



CALIFORNIA
ENERGY
CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Nonresidential Lighting (1 of 2)

Indoor Lighting Controls

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Agenda

1. Background
2. Proposed Code Changes
3. Technical and Market Barriers
4. Compliance and Enforcement
5. Cost-Effectiveness and Energy Impacts
6. Next Steps

Proposed Measures for 2019 Title 24, Part 6 Code Cycle

1. Occupant Sensing Controls in Restrooms
2. Daylight Dimming Plus OFF
3. Code Change under Evaluation: Mandatory Manual ON of Automatic Time-Switch Controls

1. Background



Introduction to Technology for “Occupant Sensing Controls in Restrooms” Measure

Technology Type	Description
Passive Infrared (PIR) Technology	Detects movement of hotter than ambient sources from one facet of a the sensor view direction to another that would indicate occupancy.
Ultrasonic Technology	Floods an area with high-frequency sound waves and then receives back reflected signal; moving objects changes frequency of reflected signal (Doppler effect).
Microphonics Technology	Microphonic sensor detects sounds and processing algorithms determine which sounds indicate occupancy.
Dual Technology	<ul style="list-style-type: none">• Typical PIR combined with either ultrasonic or microphonics technology.• Triggering both technologies required to turn lights ON, while sensing of occupancy by either technology keeps the lights ON.
Microwave Technology	Emits microwave signal and reflected signal of moving objects (doppler shift) indicates occupancy in area.

Introduction to Technology for “Daylight Dimming Plus OFF” Measure

Type of Dimming Control	Description
0-10 VDC	<ul style="list-style-type: none">• An analog controller that adjusts the voltage from 0-10V with the low voltage wire pair connecting the controller to one or more LED drivers.• Currently no industry standard for low end cutoff.• The low end cutoff varies from OFF to 10% of full lighting output.
Digital, including DALI (Digital Addressable Lighting Interface)	<ul style="list-style-type: none">• A standard for digital control of individual fixtures via a low voltage communication protocol comprising of a single set of control wires from a low-voltage control bus that can send information to light fixtures while also receiving information from the fixtures.• DALI protocol provides 254 levels of brightness between OFF and 100% of full lighting output.
Two-Wire Phase Dimming	<ul style="list-style-type: none">• Types include reverse phase and forward phase dimming controls.• The low end cutoff is usually around 15% of full lighting output; some go as low as 1% of full lighting output.

Relevant Code History: Existing 2016 Title 24, Part 6 Requirements



- **Restrooms Controls**

Mandatory: Auto shut-OFF. All indoor lighting is required to be “controlled with an occupant sensing control, automatic time-switch control, or other control capable of automatically shutting OFF all of the lighting when the space is *typically* unoccupied.”¹

- **Daylight Dimming Plus OFF**

- **Mandatory:** All Daylit zones are required to dim to 35% of full lighting output, or lower
- **Voluntary:** PAF of 0.10 for daylight dimming plus OFF control.²

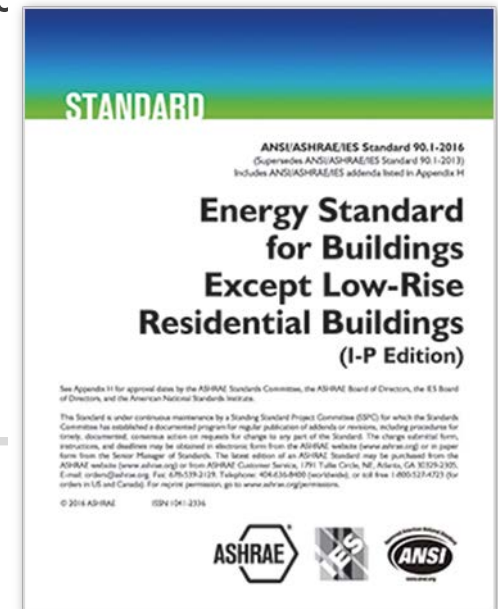
¹ Code reference: Title 24, Part 6, Section 130.1 Mandatory Indoor Lighting Controls, Section (c) part 1 and 5.

² Code reference: Title 24, Part 6, Section 140.6 Prescriptive Requirements for Indoor Lighting, Table 140.6-A.

Relevant Code History: Other Relevant Code Requirements

Restrooms – ASHRAE 90.1-2016 Standards

- Section 9.4.1.1 (h) **Automatic full OFF** requires that “All lighting shall be automatically shut off within 20 minutes of all occupants leaving the space.”
 - **Occupancy sensor control** required in restrooms
- Table 9.6.1 lists nonresidential space types required to have automatic full OFF, including restrooms.



Relevant Code History: Other Relevant Code Requirements

Daylighting Controls – ASHRAE 90.1-2016 Standards

- Section 9.4.1.1 (e) and (f): “The photocontrol shall reduce electric lighting in response to available daylight using continuous dimming or with at least one control point between 50% and 70% of design lighting power, a second control point between 20% and 40% of design lighting power or the lowest dimming level the technology allows, and **a third control point that turns off all the controlled lighting.**”
- Table 9.6.1 lists nonresidential space types required to have automatic daylighting controls for sidelighting and toplighting.
- **Retail spaces are exempt** from automatic daylighting controls for sidelighting.

2. Proposed Code Changes



Proposed Code Change for “Occupant Sensing Controls in Restrooms” Measure

To align the existing Title 24, Part 6 requirements with ASHRAE 90.1-2016, require occupancy-based full OFF controls in nonresidential restrooms

- Mandatory
- Nonresidential buildings
- Applies to new construction and alterations



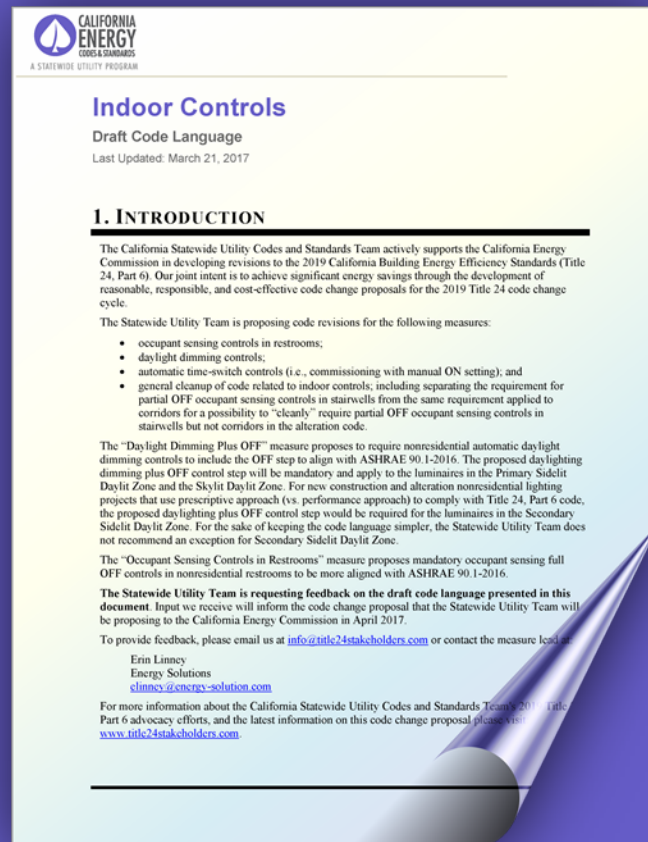
Proposed Code Change for “Daylight Dimming Plus OFF” Measure

To align the existing Title 24, Part 6 requirements with ASHRAE 90.1-2016, require daylight dimming controls to be commissioned with OFF step (and remove corresponding Power Adjustment Factor).

- Mandatory (but end-users can adjust the OFF setting after commissioning)
- Applicable to luminaires in Skylit Daylit Zone, Primary Sidelit Daylit Zone, and Secondary Sidelit Daylit Zone (**for code simplicity**)
- Nonresidential buildings
- Applies to new construction and alterations



Let's look at the draft proposed language



Discussion



- Should Secondary Sidelit Daylit Zones be required to have dimming plus OFF controls?
- Should retail Sidelit Daylit Zones be exempted similar to ASHRAE 90.1-2016?

Code Change Under Evaluation: “Manual ON for Automatic Time-Switch Controls”

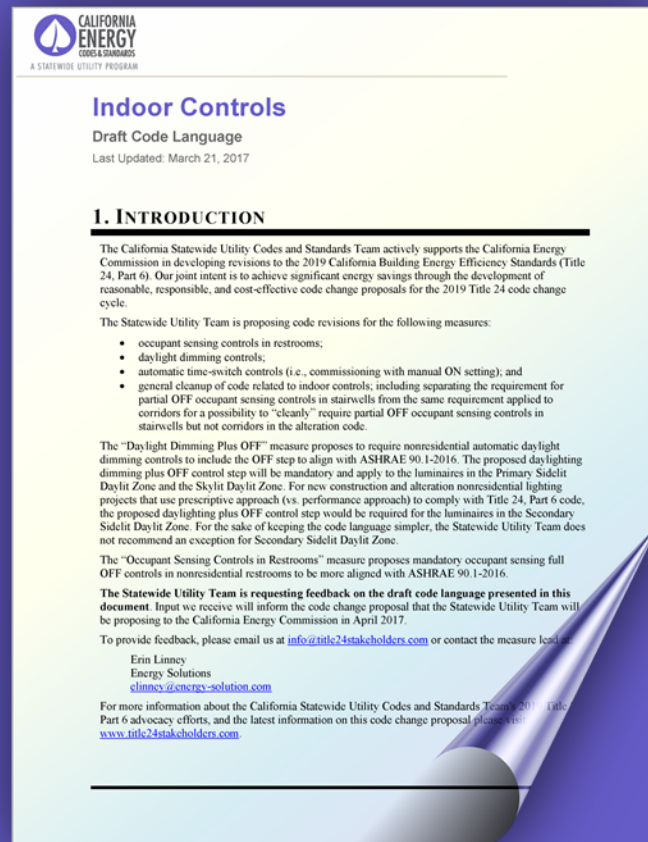
This measure is under evaluation, if proposed, the measure:

- Would be mandatory;
- Would apply to spaces that do not have occupant sensing controls and rely on time-switch controls to turn lighting ON and OFF;
- Would include exceptions for time-switch controlled areas where the public enters, such as single tenant retail, malls, auditoriums, concourses, and lobbies; and
- Would include exceptions for Industrial spaces from the manual ON requirements for speed of starting up production.

Note that time-switch control:

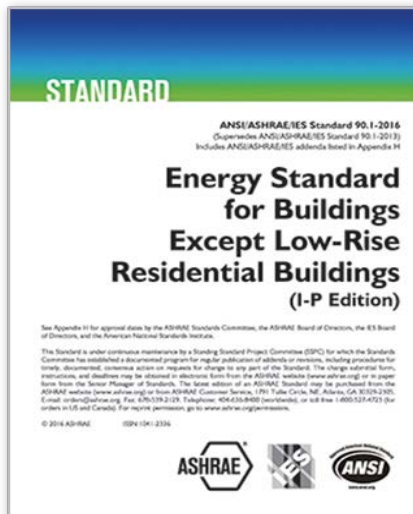
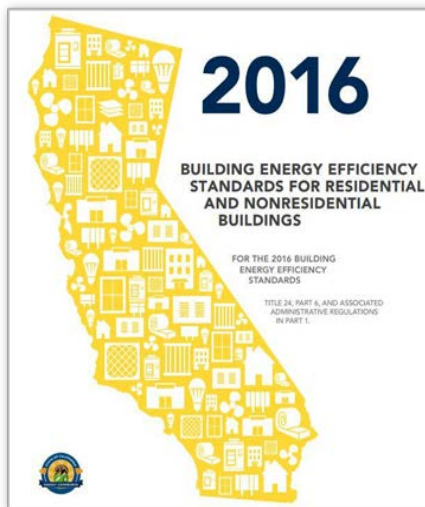
- Would only turn OFF electric lighting automatically and that a building occupant would need to turn ON electric lighting manually when needed; and
- Could be re-programmed to automatic ON, if desired, after completing acceptance test and commissioning.

Let's look at the draft proposed language



Why Are We Proposing These Code Changes?

- ✓ Align with ASHRAE 90.1-2016
- ✓ Support ZNE goals
- ✓ Existing technology has the capability and is cost-effective



3. Technical and Market Barriers

Technical and Market Barriers

Occupant Sensing Controls in Restrooms

- No technical or market barriers

Daylight Dimming Plus OFF

- No significant technical barriers
 - Some automatic daylighting systems are capable to dim lighting to OFF
- User acceptance
 - Automatic daylighting controls, especially with OFF step, are not widespread in buildings, so occupant education would be critical

What about barriers for “Daylight Dimming Plus OFF” measure?



4. Compliance and Enforcement

Compliance Process



Design Phase

- Designers identify whether indoor lighting controls will be required:
 - Occupant sensors would need to be installed in restrooms
 - Daylight dimming controls will need to dim to OFF.
- Submit construction documents including forms to Building Department for plan check.
 - Certificate of Compliance Forms, NRCC forms, would need minimal changes for both measures
 - **Occupant Sensors in Restrooms:** Other control types would no longer meet compliance.
 - **Daylight Dimming Plus OFF:** Commission to ensure system dims to OFF.

Compliance Process



Permit Application Phase

No significant changes to this phase.

- Plans examiner reviews all applicable compliance worksheets and compares to construction documents to verify system design specifications are consistent.
- Plans examiner may provide correction comments to the designer to resolve any issues.

Compliance Process



Construction Phase

No significant changes to this phase.

- Facility is constructed per design specifications.
- Lighting installer completes Certificate of Installations.
 - Certificate of Installations are required to be submitted or posted at the building site prior to functional testing and completion of the Certificate of Acceptance.

Compliance Process



Commissioning
Phase

- Commissioning Agent helps develop Operation and Maintenance (O&M) Manuals
 - End-user education is critical at this stage

Compliance Process



Inspection Phase

- Building inspector reviews Certificates of Installation in the field and issues certificate of occupancy.
- Building inspectors can use notes from plans examiners to identify top field verification priorities.
- Acceptance testing to be completed:
 - Daylight Dimming Plus OFF: must be tested to dim to OFF.

What do you think?



- Are you aware of additional compliance or enforcement barriers that we haven't identified?
- Do you have other ideas on ways to support compliance and enforcement?

5a. Cost-Effectiveness and Energy Impacts: “Occupant Sensing Controls in Restrooms” Measure



Definition of Baseline and Proposed Conditions for “Occupant Sensing Controls in Restrooms” Measure

Baseline Conditions

- Restroom minimally compliant with 2016 Standards
- New Construction¹: Draft 2019 Indoor Lighting Power Density (LPD) of 0.5 W/ft²
- Alterations: 2016 Indoor LPD of 0.6 W/ft²
- 3,644 annual operating hours
- Space Area²
 - Typical single occupant: 75 ft²
 - Typical multiple occupant: 320 ft²

Proposed Conditions

- Compliant with proposed code change of mandatory occupant sensing controls in restrooms
- New Construction: Proposed 2019 Indoor Lighting Power Density (LPD)¹
- Alterations: 2016 Indoor LPD of 0.6 W/ft²
- 2,405 annual operating hours
- Space Area²
 - Typical single occupant: 75 ft²
 - Typical multiple occupant: 320 ft²

¹ Assuming LPD will be lowered in the 2019 Title 24, Part 6 Standards. If LPD value does not change in 2019, the per unit energy savings will be the same for new construction and alterations (0.6 W/ft²).

² PNNL Cost-Effectiveness Study in ASHRAE 90.1-2007 Addendum

Cost-Effectiveness Analysis for “Occupant Sensing Controls in Restrooms”

Incremental Costs

Measure	Typical Restroom Type	Sensor Equipment Type	Material	Labor Cost	Incremental Commissioning Cost	Maintenance Cost	Total Incremental Cost over 15-year period of analysis (2020 PV \$)
New Construction	Single occupant	<ul style="list-style-type: none"> • Dual technology Ultrasonic/PIR • Wall Mount • Wired 	\$113	\$19	\$6	\$0	\$137
New Construction	Single occupant	<ul style="list-style-type: none"> • PIR • Wall Mount • Wired 	\$29	\$19	\$6	\$0	\$54
New Construction	Multiple occupant	<ul style="list-style-type: none"> • Dual Technology Ultrasonic/PIR • Wired 	\$112	\$65	\$8	\$0	\$185
Alterations	Single occupant	<ul style="list-style-type: none"> • Dual technology Ultrasonic/PIR • Wall Mount • Wired 	\$113	\$19	\$6	\$0	\$137
Alterations	Single occupant	<ul style="list-style-type: none"> • PIR • Wall Mount • Wired 	\$29	\$19	\$6	\$0	\$54
Alterations	Multiple occupant	<ul style="list-style-type: none"> • Dual technology Ultrasonic/PIR • Wireless 	\$162	\$65	\$10	\$0	\$237

Cost-Effectiveness Analysis, *cont'd*

Incremental Cost Savings (Benefits)

Measure	Restroom Type (Typical)	Technology	15-Year TDV Electricity Cost Savings Per Restroom (2020 PV \$)
New Construction	Single occupant	Dual Technology	\$122
New Construction	Single occupant	PIR	\$123
New Construction	Multiple occupant	Dual Technology	\$519
Alterations	Single occupant	Dual Technology	\$146
Alterations	Single occupant	PIR	\$146
Alterations	Multiple occupant	Dual Technology, Wireless	\$622

Benefit-to-Cost Ratio for “Occupant Sensing Controls in Restrooms” Measure

Measure	Typical Restroom Type	Technology	Benefits	Costs	Benefit-to-Cost Ratio
			TDV Energy Cost Savings + Other PV Savings (2020 PV \$)	Total Incremental Present Valued (PV) Costs (2020 PV \$)	
New Construction	Single occupant	Dual Technology	\$122	\$137	0.89
New Construction	Single occupant	PIR	\$123	\$54	2.30
New Construction	Multiple occupant	Dual Technology	\$519	\$185	2.81
Alterations	Single occupant	Dual Technology	\$146	\$137	1.06
Alterations	Single occupant	PIR	\$146	\$54	2.72
Alterations	Multiple occupant	Dual Technology, Wireless	\$622	\$237	2.62

Cost Effective in Both Single and Multiple Occupant Restroom

If Benefit-to-Cost Ratio is over 1, measure is cost effective.

Annual Statewide Energy Savings for “Occupant Sensing Controls in Restrooms” Measure

Climate Zone	Statewide Construction in 2020 (million square feet)	First Year Electricity Savings (GWh)
New Construction (CZ 1 through 16)	1.7	1.1
Alterations (CZ 1 through 16)	4.1	3.1
TOTAL	5.9	4.1

What about initial and maintenance costs?



5b. Cost-Effectiveness and Energy Impacts: “Daylight Dimming Plus OFF” Measure

Definition of Baseline and Proposed Conditions for “Daylight Dimming Plus OFF” Measure

- **Baseline Conditions**

- Compliant with 2016 standards
- Continuous dimming to 20%
- Draft 2019 Title 24, Part 6 LPD levels
- Considered 6 building prototypes
 - Hotel Small
 - Office Medium
 - Office Small
 - Retail Large
 - School Small
 - Warehouse

- **Proposed Conditions**

- Continuous dimming to OFF (modeled in **CBECC-Com 2019 Research version**)

What about Baseline Conditions for “Daylight Dimming Plus OFF” Measure?



Areas Included in Modeled Per Unit Energy Savings Available for Daylighting

Building Type	Modeled Areas for Daylighting Plus OFF	Total Area of Skylit Daylit Zone Subject to Plus OFF (square feet)	Total Area of Primary Sidelit Daylit Zone Subject to Plus OFF (square feet)	Percent of Daylit Zones Subject to Plus OFF of Total Building Area
Hotel Small	Front Lounge, Offices and Meeting Rooms	N/A	2,023	3.3%
Office Medium	Perimeter Zones	N/A	11,784	22%
Office Small	Perimeter Zones	N/A	2,022	37%
Retail Large	All areas currently subject to Mandatory Daylight Dimming	167,928	4,621	72%
School Small	Lobby, Corridor, Cafeteria <i>Note: classrooms were excluded</i>	N/A	1,914	7.8%
Warehouse	All areas currently subject to Mandatory Daylight Dimming	45,117	539	92%

Cost-Effectiveness Analysis for “Daylight Dimming Plus OFF” Measure

- There may be incremental costs for the premium on equipment costs for “Daylight Dimming Plus OFF” measure
- No additional commissioning costs



Annual Per-Unit Energy Savings by Building Type: Per Daylit Square Foot

Building Prototype	Electricity Savings (kWh per daylit square foot per year)
Hotel (CZ1- CZ16)	0.20 – 0.25
Office Medium (CZ1- CZ16)	0.28 – 0.29
Office Small (CZ1- CZ16)	0.21 – 0.24
Retail Large (CZ1- CZ16)	0.13 – 0.35
School Small (CZ1- CZ16)	0.27 – 0.41
Warehouse (CZ1- CZ16)	0.122-0.124

REMINDER for “Daylight Dimming Plus OFF” measure

Baseline Conditions:

- Continuous dimming to 20%
- Draft 2019 Title 24, Part 6 LPD levels

Proposed Conditions:

- 20% to OFF

Annual Statewide Energy Savings by Building Type

Key Assumptions in Calculating Statewide Energy Savings

For existing building floor stock:

- 10% of the existing lighting systems are retrofitted per year
- 15% of retrofits install daylighting controls, thus 1.5% of existing floor stock per year would be subject to the proposed measure to dim to OFF

For alterations and new construction floor stock, only consider daylight area (a fraction of the building area)

The energy savings have **not** been discounted to account for the savings that would be lost due to occupants adjusting the plus OFF setting after commissioning

Annual Statewide Energy Savings by Building Type, *cont'd*

Key Assumptions in Calculating Statewide Energy Savings

Energy savings from the following building/area types (new construction and existing floor stock) are **excluded** in the presented statewide energy savings:

- Stand-alone retail
- Strip mall
- Mixed-use retail
- Classrooms in school
- Secondary daylight sidelit zones across all considered building types

For retail building type, only energy savings from Large Retail – daylight sidelit and daylight toplit zones (new construction and existing floor stock) are **included** in the presented statewide energy savings.

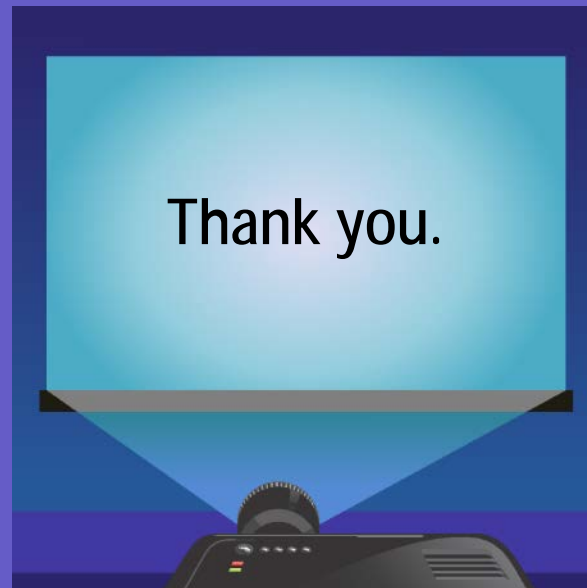
6. Next Steps

Next Steps

- Please send any additional feedback to:
 - CASE Author (see contact info at end of this presentation)
 - Info@title24stakeholders.com
- Take the Title 24, Part 6 Indoor Controls Stakeholder Survey:
<https://www.surveymonkey.com/r/Title24Part6IndoorControls>
- Keep an eye on Title24Stakeholders.com for:
 - Presentations from today's meeting
 - Draft Code Change Language
 - Notes from today's meeting
 - Draft CASE Report (will be posted in April)

Let's move on to...

Nonresidential Lighting Alterations



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