




Lighting & Electrical Issues in 2021 WA & Seattle Commercial Energy Codes


Presented by
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Construction & Inspection
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February 20, 2025



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Shaun Darragh

liteshaun@gmail.com

- 37 years in the lighting industry
- Award winning lighting designer
- Lighting Educator



SPD
LIGHT STUDIO



lighting design lab

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Duane Jonlin, FAIA

- 30 years as technical architect
- 13 years on Energy Code
- 4th generation Seattleite



We got this.

Seattle Department of Construction & Inspections Seattle City Light

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Lighting the way towards our environmental goals



Washington state:
70% less building energy use by 2030

- And get to zero-carbon buildings

Washington state:
45% reduction in GHG emissions by 2030

- 95% reduction by 2050

Seattle: Carbon-neutral building & vehicle operations by 2050

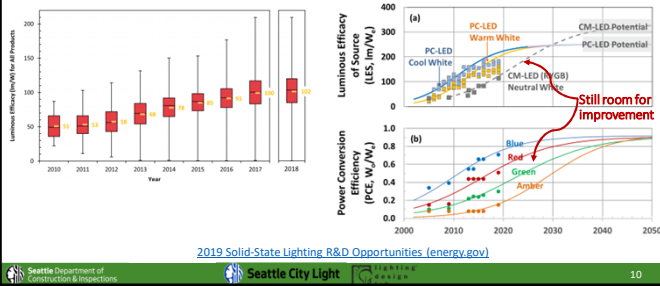
- ...or sooner with Green New Deal?

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LED efficacy trends



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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

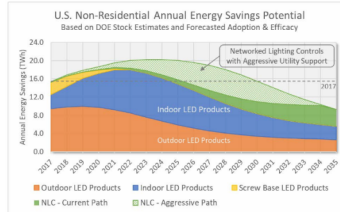


Figure 4: Non-residential (C&I) annual energy savings potential from LED & networked lighting controls, assuming aggressive utility support

Courtesy: DLC

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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 electric & solar

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

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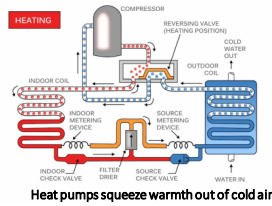
Space heating (Seattle & WA – C403.1.4)

No electric resistance or fossil fuel combustion for space heating

(Unless using “fossil fuel compliance path”)

Exceptions allow electric resistance heat for:

1. Permits applied for before 01/31
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



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Heat Pump Water Heating (Seattle & WA – C404.2)

Unless using the “Fossil Fuel Compliance Path”

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



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Lighting Changes: 2018 to 2021

- C405.1 Min efficacy in dwelling & sleeping units
 - 65 lumens/W lamps (is an LED a “lamp”?)
 - Seattle adds: ...or 45 lumens/W fixtures
- C405.2 Max 24/7 lighting in “exit access” 0.1 W/sf (not 0.2 W)
- C405.2.1.2 Library stacks now follow warehouse aisle requirements
 - 50% reduction after 20 minutes unoccupied
- C405.2.1.3 Open office – max 600 sf zones
 - Lights on in each zone when someone enters
 - Lights either remain off or turn on to 20% in other unoccupied areas
 - Lights either turn off or turn down to 20% after 20 minutes
 - For open office over 5,000 sf, must be LLLC or Networked

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More changes

- C405.2.1.5 Corridors: Reduce lighting 50% after 20 minutes with no activity
- C405.2.5 Daylight responsive control thresholds:
 - Over 75 W general lighting in primary zone (instead of 2 fixtures)
 - Over 150 W general lighting in primary + secondary zone
 - Over 75 W general lighting in toplit zone
- C405.2.5 Additional lighting controls section reorganized.
- C405.3 Indoor grows – WA copies Seattle code:
 - 1.90 micromoles/joule for warehouse
 - 1.70 greenhouse
- C405.4.2.1 Building Area Method: might be viable now



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Lighting controls: summary (C405.2)

Two basic paths for controls:

1. Provide LLLC fixtures everywhere, or

2. Comply with *all* lighting controls

- **Plus** LLLC or networked lighting control in large open office (Seattle)
- Exceptions:
 - Designated "security or emergency" areas
 - 0.01 W/sf in "exit access" areas can remain on 24/7
 - 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

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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>

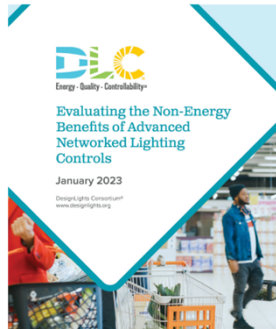


San Francisco Public Utilities Commission Headquarters KMD

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Why use lighting controls?

- Flexibility
- Productivity
- User Satisfaction
- Aesthetics
- Maintenance
- LEED / WELL / LBC
- Energy Savings
- Energy Codes

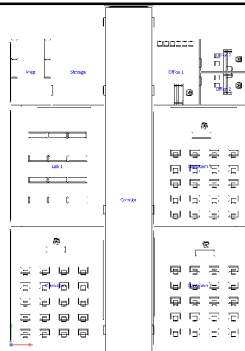


Courtesy: DLC

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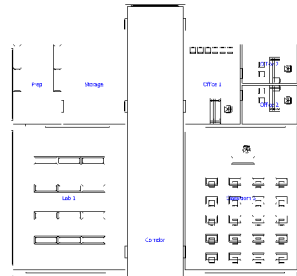
Typical School Spaces

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

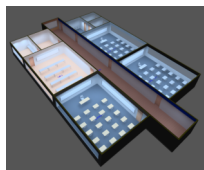


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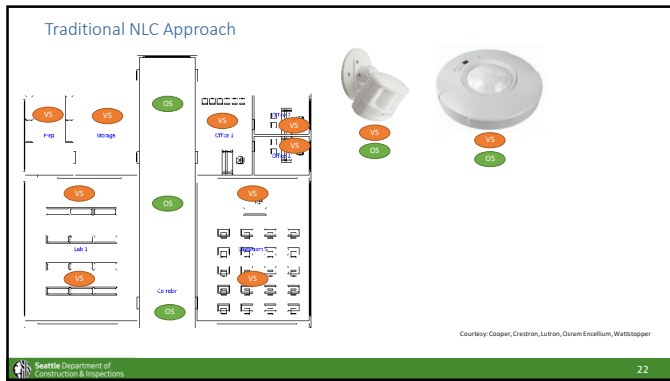
Traditional NLC Approach



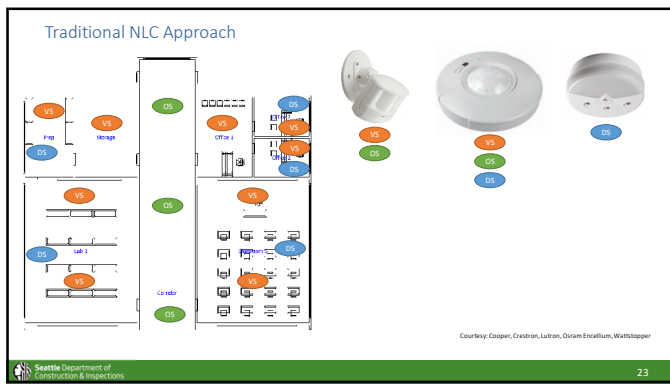
- Classrooms
- Teaching Lab
- Prep Space
- Office Anteroom
- Private Offices
- Corridor
- Storage



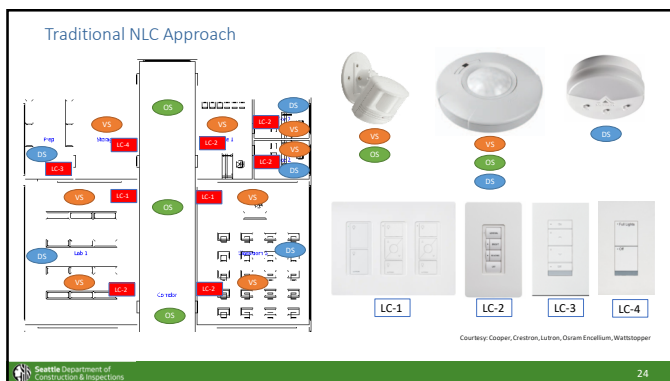
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Sequence of Operations - Matrix

Typical School Example													
Room Number	Room Name	Room Type/Use	Lighting Type	Footlight Level	Footlight Level	Footlight Level	Footlight Level	Footlight Level	Footlight Level	Footlight Level	Footlight Level	Footlight Level	Footlight Level
1	1	Classroom	Trufluor	30	1, 2								
2	2	Classroom	Trufluor	30	1								
3	3	Classroom	Trufluor	30	1, 2								
4	4	Classroom	Trufluor	30	1								
5	5	Classroom	Trufluor	30	1, 2								
6	6	Classroom	Trufluor	30	1								
7	7	Lab Classroom	Trufluor	30	1, 2								
8	8	Lab Classroom	Trufluor	30	1								
9	9	Shop Room	Trufluor	30	2								
10	10	Storage	Trufluor	15	4								
11	11	Office Reception	Trufluor	30	2								
12	12	Private Office	Trufluor	30	2								
13	13	Private Office	Trufluor	30	2								
14	14	Corridor	Trufluor Linear	15									

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"Additional lighting controls" C405.2.6

- Some just need separate switching:
 - Display & accent
 - Display cases
 - Task lighting
 - Lighting for sale
 - Plant growth
 - Food warming
- Hotel rooms (sleeping units)
 - Auto-off lights
 - Auto-off controlled receptacles
- The "exit access"
 - (Uhh, what's an Exit Access?)
 - Off when general lighting is off
 - ON during power failure
 - 0.1 W/sf can stay on 24/7

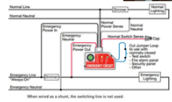


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Egress / Exit / Emergency Lighting

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

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



Spokane Public Library

Courtesy: Wattstopper, Encellium, Lutron

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Exterior lighting controls c405.2.9

- Off during daylight hours
- Façade and landscape lighting
 - Off 6 hours/night
- Outdoor parking
 - 50% reduction after 15 min
 - If over 40 W & under 24 feet
- Other exterior lighting reduced by 30%:
 - Midnight to 6 AM, or
 - 1 hour after closing to 1 hour before opening, or
 - No activity for 15 minutes

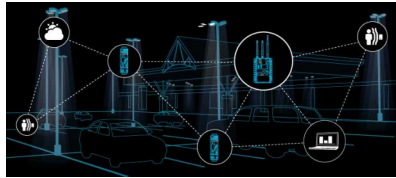


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Exterior Lighting Controls

Consider wireless controls

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



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Georgia Power is using DALI for street lights

Intra-luminaire DALI enables Georgia Power to fast-track smart lighting project

Location: Multiple outdoor locations, South-East USA

DIA Member: Telensa

Georgia Power, a US-based utility, has implemented wireless controls on nearly 300,000 LED street lights since 2015, in a project which is already one of the world's largest deployments of connected street lighting. Within the next 3 years, Georgia Power expects to operate up to 1 million networked LED lights.

DALI plays a key role in the project, automating the data transfer of asset information from the lighting fixtures to the Telensa lighting control system. Georgia Power's Kevin Fitzmaurice explained the role played by DALI during the DALI seminar at Lightfair International in May 2019 - see [Georgia Power uses DALI for asset management and operational control](#)

A detailed insight into the project is provided in a White Paper by Navigant Research entitled "The Utility Case for Smart Street Lighting: Insights from Georgia Power". The paper was commissioned by DALI member Telensa, and can be downloaded from the [Telensa website](#)

Telensa's PLANet lighting-control system connects Georgia Power's LED fixtures. It includes individual network lighting controllers (NLC) on each fixture, an Ultra-Narrow Band long-range communications network, and a central management system (CMS) for remote monitoring and control.



<https://www.dali-alliance.org/projects/georgia-power.html>

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2023 ANNUAL CONFERENCE
LIGHT RESPONSIBLY
AUGUST 3-5 | CHICAGO LAND | RENAISSANCE SCHUMBURG HOTEL & CONVENTION CENTER

+ Master Planning Light for Environment & Social Justice

+ How We Are Thinking Differently About Outdoor Lighting These Days

+ The Big Picture of Light at Night: What Can We Learn About Responsible Outdoor Lighting From The Stratosphere?


Courtesy: IES


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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 **5% below WA**
 - Was 10% below WA in 2015 code




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Seattle LPA 5% below WA Table C405.4.2(2)

Common Space-by-Space Types*	(LPD (lm/ft ²))	LPD (w/ft ²)
Atrium - Less than 20 feet in height	0.30	0.30
Atrium - 20 to 40 feet in height	0.48	0.39
Atrium - Above 40 feet in height	0.60	0.48
Audience/seating area - Permanent		
In an auditorium	0.64	0.54
In a gymnasium	0.23	0.22
In a motion picture theater	0.22	0.26
In a pententary	0.62	0.56
In a performing arts theater	1.16	1.04
In a religious building	0.72	0.68
In a sports arena	0.33	0.26
Otherwise	0.23	0.22
Banking activity area ^(m)	0.64	
Breakroom (see lounge-breakroom)		
Classroom/lecture hall/training room		
In a pententary	0.80	0.74
Otherwise ^(m)	0.71m	0.68

*"Building Area Method" table values now much better aligned with space-by-space method values

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Table footnotes: extra lighting allowances

- (m) **Classroom:** 4.5 W/lin. ft. of white board
- (n) **Ornamental lighting:** 0.15 W/sf in any space
 - Used in a decorative manner
 - Not general lighting
 - Controlled separately
- (o) **Scientific labs:** 0.35 W/sf lighting for “specialized task work”
- (p) **Office:** 0.20 W/sf for portable lighting, includes furniture-mounted
- (r) **Corridor:** 0.25 W/sf for display and decorative lighting (Seattle)



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Retail Allowance

C405.4.2.2.1 Additional interior lighting power. Where using the Space-by-Space Method, an increase in the interior lighting power allowance is permitted for specific lighting functions. Additional power shall be permitted only where the specified lighting is installed in addition to and automatically controlled separately from general lighting, in accordance with Section C405.2.6. This additional power shall be used only for the specified luminaires and shall not be used for any other purpose.

An increase in the interior lighting power allowance is permitted for lighting equipment to be installed in sales areas specifically to highlight merchandise. The additional lighting power shall be determined in accordance with Equation 4-14.

(Equation 4-14)

$$\text{Additional Interior Lighting Power Allowance} = 500 \text{ watts} + (\text{Retail Area 1} \times 0.45 \text{ W/ft}^2) + (\text{Retail Area 2} \times 0.45 \text{ W/ft}^2) + (\text{Retail Area 3} \times 1.05 \text{ W/ft}^2) + (\text{Retail Area 4} \times 1.87 \text{ W/ft}^2)$$

Where:

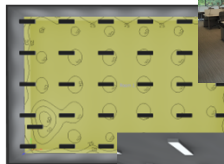
- Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.
- Retail Area 2 = The floor area used for the sale of vehicles, sporting goods and small electronics.
- Retail Area 3 = The floor area used for the sale of furniture, clothing, cosmetics and artwork.
- Retail Area 4 = The floor area used for the sale of jewelry, crystal and china.



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Office Example - Troffer

- Allowed LPD **0.53 w/sf**
- Proposed LPD: 0.40 w/sf
- Target Light Level: 25fc
- Estimated: ~ 34 fc
- ~25% better than code
- Controls:
 - Vacancy Sensing
 - Daylight Harvesting
 - Manual Dimming / Preset
 - Task Tuning



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Office Example - Indirect

- Allowed LPD **0.53 w/sf**
- Actual LPD: 0.36 w/sf
- Target Light Level: 25fc
- Estimated: ~ 29 fc
- ~ 32% better than code
- Controls:
 - Vacancy Sensing
 - Daylight Harvesting
 - Manual Dimming / Preset
 - **Task Tuning**



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Classroom Troffer

- Allowed LPD **0.68 w/sf**
- 4.5 w / LF whiteboard*
- Area: 1008 SF
- Allowed: 685w
- Whiteboard allowance: 0 w
- Allowance: 685 w
- General Area Lighting: 612 w
- Whiteboard Lighting: 0 w
- Proposed: 612 w
- Proposed: 0.61 w/sf
- ~11% better than code



Target: 30FC Min
Calculated: 52 fc / 31 fc Min

Controls:
Vacancy Sensing
Scene Control
Daylight Harvesting

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Classroom Troffer

- Allowed LPD **0.68 w/sf**
- **4.5 w / LF whiteboard***
- Allowed: 685w
- Whiteboard allowance: 198w
- Aggregate Allowance: 883 w
- General Area Lighting: 432 w
- Whiteboard Lighting: 165 w
- Proposed: 597 w
- Proposed General: 0.43 w/sf
- Proposed Aggregate: 0.59 w/sf
- ~32% better than code



Target: 30FC Min
Calculated: 51 fc / 31 fc Min

Controls:
Vacancy Sensing
Scene Control
Daylight Harvesting


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Classroom ID/D

- Allowed LPD 0.68 w/sf
- 4.5 w / LF whiteboard*

- Allowed: 685w
- Whiteboard allowance: 198w
- Aggregate Allowance: 883 w

- General Area Lighting: 428 w
- Whiteboard Lighting: 165 w
- Proposed: 592 w
- Proposed General: 0.42 w/sf
- Proposed Aggregate: 0.59 w/sf
- ~33% better than code



Target: 30FC Min
Calculated: 45 fc / 30 fc Min

Controls:
Vacancy Sensing
Scene Control
Daylight Harvesting

Seattle Department of Construction & Inspections Seattle City Light LIGHTING DESIGN SPD 40


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Corridor

- Allowed LPD 0.42 w/sf
- 0.25 w / sf for display and decorative*

- Allowed: 689 w
- Display allowance: 0 w
- Aggregate Allowance: 689 w

- General Area Lighting: 276 w
- Display Lighting: 0 w
- Proposed: 276 w
- Proposed General: 0.17 w/sf
- Proposed Aggregate: 0.17 w/sf
- ~60% better than code



Target: 10-15 fc
Calculated: 14 fc

Controls:
Occupancy Sensing
Time of Day
Task Tuning

Seattle Department of Construction & Inspections Seattle City Light LIGHTING DESIGN SPD 41

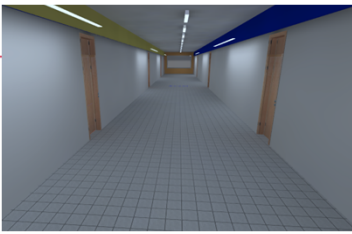
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Corridor w/display

- Allowed LPD 0.42 w/sf
- 0.25 w / sf for display and decorative*

- Allowed: 689 w
- Display allowance: 160 w
- Aggregate Allowance: 849 w

- General Area Lighting: 276 w
- Display Lighting: 148 w
- Proposed: 424 w
- Proposed General: 0.17 w/sf
- Proposed Aggregate: 0.26 w/sf
- ~50% better than code



Target: 10-15 fc
Calculated: 18 fc

Controls:
Occupancy Sensing
Time of Day
Task Tuning
Manual Dimming

Seattle Department of Construction & Inspections Seattle City Light LIGHTING DESIGN SPD 42

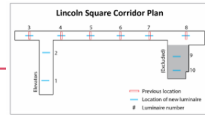
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Corridors – with Controls

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

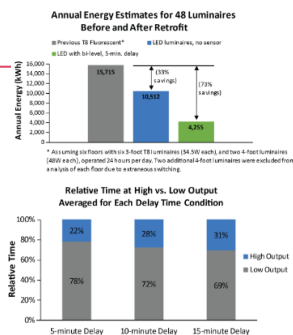
www.lrc.rpi.edu/programs/DELTA/pdf/DELTAMultiFamilyCorridors.pdf



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
- LLLC Controls required no additional wiring or complexity.



Germicidal Ultra Violet (GUV) “Antimicrobial”

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

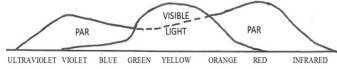
- Water
- Upper Air
- Surfaces

- 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/>



Seattle & WA: Indoor horticulture C405.3

- 1.7 micromoles per joule greenhouse
- 1.9 micromoles per joule warehouse
- Because "Lumens are for humans"
- Exception: less than 10 kW
- Seattle: 1.4 for "decorative" plant lighting, not for horticulture (C405.4)



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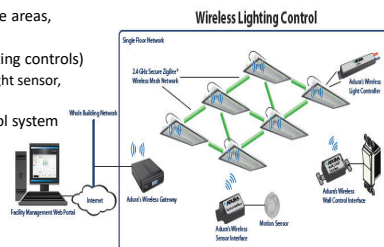
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Seattle & WA: Lighting in Open Office C405.2.1.3

- 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



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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

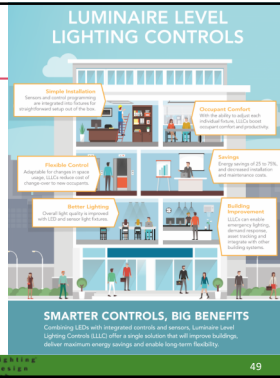
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LLLC Considerations

- 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>



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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

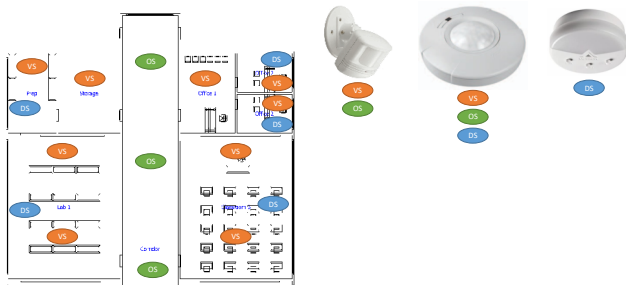
Luminaire Level Lighting Controls Replacement vs Redesign Comparison Study

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

Prepared by: Alan Mahr, Jeff Pines, Dale Fortnoff, Kevin Van Den Wyngaertberg
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Portland, OR 97205Northwest Energy Efficiency Alliance PHONE: 503-465-5655
EMAIL: info@neea.org
WWW: neea.org

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Traditional NLC Approach



Courtesy: Cooper, Crabtree, Luthin, Oram-Encaillon, Wertschapper

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

Click to access the LDL networked lighting control learning guides

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SMT Relight

Seattle Municipal Tower General Lighting

- High performance recessed troffer
- Fluorescent T8
- Minimal Lighting Controls
- Replacement luminaires no longer available

LDL hosted a mockup to review alternatives

LLC Options selected in 2019 as the best choice moving forward

Courtesy: DLR Group, FAS, SCL, LLC

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SMT Relight

Luminaire Replacement

- High performance recessed troffer
- LED Based
- LLC Control System

Existing Luminaire: 2T8 56 W
Retrofit Luminaire: LED 32 W

Luminaire savings: 43%

Estimated LPD: ~ 0.4 W / SF

Courtesy: DLR Group, FAS, SCL, LLC

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SMT Relight

Controls

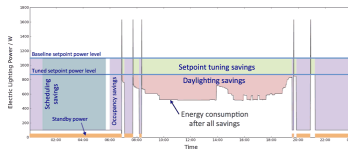
Existing:

- Large area relay; several per floor
- Time of Day 12 HR with over-ride
- Analog daylight control at perimeter

Retrofit:

- LLLC with central control
- Occupancy Sensing
- Daylight Sensing

- Estimated Controls Savings: ~60%
- Estimated overall savings **per floor**: 29,000 kWh / Yr
- SMT has 57 floors.....



Courtesy: IBM, DLR Group, F&S, SCL, LRI

Light reduction controls (Seattle)

C405.2.4 Light reduction controls.

Light reduction controls required except where:

- Occupant sensors
- Daylight controls
- "Special application controls" per C405.2.6
- Less than 0.45 W/ft²
- Corridors
- Lobbies
- Electrical rooms
- Mechanical rooms

So, maybe only gyms and the inboard areas of open office?

Daylight responsive controls require dimming.

Spaces required to have dimming control shall be provided with *manual* controls that allow lights to be dimmed from full output to 10 percent of full power or lower with continuous dimming, as well as turning lights off. **Manual control shall be provided within each space to dim lights.**

C405.2.4.1 Light reduction control function

- Continuous dimming - **unnoticeable**
- Switched to between 30% & 70% - **distracting**
- Switching alternate rows to between 30% & 70% - **terrible**

Why Dim?

- Smooth dimming is less obtrusive than step switching in most instances.
- Smooth dimming is more even than checkerboard pattern step switching.
- Dimming is now easier to design and implement than steps witching.
- It's standard in most luminaires....

Why use lighting controls?

- Flexibility
- Productivity
- User Satisfaction
- Aesthetics
- Maintenance
- LEED / WELL / LBC
- Energy Savings
- Energy Codes



Occupancy/Vacancy Sensors

Passive Infrared

- Passively scans the field of view for moving heat sources across sensor segments.
- Must have line of sight to function
- May be wireless or wired

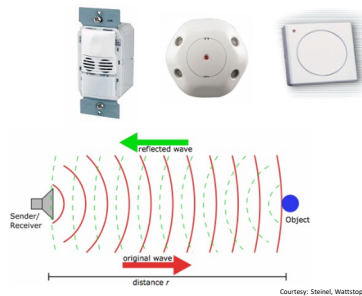


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Occupancy/Vacancy Sensors

Ultrasonic

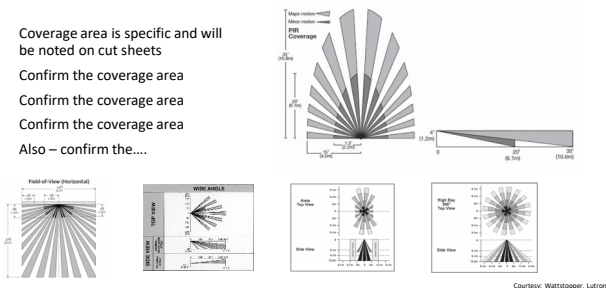
- Emits high frequency sound waves and measures return waves for doppler shift.
- Does not need line of sight to function
- Generally used in larger or obstructed areas
- Great for restrooms
- May have problems in areas with heavy airflow
- Requires wired installation



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Occupancy/Vacancy Sensors

- Coverage area is specific and will be noted on cut sheets
- Confirm the coverage area
- Confirm the coverage area
- Confirm the coverage area
- Also – confirm the....



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Line of Sight

Field Of View

Bookcase

Courtesy: Wattstopper

Seattle Department of Construction & Inspections

Seattle City Light

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Occupancy/Vacancy Sensors

Wall Mounted

- Wall rather than ceiling when line of sight or access is better
- Frequently corner mounted
- Consult product spec sheets for effective coverage area and field of view
- Generally requires a remote relay pack or networked system
- Wired or wireless

Field Of View

Courtesy: Wattstopper

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Seattle City Light

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Occupancy/Vacancy Sensors

Ceiling Mounted

- Will require a remote relay pack or provide data to a networked system
- Larger coverage areas
- Wired or wireless

Field Of View

Extended Range Lens (standard)
CI-200, CI-205

Courtesy: Wattstopper

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Seattle City Light

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Exterior LPAs reduced
(a lot)

2018 Code

Table C405.5.3(2)

Lighting Power Allowances for Building Exteriors

Lighting Zones	Lighting Zones			
	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance	160 W	280 W	400 W	560 W
Uncovered Parking Areas				
Parking areas and drives	0.03 W/ft ²	0.04 W/ft ²	0.05 W/ft ²	0.08 W/ft ²
Building Grounds				
Walkways and ramps less than 10 feet wide	0.5 W/linear foot	0.6 W/linear foot	0.6 W/linear foot	0.7 W/linear foot
Walkways and ramps 10 feet wide or greater, plaza areas, special feature areas	0.10 W/ft ²	0.10 W/ft ²	0.11 W/ft ²	0.14 W/ft ²
Dining areas	0.65 W/ft ²	0.65 W/ft ²	0.75 W/ft ²	0.90 W/ft ²
Building Grounds				
Walkways and ramps less than 10 feet wide	0.04 W/ft ²	0.07 W/ft ²	0.10 W/ft ²	0.14 W/ft ²
Walkways and ramps 10 feet wide or greater, plaza areas, special feature areas	0.04 W/ft ²	0.07 W/ft ²	0.10 W/ft ²	0.14 W/ft ²
Dining areas	0.15 W/ft ²	0.27 W/ft ²	0.39 W/ft ²	0.54 W/ft ²


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Electrical Receptacle at Gas Appliances
in Dwelling unit C405.7.1

Inside the 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



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Power for future electric appliances
Commercial kitchens (Seattle – C405.14)

- New buildings only
- Electrical panel at each commercial food prep area
- Capacity to replace all gas appliances with electrical
 - ...making future electrification "plug and play"
- Intent is to ensure sufficient capacity on utility service and main panel

Seattle Department of Construction & Inspections

Seattle City Light

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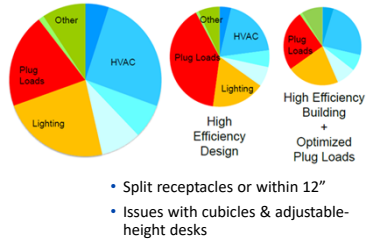
Controlled receptacles C405.10

50% of outlets in:

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

Turn off via:

- Occ sensor or Timeclock



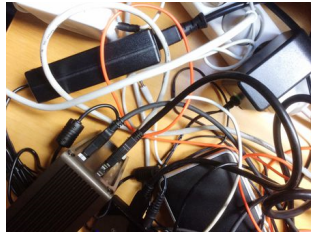
Vampire Plug Loads

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

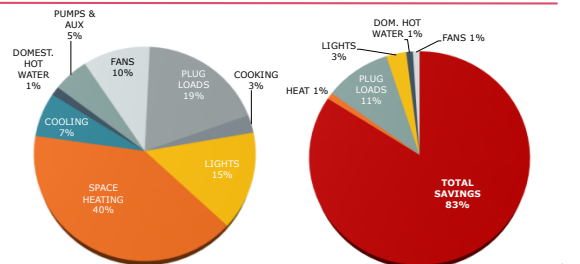
- Task Lights
- Printers / Plotters
- Microwaves
- Faxes
- Monitors

• CPUs? (Don't try it)

• Try an inventory some time....



Vampire Plug Loads



Smart Receptacles and Relays

How to control receptacles?

- 20A relay feeding a circuit of receptacles
- Smart Receptacles
- Either can be more or less stand alone or part of a NLC System



Note: Must be Labelled

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C406 Efficiency Package Credits

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

- New school needs 48 efficiency credits
- + 15 Load Management Credits
- Each 2021 code credit + 0.1% EUI

Table C406.1
Energy Measure Credit Requirements

Required Credits for Projects	Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
New building energy efficiency credit requirement	C406.2	54	41	42	48	74	49
Building additions energy efficiency credit requirement	C406.2	27	20	21	23	36	21
New building load management credit requirement	C406.3	12	15	27	15	13	26

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Efficiency credits

Table C406.2(1)
Efficiency Measure Credits

Measure Title	Applicable Section	Prorating Flag	Occupancy Group					
			Group R-1	Group R-2	Group B	Group E	Group M	All Other
1. Dwelling unit HVAC control	((C406.2.3)) C406.2.1	Heat	NA	7	NA	NA	NA	NA
2. Improved HVAC TSPR ^a	C406.2.3.1	Heat	NA	8	11	17	22	NA
3. Improve cooling and fan efficiency	C406.2.2.2	Heat	((8)) 8	((8)) 8	((8)) 10	((4)) 10	((8)) 8	((8)) 8
4. Improve heating efficiency	C406.2.3.3	Heat	((8)) 1	((8)) 1	((8)) 1	((4)) 1	((8)) 1	((8)) 1
5. 10% reduced lighting power	C406.2.3.1	Heat	7	4	18	16	((20)) 16	((18)) 16
10. 20% reduced lighting power ^d	C406.2.3.2	Heat	13	8	36	32	((52)) 22	((39)) 22
11. Lamp efficacy improvement	C406.2.3.3	Heat	5	6	NA	NA	NA	NA
12. Residential lighting control	C406.2.4.1	Heat	NA	8	NA	NA	NA	NA
13. Enhanced lighting control	C406.2.4.2	Heat	1	1	6	6	11	((6)) 5
14. Renewable energy	C406.2.5	SWH	7	12	13	13	10	11
15. Shower drain heat recovery	C406.2.6.1	SWH	9	30	NA	7	NA	NA
16. Service water heat recovery	C406.2.6.2	SWH	35	111	13	14	(Grocery)	NA

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Renewable credits

$$AEC_{RRa} = AEC_b \times \frac{\sum (REF \times RR_t) - RR_r}{RR_b \times PGFA}$$

Table C406.2(1)

Efficiency Measure Credits

Measure Title	Applicable Section	Prorating Flag	Group R-1	Group R-2	Group B	Group E	Group M	All Other
1. Dwelling unit HVAC control	((C406.2.2)) C406.2.1	Heat	NA	7	NA	NA	NA	NA
2. Improved HVAC TSPPR ^a	C406.2.2.1	Heat	NA	8	11	17	22	NA
3. Improve cooling and fan efficiency	C406.2.2.2	Heat	((2)) 8	((2)) 5	((3)) 10	((4)) 10	((5)) 8	((2)) 8
4. Improve heating efficiency	C406.2.2.3	Heat	((2)) 1	((3)) 1	((3)) 1	((4)) 1	((4)) 2	((7)) 1
9. 10% reduced lighting power	C406.2.3.1	Heat	7	4	18	16	((30)) 16	((14)) 16
10. 20% reduced lighting power ^d	C406.2.3.2	Heat	13	8	36	32	((50)) 22	((29)) 12
11. Lamp efficacy improvement	C406.2.3.3	Heat	5	6	NA	NA	NA	NA
12. Residential lighting control	C406.2.4.1	Heat	NA	8	NA	NA	NA	NA
13. Commercial lighting control	C406.2.4.2	Heat	1	1	6	6	11	((6)) 5
14. Renewable energy	C406.2.5		7	12	13	13	10	11
15. Storage heat recovery	C406.2.6.1	SWH	9	30	NA	3	NA	NA
16. Service water heat recovery	C406.2.6.2	SWH	35	111	13	14	(Grocery)	NA

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$$AEC_{RRa} = AEC_b \times \frac{\sum (REF \times RR_t) - RR_r}{RR_b \times PGFA}$$

- School
- 25,000 ft²
- 5 kW solar on roof
- 15 kW solar PPA in-state

Credits from Table C406.2(1)

$$13 \times \frac{(1.0 \times 5,000) + (0.75 \times 15,000) - (0.5 \times 25,000)}{(0.1 \times 25,000)}$$

$$13 \times \frac{(5,000 + 11,250 - 12,500)}{2,500}$$

$$13 \times 1.5 = 19 \text{ credits}$$

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Off-site renewables

- Directly-owned renewables
- Community solar
- PPA
- Part of Western Interconnection
- Multiply by procurement factors



Table C411.2.1

Multipliers for Renewable Energy Procurement Methods

Location	Renewable Energy Source	Renewable Energy Factor		
		In the state of Washington	Western Interconnection	In the states of Oregon or Idaho
On-site	On-site renewable energy system	1	NA	NA
Off-site	Directly owned off-site renewable energy system that begins operation after submission of the initial permit application	0.95	0.75	0.85
Off-site	Community renewable energy facility that begins operation after submission of the initial permit application	0.95	0.75	0.85
Off-site	Directly owned off-site renewable energy system that begins operation before submission of the initial permit application	0.75	0.55	0.65
Off-site	Community renewable energy facility that begins operation before submission of the initial permit application	0.75	0.55	0.65
Off-site	Renewable Power Purchase Agreement (PPA)	0.75	0.55	0.65
Off-site	Renewable Energy Lease Agreement (RELA)	0.95	0.75	0.85

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Load Management Credits

Table C406.3
Load Management Measure Credits

Measure Title	Applicable Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
1. Lighting load management	C406.3.1	12	15	27	15	NA	NA
2. HVAC load management	C406.3.2	29	24	42	33	13	26
3. Automated shading	C406.3.3	NA	7	12	16	NA	NA
4. Electric energy storage	C406.3.4	41	50	126	72	37	65
5. Cooling energy storage	C406.3.5	13	10	14	19	NA	14
6. Service hot water energy storage	C406.3.6	31	248	59	8	5	70
7. Building thermal mass	C406.3.7	NA	NA	50	95	96	80

- Lighting load management:
- 75% of general lighting controllable to reduce power by 20%

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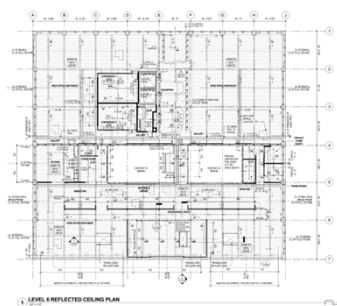
Exceeding code requirements

- 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.

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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

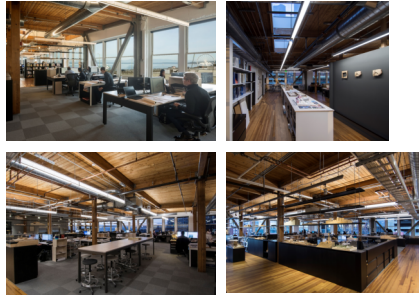


Courtesy: Miller Hull

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Miller Hull Studios

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



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Solar Readiness

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



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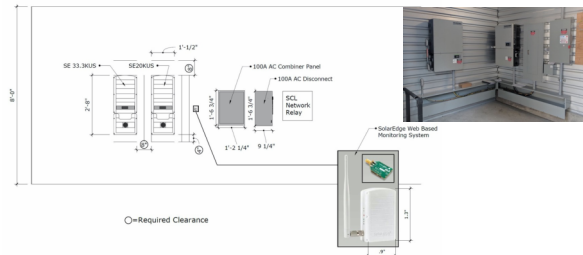
Structural considerations for solar

- 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



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Electrical gear space requirements for solar



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Renewable Energy: 0.5 W/ft²

WA Exceptions

- 50% of roof area shaded >2,500 hours/year 8:00 – 4:00
 - Out of 2,920 hours total
 - So, half of roof shaded almost all the time
- 80% roof area covered with:
 - Equipment
 - Planters, Vegetated roof
 - Skylights
 - Occupied roof deck
- Reduced solar OK if not enough roof area for 100%

Seattle Exceptions

- Additional efficiency credits:
 - Only for the portion that doesn't fit on roof
 - 5X credits from Table C406.2(1)
- Off-site renewable energy
 - Only for the portion that doesn't fit on roof
- Modeling: BPF 3% lower
- Direct gift to affordable housing
- Transfer to WSHFC @ \$2.50/W
- Not required for affordable housing

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Seattle: Renewable energy & affordable housing

- 0.50 W/sf, based on area of all floors
 - Same as WA
- "Solar-ready" roof & main panel
- Affordable housing exempted
- Option: Gift to affordable housing
 - Projects can donate turnkey system to a Seattle affordable housing building.
 - Or \$2.50/W to WHFC solar program




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How big is 0.50 W/sf?

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

Building Stories	Roof Area Required
1	4%
4	14%
10	36%
20	72%




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Suggestions to reduce solar cost

- Create solar-only areas on the roof
- Consolidate vents and HVAC within limited areas
 - Ideally north side if taller than the solar
- Engage solar installer early on to review design considerations for:
 - Tall buildings
 - Atypical roof orientations
 - Shading impacts
 - Limited roof space



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Commissioning: Lighting (& controlled receptacles)

If over 20 kW lighting load or over 10 kW with occ sensors or daylight sensors, test:

- 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



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Commissioning (Cx) Compliance

Washington

- Evidence that owner was given the Cx Report
 - Completed checklist OK
- Can phase checklist per trade
- If any unresolved deficiencies at final inspection, submit Cx Report & describe deficiencies

Seattle

- Submit Mech & SWH portions of Cx Report before completion of mechanical final inspection
- Submit lighting, controlled receptacle, and metering before completion of electrical final
- Before completion of final inspection, submit:
 - Cx Report, with unresolved deficiencies & anticipated dates of completion
 - For tenant spaces, clarification of Cx scope
 - Cx checklist, signed by CCP
 - Statement that owner was given Cx report

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(Seattle) Post-occupancy Completion

If unresolved deficiencies or incomplete commissioning tasks after final inspection, pick one of these options:

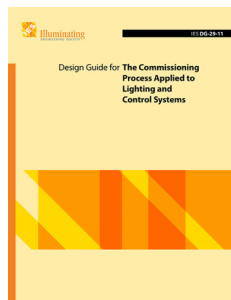
1. TCO until resolution of Cx work & revised Cx Report
 1. Useful for short completion timeframe
2. Performance bond for 2% of project valuation
 1. To ensure completion within 12-months
3. Pull new mech & elec permits with all remaining work, including commissioning those remaining systems
 1. This is probably the easiest path
 2. Commonly done anyway for end of project completion

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Commissioning

- Commissioning Plan
- Certified Commissioning Professional
- Functional Testing
- Final Report

Startup and Commissioning are not the same thing



Courtesy: Illuminating Engineering Society

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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?

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Commissioning

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

Commission the occupants....

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



Microsoft Building 17
Gender

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Sub-metering Actionable graphic display



Sub-meter displays for:

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

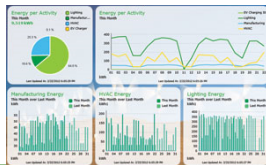
Building manager gets display showing energy use over time (day, week, year)

Full-floor tenants see next slide

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Full-Floor Tenant Dashboard

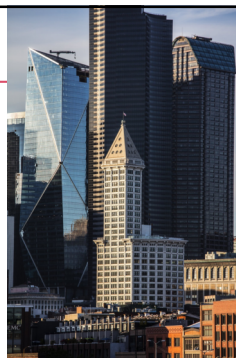
- Electrical sub-metering for each full floor tenant space
 - In new construction and tenant improvements
 - Including all HVAC & SWH equip dedicated to that space
- Data sent to tenant dashboard
- Tenants able to monitor (and manage) their own energy use
- Check with City Light before using tenant meters for billing!
 - Typically only permitted for exceptional situations
 - Such as populations that can't or don't pay their own utility bills.



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Existing buildings

- You (mostly) don't have to upgrade existing elements you don't touch
 - ...if it met code back when it was built
 - ...there are a few exceptions
- New work must meet current code
- "Substantial Alterations" Comply with C503.9
 - Change of space conditioning C505.2
 - Change of occupancy C505.3
- Don't harm anything protected by Landmarks



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Metering for major HVAC alterations c506.2.2

- 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 c506.2.1

- "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 c506.4

- Provide complete metering

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Lighting Alterations c503.7

- 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
 - *Seattle adds: or even just the lamps and ballasts in existing fixtures
 - 20% now applies to WA code also



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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 for:
 - Display lights
 - Under-counter lights
 - Stairwell lights
 - Etc.
- Occupancy sensors in all spaces listed in Table C405.2.1

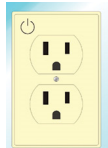
Stage 3: New or Relocated Panel

- A new or moved lighting panel, with new raceway and wiring to the fixtures, must conform to the rest of C405.2. Therefore:
 - Automatic time switch for rooms without occupancy sensors, plus manual override



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Controlled Receptacle Alterations c503.7.7



- Now also in WA code
- Office, classroom, break room, etc:
- Control 50% of new outlets, 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 use

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Retrofits?

Luminaires

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

Controls

- Consider LLC first wherever possible
- Wireless controls save labor, time, \$\$
- Work with utility incentive programs



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What Is This “Lighting Design Lab”?

- Seattle City Light's go-to resource for lighting and lighting controls since 1989 – 30+ years
- Formed by BPA and NW utilities to fill education needs for the transforming market
- Now expanded to include resources that support whole buildings
- Being rebranded!



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Upcoming 2018 Code Update Deliveries

Webinar Topic	Delivery Date	Time
HVAC Requirements in the 2021 Energy Codes	March 20	10:00 – Noon
Service Water Heating Requirements in the 2021 Energy Codes	April 17	10:00 – Noon
2021 Energy Code Requirements for Alterations	May 15	10:00 – Noon

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

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Upcoming Events

Course	Day	Time
Lessons Learned on Commercial Hot Water Heat Pump Installations	Thu Feb 27	10:00-11:00 a.m.
It Takes a Village: Learn How Some of Our Partners Can Advance Your Knowledge and Get Your Projects on the Right Track	Thu Mar 11	10:00-11:30 a.m.
HVAC Issues in 2021 WA & Seattle Commercial Energy Codes	Thu Mar 20	10:00-11:30 a.m.
Boilers to Heat Pumps	Tue April 1	10:00-11:30 a.m.
Water Heating Issues in 2021 WA & Seattle Commercial Energy Codes	Thu April 17	10:00-11:30 a.m.
Alterations Issues in 2021 WA & Seattle Commercial Energy Codes	Thu May 15	10:00-11:30 a.m.

Event	Day	Time
Seattle City Light Trade Ally Office Hours	Fri Feb 21	9:00 a.m.

Stay up-to-date at LightingDesignLab.com and by [subscribing to our newsletter](#).

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Q & A and closing

- Questions?
- Take the survey!

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THANK YOU



Seattle City Light

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