



# Lighting Specification Development Update: Luminaires and Lamps

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ICF International

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# Outline



- Lighting Integration Plan
- Luminaires / Light Fixtures:
  - ENERGY STAR Luminaires V1.0
  - ENERGY STAR Luminaires V1.1
  - ENERGY STAR Luminaires V1.2 (currently in draft)
  - TM-21 Calculator
  - Certified Lighting Subcomponent Database (CSD)
  - Ceiling Fans V3.0 & Ventilation Fans V3.2
- Lamps / Light Bulbs:
  - Compact Fluorescent Lamps V4.3
  - Integral LED Lamps V1.4
  - Lamps V1.0 (currently in draft)
- Program Guidance Regarding LED Lumen Maintenance Data
- Decorative Light Strings V1.5
- Questions



# Lighting Integration Plan

# ENERGY STAR Lighting History: Four Existing Specifications



- Residential Light Fixtures (est. 1997)
- Compact Fluorescent Lamps (est. 1999)
- Solid State Lighting Luminaires (est. 2007)
- Integral LED Lamps (est. 2009)



# ENERGY STAR Lighting Specification Integration



Residential Light Fixtures V4.2

Solid State Lighting Luminaires V1.3

## **ENERGY STAR Luminaires V1.1**

- finalized February 16, 2011
- effective April 1, 2012
- [www.energystar.gov/luminaires](http://www.energystar.gov/luminaires)

Compact Fluorescent Lamps V4.3

Integral LED Lamps V1.4

## **ENERGY STAR Lamps V1.0**

- currently in development
- first draft October 21, 2011
- second draft July 6, 2012
- third draft Q4 2012
- [www.energystar.gov/lamps](http://www.energystar.gov/lamps)



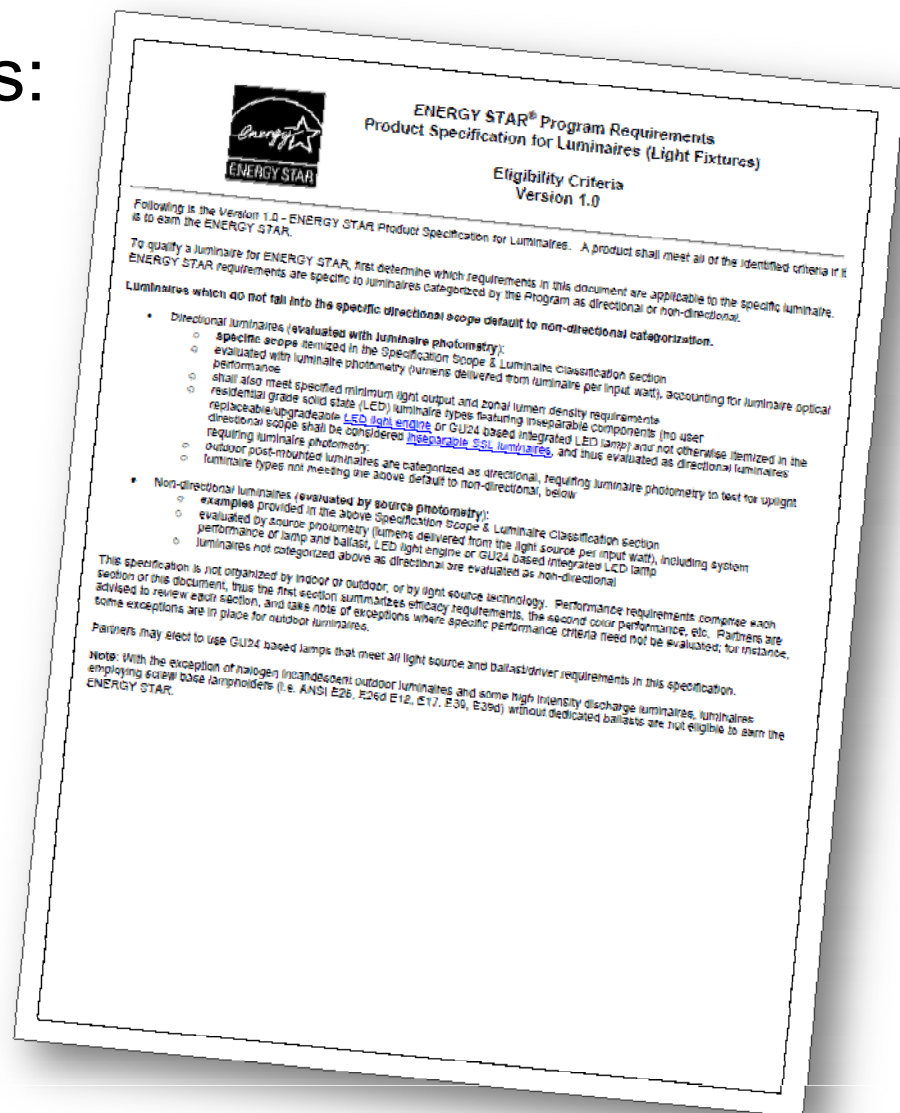
# **ENERGY STAR**

## **Luminaires Specification**

# ENERGY STAR Luminaires V1.0



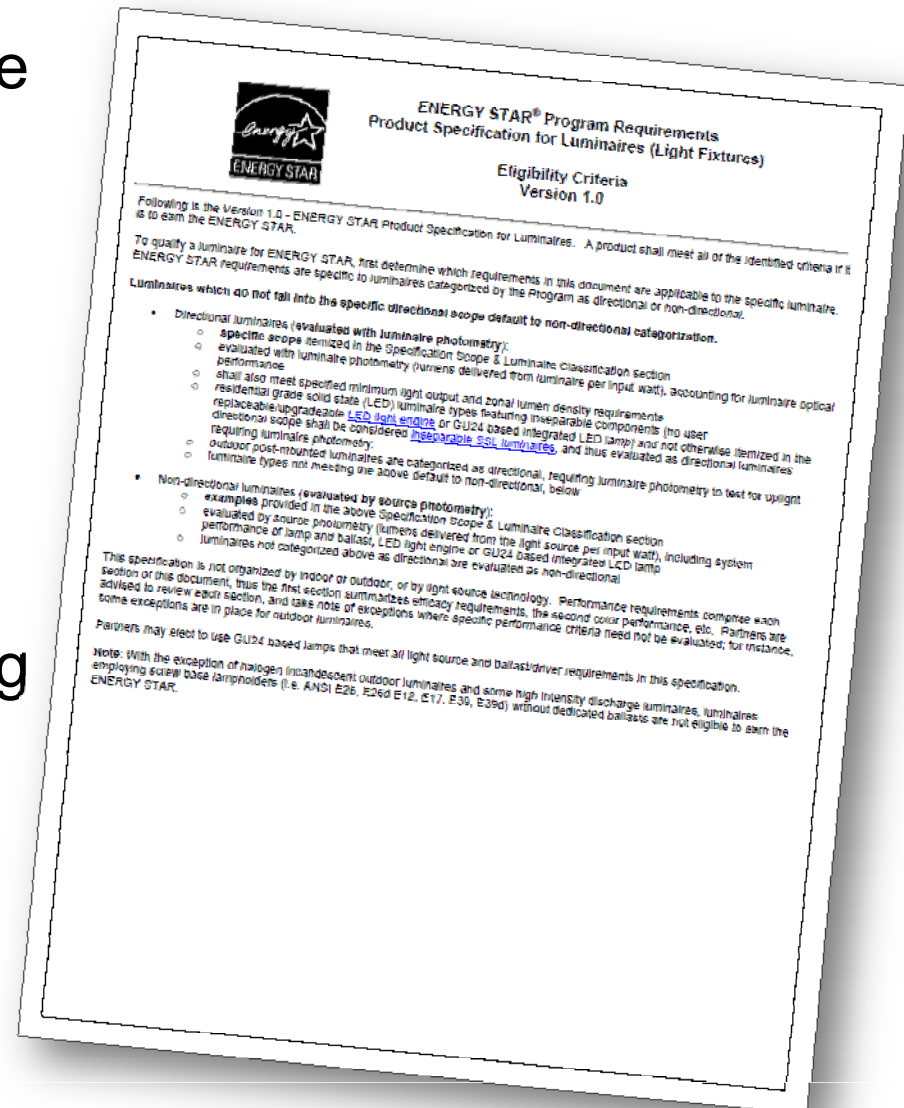
- Spec development process:
  - Draft 1: May 10, 2010
  - Draft 2: October 4, 2010
  - Final Draft: December 20, 2010
  - Finalized February 16, 2011



# ENERGY STAR Luminaires V1.0



- Technology-neutral performance requirements
- Industry standard methods of measurement
- Categorizes fixtures as directional or non-directional independent of technology
- For non-directional, maintains optional component-level testing approach to qualification

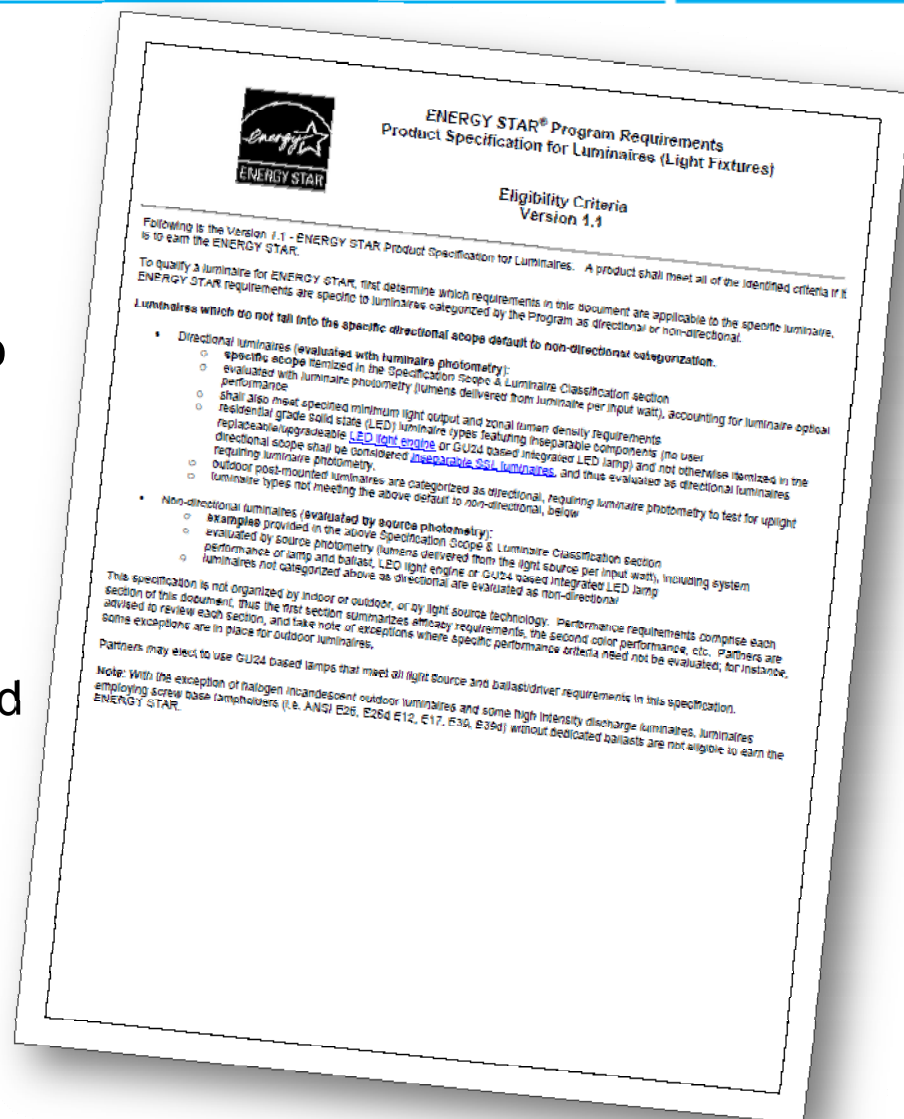




# ENERGY STAR Luminaires V1.1



- Version 1.1 finalized July 1, 2011
  - Reduced sample sizes for directional goniophotometry
  - Reduced LM-80 sample sizes to align with TM-21
  - Other changes related to:
    - Extended SSL V1.3 spec for (only): ceiling mount w/ diffuser, outdoor porch and desk task lights, until LM-82 was published
    - Mounting variations for outdoor
    - Directional vent fans lighting
- Effective date was April 1, 2012



# ENERGY STAR Luminaires V1.1: Directional Luminaires



- IES RP-16-10 “direct lighting”
- Put light on a specific surface or area
- Evaluated with luminaire photometry: delivered lumens per input watt: IES LM-79 (SSL), LM-41 (fluorescent)
- Zonal lumen density requirements (requires goniophotometry)
- Minimum light output requirements
- **Specific scope** detailed in spec, including limited scope for commercial grade products
- **Luminaires not listed in directional scope are treated as non-directional**

# ENERGY STAR Luminaires V1.1:

## Non-Directional Luminaires



- Not intended to illuminate specific surfaces
- Evaluated with source photometry: source lumens per input watt: IES LM-82 (SSL), LM-9 & LM-66 (fluorescent)
- Minimum source light output requirements
- Does not measure luminaire optical loss
- Does not have specific scope – **examples only** provided in spec



# First Certified to ENERGY STAR Luminaires V1.1



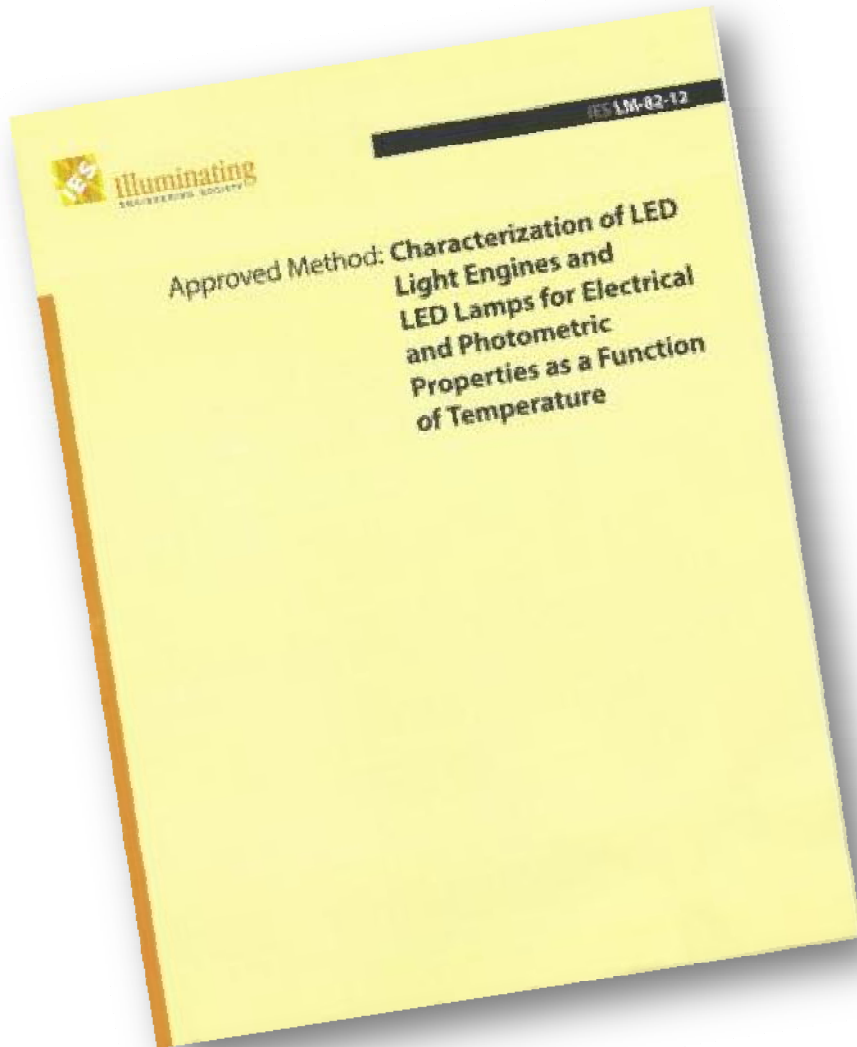
- More than 9,200 models qualified thus far
- Mix of residential and commercial
- Mix of fluorescent and solid state
- Mix of fixture types:
  - Accent lights
  - Recessed downlights
  - Solid state downlight retrofits
  - Portable desk task lights
  - Ceiling fan light kits
  - Wall sconces
  - Under cabinet

# Luminaires V1.2



- Considerations in development
  - reducing the minimum light output levels of specific luminaire types
  - removing 70 LPW requirement slated to go into effect in September 2013
  - clarifying items that are causing confusion, e.g. inseparable SSL requirements.

# IES LM-82-12 for Testing LED Light Engines

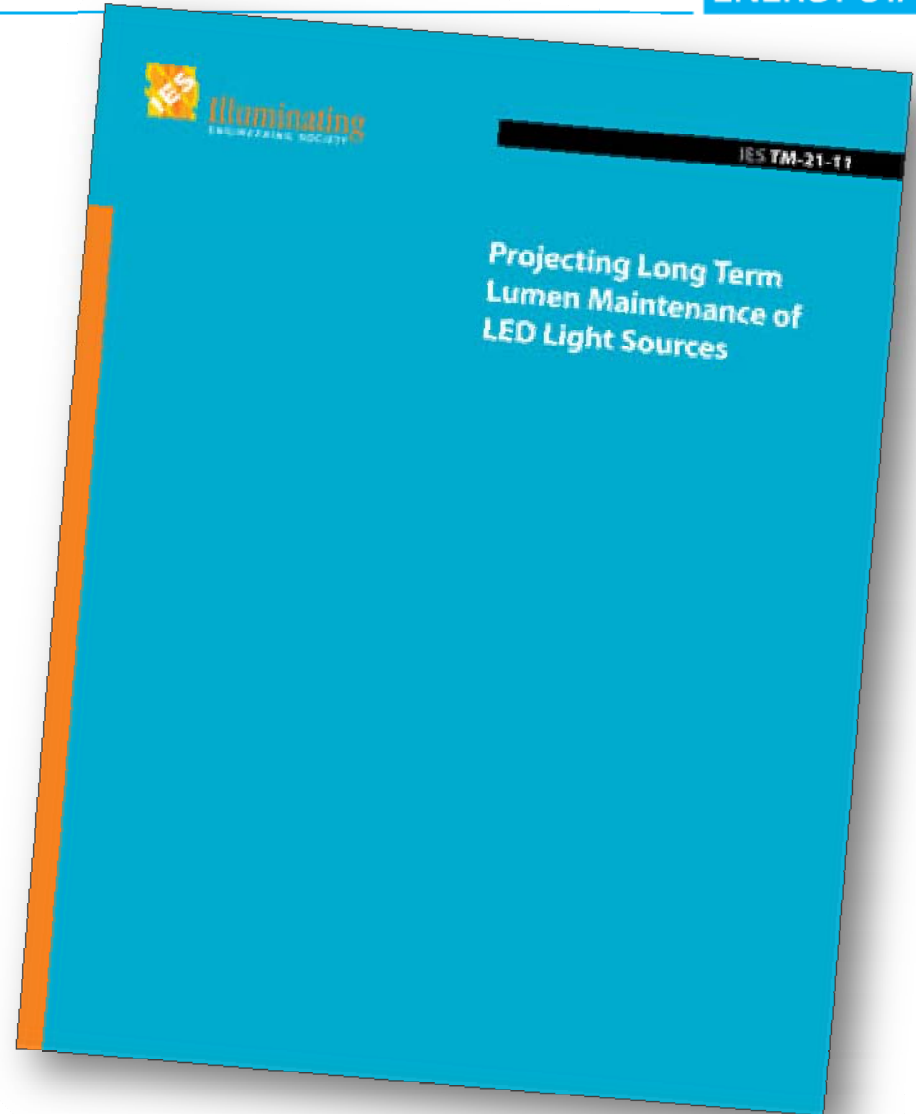


- IES LM-82-12
  - Normative reference: IES LM-79-08 for photometric and electrical measurements
- 'LM-79 as a function of temperature'
- Nine labs with accreditation
  - ✓ Bay Area Compliance Laboratories Corp., Shenzhen
  - ✓ BEST Test Service Shenzhen Co., Ltd.
  - ✓ GE Nela Park, Product Testing
  - ✓ Intertek Cortland Lab
  - ✓ LCTECH (Zhongshan) Testing Service Co., Ltd.
  - ✓ SGS Taiwan Ltd., Optics Laboratory
  - ✓ Spectralux Laboratory
  - ✓ UL Verification Services (Guangzhou) Co., Ltd
  - ✓ UL Verification Services Inc. Luminaire Testing Laboratory

# IES TM-21-11: Projecting Long Term Lumen Maintenance of LED Sources



- Lumen maintenance projections using LM-80 data using IES TM-21-11
- Covers LED packages, arrays, modules
- Sample size recommendation adopted by EPA (LM-80 silent)
- Available now through IES



# ENERGY STAR TM-21 Calculator



TM-21 Workbook\_11-04-2011.xlsx - Microsoft Excel

Home Insert Page Layout Formulas Data Review View

From Access From Web From Text From Other Sources Existing Connections Refresh All Properties Edit Links Connections Sort & Filter Filter Clear Reapply Advanced Text to Columns Remove Duplicates Data Validation Consolidate What-If Analysis Group Ungroup Subtotal Show Detail Hide Detail Outline

C3 200

Enter in situ test data here:

Luminaire LED Drive Current	200
Enter In Situ Case Temperature (°C):	65
Project life to X% lumen maintenance:	70
(t)	15000
Lumen Maintenance [at time (t)]	0.927837759

-- Use this field to estimate lumen maintenance at time t

Calculations:

Minimum Case Temperature ( $T_{1,1}$ ) for Extrapolation (K):	328.15
$\alpha_1$	1.68E-06
$B_1$	0.96
Maximum Case Temperature ( $T_{1,2}$ ) for Extrapolation (K):	358.15
$\alpha_2$	3.35E-06
$B_2$	0.95
$E_g/k_B$	2699.36
$k_B$ (eV/K)	8.6173E-05
$E_g$ (eV)	2.3261E-01
A	6.2940E-03
$B_0$	0.95822
In Situ Case Temperature ( $T_{1,1}$ ) (K):	338.15
$\alpha_1$	2.15E-06
Calculated L70 (hrs):	146170
Reported L70 (hrs):	≥60000

LM-80 Test Results:

Case Temperature 1		Case Temperature 2		Case Temperature 3	
Temperature (°C):	55	Temperature (°C):	85	Temperature (°C):	
Temperature (°K):	328.15	Temperature (°K):	358.15	Temperature (°K):	
$\alpha$ :	1.68E-06	$\alpha$ :	3.35E-06	$\alpha$ :	
B:	0.96	B:	0.95	B:	
Calculated L70 (hrs):	189961	Calculated L70 (hrs):	91821	Calculated L70 (hrs):	
Reported L70 (hrs):	≥60000	Reported L70 (hrs):	≥60000	Reported L70 (hrs):	



# ENERGY STAR TM-21 Calculator



TM-21 Workbook\_11-04-2011.xlsx - Microsoft Excel

Home Insert Page Layout Formulas Data Review View

From Access From Web From Text From Other Sources Existing Connections Refresh All Properties Edit Links Connections Sort & Filter Sort Filter Clear Reapply Advanced Text to Columns Remove Duplicates Data Validation Consolidate What-If Analysis Group Ungroup Subtotal Outline

F20 fx =!Calculations - Case Temp 2!F33

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

A B C D E F G H I J K L

Description of LED light source tested (manufacturer, model, catalog number):

Test Condition 1

Number of Samples Tested:	25
Number of Failures:	5
Number of Samples Measured:	20
(mA):	550
Test duration (hrs):	10000
Test duration used for projection (hr to hr):	5,000
Tested case temperature (°C):	55
$\alpha$ :	1.68431E-06
B:	9.63945E-01
Calculated L70 (hrs):	189961
Reported L70 (hrs):	≥60000

Test Condition 2

Number of Samples Tested:	25
Number of Failures:	5
Number of Samples Measured:	20
(mA):	550
Test duration (hrs):	10000
Test duration used for projection (hr to hr):	5,000
Tested case temperature (°C):	85
$\alpha$ :	3.35482E-06
B:	9.52533E-01
Calculated L70 (hrs):	91821
Reported L70 (hrs):	≥60000

Test Condition 3

Number of Samples Tested:	25
Number of Failures:	5
Number of Samples Measured:	20
(mA):	550
Test duration (hrs):	
Test duration used for projection (hr to hr):	
Tested case temperature (°C):	
$\alpha$ :	
B:	
Calculated L70 (hrs):	
Reported L70 (hrs):	

In-situ Results

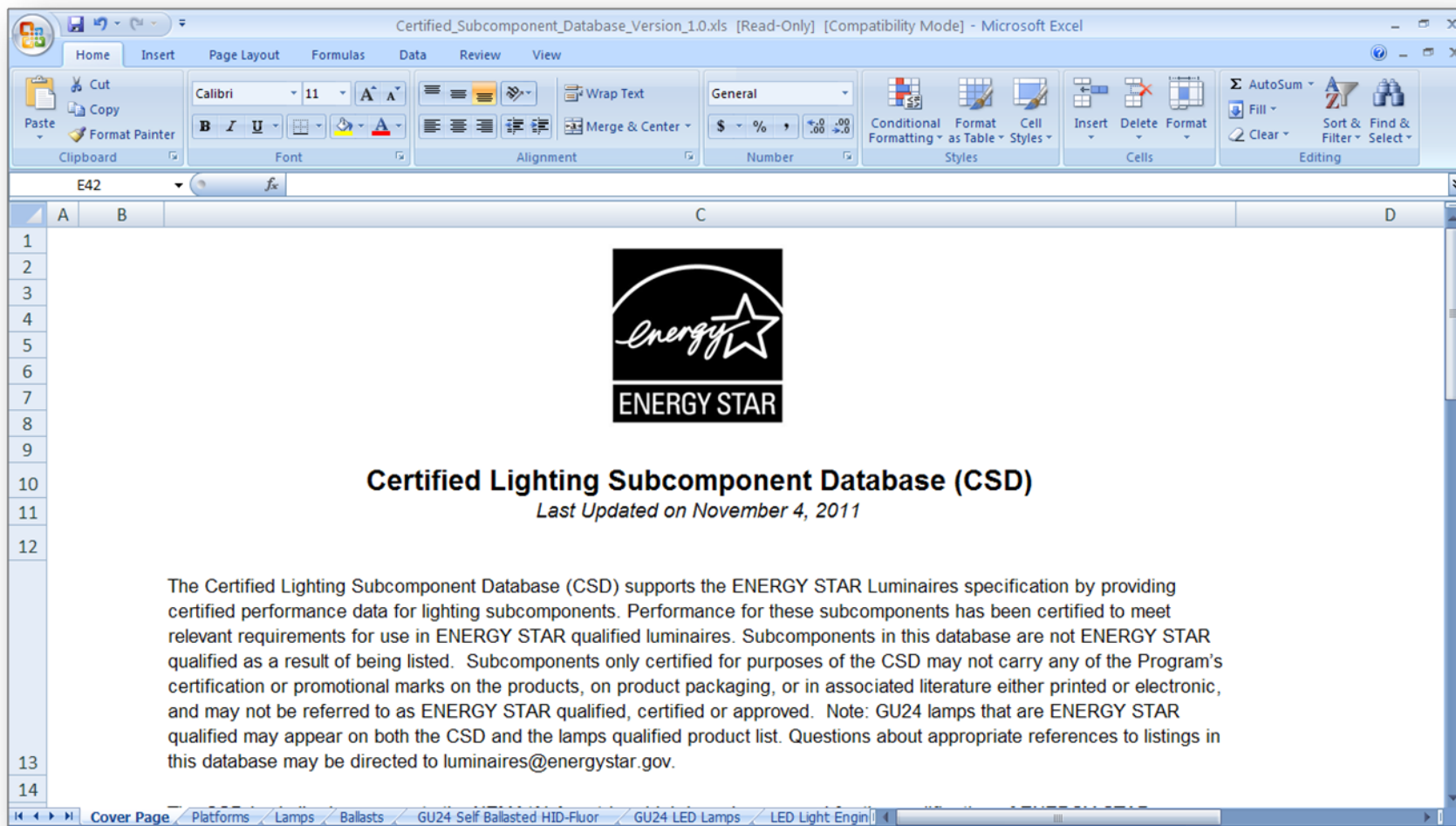
$T_{s,1}$ (°C)	55.00
$T_{s,1}$ (K)	328.15
$\alpha_1$	1.68E-06
$B_1$	9.64E-01
$T_{s,2}$ (°C)	85.00
$T_{s,2}$ (K)	358.15
$\alpha_2$	3.35E-06
$B_2$	9.53E-01
$E_0/k_0$	2.70E+03
A	0.00629401
$B_0$	0.95822217
$T_{s,i}$ (°C)	65
$T_{s,i}$ (K)	338.15
$\alpha_i$	2.15E-06
Calculated L70 (hrs)	146170
Reported L70 (hrs)	≥60000

# ENERGY STAR TM-21 Calculator



- For use by manufacturers, EPA-recognized laboratories and CBs
- Mitigates the need for accreditation
- Available at [www.energystar.gov/TM-21calculator](http://www.energystar.gov/TM-21calculator)

# Certified Lighting Subcomponent Database (CSD)



# CSD: An Overview



- **Ballasts: 212**
  - Electronic Dimming 4-Pin CFL Ballasts, Electronic T8 Ballasts, Electronic T5 Ballasts
- **Platforms: 134**
  - T5 Circline + Electronic ballast, 4-Pin CFL + Electronic ballast, High Efficiency T8 + Electronic High Ballast Factor Ballast
- **Lamps: 44**
  - 4-Pin CFL, Linear T5 Lamp, Circular Fluorescent T9
- **Fluorescent GU24s: 154**
  - Bare Spiral GU24 Lamps, Reflector GU24 Lamps, Covered GU24 Lamps

# Ceiling Fan Lighting



- Ceiling Fans V3.0 references Luminaires V1.1 for light kits



Non-directional



Directional

# Ventilation Fan Lighting



- Ventilation Fans V3.2 references  
Luminaires V1.1 for lighting
  - Exemptions included for Luminaires spec safety requirements, product labeling & packaging
  - Exemptions for range hoods and night lights

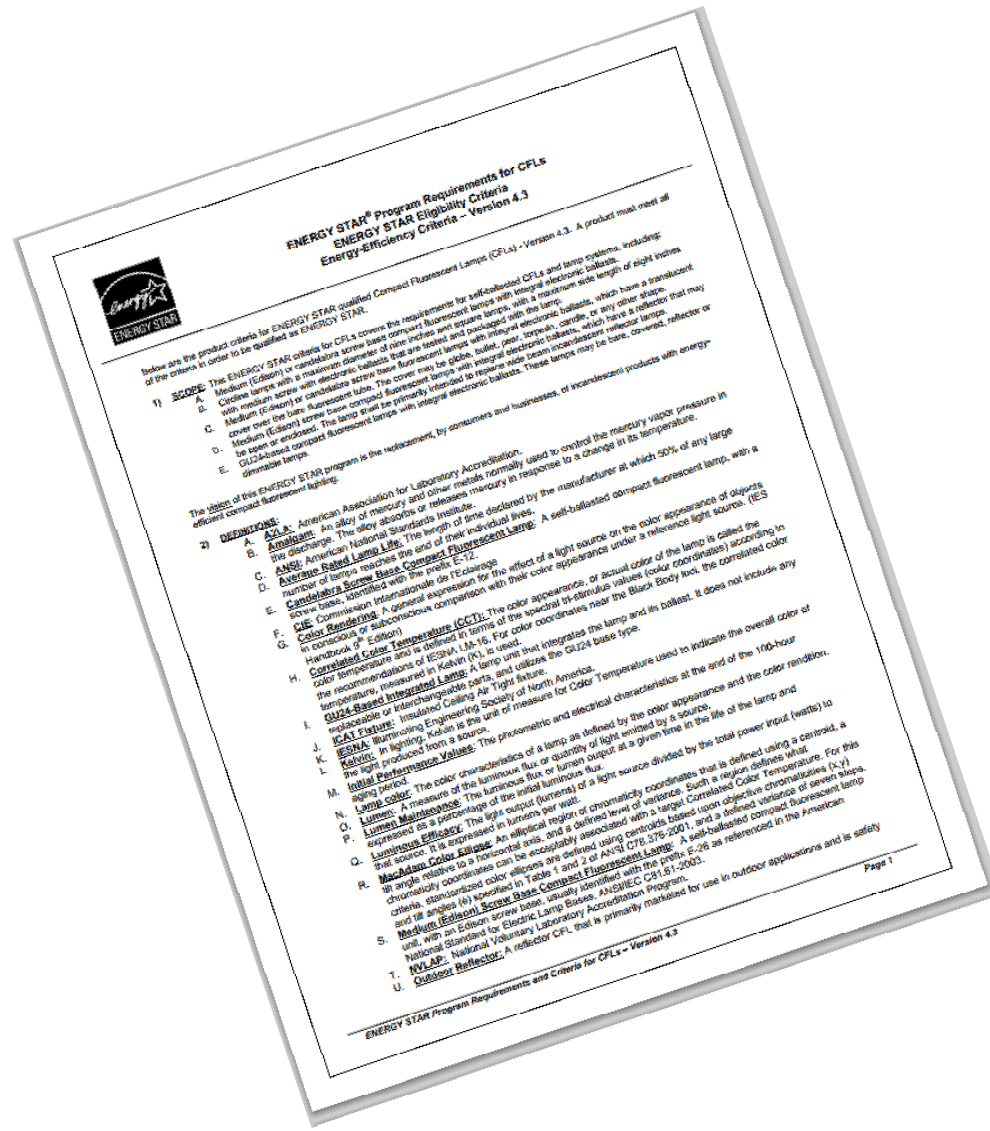


# **ENERGY STAR**

## **Compact Fluorescent Lamps V4.3**

# Compact Fluorescent Lamps

## V4.3



- Interim relocation of GU24 replacement lamp requirements
- Elimination of the 36 month requalification requirement
- Changes to verification testing procedures
- Effective February 10, 2012





# **ENERGY STAR**

## **Integral LED Lamps V1.4**

# ENERGY STAR

## Integral LED Lamps V1.4

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- Expanded upon packaging requirements for non-standard lamps
- Updated specification language to reflect Program change to third party certification
  - Removed references to NVLAP accredited or CALiPER recognized labs
  - Removed verification testing language; will be handled by CBs going forward
- Added provisions for minor product variations

A small image in the top left corner showing a person standing by a window, looking out at a green landscape.

# **ENERGY STAR**

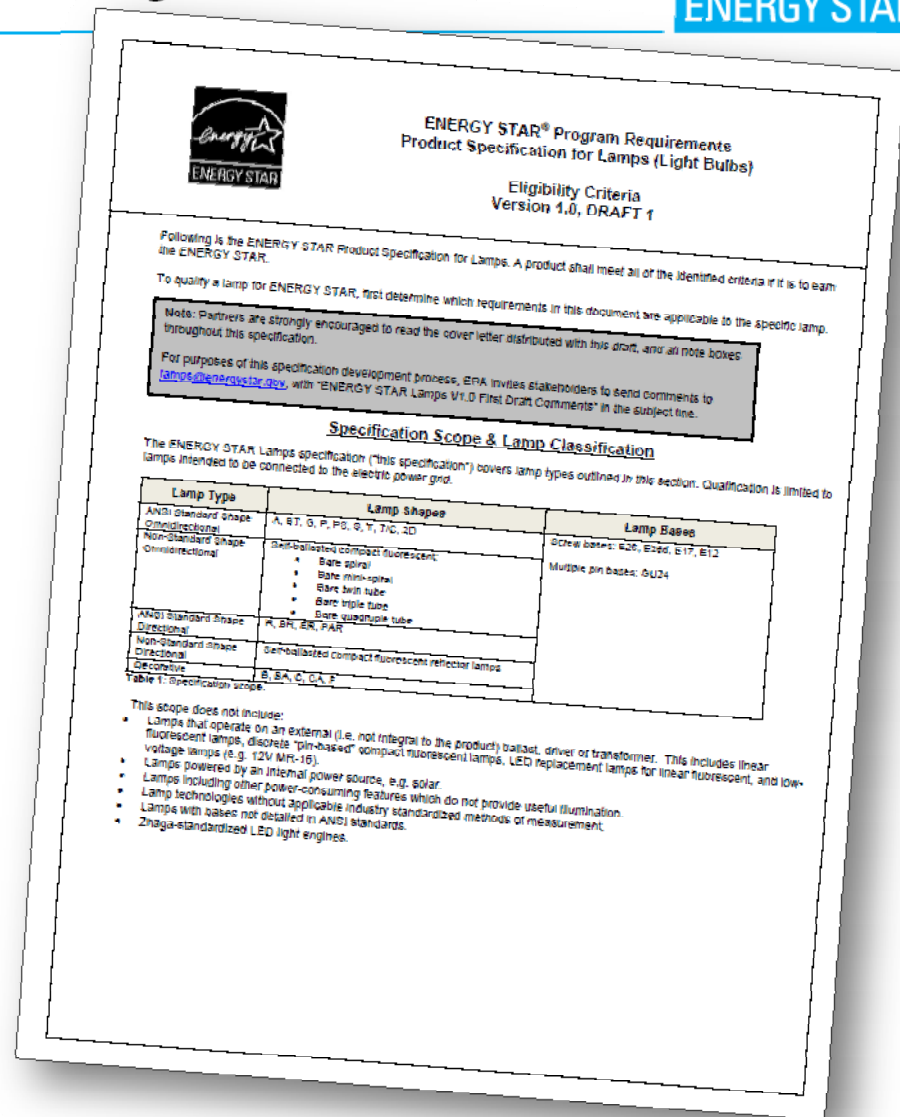
## **Lamps V1.0 Specification**

### **(in development)**

# ENERGY STAR Lamps V1.0 Draft History



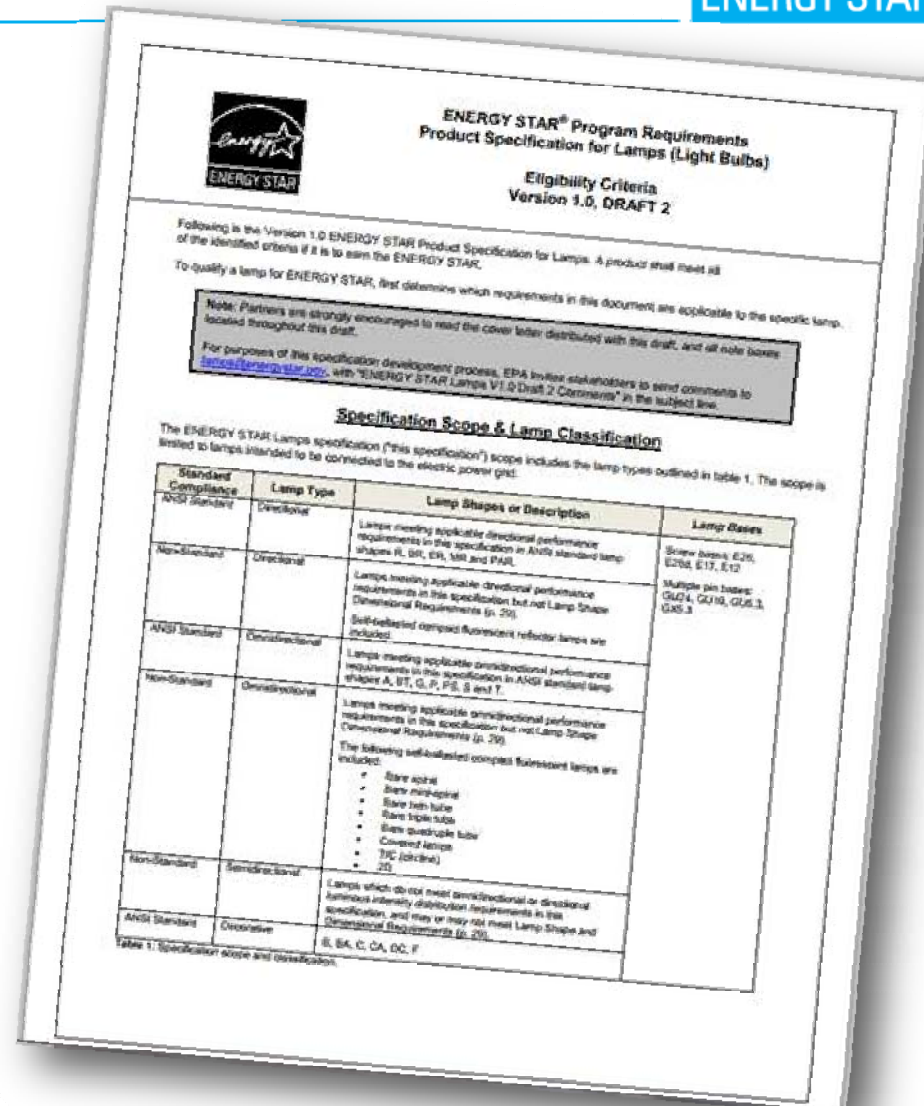
- Draft 1 issued October 21, 2011
- Draft 2 issued July 6, 2012
- EPA's intent: merge existing specifications into one technology-neutral specification, taking the opportunity to further increase quality and reliability



# ENERGY STAR Lamps V1.0 Draft



- Focused on remaining barriers to adoption
- Minor efficacy increases are proposed
- Efficacy levels will need to be revisited after completion of phase-in of new minimum efficiency standards required by EISA 2007 in 2014.



# ENERGY STAR Lamps V1.0 Draft 1 & 2: Scope



- ANSI standard omni-directional A, BT, G, P, PS, S, T, T/C, 2D
- ANSI standard directional R, BR, ER, P, MR\*
- ANSI standard decorative B, BA, C, CA, F
- Non-standard shapes for directional and omni-directional CFLs
- Non-standard semi-directional \*
- Lamp bases: E12, E17, E26, E26d, GU24, GU10\*, GU5.3\*

\* new in draft 2

# ENERGY STAR Lamps V1.0 Draft 1&2: Efficacy



Luminous Efficacy Requirements: All Lamps		
Lamp Type	ENERGY STAR Requirements	
	Lamp Input Power (watts)	Lamp Efficacy (initial lm/W)
Omnidirectional	<10	55
	≥10	60
Directional	<10	40
	≥10	45
Decorative	<10	45
	≥10	50

- Of qualified lamps, these levels are met by:
  - 92% of omnidirectional lamps
  - 80% of directional lamps

# ENERGY STAR Lamps V1.0 Draft 1 & 2: Minimum Light Output



- Same requirements as previous for:
  - Non-globe (G) shape omnidirectional
  - Decorative
- Proposed globe (G) shape requirements based on analysis of soft white standard incandescent globe lamps on the market
- R, BR and ER: Aligns with DOE rulemaking\*
- PAR lamps: not applicable

\* new in draft 2



# ENERGY STAR Lamps V1.0 Draft 1&2: Correlated Color Temperature (CCT)



- 2700K to 5000K + 6500K\* inside 4-step(D1) 7-Step\* MacAdam ellipses / quadrangles
  - Proposal intended to ensure greater consistency between makes, models & technologies
  - Current requirements allow lamps with obvious magenta or green tints to share the same CCT
  - Fluorescent ANSI standard established 4-step, ANSI SSL standard predicted return to 4-step
  - Some manufacturer support \* new in draft 2

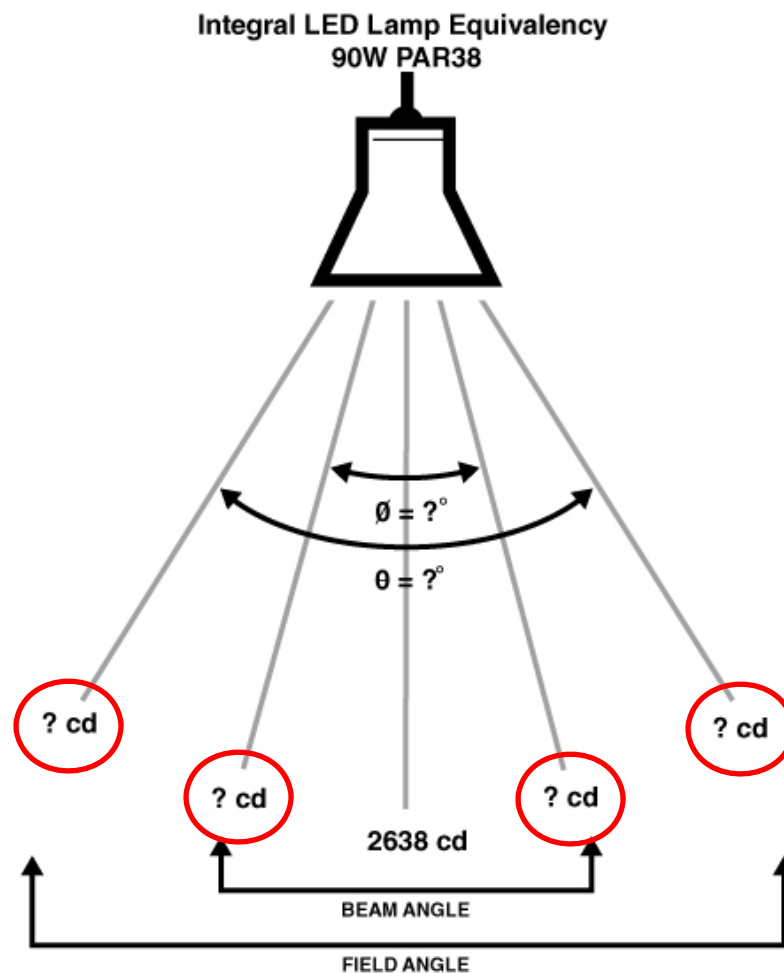
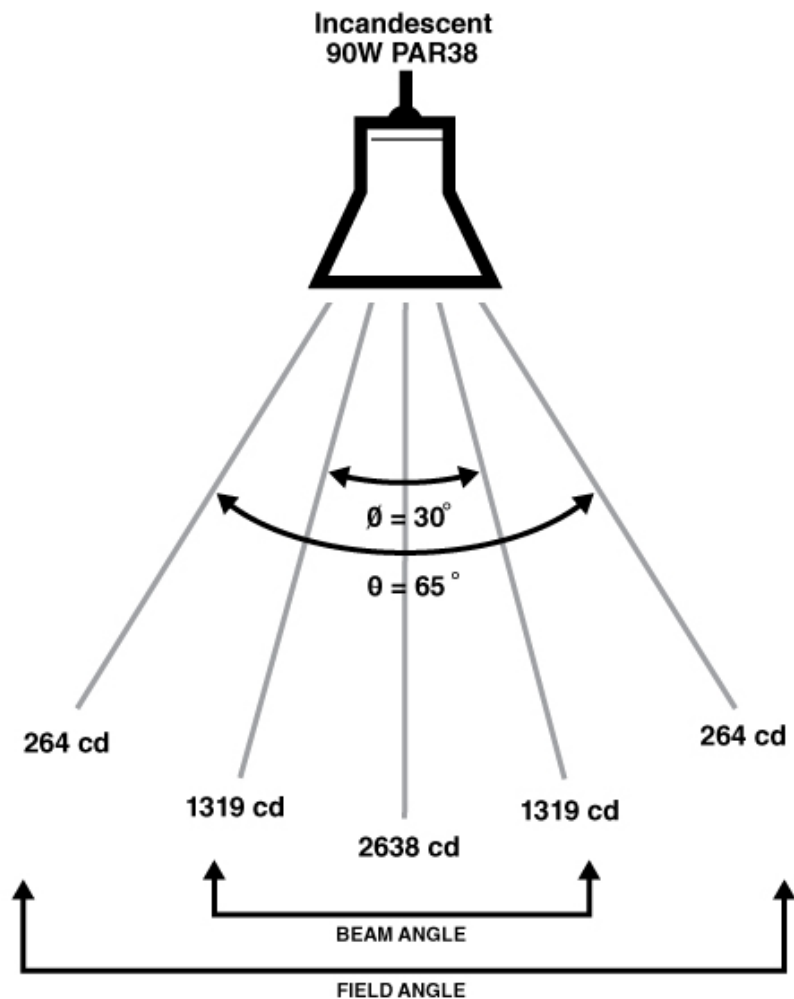
# ENERGY STAR Lamps V1.0 Draft 1&2: Color Rendering



Color Rendering Requirements: All Lamps	
Lamp Type	ENERGY STAR Requirements
All Lamps	Lamps shall exhibit color rendering index scores of $R_a \geq 80$ and $R_9 > 0$ .

- Requirement from the Integral LED Lamps spec:  $R_a \geq 80$  and  $R_9 > 0$
- Note: Color Quality Scale (CQS) is not yet available
- Positive  $R_9$  should help with consumer satisfaction with how the light shows skin and wood tones

# ENERGY STAR Lamps V1.0 Draft 2: Luminous Intensity Distribution



# ENERGY STAR Lamps V1.0 Draft 1&2: Reliability / Lumen Maintenance



- CFL: minimum 10,000 hour rated life
  - Early interim qualification option @ 40% rated life
- LED: ~~10,000 hour minimum life claim~~  
15,000 min (decorative), 25,000 min\*
  - Early interim qualification option @ 3,000 hours
  - Lamp-level testing to 6,000 hours for life claims  $\leq 25,000$  hours
- Elevated Temperature Test for all lamps  $\geq 5$  10\* watts (decorative lamps exempt)\*

\* Draft 2

# ENERGY STAR Lamps V1.0 Draft 1&2: Rapid Cycle Stress Test



Rapid Cycle Stress Test: All Lamps	
Lamp Type	ENERGY STAR Requirements
All Lamps	Lamp shall survive cycling once for every hour of rated life (minimum of 10,000 cycles). Each cycle shall be 5 minutes on, 5 minutes off.

- Need to ensure qualified lamps are robust replacements for incandescent
  - 1 cycle for each hour of rated life
  - Sample size 10 instead of 6, maintaining single failure
  - 5 min on / off to ensure adequate  $\Delta T$
  - Cap of 15,000 cycles\*

\* new in draft 2

# ENERGY STAR Lamps V1.0 Draft 1&2: Power Factor



- Draft 1 proposed 0.7 power factor for all lamps except lamps  $\leq 5W$ .
- Adjusted levels in Draft 2 to match levels in Luminaires specification\*

Technology	Existing Specifications	Draft 1 Requirement	Draft 2 Requirement
Compact Fluorescent	$\geq 0.5$ All Lamps	$\geq 0.7$ All Lamps	$\geq 0.5$ Residential Lamps $\geq 0.9$ Commercial Lamps
Solid State	$\geq 0.7$ for Lamps $>5W$	$\geq 0.7$ All Lamps	$\geq 0.7$ Residential Lamps $\geq 0.9$ Commercial Lamps

# ENERGY STAR Lamps V1.0 Draft 1&2: Start Time



Start Time Requirements: All Lamps	
Lamp Type	ENERGY STAR Requirements
All Lamps	Lamp shall remain continuously illuminated within 0.5 second of application of electrical power.

- 89% of ENERGY STAR qualified lamps meet this
  - 74% of 3-way and dimmable
- Adjusted start time from 0.5 to 1 second\*
- Start Time Test Method introduced in Annex D\*

\* new in draft 2

# ENERGY STAR Lamps V1.0 Draft 1&2: Run-Up Time



Run-Up Time Requirements	
Lamp Type	ENERGY STAR Requirements
Covered Compact Fluorescent	Lamp shall achieve full stabilized light output in $\leq 90$ seconds.
All Other Lamps	Lamp shall achieve:  $\geq 50\%$ of stabilized light output in $\leq 30$ seconds; and,  $\geq 80\%$ of stabilized light output in $\leq 45$ seconds; and,  full stabilized light output in $\leq 60$ seconds.

- Run-up times are a known consumer dissatisfier
- Proposal taken from California Super Lamp spec
- Maintained Draft 1 levels, exempted solid state products\*
- Run-Up Time Test Method introduced in Annex E\*

\* new in draft 2



# ENERGY STAR Lamps V1.0 Draft 1&2: Lighting Toxics Reduction



Lamp Type	ENERGY STAR Requirements
All Lamps	Lamps $\leq$ 23.0 watts shall contain $\leq$ 2.5 milligrams (mg) mercury per lamp  Lamps $>$ 23.0 watts shall contain $\leq$ 3.0 milligrams (mg) mercury per lamp

**Note:** The above requirements for mercury content are based upon analyses of what is technically feasible today for compact fluorescent lamps. Beyond the mercury requirements, in the interest of transparency the relevant toxics reduction requirements have been printed in the specification draft, rather than a reference to

- ... EU RoHS resources

## Draft 2

- Added test procedure reference (IEC 62554) for documenting mercury content
- Clarified that levels are based on rated lamp wattage

# ENERGY STAR Lamps V1.0 Draft 1&2: Dimming



- TBD in Drafts 1 & 2
- Working with stakeholders to develop performance & compatibility requirements, and methods of measurement
- Developing with consideration of work by ASSIST, IEEE, NEMA, PNNL, etc.

# ENERGY STAR Lamps V1.0 Draft: Next Steps (Draft 3)

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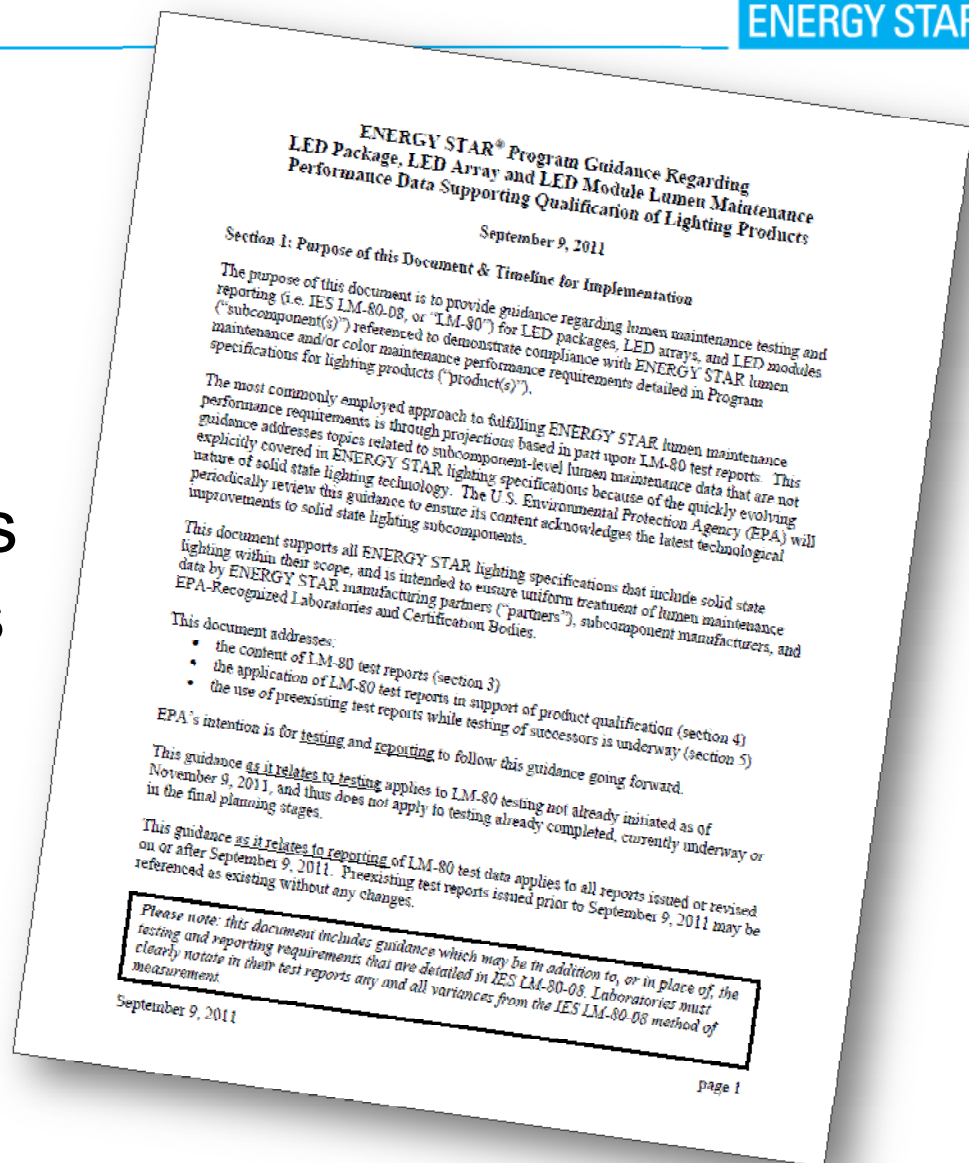
- Webinar held August 8, 2012; Comment period closed August 24, 2012
- Diligent review of stakeholder comments
  - More than 30 individual stakeholder comment letters received
  - Received from manufacturing partners, test labs, certification bodies, utility programs, and various others
- Based on feedback, considering making changes, e.g. requirements for low voltage MR-16 lamps
- Considering proposals to better align with DOE

# Program Guidance Regarding LED Lumen Maintenance Data

# Program Guidance Regarding LED Lumen Maintenance Data



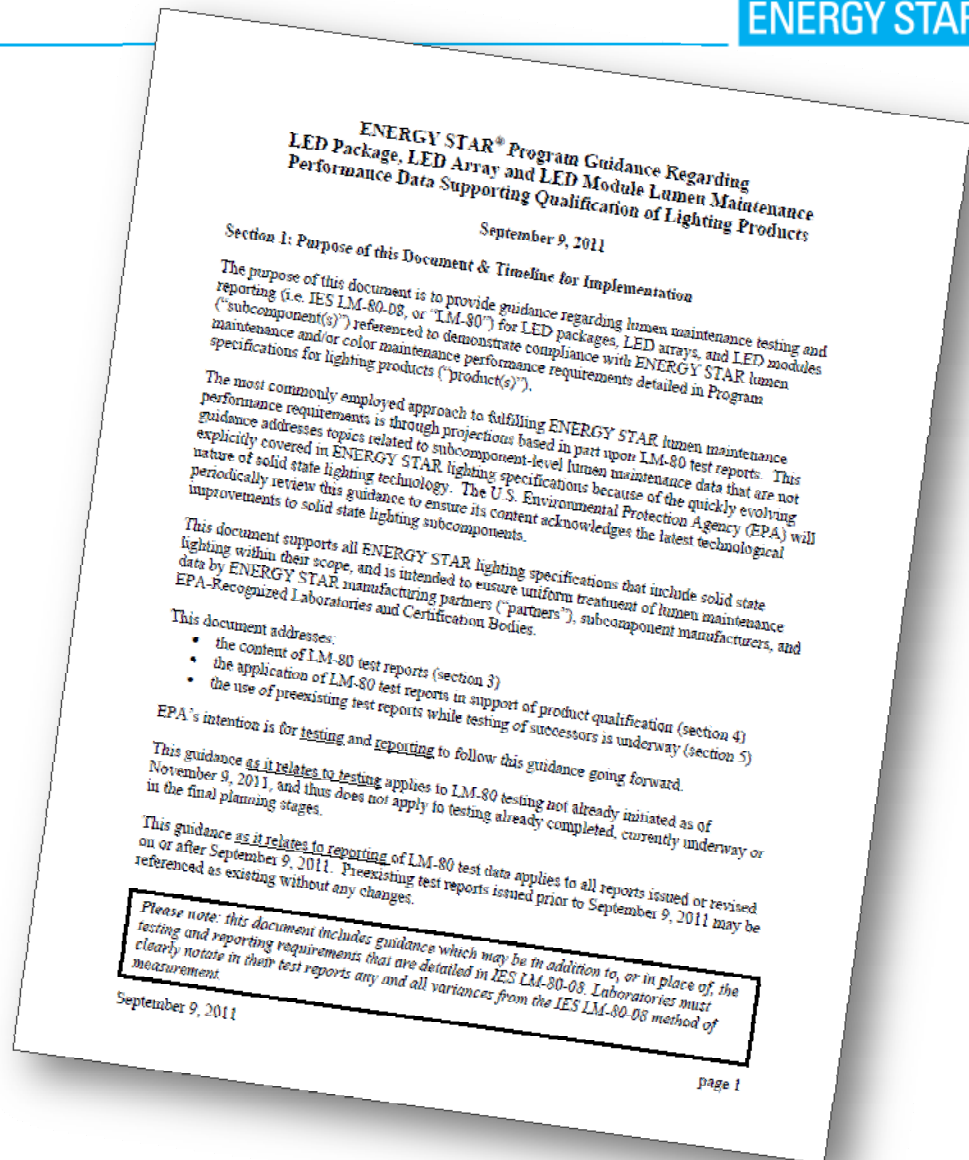
- Intended to ensure uniform treatment of data by partners, LED manufacturers, EPA-recognized laboratories and certification bodies



# Program Guidance Regarding LED Lumen Maintenance Data



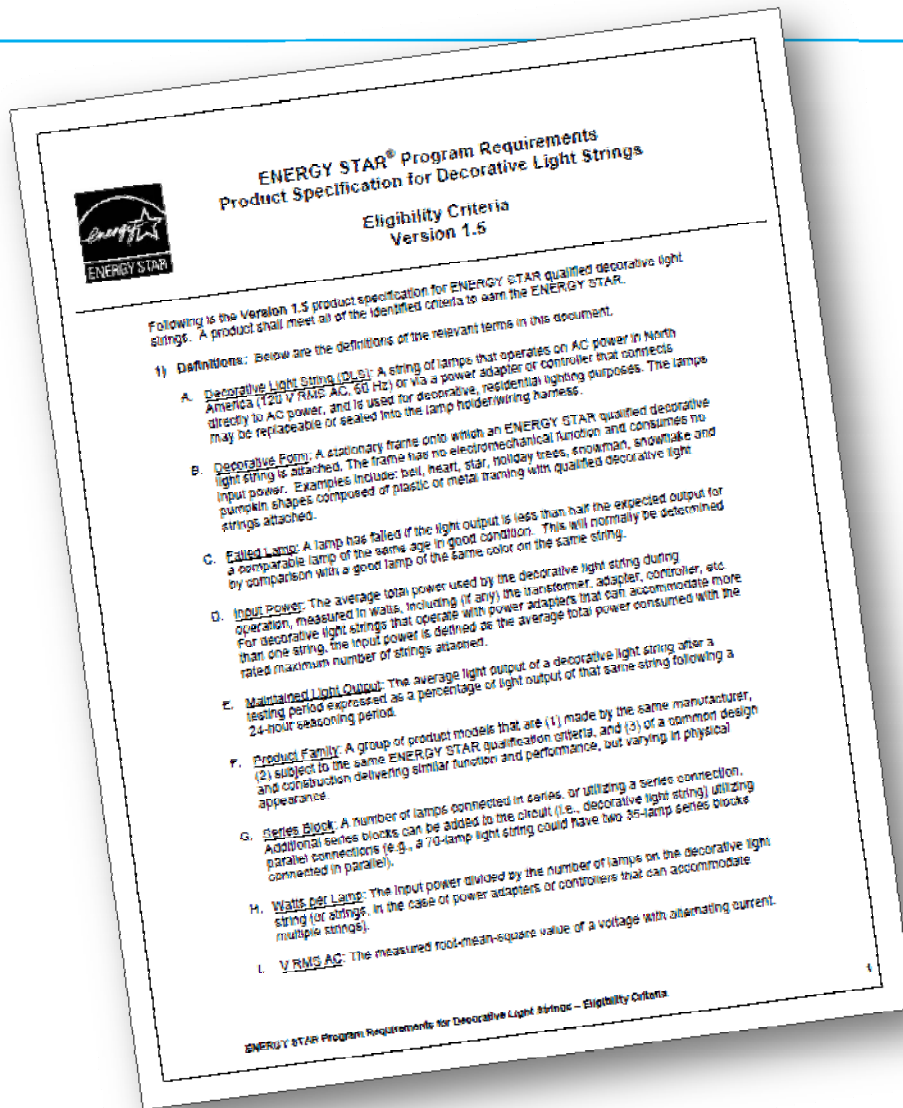
- Guides Certification Bodies on:
  - Content of LM-80 reports
  - Application of LM-80 reports
  - Use of preexisting test reports while successor testing is underway



# **ENERGY STAR**

## **Decorative Light Strings V1.5**

# Decorative Light Strings V1.5



- No change in requirements
- Updated to format established by EPA as part of the transition to third-party certification
- An expansion of scope to cover 'decorative forms'







# Questions?



# Thank you!



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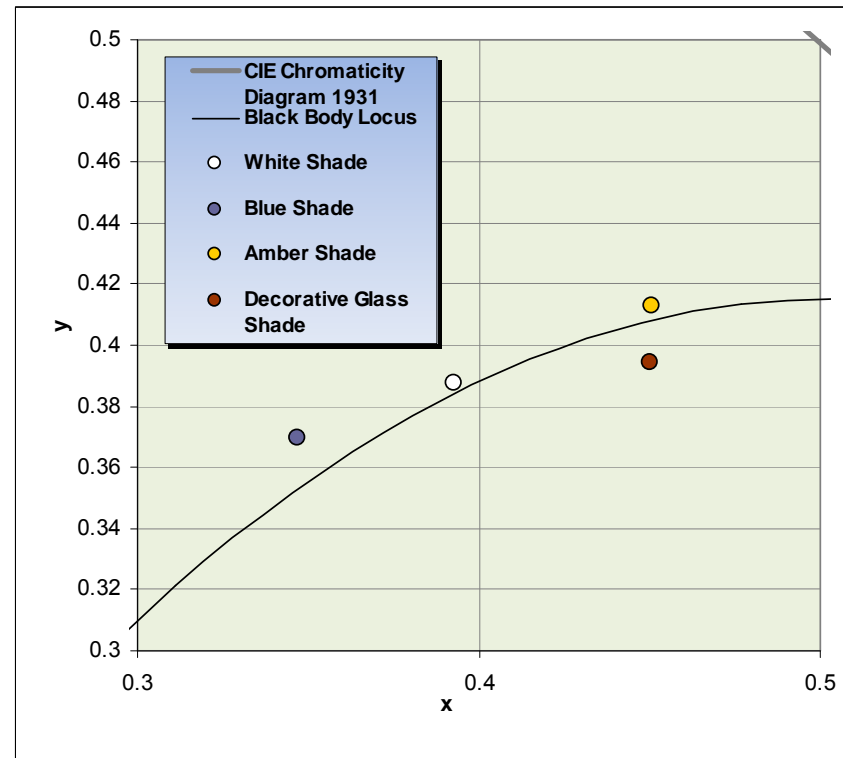
Tanya Hernandez  
ICF International  
(919) 294-9004

[Tanya.Hernandez@icfi.com](mailto:Tanya.Hernandez@icfi.com)



# Reference Slides

# LM-79 and Decorative Shades



# LM-79 and Decorative Shades



Product Description	Ambient Temperature (°C)	Input Voltage (V)	Input Power (W)	Luminous Flux (lm)	Luminous Efficacy (lm/W)	x	y	CCT	CRI
White shade	24.7	120.11	4.48	165.0	36.83	0.3929	0.3876	3761	73.6
Blue shade	24.7	120.11	4.48	129.9	28.99	0.3468	0.3698	4998	72.0
Amber Shade	24.7	120.02	4.48	82.6	18.44	0.4507	0.4129	2851	69.0
Decorated glass	24.7	120.12	4.48	34.9	7.78	0.4499	0.3942	2711	78.1

Testing Decorative LED Fixtures Per IES LM-79-08

Lighting Research Center (NVLAP Lab Code: 200480-0)

2/13/2011

# LED Light Engines



## **LED Light Engine:**

An integrated assembly comprised of LED packages (components) or LED arrays (modules), LED driver, and other optical, thermal, mechanical and electrical components. The device is intended to connect directly to the branch circuit through a custom connector compatible with the LED luminaire for which it was designed and does not use an ANSI standard base. (IES RP-16-10)



# LED Light Engines

