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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.

Seattle City Light

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Brought to you by:

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Seattle City Light

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Duane Jonlin, FAIA

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

We got this.

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Shaun Darragh
liteshaun@gmail.com

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

SPD LIGHT STUDIO

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Lighting the way towards environmental goals

<p>Washington state: 70% less building energy use by 2030</p> <ul style="list-style-type: none"> • Zero-carbon buildings • Gov says move faster 	<p>Washington state: 45% reduction in GHG emissions by 2030</p> <ul style="list-style-type: none"> • 95% reduction by 2050 	<p>Seattle: Carbon-neutral building & vehicle operations by 2050</p> <ul style="list-style-type: none"> • ...or sooner with Green New Deal?
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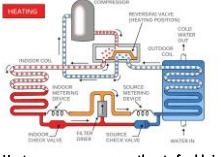
6

Seattle & WA: Heat pump space heating

No electric resistance or fossil fuel combustion for space heating

Exceptions allow electric resistance heat for:

1. "Passive House" rule: Max 2.5 W/sf total installed heating
2. Dwelling & sleeping units: Max **750 W** per habitable room
 - **1000 W** for corner room
 - 250 W for room at exterior wall, but no window
3. Buildings smaller than 2,500 sf
4. Heat pump defrost



Heat pumps squeeze warmth out of cold air


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Heat Pump Water Heating It's not just Seattle anymore

2021 WA code adopts 2018 Seattle HPWH rules (mostly)

- Commercial *and* multifamily
- Central systems *and* unitary equipment
- Primary SWH system must be heat pump, air source or ground source.
 - WA allows gas or resistance for supplemental heating
 - Seattle allows minor electric resistance
- Exceptions? next slide



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Lighting controls: summary

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
- 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



San Francisco Public Utilities Commission Headquarters
RWD

Networked Lighting Controls Fundamentals:
<https://youtu.be/Y3logh4sTY>

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Why use lighting controls?

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



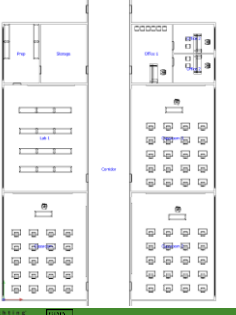
DCO Energy Quality Connectivity
Evaluating the Non-Energy Benefits of Advanced Networked Lighting Controls
January 2023
https://www.dco.org
www.dco.org

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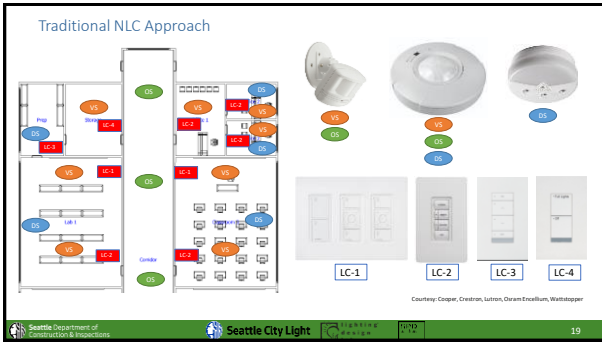
Typical School Spaces

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



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Sequence of Operations - Matrix

Typical School Example

Room Number	Room Name	Room Type	Lighting Type	Control Type	Control Location	Control Type	Control Location	Control Type	Control Location	Control Type	Control Location	Control Type	Control Location	Control Type	Control Location	Control Type	Control Location
1	1	Classroom	Teacher	30	1,2												
1	2	Classroom	High Chair	1													
1	3	Classroom	Teacher	30	1,2												
1	4	Classroom	High Chair	1													
2	5	Classroom	Teacher	30	1,2												
2	6	Classroom	High Chair	1													
4	7	Lab Classroom	Teacher	30	1,2												
4	8	Lab Classroom	High Chair	1													
5	9	Play Room	Teacher	30	1,2												
5	10	Play Room	Storage	10	1,2												
7	11	Office Assistant	Teacher	30	1,2												
8	12	Private Office	Teacher	30	1,2												
8	13	Private Office	Teacher	30	1,2												
10	14	Corridor	Surface Linear	10													

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“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 general lighting is off
 - ON during power failure

Footer: Seattle Department of Construction & Inspections, Seattle City Light, 21

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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

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Courtesy: Wattstapper, Excellium, Lutron

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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

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Exterior Lighting Controls

Consider wireless controls

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

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Georgia Power is using DALI

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

Location: Multiple outdoor locations, South-East USA

DALI Member: Telexius

Georgia Power, a US-based utility, has implemented wireless controls on nearly 200,000 LED street lights since 2016, in a project which is already one of the world's largest deployments of connected street lighting. Within the next 5 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 Telexius lighting control system. Georgia Power's team remains excited with the role played by DALI during the DALI seminar at Lightfair International in May 2020 - see [Georgia Power uses DALI for smart-connected LED streetlights control](#).

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

Telexius 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, IL | RENAISSANCE SCHAUMBURG 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) about 6% overall
 - Some smaller room types get larger LPA
 - From ASHRAE 90.1 - 2022
- Seattle: Interior LPAs **10% below WA**
 - Was 10% below WA in 2018 code also




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Table footnotes: extra lighting allowances

- (h) **Classroom:** 4.5 W/lin. ft. of white board
- (i) **Banking area, lounge, breakroom, stairwell, restroom, library reading room, religious:** 0.15 W/sf for "ornamental lighting"
 - "...Qualifying ornamental lighting includes luminaires that are specifically used in a decorative manner."
- (k) **Corridor:** 0.25 W/sf for display and decorative lighting (Seattle)


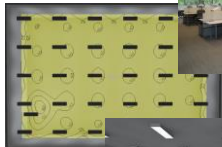
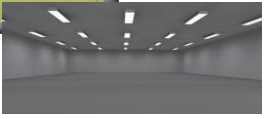


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Office Example - Troffer

- Allowed LPD **0.51 w/sf**
- Actual LPD: 0.40 w/sf
- Target Light Level: 25fc
- Estimated: ~ 34 fc
- Controls:
 - Vacancy Sensing
 - Daylight Harvesting
 - Manual Dimming / Preset
 - **Task Tuning**


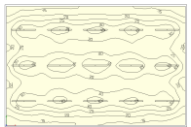





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Office Example - Indirect

- Allowed LPD **0.51 w/sf**
- Actual LPD: 0.36 w/sf
- Target Light Level: 25fc
- Estimated: ~ 29 fc
- Controls:
 - Vacancy Sensing
 - Daylight Harvesting
 - Manual Dimming / Preset
 - **Task Tuning**

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Classroom Troffer

- Allowed LPD 0.65 w/sf
- 4.5 w / LF whiteboard*

- Area: 1008 SF
- Allowed: 655w
- Whiteboard allowance: 0 w
- Allowance: 655 w

- General Area Lighting: 612 w
- Whiteboard Lighting: 0 w
- Proposed: 612 w
- Proposed: 0.61 w/sf



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

Controls:
Vacancy Sensing
Scene Control
Daylight Harvesting

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Classroom Troffer

- Allowed LPD 0.65 w/sf
- 4.5 w / LF whiteboard*

- Allowed: 655w
- Whiteboard allowance: 198w
- Aggregate Allowance: 853 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



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 0.65 w/sf
- 4.5 w / LF whiteboard*

- Allowed: 655w
- Whiteboard allowance: 198w
- Aggregate Allowance: 853 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



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

Controls:
Vacancy Sensing
Scene Control
Daylight Harvesting

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Corridor

- Allowed LPD 0.4 w/sf
- 0.25 w / sf for display and decorative*

- Allowed: 656 w
- Display allowance: 0 w
- Aggregate Allowance: 656 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



Target: 10-15 fc
Calculated: 14 fc

Controls:
Occupancy Sensing
Time of Day
Task Tuning

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Corridor w/display

- Allowed LPD 0.4 w/sf
- 0.25 w / sf for display and decorative*

- Allowed: 656 w
- Display allowance: 160 w
- Aggregate Allowance: 816 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



Target: 10-15 fc
Calculated: 18 fc

Controls:
Occupancy Sensing
Time of Day
Task Tuning
Manual Dimming

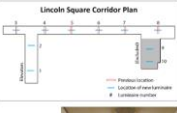

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Corridors – with Controls

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

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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.

Annual Energy Estimates for 48 Luminaires Before and After Retrofit

Scenario	Annual Energy (kWh)
Pre-retrofit, no sensor	15,715
LLLC with bi-level, 5 min. delay	14,219
LLLC luminaires, no sensor	4,291

77% savings (average)

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

Delay Time	High Output (%)	Low Output (%)
5-minute Delay	72%	28%
10-minute Delay	29%	71%
15-minute Delay	51%	49%

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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](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/](https://www.ies.org/standards/committee-reports/ies-committee-report-cr-2-20-faqs/)

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Indoor horticulture

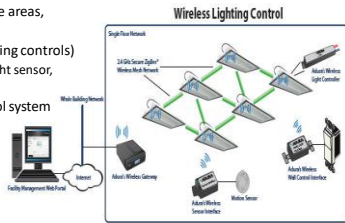
- 1.70 micromoles per joule greenhouse
- 1.90 micromoles per joule warehouse
- "Lumens are for humans"

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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



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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



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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 \$20-\$50 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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LLCC Replacement vs Redesign Study

- 1000 sf office test bed at UO
- 1 for 1 replacement with LLCC
- Redesign with NLC



September 3, 2020
REPORT #E20-016

Luminaires Level Lighting Controls Replacement vs Redesign Comparison Study

Prepared For: NEEA
Chris Wegman, Sr. Product Manager

Prepared by:
Alan Knapik
Jeff Hise
Dale Hoffquist
Adam Van Cael, PhD Candidate
University of Oregon Energy Studies in Building Laboratory
100A White Stag Building
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Eugene, OR 97403
954-753-1234
info@neea.org

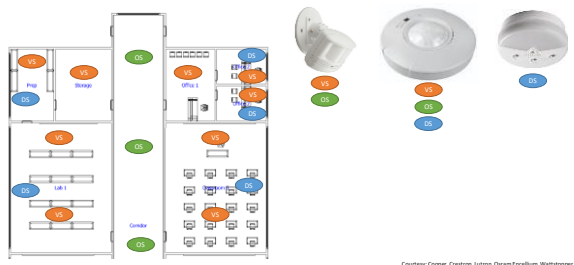
- Key Findings:
- Replacement: 50-74% energy savings
- Redesign: 59% energy savings
- Replacement was 1/3 to 1/2 the cost

• <https://neea.org/resources/llcc-replacement-vs-redesign-comparison-study>

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Traditional NLC Approach

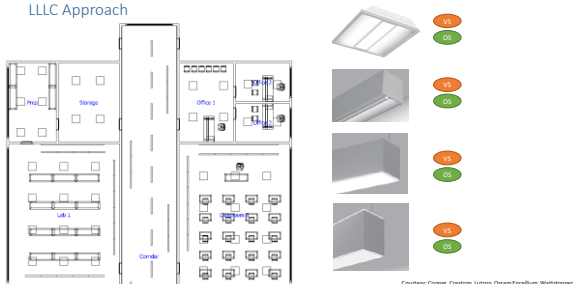


Courtesy: Cooper, Crestron, Lutron, Osram Excellence, Westlapper

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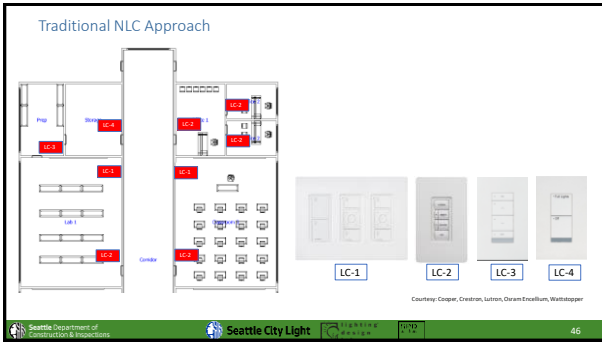
LLCC Approach



Courtesy: Cooper, Crestron, Lutron, Osram Excellence, Westlapper

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Sequence of Operations - Matrix

Typical School Example

Room Number	Room Name	Room Type	Room Size	Room Type Code	Room Code	Room Name	Room Code	Room Name	Room Code	Room Name	Room Code	Room Name	Room Code	Room Name	Room Code	Room Name	Room Code	Room Name	Room Code
1	Classroom	Classroom	30	1.2	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1
2	Classroom	Classroom	30	1.2	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1
3	Classroom	Classroom	30	1.2	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1	Classroom	1
4	Lab Classroom	Lab Classroom	30	1.2	1	Lab Classroom	1	Lab Classroom	1	Lab Classroom	1	Lab Classroom	1	Lab Classroom	1	Lab Classroom	1	Lab Classroom	1
5	Play Room	Play Room	30	1.2	1	Play Room	1	Play Room	1	Play Room	1	Play Room	1	Play Room	1	Play Room	1	Play Room	1
6	Storage	Storage	10	1	1	Storage	1	Storage	1	Storage	1	Storage	1	Storage	1	Storage	1	Storage	1
7	Office Assistant	Office Assistant	30	1	1	Office Assistant	1	Office Assistant	1	Office Assistant	1	Office Assistant	1	Office Assistant	1	Office Assistant	1	Office Assistant	1
8	Private Office	Private Office	30	1	1	Private Office	1	Private Office	1	Private Office	1	Private Office	1	Private Office	1	Private Office	1	Private Office	1
9	Private Office	Private Office	30	1	1	Private Office	1	Private Office	1	Private Office	1	Private Office	1	Private Office	1	Private Office	1	Private Office	1
10	Canteen	Canteen	30	1	1	Canteen	1	Canteen	1	Canteen	1	Canteen	1	Canteen	1	Canteen	1	Canteen	1

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

Click to access the LDL networked lighting control learning guides

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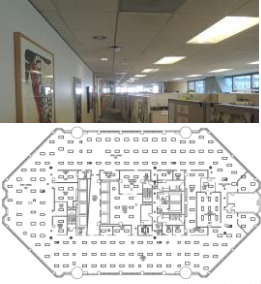
SMT Relight

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

LLLC Options selected in 2019 as the best choice moving forward



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SMT Relight

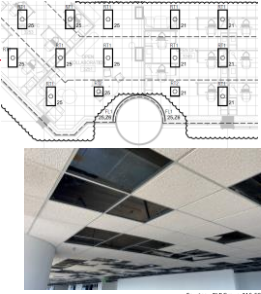
Luminaire Replacement

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

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

Luminaire savings: 43%

Estimated LPD: ~ 0.4 W / SF



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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

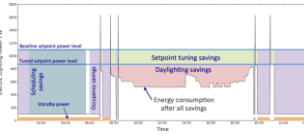
Retrofit:

- 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.....



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C405.2.4 ((Light-reduction-controls)) Dimming controls.
 Dimming controls complying with Section C405.2.4.1 are required for general lighting in the following space types. The space types listed include other spaces with substantially similar uses.

Space Type
Classroom / lecture hall / training room.
Conference / multipurpose / meeting room.
In a dining area for bar/lounge or leisure, family dining.
Laboratory.
Lobby.
Lounge / Break Room.
Offices.
Gymnasium / fitness center.
Library reading room.
In a health care facility for imaging rooms, exam rooms, nurse and nurses' station.
Spaces not provided with occupant sensor controls complying with Section C405.2.1.1.

Dimming controls (Seattle)

Exceptions

- Luminaires controlled by daylight responsive controls complying with Section C405.2.5.
- Luminaires controlled by special application controls complying with Section C405.2.6.

Where provided with manual control, the following areas are not required to have light reduction control:

- Spaces that have only one luminaire with a rated power of less than 60 watts.
- Spaces that use less than 0.45 watts per square foot (4.9 W/m²).
- Corridors, lobbies, electrical rooms and/or mechanical rooms.

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.**

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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 switching.
- It's standard in most luminaires....

Why use lighting controls?

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

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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

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Seattle: Electric-ready new kitchens

C405.14.1 Electric power at gas-fired commercial cooking appliances. Where gas-fired commercial cooking appliances in commercial kitchens are provided in a building permitted under this 2021 edition of the Seattle Energy Code, **an electrical panel** shall be provided within or adjacent to each space in which commercial cooking appliances are located, **sized to serve future electric appliances** to replace all gas-fired appliances in the space with a minimum capacity of 293 VA per kBtu/h of gas appliance input capacity. The main electric service panel for the building shall be wired to and sized to accommodate all such commercial cooking appliance panels. Permit documents shall include a table listing each gas-fired commercial cooking appliance as well as an equivalent electric appliance providing the same or greater cooking capacity, and the total amperage required for the commercial kitchen electrical panel. This information shall be provided in both the mechanical and the electrical permit documents.

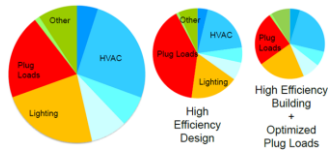
EXCEPTION: This requirement does not apply to gas-fired commercial cooking appliances installed in buildings originally permitted in compliance with an earlier edition of the Seattle Energy Code, if the building's main service panel lacks sufficient capacity to provide power for equivalent electric versions of all the gas-fired commercial cooking appliances identified in the permit application.

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Controlled receptacles C405.10

50% of outlets in:

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



Turn off via:

- Occ sensor
- Timeclock

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

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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....

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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

Courtesy: Leviton, Lutron, Cooper Wauwiler

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New C406 credit system (1 old credit = 6 new credits)

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	(154) 29	(143) 25	(142) 16	(148) 53	(74) 61	(149) 54
Building additions energy efficiency credit requirement	C406.2	(22) 30	(20) 22	(23) 23	(23) 25	(36) 30	(23) 23
New building load management credit requirement	C406.3	12	15	27	15	13	26

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Lighting C406 energy credits

Measure Title	Applicable Section	Group R-1	Group R-2	Group B	Group E	Group M	All Other
8. Fault detection & diagnostics (FDD)	C406.2.2.7	2	2	2	6	9	4
9. 10% reduced lighting power	C406.2.3.1	7	4	18	16	(39) 26	(39) 16
10. 20% reduced lighting power*	C406.2.3.2	13	8	36	32	(52) 22	(49) 32
11. Lamp efficacy improvement	C406.2.3.3	5	6	NA	NA	NA	NA
12. Residential lighting control	C406.2.4.1	NA	8	NA	NA	NA	NA
13. Enhanced lighting control	C406.2.4.2	1	1	6	6	11	(6) 5
14. Renewable energy	C406.2.5	7	12	13	13	10	11

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C406 Renewables: 0.1 W/ ft²

Measure Title	Applicable Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
14. Renewable energy	C406.2.5	7	12	13	13	10	11

Credits can be prorated:

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

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Lighting C406 load management 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	23	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

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Exceeding code requirements

- Classroom Troffer
 - General Area Lighting: 7%
 - With Whiteboard: 31%
 - Classroom Indirect / Direct
 - General Area Lighting: 26%
 - With Whiteboard: 31%
 - School Corridor
 - General Lighting: 58%
 - With Display: 36%
 - Typical Office
 - Indirect: 30%
 - Troffer: 22% (task tune to ~ 30%)
- 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



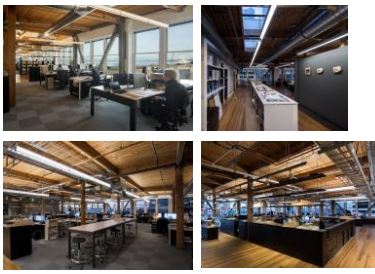
LEVEL 3 REFLECTED CEILING PLAN
Courtesy Miller Hull

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Miller Hull Studios

- Improved lighting
- Lighting Controls
- Happier staff
- LPD: 0.3 W/sf
~60% better than code
- Today ~ 45% better
- Ctrls ~ \$0.50 - \$1.00 / sf




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Small versus large solar for code compliance

- 0.75 watts/ft² code: 75 – 600 panels with central string inverters and a much more competitive cost per watt, which is a better way to recognize financial benefits of solar
- Add more for C406 credits, and cost per watt is even lower




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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 equip
- Solar zone
 - Unshaded, no obstructions
 - 4 psf additional dead load
- 2" roof conduit penetration @ 2,500 sf
- Space for breaker at main panel




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Structural considerations for solar

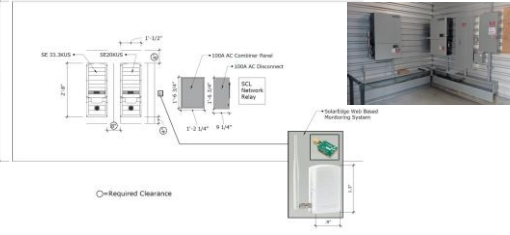
- Taller buildings or high wind areas can require supplemental attachments for typical ballasted systems, which increases roofer coordination costs
- 6-10 psf is a more typical ballasted requirement, but a fully attached system can see a distributed weight as low as 3psf, so there are always options



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Electrical gear space requirements for solar



Required Clearance

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Renewable energy

- ~~0.50~~ **0.75** W/sf of conditioned floor area
- Option: More efficiency credits
- Affordable housing **exempted**
- Option: Gift to affordable housing

Building Stories	Roof Area Required
4	21.6%
10	54.3%
18	98.0%

(Renewable Energy Investment Fund?)




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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



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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



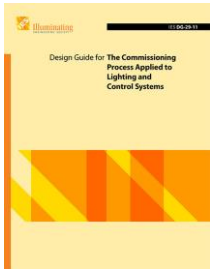
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Commissioning

- 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

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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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Sequence of Operations

There are lots of ways that SOO information may be conveyed.

- Basic Matrix
- Narrative
- Detailed Matrix
- Panel Schedule
- Dimming Schedule
- Most manufacturers have their own system

J. Typical private office

- All general lighting will be programmed to automatically turn "ON" as the user enters the room through the Occupancy Sensor initial light level will be 50% of light output.
- Four button switch with off and raise/lower function override switch located at door will override current light setting as long as the override light level isn't above the set point for the daylight sensor during daytime hours.
 - Pressing Button 1 will turn all fixtures to 50% light output.
 - Pressing Button 2 will turn all fixtures to 70% light output.
 - Pressing Button 3 will turn all fixtures to 90% light output.
 - Pressing Button 4 will turn all fixtures to 100% light output.
 - Pressing Button 5 will turn all lighting fixtures "OFF".
- Photo sensor will continuously dim the light fixture up/down depending on the amount of daylight present. Daylight sensor to be calibrated to provide an average of (+/-) 50 footcandles measured at work surface (30" above finished floor).
- When the user leaves the room, the lights will automatically turn "OFF" after a 15 minute delay (from unoccupied signal).

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Sequence of Operations

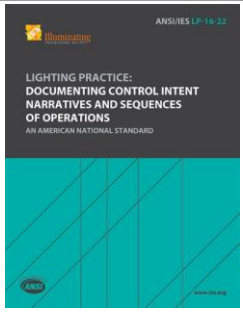
Project X Sequence of Operations Matrix													
Room Number	Room Name	Room Type / Use	Lighting Type	Target Light Level	GLB	Mount Height	Mount Depth	Mount Spacing	Power Source	Control System	Occupancy Sensor	Occupancy Threshold	Occupancy Time Out
1	01	Conference Room	Linear Indirect - Direct	30	1								10
	02		Track - Direct Down	300									
	03		Track - Wall Wash	300									
2	04	Janitor	Incandescent	20									10
3	05	Private Office	Recessed Troffer	30	1								10
	06		AV Mount	300		2							
	07		Indirect Direct - Downlight	30									10
4	08-13	Open Office	Indirect - Overhead	30	1								10
	08-14		Overhead	30									100%

Sequence of Operations

Project X Sequence of Operations Street Notes - Traditional NLC			
Typical Notes			
1	Street Light Pole	Street Light Pole	Street Light Pole
2	Street Light Pole	Street Light Pole	Street Light Pole
3	Street Light Pole	Street Light Pole	Street Light Pole
4	Street Light Pole	Street Light Pole	Street Light Pole
5	Street Light Pole	Street Light Pole	Street Light Pole
6	Street Light Pole	Street Light Pole	Street Light Pole
Specific Notes			
1	Street Light Pole	Street Light Pole	Street Light Pole
2	Street Light Pole	Street Light Pole	Street Light Pole
3	Street Light Pole	Street Light Pole	Street Light Pole
4	Street Light Pole	Street Light Pole	Street Light Pole
5	Street Light Pole	Street Light Pole	Street Light Pole
6	Street Light Pole	Street Light Pole	Street Light Pole

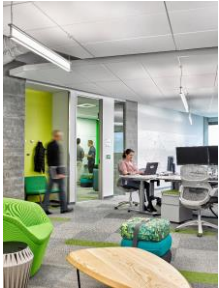
Sequence of Operations

- IES is trying to standardize the documentation of Sequence of Operations



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 Gender

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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

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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!





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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



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Retrofits?

Luminaires

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

Controls

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



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SMT Relight

LLLC Luminaire replacement

- 1 for 1 in most cases
- Existing power wiring reused
- Wireless controls
- No controls wiring to luminaires
- Programming and commissioning through smart device apps

The potential labor savings in meeting code is very significant



Courtesy: OLF Group, IAS, SCL, LLC | Seattle Department of Construction & Inspections | Seattle City Light | 84


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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
 - *or just the lamps and ballasts in existing fixtures



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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 (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



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Controlled Receptacles c503.7.7




- 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

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Controlled Receptacles c503.7.7




- 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

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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

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3 Ways SCL Can Save You \$\$ on Your Project




- Discounts**
Instant savings (\$/lamp or \$/fixture or \$/HVAC equipment) at sale from qualified distributors (midstream)
[Lighting](#): Purchase lamps and fixtures from [distributors](#)
[HVAC/water heating](#): Heat pumps < 5.4 tons, heat pump water heaters < 120 gallons, chillers, etc. from [distributors](#)
- Rebates**
\$/equipment returned to customer after sale (midstream)
[Connected thermostats](#), advanced rooftop controls, comm kitchen equipment, demand control ventilation (DCV)
Apply using [online form](#) (no pre-approval)
- Incentives**
Calculated \$/kWh energy savings (downstream)
[Commercial retrofit/new construction](#) (\$/kWh savings)

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3 Types of SCL Incentive Programs (retrofit)




1. Lighting



LED fixtures, controls

2. HVAC



Chiller plant upgrades, VFD on AHU fans, controls

3. Whole Building




Retro-commissioning (EBCx, MBCx), Pay for Performance (P4P), Energy Efficiency as a Service (EEaS)


Light
91

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2023 Lighting Incentives




New/retrofit fixtures*



\$0.15/kWh saved - outdoor, indoor, high-bay, display case, integrated retrofit kits, downlights

Networked Lighting Controls (NLC)*




\$75/fixture bonus + \$0.15/kWh fixture/controls savings

* Must be listed on **DLC** QPL to qualify


Light
92

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HVAC



Chiller plant upgrades, VSD on AHU, BAS controls



\$0.27/kWh saved (chiller plant upgrade)
\$300/HP (VFD on AHU fan)

SEATTLE CITY LIGHT 2022 ENERGY CONSERVATION INCENTIVES (Effective January 1, 2022)	COMMERCIAL, INDUSTRIAL, AND MULTIFAMILY RETROFIT PROJECTS
DESCRIPTION OF PROJECT	INCENTIVE VALUE
Chiller plant upgrades	\$0.27/kWh saved
VSD on AHU fans	\$300/HP
BAS controls	\$500/RTU

Advanced Rooftop Controls (ARC)

Gas or electric (rebate)
\$500/RTU single phase to \$4500/ton > 20 ton

SEATTLE CITY LIGHT 2022 ENERGY CONSERVATION INCENTIVES (Effective January 1, 2022)	COMMERCIAL, INDUSTRIAL, AND MULTIFAMILY RETROFIT PROJECTS
DESCRIPTION OF PROJECT	INCENTIVE VALUE
Advanced Rooftop Controls (ARC)	\$500/RTU single phase to \$4500/ton > 20 ton

Light
93

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Whole Building

Seattle City Light

Existing Building Commissioning (EBCx)/ Monitoring Building Commissioning (MBCx)

- 50,000 sf or more of conditioned space
- >75% of the space is occupied year round
- Equipped with a Direct Digital Control (DDC)

Typical energy savings of 7-20%

- Payback period 2 years or less
- Meet Seattle Tune-Up Ordinance (req.)

Pay for Performance (P4P)

- 50,000 sf or more of conditioned space
- Interval meter (hourly/15-minute energy use)
- Stable building energy use over the past year

Typical energy savings of 15-20%

- 3 year performance period (\$0.08/kWh)
- 5 year performance period (\$0.18/kWh)
- Meet Seattle Tune-Up Ordinance (req.)

Light 94

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New Construction Incentives

Seattle City Light

Multifamily/Commercial/Industrial

- MF – generally deemed measures (\$/unit)
- Whole building funding (Total Building Performance C407 2018 Seattle Energy Code)
- No lighting incentives (projects received > Jan 1, 2022)

SEATTLE CITY LIGHT 2022 ENERGY CONSERVATION INCENTIVES (Project classes under MULTIFAMILY, COMMERCIAL, AND INDUSTRIAL NEW CONSTRUCTION PROJECTS)

MEASURE CATEGORY	MEASURE	MEASURE DESCRIPTION	MEASURE UNIT	MEASURE COST	MEASURE PAYBACK PERIOD	MEASURE ELIGIBILITY
MULTIFAMILY RESIDENTIAL	Energy Efficient Windows	Energy Efficient Windows (EEW)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Doors	Energy Efficient Doors (EED)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Roofs	Energy Efficient Roofs (EER)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Siding	Energy Efficient Siding (EES)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Insulation	Energy Efficient Insulation (EEI)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient HVAC	Energy Efficient HVAC (EEHVAC)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Water Heating	Energy Efficient Water Heating (EEWH)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Lighting	Energy Efficient Lighting (EEL)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Appliances	Energy Efficient Appliances (EEA)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Landscaping	Energy Efficient Landscaping (EELAND)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
COMMERCIAL AND INDUSTRIAL	Energy Efficient Windows	Energy Efficient Windows (EEW)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Doors	Energy Efficient Doors (EED)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Roofs	Energy Efficient Roofs (EER)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Siding	Energy Efficient Siding (EES)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Insulation	Energy Efficient Insulation (EEI)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient HVAC	Energy Efficient HVAC (EEHVAC)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Water Heating	Energy Efficient Water Heating (EEWH)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Lighting	Energy Efficient Lighting (EEL)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Appliances	Energy Efficient Appliances (EEA)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.
	Energy Efficient Landscaping	Energy Efficient Landscaping (EELAND)	Sq. Ft.	\$100	1-2 years	Must be new construction or major renovation project.

Light 95

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I already forgot everything you said – where do I start?

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Energy Efficiency Program Tools and Resources one-stop shopping:

Seattle

Energy Efficiency Program Tools and Resources

Whether you are a business, contractor, consultant, or individual, find out what incentives and programs are available to help you save energy and reduce your carbon footprint. You can also find out what programs are available to help you save energy and reduce your carbon footprint.

- Incentive Programs
- Loan Guarantees
- Program Overview and Details
- **Energy and Resource Links**
- **Qualification and Pre-qualification Forms**
- Energy Assessment
- Other Resources

If all else fails: Contact the Energy Advisors

206-684-3800

Light 96

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 liteshaun@gmail.com

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Upcoming Lighting Design Lab Events

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

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 ▶ Duane.Jonlin@seattle.gov
- ▶ Shaun Darragh LC, MIES
 ▶ liteshaun@gmail.com

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Today's slide deck will be posted here!

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We'll *SEE* you on the next call... ☺

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