

# Support for High-Color-Rendering LED Lamps for EnergyStar

# OUTLINE

- The Importance of Light Quality
- Luminosity & Color Rendering
- Fundamental Trade-Off Between Efficacy & Color
- Recommendation regarding EnergyStar

# BARRIERS TO ADOPTION: QUALITY

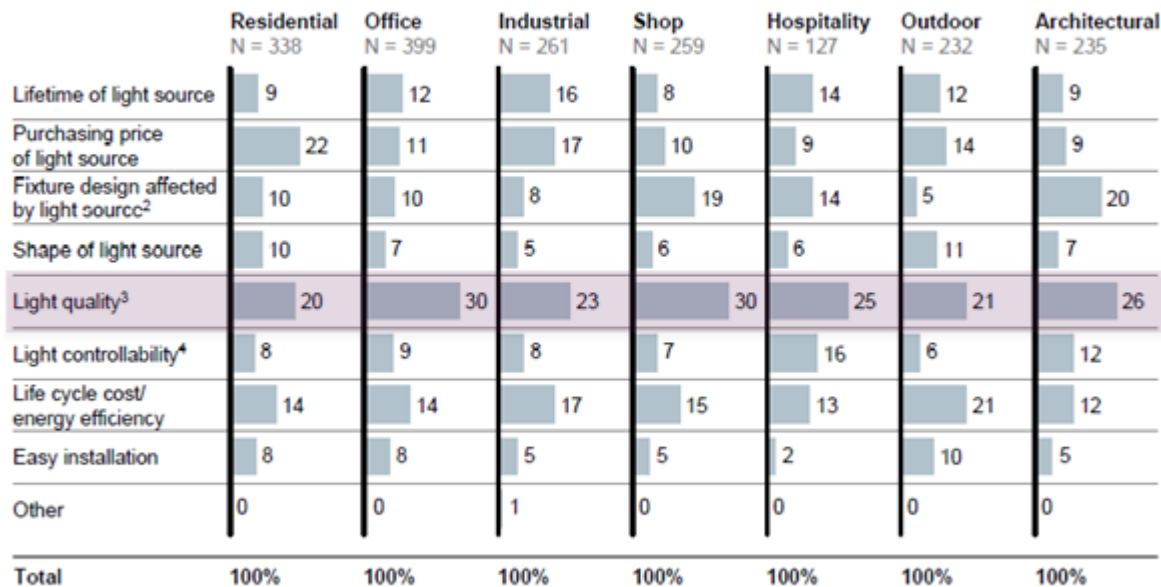
## Compact Fluorescent Lamps (CFL)

Only 10-15% penetration after decades and \$millions spent (U.S.)\*

### Decision criteria for fixture installation in new buildings/structures

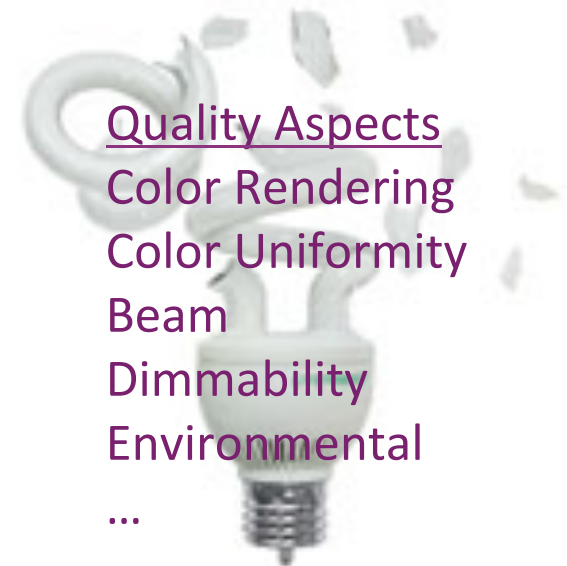
What are the most important criteria when deciding on the type of light source technology in a new fixture installation?

Percent; No. of respondents<sup>1</sup> who selected this response as their 1st decision criterion



1 1 respondent could answer up to 3 applications in the survey  
 2 Incl. design flexibility  
 3 CRI, color temperature, color consistency, and light distribution  
 4 Dimmability, color controllability, etc.

Source: McKinsey Global Lighting Professionals & Consumer Survey



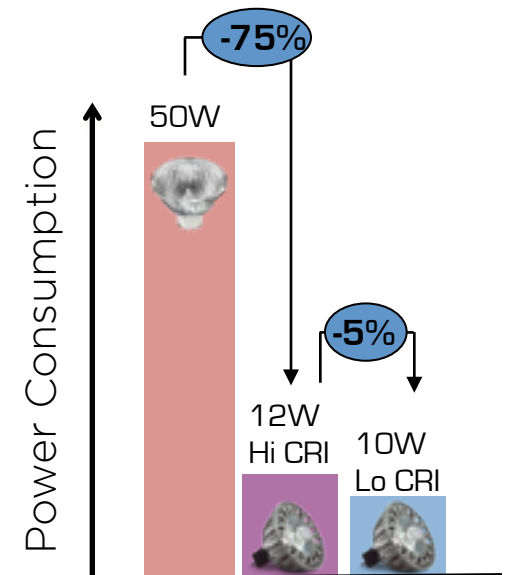
\*Proposed voluntary California quality light-emitting diode (LED) lamp specification, California Energy Commission, Sept. 2012

*Low-cost, high-efficacy focus alone is not sufficient to transform the marketplace*

# LIGHT QUALITY DRIVES LED ADOPTION

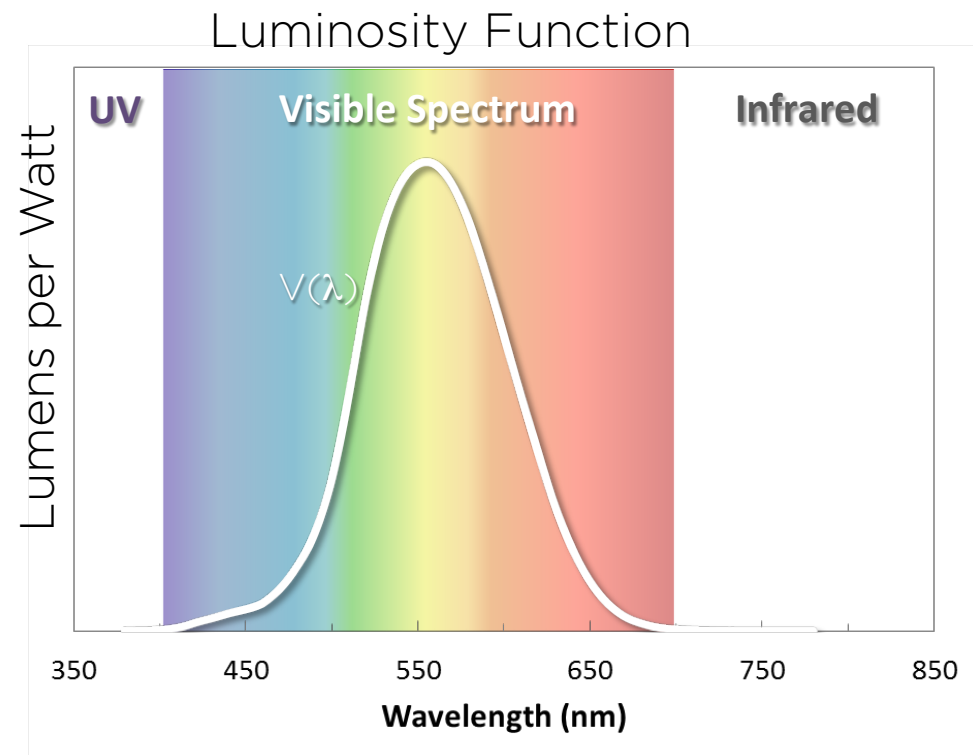
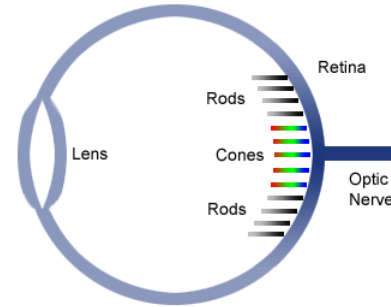
- Retail operators and end-users care about
  - Revenue Creation
  - Customer Experience
- For many end-users, CRI 80 is “not good enough”

Retail  
Hospitality & Resorts  
Restaurants  
Museums  
etc.



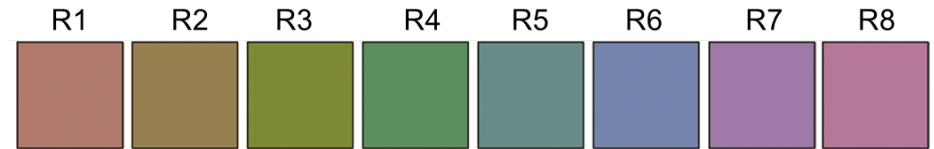
# LUMINOSITY

- Human eye is not equally sensitive to all wavelengths of light
- Eye sensitivity is represented by the Luminosity Function (CIE)
- Example:  
1 Watt at 555 nm = 683 lumens
- Lumens decrease in the blue and red spectral regions

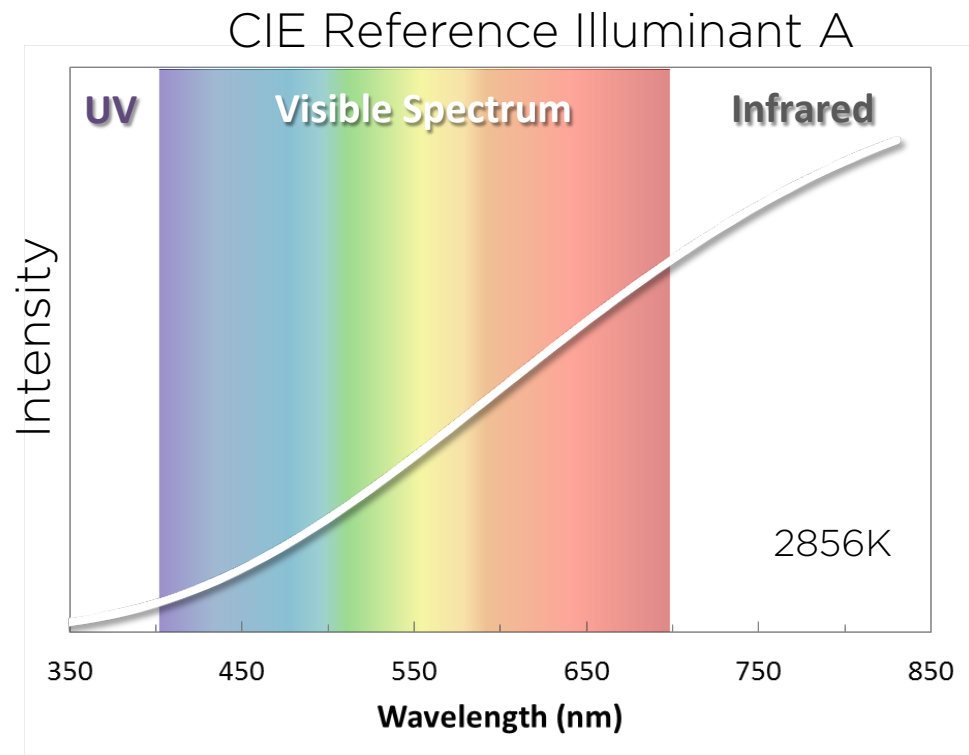


# COLOR RENDERING

- Measure of light source's ability to faithfully reproduce colors of select (Munsell) color samples
- Many metrics. Most common is Color Rendering Index (CRI)
- Benchmarked against a Reference Illuminant
- For warm white, reference illuminant is tungsten incandescence



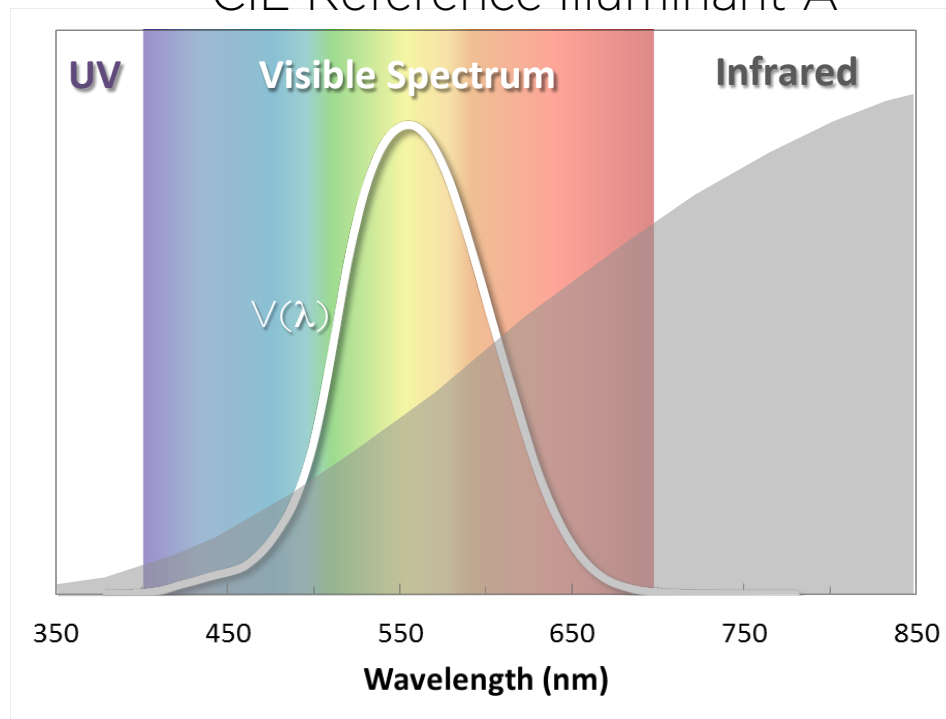
Munsell Color Samples (1<sup>st</sup> eight)



# IMPACT OF RED EMISSION

- Luminosity and CRI are extremely sensitive to red content
- Truncation of red-emission leads to high luminosity (lumens), but lower CRI

CIE Reference Illuminant A

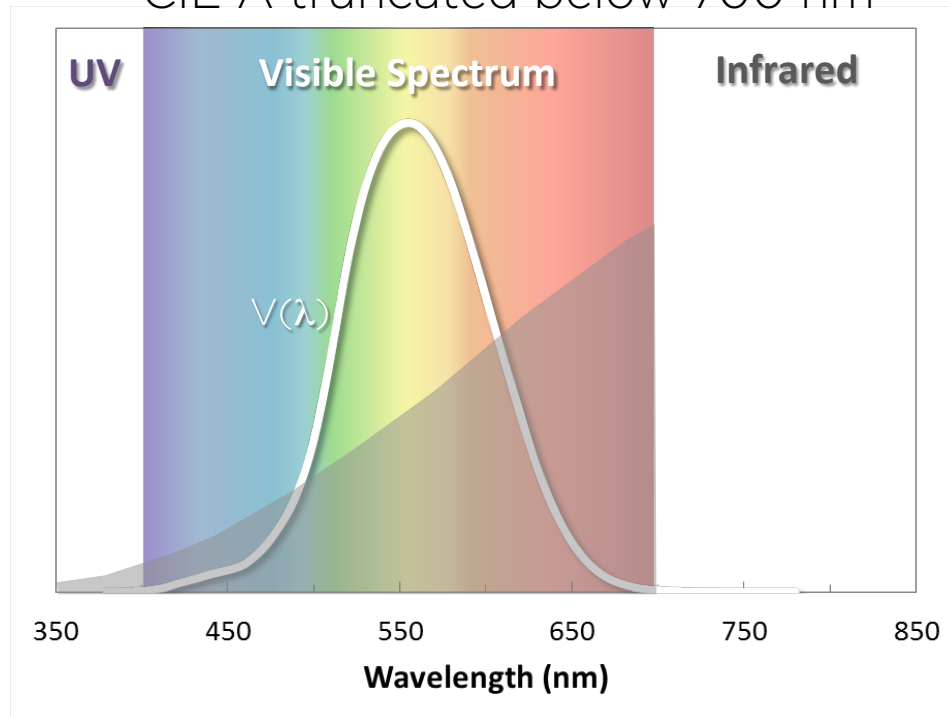


	CIE A
R1	100
R2	100
R3	100
R4	100
R5	100
R6	100
R7	100
R8	100
Ra	100
LUM	100%

# IMPACT OF RED EMISSION

- Luminosity and CRI are extremely sensitive to red content
- Truncation of red-emission leads to high luminosity (lumens), but lower CRI

CIE A truncated below 700 nm



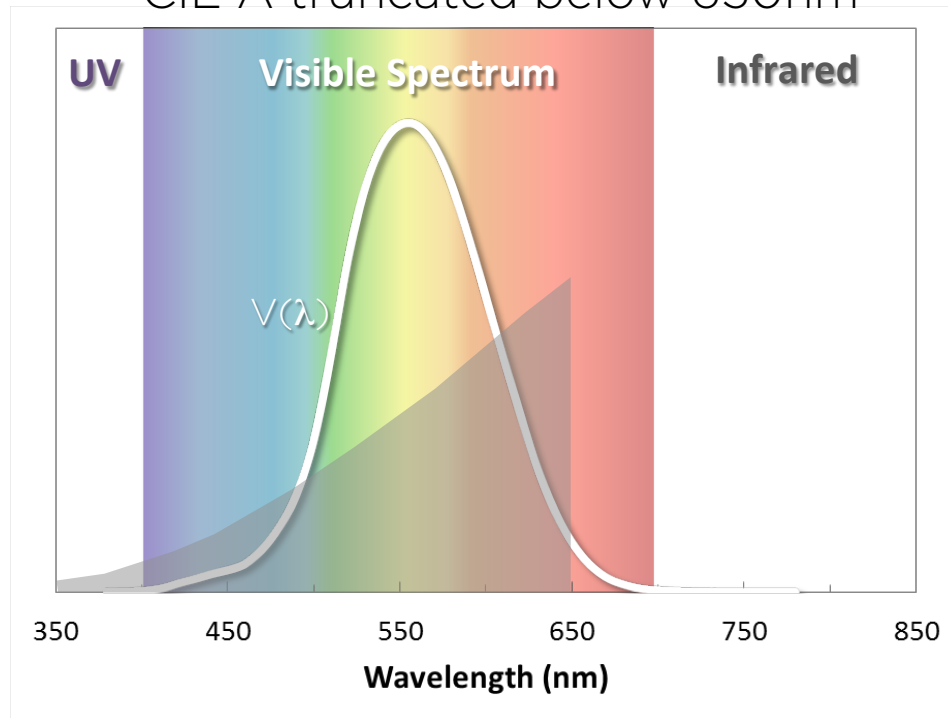
	CIE A	<700
R1	100	100
R2	100	100
R3	100	99
R4	100	100
R5	100	100
R6	100	100
R7	100	99
R8	100	99
Ra	100	100
LUM	100%	155%



# IMPACT OF RED EMISSION

- Luminosity and CRI are extremely sensitive to red content
- Truncation of red-emission leads to high luminosity (lumens), but lower CRI

CIE A truncated below 650nm

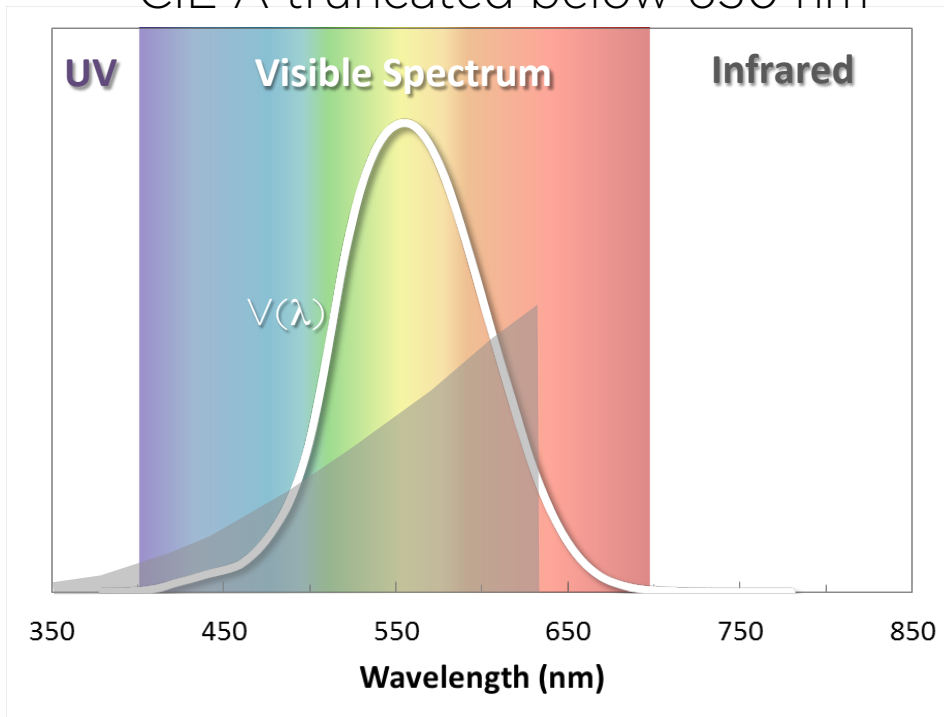


	CIE A	<700	<650
R1	100	100	91
R2	100	100	96
R3	100	99	99
R4	100	100	91
R5	100	100	91
R6	100	100	97
R7	100	99	90
R8	100	99	76
Ra	100	100	91
LUM	100%	155%	212%

# IMPACT OF RED EMISSION

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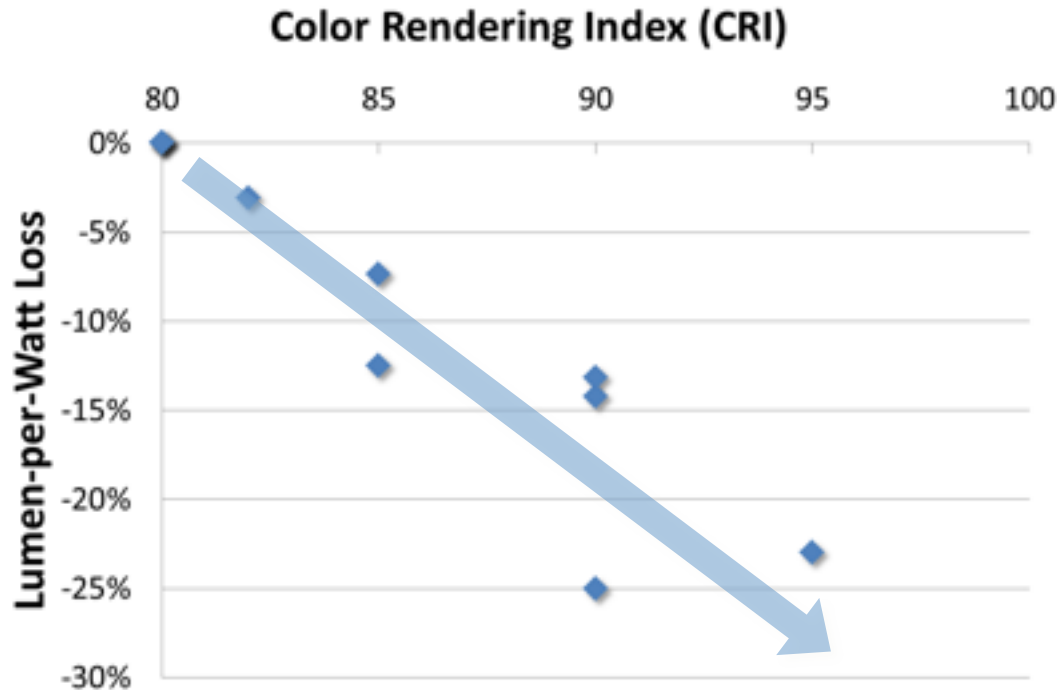
CIE A truncated below 630 nm



	CIE A	<700	<650	<630
R1	100	100	91	73
R2	100	100	96	87
R3	100	99	99	94
R4	100	100	91	73
R5	100	100	91	74
R6	100	100	97	88
R7	100	99	90	77
R8	100	99	76	37
Ra	100	100	91	75
LUM	100%	155%	212%	237%

# COLOR RENDING vs. EFFICACY

- LEDs show strong dependence of performance on Color Rendering Index (CRI)
- Top-tier suppliers: ~1.5-2% decrease in Lumens-per-Watt per point of CRI
- CRI 80 → 95: ~25-30% penalty in Lumens-per-Watt



Datasheet typicals from several top-tier LED companies, normalized



Munsell Color Samples (1<sup>st</sup> eight)



**Color Rendering Index (CRI)**

# RECOMMENDATION for LAMPS ENERGYSTAR 9.1

- Quality is a critical factor for solid-state lighting (SSL) adoption
- Government regulations should support development of high color quality SSL

## CURRENT SPEC

	Lamp Rated Wattage (Watts)	Minimum Lamp Efficacy (initial lm/W)
Omnidirectional	<15	55
	≥15	65
Directional	<20	40
	≥20	50
Decorative	<15	45
	15 ≤ W < 25	50
	≥25	60

## PROPOSAL

	Lamp Rated Wattage (Watts)	Minimum Lamp Efficacy (initial lm/W)	
		80 ≤ CRI < 90	CRI > 90
Omnidirectional	<15	55	45
	≥15	65	55
Directional	<20	40	35
	≥20	50	40
Decorative	<15	45	35
	15 ≤ W < 25	50	40
	≥25	60	50

- Above proposal *levels the playing field* and provides path for E\* certification for reasonably-priced high-CRI LED lamps
- Already broad support from Lighting Designers, Utilities, LED Mfrs., Academics, etc.

S  R A A

Simply Perfect