



**CALIFORNIA
ENERGY**
CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Nonresidential Lighting (1 of 2)

Nonresidential Lighting Alterations

March 22, 2017

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Agenda

1. Background
2. Proposed Code Changes
3. Preliminary Results of 2019 Title 24, Part 6 Lighting Alteration Analysis
4. Overview of Methodology
5. Next Steps

1. Background

Existing Title 24, Part 6 Definition of “Space” (§ 100.1)

ENCLOSED SPACE is space that is substantially surrounded by solid surfaces, including walls, ceilings or roofs, doors, fenestration areas, and floors or ground.

- “Space” = “Enclosed Space” = Room
- No changes proposed



2016 Title 24, Part 6 Lighting Alterations: Scope (§ 141.0(b)2 I&J)

Triggers for Entire Luminaire Alterations	Triggers for Luminaire Component Modifications
<p>For each enclosed space:</p> <ul style="list-style-type: none">• Removing and reinstalling (same luminaires) $\geq 10\%$ of existing luminaires; OR• Replacing 3+ luminaires as entire luminaires (one-for-one luminaire replacement); OR• Adding entire luminaire(s); OR• Adding, removing, or replacing walls or ceilings along with any redesign of the lighting system.	<ul style="list-style-type: none">• Component modifications in place (replacing ballasts or drivers and the associated lamps, permanently changing the light source, or the optical system); AND• ≥ 70 existing luminaires per floor per tenant per year are modified. <p>Note: lamp replacements alone and ballast replacements alone are not a modification if installed and powered w/o modifying the luminaire.</p>

2016 Title 24, Part 6 Lighting Alterations: Compliance Options for Entire Luminaire and Component Modification

Compliance Option	Control Requirements
Option 1 85-100% of LPD allowance	<ul style="list-style-type: none"> • Manual area controls • Manual multi-level lighting controls (≥ 100 sf/enclosed space and lighting load > 0.5 W/sf) • Auto shut-off controls • Auto daylighting controls • Demand responsive controls ($> 10,000$ sf/single building AND ONLY when the alteration also changes the area of the space, changes the occupancy type of the space, or increases the lighting power)
Option 2 $\leq 85\%$ of LPD allowance	<ul style="list-style-type: none"> • Manual area controls • Manual multi-level lighting controls OR two level lighting control for each enclosed space (≥ 100 sf/enclosed space and lighting load > 0.5 W/sf) • Auto shut-off controls
Option 3 35/50% wattage reduction <ul style="list-style-type: none"> • 50% for office, retail, and hotel • 35% for all other 	<ul style="list-style-type: none"> • Manual area controls • Auto shut-off controls (except 130.1(c)1D, separate shut-off controls for display/ornamental; 130.1(c)6B, full or partial off occupancy sensing in library stacks; 130.1(c)6C, full or partial off occupancy sensing in corridors and stairwells; 130.1(c)7A, partial off occupancy sensing in corridors and stairwells in hotels; 130.1(c)8, guest room card key/occupancy sensing)

Scope of 2019 Title 24, Part 6 Lighting Alteration Analysis

- Provide a tool to California Energy Commission to evaluate code change proposals related to lighting alterations from stakeholders, by comparing energy use and savings for three prescriptive pathways to comply with Title 24, Part 6, Section 149 nonresidential lighting alteration code; and
- Using the tool, quantify the effect of lower 2019 Lighting Power Densities (LPDs) levels and proposed indoor control measures on energy savings from nonresidential lighting alterations.



2. Proposed Code Changes

Proposed Code “Cleanup” Changes

At this time, the Statewide CASE Team proposes the following “code cleanup” changes:

- Restate the existing requirements more clearly, by organizing key information in two tables;
- Clarify that entire luminaire or component modification retrofit projects that increase lighting power have to meet all Lighting Power Density (LPD) and control requirements;
- Modify the exception for entire luminaire alterations from two or fewer luminaires in an enclosed space to one luminaire in an enclosed space; and
- Remove the exception for luminaire component modifications for two or fewer luminaires in an enclosed space (while keeping the <70 luminaires per floor per tenant per year exception).

Proposed Concepts for Code Change

The Statewide CASE Team would like to hear stakeholder feedback on the idea of:

- Requiring Option 3 to be applied to the entire enclosed space to reduce the ability for partial retrofits in an enclosed space; and
- Requiring partial OFF occupant sensing controls in stairwells under Option 3 (while keeping the exception for the requirement to have partial OFF occupant sensing controls in corridors).



Proposed Code Language for Entire Luminaire Alterations (§ 141.0(b)2 I)

I. Entire Luminaire Alterations. Alterations that do not increase lighting power in a space shall meet the applicable requirements in Table 141.0-E according to the criteria in Table 141.0-D. Any alteration that increases lighting power in an enclosed space shall meet the requirements of Sections 110.9, 130.0, 130.1, 130.4, and 140.6.

EXCEPTION 1 to Section 141.0(b)2I. Alteration of portable luminaires, luminaires affixed to moveable partitions, or lighting excluded as specified in Section 140.6(a)3.

EXCEPTION 2 to Section 141.0(b)2I. In an enclosed space where one luminaire is replaced or reinstalled and is not increasing connected lighting power.

EXCEPTION 3 to Section 141.0(b)2I. In an enclosed space where less than 10 percent of existing luminaires are removed and reinstalled.

EXCEPTION 4 to Section 141.0(b)2I. Alterations not increasing connected lighting power that would directly cause the disturbance of asbestos, unless the alterations are made in conjunction with asbestos abatement.

EXCEPTION 5 to Section 141.0(b)2I. Acceptance testing requirements of Section 130.4 are not required for alterations where lighting controls are added to control 20 or fewer luminaires.

Proposed Code Language for Luminaire Component Modifications (§ 141.0(b)2 J)

J. Luminaire Component Modifications. Luminaire component modifications in place without increasing the lighting power of the space shall meet the applicable requirements in Table 141.0-E according to the criteria in Table 141.0-D. Luminaire component modifications shall not prevent or disable the operation of any multi-level, shut-off, or daylighting controls. Any luminaire component modification that increases lighting power in an enclosed space shall meet the requirements of Sections 110.9, 130.0, 130.1, 130.4, and 140.6.

EXCEPTION 1 to Section 141.0(b)2J. Modification of portable luminaires, luminaires affixed to moveable partitions, or lighting excluded by Section 140.6(a)3.

EXCEPTION 2 to Section 141.0(b)2J. Modifications not increasing connected lighting power that would directly cause the disturbance of asbestos, unless the modifications are made in conjunction with asbestos abatement.

EXCEPTION 3 to Section 141.0(b)2J. Modifications not increasing lighting power where less than 70 existing luminaires are modified either on any single floor of a building or, where multiple tenants inhabit the same floor, in any single tenant space, in any single year.

EXCEPTION 4 to Section 141.0(b)2J. Acceptance testing requirements of Section 130.4 are not required for modifications where lighting controls are added to control 20 or fewer luminaires.

Proposed Code Language, *cont'd* (§ 141.0(b)2 I&J)

TABLE 141.0-D CRITERIA FOR ENTIRE LUMINAIRE ALTERATION AND LUMINAIRE COMPONENT MODIFICATION REQUIREMENTS

Entire Luminaire Alterations	Luminaire Component Modifications
<p>For each enclosed space:</p> <p>Use Option 1, 2, or 3 in Table 141.0-E to comply IF:</p> <p>A. Replacing luminaires as entire luminaires (one-for-one luminaire replacement) without adding, removing, or replacing walls or ceilings.</p> <p>For each enclosed space:</p> <p>Use Option 1 or 2 in Table 141.0-E to comply IF:</p> <p>B. Adding entire luminaire(s); OR</p> <p>C. Replacing luminaires; OR</p> <p>D. Removing and reinstalling existing luminaires.</p>	<p>Use Option 1, 2, or 3 in Table 141.0-E to comply IF</p> <ul style="list-style-type: none"> • Replacing ballasts or drivers AND the associated lamps, permanently changing the light source, or the optical system. <p>NOTE: Lamp replacements alone and ballast replacements alone shall not be considered a modification of the luminaire provided that the replacement lamps or ballasts are installed and powered without modifying the luminaire.</p>

Proposed Code Language, *cont'd* (§ 141.0(b)2 I&J)

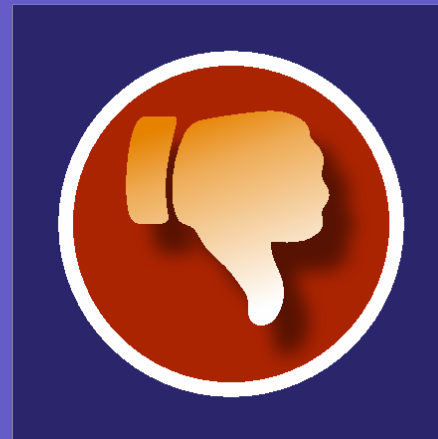
TABLE 141.0-E REQUIREMENTS FOR ENTIRE LUMINAIRE ALTERATIONS AND LUMINAIRE COMPONENT MODIFICATIONS (table continues on the next slide)

Requirements that shall be met for Entire Luminaire Alterations and Luminaire Component Modifications for each enclosed space	Option 1	Option 2	Option 3 (Not available for Entire Luminaire Alterations Criteria B, C, or D)
Resulting lighting power density (LPD), compared to the lighting power allowance specified in Section 140.6(c)2, Area Category Method	> 85 to 100% of LPD allowance	≤ 85% of LPD allowance	Not Applicable
Total lighting wattage in enclosed space after luminaire alteration or modification as compared to existing lighting wattage	Not Applicable	Not Applicable	Existing wattage of all lighting in enclosed space reduced by 50% from full light output for hotel, office, retail occupancy, and reduced by 35% from full light output for all other occupancies

Proposed Code Language, *cont'd* (§ 141.0(b)2 I&J)

Requirements that shall be met for Entire Luminaire Alterations and Luminaire Component Modifications for each enclosed space	Option 1	Option 2	Option 3 (Not available for Entire Luminaire Alterations Criteria B, C or D)
Section 130.1(a)1, 2, and 3 Area Controls	Yes	Yes	Yes
Section 130.1(b) Multi-Level Lighting Controls only for alterations to general lighting of enclosed spaces 100 square feet or larger with a connected lighting load that exceeds 0.5 watts per square foot	Yes	Yes OR bi-level with a minimum one step between 30-70 percent of lighting power regardless of luminaire type	No
Section 130.1(c) Shut-Off Controls	Yes	Yes	Yes EXCEPT for 130.1(c)1D, 130.1(c) 6B, 130.1(c) 6C, 130.1(c) 7A, 130.1(c) 8
Section 130.1(d) Automatic Daylight Controls	Yes	Not Required	Not Required
Section 130.1(e) Demand Responsive Controls only for lighting alterations greater than 10,000 ft ² in a single building, where the alteration also changes the area of the space, or changes the occupancy type of the space, or increases the lighting power	Yes	Not Required	Not Required

What about the proposed code changes?



3. Preliminary Results of 2019 Title 24, Part 6 Lighting Alteration Analysis

Calculated 2019 Standards Per-Unit Energy Use Values (DRAFT)

2019 STANDARDS Per-Unit Energy Use

Weights by Building Type Stock % of Considered Stock	Building Type	OPTION 1 85-100% of 2019 LPD allowance kWh/sf per year	OPTION 2 ≤85% of 2019 LPD allowance kWh/sf per year	OPTION 3 Weighted 35/50% wattage reduction kWh/sf per year
7%	Hotel (excl. rooms)	2.6	2.3	2.1
26%	Office Large	1.7	1.5	1.3
7%	Office Small	1.6	1.5	1.3
4%	Restaurant	2.8	2.6	3.6
24%	Retail	2.7	2.3	2.6
11%	School	2.1	1.9	2.0
21%	Warehouse Non-Refrigerated	0.84	0.98	0.99
	Weighted AVERAGE			
100%	(by Building Type Stock)	1.89	1.74	1.75

Note: The numbers are preliminary and may change as the model is refined.

Calculated 2019 Standards Per-Unit Energy Use Values for Option 3 (DRAFT)

2019 STANDARDS Per-Unit Energy Use

Building Type	OPTION 3					
	Weighted 35/50% wattage reduction	2001	2005	2008	2013	2016
	kWh/sf per year	Title 24, Part 6	Title 24, Part 6	Title 24, Part 6	Title 24, Part 6	Title 24, Part 6
Hotel (excl. rooms)	2.1	2.5	2.1	2.1	2.1	1.9
Office Large	1.3	1.5	1.4	1.2	1.1	1.0
Office Small	1.3	1.5	1.4	1.2	1.1	1.1
Restaurant	3.6	3.7	3.6	3.6	3.6	3.0
Retail	2.6	3.2	2.8	2.6	2.0	2.0
School	2.0	2.5	2.1	2.0	2.0	1.9
Warehouse Non-Refrigerated	0.99	1.0	1.0	0.98	0.96	0.96
Weighted AVERAGE (by Building Type Stock)	1.75	2.06	1.85	1.72	1.54	1.49
Weights by Code Vintage		0%	45%	40%	15%	0%
	100%					

Note: The numbers are preliminary and may change as the model is refined.

4. Overview of the Methodology (to calculate per-unit energy use values)

Calculating Per-Unit Energy Use Values

$$\text{Per-Unit Energy Use [kWh/sf per year]} = \text{LPD [W/sf]} \times \text{Annual FLE Hours [hr]} \times 1/1,000 \text{ [kW/W]}$$

	OPTION 1 85-100% of LPD allowance	OPTION 2 ≤ 85% of LPD allowance	OPTION 3 35/50% wattage reduction
Granularity Level	Calculations are made at the space type level within considered buildings (using DEER2016 building prototypes)		
LPD	100% of 2019 LPD allowance	85% of 2019 LPD allowance	65% or 50% of vintage LPD allowance (2001, 2005, 2008, 2013, and 2016 Title 24, Part 6)
Annual Full Load Equivalent (FLE) Hours	<ul style="list-style-type: none"> Mandatory occupancy controls Automatic daylighting controls <p>Note that savings from demand responsive controls are ignored</p>	<ul style="list-style-type: none"> Mandatory occupancy controls 	<ul style="list-style-type: none"> Mandatory occupancy controls (not applied in corridors and stairwells)

Baseline lighting schedules from DEER2014

Assume DEER2014 baseline lighting schedules incorporate energy savings from area controls, manual multi-level / bi-level controls and automatic time-switch controls



Calculating Annual FLE Hours

For each function area, Annual FLE Hours are calculated as follows:

$$\begin{aligned} \text{Annual FLE Hours [hr]} = & \\ & 251 \times \left(\sum_{i=1}^{24} \text{Baseline Weekday Hour Fraction}_i \text{ [hr]} \times \text{Hour Control Factor}_i \right) + \\ & 104 \times \left(\sum_{i=1}^{24} \text{Baseline Weekend Hour Fraction}_i \text{ [hr]} \times \text{Hour Control Factor}_i \right) + \\ & 10 \times \left(\sum_{i=1}^{24} \text{Baseline Holiday Hour Fraction}_i \text{ [hr]} \times \text{Hour Control Factor}_i \right) \end{aligned}$$

Control Factors for Occupant Sensing Controls

- Based on the values published in an LBNL meta-study on lighting controls (Williams, 2012)
- For Partial OFF occupancy sensor control factor, assume lights are ON at 50% lighting power output when space is unoccupied

Building Type	Occupancy Sensor Control Factor (Full OFF)	Occupancy Sensor Control Factor (Partial OFF)
Hotel	0.93	0.965
Office Large	0.88	0.94
Office Small	0.88	0.94
Restaurant	0.93	0.965
Retail	0.93	0.965
School	0.82	0.91
Warehouse	0.69	0.845
Restrooms in all building types	0.66	0.83

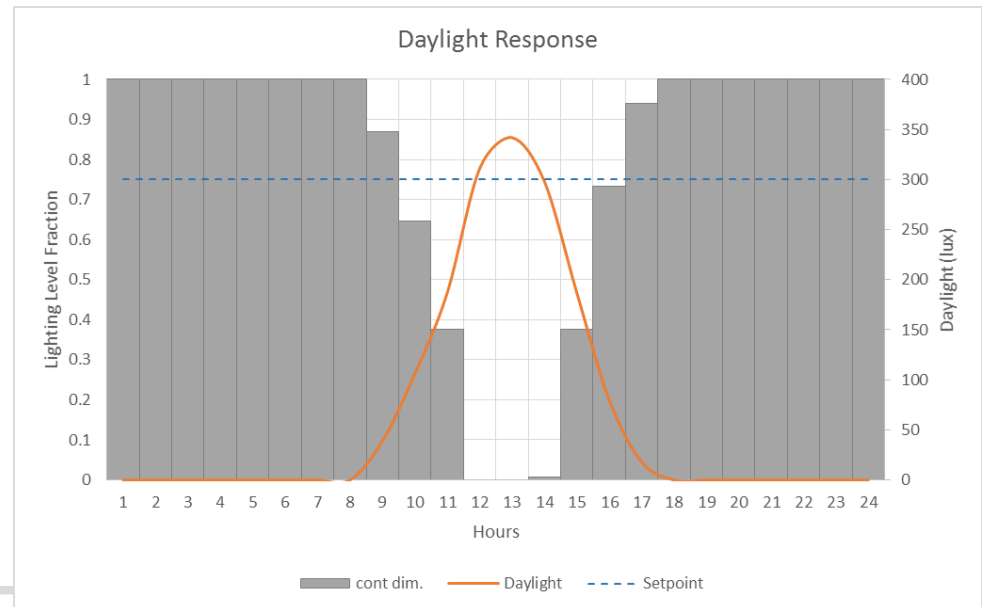
Control Factors for Automatic Daylighting Controls

- Daylighting control factors were developed using Radiance based daylighting simulations and a daylighting template based approach. The approach is described in the PIER Office Daylighting Research Study.¹
- Savings from automatic daylighting controls are discounted by 10 percent based on the findings from an LBNL study, reporting that modeled savings tend to overestimate actual savings from automatic daylighting controls by at least 10 percent (Williams, 2012).

¹ Saxena, M. (Heschong Mahone Group). 2011. Office Daylighting Potential (Publication No. CEC-500-2013-002). Sacramento, CA: California Energy Commission

Control Factors for Automatic Daylighting Controls, *cont'd*

Variable	Value
Lighting Type	LED
Daylighting Setpoint	300 lux
Lighting Control Types	Continuous dim to 10%, or Continuous dim to OFF
Climate Zone	California Climate Zone 2



Per-Unit Energy Use: Office Large / Inputs

INPUTS				OFFICE LARGE					
Title 24, Part 6 Area Category	DEER Activity Area	% of Total Area	2001 LPD, W/sf	2005 LPD, W/sf	2008 LPD, W/sf	2013 LPD, W/sf	2016, LPD W/sf	2019 LPD, W/sf	
Office Area > 250 sf	OfficeOpen	46%	1.3	1.2	0.9	0.75	0.75	0.68	
Office Area ≤ 250 sf	OfficeSmall	20%	1.3	1.2	1.1	1.0	1.0	0.85	
Corridors, Restroom, Stair, and Support Areas	CorridorStairway	13%	0.6	0.6	0.6	0.6	0.6	0.54	
Commercial Storage	StorageSmlCond	5%	0.6	0.6	0.6	0.6	0.6	0.46	
Waiting Area	LobbyWaiting	4%	1.1	1.1	1.1	1.1	0.8	0.72	
Convention, Conference, Multipurpose and Meeting Center Areas	Conference	3%	1.5	1.4	1.4	1.4	1.2	0.93	
Corridors, Restroom, Stair, and Support Areas	Restroom	3%	0.6	0.6	0.6	0.6	0.6	0.54	
Dining Area	Break	2%	1.1	1.1	1.1	1.1	1.0	0.54	
Electrical, Mechanical, Telephone Rooms	MechElecRoom	2%	0.7	0.7	0.7	0.7	0.55	0.39	
Corridors, Restroom, Stair, and Support Areas	CopyRoom	1%	0.6	0.6	0.6	0.6	0.6	0.54	
	TOTAL	100%							

Per-Unit Energy Use: Office Large / 2019 Standards Energy Use for OPTION 1

2019 STANDARDS | OPTION 1: 85-100% of 2019 LPD allowance | kWh/sf per year by AREA CATEGORY

OFFICE LARGE

DEER Activity Area	LIGHTING CONTROLS		2019 LPD, W/sf	Annual FLE Hours, hr	% of Total Area	OUTPUT kWh/sf per year
	Occupancy Controls	Auto Daylighting				
OfficeOpen		Yes (plus OFF)	0.68	2,670	46%	1.80
OfficeSmall	Yes	Yes (plus OFF)	0.85	1,985	20%	1.69
CorridorStairway	Yes (partial)		0.54	2,607	13%	1.41
StorageSmlCond			0.46	2,774	5%	1.28
LobbyWaiting		Yes (plus OFF)	0.72	2,412	4%	1.74
Conference	Yes	Yes (plus OFF)	0.93	2,350	3%	2.19
Restroom	Yes		0.54	1,831	3%	0.99
Break		Yes (plus OFF)	0.54	2,447	2%	1.31
MechElecRoom			0.39	2,774	2%	1.08
CopyRoom			0.54	2,774	1%	1.50
Weighted AVERAGE					100%	1.66

Per-Unit Energy Use : Office Large / 2019 Standards Energy Use for OPTION 2

2019 STANDARDS | OPTION 2: ≤85% of 2019 LPD allowance | kWh/sf per year by AREA CATEGORY

OFFICE LARGE

	LIGHTING CONTROLS		85% of 2019 LPD, W/sf	Annual FLE Hours, hr	% of Total Area	OUTPUT kWh/sf per year
	Occupancy Controls	Auto Daylighting				
DEER Activity Area						
OfficeOpen			0.57	2,774	46%	1.59
OfficeSmall	Yes		0.72	2,441	20%	1.76
CorridorStairway	Yes (partial)		0.46	2,607	13%	1.20
StorageSmlCond			0.39	2,774	5%	1.08
LobbyWaiting			0.61	2,774	4%	1.70
Conference	Yes		0.79	2,441	3%	1.93
Restroom	Yes		0.46	1,831	3%	0.84
Break			0.45	2,774	2%	1.26
MechElecRoom			0.33	2,774	2%	0.92
CopyRoom			0.46	2,774	1%	1.27
Weighted AVERAGE					100%	1.52

Per-Unit Energy Use : Office Large / 2019 Standards Energy Use for OPTION 3

2019 STANDARDS | OPTION 3: 35/50% wattage reduction | kWh/sf per year by AREA CATEGORY

OFFICE LARGE

DEER Activity Area	LIGHTING CONTROLS		50% of 2001	50% of 2005	50% of 2008	50% of 2013	50% of 2016	Annual FLE	% of Total	OUTPUT				
	Occupancy Controls	Auto Daylighting	LPD, W/sf	LPD, W/sf	LPD, W/sf	LPD, W/sf	LPD, W/sf	Hours, hr	Area	2001 kWh/sf per year	2005 kWh/sf per year	2008 kWh/sf per year	2013 kWh/sf per year	2016 kWh/sf per year
OfficeOpen			0.65	0.60	0.45	0.38	0.38	2,774	46%	1.80	1.66	1.25	1.04	1.04
OfficeSmall	Yes		0.65	0.60	0.55	0.50	0.50	2,441	20%	1.59	1.46	1.34	1.22	1.22
CorridorStairway			0.30	0.30	0.30	0.30	0.30	2,774	13%	0.83	0.83	0.83	0.83	0.83
StorageSmlCond			0.30	0.30	0.30	0.30	0.30	2,774	5%	0.83	0.83	0.83	0.83	0.83
LobbyWaiting			0.55	0.55	0.55	0.55	0.40	2,774	4%	1.53	1.53	1.53	1.53	1.11
Conference	Yes		0.75	0.70	0.70	0.70	0.60	2,441	3%	1.83	1.71	1.71	1.71	1.46
Restroom	Yes		0.30	0.30	0.30	0.30	0.30	1,831	3%	0.55	0.55	0.55	0.55	0.55
Break			0.55	0.55	0.55	0.55	0.50	2,774	2%	1.53	1.53	1.53	1.53	1.39
MechElecRoom			0.35	0.35	0.35	0.35	0.28	2,774	2%	0.97	0.97	0.97	0.97	0.76
CopyRoom			0.30	0.30	0.30	0.30	0.30	2,774	1%	0.83	0.83	0.83	0.83	0.83
Weighted AVERAGE									100%	1.50	1.41	1.19	1.07	1.04
Distribution of lighting systems by 2001-2016 Title 24, Part 6 code vintages										0%	45%	40%	15%	0%
Weighted 35/50% wattage reduction														1.27

What about the proposed methodology?



Next Steps

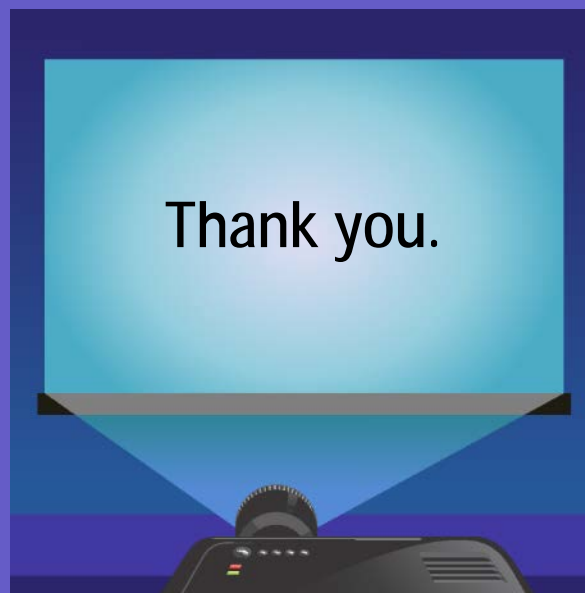


5. Next Steps

Next Steps

- Please send any additional feedback within 2 weeks to:
 - CASE Author (see contact info at end of this presentation)
 - Info@title24stakeholders.com
- Please complete the survey to support 2019 Title 24, Part 6 Alteration Analysis **by April 8, 2017** (open for 45 days since 2/21/2017):
<https://www.surveymonkey.com/r/Title24Part6Alterations>
- Keep an eye on Title24Stakeholders.com for:
 - Presentations from today's meeting
 - Draft Code Change Language and Draft Methodology for a tool to evaluate alteration code change proposals
 - Notes from today's meeting
 - Draft CASE Report (will be posted in April)

Wrap Up



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Appendix:

Second Stakeholder Meeting for Nonresidential Lighting Alterations

March 22, 2017

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References

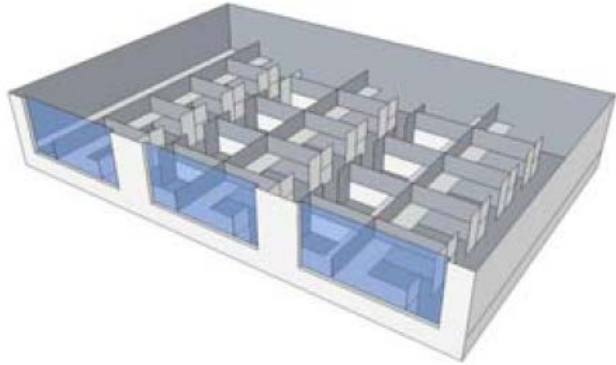
- Title24Stakeholders.com
- EnergyCodeAce.com
 - See [Reference Ace](#) for 2016 Standards, Appendices, and Compliance Manuals
- [California Energy Commission 2019 Standards Webpage](#)
 - Draft Code Language
 - Draft Methodology

Deeper Dive: Control Factors for Automatic Daylighting Controls

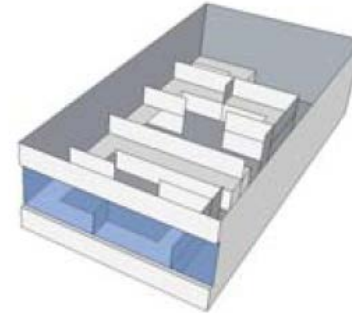
- Developed a method to estimate daylighting savings from prototypical “template spaces” that can be applied to multiple space types ¹
- Used Radiance daylighting simulation program
 - Highly accurate backwards ray-racing method
 - Annual calculations include blinds and shades operation

¹ Saxena, M. (Heschong Mahone Group). 2011. Office Daylighting Potential (Publication No. CEC-500-2013-002). Sacramento, CA: California Energy Commission

Deeper Dive: Control Factors for Automatic Daylighting Controls, *cont'd* Sidelit Template Spaces



- 60ft x 40ft large open space
- 20ft x 40ft small space

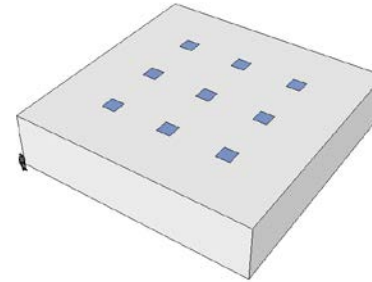
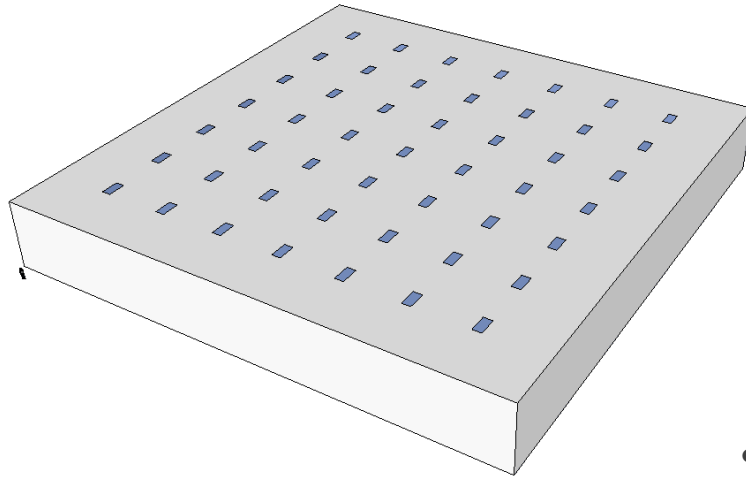


- Orientations: N, S, E, W
- Ceiling Heights: 8', 10'
- Net WWR: 26%, 52%, 96%
- Window VT: 10% - 90% (10% inc)
- Furniture Heights: 30", 60"
- Window blinds, overhangs
- Multiple Climate Zones

17,280 Templates

Deeper Dive: Control Factors for Automatic Daylighting Controls, *cont'd*

Toplit Template Spaces



- 231ft x 231ft Large Space
- 69ft x 69ft Small Space

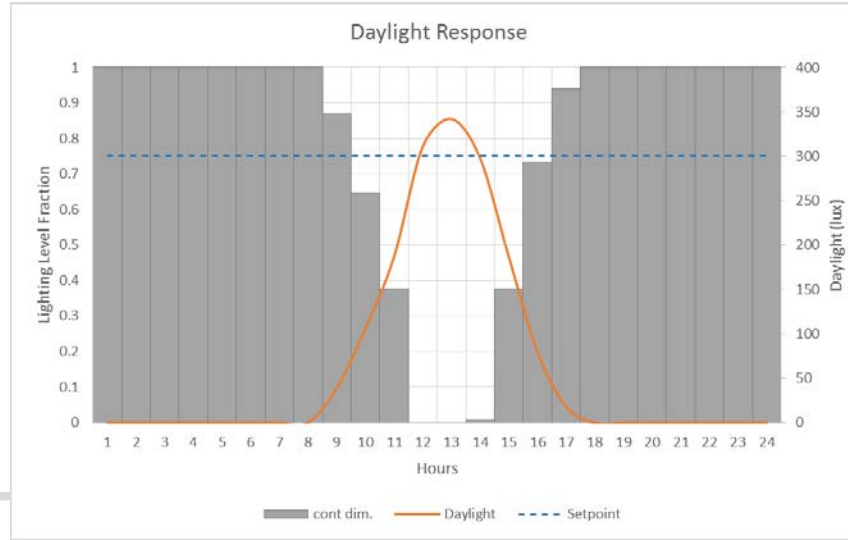
- Ceiling Heights: 20', 16', 12' (small)
- SFR: 1.5%, 3%
- Skylight VT: 10% - 90% (10% inc)
- Multiple Climate Zones

1,080 Templates

Deeper Dive: Control Factors for Automatic Daylighting Controls, *cont'd* Daylight Illuminance to Energy Use

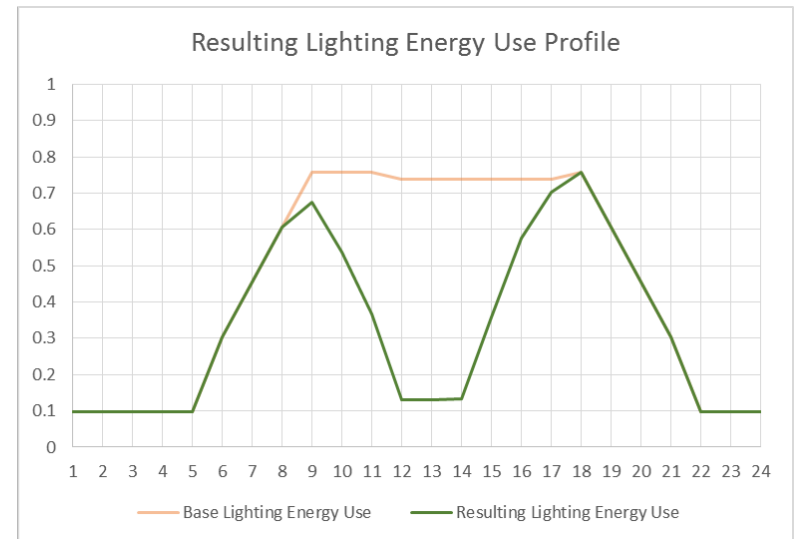
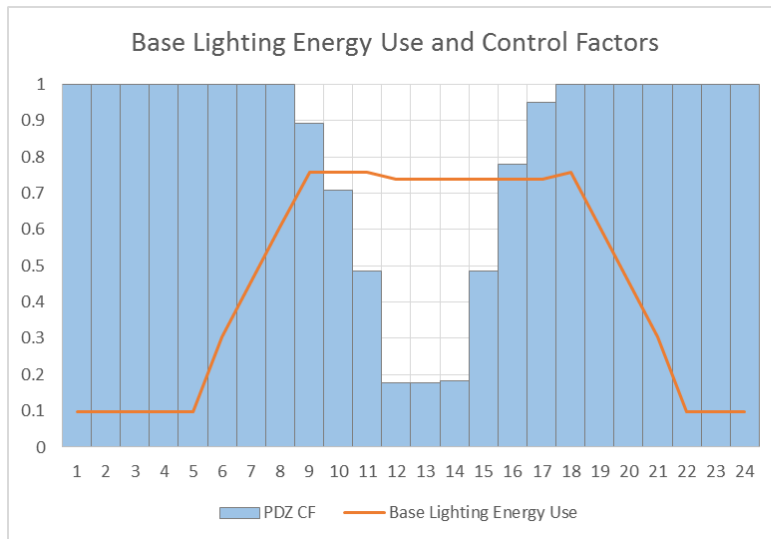
Hourly (8,760) daylight illuminance from Radiance simulations used to calculate:

- A “light level fraction” for each hour to maintain set point 300 lux illuminance using daylight or electric lighting
- Light to power relation for lighting technology used to convert “light level fraction” to “power level fraction” or control factor



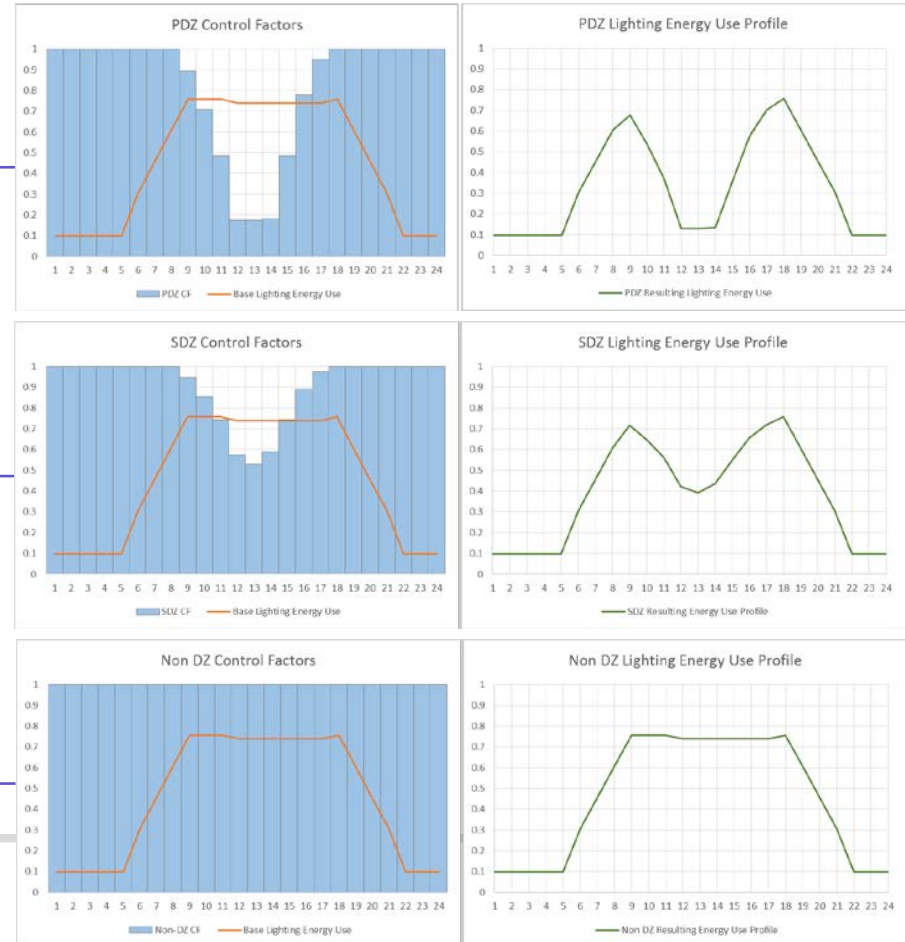
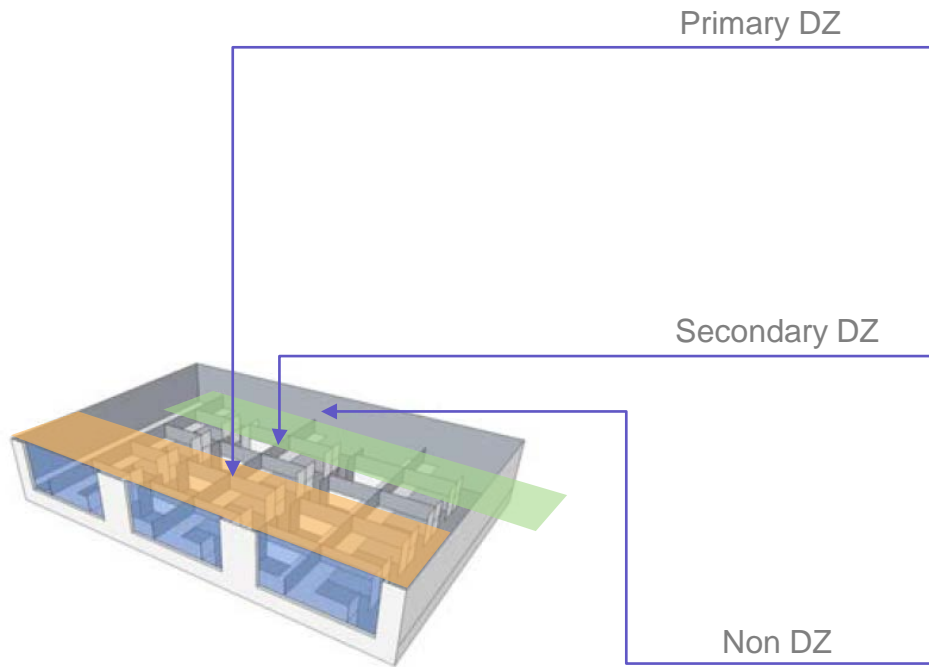
Deeper Dive: Control Factors for Automatic Daylighting Controls, *cont'd*

Control Factors applied to the base lighting energy use profile for the space to estimate energy use with daylighting controls



Deeper Dive: Control Factors for Automatic Daylighting Controls, *cont'd*

A space is fractioned into 3 lighting zones – primary daylit, secondary daylit and non-daylit zones.



Deeper Dive: Control Factors for Automatic Daylighting Controls, *cont'd*

Finally resulting energy use profiles for each lighting zone combined to develop a lighting profile for the space

