

Cost-Effective Code Compliance Lighting & Electrical

A scenic view of the Seattle skyline, featuring the Space Needle and various skyscrapers, framed by dark, silhouetted tree branches in the foreground. The sky is a clear, bright blue with a few wispy clouds. The foreground shows a balcony railing and the side of a building with a window.

Seattle City Light
Lighting Design Lab
February 2, 2021

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 periodically.
- 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 with comments or questions.



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Seattle Department of
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Shaun.Darragh@seattle.gov

More than 30 years in the lighting industry as an architectural lighting designer, instructor, daylighting and sustainability specialist, lighting control system consultant, and theatrical designer.

Has taught and consulted on sustainability issues, lighting, and daylighting for the Lighting Design Lab and University of Washington Architecture Department

Selected Projects

- King Abdullah University of Science and Technology
- Masdar Headquarters
- Pearl River Tower
- Canyon Ranch Spa Club
- Amgen Helix Campus
- Reebok World Headquarters
- Reno Sparks Convention Center
- Pacific Place Retail Center
- Ala Moana Retail Center
- REI Denver Flagship Store
- Boeing Commercial Airplanes Offices
- Real Networks Headquarters
- Tommy Bahama Headquarters
- Microsoft B16/17
- San Francisco PUC Headquarters

Selected Awards

- Amgen Helix Campus
- Amgen Helix Pedestrian Bridge
- Canyon Ranch Spa Club
- Harvard University 60 Oxford
- King Street Station
- Lighting Design Lab
- Methodist Hospital Research Institute
- Microsoft B16/17
- One Cambridge Center
- Pacific Place Retail Center
- Reebok World Headquarters
- Reno Sparks Convention Center
- Real Networks Headquarters
- SFPUC Headquarters
- Tommy Bahama Headquarters

AIA COTE Top 10

- REI Flagship Store Denver
- King Abdullah University of Science and Technology
- San Francisco PUC Headquarters
- Manitoba Hydro Place

Duane Jonlin, FAIA

- 30 years as technical architect
- 9 years as Energy Code guy
- 4th generation Seattleite



We got this.

Lighting the way towards our environmental goals



Washington state:

70% less building energy use by 2030

- Zero-carbon buildings
- Gov says move faster

Washington state:

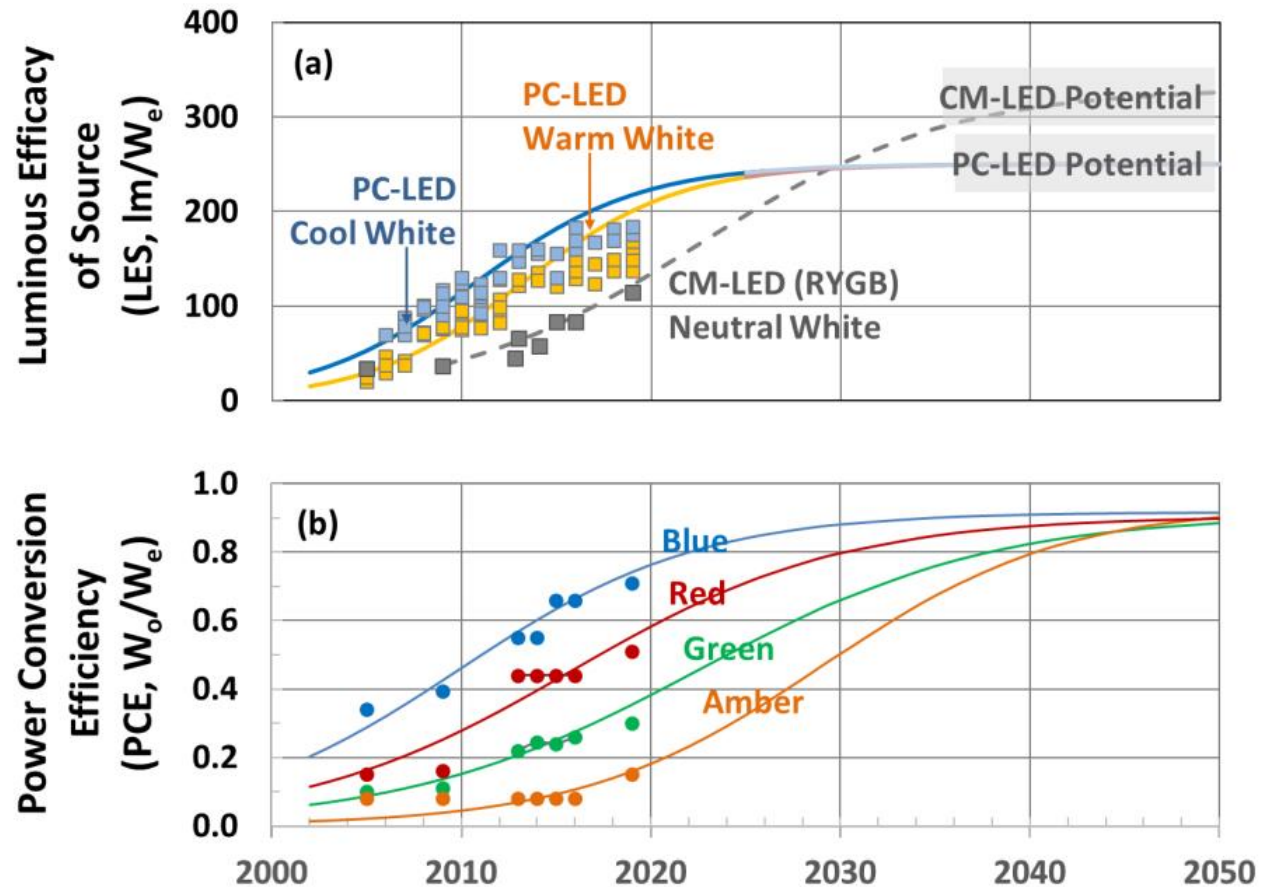
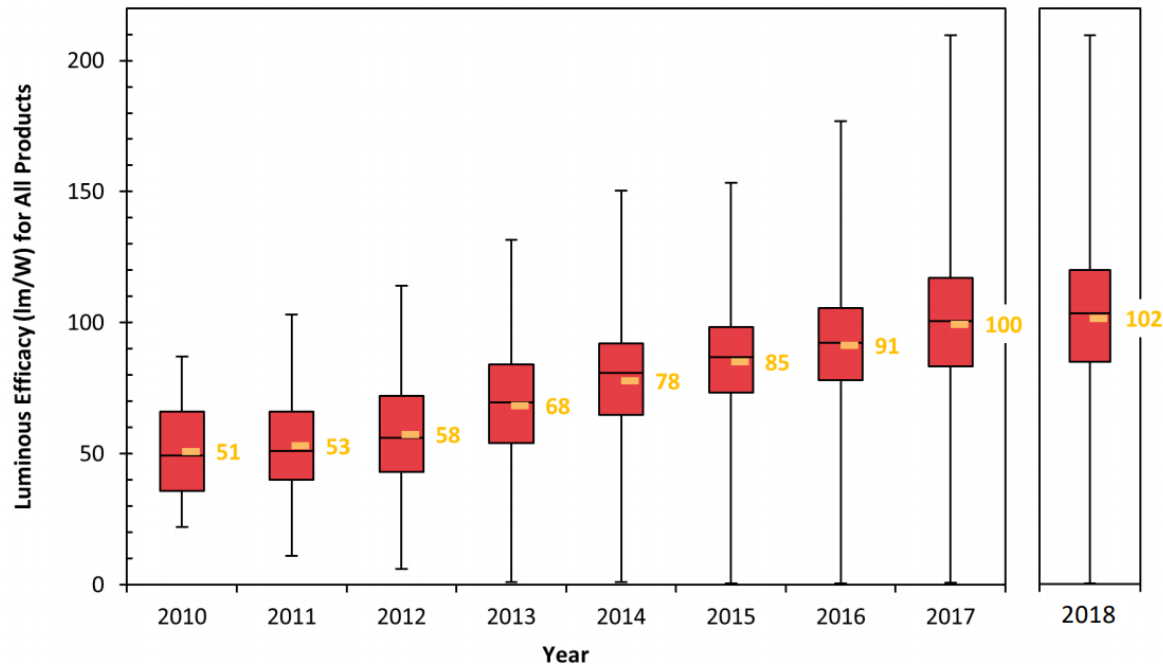
45% reduction in GHG emissions by 2030

- 95% reduction by 2050

Seattle: Carbon-neutral building & vehicle operations by 2050

- ...or sooner with Green New Deal?

LED efficacy trends



[2019 Solid-State Lighting R&D Opportunities \(energy.gov\)](https://www.energy.gov/2019-solid-state-lighting-r&d-opportunities)

Low Hanging Fruit

Lighting has long been the go-to solution for major energy efficiency upgrades and code revisions.

- Research into visual systems
- Improvements in design and systems
- Improvements in light sources
- Cultural shifts
- Lighting Controls are next up

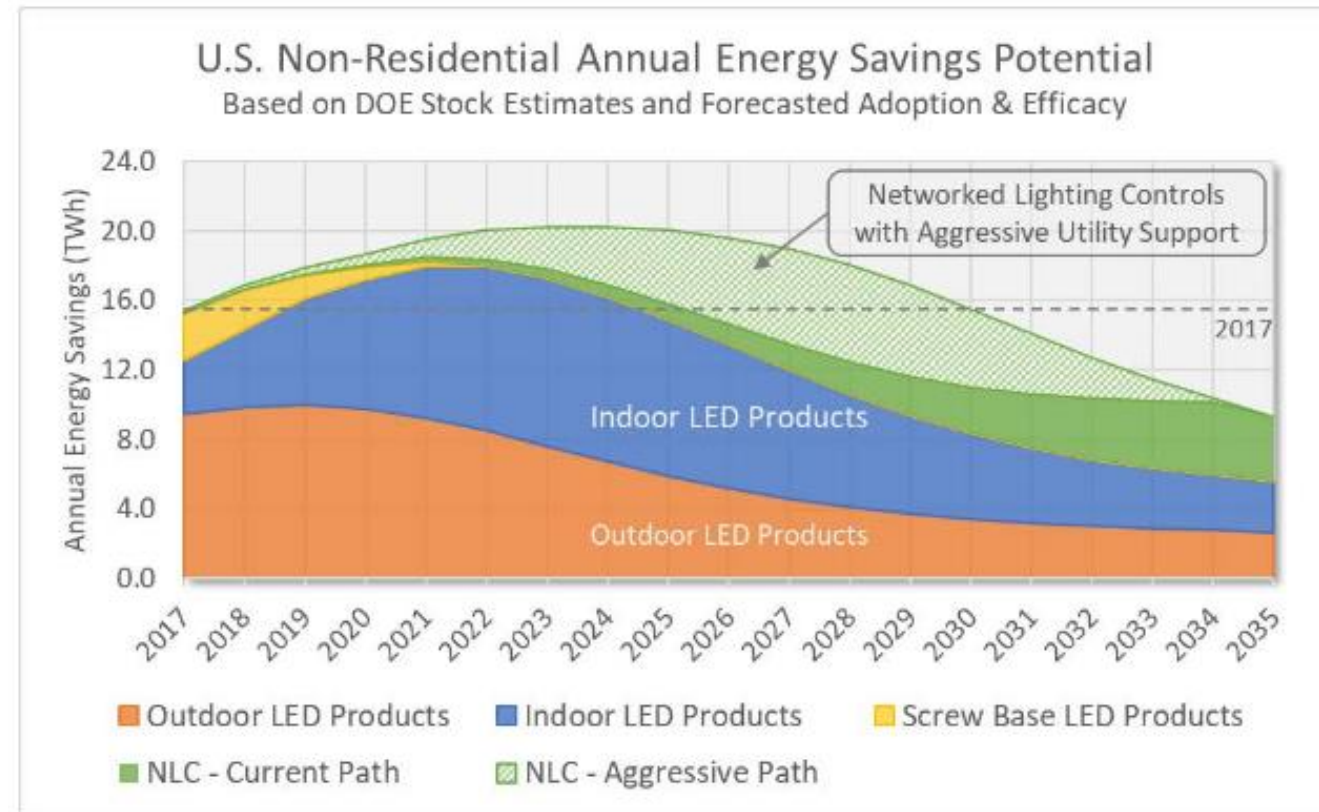


Figure 4: Non-residential (C&I) annual energy savings potential from LED & networked lighting controls, assuming aggressive utility support

Seattle amendments: 4 Guiding Principles

1. Envelopes meet our “2050” standard
 - We have to decide what that 2050 standard is
2. No “internal combustion buildings”
 - Electrical infrastructure for exceptions
3. Efficient use of electricity
 - Typically heat pumps for space heating & water heating
 - Highly efficient systems & controls
4. Increased on-site renewables
 - Options for off-site purchase
 - Plus “solar readiness” for bigger future system

Today:
Lighting
& Elec

New buildings must be *capable of* meeting Seattle’s 2050 targets.

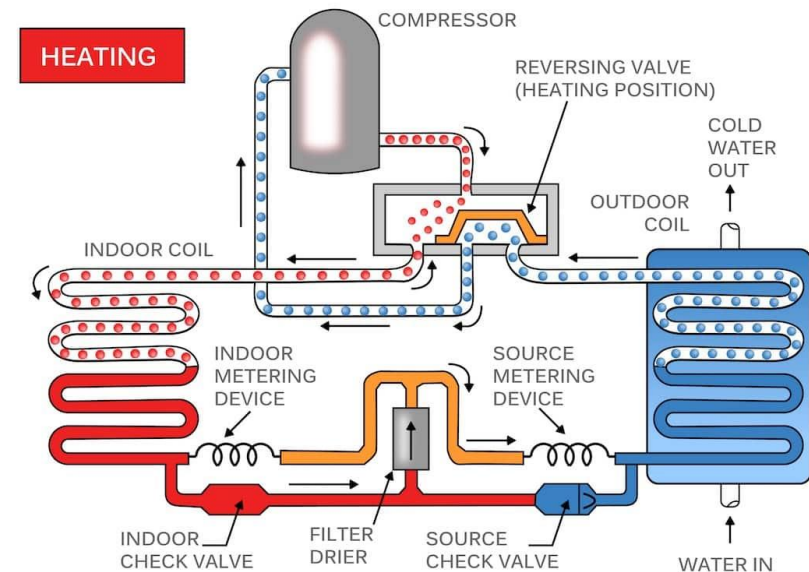
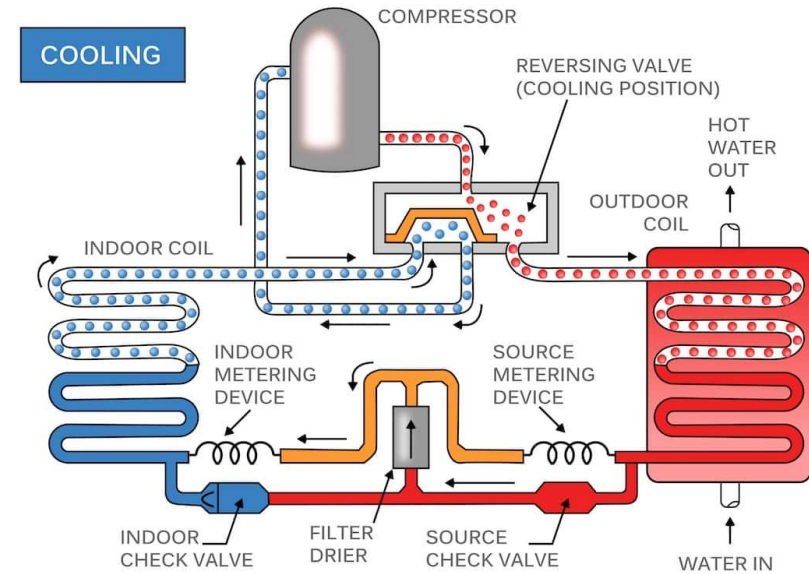
Seattle: Space heating

No electric resistance or fossil fuel combustion for space heating

(Usually means “Heat with heat pumps”)

Exceptions allow electric resistance heat for:

1. Permits applied for before ~~1/1/22~~ 6/1/21
2. Dwelling units: Max **750 W** per habitable room (**1000 W** for corner room)
3. Other space types: Max 2.5 W/sf total installed heating (The “Passive House” rule)
4. Heat pump auxiliary heat in cold weather
5. Buildings smaller than 2,500 sf
6. ...etc



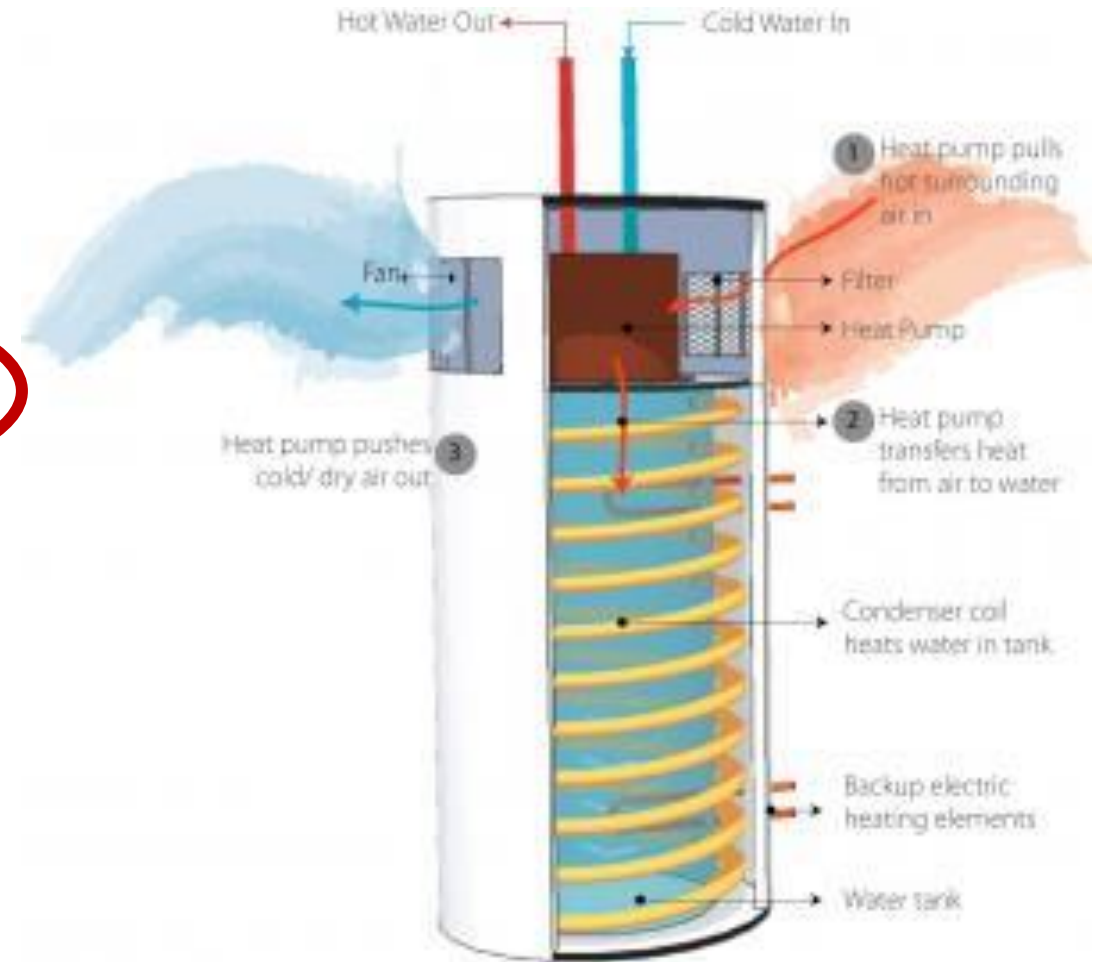
Heat pumps squeeze warmth out of cold air

Seattle: Multifamily Heat Pump Water Heating

Effective January 1, 2022

Only for hotel & multifamily buildings with central domestic water heating:

- No electric resistance or fossil fuel water heating equipment.
 - Typically, use heat pumps instead
- Some auxiliary heat OK below 40 F
- Elec resistance OK to reheat circulating water



Lighting controls: summary

Two basic paths for controls:

1. Provide LLC fixtures everywhere, or
2. Comply with *all* lighting controls
 - Plus LLC or networked lighting control in large open office (Seattle)
- Exceptions:
 - Designated “security or emergency” areas
 - 0.01 W/sf in “exit access” areas
 - Egress lighting that’s normally off
 - Industrial

- Occ sensors in 14 space types
 - Plus special rules for warehouse, storage, open office, garage, stair
- Time switch where no occ sensors
 - Except: patient care, “safety or security,” continuous operation, shop & lab
- Manual controls everywhere
 - Except: Restroom, stair & garage (Sea)
- Daylight controls in daylight zones
 - Except: 1 or 2 fixtures, patient care, retail/restaurant at sidewalk
- Light reduction: no daylight controls
 - Long list of exempt space types

Typical Control Strategies

- Manual Switching
- Manual Dimming
- Scene / Preset Control
- Occupancy Sensing
- Vacancy Sensing
- Daylight Harvesting
- Task Tuning
- Time Scheduling
- Astronomic Scheduling

Networked Lighting Controls Fundamentals:

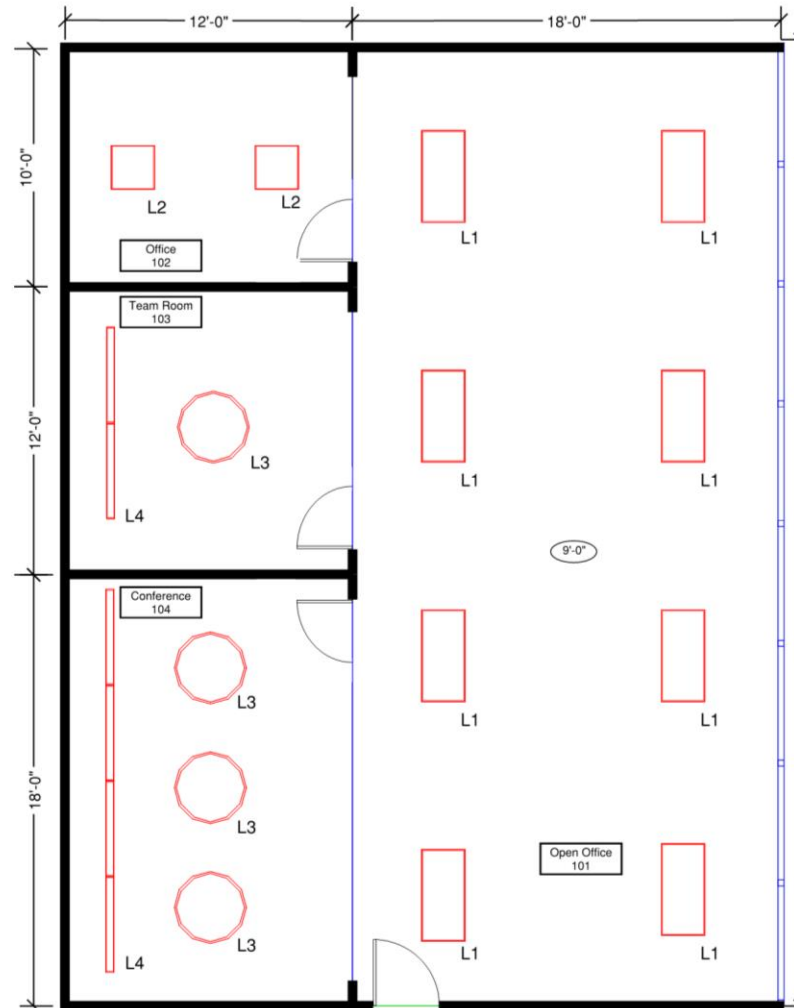
<https://youtu.be/Y3logJxHsTY>



San Francisco Public Utilities Commission Headquarters
KMD

Project – Tech X Offices

- Manual Dimming
- Scene / Preset Control
- Occupancy Sensing
- Vacancy Sensing
- Daylight Harvesting
- Task Tuning
- Time Scheduling



OFFICE NEIGHBORHOOD ENLARGED LIGHTING PLAN
SCALE: N.T.S

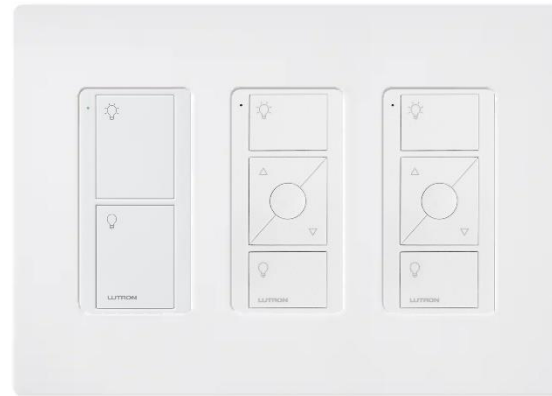
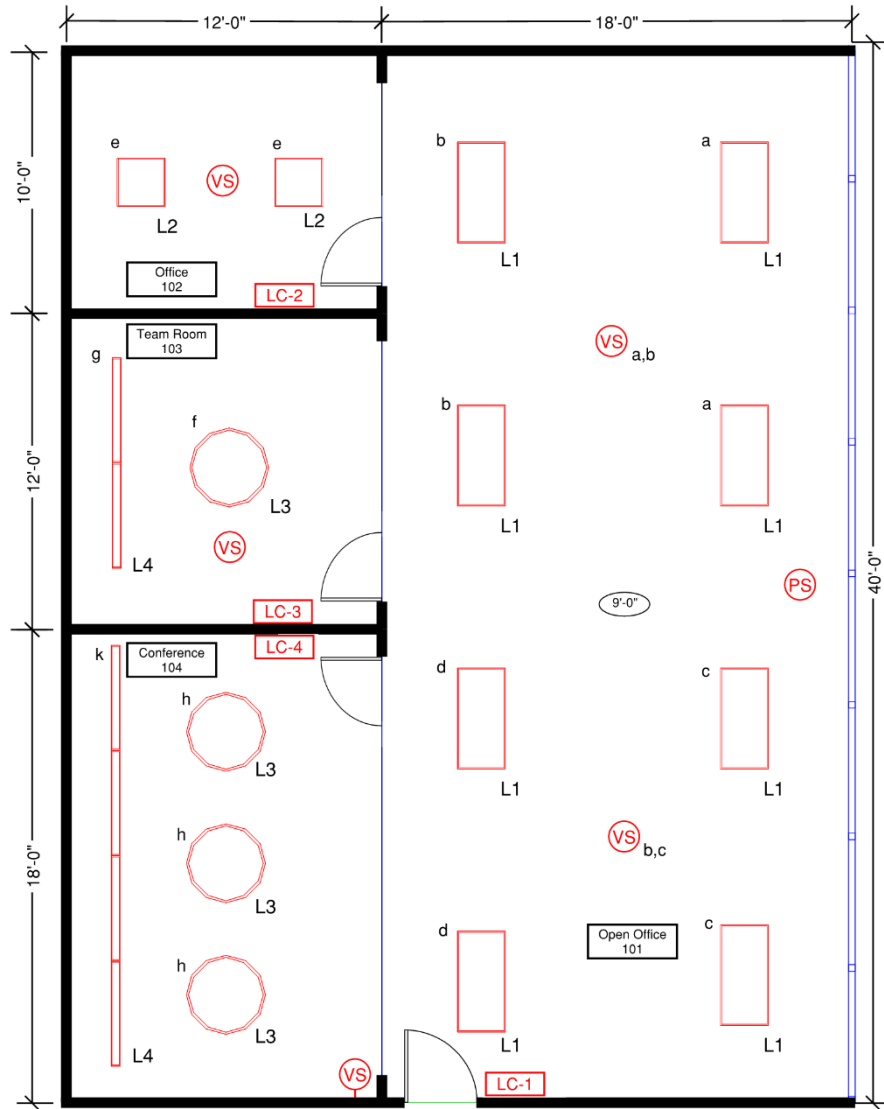


Project – Tech X Offices

Rendered Side Views



Traditional NLC Approach



LC-1



LC-2



LC-3



LC-4

Courtesy: Cooper, Crestron, Lutron, Osram Encellium, Wattstopper

Sequence of Operations - Matrix

Project X Sequence of Operations Matrix - Traditional NLC

Room Number	Control Zone	Space Type \ Use	Lighting Type	Target Light Level	LCS	Manual Switch	Dimmer Switch	Preset Station	Time Clock	Astronomic Time Clock	Occupancy Sensor	Vacancy Sensor	OS / VS Time Out	Daylight Dimming	Daylight Minimum	Task Tuning	Site Occupancy Sensor	Site Photo Control	Specialty Note	Typical Note
101	a	Open Office	Recessed Troffer	25	1						7p-7a	7a-7p	15	1	20%	30%			1	1, 4, 5, 6
	b													2						
	c										7p-7a	7a-7p		1						
	d													2						
102	e	Private Office	Recessed Troffer	30	2						7p-7a	7a-7p	5			35%			2	1, 5
103	f	Team Room	Suspended Indirect Direct	25	3								5			15%			3	1
	g		Recessed Wall Wash	n/a																
104	h	Conference	Suspended Indirect Direct	40	4								10			25%			4	1
	k		Recessed Wall Wash	n/a																
105	z1-10	Open Office	Recessed Troffer	25	1						7p-7a	7a-7p	15	1	10%	30%			1	1, 4, 5, 6
	z1-11		Recessed Troffer											2						
	z1-12		Recessed Troffer								7p-7a	7a-7p		1						
	z1-13		Recessed Troffer											2						

“Additional lighting controls”

- Some just require separate switching
 - Display & accent, display cases, task lighting, lighting for sale, plant growth, food warming
- Hotel rooms (sleeping units)
- Dwelling units
- The “exit access” egress illumination
 - OFF when lights are off
 - ON during power failure



Egress / Exit / Emergency Lighting

Most emergency lighting needs to be controlled with normal lighting loads when architectural luminaires are used.

- Generator feeding emergency circuits
- Inverters system feeding emergency circuits
- Battery backup per designated emergency luminaire
- UL 924 Devices



Spokane Public Library

Exterior lighting controls

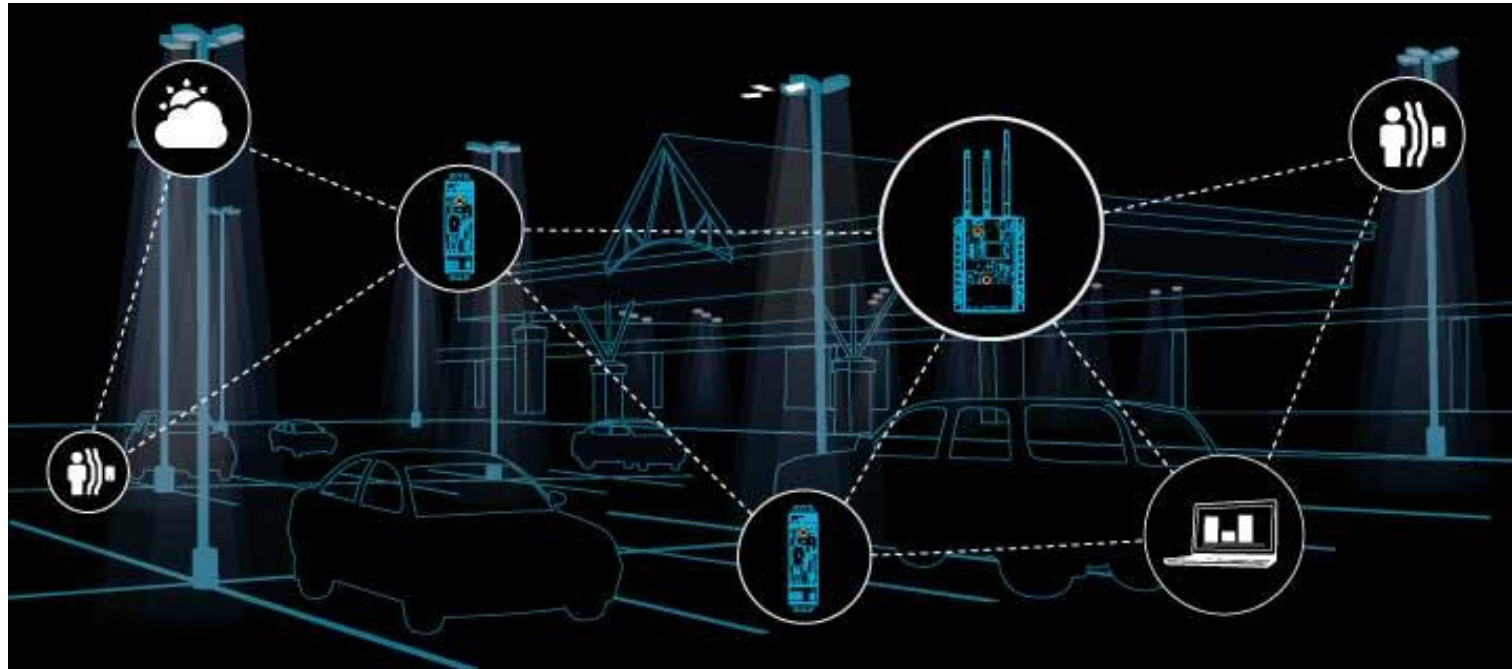
- Off during daylight hours
- Façade and landscape lighting off midnight to 6:00 AM
- “All other” lighting reduced by 30%:
 - Midnight to 6 AM, or
 - 1 hour after closing to 1 hour before opening, or
 - No activity for 15 minutes



Exterior Lighting Controls

Consider wireless controls

- Dimming
- Task Tuning
- Dynamic Scheduling
- Astronomic Timeclock
- Occupancy Sensing
- Tunable White



Interior Lighting Power Allowance

- WA – Reduce interior LPAs (lighting power allowances) 11% overall
 - But many smaller rooms get *larger* LPA
 - From ASHRAE 90.1 - 2019
- Seattle: Interior LPAs **10% below WA**
 - Was 10% below WA in 2015 code also



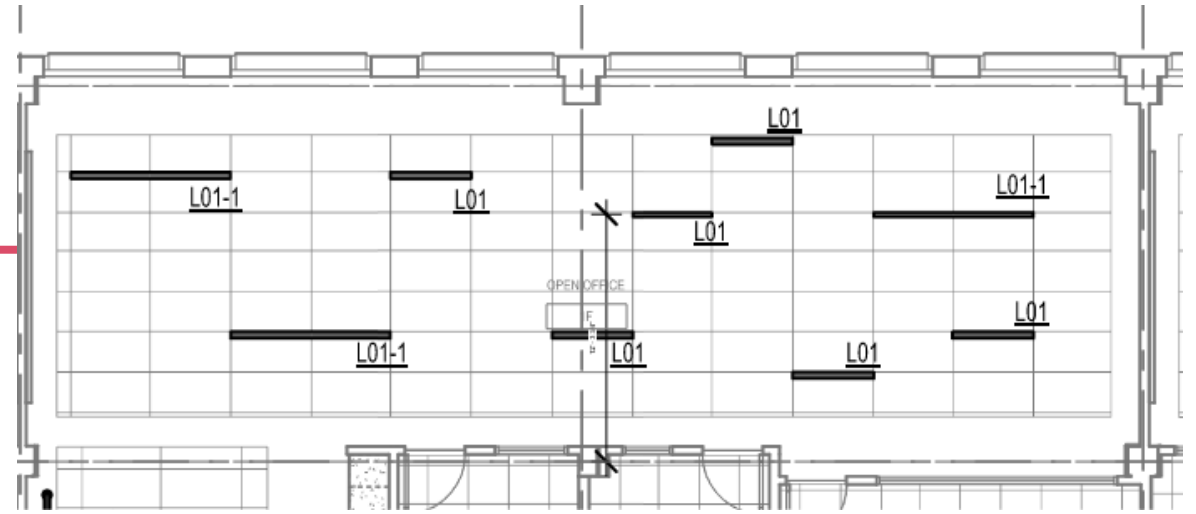
Table footnotes: extra lighting allowances

- (m) **Classroom:** 4.5 W/lin. ft. of white board
- (n) **Banking area, lounge, breakroom, stairwell, restroom, library reading room, religious:** 0.3 W/sf for “ornamental lighting”
 - “...used in a decorative manner and not serving as general lighting or display lighting”
- (o) **Scientific labs:** 0.35 W/sf lighting for “specialized task work”
- (p) **Office:** 0.20 W/sf for portable lighting, includes furniture-mounted
- (q) **Corridor:** 0.25 W/sf for display and decorative lighting (Seattle)
- “**Germicidal lighting**” exempt (Seattle)



Office Example

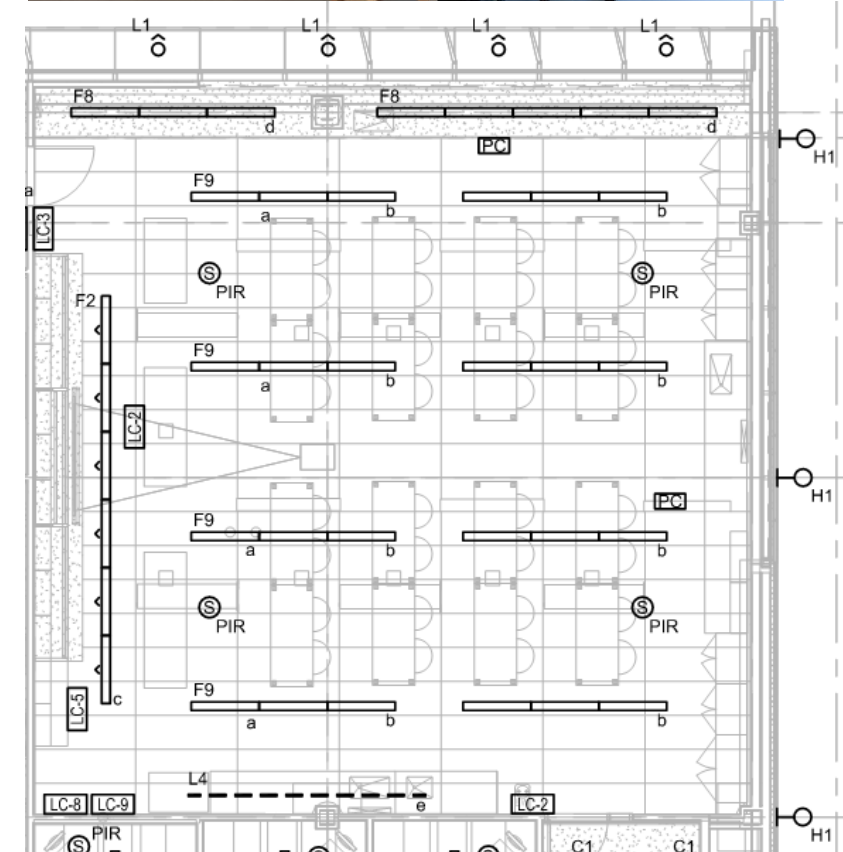
- Allowed LPD **0.55** w/sf
- Actual LPD: 0.42 w/sf
- Target Light Level: 25fc
- Measured: ~ 30 fc
- Controls:
 - Occupancy Sensing
 - Daylight Harvesting
 - Task Tuning
- Completed: 2016



Classroom Example

- Allowed LPD 0.64 w/sf
- 4.5 w / LF whiteboard
- Area: 1320 SF
- Allowed LPD: 845w
- Whiteboard allowance: 108w
- Allowance: 953 w
- General Area Lighting: 720 w
- Perimeter Lighting: 120 w
- Whiteboard: 90 w
- Proposed: 930 w

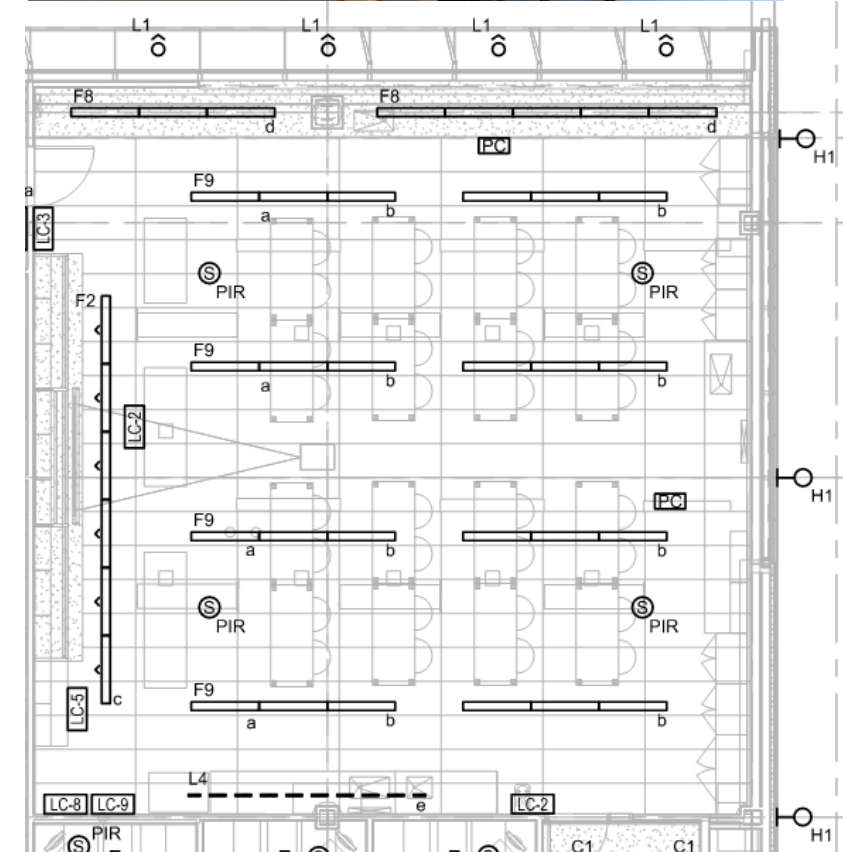
Controls:
Occupancy Sensing
Scene Control
Daylight Harvesting



But is it a Lab Classroom?

- Allowed LPD **1.0** w/sf
- **4.5 w / lf whiteboard**
- Area: 1320 SF
- Allowed LPD: 1320 w
- Whiteboard allowance: 108w
- Allowance: 1428 w
- General Area Lighting: 720 w
- Perimeter Lighting: 120 w
- Whiteboard: 90 w
- Proposed: 930 w

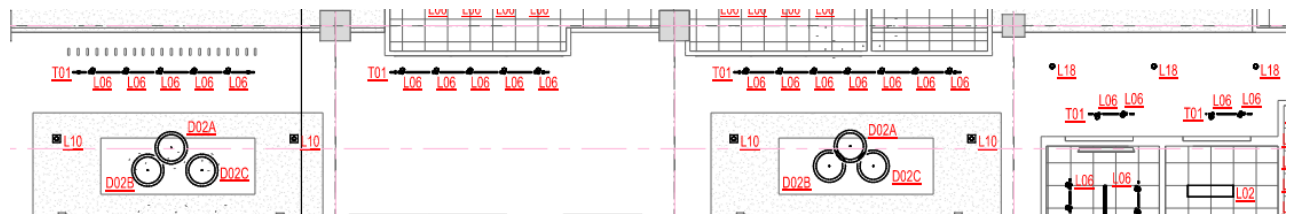
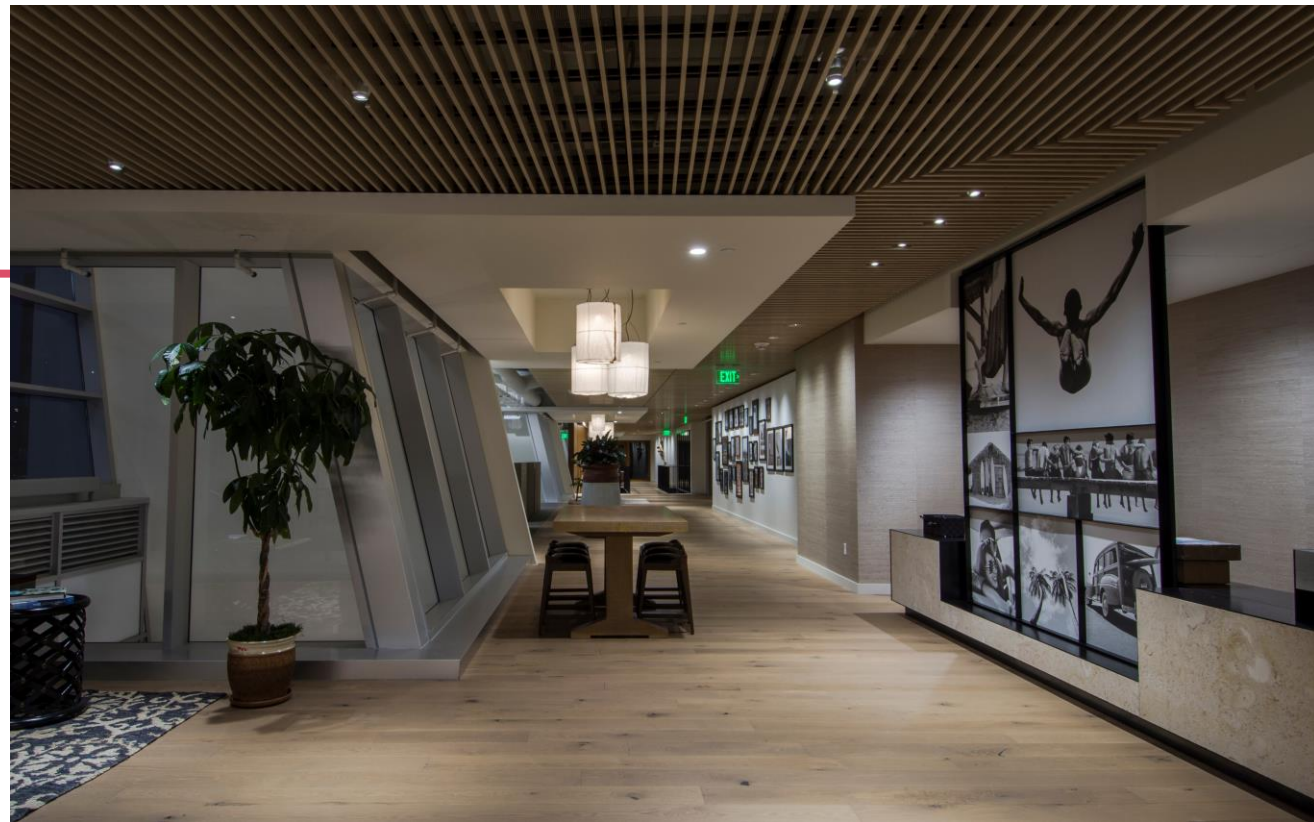
Controls:
Occupancy Sensing
Scene Control
Daylight Harvesting



Corridor

- Allowed LPD **0.37 w/sf**
- **0.25 w / sf** for display and decorative
- Area: 1671 sf
- Allowed LPD: 618 w
- Additional Allowance: 417 w
- Total Allowance: 1,035 w
- Installed: 820 w

Note: Sampled Segment is reviewed

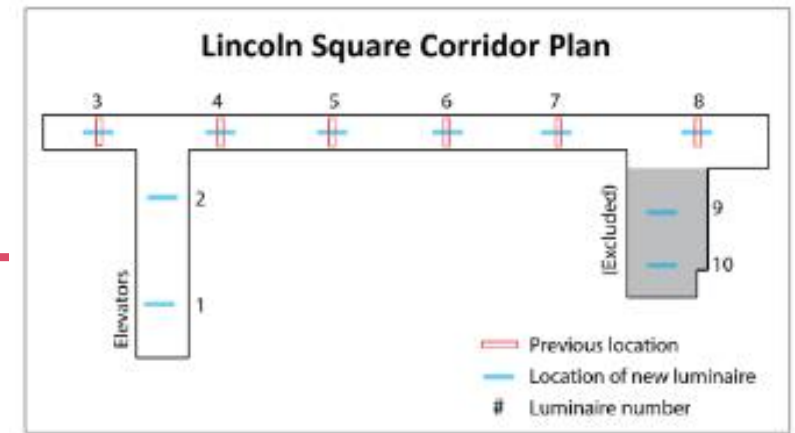


Corridors – with Controls

Delta Snapshot: Sensor Controlled Lighting in Multi-Family Corridors

- One for one luminaire replacement
- Increased light level from ~100 lux to ~300 lux
- LPD ~ 0.38 w/sf
- LLLC luminaires
- 20% output when no occupancy detected
- No rewiring required

www.lrc.rpi.edu/programs/DELTA/pdf/DELTAMultiFamilyCorridors.pdf

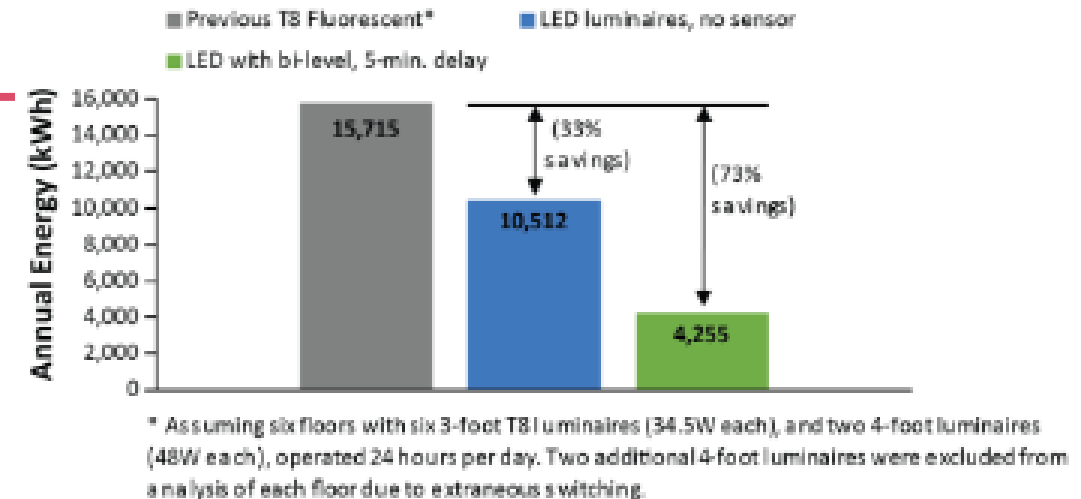


Courtesy: LRC Delta Snapshots

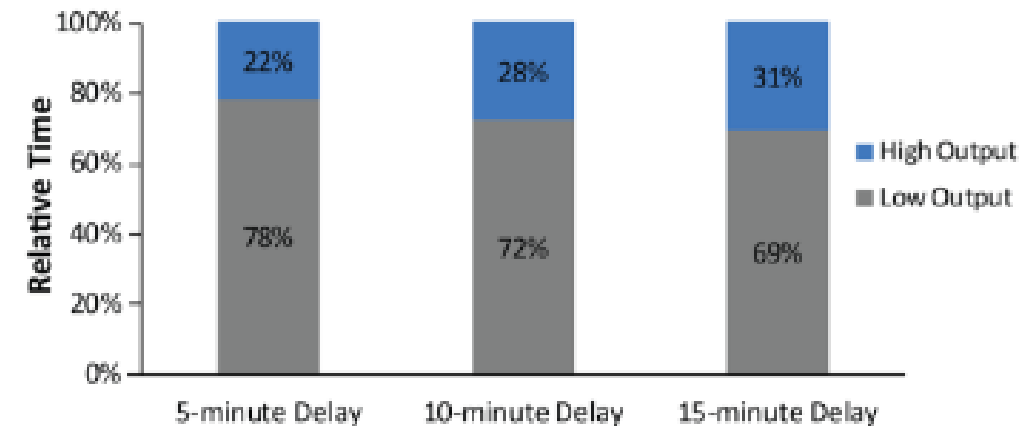
Corridors – with Controls

- 78% of occupants approved of bi-level lighting
- 5 minute time delay was not objectionable
- Dimming to 20% when vacant was not objectionable
- Sensors more than doubled energy savings
- LLC Controls required no additional wiring or complexity.

Annual Energy Estimates for 48 Luminaires Before and After Retrofit



Relative Time at High vs. Low Output Averaged for Each Delay Time Condition



Germicidal Ultra Violet (GUV)

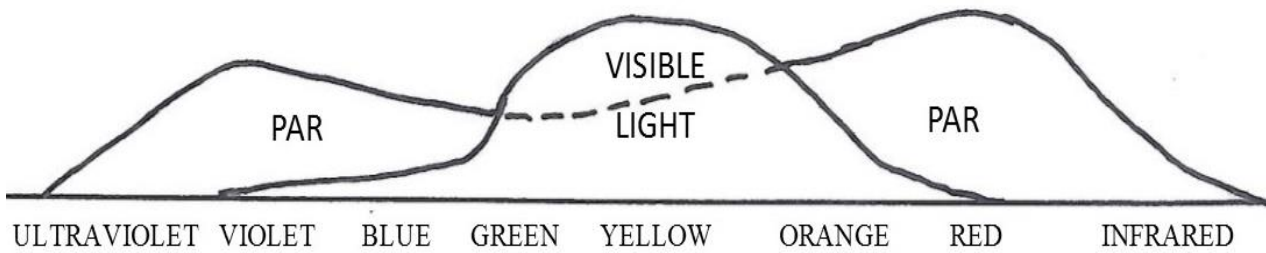
Ultraviolet Radiation has been known to be useful in disinfection since the 19th century

- Water
- Upper Air
- Surfaces
- IES CR-2-20-V1: <https://media.ies.org/docs/standards/IES%20CR-2-20-V1a-20200507.pdf>
- FAQs: <https://www.ies.org/standards/committee-reports/ies-committee-report-cr-2-20-faqs/>
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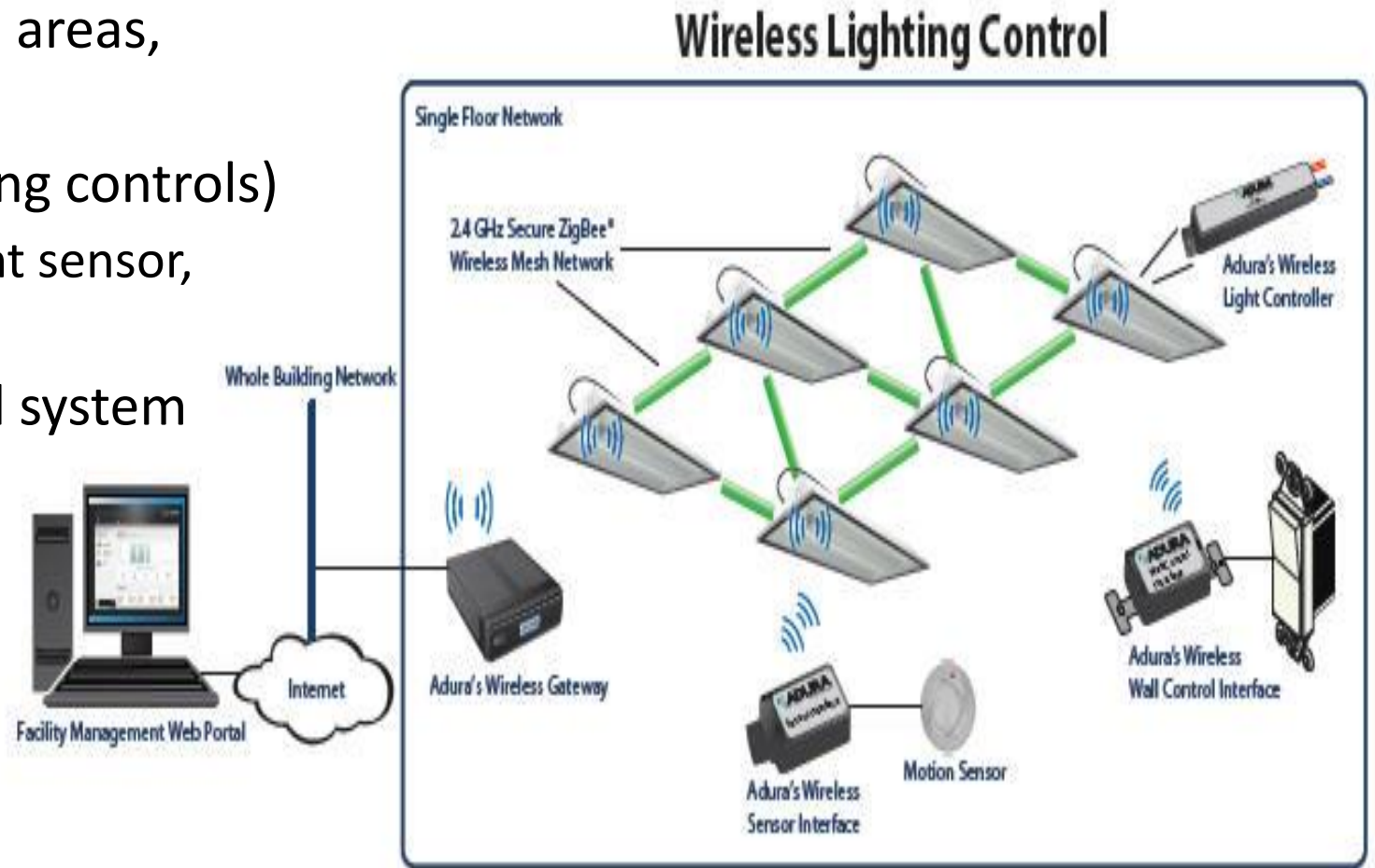
Seattle: Indoor horticulture

- 1.70 micromoles per joule greenhouse
- 1.90 micromoles per joule warehouse
- “Lumens are for humans”



Seattle: Lighting in Open Office

- Large (>5,000 sf) open office areas, choose either:
 1. LLLC (luminaire-level lighting controls)
 - Onboard occ sensor, daylight sensor, wireless controller
 2. Networked lighting control system



Luminaire Level Lighting Controls

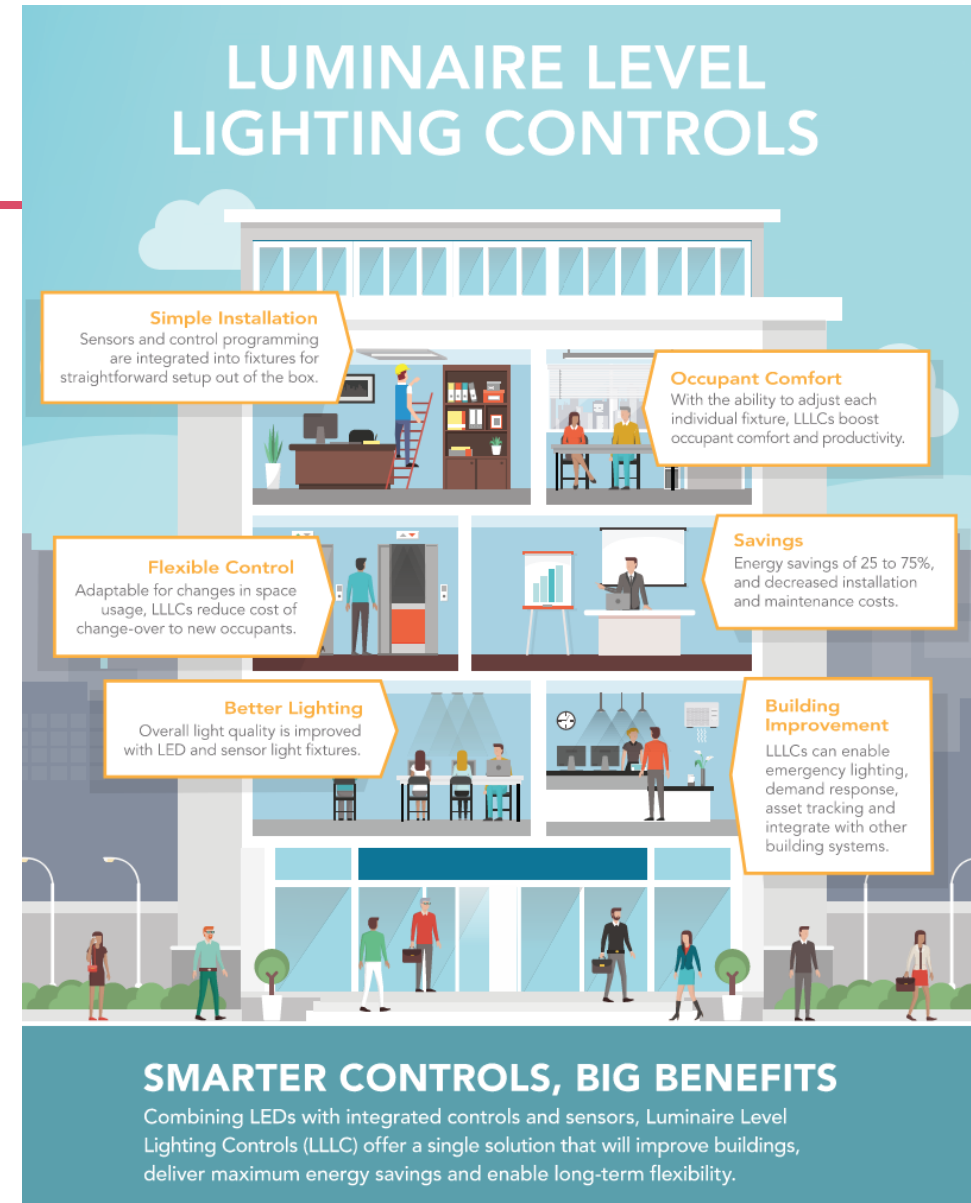
- Wrap all of the sensors and most of the logic into the luminaire itself
- Simple to specify and install
- Will require commissioning to function most effectively.
- May be capable of all control strategies
- May be capable of only OS/VS and Daylight harvesting
- Smarter systems will be more capable



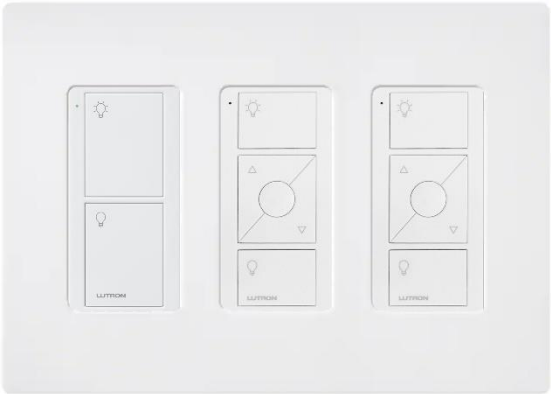
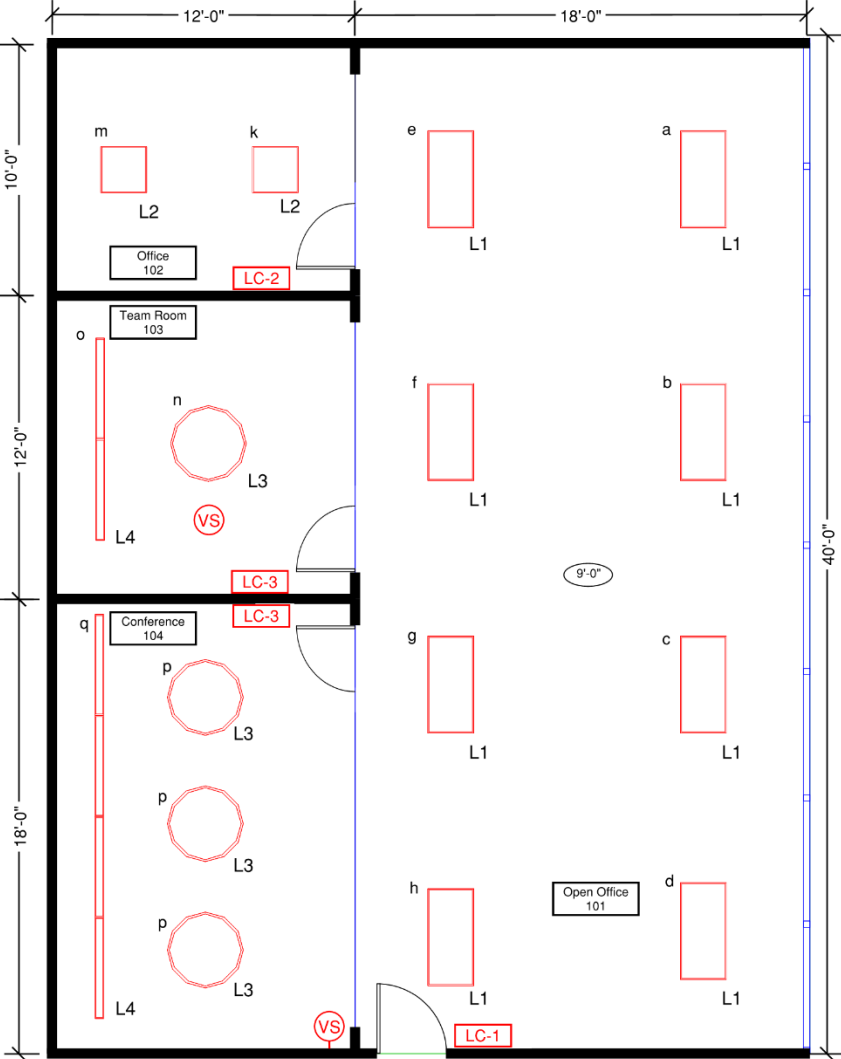
Courtesy: Acuity, Cree

LLLC Considerations

- Simplifies zoning and initial documentation
- Simplifies code compliance documentation
- Maximizes potential flexibility
- Provides some level of plug and play functionality
- Shifts some programming time
- Simplifies installation – 3 connections
- Adds capital cost – typically \$35-\$75 per luminaire
- Capital cost may be offset by utility incentives
- Retrofit simplicity
- Fully integrated into NLC
- <https://www.lightingdesignlab.com/resources>



LLLC NLC Approach



LC-1



LC-2



LC-3



LC-4

Courtesy: Cooper, Crestron, Lutron, Osram Encellium, Wattstopper

PSE LLC Pilot

- 2015 retrofit study ~11,000 SF Office
- Replace 67 T8 parabolic with 100 LED smart troffers
- Connected load: 6,062 w / LPD: 0.56 w/sf
- Troffers equipped with dimming and LLC
 - Occupancy Vacancy
 - Daylight Harvesting
 - Task Tuning
- **Better Lighting – Happier Staff**
- 35% Energy Savings – Luminaires
- 72% Energy Savings – Luminaires and LLC Controls
- PSE.com/businesslighting



LLLC Replacement vs Redesign Study

- 1000 sf office test bed at UO
- 1 for 1 replacement with LLLC
- Redesign with NLC
- Key Findings:
 - Replacement: 50-74% energy savings
 - Redesign: 59% energy savings
 - Replacement was 1/3 to 1/2 the cost
- <https://neea.org/resources/lllc-replacement-vs-redesign-comparison-study>



September 3, 2020

REPORT #E20-315

Luminaire Level Lighting
Controls Replacement vs
Redesign Comparison Study

Prepared For NEEA:
Chris Wolgamott, Sr. Product Manager,

Prepared by:
Alan Mahić
Jeff Kline
Dale Northcutt
Kevin Van Den Wymelenberg

University of Oregon Energy Studies in
Buildings Laboratory
105A White Stag Building
70 Northwest Couch Street
University of Oregon
Portland, OR 97209

Northwest Energy Efficiency Alliance PHONE
503-688-5400
EMAIL
info@neea.org

LDL as a Resource: NLC / LLLC Best Practice Guides and Video

NETWORKED LIGHTING CONTROLS SERIES



COMMUNICATING THE VALUE PROPOSITION

This guide will help simplify and clarify your value proposition by outlining distinct stakeholder groups and detailing what matters to them.

KNOW YOUR AUDIENCE – PLAN YOUR APPROACH

Networked lighting control systems offer plenty of benefits – but potential customers can feel overwhelmed or turn skeptical when they perceive too many promised benefits. Effectively communicating the value of NLC systems starts with knowing your audience – and planning your approach.

STEP 1: IDENTIFY YOUR STAKEHOLDERS

Yes, working with the key decision maker is paramount to making a project come together – but the key decision maker represents a cohort of stakeholders whose opinions matter.



STEP 2: SIMPLIFY YOUR MESSAGE

Instead of trying to convey all the potential system benefits to a general audience – examine the needs for each stakeholder group and use concise language to address their needs.



NETWORKED LIGHTING CONTROLS SERIES - COMMUNICATING THE VALUE PROPOSITION

Part #3: Networked Lighting Controls and Luminaire Level Lighting Controls, What's the Difference?

Now that you understand the basic components and concepts, we can take a closer look at the two primary ways these lighting systems operate in commercial buildings.

LLLC IS A TYPE OF NETWORKED LIGHTING CONTROLS SYSTEM

NLC and Luminaire Level Lighting Controls (LLLC) systems both deploy the same control strategies to ensure code compliance, tenant comfort, and sustained energy savings. Some products can be configured to operate in either mode.

The primary difference (and key concept) between these two approaches can be understood as a 1 to 1 vs. a 1 to many relationship.

NETWORKED LIGHTING CONTROLS

A Networked Lighting Controls (NLC) system is the combination of sensors, network interfaces, wall stations, and controllers that affect lighting changes to luminaires.

In a NLC system configuration there is a one to many relationship with one sensor controlling many luminaires.

BASIC NLC CONFIGURATION



1-8 zones possible with additional sensors

LLLC CONFIGURATION



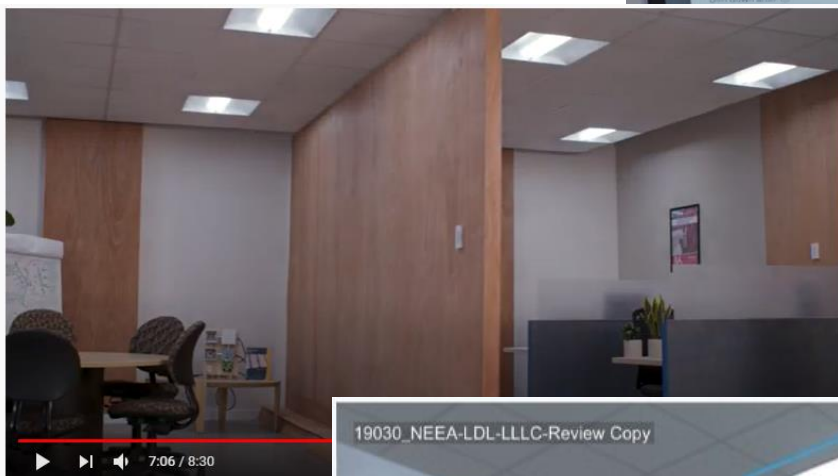
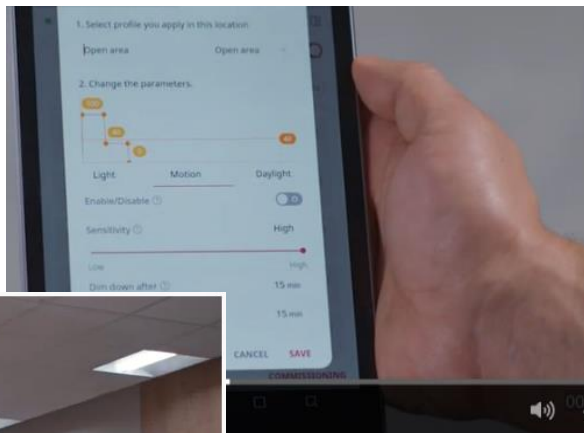
1-8 zone capable out of the box

LUMINAIRE LEVEL LIGHTING CONTROLS

Increasingly, manufacturers are integrating NLC system components directly into luminaires. With LLLC, there is a one to one relationship with every light fixture being capable of being controlled directly. Each luminaire is its own control zone or may be grouped into zones with multiple luminaires – simplifying design, installation, and space reconfiguration.



NETWORKED LIGHTING CONTROLS SERIES - CONTROL TECH TERMS



[Click to access the LDL networked lighting control learning guides](#)

Electrical Receptacle at Gas Appliances

Inside dwelling units:

- Electric receptacle and circuit at gas appliances
 - Stove/cooktop: 240/208 40-amp
 - Water heater: 240/208 30-amp
 - Gas dryer: 240/208 30-amp
 - Decorative fireplace: none required



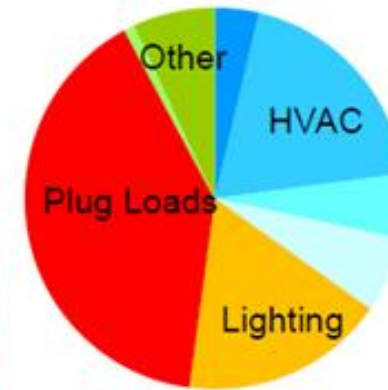
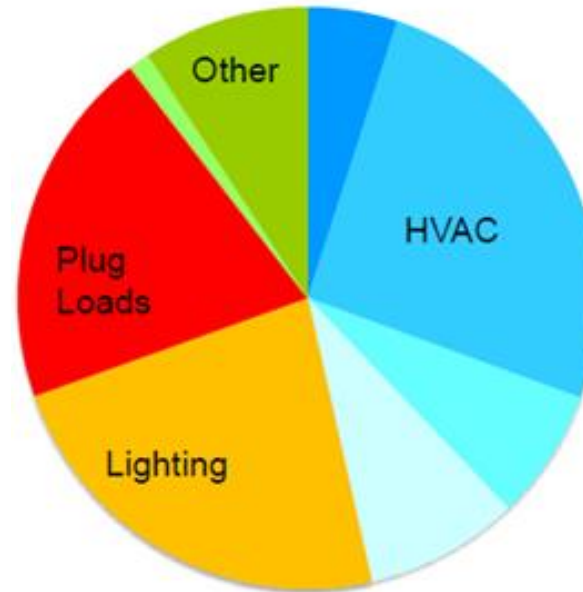
Controlled receptacles C405.10

50% of outlets in:

- Private office
- Open office
- Print room
- Break room
- Classroom
- Workstation
- Office cube

Turn off via:

- Occ sensor or Timeclock



High Efficiency Design



High Efficiency Building
+
Optimized Plug Loads

- Split receptacles or within 12"
- Issues with cubicles & adjustable-height desks

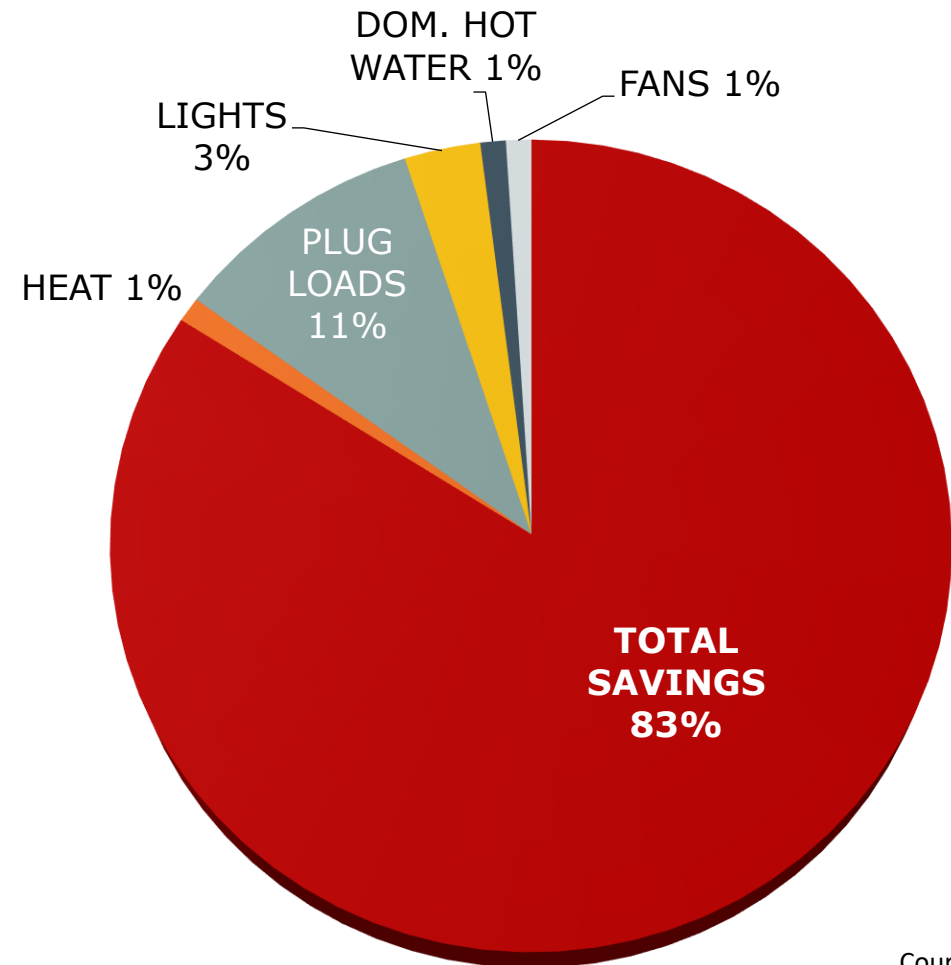
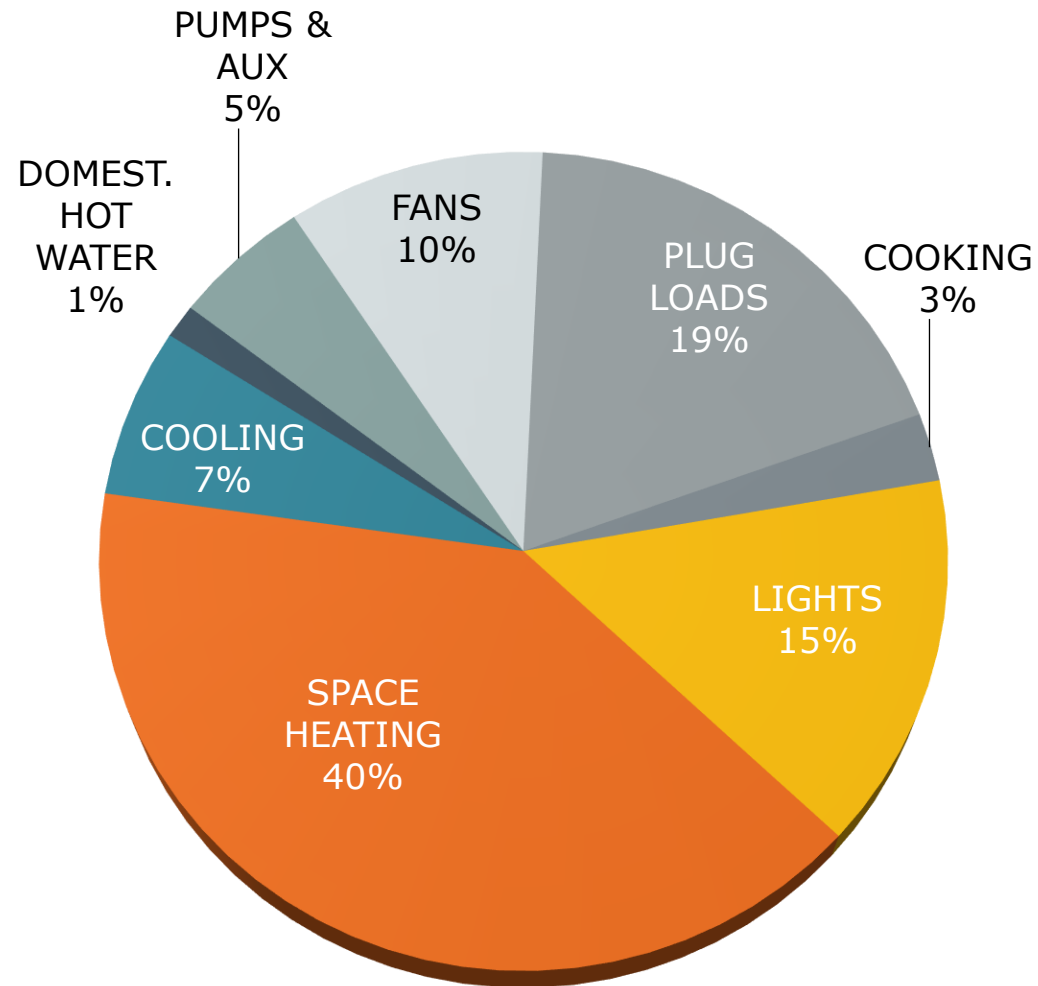
Vampire Plug Loads

Many devices continue to draw energy during non-business hours...

- Task Lights
- Printers / Plotters
- Microwaves
- Faxes
- Monitors
- CPUs? (Don't try it)
- Try an inventory some time....



Vampire Plug Loads



Courtesy: PAE / Luma

C406 Efficiency Package Credits

Moving towards all-electric

- | | | | |
|--------------------|----------------------|-------------------------|-----------------------|
| 1. HVAC efficiency | 4. Lighting controls | 7. High-perf DOAS | 10. Envelope |
| 2. Lighting 10% | 5. Renewable energy | 8. Water heating | 11. Air infiltration |
| 3. Lighting 20% | 6. DOAS | 9. High-perf water heat | 12. Kitchen appliance |

- WA: 6 credits required
 - 3 credits for low-energy occupancies

- **Seattle: 8 credits required**
- Seattle: Gas equip doesn't qualify

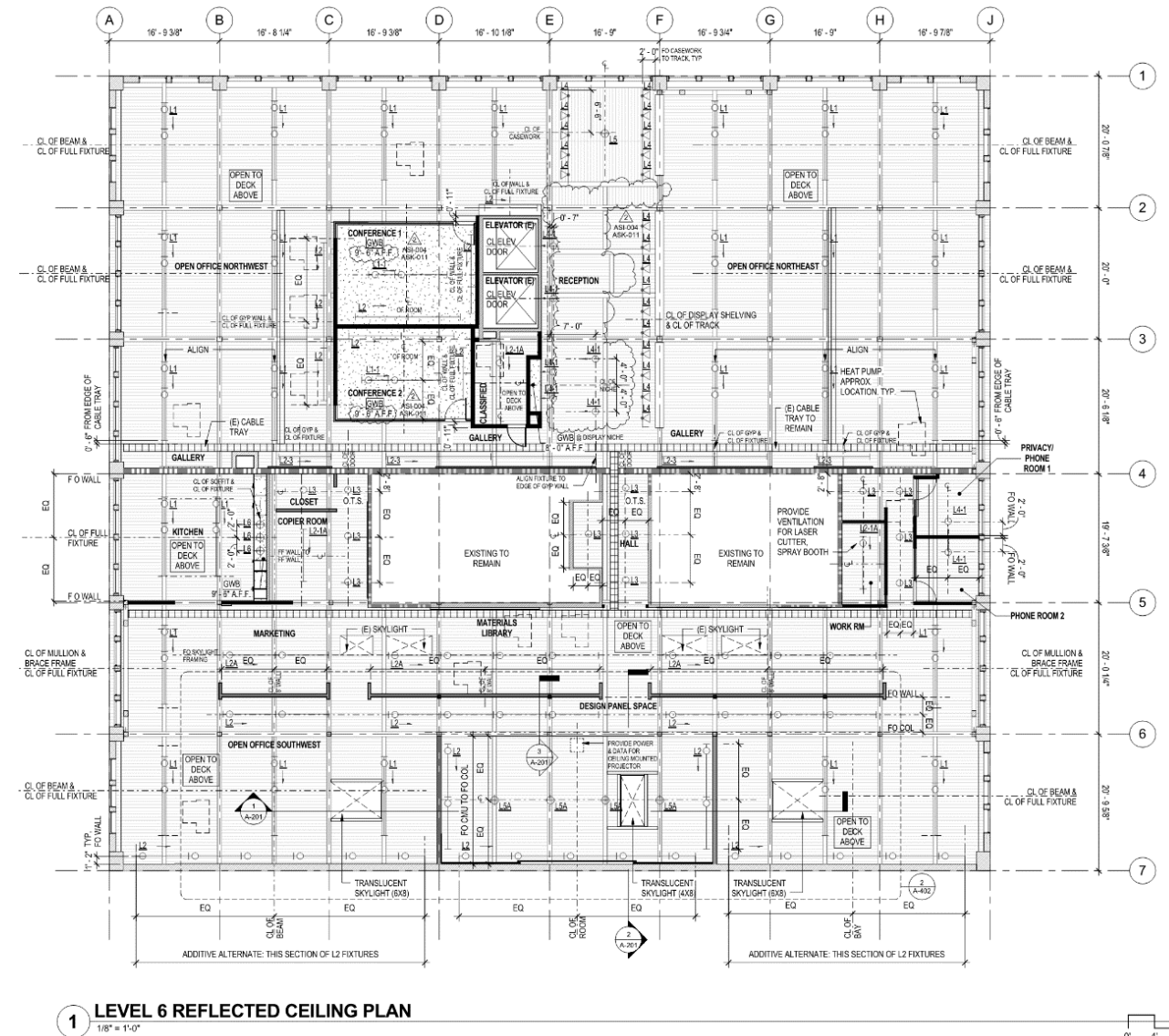
	R1	R2	B	E	M	Other
1. More efficient HVAC performance in accordance with Section C406.2	2.0	3.0	3.0	2.0	1.0	2.0
2. Reduced lighting power: Option 1 in accordance with Section C406.3.1	1.0	1.0	2.0	2.0	3.0	2.0
3. Reduced lighting power: Option 2 in accordance with Section C406.3.2 ^a	2.0	3.0	4.0	4.0	6.0	4.0

Exceeding code requirements

- Software Company example exceeds proposed code by 24%
 - Tommy Bahama corridor example exceeds proposed code by 21%
 - Note decorative and display allowance
 - Lab Classroom example exceeds proposed code by 35%
- Not all projects will be able to meet these performance goals, but it is reasonably possible in many cases.

Miller Hull Studios

- Occupant is an architecture firm in the Polson Building - an old fir beam structure in Pioneer Square.
- Approximately 14,000 square feet
- TI renovation
- Completed in 2017

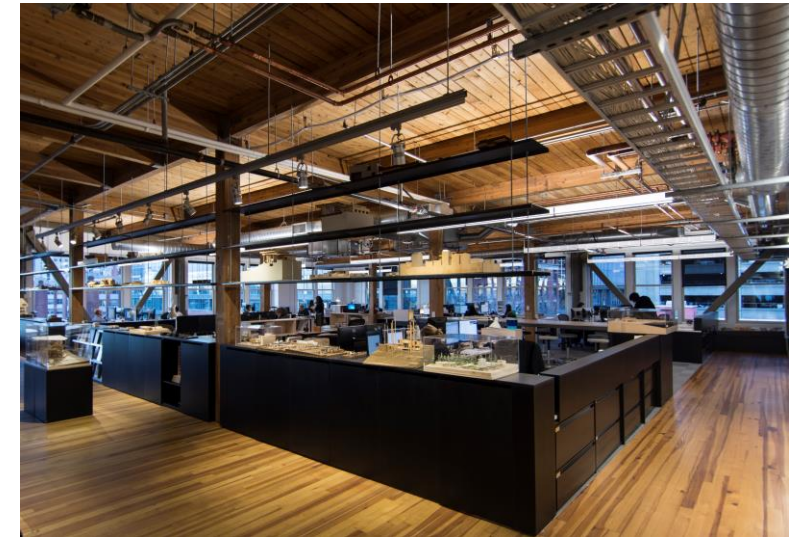
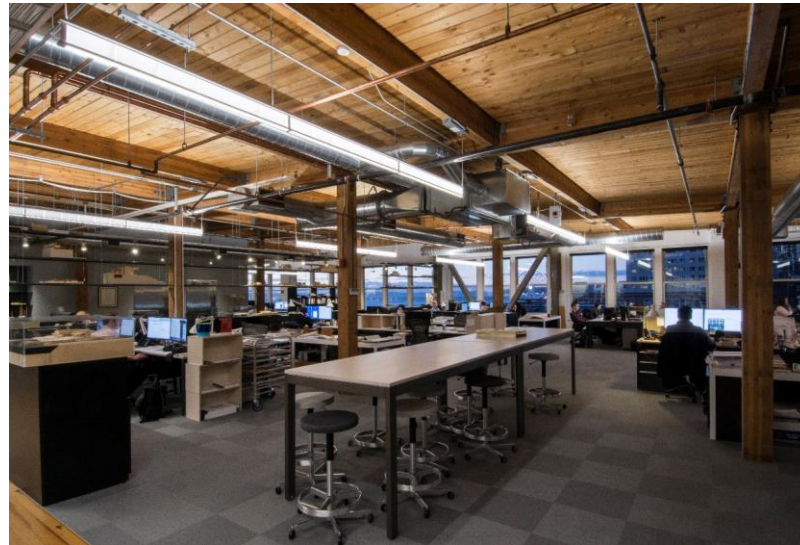


Courtesy: Miller Hull



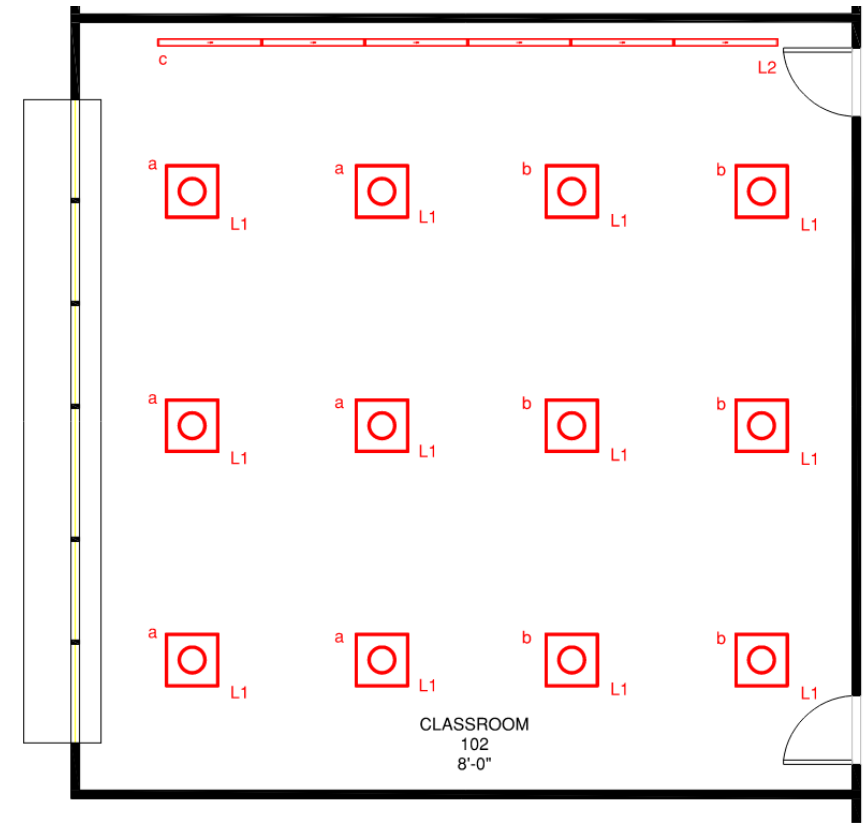
Miller Hull Studios

- Improved lighting
- Lighting controls
- Happier staff
- LPD: 0.3 W/sf
~60% better than code
- Effective LPD: 0.15 W/sf ?



Classroom Options - Direct

- Recessed 2x2 Lensed LED type L1
- Linear Wall Grazer type L2
- 900 sf classroom
- Allowed LPD $0.64 \text{ w/sf} = 576 \text{ w}$
- White board allowance $4.5 \text{ w/lf} = 108 \text{ w}$
- Total Allowance = 684 w



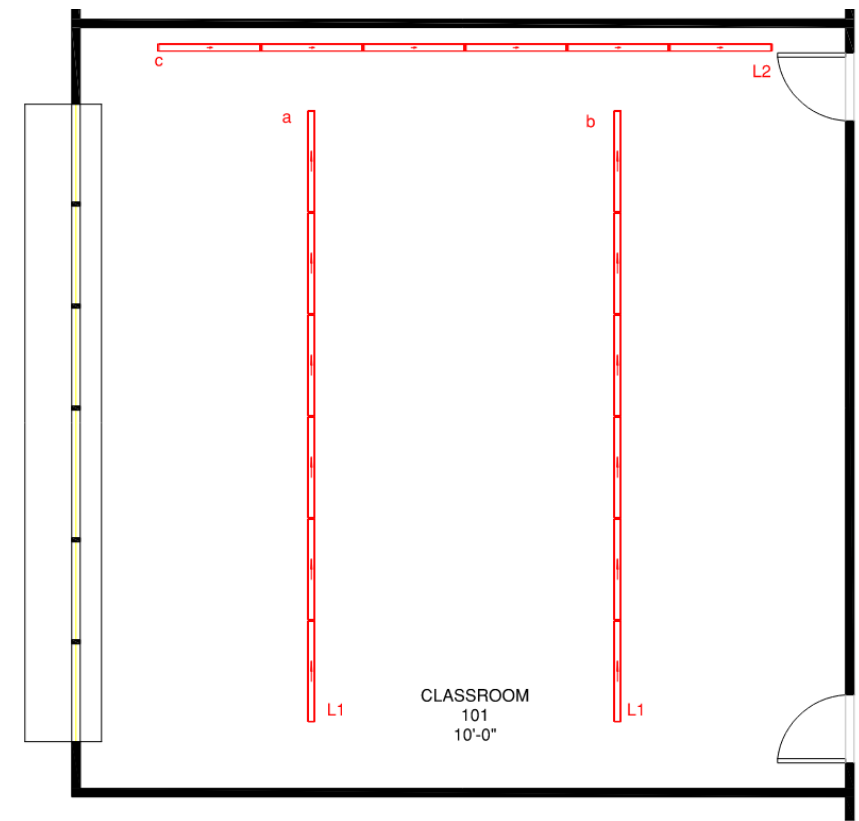
- Target Light Level: 30 fc
- Estimated Light Level: 36
- Proposed: 414 w
- Exceeds code by 40%



Classroom Options – Indirect / Direct

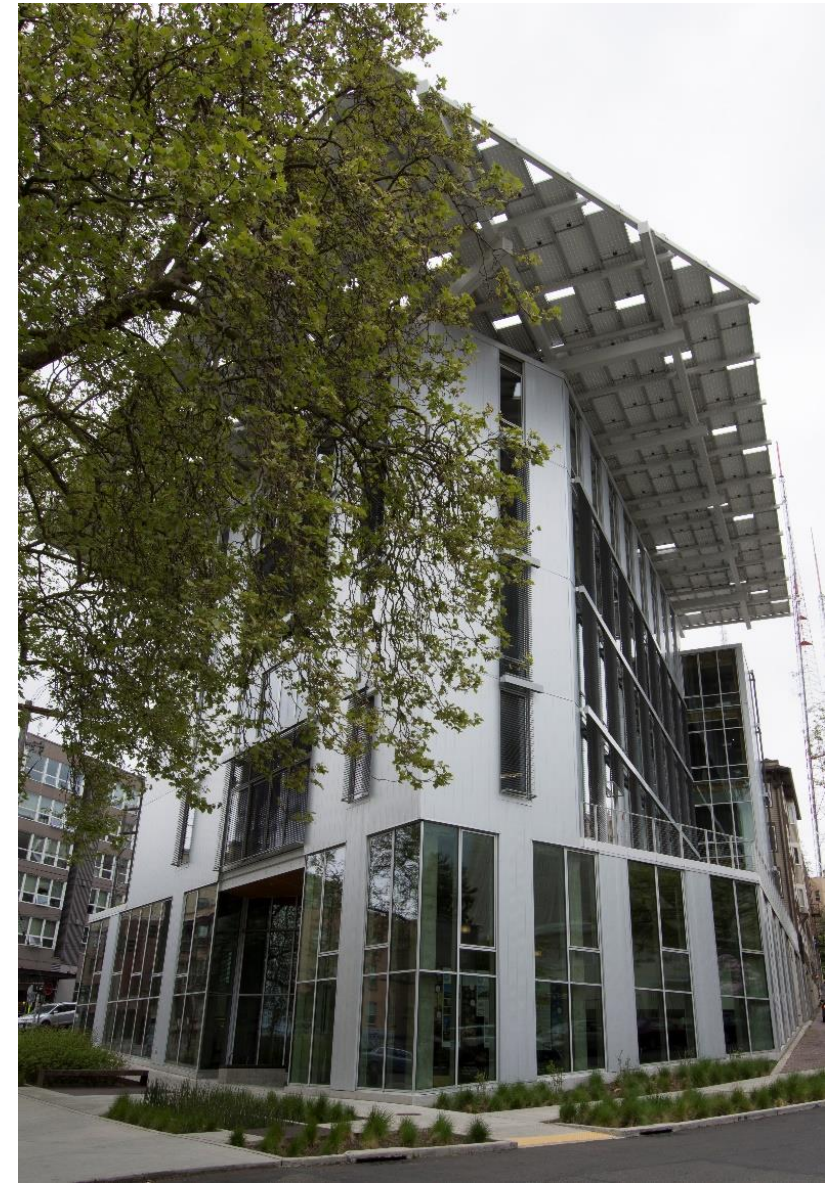
- Suspended Indirect / Direct type L1
- Linear Wall Grazer type L2
- 900 sf classroom
- Allowed LPD $0.64 \text{ w/sf} = 576 \text{ w}$
- White board allowance $4.5 \text{ w/lf} = 108 \text{ w}$
- Total Allowance = 684 w

- Target Light Level: 30 fc
- Estimated Light Level: 35
- Proposed: 450 w
- Exceeds code by 35%



Quick Case Study

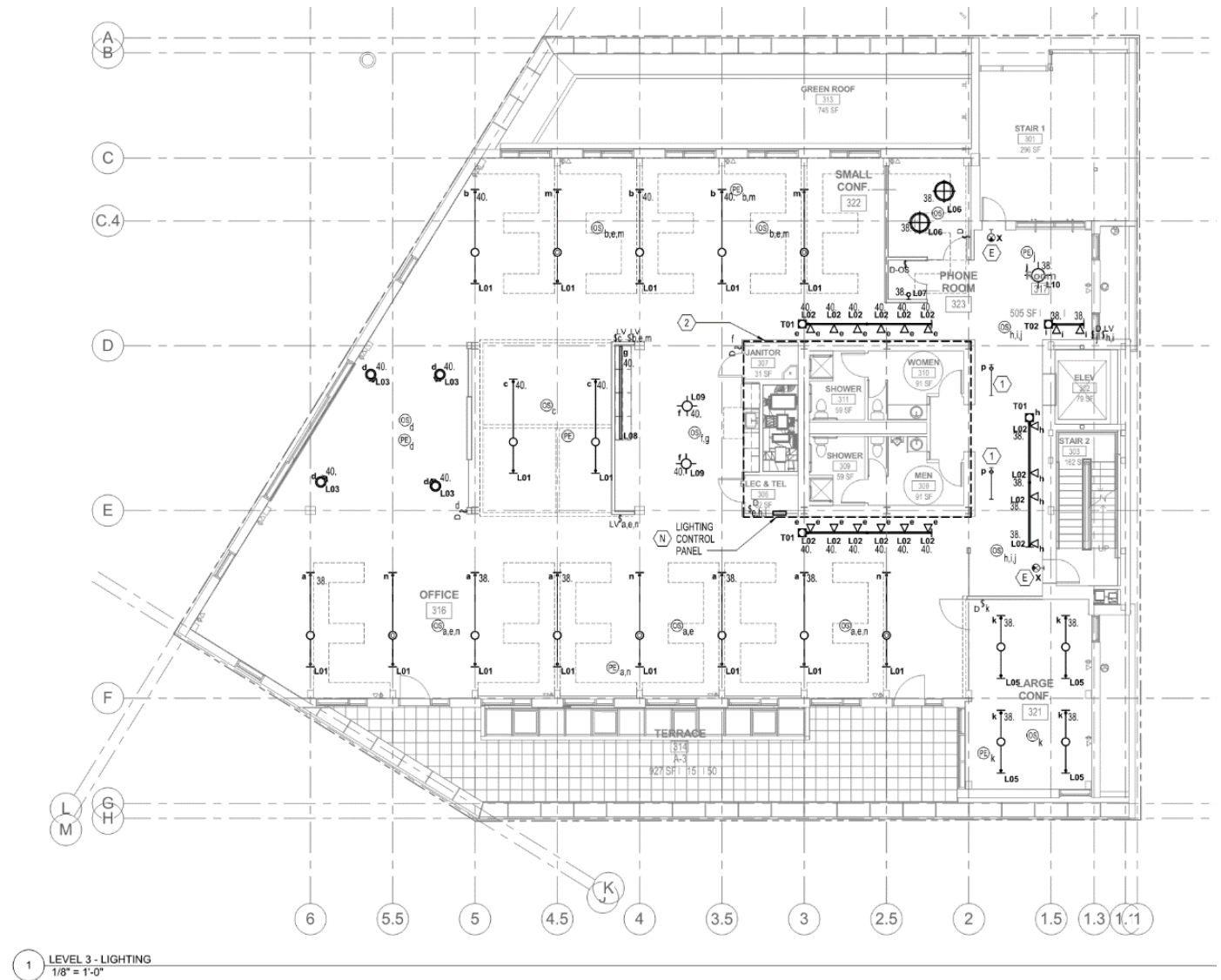
- Occupant is an MEP engineering firm in the third floor of the Bullitt Center in Seattle.
- Approximately 6,100 square feet
- TI renovation
- Completed in 2017



Bullitt Center
Miller Hull

Lighting Design

- High performance LED lighting
- LED decorative
- 3400 watts connected load
- LPD: ~ 0.55 W/sf
- Allowed LPD per proposed: 0.58 w/sf
- Controls
 - Dimming
 - Task tuning
 - Vacancy sensing
 - Daylight harvesting
 - Manual dimming



Courtesy: PAE/Luma

Value Engineering

- Controls design VE
 - Met Energy Code...
 - Cheapest way possible..
 - Barely functional...
-
- Not possible to fully extinguish electric lights...



Lighting Control Retrofit

- Distributed load controls
- Luminaire level addressing
- Wireless switches/dimmers
- Wireless sensors
- Daylight harvesting
- Task tuning
- Manual dimming
- Time of day schedule
- More or less LLLC



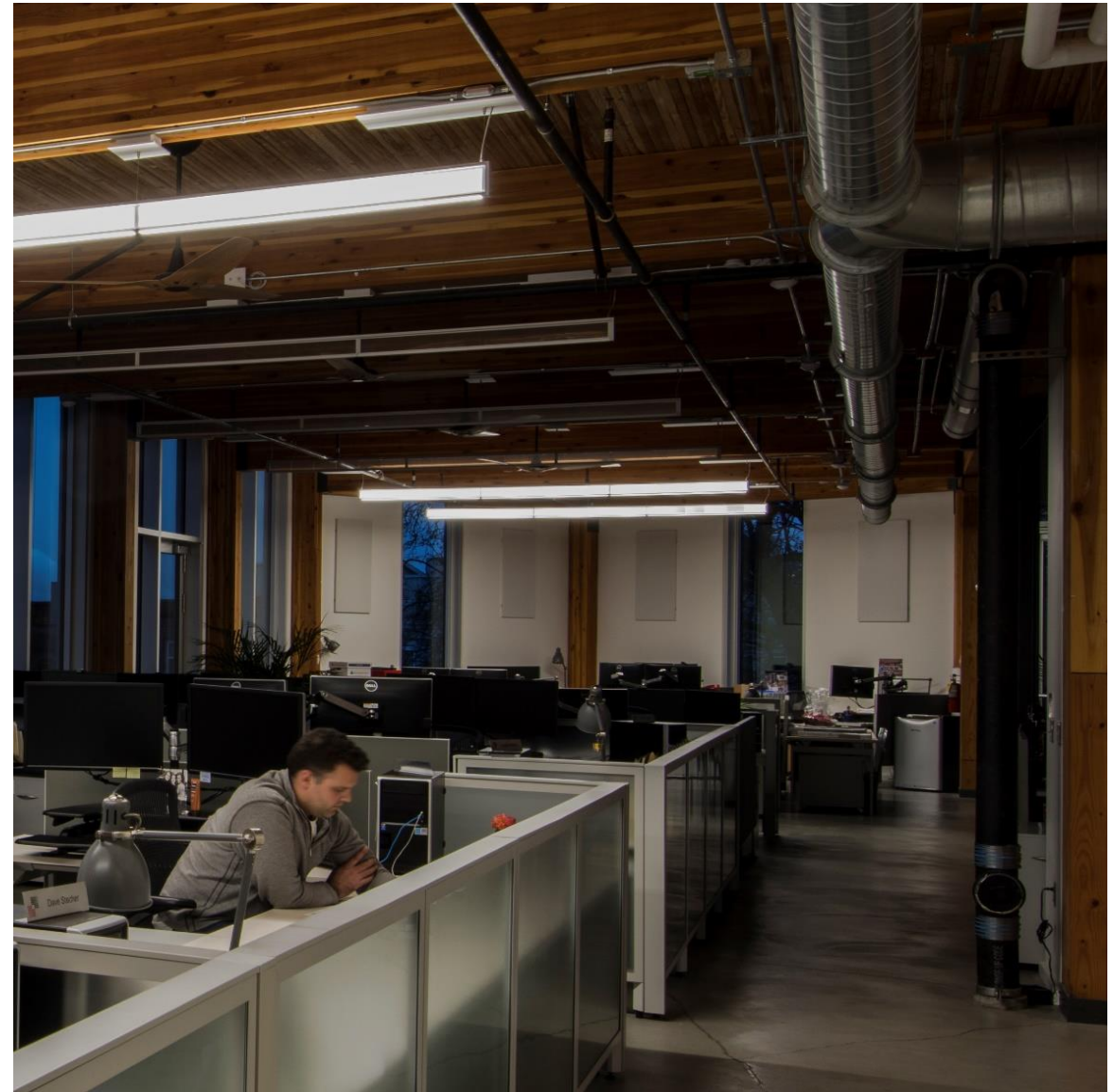
Results

- Staff can turn all of the lights off
- Staff can select appropriate dimmed levels



Results

- Task-tuned by more than 25%
- Daylight dimming fully functional
- Vacancy sensing by contiguous row
- **Effective LPD is ~ 0.15 W/sf**
- More than 70% effective reduction
- Controls cost: $\sim \$4,500$
- $\sim \$0.78$ / sf



Renewables = 3 credits (or 2, or 1)
0.25 watts/square foot of building floor area

Code Section	Commercial Building Occupancy					
	Group R-1	Group R-2	Group B	Group E	Group M	All Other
	Additional Efficiency Credits					
1. More efficient HVAC performance in accordance with Section C406.2	2.0	3.0	3.0	2.0	1.0	2.0
5. On-site supply of renewable energy in accordance with C406.5	3.0	3.0	3.0	3.0	3.0	3.0
5.1 1/3 of renewable energy required by C406.5	1.0	1.0	1.0	1.0	1.0	1.0
5.2 2/3 of renewable energy required by C406.5	2.0	2.0	2.0	2.0	2.0	2.0
6. Dedicated outdoor air system in accordance with Section C406.6 ^b	4.0	((4.0)) 2.0 ^d	4.0	NA	NA	4.0

~~((TABLE C406.5
ON-SITE RENEWABLE ENERGY))~~

Building Area Type	kBTU per year	kWh per year
Assembly	1.8	0.53
Dining	10.7	3.14
Hospital	3.3	1.06
Hotel/Motel	2.0	0.59
Multi-family residential	0.50	0.15
Office	0.82	0.24
Other	2.02	0.59
Retail	1.31	0.38
School/University	1.17	0.34
Supermarket	5.0	1.47
Warehouse	0.43	0.13

Small versus large solar for code compliance

- 0.07 watts per sqft code: less than 25 solar panels paired with micro-inverters results in a high cost per watt due to heavy coordination with construction team
- 0.25 watts per sqft code: 25-200 solar panels with central string inverters and a much more competitive cost per watt, which is a better way to recognize financial benefits of solar



Solar Readiness

- Solar-ready zone 40% of *net* roof area
- Seattle: now includes multifamily
- Net area is gross area, *minus*:
 - Skylights
 - Occupied decks
 - Planted areas
 - Mechanical equipment
- Solar zone
 - Unshaded, no obstructions
 - 4 psf additional dead load
- Roof sleeve 2" @ 2,500 sf
- Space for breaker at main panel

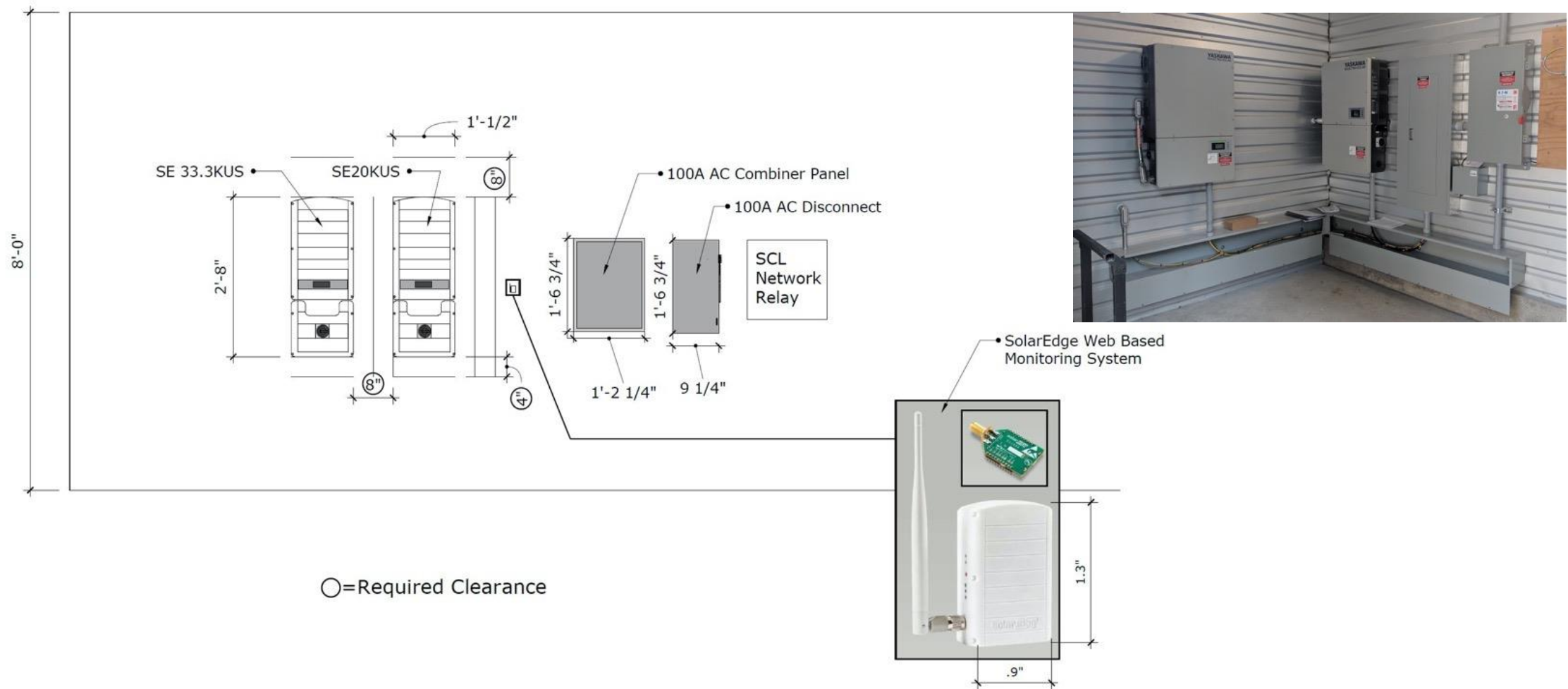


Structural considerations for solar

- Taller buildings or high wind areas can require supplemental attachments for typical ballasted systems, which increases roofer coordination costs
- 6-10psf is a more typical ballasted requirement, but a fully attached system can see a distributed weight as low as 3psf, so there are always options



Electrical gear space requirements for solar



Seattle: Renewable energy

- **0.25 W/sf**, based on area of all floors
 - Instead of 0.07 W/square foot
 - Instead of just largest 5 floors
- Affordable housing exempted
- Option: Gift to affordable housing
 - Projects can donate turnkey system to Seattle affordable housing.
 - Or to state agency solar program
- “Solar-ready” roof & main panel



How big is 0.25w/sf?

- Assume all floors same size
- Area includes space between PV rows



Thanks to FSI Engineers

Building Stories	Roof Area Required
1	1.8%
2	3.6%
4	7.2%
6	10.9%
8	14.5%
10	18.1%
12	21.7%
14	25.4%
16	29.0%
18	32.6%
20	36.2%

Suggestions to reduce solar cost

- Create a solar-only space on the roof, or minimize/consolidate vents and HVAC to one area of the roof, ideally on the north side of pitched roofs
- Engage a solar installer early on to review design considerations for tall buildings, atypical roof orientations, shading impacts, or unique ways to address limited roof space



Commissioning: Lighting & controlled receptacles

If over 20 kW lighting load *and* over 10 kW with occ sensors or daylight sensors:

- Occ sensors
- Time switches
- Manual overrides
- Night sweep
- Daylight controls
- Controlled receptacles

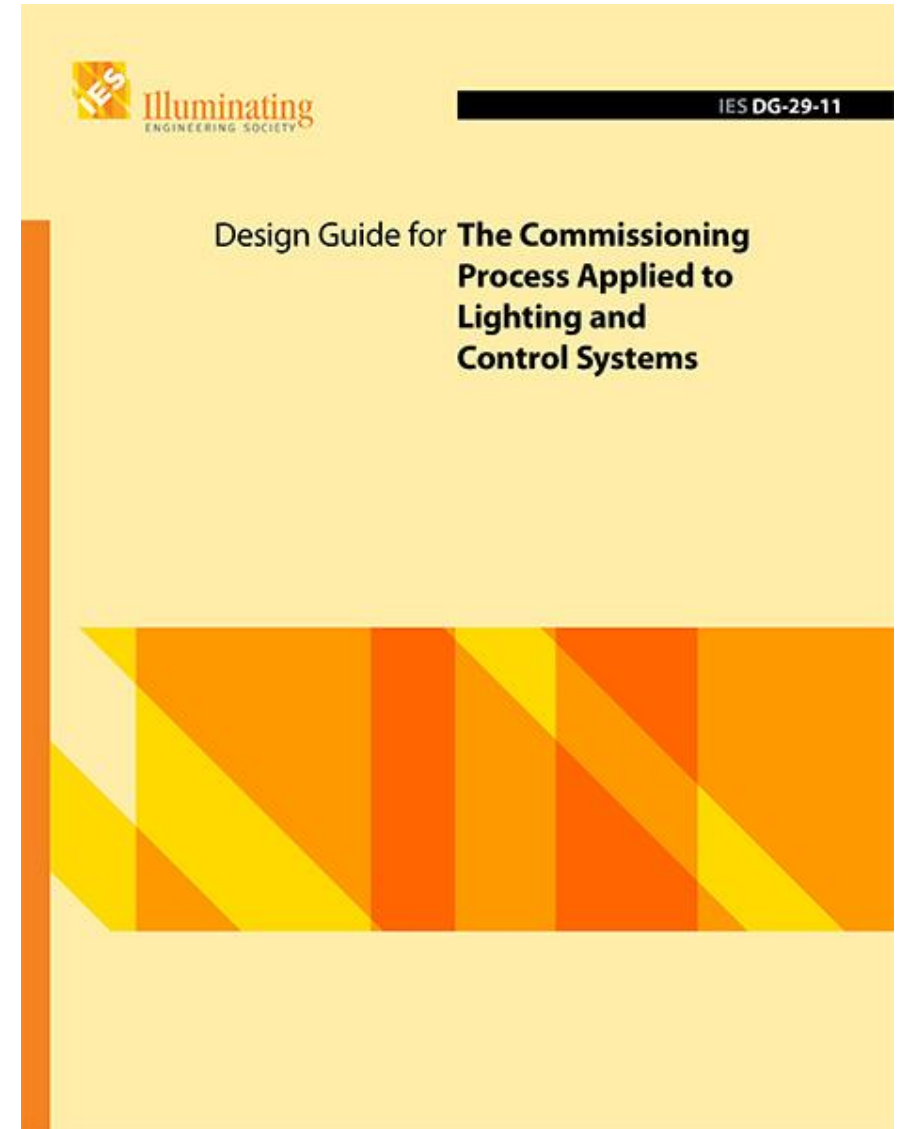
Check functions during:

- Normal operation
- Redundant or auto back-up mode
- Alarm
- Power loss & restoration



Commissioning

- Third Party Commissioning may be required
 - Commissioning Plan
 - Certified Commissioning Professional
 - Functional Testing
 - Final Report
- Startup and Commissioning are not the same thing



Courtesy: Illuminating Engineering Society

Sequence of Operations

Whoever winds up doing it....a sequence of operations is required to tell the contractor, startup technician, and commissioning agent how the system is supposed to function.

- What are the time and astronomic schedules
- Which sensors are vacancy and which are occupancy?
- What is the vacancy timeout?
- What are the target light levels for task tuning?
- What switches or dimmers are tied to which zones?
- What zones are included in each preset and at what levels?
- What are the daylight zone dimming thresholds?
- Are there any specialty programming tasks like partition controls?

Commissioning

- One of the most often overlooked Commissioning elements....

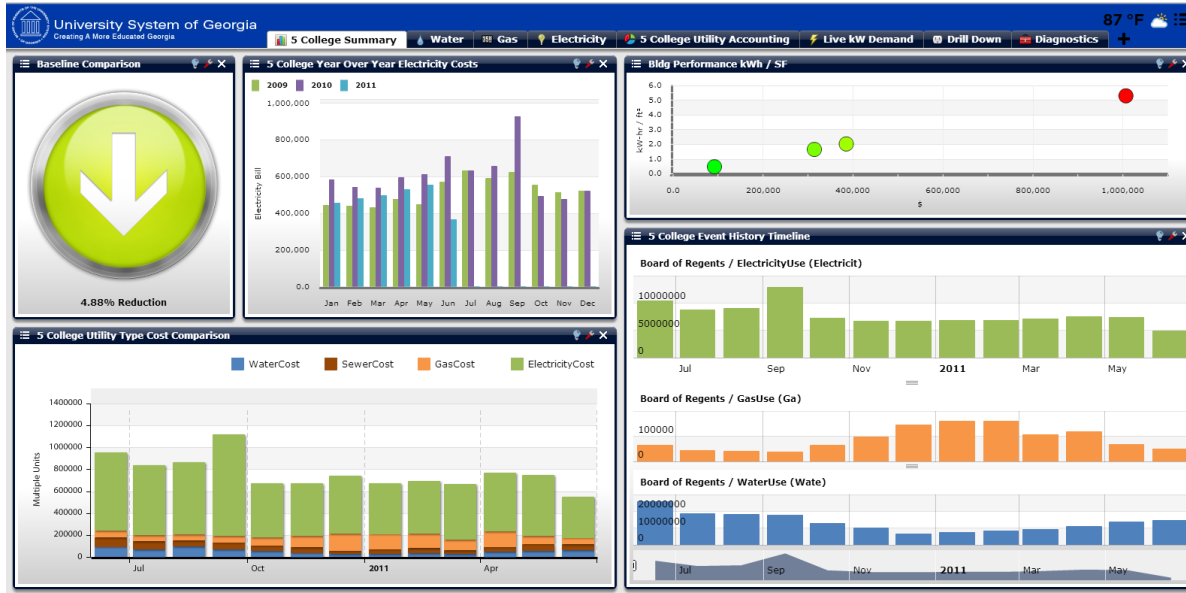
Commission the occupants....

- Let them know what to expect from the system and how it operates....and why....



Microsoft Building 17
Gensler

~~Sub-metering~~ Actionable graphic display



Sub-meter displays for:

- Lights
- HVAC
- Water heating
- Plug loads
- Process loads

Building manager gets display showing energy use over time (day, week, year)

Full-floor tenants see next slide

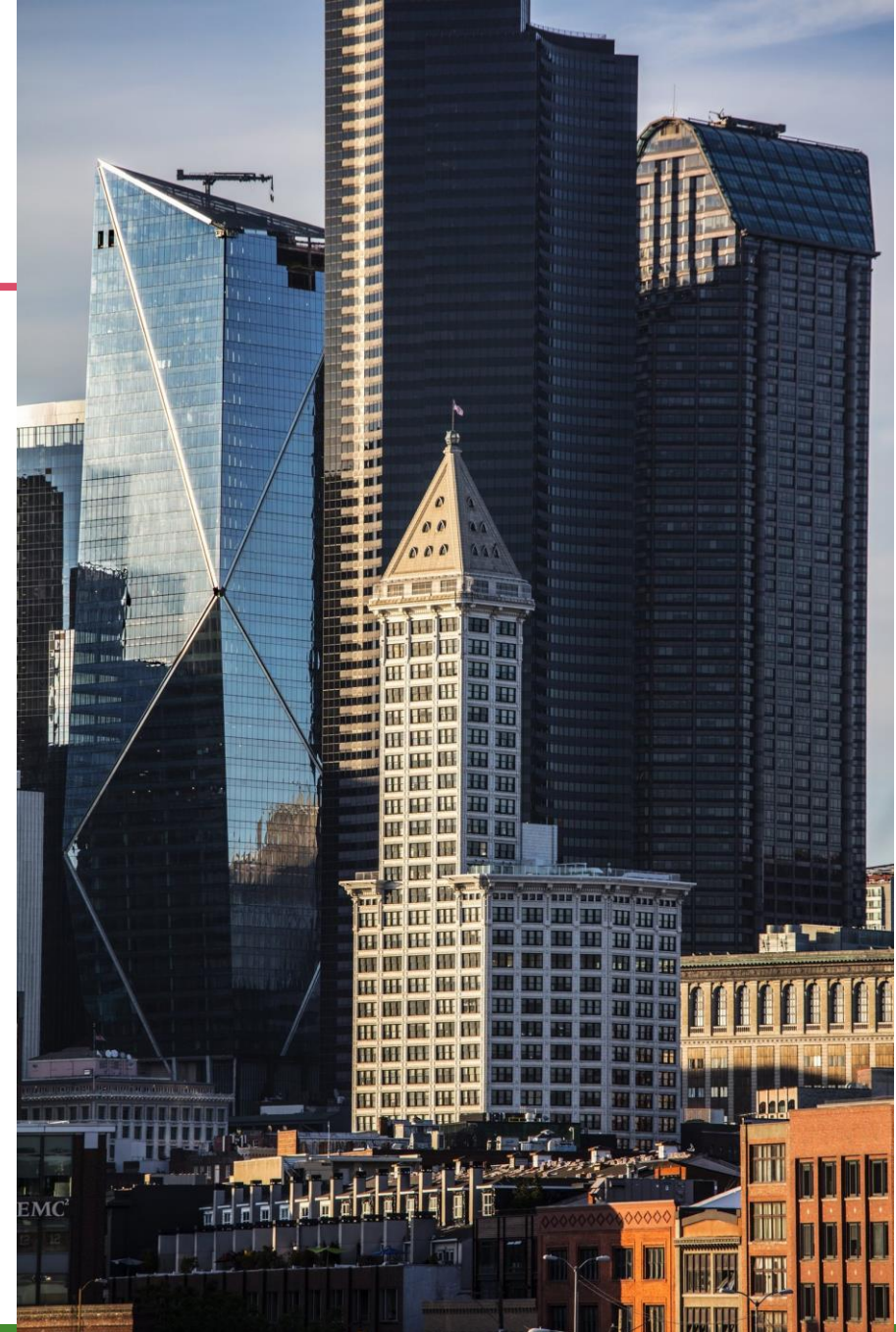
Full-Floor Tenant Dashboard

- Electrical sub-metering for each full floor tenant space
 - new construction and tenant improvements
- Data sent to tenant dashboard
- Tenants able to monitor (and manage) their own energy
- Check with City Light before trying to use meters for billing tenants!



Existing buildings

- You (mostly) don't have to upgrade what you don't touch
 - ...if it met code back when it was built
 - ...there are a few exceptions
- But new work must meet current code
- “Substantial Alterations” Comply with C503.8
 - Change of occupancy C505
 - Change of space conditioning C503.2
- Don't harm anything protected by Landmarks



Lighting Alterations c503.6

- Bring buildings closer to current code, one project at a time.
- Proportionate to scale of work

Stage 1: Fixture Replacement only

- If you replace 20% of the light fixtures* in any space or on the building exterior, meet the LPA or exterior lighting allowance
 - *or just the lamps and ballasts in existing fixtures



Stage 2: New Fixtures or Re-Circuiting Existing

- If new fixtures are wired or existing fixtures are being re-circuited, controls must have:
 - Manual controls (usually switches)
 - Light reduction controls (50% switching)
 - Automatic daylight zone controls
 - Specific application controls (display lights, under-counter lights, stairwell lights, etc.)
 - Occupancy sensors wherever required by C405.2.2.2

Stage 3: New or Relocated Panel

- A new or moved lighting panel, with new raceway and wiring to the fixtures, must conform to the rest of C405.2.2. Therefore:
 - Automatic time switch for rooms that don't have occupancy sensors, with manual override



Retrofits?

Luminaires

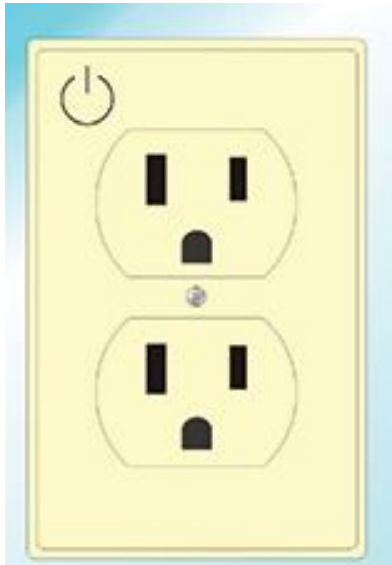
- Review existing lighting for suitability
- Replacement or redesign?
- If possible, keep existing wiring

Controls

- Consider LLC first wherever possible
- Wireless controls save a lot of labor
- Work with utility incentive programs



Controlled Receptacles C503.6.6



- Office, classroom, break room, etc:
- Control 50% of new outlets with time clock or occupancy sensor, except:
 - Alterations smaller than **5000 sf**
 - Systems furniture or office cubicle partitions reconfigured or relocated within the same area
 - Existing outlets in existing walls
 - Outlets for safety, security, maint, 24-hour

Metering for major HVAC alterations

- For full HVAC replacement (or more than half of heating & cooling capacity):
 - Meter incoming gas & electric
 - Sub-meter HVAC
 - Data acquisition & display




Metering for HVAC equip replacement

- “Local” meter required for:
 - Branch circuit over 50 kVA serving new HVAC equipment
 - New HVAC equipment on variable speed drive
- Gas metering required for new gas connection over 1,000 kBTU

Metering for complete new electrical system

- Provide complete metering



“That which exists,
must be possible.”
Mark Frankel



The structure is a design in light.

- *Louis Kahn*

Duane Jonlin, FAIA

duane.jonlin@seattle.gov

206-233-2781

Shaun Darragh

Shaun.darragh@seattle.gov



Now a Few Words with

Customer Care & Energy Solutions (CCES)

Questions to consider:

Is your lighting project eligible for retrofit incentives?

1. Is this a newly-constructed facility?
2. Is this a newly-constructed exterior area with new lighting fixtures?
3. Is this a newly-constructed addition to an existing facility that adds usable floor area?
4. Is the project a major renovation?
 - Is a whole building permit required?
5. Is there a change in occupancy type?
 - e.g. office to food service or retail to office

Upcoming 2018 Code Update Deliveries

Webinar Topic	Delivery Date	Time
Cost Effective Code Compliance: HVAC	January 19 th	10:00 - Noon
Cost Effective Code Compliance: Building Envelope	January 26 th	10:00 - Noon
Cost Effective Code Compliance: Lighting	January 2 nd	10:00 - Noon
Cost Effective Code Compliance: Water Heating	February 9 th	10:00 - Noon

Today's slide deck and video recording can be found on
www.lightingdesignlab.com

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- ▶ Duane Jonlin, FAIA
 - ▶ 206-233-2781
 - ▶ Duane.Jonlin@seattle.gov

- ▶ Shaun Darragh LC, MIES
 - ▶ 206-256-6171
 - ▶ Shaun.Darragh@seattle.gov

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