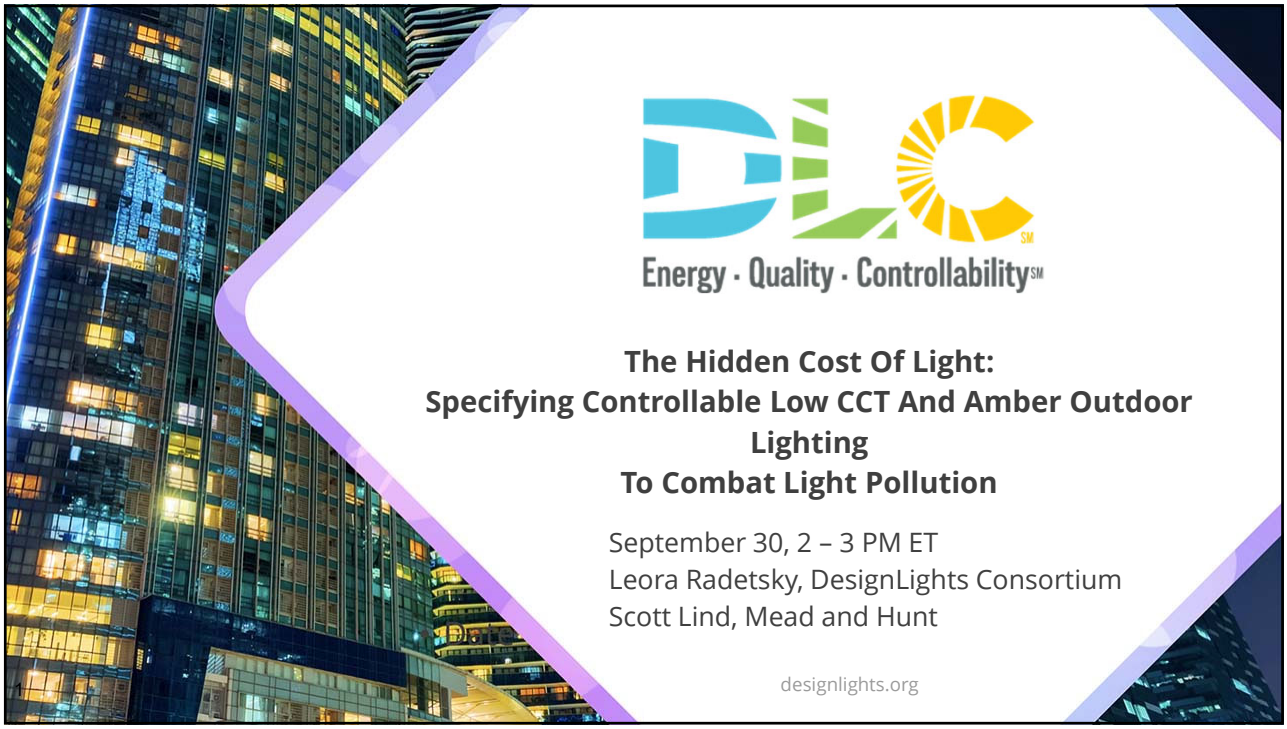

DLC
Energy · Quality · Controllability℠
The Hidden Cost Of Light:
Specifying Controllable Low CCT And Amber Outdoor Lighting
To Combat Light Pollution
September 30, 2 – 3 PM ET
Leora Radetsky, DesignLights Consortium
Scott Lind, Mead and Hunt
designlights.org
1

1


Light pollution is...
"an increased volume concentration of photons in the nocturnal environment above naturally expected values"
Arroyo et al. 2024
2

2

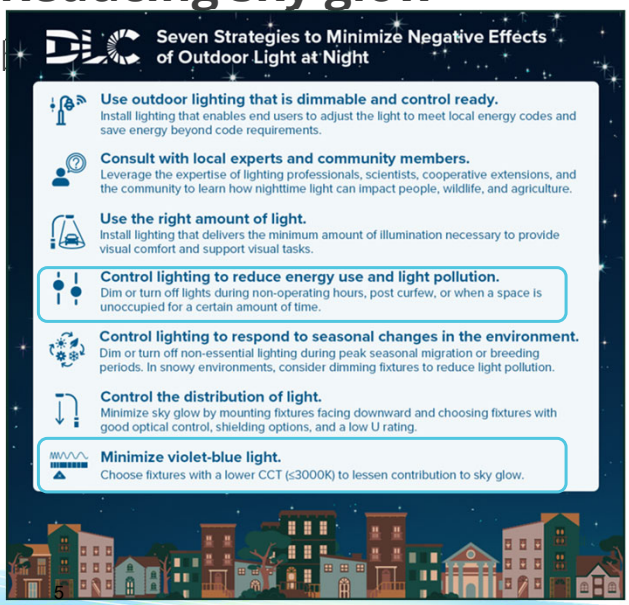

Light pollution is bad and getting worse
• Global satellite data indicates ALAN has increased by at least 2% each year over 25 years
• Citizen science data indicates that ALAN is growing by 9.6% each year over 10 years
• ALAN is causing negative ecological impacts and contributes to systemic inequities
3

3


What happens in Las Vegas doesn't stay in Las Vegas
planet
BELLAGIO
Lake Mead NRA Government Wash Viewpoint May 31, 2016 21.2 hours LMT
Visual Magnitudes per square arc-second
Full Resolution Mosaic
U.S. National Park Service
Night Skies Program
Data collected by: D Duriscoe, J Heller
Data processed by: D Duriscoe
https://www.nps.gov/subjects/nightskies/NSQreport.html?DNIGHT=LAKE160601
Hammer-Aitoff Equal Area Projectic
4
ThePhoto by PhotoAuthor is licensed under CC BY-SA

4

Reducing sky glow



Seven Strategies to Minimize Negative Impacts of Outdoor Light at Night

7 Strategies

5

5

Light Usage for Night Applications (LUNA)

- Address the increasing global issue of light pollution
- Educate end users on impacts and solutions
- Focus on all aspects of outdoor lighting: Policy, energy efficiency, controllability and light pollution mitigation strategies
- https://designlights.org/our-work/luna

6

6

Why LUNA qualified products?

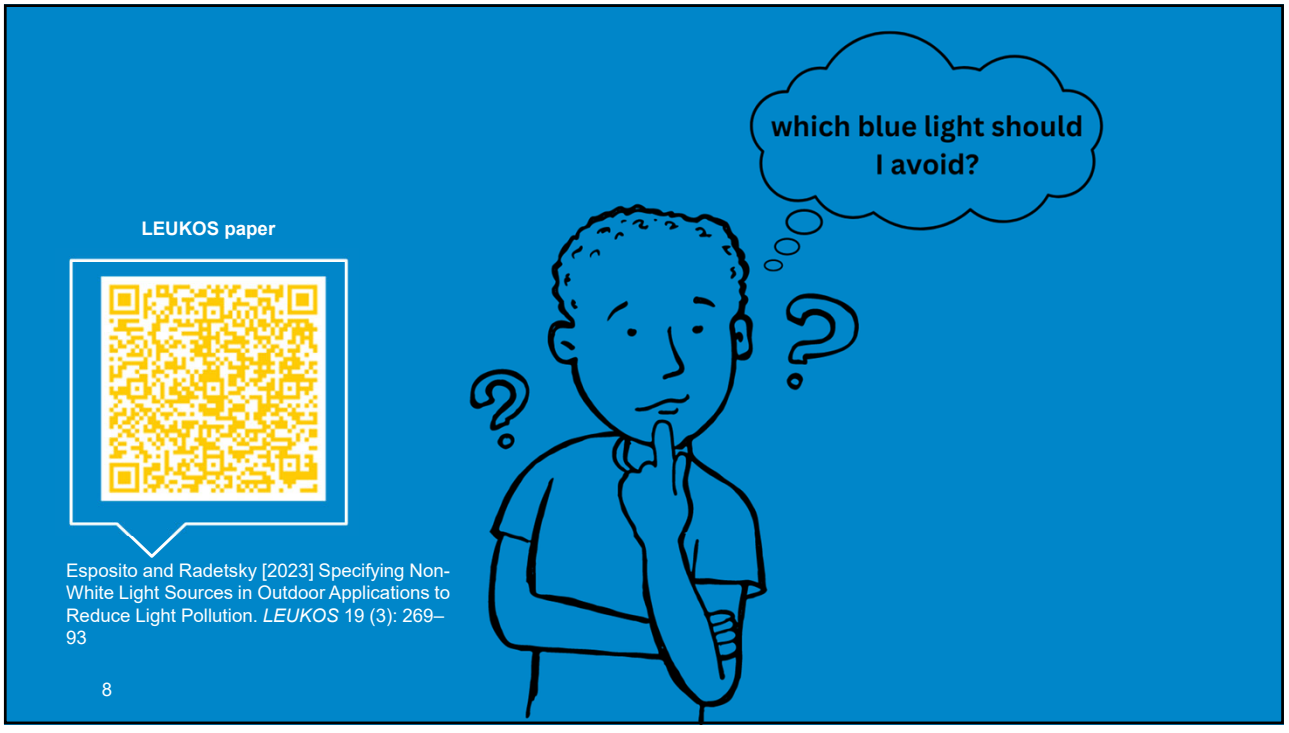
- Minimize light pollution
- Minimize energy use
- Provide appropriate visibility for people

LUNA V2.0 adds:

- Non-white light LEDs
- Turtle lighting
- Lamps/retrofit kits

7

7



8

Just use amber

Amber 590 peak

pc-Amber

1800 K 1900 K

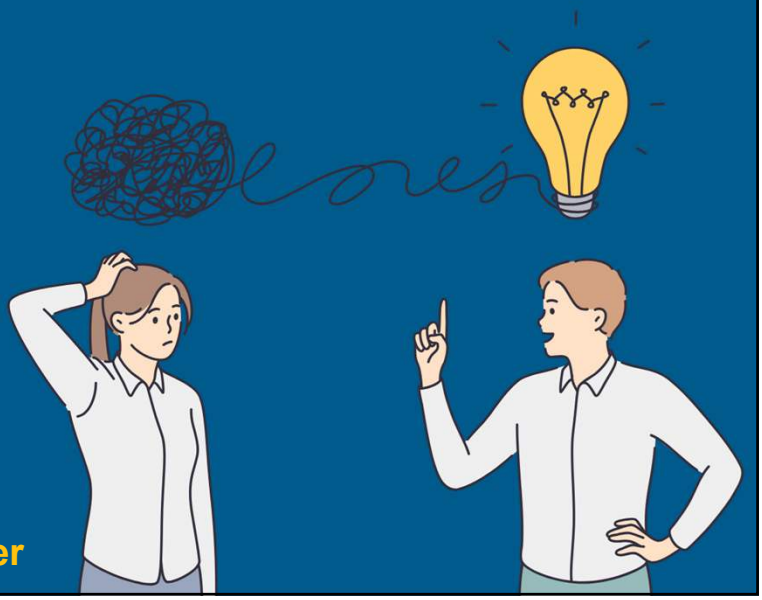
true Amber

limited wavelength Amber

narrowband Amber

pure Amber

direct emission Amber



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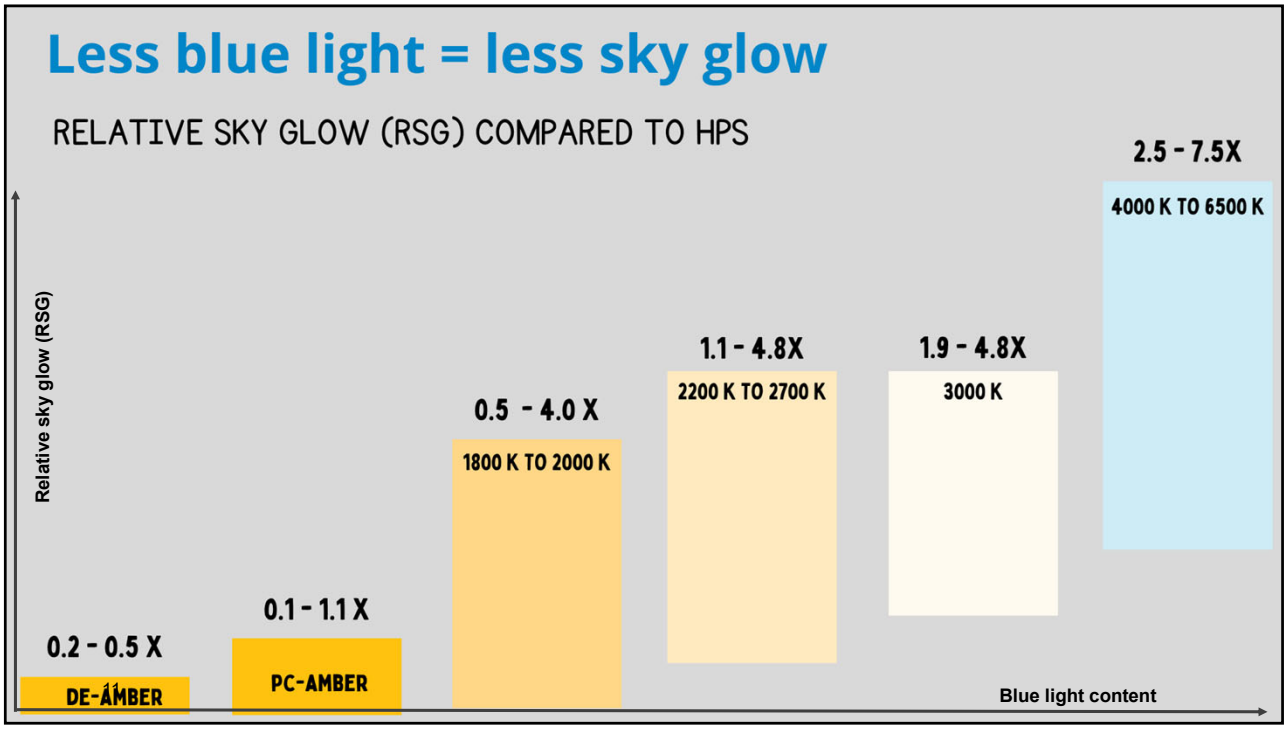
10

10



11

Combining photometrics with RSG

Weighting off-site lumens by spectrum

12

12

Combining photometrics with RSG

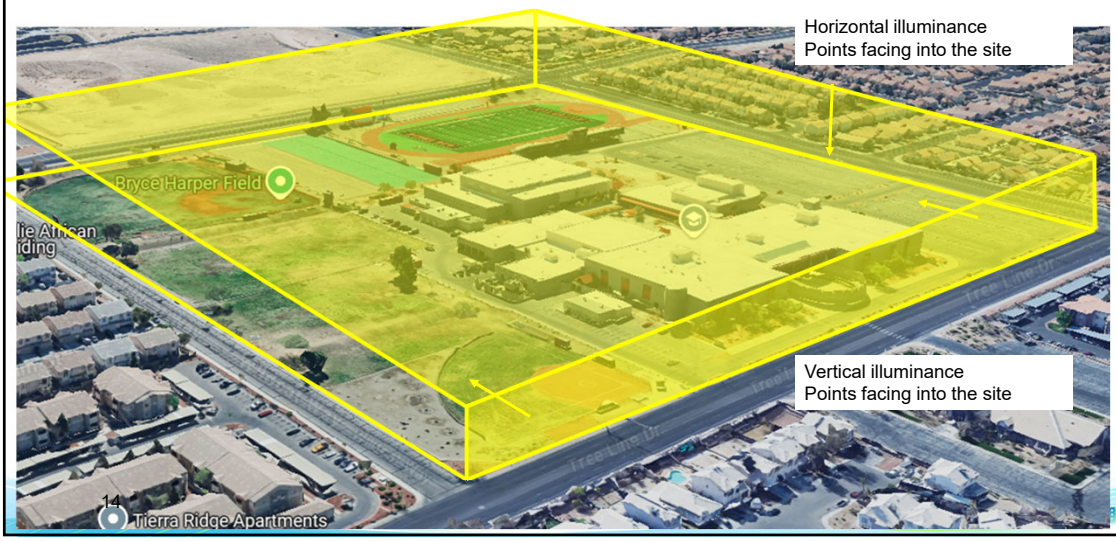
Using an “offsite lumens box” (like the MLO box)

13

13

Combining photometrics with RSG

Calculate illuminance values

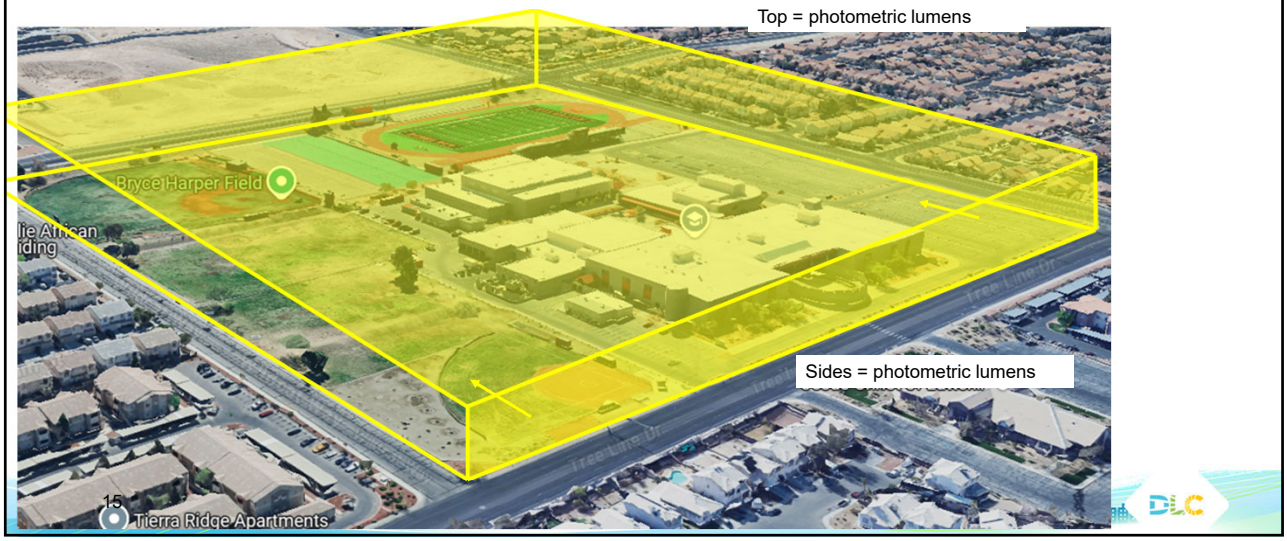


14

14

Combining photometrics with RSG

Offsite lumens = ∑ (offsite illuminance x area)



15

Combining photometrics with RSG

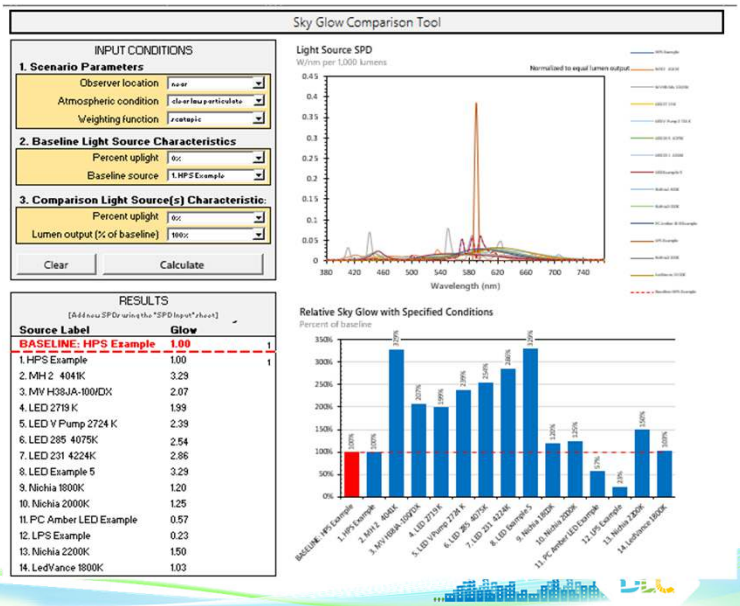
Weight offsite lumens by RSG

16

Reducing sky glow

Calculate RSG from SPD

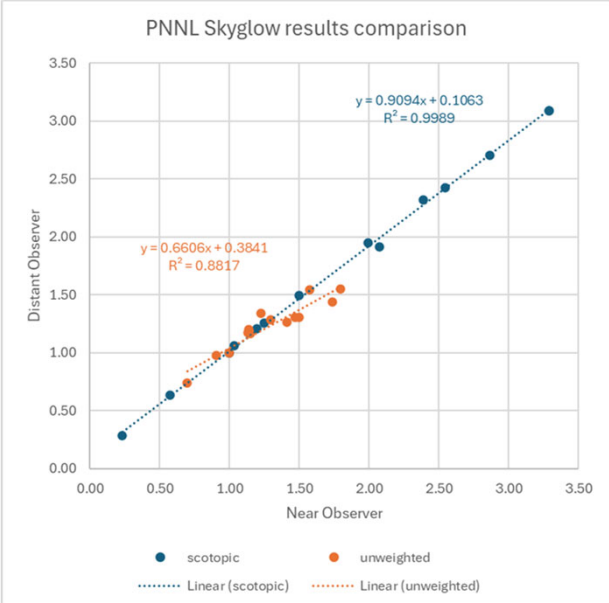
- PNNL Skyglow tool: SkyGlowTool@pnnl.gov
- Input SPD data
- Values are **relative** to baseline
- RSG is non-linear



RSG comparisons

DLC chose “near location” and “scotopic weighting function”

Scotopic weighting function is more ideal



Estimate RSG instead of using calculator

Always better to use SPD data

Baseline

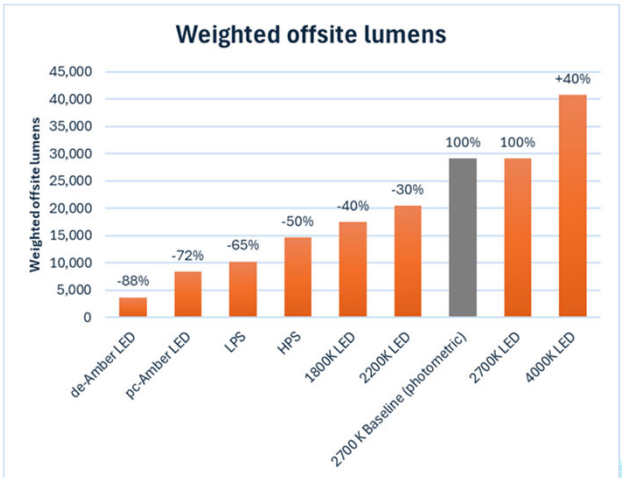
Technology/CCT	RSG (average)	S/P Ratio (average)
HPS	1.0	0.6
LED (2000K)	1.5	0.9
LED (2200K)	1.4	0.9
LED (2700K)	2.0	1.2
LED (3000K)	2.1	1.2
LED (4000K)	2.8	1.5
LED (5000K)	3.5	1.9
LED (5700K)	3.6	1.9
LED (6500K)	4.3	2.2

19

19

Weighting offsite lumens by RSG

Source type	RSG
de-Amber LED	0.13
pc-Amber LED	0.29
LPS	0.35
HPS	0.50
1800K LED	0.60
2200K LED	0.70
2700 K LED Baseline (photometric)	1.00
2700K LED	1.00
4000K LED	1.40



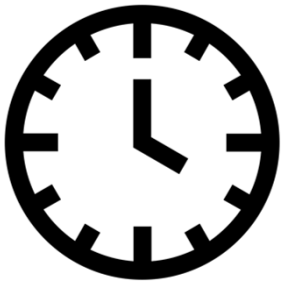
20

20

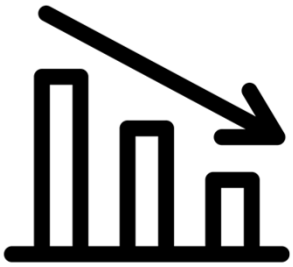
Non-white light trade offs

21

Impact of lighting controls



Meet energy code
Reduce overlighting
Nightly dimming
Seasonal dimming



Lighting controls reduce sky glow in a linear manner

May not be enough to overcome spectral impacts of high CCT installations

22

Digital twin example with controls

Choosing Both Energy Efficiency and Light Pollution Mitigation for Commercial Outdoor Lighting

LUNA Report

23

23

Digital twin example with controls

Base Case

MH fixtures

Not dimmed

RS1

DLC LED V5.1 qualified fixtures

Dimmed 50%

RS2

LUNA LED qualified/eligible fixtures

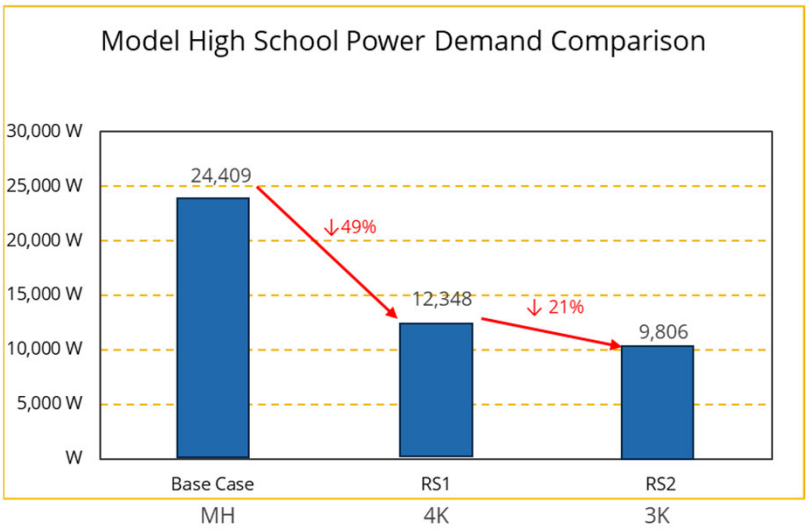
Dimmed 80%

Pre-curfew light pollution mitigations: minimizing overlighting, uplight and blue light scatter

24

24

Energy savings are achievable

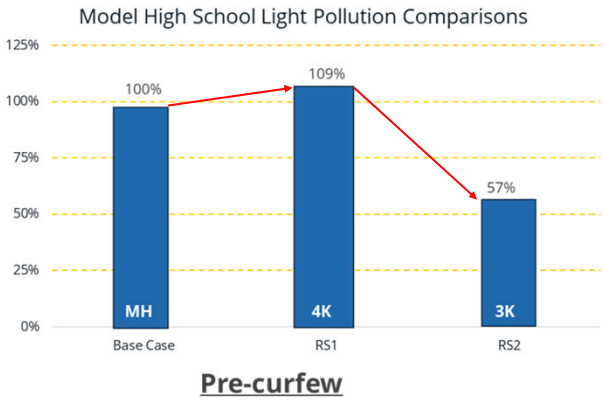


25

25

High CCT products increase sky glow

Includes RSG weighting factors

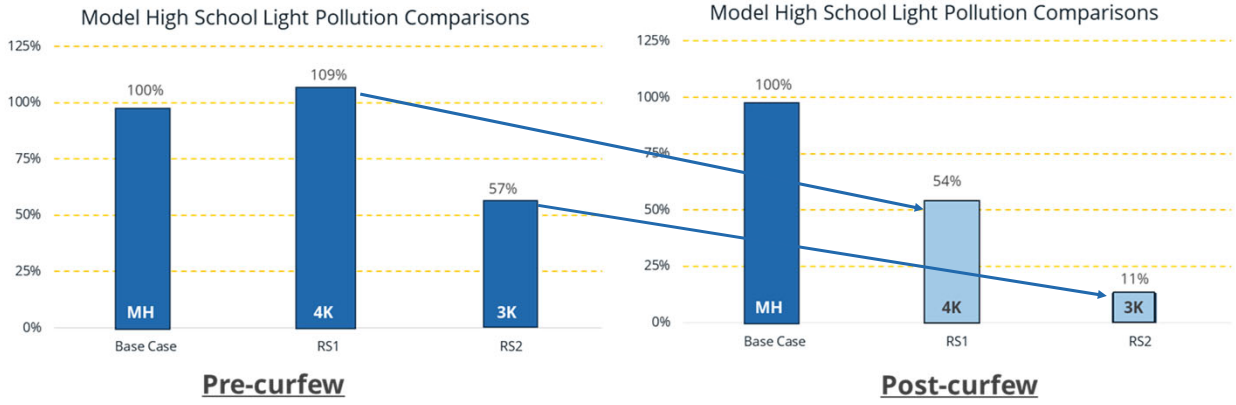


26

26

High CCT products increase sky glow

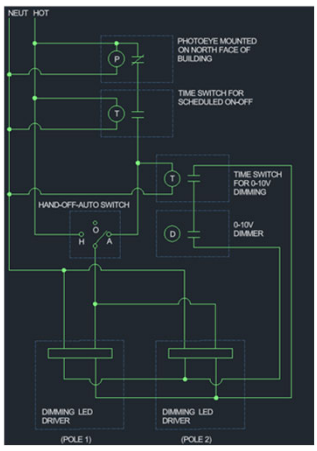
but lighting controls reduce the impact



27

Controls

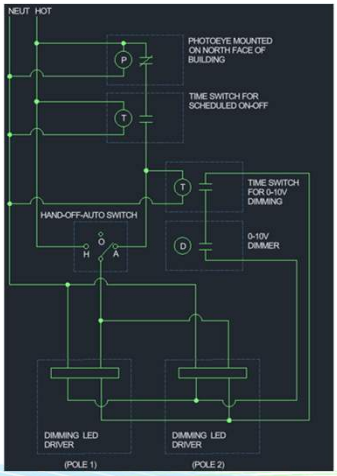
Old school wired

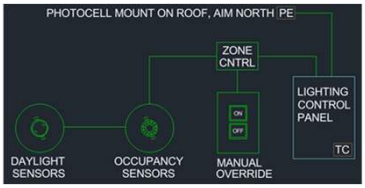


28

Controls

Wired vs. wireless vs. fully integrated & flexible





MS/DIM-L40=Motion Sensor for Dimming Operation, 21' - 40' Mounting Height [11, 12, 13]

SPB4=Motion Sensor for Dimming Operation, BLE Interface, 21' - 40' Mounting Height [11, 14, 28]

PIR	High/low, motion/ambient sensor, 8-40' mounting height, ambient sensor enabled at 2fc [13, 18, 19]
NLTAIR2 PIRHN	nLight AIR gen 2 enabled with bi-level motion / ambient sensor, 8-40' mounting height, ambient sensor enabled at 2fc. [11, 12, 18, 19]

DIM 0-10V Dimming
- Control by others
- Refer to Dimming spec sheet for details
- Can't exceed specified drive current
- Not available with PML options

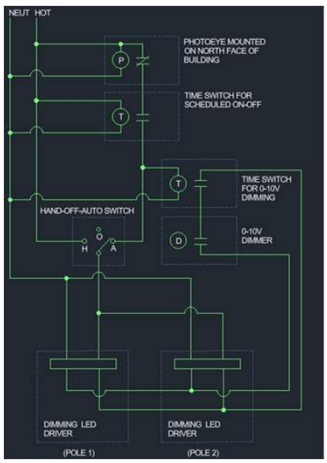
PML2 Programmable Multi-Level, 10-30' Mounting Height
- Refer to PML spec sheet for details
- Intended for downlight applications at 0° tilt

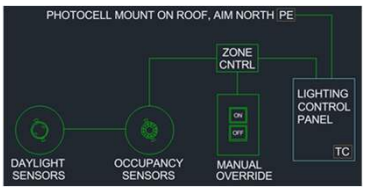
29

29

Controls

Non-white LED systems are controllable, just ask





MS/DIM-L40=Motion Sensor for Dimming Operation, 21' - 40' Mounting Height [11, 12, 13]

SPB4=Motion Sensor for Dimming Operation, BLE Interface, 21' - 40' Mounting Height [11, 14, 28]

PIR	High/low, motion/ambient sensor, 8-40' mounting height, ambient sensor enabled at 2fc [13, 18, 19]
NLTAIR2 PIRHN	nLight AIR gen 2 enabled with bi-level motion / ambient sensor, 8-40' mounting height, ambient sensor enabled at 2fc. [11, 12, 18, 19]

Non-white LED control options are equal to white-light sources:

- Dimming
- Motion Sensing
- Bi-level
- Multi-level
- Wireless

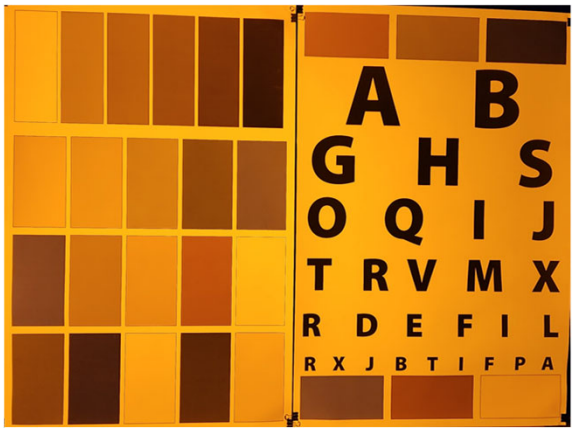
DIM 0-10V Dimming
- Control by others
- Refer to Dimming spec sheet for details
- Can't exceed specified drive current
- Not available with PML options

PML2 Programmable Multi-Level, 10-30' Mounting Height
- Refer to PML spec sheet for details
- Intended for downlight applications at 0° tilt

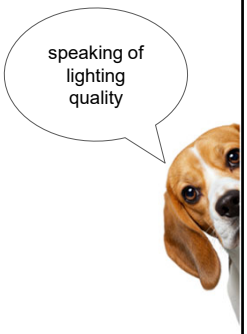
30

30

What CCT/technology is being used here?



HPS (2000 K)

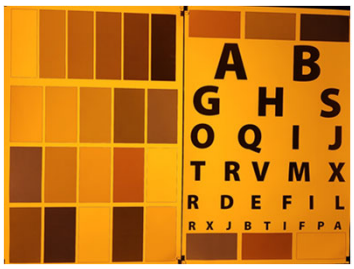


31

31

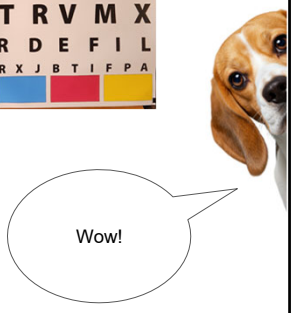
Can you guess these CCTs?

HPS (2000 K)



1800 K LED

2200 K LED

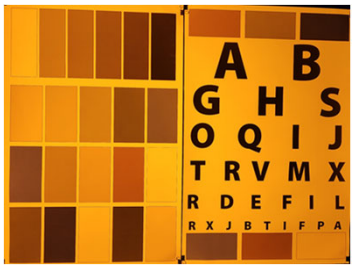


32

32

Good color rendition is achievable with low CCT

HPS (2000 K)



1800 K LED

2200 K LED

2700 K LED

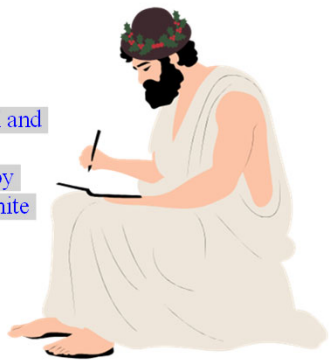
3000 K LED

4000 K LED

Spec editor notes are your friend

Embed guidelines for unique requirements in notes:

When including non-white light sources in the project, edit requirements for each characteristic for each included type accordingly. Some non-white sources have CCT definitions in Kelvin defined in ANSI C78.377-2024 and others are not defined in that standard and require the specifier to state color and/or specific wavelength. For more information on specifying non-white light sources see Annex F, Specifications for 2000K and 1800K (Informative) in ANSI C78.377-2024. It is recommended that specifiers refer to *Specifying Non-White Light Sources in Outdoor Applications to Reduce Light Pollution* by Esposito and Radetsky (2023) to fully appreciate the factors involved when using non-white sources. The editors notes in this section related to non-white light are sourced from that paper.



Are current standards referenced?

Ensure that the most current ANSI C78.377 – **2024** is listed. Prior to 2024 the 1800K and 2000K CCT bins were not defined.

35

35

Where are terms defined?

At a minimum add:

Direct-emission amber LED (DE-Amber): A DE Amber LED is based on an Aluminum-Indium-Gallium-Phosphide chip (AlInGaP) directly emitting long wavelength radiation with a peak wavelength of 590 nm to 605 nm, and a FWHM of approximate 15 nm to 20 nm.

Direct-emission other: Other direct-emission narrowband LEDs (e.g., "DE Red"): These non-white LEDs, such as direct emitting AlInGaP red LEDs, emit narrowband radiation directly (FWHM from approximately 15 nm to 20 nm). They have saturated color appearances and chromaticity coordinates very near the spectrum locus.

Phosphor-converted amber LED (PC-Amber): A PC Amber LED is based on a blue-emitting Indium Nitride-Gallium Nitride chip (InGan) paired with a reddish phosphor that fully, or nearly fully, down-converts the short wavelength radiation into longer wavelength broadband emission with a peak wavelength occurring near approximately 595 nm to 605 nm, and a full-width at half-maximum (FWHM) range of 80 nm to 90 nm.

36

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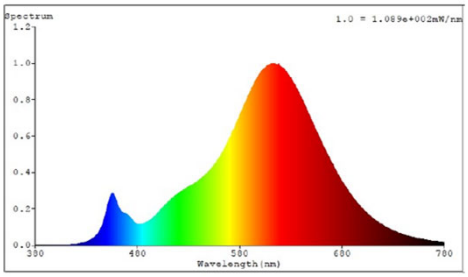
Expanded submittal data

For all types require submission of Spectral Power Distribution (SPD) XML document (SPDX) to verify spectrum and to calculate Scotopic/Photopic (S/P) ratio.

ANSI/IES TM-27 standard



Plotted SPD data in SPDX document

	I	M	N
	ReportDate	SpectralData	Wavelength
1	7/22/2024	0.000027	380
2	7/22/2024	0.000134	381
3	7/22/2024	0.000012	382
4	7/22/2024	0.000122	383
5	7/22/2024	0.000026	384
6	7/22/2024	0.000069	385
7	7/22/2024	0.000009	386
8	7/22/2024	0.000008	387
9	7/22/2024	0.000103	388
10	7/22/2024	0.000029	389
11	7/22/2024	0.000039	390
12	7/22/2024	0.000003	391

Tabular SPD data from SPDX document

37

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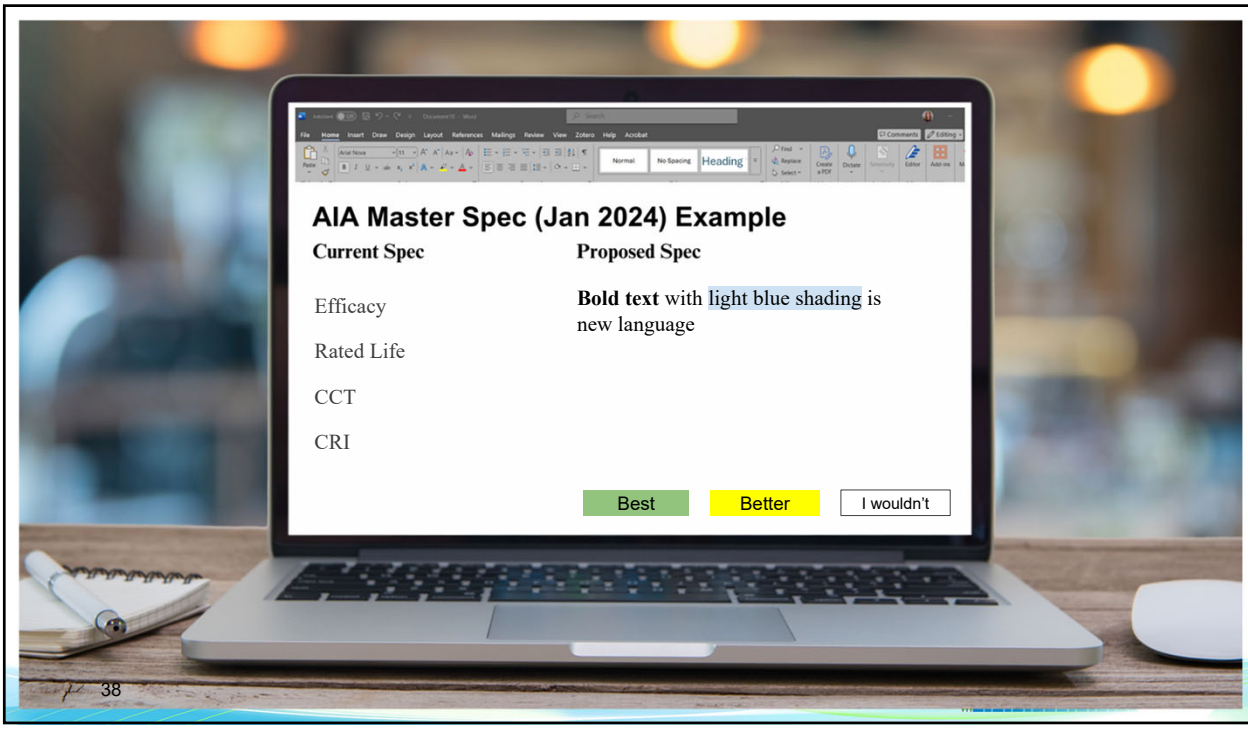

38

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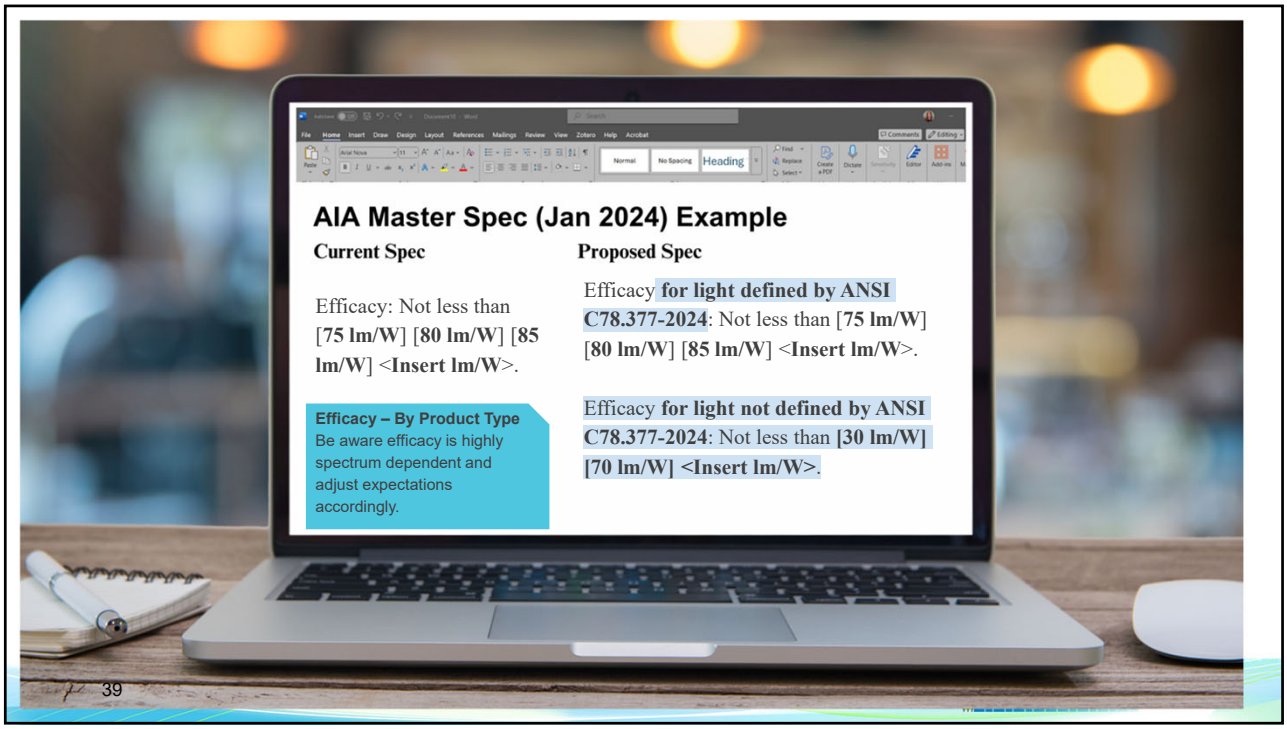
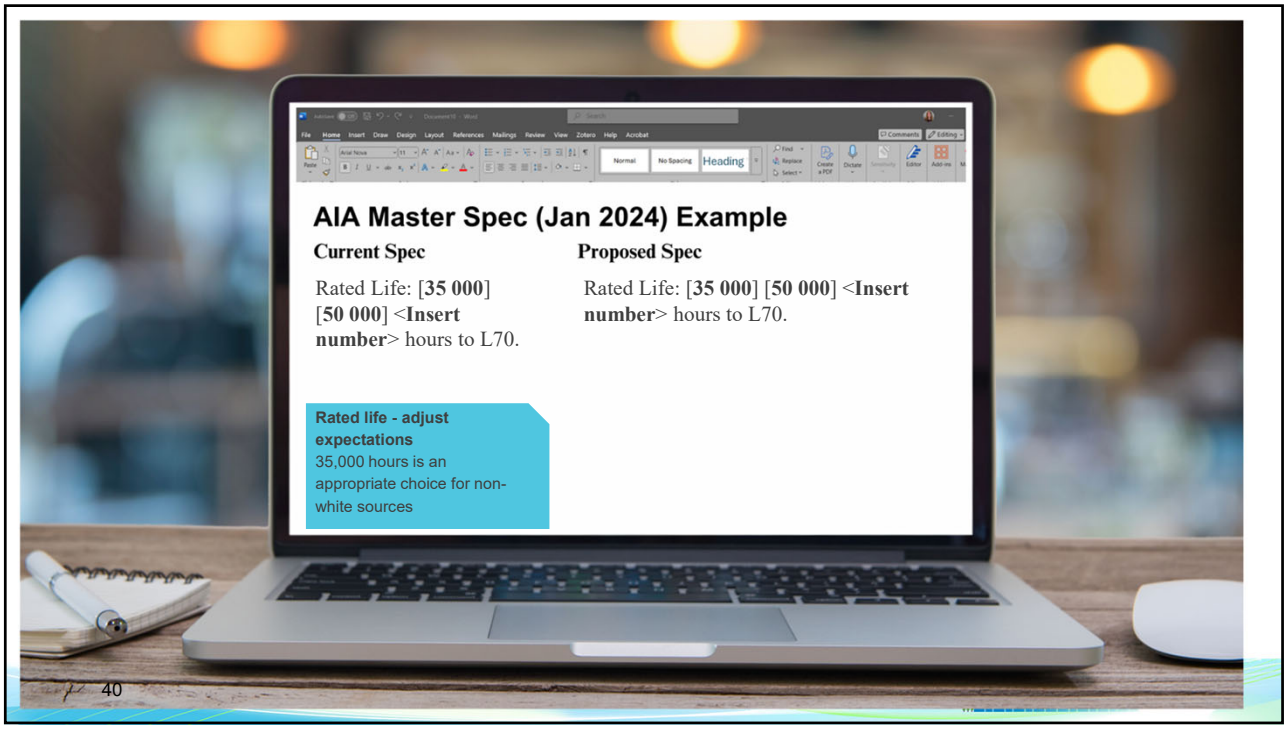
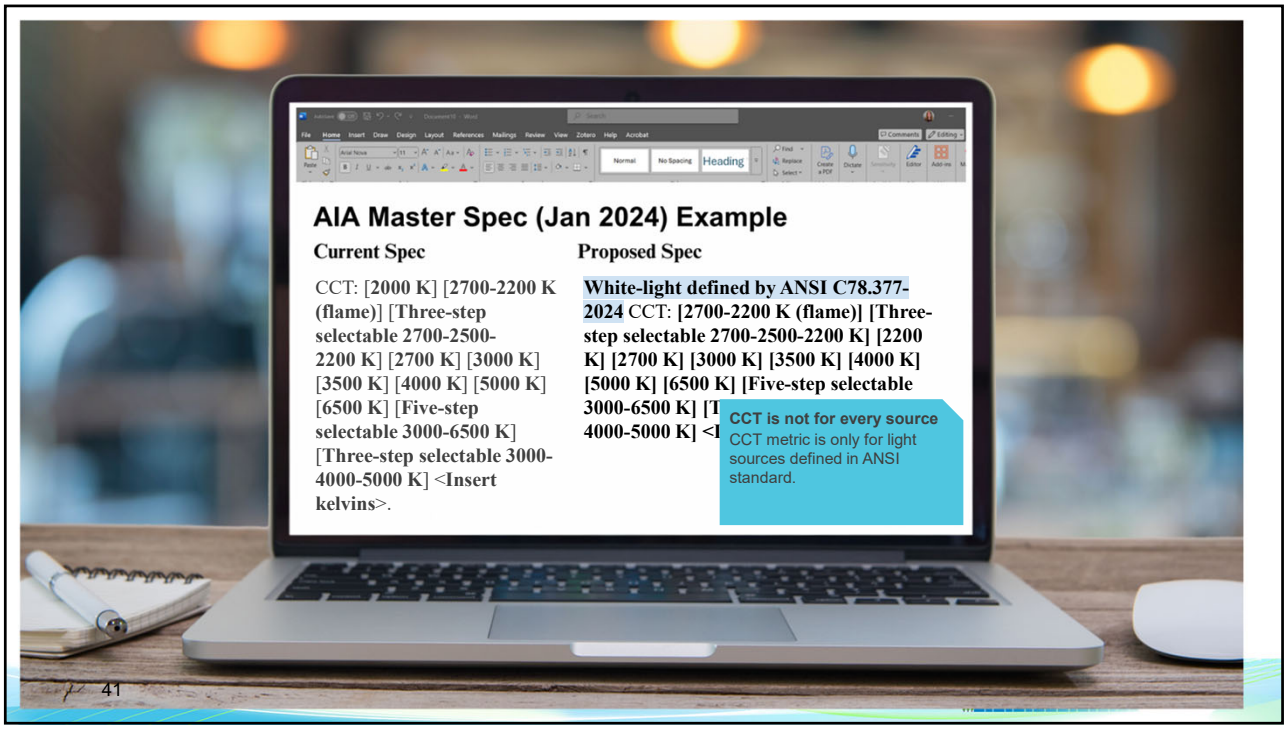

AIA Master Spec (Jan 2024) Example
Current Spec
Efficacy: Not less than [75 lm/W] [80 lm/W] [85 lm/W] <Insert lm/W>.
Proposed Spec
Efficacy for light defined by ANSI C78.377-2024: Not less than [75 lm/W] [80 lm/W] [85 lm/W] <Insert lm/W>.
Efficacy for light not defined by ANSI C78.377-2024: Not less than [30 lm/W] [70 lm/W] <Insert lm/W>.
Efficacy – By Product Type
Be aware efficacy is highly spectrum dependent and adjust expectations accordingly.
39

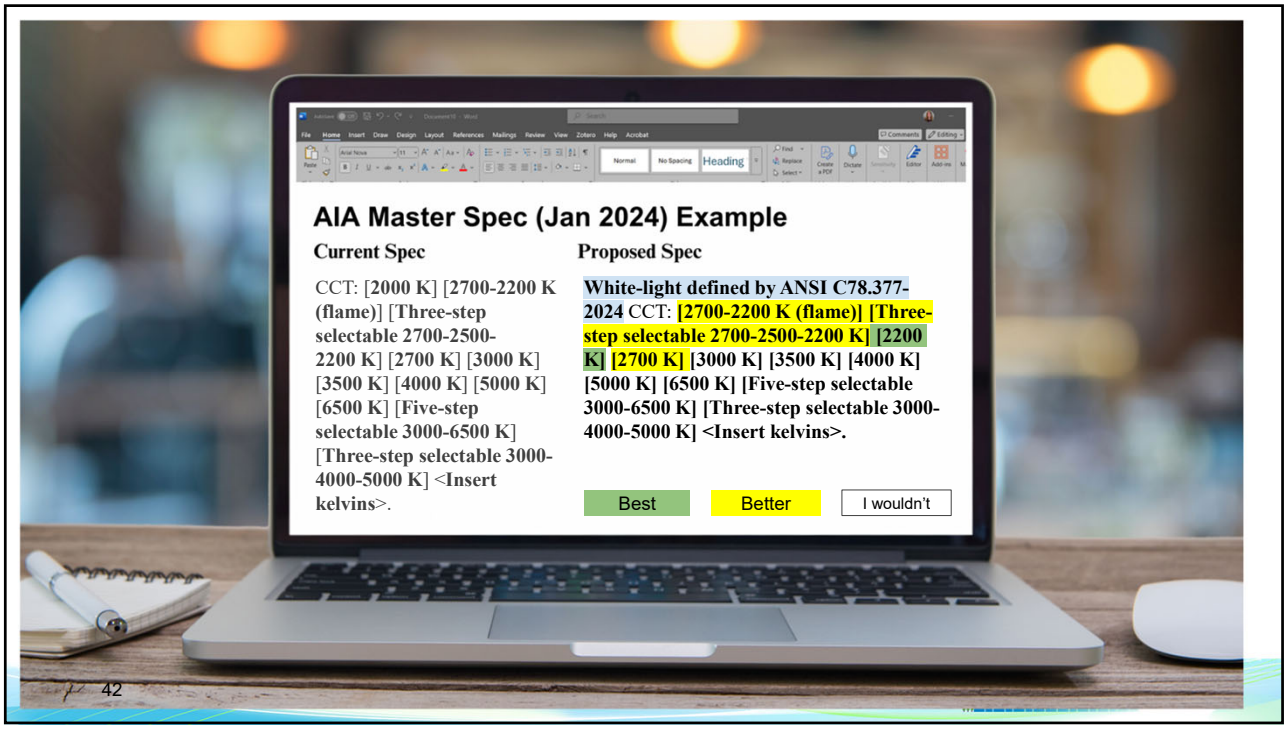
39


AIA Master Spec (Jan 2024) Example
Current Spec
Rated Life: [35 000] [50 000] <Insert number> hours to L70.
Proposed Spec
Rated Life: [35 000] [50 000] <Insert number> hours to L70.
Rated life - adjust expectations
35,000 hours is an appropriate choice for non-white sources
40

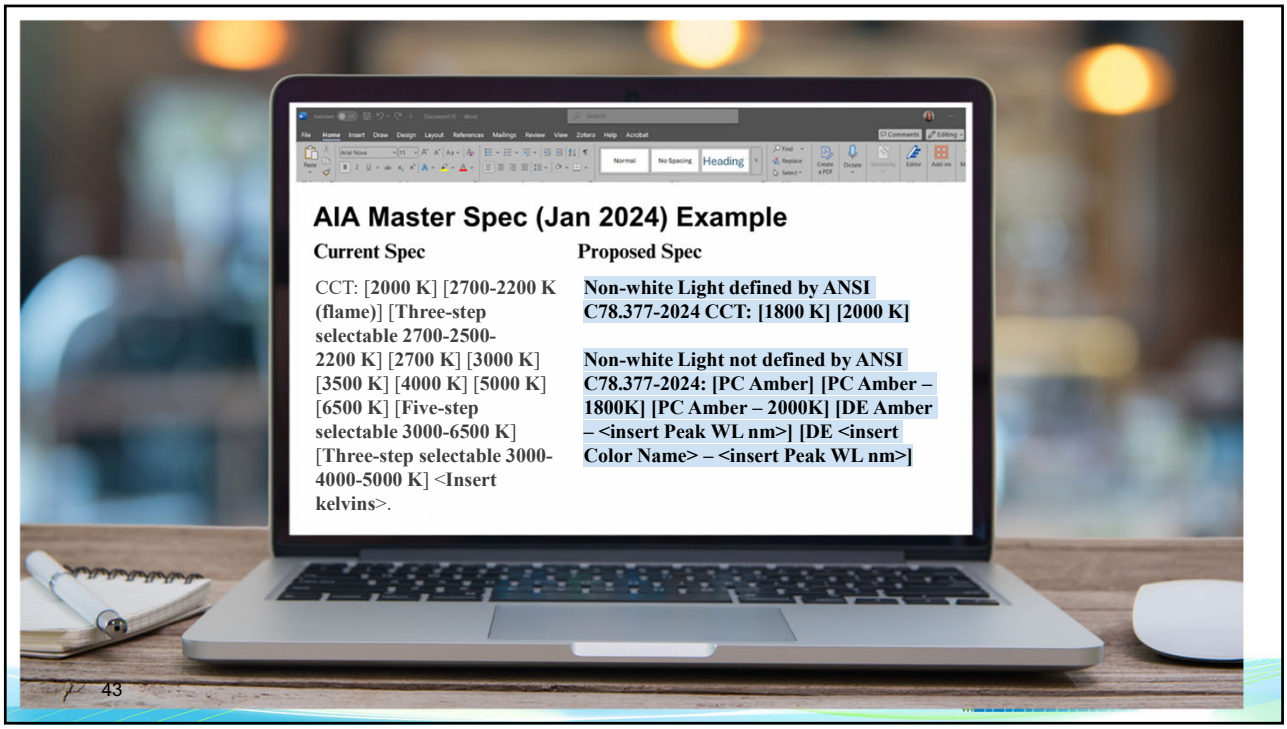
40


AIA Master Spec (Jan 2024) Example
Current Spec
CCT: [2000 K] [2700-2200 K (flame)] [Three-step selectable 2700-2500-2200 K] [2700 K] [3000 K] [3500 K] [4000 K] [5000 K] [6500 K] [Five-step selectable 3000-6500 K] [Three-step selectable 3000-4000-5000 K] <Insert kelvins>.
Proposed Spec
White-light defined by ANSI C78.377-2024 CCT: [2700-2200 K (flame)] [Three-step selectable 2700-2500-2200 K] [2200 K] [2700 K] [3000 K] [3500 K] [4000 K] [5000 K] [6500 K] [Five-step selectable 3000-6500 K] [T
4000-5000 K] <I
CCT is not for every source
CCT metric is only for light sources defined in ANSI standard.
41

41


AIA Master Spec (Jan 2024) Example
Current Spec
CCT: [2000 K] [2700-2200 K (flame)] [Three-step selectable 2700-2500-2200 K] [2700 K] [3000 K] [3500 K] [4000 K] [5000 K] [6500 K] [Five-step selectable 3000-6500 K] [Three-step selectable 3000-4000-5000 K] <Insert kelvins>.
Proposed Spec
White-light defined by ANSI C78.377-2024 CCT: [2700-2200 K (flame)] [Three-step selectable 2700-2500-2200 K] [2200 K] [2700 K] [3000 K] [3500 K] [4000 K] [5000 K] [6500 K] [Five-step selectable 3000-6500 K] [Three-step selectable 3000-4000-5000 K] <Insert kelvins>.
Best
Better
I wouldn't
42

42



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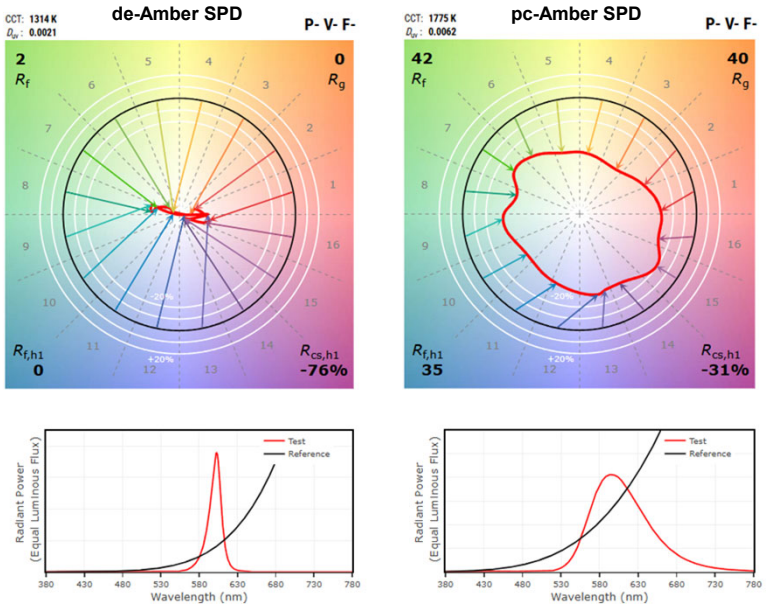
Quality Metrics

- Color rendition is very poor for DE-Amber or PC-Amber
- Metrics: CRI (Ra), Rf, Rg
- Master Spec only references CRI



Calculation from: https://www.ies.org/standards/standards-toolbox/tm-30-spectral-calculator/

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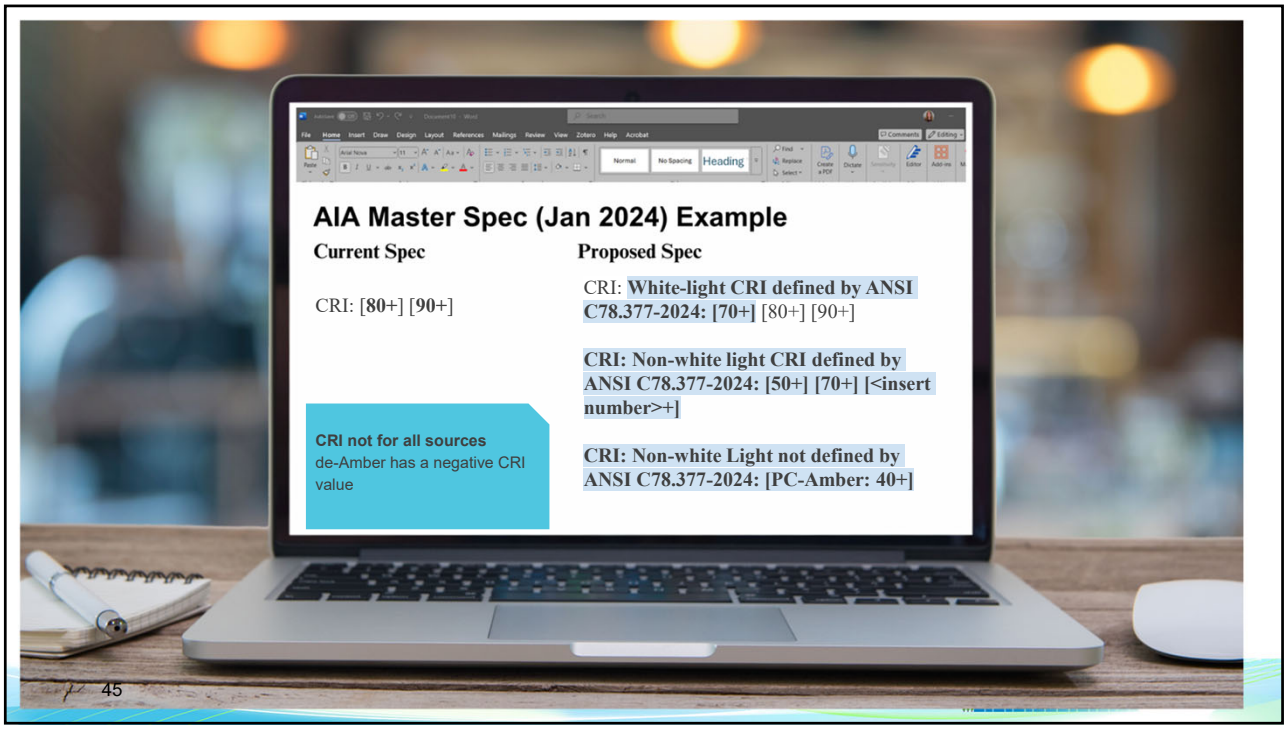
AIA Master Spec (Jan 2024) Example
Current Spec
CRI: [80+] [90+]
Proposed Spec
CRI: White-light CRI defined by ANSI C78.377-2024: [70+] [80+] [90+]
CRI: Non-white light CRI defined by ANSI C78.377-2024: [50+] [70+] [<insert number>+]
CRI: Non-white Light not defined by ANSI C78.377-2024: [PC-Amber: 40+]
CRI not for all sources
de-Amber has a negative CRI value
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Collaborators
DLC members and colleagues
Tony Esposito
Valeria Holland
ANSI C78 WG members
LUNA Advisory Group
Kristin Raduenz
Chris Wilson
Ligia Orlandini
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Scott Lind PE
Electrical Engineer |
Building Engineering
Mead & Hunt
scott.lind@meadhunt.com
THANK YOU
Leora Radetsky
LUNA Program Director/
Senior Lighting Scientist
DesignLights Consortium
lradetsky@designlights.org
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