DOCKETED	
Docket Number:	19-BSTD-03
Project Title:	2022 Energy Code Pre-Rulemaking
TN #:	236965
Document Title:	Statewide Utility Codes and Standards Enhancement Team Comments - Final NR CEH CASE Report Addendum
Description:	N/A
Filer:	System
Organization:	Statewide Utility Codes and Standards Enhancement Team
Submitter Role:	Public
Submission Date:	3/3/2021 2:50:46 PM
Docketed Date:	3/3/2021

Comment Received From: Statewide Utility Codes and Standards Enhancement Team
Submitted On: 3/3/2021
Docket Number: 19-BSTD-03

Statewide Utility Codes and Standards Enhancement Team Comments - Final NR CEH CASE Report Addendum

Additional submitted attachment is included below.

Controlled Environment Horticulture

2022-NR-COV-PROC4-F | Covered Processes | March 2021 ADDENDUM

Prepared by Energy Solutions and Cultivate Energy and Optimization

Please submit comments to info@title24stakeholders.com.

This report was prepared by the California Statewide Codes and Standards Enhancement (CASE) Program that is funded, in part, by California utility customers under the auspices of the California Public Utilities Commission.

Document Information

Category:	**Codes and Standards**
Keywords:	Statewide Codes and Standards Enhancement (CASE) Initiative; California Statewide Utility Codes and Standards Team; Codes and Standards Enhancements; 2022 California Energy Code; 2022 Title 24, Part 6; efficiency; horticultural lighting; dehumidification; greenhouse envelope.
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Addendum to Controlled Environment Horticulture – Final CASE Report

The Statewide CASE Team originally proposed a horticultural lighting minimum efficacy of 2.1 micromoles (µmol) per joule (J) for indoor luminaires and 1.7 µmol/J for greenhouse luminaires in the Final CASE Report that was published in October 2020. This proposal also included time-switch and multilevel lighting controls for both indoor growing facilities and greenhouses and designing electrical power distribution systems serving controlled environment horticulture (CEH) spaces to allow energy use monitoring of aggregate horticultural lighting load.

The proposed lighting efficacy requirements in the Final CASE Report applied to new construction, additions to CEH facilities, alterations that change the occupancy classification of a building (for example, a warehouse converted to a CEH facility), and lighting alterations that involve replacing 10 percent or more of the horticultural luminaires serving an enclosed space. For lighting alterations involving replacement of 10 percent or more of luminaires serving an enclosed space, only the newly installed lighting would be subject to the proposed code. Lighting alterations involving replacing lamps only, ballasts only, or drivers only would not be subject to the proposed code.

Since the Final CASE Report's publication in October 2020, the Statewide CASE Team determined that changes to the minimum efficacy requirements are needed based on extensive stakeholder suggestions. Stakeholders included the cannabis grower community, trade associations, and energy consultants that serve the indoor CEH sector. The Statewide CASE Team also conducted targeted outreach to conventional greenhouse agricultural interests including producers of leafy greens and other food crops to understand potential impacts to their industry. This adjustment only impacts the efficacy of lighting for growing plants in indoor controlled environment horticulture applications. No change in lighting efficacy stringency is recommended for the greenhouse lighting proposal. Minor language clarifications for impacted products are also added. Highlights of the suggestions received by industry members are noted below:

1. Stakeholders raised concerns regarding the proposed 2.1 micromole per joule luminaire efficacy. One of their most prominent concerns was the ability of small cannabis growers to afford the high first cost of LED lighting while suffering from a lack of access to capital.
2. Stakeholders also expressed reluctance to switch to LED until more research is completed. These stakeholders highlighted that there is limited publicly available data comparing the yield and quality performance of LED

grow lighting to conventional grow lighting such as ceramic metal halide (CMH) and High-pressure sodium (HPS) lighting.

3. The California legal cannabis industry is still in its early stages, and a strict energy efficiency mandate may slow the growth of the industry and potential tax revenues produced by the industry.

In lowering the required minimum PPE from 2.1 to 1.9 µmol/J for indoor horticulture luminaires and lamps that are a part of luminaires, the proposal now will allow indoor growers to use the highly efficient doubled-ended HPS grow lights in addition to LEDs. Some growers expressed more confidence in the outcomes and experience with HPS lights than LEDs. After additional discussions with the Energy Commission, it was determined that the reduced minimum efficacy requirement would be more feasible for the market while the cost of LED horticultural luminaires continues to drop, confidence increases in the ability of LEDs to provide high yields of high-quality product, the industry matures, and additional data is made available.

Updated Recommendation for Horticultural Lighting Minimum Efficacy Proposal

The Statewide CASE Team recommended revisions to code language in Sections 120.6(h)3, 120.6(h)7, and 100.1 which were presented in the Final CASE Report as described below.

- Section 120.6(h)3 was revised to require horticultural luminaires with removable lamps to have lamps with a lamp PPE of at least 1.9 µmol/J, and to require that all other horticultural luminaires have a luminaire PPE of at least 1.9 µmol/J.
- Section 120.6(h)7 was revised to require horticultural luminaires with removable lamps have lamps with a lamp PPE of at least 1.7 µmol/J, and to require that all other horticultural luminaires have a luminaire PPE of at least 1.7 µmol/J.
- Section 100.1 was updated with two definitions to clarify the meaning of lamp photosynthetic photon efficacy and luminaire photosynthetic photon efficacy.

Updated Savings

The Statewide CASE Team conducted additional analysis to demonstrate the savings impact of lowering the required PPE levels from 2.1 µmol/J to 1.9 µmol/J and creating the path for lamp efficacy. The updated minimum efficacy requirements for indoor and greenhouse horticultural lighting affect the per-unit energy savings, statewide energy savings, and cost-effectiveness. Several new assumptions were utilized in addition to the existing assumptions presented in the Final CASE Report.

The updated indoor lighting energy savings analysis assumes that 20 percent of growers would install LED luminaires with a luminaire efficacy of at least 1.9 µmol/J and 80 percent of growers would be installing HPS products with a lamp efficacy of at least 1.9 µmol/J. For HPS lamp products, the Statewide CASE Team made an additional correction to account for the impact of ballast inefficiencies, resulting in a full luminaire efficacy of 1.70 µmol/J for compliant HPS products. Lamp efficacy does not account for ballast losses or optical losses of the luminaire, so a 0.2 µmol/J correction factor was utilized on lamp efficacy to obtain luminaire efficacy. Combining the expected market share of these two compliance pathways resulted in a blended luminaire PPE of 1.74 µmol/J. This blended luminaire PPE was used in the updated indoor lighting savings calculations and is a conservative assumption as there is evidence that the market prevalence of LEDs will be above the 20 percent when these requirements come into effect. A study from the Cannabis Business Times 2020 State of the Lighting Market report found that 38 percent of growers plan on implementing LED lighting in the next 12 months during the flowering period (U.S. DOE 2020) (Cannabis Business Times 2020). The study also found a rapid increase in LED adoption from 4 to 11 percent in the last three years (2018 to 2020)

For greenhouse lighting energy savings analysis, the Statewide CASE Team assumed that 80 percent of growers would meet the requirement by using a double-ended HPS lamps with PPE of 1.9 µmol/J while 20 percent would use CMH lamps with a PPE of 1.7 µmol/J. In both of these cases, the Statewide CASE Team used a 0.2 µmol/J correction factor to account for ballast and optical losses for a blended luminaire PPE of 1.66 µmol/J.

The baseline assumptions remain unchanged from what was done in the Final CASE Report. As noted in Table 25 and 26 of Section 4.1.1, the baseline PPE assumed for the purposes of the energy savings analysis was 1.02 µmol/J for both greenhouses and indoor grows. As Table 9 of the Final CASE Report shows, single-ended HPS lamps, CMH, and fluorescent luminaires have PPEs around 1.0 µmol/J.

The following tables detail the savings and cost effectiveness of the updated horticultural lighting proposal. The submeasures are still cost effective across all climate zones. With a 15-year benefit-to-cost ratio ranging from 6.9 to 8.4 as shown by Table 5, the simple payback period for indoor facilities ranges is roughly 2 years depending on climate zone. For greenhouses, with a 15-year benefit-to-cost ratio ranging from 2.0 to 3.5 as shown by Table 6, the simple payback period ranges from 4 to 8 years.[1]

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[1] Please note that costs included in this calculation have a discount rate and determining a simple payback period does not factor this in.

As can be seen from the below tables, the indoor lighting proposal yields significantly more savings than the greenhouse proposal. This occurs primarily for two reasons. First, as noted in Section 4.1.1 of the Final CASE Report, indoor grows have lights on for a longer period of time compared to greenhouses which utilize sunlight for much of the day. Additionally, the higher PPE of 1.9 µmol/J will lead to higher savings for indoor grows since the greenhouse level of 1.7 µmol/J was compared to the same baseline PPE level.

Table 1: First-Year Energy Impacts Per Square Foot of Canopy – Indoor Lighting

Climate Zone	Electricity Savings (kWh/ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Natural Gas Savings (therms/ ft^2)	TDV Energy Savings (TDV kBtu/ ft^2)
1	169.3	0.010	N/A	3,801.2
2	171.7	0.010	N/A	4,295.4
3	170.9	0.011	N/A	4,077.5
4	172.3	0.011	N/A	4,390.6
5	171.1	0.010	N/A	3,956.0
6	172.7	0.011	N/A	4,261.3
7	172.2	0.011	N/A	4,062.9
8	173.2	0.011	N/A	4,576.3
9	173.4	0.011	N/A	4,573.4
10	174.0	0.011	N/A	4,418.5
11	173.5	0.011	N/A	4,341.3
12	172.8	0.010	N/A	4,282.4
13	173.7	0.011	N/A	4,335.8
14	173.9	0.010	N/A	4,513.5
15	177.8	0.011	N/A	4,481.9
16	169.7	0.010	N/A	3,842.9

Table 2: First-Year Energy Impacts Per Square Foot of Canopy – Greenhouse Lighting

Climate Zone	Electricity Savings (kWh/ ft^2)	Peak Electricity Demand Reductions (kW/ ft^2)	Natural Gas Savings (therms/ ft^2)	TDV Energy Savings (TDV kBtu/ ft^2)
1	22.3	0.002	N/A	575.7
2	17.9	0.002	N/A	456.1
3	18.0	0.002	N/A	461.4
4	17.0	0.002	N/A	431.5
5	15.4	0.002	N/A	402.7
6	15.8	0.002	N/A	413.5
7	14.9	0.002	N/A	376.2
8	15.7	0.002	N/A	427.0
9	15.3	0.002	N/A	399.9
10	15.1	0.002	N/A	383.8
11	18.0	0.002	N/A	451.8
12	17.9	0.002	N/A	448.0
13	17.5	0.002	N/A	441.0
14	13.0	0.002	N/A	319.4
15	13.6	0.002	N/A	331.4
16	16.9	0.002	N/A	435.9

Table 3: 2023 PV TDV Energy Cost Savings Over 15-Year Period of Analysis Per Square Foot of Canopy – New Construction, Alterations, and Additions Indoor

Climate Zone	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	$338	$0	$338
2	$382	$0	$382
3	$363	$0	$363
4	$391	$0	$391
5	$352	$0	$352
6	$379	$0	$379
7	$362	$0	$362
8	$407	$0	$407
9	$407	$0	$407
10	$393	$0	$393
11	$386	$0	$386
12	$381	$0	$381
13	$386	$0	$386
14	$402	$0	$402
15	$399	$0	$399
16	$342	$0	$342

Table 4: 2023 PV TDV Energy Cost Savings Over 15-Year Period of Analysis Per Square Foot of Canopy – New Construction, Alterations, and Additions Greenhouse

Climate Zone	15-Year TDV Electricity Cost Savings (2023 PV$)	15-Year TDV Natural Gas Cost Savings (2023 PV$)	Total 15-Year TDV Energy Cost Savings (2023 PV$)
1	$51	$0	$51
2	$41	$0	$41
3	$41	$0	$41
4	$38	$0	$38
5	$36	$0	$36
6	$37	$0	$37
7	$33	$0	$33
8	$38	$0	$38
9	$36	$0	$36
10	$34	$0	$34
11	$40	$0	$40
12	$40	$0	$40
13	$39	$0	$39
14	$28	$0	$28
15	$29	$0	$29
16	$39	$0	$39

Table 5: 15-Year Cost-Effectiveness Summary Per Square Foot of Canopy – Indoor Lighting

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	$ 338.30	$ 48.73	6.9
2	$ 382.29	$ 48.73	7.8
3	$ 362.90	$ 48.73	7.4
4	$ 390.76	$ 48.73	8.0
5	$ 352.09	$ 48.73	7.2
6	$ 379.26	$ 48.73	7.8
7	$ 361.60	$ 48.73	7.4
8	$ 407.29	$ 48.73	8.4
9	$ 407.04	$ 48.73	8.4
10	$ 393.25	$ 48.73	8.1
11	$ 386.38	$ 48.73	7.9
12	$ 381.14	$ 48.73	7.8
13	$ 385.89	$ 48.73	7.9
14	$ 401.70	$ 48.73	8.2
15	$ 398.89	$ 48.73	8.2
16	$ 342.02	$ 48.73	7.0

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 2020). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost. Includes PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis. Costs are discounted at a real (inflation-adjusted) three percent rate and if PV of proposed maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

Table 6: 15-Year Cost-Effectiveness Summary Per Square Foot of Canopy – Greenhouse Lighting

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings[a] (2023 PV$)	Costs Total Incremental PV Costs[b] (2023 PV$)	Benefit-to-Cost Ratio
1	$ 51.24	$ 14.50	3.5
2	$ 40.60	$ 14.50	2.8
3	$ 41.06	$ 14.50	2.8
4	$ 38.41	$ 14.50	2.6
5	$ 35.84	$ 14.50	2.5
6	$ 36.80	$ 14.50	2.5
7	$ 33.48	$ 14.50	2.3
8	$ 38.00	$ 14.50	2.6
9	$ 35.59	$ 14.50	2.5
10	$ 34.16	$ 14.50	2.4
11	$ 40.21	$ 14.50	2.8
12	$ 39.88	$ 14.50	2.8
13	$ 39.25	$ 14.50	2.7
14	$ 28.43	$ 14.50	2.0
15	$ 29.49	$ 14.50	2.0
16	$ 38.79	$ 14.50	2.7

a. **Benefits: TDV Energy Cost Savings + Other PV Savings:** Benefits include TDV energy cost savings over the period of analysis (Energy + Environmental Economics 2020). Other savings are discounted at a real (nominal – inflation) three percent rate. Other PV savings include incremental first-cost savings if proposed first cost is less than current first cost. Includes PV maintenance cost savings if PV of proposed maintenance costs is less than PV of current maintenance costs.

b. **Costs: Total Incremental Present Valued Costs:** Costs include incremental equipment, replacement, and maintenance costs over the period of analysis. Costs are discounted at a real (inflation-adjusted) three percent rate and if PV of proposed maintenance costs is greater than PV of current maintenance costs. If incremental maintenance cost is negative, it is treated as a positive benefit. If there are no total incremental PV costs, the B/C ratio is infinite.

Table 7: Statewide Energy and Energy Cost Impacts – New Construction – Lighting

Climate Zone	Statewide New Construction Impacted by Proposed Change in 2023 (ft^2 of canopy)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMTherms)	15-Year Present Valued Energy Cost Savings (million 2023 PV$)
1	337,875	11.08	1.03	N/A	$24.24
2	502,266	16.11	1.51	N/A	$36.23
3	462,964	35.24	2.45	N/A	$75.65
4	60,974	6.14	0.40	N/A	$13.94
5	88,338	1.74	0.18	N/A	$3.94
6	288,303	7.57	0.69	N/A	$17.19
7	16,780	0.99	0.07	N/A	$2.10
8	100,695	16.37	1.00	N/A	$38.51
9	239,564	40.68	2.48	N/A	$95.47
10	16,245	2.55	0.16	N/A	$5.77
11	35,278	3.88	0.25	N/A	$8.63
12	168,313	24.05	1.50	N/A	$53.07
13	36,583	6.35	0.38	N/A	$14.10
14	92,694	14.99	0.91	N/A	$34.63
15	149,275	25.25	1.52	N/A	$56.65
16	82,311	1.98	0.20	N/A	$4.36
TOTAL	**2,678,458**	**214.98**	**14.73**	**N/A**	**$484.48**

a. First-year savings from all buildings completed statewide in 2023.

Table 8: Statewide Energy and Energy Cost Impacts – Alterations – Lighting

Climate Zone	Statewide Alterations Impacted by Proposed Change in 2023 (ft^2 of canopy)	First-Year[a] Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First-Year Natural Gas Savings (MMTherms)	15-Year Present Valued Energy Cost Savings (million 2023 PV$)
1	260,785	6.88	0.70	N/A	$15.42
2	382,302	8.96	0.97	N/A	$20.24
3	284,376	13.14	1.03	N/A	$28.55
4	32,490	2.07	0.15	N/A	$4.70
5	70,147	1.19	0.13	N/A	$2.75
6	223,227	4.43	0.45	N/A	$10.17
7	11,172	0.39	0.03	N/A	$0.83
8	33,458	4.93	0.30	N/A	$11.60
9	74,163	12.16	0.74	N/A	$28.54
10	5,720	0.77	0.05	N/A	$1.75
11	17,876	1.29	0.09	N/A	$2.87
12	66,716	7.46	0.48	N/A	$16.47
13	10,923	1.89	0.11	N/A	$4.20
14	31,174	4.51	0.28	N/A	$10.42
15	48,459	7.58	0.46	N/A	$16.99
16	64,558	1.26	0.14	N/A	$2.85
TOTAL	**1,617,544**	**78.91**	**6.14**	**N/A**	**$178.36**

a. First-year savings from all alterations completed statewide in 2023.

Table 9: Statewide Energy and Energy Cost Impacts – New Construction, Alterations, and Additions – Lighting

Construction Type	First-Year Electricity Savings (GWh)	First-Year Peak Electrical Demand Reduction (MW)	First - Year Natural Gas Savings (MMTherms)	15-Year Present Valued Energy Cost Savings (PV$ million)	First-year TDV Energy Savings (million TDV kBtu/yr)
New Construction	215.0	14.7	N/A	484.48	5,443.6
Additions and Alterations	78.9	6.1	N/A	178.36	2,004.0
TOTAL	**293.9**	**20.9**	N/A	**662.84**	**7,447.6**

Proposed Code Language

The Statewide CASE Team is proposing the following code change to Section 100.1 and 120.6(h). Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions) and represent language proposed in the Final CASE Report published in October 2020. Changes to the proposed language from the October 2020 Final CASE Report are marked with blue double underlining (new language) and double ~~strikethroughs~~ (deletions).

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

(…)

Photosynthetic photon efficacy (PPE) is photosynthetic photon flux divided by input electric power in units of micromoles per second per watt, or micromoles per joule as defined by ANSI/ASABE S640.

Lamp photosynthetic photon efficacy is the lamp photosynthetic photon flux divided by rated input electric power of the lamp in units of micromoles per second per watt, or micromoles per joule as defined by ANSI/ASABE S640.

Luminaire photosynthetic photon efficacy is the luminaire photosynthetic photon flux divided by rated input electric power of the luminaire in units of micromoles per second per watt, or micromoles per joule as defined by ANSI/ASABE S640.

Photosynthetic photon flux (PPF) is the rate of flow of photons between 400 to 700 nanometers in wavelength from a radiation source as defined by ANSI/ASABE S640.

(…)

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

(h) Mandatory Requirements for Controlled Environment Horticulture (CEH) Spaces

(…)

3. **Indoor Growing, Horticultural Lighting.** In a building with CEH spaces and with more than 40 kW of aggregate horticultural lighting load, the electric lighting systems used for plant growth and plant maintenance shall meet the following requirements:

   A. Luminaires ~~shall have~~ with removable lamps shall contain lamps with a lamp lamp photosynthetic photon efficacy of at least ~~2.1~~ 1.9 micromoles per joule ~~rated in accordance with ANSI / ASABE S640 for wavelengths from 400 to 700 nanometers~~; all other luminaires shall have a luminaire photosynthetic photon efficacy of at least 1.9 micromoles per joule.

   B. Time-switch lighting controls shall be installed and comply with Section 110.9(b)1, Section 130.4(a)4, and applicable sections of NA7.6.2.

   C. Multilevel lighting controls shall be installed and comply with Section 130.1(b).

(…)

7. **Greenhouses, Horticultural Lighting.** In a greenhouse with more than 40 kW of aggregate horticultural lighting load, the electric lighting system used for plant growth and plant maintenance shall meet the following requirements:

   A. Luminaires ~~shall have~~ with removable lamps shall contain lamps with a lamp photosynthetic photon efficacy of at least 1.7 micromoles per joule ~~rated in accordance with ANSI / ASABE S640 for wavelengths from 400 to 700 nanometers~~; all other luminaires shall have a luminaire photosynthetic photon efficacy of at least 1.7 micromoles per joule.

   B. Time-switch lighting controls shall be installed and comply with Section 110.9(b)1, Section 130.4(a)4, applicable sections of NA7.6.2.

   C. Multilevel lighting controls shall be installed and comply with Section 130.1(b).