CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Draft Measure Information Template – Daylighting

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team, March 2011

This report was prepared by the California Statewide Utility Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

Measure Information Template – Daylighting

2011 California Building Energy Efficiency Standards

[Proposer and date]

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1. Purpose

This document describes the code change proposals for 2013 Title 24 - Part 6 Building Energy Efficiency Standards, for the topic of Daylighting.

2. Overview

Complete the following table, providing responses for each category of information.

a. Measure Title	Proposed changed to the daylighting requirements in Title 24-Part6
b. Description	Three code changes are being proposed, that increase stringency of daylight code requirements, resulting in greater energy savings, and simplify the daylighting code implementation process, removing key barriers to code compliance for greater and more widespread use. **Proposal 1 - Simplification of the Daylighting Code:** This proposal modifies the mandatory requirements for indoor lighting controls section 131(c), the prescriptive requirements for indoor lighting in section 146(d) and introduces a method to quantify lighting energy savings from daylighting for a performance approach in Section 141. The proposal also modifies the additions alternations and repairs section 149 as it relates to daylighting. **Proposal 2 - Photocontrols requirement trigger:** This proposal modifies the mandatory requirement photocontrols in sidelit and toplit spaces by changing the exception under 131(c)2A and 131(c)2B. **Proposal 3 - Minimum skylight area requirement:** This proposal modifies the prescriptive requirements for building envelopes - Section 143(c) by increasing the minimum skylight area requirement. The proposed code change applies to all non-residential, high-rise residential and hotel/motel occupancies.
c. Type of Change	**Modeling** - The change proposed in proposal 1 would modify section 149 and the ACM to include a method to quantify lighting energy savings from daylighting in sidelit spaces. **Mandatory Measure** - The change proposed in proposal 1 and 2 would modify the mandatory requirements for indoor lighting controls in section 131(c). **Prescriptive Requirement** - The changes proposed in proposal 1 and 3 would modify the prescriptive requirement in Section 146(d) and 143(c). Also proposal 1 would modify the calculation of reduction of wattage through controls in Section 146(a)2. The documents that would need to be modified in order to implement the proposed change are the Standards, ACM, Manuals and compliance forms. None of the proposed changes would add a compliance option or a new requirement.
d. Energy Benefits	1. *TBD*

e. Non-Energy Benefits	*TBD*
f. Environmental Impact 2. *TBD*	
g. Technology Measures	*TBD*
h. Performance Verification of the Proposed Measure	*TBD*
i. Cost Effectiveness *TBD*	
j. Analysis Tools	*TBD*
k. Relationship to Other Measures	*TBD*

3. Methodology

This section describes the methodology that we followed to determine the code change proposals, collect costs and calculate energy savings and cost effectiveness.

The methodology section is sub-divided into four sections, one for each code change proposal as described below:

1. Simplification of the Daylighting Code: A proposal to simplify the mandatory requirements for indoor lighting controls section 131(c) and the prescriptive requirements for indoor lighting in section 146(d). A proposal for a method to quantify lighting energy savings from daylighting for a performance approach in Section 141. A proposal to modify the additions alternations and repairs section 149.
2. Photocontrols Requirement Trigger: A proposal to change the threshold for requiring photocontrols in sidelit and toplit spaces in Section 131(c).
3. Minimum Skylight Area Requirement: A proposal to increase the minimum skylight area required for large enclosed spaces in Section 143(c).
4. Stakeholder Outreach Process: A description of the outreach process undertaken to solicit stakeholder feedback.

This work was publicly vetted through our stakeholder outreach process, which through in-person meetings, webinars, email correspondence and phone calls, requested and received feedback on the direction of the proposed changes. The stakeholder meeting process is described at the end of the Methodology section.

3.1 Proposal 1: Simplification of Daylighting Code

This section describes the methodology used to develop simplified mandatory and prescriptive requirements for indoor lighting controls for new construction as well as additions alterations and repairs. This section also describes the methodology used to determine a prescriptive approach for sidelit spaces, called the Watt Calculation Method.

To be completed …

3.2 Proposal 2: Photocontrols Requirement Trigger

This section describes the methodology used to update the minimum daylit area trigger for photocontrols for sidelit and toplit spaces in Sections 131(c)2B and 131(c)2C, to a more aggressive requirement based on updated costs of photocontrols, and updated energy costs compared to the 2008 code change proposal.

The key elements of the methodology were as follows:

- Photocontrols Cost Survey
- Analysis

3.2.1 Photocontrols Cost Survey

HMG conducted a market assessment of the purchase price for photosensors and associated equipment (e.g. controllers, dimmers, switches, power packs). In preparation for this data collection effort, HMG created a database including a photosensor product list with 30 products from 10 manufacturers. For each manufacturer, HMG collected distributor contacts from across California. A sample of these 184 distributors was contacted from six regions of the state (Sacramento, SF Bay Area, LA, Riverside County/Fresno, San Diego and Other). Each distributor was asked to provide the cost for photosensor and associated equipment needed for two sample projects:

1. 800 sf side lit open office area; 250 sf daylit area; 4 fixtures controlled
2. 1120 sf top lit warehouse space; 896 sf daylit area; 14 fixtures controlled

Cost data was broken down into two categories:

(a) Fixed Cost: cost of equipment and labor which is fixed for any size daylit space.

(b) Variable Cost: cost of equipment and labor, which vary by the size of the daylit space.

Finally, both costs were combined to determine the cost of photocontrols for different sizes of daylit spaces.

3.2.2 Analysis

Cost data from photocontrols from the photocontrols cost survey was used to determine the cost of photocontrols for a range of daylit space sizes. A threshold of daylight sufficiency was then used to determine energy savings at each daylit space size. Daylight sufficiency was measured in terms of daylight autonomy, or percent of time that daylight in the space is equal to or greater than 300 lux of illuminance. This translates to percent hours that a simple on-off photocontrol can turn electric lights off.

Once savings were calculated, benefit-to-cost ratios were generated for each daylit space size to determine a new threshold where photocontrols should be required.

3.3 Proposal 3: Minimum Skylight Area Requirement

This section describes the methodology used to derive a new minimum skylit area requirement for Section 143(c).

The key elements of the methodology were as follows:

- Rooftop Survey
- Analysis

3.3.1 Rooftop Survey

HMG conducted a visual survey of building rooftops to determine the existence of typical rooftop obstructions. HMG used data collected by the Western Cooling Energy Center (WCEC) and the Cool Ducts CASE team to establish a sample of target buildings to survey. The original data provided by

the WCEC included address and lot characteristics, such as building size and end use, as well as information on the presence and area of exposed ducts, for a sample of 500 commercial buildings throughout Climate Zone 12. From this dataset, HMG developed a targeted sample of building types likely to be required to have skylights. The targeted building types (as described in the survey data) were general commercial, shopping centers, retail stores, grocery stores, and industrial. The survey does not provide detailed information about the use of each building, but it is expected that these targeted building types could correspond to one or more of the following space types defined in Title 24: auto repair, commercial and industrial storage, exercise center/gymnasium, general commercial and industrial work, grocery sales, grocery store, mall, office, retail merchandise sales, or tenant lease space.

For each of the five target building types, HMG surveyed 25% of the original sample (125 buildings), targeting 70 buildings most likely to trigger skylighting requirements if built under current 2008 code (i.e. single story, high ceilinged buildings over 8000 square feet, such as big-box retail, industrial factory or warehouses). Final quantities of surveyed buildings are as follows:

	Number of Buildings
General Commercial	36
Shopping Centers	5
Retail Sales	7
Grocery Stores	1
Industrial	21
Total	**70**

Figure 1: Number of buildings surveyed

Each of the 70 buildings was visually surveyed for rooftop obstructions using satellite imagery from Bing maps (www.bing.com/maps). Area (square footage) of rooftop obstructions, such as packaged HVAC units was calculated using tools available in Bing maps. Area of exposed ducts was already included in the original data set from WCEC. Because the objective of the survey was to determine the amount of roof space available for skylights, existing skylights were not considered to be rooftop obstructions.

3.3.2 Analysis

Following the rooftop survey, a metric of percent obstructed area was analyzed for the dataset, and based on findings, a new minimum skylight area requirement was recommended.

3.4 Stakeholder Outreach Process

All of the main approaches, assumptions and methods of analysis used in this proposal have been presented for review at one of three public Daylighting Stakeholder Meetings.

At each meeting, the utilities' CASE team invited feedback on the proposed language and analysis thus far, and sent out a summary of what was discussed at the meeting, along with a summary of outstanding questions and issues.

A record of the Stakeholder Meeting presentations, summaries and other supporting documents can be found at www.calcodes.com. Stakeholder meetings were held on the following dates and locations:

- First daylighting stakeholder meeting: June 23rd 2010, California Lighting Technology Center, Davis, CA
- Second daylighting stakeholder meeting: December 15th 2010, Webinar event
- Additional stakeholder webinar to review Watt Calculation Method: March 17th 2011, Webinar event

4. Analysis and Results

This section describes the analysis done for each of the four proposals described in the Methodology section and the associated results.

4.1 Proposal 1: Simplification of Daylighting Code

This section describes the analysis steps undertaken to develop the mandatory requirements, and the prescriptive and performance approaches for daylighting.

To be completed …

4.2 Proposal 2: Photocontrols Requirement Trigger

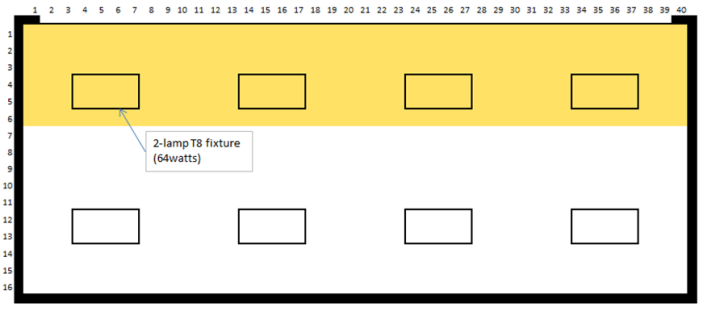
This section describes the analysis steps used to update the minimum daylit area trigger for photocontrols for sidelit and toplit spaces in Sections 131(c)2B and 131(c)2C, to a more aggressive requirement based on updated costs of photocontrols, and updated energy costs from the 2008 code change proposal. This section also discusses the results from the analysis and their code implications.

4.2.1 Photocontrol System Cost

As discussed in section 3.2.1, above, HMG collected cost data for daylighting control equipment from product distributers throughout California, based on two hypothetical projects:

- 800 sf side lit open office area; 250 sf daylit area; 4 fixtures controlled
- 1120 sf top lit warehouse space; 896 sf daylit area; 14 fixtures controlled

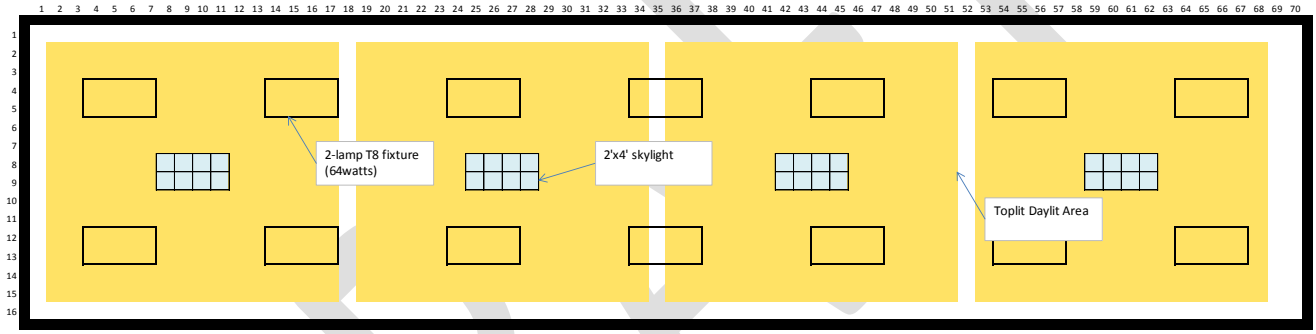
Diagrammatic plans of the two scenarios are illustrated below in Figure 2 and Figure 3. Yellow shading in each diagram indicates areas where current code requires luminaires to be controlled by separately for daylighting. For these cost assessments we assumed that luminaires in the daylit zone will be automatically controlled by photocontrols.



Area = 40' x 16' = 640sf
8 x 2-lamp T-8 fixures = 512 watts
LPD = 0.8 W/sf

Daylit Area = 250sf
# of fixtures in sidelit daylit area = 4
Watts Controlled = 256 watts

Figure 2: Plan diagram of hypothetical sidelit space



Area = 70' x 16' = 1120sf
14 x 2-lamp T-8 fixures = 896 watts
LPD = 0.8 W/sf

Daylit Area = 896 sf
3% Skylights = 4 x 2'x4' skylights
# of fixtures in skylit daylit area = 14
Watts Controlled = 896 watts

Figure 3: Plan diagram of hypothetical toplit space

HMG received 40 price quotes of retail prices for 11 different photocontrol products and their required auxiliary components (lens, relay, power pack etc.).

Costs were collected for three different types of photocontrol products:

- Wireless Systems: a photosensor sends a wireless signal to a controller that turns off or dims lights at the pre-determined setpoint(s).
- Wired Stand-Alone Products: a photosensor sends a wired signal (line- or low-voltage) directly to the lighting to be turned off or dimmed.

- Wired Systems: a photosensor sends a wired signal (usually low-voltage) to a controller at the pre-determined setpoint(s); the controller then relays a control signal to the lighting to be turned off or dimmed.

The specific capabilities of each product were taken into account, and any auxiliary equipment such as power packs, controllers, or transformers was included in the cost data for each product. In addition, some of the products would require more than one sensor or controller to meet the current multi-level requirements for Automatic Daylight Control Devices in the current code, section 131(c)2D. The cost of the additional equipment was included. Results of the cost survey for the three product types are summarized below in Figure 4.

	Max Price	Average Price	Min Price
Wireless Photocontrols System (n=3)	**$436.00**	**$320.94**	**$261.00**
Wireless Photosensors	$134.49	$115.16	$100.00
Wireless Reciever	$336.00	$205.78	$131.33
Wired Stand-Alone System (n=4)	**$231.82**	**$129.89**	**$62.00**
Wired Photosensors	$181.82	$99.89	$62.00
Power Pack	$50.00	$30.00	$0.00
Wired Phtocontrols System (n=4	**$662.50**	**$381.22**	**$121.87**
Wired Photosensors	$236.00	$138.72	$84.50
Controller & Aux Equipment	$550.00	$242.50	$0.00

Figure 4: Photocontrols price summary

Initial fixed costs for wireless photocontrol systems are more than wired stand-alone photocontrol systems and wired complete systems (photosensor with controller). However, when the cost of installation and commissioning is included (analysis outlined below), the wireless daylight systems are the least expensive to install, but on balance, not considerably different from the cost of wired photosensor control systems. The major drawback to wireless daylight systems are in buildings where the wireless signal affects the performance of the building, some examples include: government buildings where outside access to insecure wireless communication is a security concern and hospitals where wireless signals could reduce equipment performance.

In addition to the fixed equipment costs, we estimated the variable cost of labor to install and commission the system. We obtained estimates of electrical contractor labor hours from a variety of industry stakeholders, ranging from manufacturers, to contractors, to consultants. Estimated installation times ranged from 30 minutes per fixture for wireless systems to 2 hours per fixture for wired systems. In addition to installation, the systems were assumed to require 15-30 minutes per ballast for commissioning of dimming systems, or up to 15 minutes per ballast for switching systems (larger systems are assumed to have a commissioning cap of $2000, based on daily fees for manufacturer support services).

A more detailed summary of the basis for the labor time assumptions can be found in Appendix xx.

Using the labor estimates obtained from stakeholders, and data sourced from RS Means CostsWorks for electrical contractor labor rates throughout the state (see Figure 5), we estimated the variable cost for installation and commissioning daylight control systems (in Sacramento) to be $350.50 (switching) or $467.75 (dimming) for the sample office sidelit project (shown in Figure 2) and $559.50 (switching) or $886.75 (dimming) for the sample warehouse top lit project (shown in Figure 3). See Figure 6, below, for a detailed summary of labor and commissioning cost estimates.

Labor + O&P ($/hr) from RS Means	City	City Multipliers RS Means (%)	Labor O+P by city
$72.85	Sacramento	115.1	$83.85
	Bay Area	151.6	$110.44
	Los Angeles	122.1	$88.95
	Riverside	110.2	$80.28
	San Diego	103.7	$75.55
	Other (avg)	106.5	$77.59

Figure 5: RS Means CostWorks Hourly Labor Rates for Electrical Contractors

	Sidelighting 4 fixtures controlled			Toplighting 14 fixtures controlled		
	Installation Cost		Comissioning Cost	Installation Cost		Comissioning Cost
	Wireless	Wired		Wireless	Wired	
	0.5 hrs	2hrs	2hrs	0.5 hrs	2hrs	7hrs
Sacramento	$41.93	$167.70	$167.70	$41.93	$167.70	$586.95
Bay Area	$55.22	$220.88	$220.88	$55.22	$220.88	$773.08
Los Angeles	$44.47	$177.90	$177.90	$44.47	$177.90	$622.65
Riverside	$40.14	$160.56	$160.56	$40.14	$160.56	$561.96
San Diego	$37.77	$151.09	$151.09	$37.77	$151.09	$528.82
Other (avg)	$38.79	$155.17	$155.17	$38.79	$155.17	$543.10

Figure 6: RS Means CostWorks Variance in labor cost by region

The total costs, documented below in Figure 7 (switching system) and Figure 8 (dimming system) include photocontrol equipment, installation labor and commissioning labor. The cost differential between a std ballast and a dimmable ballast was not included based on a companion CASE proposal requiring controllable ballasts. Labor costs from the Sacramento area were used to represent an average labor cost for the state. Total costs for wireless and wired jobs were averaged to provide an average total project cost for both dimming and switching systems for both hypothetical spaces.

Example Job		Wireless Job Cost	Wired Job Cost	Average Cost
Sidelit space 800sf - 4 switching fixtures controlled. Daylit Area = 250sf	Purchase Price	$261.00	$62.00	$161.50
	Installation (SAC)	$42.00	$168.00	$105.00
	Commissioning	$84.00	$84.00	$84.00
	Total Cost	**$387.00**	**$314.00**	**$350.50**
Toplit space 1120sf - 14 switching fixtures controlled. Daylit Area = 896sf	Purchase Price	$261.00	$62.00	$161.50
	Installation (SAC)	$42.00	$168.00	$105.00
	Commissioning	$293.00	$293.00	$293.00
	Total Cost	**$596.00**	**$523.00**	**$559.50**

Figure 7: Total Costs for Switching System, Sacramento, CA

Example Job		Wireless Job Cost	Wired Job Cost	Average Cost
Sidelit space 800sf - 4 dimming fixtures controlled. Daylit Area = 250sf	Purchase Price	$261.00	$128.50	$194.75
	Installation (SAC)	$42.00	$168.00	$105.00
	Commissioning	$168.00	$168.00	$168.00
	Total Cost	**$471.00**	**$464.50**	**$467.75**
Toplit space 1120sf - 14 dimming fixtures controlled. Daylit Area = 896sf	Purchase Price	$261.00	$128.50	$194.75
	Installation (SAC)	$42.00	$168.00	$105.00
	Commissioning	$587.00	$587.00	$587.00
	Total Cost	**$890.00**	**$883.50**	**$886.75**

Figure 8: Total Costs for Dimming System, Sacramento, CA

4.2.2 Energy Savings

In order to determine cost effectiveness, energy savings were calculated for the two hypothetical projects described above using the following parameters:

- 15 year analysis period
- LPD of 0.8 W/sf
- 3000 annual hours of operation
- Energy costs of $0.12/kWh
- Simple on-off photocontrols system applied to luminaries one head height from the windows, and 0.7*Ceiling Height from the skylights

To estimated energy savings, we used a theoretical method that assumes various Daylight Autonomy levels (ranging from 20% to 70% at 10% intervals) in the region identified as one head height from the windows, and 0.7*Ceiling Height from the skylights. The actual levels of daylight illuminance

and hours per year of sufficient daylight availability will depend on multiple factors identified in the watt calculation method in Section 4.1, such as, window to wall ratio, window VLT, sill height, head height, ceiling height, orientation etc. Simulation runs and analysis done in Sections **Error! eference source not found.** and **Error! Reference source not found.** shows that 50% Daylight Autonomy in the one head height region, and the 0.7*Ceiling Height region is achievable in most cases.

An example of a theoretical calculation using Daylight Autonomy is provided below:

At 20% Daylight Autonomy, the lights are assumed to be off for 20% of the year, or 520 hours. At 0.8 W/sf for the sidelighting case, this results in an annual energy saving of 104 kWh for the sidelighting case and 372.7 kWh for the toplighting case, which translates to $156 for the sidelighting case, and $559 for the toplighting case, over 15 yrs.

4.2.3 Cost Effectiveness Analysis

Using the system cost data and the energy savings presented above, HMG conducted a cost effectiveness analysis to determine the viability of reducing the area thresholds for mandatory daylighting controls.

Cost Effectiveness by Controlled Wattage

We determined the cost effectiveness of automatic photocontrols based on the estimate of energy savings from the two example projects as shown above in Figure 2 and Figure 3. Savings for the various daylight autonomy levels were determined and compared to the cost of providing photocontrols for the two cases.

Overall cost effectiveness is illustrated below in Figure 9. The black line illustrates the cost of photocontrols, which increases slightly with the size of the daylit area, whereas colored lines indicate savings for various Daylight Autonomy levels. Cost effectiveness for each Daylight Autonomy level can be determined by where the corresponding colored savings line crosses the black cost line. Using the 50% DA basis, the minimum cost effective area was determined by finding the intersection of the 50% DA savings line (shown in orange) and the photocontrol cost line, which occurs at 139 Watts. In other words, automatic photocontrols will be cost effective in any space with at least 139 Watts controlled by photosensors and at least 50% daylight autonomy.

In our cost effectiveness analysis, we used several layers of conservatism. First, the cost effectiveness analysis assumes an on/off daylighting control, rather than the current multi-level requirement. A basic on/off control requires a higher daylight illuminance level threshold to turn off the electric lighting, than the code-required multi-level daylight control. Second, we used conservative energy costs of $0.124/kWh for the full 15 year assessment which is an average TDV value for a constant load over an entire year. Daylighting is maximum during peak hours that are typically high TDV value. An analysis that takes this into account will have a much higher TDV energy cost per kWh. Finally, the cost effectiveness assessment was based on 50% daylight autonomy (50% DA) at 30 footcandles in the photocontrolled area. In other words, the analysis assumes that daylighting provides all necessary illumination (in this case, 30 footcandles) in the space within one window head height of the façade during 50% of the annual occupied hours. As discussed above in Sections **Error! eference source not found.** and **Error! Reference source not found.**, the 50% daylight autonomy

threshold is a conservative assumption because our analysis of 61 daylit spaces shows that higher levels are typically achieved.

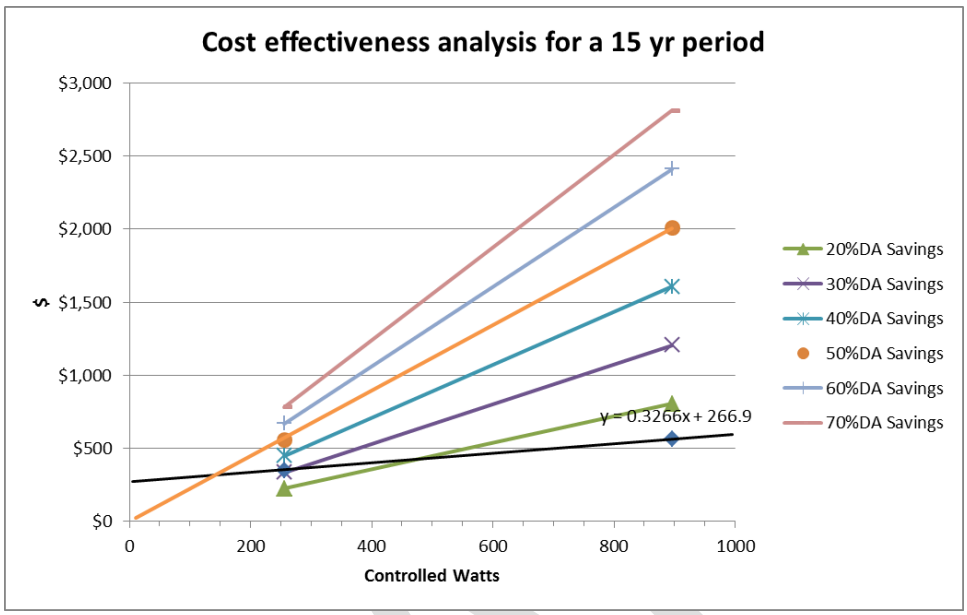


Figure 9: Cost Effectiveness Analysis for automatic daylighting controls based on controlled watts

Based on these conservatisms we can safely assume that daylighting will be cost effective at a lower threshold like 120 Watts.

4.2.4 Recommendations

As described in the analysis above, automatic daylight photocontrols are cost effective for any photocontrolled lighting wattage over 120 Watts with at least 50% daylight autonomy.

4.3 Proposal 3: Minimum Skylight Area Requirement

This section describes the analysis used to derive a new minimum skylit area requirement for Section 143(c).

4.3.1 Rooftop Survey

As discussed in section 3.3.1, above, HMG surveyed a sample of 70 commercial and industrial buildings in climate zone 12 for rooftop obstructions using satellite imagery from Bing maps. Using tools available in Bing maps, the survey estimated the area of the roof, and the area of any obstructions such as packaged HVAC units. Figure 10 and Figure 11, below, show examples of the survey process, illustrating the polygon tool used to estimate roof and obstruction area (in square feet) using the polygon tool in Bing maps (polygons are shown with blue outline and green transparent overlay).

Figure 10: Screen capture of Bing maps showing polygon tool to estimate total roof area.

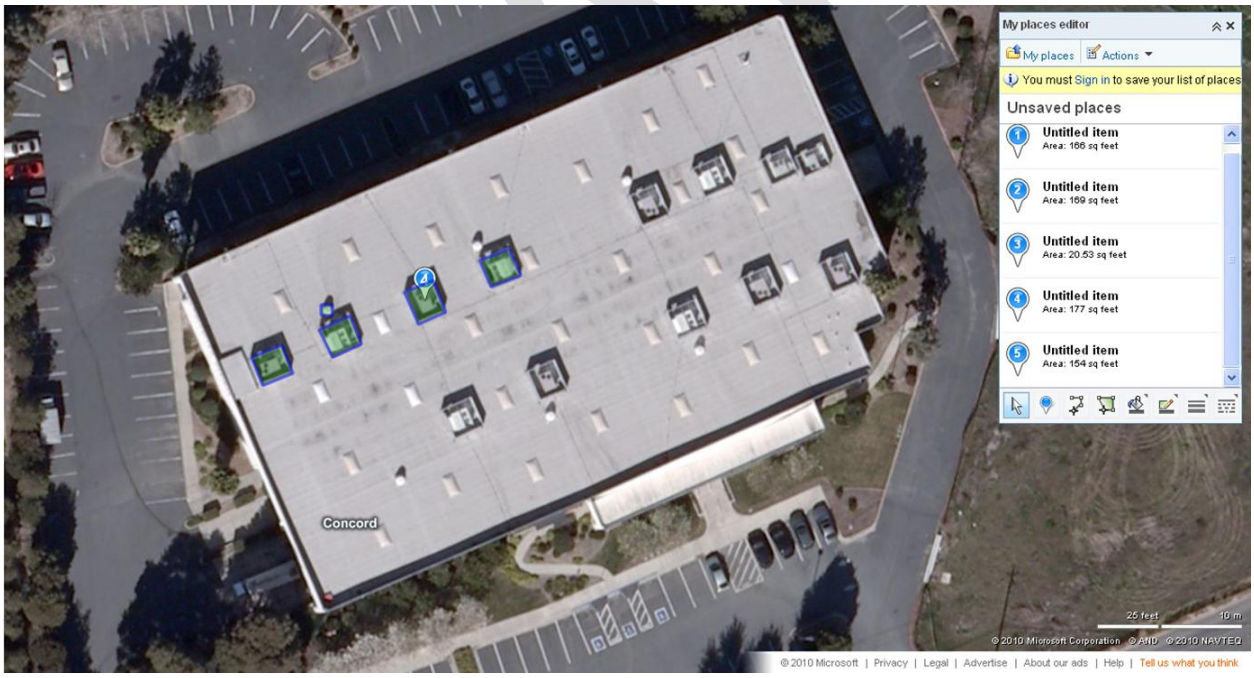


Figure 11: Screen capture of Bing maps showing polygon tool to estimate rooftop obstructions.

As summarized in Figure 12, below, of the 70 buildings surveyed, the maximum obstructed area was 11%. However, most buildings had much lower amounts of rooftop obstructions. The average was 2% roof obstruction, though 18 of the 70 buildings (26%) had no obstructions at all, and 50 of the 70 buildings (71%) had 2% or less obstructed area. These findings suggest that there is ample room for

skylights and an increase in the skylit area requirement would not create interference with other rooftop systems in typical conditions.

	Maximum	Average	Minimum
Percent Obstructed Area	11%	2%	0%

Figure 12: Summary of Rooftop Survey Findings

In addition to identifying rooftop obstructions, the survey recorded estimates of the skylit area for buildings where skylights were present. Eleven of the 70 buildings surveyed had skylights. Of those eleven, ten buildings were estimated to have more than 50% daylit area through skylights, including five where 100% of the floor area seemed to be daylit using skylights. This finding shows that there are situations where builders or building owners choose to voluntary include more skylighting that required by code. Based on this evidence, an increase in the code requirement from the current minimum skylight daylit area of 50% to a higher value should be achievable by most buildings. We recommend that the minimum skylit area be increase to 75%, as it leaves a large margin of 25%, for areas that may not be amenable to having skylights, for privacy, or any other reason.

Detailed results of the rooftop surveys can be found in Appendix A.

4.3.2 Analysis and Recommendation

Based on the findings discussed above, on average, only 2% of a building's roof area is taken up by mechanical equipment or other obstructions. In addition, of the buildings surveyed that had existing skylights, all but one exceeded the current minimum skylit area requirement of 50%. As a result of these findings, HMG recommends increasing the minimum skylit are requirement from 50% to 75%.

5. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

SECTION 131 – INDOOR LIGHTING CONTROLS THAT SHALL BE INSTALLED

(a) **Area Controls.**

(unchanged)

(b) **Multi-Level Lighting Controls**.

(unchanged)

(c) ~~**Daylight Areas.**~~ **Automatic Daylighting Controls**

~~1. Daylight areas shall be defined as follows:~~

1. Daylit Zones shall be defined as follows:

A. SKYLIT DAYLIT ZONE is the area on plan within a space, under each skylight, 0.7 times ceiling height in each direction from the edge of the rough opening of the skylight.

B. PRIMARY SIDELIT DAYLIT ZONE is the area on plan within a space, directly adjacent to each vertical glazing, one window head height deep into the space, and window width plus 0.5 times window head height wide on each side of the rough opening of the window.

C. SECONDARY SIDELIT DAYLIT ZONE is the area on plan within a space, directly adjacent to each vertical glazing, two window head heights deep into the space, and window width plus 0.5 times window head height wide on each side of the rough opening of the window.

~~A. **DAYLIGHT AREA** the total daylight area shall not double count overlapping areas with any primary sidelit daylight area, secondary sidelit daylight area, or skylit daylight area.~~

~~B. **DAYLIGHT AREA, PRIMARY SIDELIT** is the combined primary sidelit area without double counting overlapping areas. The floor area for each primary sidelit area is directly adjacent to vertical glazing below the ceiling with an area equal to the product of the sidelit width and the primary sidelit depth.~~

~~The primary sidelit width is the width of the window plus, on each side, the smallest of:~~

~~i. 2 feet; or~~

~~ii. The distance to any 5 feet or higher permanent vertical obstruction.~~

~~The primary sidelit depth is the horizontal distance perpendicular to the glazing which is the smaller of:~~

~~i. One window head height; or~~

~~ii. The distance to any 5 feet or higher permanent vertical obstruction.~~

~~C. **DAYLIGHT AREA, SECONDARY SIDELIT** is the combined secondary sidelit area without double counting overlapping areas. The floor area for each secondary sidelit area is directly adjacent to primary sidelit area with an area equal to the product of the sidelit width and the secondary sidelit depth.~~

~~The secondary sidelit width is the width of the window plus, on each side, the smallest of:~~

~~i. 2 feet; or~~

~~ii. The distance to any 5 feet or higher permanent vertical obstruction; or~~

~~iii. The distance to any skylit daylight area.~~

~~The secondary sidelit depth is the horizontal distance perpendicular to the glazing which begins from one window head height, and ends at the smaller of:~~

~~i. Two window head heights;~~

~~ii. The distance to any 5 feet or higher permanent vertical obstruction; or~~

~~iii. The distance to any skylit daylight area.~~

~~D. **DAYLIGHT AREA, SKYLIT** is the combined daylight area under each skylight without double counting overlapping areas. The daylight area under each skylight is bounded by the rough opening of the skylight, plus horizontally in each direction the smallest of:~~

~~i. 70 percent of the floor-to-ceiling height; or~~

~~ii. The distance to any primary sidelit area, or the daylight area under rooftop monitors; or~~

~~iii. The distance to any permanent partition or permanent rack which is farther away than 70 percent of the distance between the top of the permanent partition or permanent rack and the ceiling.~~

2. Luminaires providing general lighting that are in or partially in the skylit daylit zones and/or the primary sidelit daylit zones, shall be controlled independently by an automatic daylighting control device that meets the applicable requirements of Section 119 and is installed in accordance with Section 131(c) 2D

EXCEPTION 1 to Section 131(c) 2: Total wattage of general lighting that is in, or partially in, a skylit daylit zone and/or primary sidelit daylight zone is less than 120 Watts

EXCEPTION 2 to Section 131(c) 2: Parking garages.

A. All skylit daylit zones and primary sidelit daylit zones shall be shown on plan

B. Luminaires in the skylit daylit zone shall be controlled separately from those in the primary sidelit daylit zones

C. Luminaires that fall in a skylit and primary sidelit daylit zone shall be controlled as part of the skylit daylit zone

~~2. Luminaires providing general lighting that are in or are partially in the skylit daylight area and/or the primary sidelit daylight area, shall be controlled as follows:~~

~~A. Primary sidelit and skylit daylight areas shall have at least one lighting control that:~~

~~i. Controls at least 50 percent of the general lighting power in the primary sidelit and skylit daylight areas separately from other lighting in the enclosed space.~~

~~ii. Controls luminaires in primary sidelit areas separately from skylit areas.~~

~~**EXCEPTION to Section 131(c) 2A**: Primary sidelit and skylit daylight areas that have a combined area totaling less than or equal to 250 square feet within any enclosed space.~~

~~B. For all skylit daylight areas:~~

~~i. The skylit daylight area shall be shown on the plans.~~

~~ii. All of the general lighting in the skylit area shall be controlled independently by an automatic daylighting control device that meets the applicable requirements of Section 119.~~

~~iii. The automatic daylighting control shall be installed in accordance with Section 131(c)2D.~~

~~**EXCEPTION 1 to Section 131(c)2B**: Where the total skylit daylight area in any enclosed space is less than or equal to 2,500 square feet.~~

~~**EXCEPTION 2 to Section 131(c)2B**: Skylit daylight areas where existing adjacent structures obstruct direct beam sunlight for at least 6 hours per day during the equinox as calculated using computer or graphical methods.~~

~~**EXCEPTION 3 to Section 131(c)2B**: When the skylight effective aperture is greater than 4.0 percent, and all general lighting in the skylit area is controlled by a multi-level astronomical time switch that meets the requirements of Section 119(h) and that has an override switch that meets the requirements of Section 131(d)2.~~

~~**EXCEPTION 4 to Section 131(c)2B**: Skylit daylight areas where the effective aperture is less than 0.006. The effective aperture for skylit daylight areas is specified in Section 146(a)2E.~~

~~C. The primary sidelit area(s) shall be shown on the plans, and the general lighting in the primary sidelit areas shall be controlled independently by an automatic daylighting control device that meets the applicable requirements of Section 119 and is installed in accordance with Section 131(c) 2D.~~

~~**EXCEPTION 1 to Section 131(c) 2C**: Where the total primary sidelit daylight area in any enclosed space has an area less than or equal to 2,500 square feet.~~

~~**EXCEPTION 2 to Section 131(c) 2C**: Primary sidelit daylight areas where the effective aperture is less than 0.1. The effective aperture for primary sidelit daylight areas is specified in Section 146(a)2E.~~

~~**EXCEPTION 3 to Section 131(c) 2C**: Primary sidelit daylight areas where existing adjacent structures are twice as tall as their distance away from the windows.~~

~~**EXCEPTION 4 to Section 131(c) 2C**: Parking garages.~~

D. Automatic Daylighting Control Device Installation and Operation. Automatic daylighting control devices shall be installed and configured to operate according to all of the following requirements:

i. Automatic daylighting control devices shall have photosensors that are located so that they are not readily accessible in accordance with the designer's or manufacturer's instructions.

ii. The location where calibration adjustments are made to the automatic daylighting control device shall be readily accessible to authorized personnel, or located within 2 feet of a ceiling access panel that is no higher than 11 feet above floor level.

iii. Automatic daylighting controls shall be multi-level, including continuous dimming, and have at least ~~one control step that is between 50 to 70 percent of rated power of the controlled lighting~~ the number of control steps specified in Table 131-A

EXCEPTION 1 to Section 131(c) 2Diii:

Controlled lighting having a lighting power density less than 0.3 W/ft^2.

EXCEPTION 2 to Section 131(c)2Diii: When skylights are replaced or added to on an existing building with an existing general lighting system.

iv Under all daylight conditions in all areas served by the controlled lighting, the combined illuminance from the controlled lighting and daylight is not less than the illuminance from controlled lighting when no daylight is available.

v When all areas served by the controlled lighting are receiving daylight illuminance levels greater than 150 percent of the illuminance from controlled lighting when no daylight is available, the controlled lighting power consumption shall be no greater than 35 percent of the rated power of the controlled lighting.

(d) **Shut-off Controls**.

(unchanged)

SECTION 141 – PERFORMANCE APPROACH: ENERGY BUDGETS.

In order to meet the energy budget, a proposed building's use of TDV energy calculated under Subsection (b) must be no greater than the TDV energy budget calculated under Subsection (a).

(a) **Energy Budget**. The energy budget for a proposed building is the sum of the space-conditioning, lighting, and service water-heating budgets in Subdivisions 1, 2, and 3 of this subsection, expressed in Btu per square foot of conditioned floor area per year.

1. **Space-conditioning budget**.

(unchanged)

2. **Lighting budget.** The lighting budget is the TDV energy used for lighting in a standard building calculated with a method approved by the Commission (expressed in Btu per square foot of conditioned floor area per year), and assuming that:

   A. The lighting power density of the standard building, for areas where no lighting plans or specifications are submitted for permit and the occupancy of the building is known, is the maximum allowed lighting power density calculated according to Section 146(c)1; and

   B. The lighting power density of the standard building, for areas where no lighting plans or specifications are submitted for permit, and the occupancy of the building is not known, is 1.2 watts per square foot; and

   C. The lighting power density of the standard building, for areas where lighting plans and specifications are being submitted for permit, is the maximum allowed lighting power density calculated according to Section 146(c) 1, 2, or 3; and

   D. The lighting power density of the standard building is adjusted as described in the Nonresidential ACM Manual ~~for an astronomical timeclock when required by Section 131(c)2.~~ for the presence of automatic daylighting controls in the secondary sidelit zones as required by Section 146(d).

3. **Service water-heating budget**.

(unchanged)

(b) **TDV Energy Use of Proposed Building**. The TDV energy use of a proposed building is the sum of the space-conditioning, lighting, and service water-heating TDV energy use calculated in Subdivisions 1, 2, and 3 of this subsection, using the same Compliance software used to calculate the budget under Subsection (a), and expressed in Btu per square foot of conditioned floor area per year. If any feature of the proposed building, including, but not limited to, the envelope or the space-conditioning, lighting, or service water-heating system, is not included in the building permit application, the energy performance of the feature shall be assumed to be that of the corresponding feature calculated in Subsection (a).

1. **Space-conditioning TDV energy use**.

(unchanged)

2. **Lighting TDV energy use**. The lighting TDV energy use shall be calculated using a method approved by the Commission, and using the actual lighting power density calculated under Section 146(c), including reduction of wattage by the applicable lighting power adjustment factors specified in Section 146(a)2. The lighting power density shall also be adjusted as described in the Nonresidential ACM Manual for ~~an astronomical timeclock when required by Section 131(c)2.~~ for the presence of automatic daylighting controls in the secondary sidelit zones as required by Section 146(d).

3. **Service water-heating TDV energy use**.

(unchanged)

(c) **Calculation of Budget and Energy Use**.

(unchanged)

(d) **Relocatable Public School Buildings.**

(unchanged)

SECTION 143 – PRESCRIPTIVE REQUIREMENTS FOR BUILDING ENVELOPES

(a) **Envelope Component Approach.**

(unchanged)

(b) **Overall Envelope TDV Energy Approach.**

(unchanged)

(c) **Minimum ~~Skylight Area~~ Daylit Zone Requirement for Large Enclosed Spaces in Buildings with Three or Fewer Stories.** In climate zones 2 through 15, low rise conditioned or unconditioned enclosed spaces that are greater than 8,000 ft^2 directly under a roof with ceiling heights greater than 15 feet shall meet Sections 143(c)1-4 below.

1. At least 75% of the wattage of general lighting shall be in or partially in skylit daylit zones or primary sidelit daylit zones
2. All skylit daylit zones and the primary sidelit daylit zones shall be shown on plan
3. Luminaires in the skylit daylit zone shall be controlled separately from those in the primary sidelit daylit zones
4. Luminaires that fall in a skylit and primary sidelit daylit zone shall be controlled as part of the skylit daylit zone
5. All general lighting that is in, or partially in, skylit daylit zones or primary sidelit daylit zones shall be controlled using an automatic daylighting control device that meets the applicable requirements of Section 119 and is installed in accordance with Section 131(c) 2D

~~1. **Daylit Area.** At least one half of the floor area shall be in the skylit daylight area, the primary sidelit daylight area, or a combination of the skylit and primary sidelit daylight areas. The skylit and primary sidelit daylight areas shall be shown on the building plans. Skylit and primary sidelit daylight areas are defined in Section 131(c)1.~~

~~2. **Minimum Skylight Area or Effective Aperture.** Areas that are skylit shall have a minimum skylight area to skylit area ratio of at least 3.3 percent or minimum skylight effective aperture of at least 1.1 percent. Skylight effective aperture shall be determined as specified in Equation 146-C. If primary sidelit area is used to comply with Section 143(c)1, the primary sidelit daylight areas shall have an effective aperture greater than 10 percent. The effective aperture for primary sidelit daylight areas is specified in Section 146(a)2E.~~

~~3~~ 6. ~~**Skylight Characteristics.**~~ Skylights shall:

A. Have a glazing material or diffuser that has a measured haze value greater than 90 percent, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the Commission; and

B. If the space is conditioned, meet the requirements in Section 143(a)6 or 143(b).

~~4. **Controls.** Electric lighting in the daylit area shall be controlled as described in Section 131(c)2.~~

EXCEPTION 1to Section 143(c): Auditoriums, churches, movie theaters, museums, and refrigerated warehouses.

EXCEPTION 2 to Section 143(c): In buildings with unfinished interiors, future enclosed spaces where it is planned to have less than or equal to 8,000 square feet of floor area, or ceiling heights less than or equal to 15 feet, based on proposed future interior wall and ceiling locations as delineated in the plans. This exception shall not apply to these future enclosed spaces when interior walls and ceilings are installed for the first time, the enclosed space floor area is greater than 8,000 square feet, and the ceiling height is greater than 15 feet (see Section 149(b)1M). This exception shall not be used for S-1 or S-2 (storage), or for F-1 or F-2 (factory) occupancies.

EXCEPTION 3 to Section 143(c): Enclosed spaces having a designed general lighting system with a lighting power density less than 0.5 watts per square foot.

SECTION 146 – PRESCRIPTIVE REQUIREMENTS FOR INDOOR LIGHTING

A building complies with this section if the actual lighting power density calculated under Subsection (a) is no greater than the allowed indoor lighting power calculated under Subsection (c), lighting power trade-offs comply with Subsection (b) and general lighting in secondary sidelit zones comply with the lighting controls requirements in Subsection (d).

(a) **Calculation of Actual Indoor Lighting Power Density.** The actual indoor lighting power of the proposed building area is the total watts of all planned permanent and portable lighting systems; subject to the following specific requirements and adjustments under Subsections 1 through 4.

EXCEPTION to Section 146(a) Up to 0.2 watts per square foot of portable lighting for office areas shall not be required to be included in the calculation of actual indoor lighting power density.

1. **Multiple interlocked lighting systems serving a space.** When multiple interlocked lighting systems serve an auditorium, convention center, conference room, multipurpose room, or theater, the watts of all systems except the system with the highest wattage may be excluded if the lighting systems are interlocked with a non-programmable double throw switch to prevent simultaneous operation.
2. **Reduction of wattage through controls.** The controlled watts of any luminaire may be reduced by the number of controlled watts times the applicable Power Adjustment Factor (PAF) from TABLE 146-C if:
   A. The control complies with the applicable requirements of Section 119; and
   B. At least 50 percent of the light output of the luminaire is within the applicable space listed in TABLE 146-C; and
   C. Except as noted in TABLE 146-C, only one PAF is used for the luminaire; and
   D. Multi-level occupant sensors used to qualify for the PAF in any space less than or equal to 250 square feet enclosed by floor-to-ceiling partitions, or any size classroom, corridor, conference or waiting room, shall meet the applicable requirements of Section 119. The multi-level occupancy sensor shall be installed to meet all the multi-level and uniformity requirements of Section 131(b) for the controlled lighting. The first stage shall activate between 30-70 percent of the lighting power in a room either through an automatic or manual action, and may be a switching or dimming system. After that event occurs any of the following actions shall be assigned to occur when manually called to do so by the occupant:
      i. Activating the alternate set of lights.
      ii. Activating 100 percent of the lighting power.
      iii. Deactivating all lights.

~~E. For automatic daylighting control PAFs, the luminaire(s) shall be controlled by the automatic daylighting control(s) complying with applicable requirements of Section 119 and installed according to Section 131(c)2D. The PAF's are calculated based on PAFs described below in Section 146(a) 2E (i through iii), and at least 50 percent of the controlled luminaires shall be located within the daylit area. Daylight controls shall not control lamps that are outside of the daylight area (skylit, primary sidelit, and/or secondary sidelit daylight areas). The daylight area associated with the daylighting control receiving the PAF shall be shown on the building plans. PAFs shall not be available for automatic daylighting controls required by Section 131(c)2B and C.~~

~~i. **Power Adjustment Factor for controlling Primary Sidelit Daylight Areas:**~~

~~The PAF for the primary sidelit daylight area shall be used only if the daylighting control is separately controlling lighting within the primary sidelit daylight area. If lighting in the primary sidelit area is controlled together with lighting in the secondary sidelit area, the PAF for the secondary sidelit area in accordance with Section 146(a) 2Eii shall be used. The PAF is a function of the effective aperture of the primary sidelit daylight area in accordance with Equation 146-A.~~

EQUATION 146-A – EFFECTIVE APERTURE OF THE PRIMARY SIDELIT AREA

$$\text{Primary Sidelit Effective Aperture} = \frac{\sum \text{Window Area} \times \text{VT}}{\text{Primary Sidelit Daylight Area}}$$

Where:

Window Area = rough opening of windows adjacent to the sidelit area, ft²

Window VT = visible light transmittance of window, no units

Primary Sidelit Daylight Area = see Section 131(c)1 daylight area, primary sidelit

ii. **Power Adjustment Factor for controlling secondary sidelit areas:**

To qualify for the secondary sidelit daylight area PAF, the lighting in the secondary sidelit daylight area, or the lighting in the combined primary and secondary sidelit areas shall be controlled separately from lighting outside of these sidelit areas. The PAF is a function of the effective aperture of the secondary sidelit area in accordance with Equation 146-B.

EQUATION 146-B – EFFECTIVE APERTURE OF THE SECONDARY SIDELIT AREA

$$\text{Secondary Sidelit Effective Aperture} = \frac{\sum \text{Window Area} \times \text{VT}}{\text{Secondary Sidelit Daylight Area} + \text{Primary Sidelit Daylight Area}}$$

Where:

Window Area = rough opening of windows adjacent to the sidelit area, ft²

Window VT = visible light transmittance of window, no units

Primary Sidelit Daylight Area = see Section 131(c)1B daylight area, primary sidelit

Secondary Sidelit Daylight Area = see Section 131(c)1C daylight area, secondary sidelit.

iii. **Power Adjustment Factor for controlling skylit areas.**

The PAF is a function of the lighting power density of the general lighting in the space and the effective aperture of the skylights shall be determined in accordance with Equation 146-C.

EQUATION 146-C – EFFECTIVE APERTURE OF SKYLIGHTS

$$\text{Skylit Effective Aperture} = \frac{0.85 \times \sum \text{Skylight Area} \times \text{VT} \times \text{Well Efficiency}}{\text{Skylit Daylight Area}}$$

Where:

Skylight Area = the area of each individual skylight

Skylit Daylight Area = see Section 131(c)1D daylight area, skylit

VT = visible light transmittance. The VT shall include all skylighting system accessories including diffusers, louvers and other attachments that impact the diffusion of skylight into the space. The visible light transmittance of movable accessories shall be rated in the full open position. When the visible light transmittance of glazing and accessories are rated separately, the overall glazing transmittance is the product of the visible light transmittances of the glazings and accessories.

Well Efficiency equals the ratio of the amount of visible light leaving a skylight well to the amount of visible light entering the skylight well. Well Efficiency shall be determined from Equation 146-F or

~~Table 146-B for specular and tubular light wells and from Table 146-A for all other light wells, based on the weighted average reflectance of the walls of the well and the geometry of the light well, or other test method approved by the Commission.~~

~~The well efficiency for non-specular or non-tubular light wells is based on the average weighted reflectance of the walls of the light well and the well cavity ratio. The well cavity ratio (WCR) is determined by the geometry of the skylight well and shall be determined using either Equation 146-D or Equation 146-E.~~

~~*EQUATION 146-D WELL CAVITY RATIO FOR RECTANGULAR WELLS*~~

$$\text{~~WCR} = \left(\frac{5 \times \text{well height} \times (\text{well length} + \text{well width})}{\text{well length} \times \text{well width}} \right)\text{~~; or}$$

~~*EQUATION 146-E WELL CAVITY RATIO FOR NON-RECTANGULAR-SHAPED WELLS:*~~

$$\text{~~WCR} = \left(\frac{2.5 \times \text{well height} \times \text{well perimeter}}{\text{well area}} \right)$$

~~Where the well perimeter and well area are measured at the bottom of the well.~~

~~*EQUATION 146-F WELL EFFICIENCY FOR SPECULAR TUBULAR LIGHT WELLS:*~~

$$WE_{Tube} = \rho^{\left(2.2 * \frac{L}{D}\right)}$$

~~Where:~~

~~ρ = specular reflectance of interior light well wall~~

~~L/D = ratio of light well length to light well interior diameter~~

~~F. PAFs shall not be available for demand responsive lighting controls required by Section 131(g).~~

3. **Lighting wattage excluded**.

(unchanged)

4. **Luminaire Power.**

(unchanged)

(b) **Indoor Lighting Power Trade-offs.**

(unchanged)

(c) **Calculation of Allowed Indoor Lighting Power Density.**

(unchanged)

(d) **Automatic Daylighting Controls in Secondary Daylit Zones.** Luminaires providing general lighting that are in, or partially in, the secondary sidelit daylit zones, and not included in the primary sidelit daylit zones shall be controlled independently by an automatic daylighting control device that meets the applicable requirements of Section 119 and is installed in accordance with Section 131(c) 2C

EXCEPTION 1 to Section 146(d): Total wattage of general lighting that is in or partially in a secondary sidelit daylight zone(s) is less than 120 Watts

EXCEPTION 2 to Section 146(d): Parking garages.

1. All secondary sidelit daylit zones shall be shown on plan.
2. Luminaires in the secondary sidelit daylit zones shall be controlled separately from those in the primary sidelit daylit zones and skylit daylit zones.
3. Luminaires that fall in a skylit and secondary sidelit daylit zone shall be controlled as part of the skylit daylit zone

TABLE 146-A WELL EFFICIENCY FOR NON-SPECULAR OR NON-TUBULAR LIGHT WELLS

-	light well wall reflectance					
WCR	ρ = 99%	ρ = 90%	ρ = 80%	ρ = 70%	ρ = 60%	ρ = 40%
0	1.00	1.00	1.00	1.00	1.00	1.00
1	1.00	0.98	0.96	0.94	0.92	0.89
2	0.99	0.95	0.91	0.88	0.84	0.78
4	0.99	0.90	0.82	0.76	0.70	0.61
6	0.98	0.85	0.74	0.65	0.58	0.48
8	0.97	0.79	0.66	0.56	0.49	0.38
10	0.96	0.74	0.59	0.49	0.41	0.31
12	0.95	0.70	0.53	0.43	0.35	0.26
14	0.95	0.66	0.48	0.38	0.31	0.22
16	0.94	0.62	0.44	0.34	0.27	0.18
18	0.93	0.59	0.41	0.31	0.24	0.16
20	0.92	0.56	0.38	0.28	0.21	0.14

TABLE 146-B WELL EFFICIENCY FOR SPECULAR TUBULAR LIGHT WELLS

-	Light Well Reflectance (ρ)						
L/D	ρ = 99%	ρ = 97%	ρ = 95%	ρ = 92%	ρ = 90%	ρ = 85%	ρ = 80%
0.5	0.99	0.97	0.95	0.91	0.89	0.84	0.78
1.0	0.98	0.94	0.89	0.83	0.79	0.70	0.61
1.5	0.97	0.90	0.84	0.76	0.71	0.58	0.48
2.0	0.96	0.87	0.80	0.69	0.63	0.49	0.37
2.5	0.95	0.85	0.75	0.63	0.56	0.41	0.29
3.0	0.94	0.82	0.71	0.58	0.50	0.34	0.23
3.5	0.93	0.79	0.67	0.53	0.44	0.29	0.18
4.0	0.92	0.76	0.64	0.48	0.39	0.24	0.14
4.5	0.91	0.74	0.60	0.44	0.35	0.20	0.11
5.0	0.90	0.71	0.57	0.40	0.31	0.17	0.09
5.5	0.88	0.68	0.52	0.35	0.26	0.13	0.06
6.0	0.87	0.65	0.48	0.30	0.22	0.10	0.04

TABLE 146-C LIGHTING POWER ADJUSTMENT FACTORS

TYPE OF CONTROL		TYPE OF SPACE	FACTOR
Multi-level occupant sensor (see Note 2) combined with multi-level circuitry and switching in accordance with Section 146(a)2D		Any space ≤ 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, corridor, conference or waiting room.	0.20
Multi-level occupant sensor (see Note 2) that reduces lighting power at least 50% when no persons are present. May be a switching or dimming (see Note 3) system.		Hallways of hotels/motels , multi-family, dormitory, and senior housing	0.25
		Commercial and Industrial Storage stack areas (max. 2 aisles per sensor)	0.15
		Library Stacks (maximum 2 aisles per sensor)	0.15
Dimming system	Manual	Hotels/motels, restaurants, auditoriums, theaters	0.10
	Multiscene programmable	Hotels/motels, restaurants, auditoriums, theaters	0.20
Demand responsive lighting control that reduces lighting power consumption in response to a demand response signal. (See Note 1)		All building types	0.05
Manual dimming of dimmable electronic ballasts. (see Note 3)		All building types	0.10
Demand responsive lighting control that reduces lighting power consumption in response to a demand response signal when used in combination with manual dimming of dimmable electronic ballasts (see Note 1 and 3).		All building types	0.15
Combined controls	Multi-level occupant sensor (see Note 2) combined with multi-level circuitry and switching in accordance with Section 146(a)2D combined with automatic multi-level daylighting controls	Any space ≤ 250 square feet within a daylit area and enclosed by floor-to-ceiling partitions, any size classroom, corridor, conference or waiting room. The PAF may be added to the daylighting control credit	0.10
	Manual dimming of dimmable electronic ballasts (see Note 3) when used in combination with a multi-level occupant sensor (see Note 2) combined with multi-level circuitry and switching in accordance with Section 146(a)2D.	Any space ≤ 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, corridor, conference or waiting room	0.25

~~Automatic multi-level daylighting controls (See Note 1)~~

~~Total primary sidelit daylight areas less than 2,500 ft² in an enclosed space and all secondary sidelit areas. (see Note 4)~~

	~~Effective Aperture~~			
~~General Lighting Power Density (W/ft²)~~	~~>10% and ≤20%~~	~~>20% and ≤35%~~	~~>35% and ≤65%~~	~~> 65%~~
~~All~~	~~0.12~~	~~0.20~~	~~0.25~~	~~0.30~~

~~Total skylit daylight areas in an enclosed space less than 2,500 square feet, and where glazing material or diffuser has ASTM D1003 haze measurement greater than 90%~~

	~~Effective Aperture~~			
~~General Lighting Power Density (W/ft²)~~	~~0.6% ≤ EA < 1%~~	~~1% ≤ EA < 1.4%~~	~~1.4% ≤ EA < 1.8%~~	~~1.8% ≤ EA~~
~~LPD < 0.7~~	~~0.24~~	~~0.30~~	~~0.32~~	~~0.34~~
~~0.7 ≤ LPD< 1.0~~	~~0.18~~	~~0.26~~	~~0.30~~	~~0.32~~
~~1.0 ≤ LPD < 1.4~~	~~0.12~~	~~0.22~~	~~0.26~~	~~0.28~~
~~1.4 ≤ LPD~~	~~0.08~~	~~0.20~~	~~0.24~~	~~0.28~~

NOTES FOR TABLE 146-C:

1. PAFs shall not be available for lighting controls required by Title 24, Part 6.
2. To qualify for the PAF the multi-level occupant sensor shall comply with the applicable requirements of Section 119.
3. To qualify for the PAF all dimming ballasts for T5 and T8 linear fluorescent lamps shall be electronic and shall be certified to the Commission with a minimum RSE in accordance with Table 146-D.
4. ~~If the primary sidelit daylight area and the secondary sidelit daylight area are controlled together, the PAF is determined based on the secondary sidelit effective aperture for both the primary sidelit daylight area and the secondary sidelit daylight area.~~

SECTION 149 – ADDITIONS, ALTERATIONS, AND REPAIRS TO EXISTING BUILDINGS

To be determined

6. Bibliography and Other Research

List and describe each of the research studies, reports, and personal communications that provide background for this research. Identify all resources that have been pursued to further this measure. Identify all "experts" that were involved in further developing the change, all research and analysis reports and documents that were reviewed, and all industry standards that were consulted (e.g., ASTM, UL, ASHRAE test procedures, etc.). Include research that is underway that addresses the measure/change. Indicate if data or information will be produced in time to be used in this update of the Standards.

7. Appendices A

Detailed results for each of the properties surveyed in the rooftop survey are presented below in Figure 13, Figure 14 and Figure 15.

Survey #	Roof Area (sf)	Duct Area (sf)	Other Obstruction Area (sf)	Total Obstruction Area (sf)	% Obstructed	Approximate Skylit Area
1	78475	0	6225	6225	8%	NA
2	7904	0	0	0	0%	NA
3	46609	0	942	942	2%	NA
4	17000	0	163	163	1%	NA
5	5379	335	0	335	6%	NA
6	26420	0	1360	1360	5%	NA
7	29249	0	857	857	3%	60%
8	5932	0	503	503	8%	NA
9	3893	0	380	380	10%	NA
10	7588	0	0	0	0%	NA
11	9054	0	0	0	0%	NA
12	12459	0	700	700	6%	NA
13	5475	0	119	119	2%	NA
14	7463	0	400	400	5%	NA
15	1591	0	48	48	3%	NA
16	9774	0	0	0	0%	NA
17	17887	0	140	140	1%	NA
18	2053	0	34	34	2%	NA
19	2150	0	30	30	1%	NA
20	20274	120	80	200	1%	NA
21	5040	0	50	50	1%	NA
22	24014	0	337	337	1%	NA
23	6422	0	50	50	1%	NA
24	10198	0	24	24	0%	NA
25	4600	0	50	50	1%	NA

Figure 13: Detailed Rooftop Survey Results (part 1 of 3)

Survey #	Roof Area (sf)	Duct Area (sf)	Other Obstruction Area (sf)	Total Obstruction Area (sf)	% Obstructed	Approximate Skylit Area
26	22403	0	65	65	0%	NA
27	6099	0	86	86	1%	NA
28	20630	0	48	48	0%	NA
29	6024	0	0	0	0%	NA
30	6705	0	100	100	1%	NA
31	50267	0	250	250	0%	NA
32	145125	0	0	0	0%	NA
33	46087	0	520	520	1%	NA
34	3352	0	100	100	3%	NA
35	3960	0	0	0	0%	NA
36	2353	0	40	40	2%	NA
37	7441	0	490	490	7%	NA
38	23935	0	1343	1343	6%	NA
39	110089	100	1200	1300	1%	NA
40	5818	0	160	160	3%	NA
41	50052	0	220	220	0%	NA
42	18727	0	365	365	2%	NA
43	11073	0	600	600	5%	NA
44	25238	0	525	525	2%	NA
45	108178	0	2140	2140	2%	100%
46	5109	0	45	45	1%	NA
47	6999	751	0	751	11%	NA
48	39919	0	625	625	2%	NA
49	31705	0	1279	1279	4%	NA
50	38193	236	1518	1754	5%	NA

Figure 14: Detailed Rooftop Survey Results (part 2 of 3)

Survey #	Roof Area (sf)	Duct Area (sf)	Other Obstruction Area (sf)	Total Obstruction Area (sf)	% Obstructed	Approximate Skylit Area
51	17151	0	0	0	0%	100%
52	67176	0	0	0	0%	NA
53	12419	0	216	216	2%	NA
54	51472	0	340	340	1%	60%
55	49733	0	467	467	1%	NA
56	24615	0	0	0	0%	NA
57	20922	0	390	390	2%	NA
58	26630	0	0	0	0%	NA
59	20600	0	0	0	0%	40%
60	11734	0	40	40	0%	100%
61	14940	0	780	780	5%	NA
62	40015	0	2080	2080	5%	100%
63	16628	0	100	100	1%	NA
64	145421	0	2700	2700	2%	NA
65	154807	0	1080	1080	1%	100%
66	12477	0	80	80	1%	NA
67	20777	0	132	132	1%	80%
68	72392	0	520	520	1%	60%
69	68533	0	1300	1300	2%	60%
70	125181	0	3419	3419	3%	NA

Figure 15: Detailed Rooftop Survey Results (part 3 of 3)