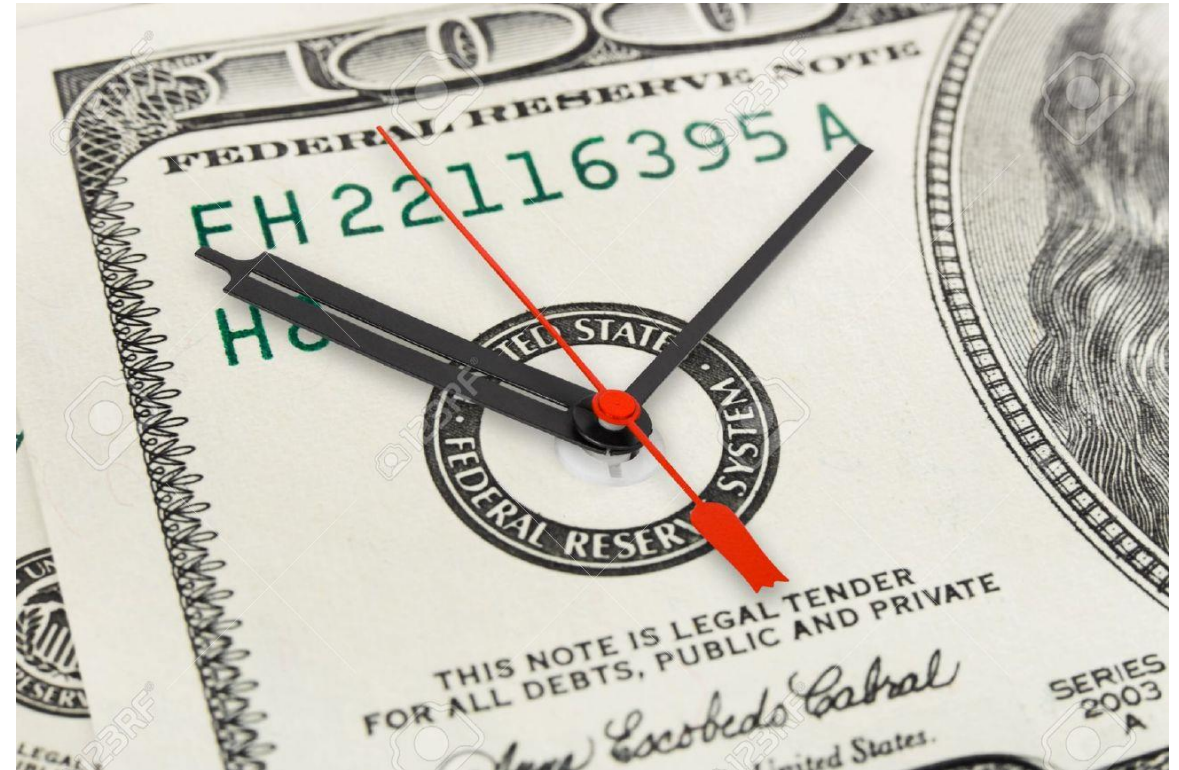
9%: Space & Layout

90%: Wellness & Productivity

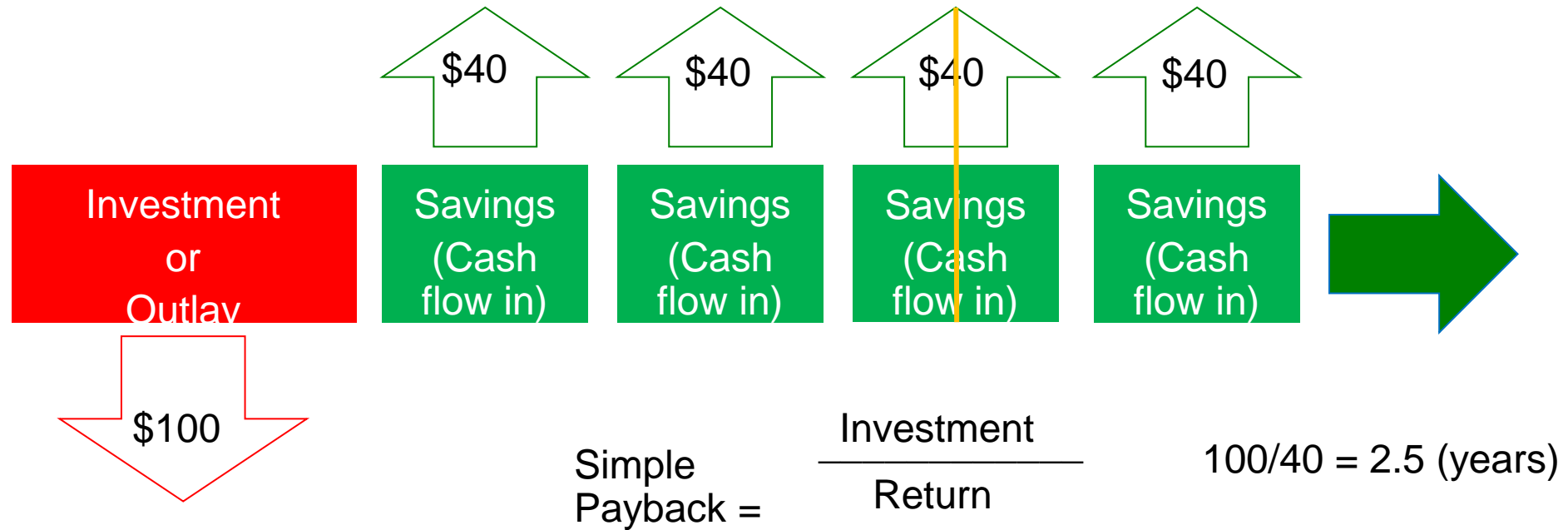
+100%: Revenue & Opportunities

# Discuss The Cost of Waiting

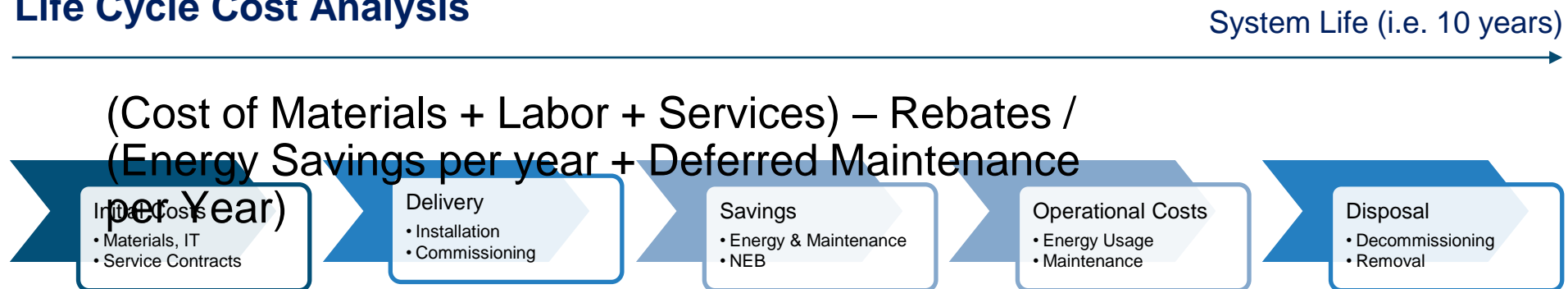
- Cost of Waiting - Urgency
  - Utility funding
  - Continue overspending on energy
  - Continue overspending on human capital
  - Equipment nearing EOL
- Listen to Stakeholder Objections
- Buy in from stakeholders



# Simple Payback vs. Life Cycle Cost



## Life Cycle Cost Analysis



To be expressed factoring Time  
Value of Money

# Simplified 10 Year Financial Plan Sample

<b>Discount Rate:</b>	10%										
<b>Date:</b>	<b>Today</b>	<b>End of Year</b>	<b>End of Year</b>	<b>End of Year</b>	<b>End of Year</b>	<b>End of Year</b>	<b>End of Year</b>	<b>End of Year</b>	<b>End of Year</b>	<b>End of Year</b>	<b>End of Year</b>
	0	1	2	3	4	5	6	7	8	9	10
<b>Cash Outflows</b>											
Lighting System:	\$(65,400.00)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Rebate Incentives:	\$ 15,400.00	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Outflow:	\$(50,000.00)										
<b>Cash Inflows</b>											
Energy Savings:		\$10,000.00	\$10,300.00	\$10,609.00	\$10,927.00	\$11,255.00	\$11,593.00	\$11,941.00	\$12,299.00	\$12,668.00	\$13,048.00
Maintenance Savings:		\$ 5,000.00	\$ 5,150.00	\$ 5,305.00	\$ 5,464.00	\$ 5,628.00	\$ 5,796.00	\$ 5,970.00	\$ 6,149.00	\$ 6,334.00	\$ 6,524.00
Inflows:		\$15,000.00	\$15,450.00	\$15,914.00	\$16,391.00	\$16,883.00	\$17,389.00	\$17,911.00	\$18,448.00	\$19,002.00	\$19,572.00
Annual Cash Flows:	\$(50,000.00)	\$15,000.00	\$15,450.00	\$15,914.00	\$16,391.00	\$16,883.00	\$17,389.00	\$17,911.00	\$18,448.00	\$19,002.00	\$19,572.00
PV of Cash Flows:	(\$50,000.00)	\$13,636.36	\$12,768.60	\$11,956.42	\$11,195.27	\$10,483.01	\$9,815.64	\$9,191.18	\$8,606.13	\$8,058.70	\$7,545.85
	<b>10-Year</b>	<b>Year-1</b>	<b>Year-2</b>	<b>Year-3</b>	<b>Year-4</b>	<b>Year-5</b>	<b>Year-6</b>	<b>Year-7</b>	<b>Year-8</b>	<b>Year-9</b>	<b>Year-10</b>
<b>NPV:</b>	\$53,257.17	(\$36,363.64)	(\$23,595.04)	(\$11,638.62)	(\$443.34)	\$10,039.67	\$19,855.31	\$29,046.48	\$37,652.61	\$45,711.31	\$53,257.17
<b>Simple Payback:</b>	3.19										
<b>ROI:</b>	34%										

# Lighting as a Service = Netflix and Lit?



- No up-front capital costs
  - Equipment, Commissioning, Maintenance by Provider
  - Monthly Payment from Savings
- Energy Metering
- Contract with Provider and Implementer





# Seattle City Light EEaS Pilot

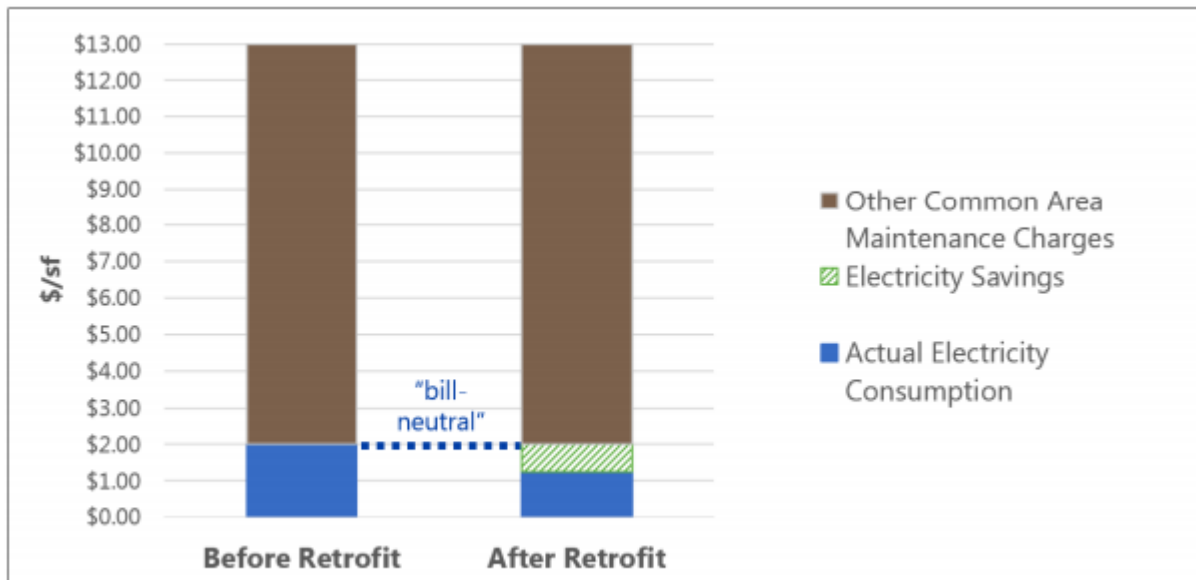


Figure 1. Example of Tenant Bill Neutrality

Energy Efficiency, News



## Seattle City Light is piloting America's first Energy Efficiency-as-a-Service program

By [Jennifer Runyon](#) | 6.19.20

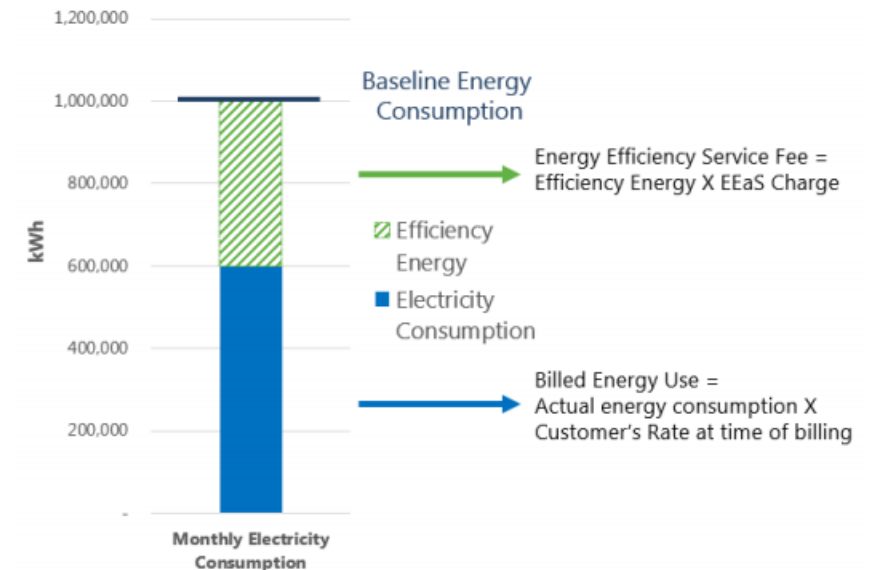


Figure 3. Basis of EEaS Seattle City Light Charges

# Stakeholder Objection

## Counter Suggestion

- **"I don't have any budget for an upgrade"**

- Consider existing cost for system and equipment maintenance
- Discuss the cost of waiting
- Demonstrate lifetime economics
- Highlight NEBs to different stakeholders
- Divide project into smaller phases
- Project will set both an economic and technical infrastructure for additional value-add building projects

- **"I Just want the cheapest option"**

- Provide at least 2 options: A cost-based option and a value-added benefit option for the building



# Dollars and Sense

What are the incremental costs of adding LLC or NLC to a project?

- Luminaire cost
- Networking hardware
- Programming time
- Others?
- I generally estimate a \$35-\$75 luminaire cost adder depending on the capabilities of the system.



January 7, 2021

REPORT #E21-415

## 2020 Luminaire Level Lighting Controls Incremental Cost Study

# NEEA Study

## General System Typologies:

### Clever

- Simple control with minimal fine tuning

### Clever – Hybrid

- All standard controls strategies

### Smart

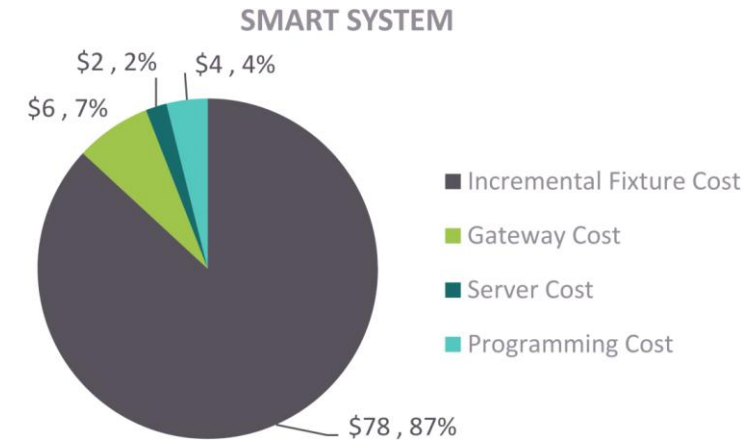
- Extended functionality and integration
- IOT
- Asst Tracking
- Smart Building Ecosystem

	Incremental Cost (per fixture)				
Year	2017	2018	2019	2020	Percent Change 2017-2020
System	Average	Average	Average	Average	Average
Clever	\$68	\$51	\$59	\$49	-28%
Clever-Hybrid	N/A	\$80	\$63	\$63	-21%
Smart	\$107	\$156	\$113	\$90	-16%

Manufacturer	Product	Clever	Clever-Hybrid	Smart
Acuity Brands	nLight Air®		Yes	
Acuity Brands	nLight®			Yes
Avi-on	Avi-on Lighting Control Platform		Yes	
Cree, Inc.	SmartCast® Technology	Yes		
Digital Lumens	Siteworx			Yes
Eaton	WaveLinx		Yes	
Enlighted Inc	Enlighted			Yes
GE Current	Daintree			Yes
Hubbell Lighting	NX Distributed Intelligence			Yes
J2 Light	Smart Blu	Yes		
Lutron Electronics	Vive™ wireless		Yes	
RAB	Lightcloud			Yes
Signify (Philips Lighting)	SpaceWise	Yes		

# NEEA Study - Smart

	Average	Min	Max
<b>Components Used to Calculate LLLC Per-Fixture Incremental Cost</b>			
LLLC Fixture (\$/fixture)	\$171	\$128	\$238
LED Fixture Without Controls (\$/fixture) <sup>a</sup>	\$93	\$93	\$93
Programming Cost (\$/node) <sup>b</sup>	\$4	\$2	\$5
Gateway Cost (\$/gateway)	\$718	\$100	\$2,000
Server Cost (\$/server)	\$2,130	\$1,000	\$3,000
Configuration Tool (\$/tool) <sup>c</sup>	\$0	\$0	\$0
<b>LLLC Per-Fixture Incremental Costs</b>			
Incremental Fixture Cost <sup>d</sup>	\$78	\$35	\$145
Gateway Cost	\$6	\$1	\$14
Server Cost	\$2	\$1	\$3
Programming Cost	\$4	\$2	\$5
<b>Total Incremental Cost</b>	<b>\$90</b>	<b>\$39</b>	<b>\$166</b>
<b>Average Total Smart Project Cost and Per Square Foot Cost – 100,000 Sq. Ft. Building</b>			
Average Total Project Cost <sup>e</sup>	\$220,701		
Average Total Project Cost (Per Sq. Ft.)	\$2.21		





# What are good strategies to combat budget shortages?

# Pause for Questions










# Keep it Simple, Students! – Solid Communication










# Sequence of Operations – Controls Schedule

## ARCHITECTURAL LIGHTING CONTROL SYSTEM LEGEND

DEVICE	DESCRIPTION		NOTES
ALCS	DISTRIBUTED INTELLIGENT ARCHITECTURAL LIGHTING CONTROL SYSTEM		DESCRIBES OVERALL SYSTEM INCLUDING SERVER, REQUIRED SOFTWARE PACKAGES, AND GENERAL ARCHITECTURE OVERVIEW.
LC-1	WALL STATION - 4 BUTTON PRESET PLUS OFF WITH RAISE LOWER		MOUNT ON WALLS FOR USER INTERFACE. COORDINATE PRECISE PLACEMENT WITH INTERIORS.
LC-2	WALL STATION - 2 BUTTON PRESET ENTRY ON/OFF		MOUNT ON WALLS FOR USER INTERFACE. COORDINATE PRECISE PLACEMENT WITH INTERIORS.
LC-3	WALL STATION - 5 BUTTON ZONE OVER-RIDE TOGGLE STATION		MOUNT ON WALLS FOR USER INTERFACE. COORDINATE PRECISE PLACEMENT WITH INTERIORS.
LC-4	WALL STATION - 4 ZONE PRESET PROGRAMMING STATION		MOUNT ON WALLS FOR USER INTERFACE. COORDINATE PRECISE PLACEMENT WITH INTERIORS.
LC-5	NOT USED		
LC-6	NOT USED		
LC-7	NOT USED		
LC-8	NOT USED		
LC-9	NOT USED		
LC-10	AV INTERFACE; RS232 AND ETHERNET		MOUNT IN UNOBTRUSIVE LOCATION NEAR TO AV EQUIPMENT REQUIRING COMMUNICATION WITH LIGHTING CONTROLS.
LC-11	CLOSURE COMBINE PARTITION SENSOR		MOUNT TO EITHER SIDE OF MOVEABLE ROOM PARTITIONS AS REQUIRED. PROVIDE IN CONJUNCTION WITH TYPE LC-11 CONTACT CLOSURE INTERFACE AND GRX-12V POWER SUPPLY AS REQUIRED.

## ARCHITECTURAL LIGHTING CONTROL SYSTEM LEGEND

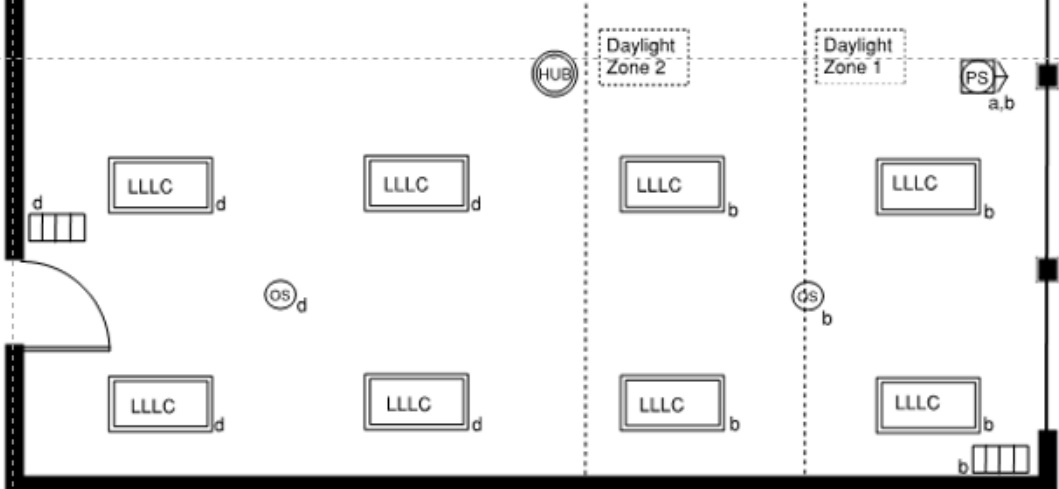
DEVICE	DESCRIPTION		NOTES
LC-12	DRY CONTACT CLOSURE INTERFACE		MOUNT IN UNOBTRUSIVE LOCATION NEAR TO EQUIPMENT REQUIRING DRY CONTACT CLOSURE TRIGGER FROM ARCHITECTURAL LIGHTING CONTROL SYSTEM.
LC-13	DMX SHOW CONTROLLER		TO BE LOCATED IN FIRST FLOOR ELECTRICAL ROOM. SIZE AS REQUIRED. INTERFACE TO TALK TO ARCHITECTURAL LIGHTING CONTROL SYSTEM.
OS-PIR	CEILING OR WALL MOUNTED PASSIVE INFRARED OCCUPANCY SENSOR		MOUNT IN CEILINGS OR ON WALLS AS SHOWN ON DRAWINGS AND IN AREAS IN WHICH OCCUPANCY SENSING IS REQUIRED AN LINE OF SIGHT TO DEVICE IS NOT OCCLUDED.
OS-DT	CEILING OR WALL MOUNTED ULTRASONIC OCCUPANCY SENSOR		MOUNT IN CEILINGS OR ON WALLS AS SHOWN ON DRAWINGS AND IN AREAS IN WHICH OCCUPANCY SENSING IS REQUIRED AND LINE OF SIGHT TO DEVICE MAY BE OCCLUDED, E.G. RESTROOMS.
LC-PC	DAYLIGHT SENSOR		MOUNT IN CEILINGS AS SHOWN ON DRAWINGS IN AREAS IN WHICH DAYLIGHT RESPONSIVE DIMMING IS REQUIRED.
LC-PP	PROCESSOR PANEL DIGITAL SYSTEM HUB.		MOUNT IN ELECTRICAL CLOSETS AS APPROPRIATE. PROVIDE QUANTITIES AND LOCATIONS AS REQUIRED TO PROVIDE ADEQUATE COMMUNICATIONS WITH ALL POWER PANELS AND INTERFACE DEVICES.
LC-SM	DISTRIBUTED RELAY SWITCHING MODULE WITH 0-10V DIMMING CAPABILITY		MOUNT IN REMOTE LOCATIONS AS APPROPRIATE. PROVIDE SIZES AND CONFIGURATIONS AS REQUIRED TO HANDLE ANTICIPATED CONTROL ZONE LOADS.

# NLC Key Collaboration Tool: Sequence of Operations

The Sequence of Operations communicates intent

Area	Typical open office		
	Lights	Zones (a) - (d)	Fully dimmable lights controlled in this area
Lighting and controls	Daylight Zones	Zones (a) - (b)	Daylight rows 1 and 2 will dim independently. Lights will automatically adjust to daylight maintaining recommended 30FC on task surfaces
	Manual Wall Control	Zones (a), (b), (c), (d)	For each independent zone, the user can select scenes on/off, 50%, and can raise/lower the zone

SPACE TYPE	CONTROL METHOD				
	HIGH END TRIM	DAYLIGHT SENSOR	MANUAL SWITCH	OCCUPANCY SENSOR	TIME CLOCK
Conference	X	X	X	X	
Equipment	X	X		X	
Office - open	X	X		X	X
Office - private	X	X	X	X	
Restrooms	X			X	

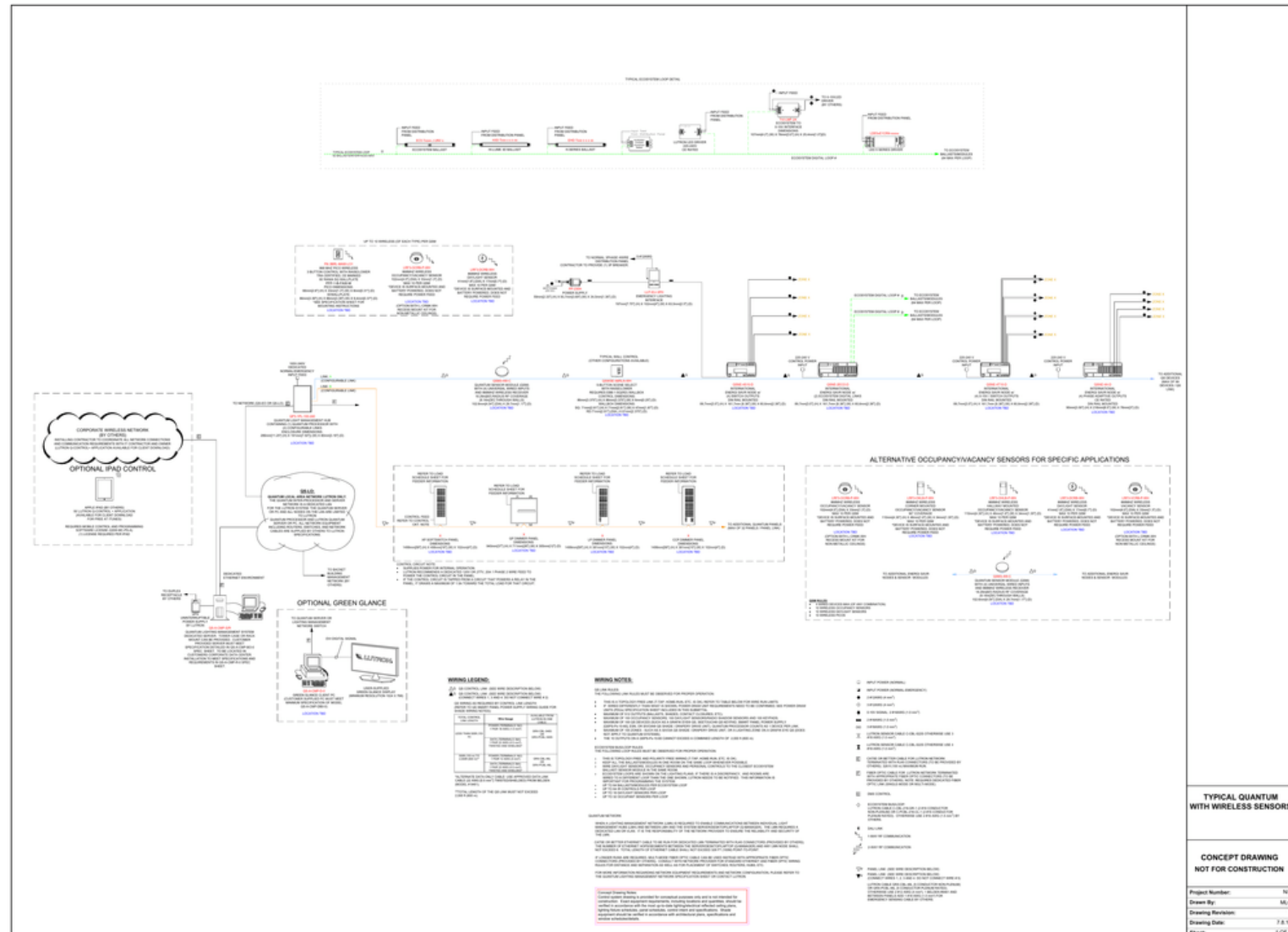


[Click to access LDL Sequence of Operations learning guide](#)



# One Line Docs for EC and Facilities

- Location specific hardware and connections
- Bonus to developing these and SOO early
- Pre-commissioning / packaging



# Key for Tenants: Wall Stations

- Another scope 'gray area'
- As NLC/LLLC systems become more flexible, wall station SOO is key to organization.
- Tenants prefer multi-scene wall stations with specific engraving and dedicated raise/lower buttons



# Key for Facility Professionals: Configuration Tools

Configuration tools are great when they provide

- An ordinal process
- Visual confirmation of settings
- Integral help features

Some are still pretty confusing!

Not every system uses an app



# Ensure There is System Training – Specs Sample

## Basis of Design:

- Division 260943
  - Lighting System Specs
  - Contractual Document

D. Manufacturer's factory service representative will instruct Owner for a minimum of sixteen (16) (less for smaller systems) hours coordinated with owner's schedule.

1. System capabilities.
2. System programming.
3. General operations.
4. Maintenance.
5. Replacement parts.
6. Available support.
7. Warranty.

# Important Questions to ask about Warranty

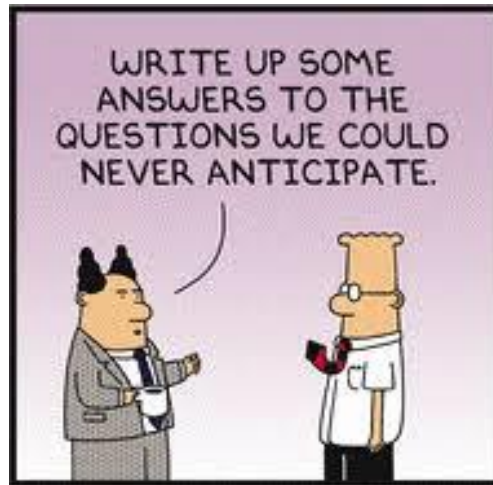
- How long has the manufacturer been in business?
- How long will the manufacturer be in business?
- Longer warranties cost more \$\$ with reputable manufacturers

## B. WARRANTY

1. Provide system manufacturer's warranty covering three (3) (or 2 or 5 – note longer warranty is more costly year parts and labor and ten (10) year limited parts warranty to repair and replace defective equipment.
2. Manufacturer will:
  - a. Maintain a standard stock of all spare parts for installed system for a minimum of ten (10) years from the date of system turn over to owner.
  - b. Provide factory direct technical support hotline 24 hours per day, 7 days per week.
  - c. Provide on-site service support within 48 hours.



# Pause for Questions



*And now – a few words from LDL*

# Upcoming LDL Online Events

LDL Course	Delivery Date	Time
<u>Get to Know City Light's Miller Community Center Microgrid</u>	5/27/2021	10am - noon
Heat Pump Series	June (3)	10am – noon

Today's slide deck and previous online courses  
can be found on our [website](#)

# Click – Call – Connect

- ▶ Armando Berdiel Chavez
  - ▶ 206-475-2722
  - ▶ [armando.berdiel@seattle.gov](mailto:armando.berdiel@seattle.gov)

## Visit us online

### Education

Advance your knowledge of complex lighting systems and energy-efficient strategies. From the science of light to the best practices of design...

LEARN MORE

### Resources

Linking you to programs and technology experts that enhance your projects and support your business.

TAP INTO

OR

## Email Us

[lightingdesignlab@seattle.gov](mailto:lightingdesignlab@seattle.gov)

Today's slide deck  
will be posted  
here!

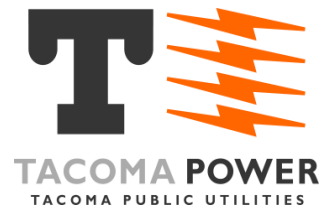


*Powered by*



# Seattle City Light

With support from 2020 member utilities







---

Please take the online survey once you exit the webinar

---

**We'll *SEE* you on the next call... 😊**