

# Solid State Lighting Annex: Product Quality and Performance Tiers

## OUTDOOR LIGHTING (STREET LIGHTING)

Efficient Electrical End-Use Equipment (4E)  
International Energy Agency

**OCTOBER 2013**

## Performance Tiers Proposed by Governments Participating in the IEA 4E SSL Annex

Government officials from 13 countries participating in the International Energy Agency's Energy Efficient End-use Equipment (IEA 4E) implementing agreement have identified solid state lighting (SSL) technologies as having the potential to cut global lighting electricity consumption by 30%. While SSL technologies promise high performance, the recent experience with compact fluorescent lamps has demonstrated the need to prevent unwarranted performance claims, which can seriously damage consumer confidence and slow down market acceptance of this emerging energy-saving technology.

Twenty technical experts from the SSL Annex's nine member countries: Australia, Denmark, France, Japan, Korea, The Netherlands, Sweden, United Kingdom, and United States of America and expert member country China have worked together to develop performance tiers for Light Emitting Diode (LED) based lighting. Several performance tier levels were set to address the various priorities and needs from each country or region. This approach is expected to help participating governments to define globally consistent requirements for programmes to promote market adoption of SSL products, as well as being useful for governments planning to adopt national energy policies and regulations covering SSL technologies.

The SSL Annex has published performance tiers associated with the following LED lamps and luminaires:

1. Non-directional Lamps for Indoor Residential Applications
2. Directional Lamps for Indoor Residential Applications
3. Downlight Luminaires
4. Linear Fluorescent LED Lamps
5. Linear Fluorescent LED "Retrofit" Lamps
6. Outdoor Lighting (Street Lighting)

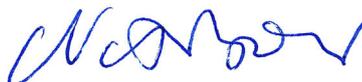
To view these performance tiers, visit our website: <http://ssl.iea-4e.org/task-1---quality-assurance>

The SSL Annex is continuing to monitor the market and the appropriateness of these published tier levels, and fully expects that additional levels will be added in the future as SSL technology advances. The Annex appreciates your interest in this process and welcomes any suggestions or thoughts you may have on these tiers.

Best regards,



Peter Bennich, PhD  
Management Committee Chair,  
SSL Annex;  
Energy Efficiency Department,  
Swedish Energy Agency



Nils Borg  
Operating Agent  
SSL Annex



Professor Georges Zissis  
SSL Annex Task 1 Leader  
LAPLACE, University of  
Toulouse, France

Parameter	Tier 1	Tier 2	Tier 3 (for future use)
<b>Energy-Efficiency</b>			
Minimum downward luminaire efficacy (lm/W) <sup>1,2</sup>	= (0.0010 x Φ) + 51 where Φ is downward lumen output	= (0.0012 x Φ) + 64 where Φ is downward lumen output	
<b>Life</b>			
Lumen maintenance	At 35000 hours, lumen maintenance should be greater than 78% of the initial flux.	At 35000 hours, lumen maintenance should be greater than 78% of the initial flux.	
Minimum rated luminaire lifetime (F50)	At least 50% shall be operative after 50,000 hours.	At least 50% shall be operative after 50,000 hours.	
<b>Colour</b>			
Colour Rendering Index (CRI)	N/A	≥ 60	
Colour maintenance (Δu',v' at 6,000h)	N/A	< 0.007	

Parameter	Common to all Tiers																		
<b>Operation</b>																			
Operating temperature (range °C)	Minimum temperature range from -10°C to 40°C without significant change of photometric and colourmetric performance, unless regional requirements are higher or lower																		
Ingress Protection (IP), Impact Protection (IK)	Must be IP65 or greater																		
<b>Light &amp; Health</b>																			
Correlated colour temperature (K) and tolerance < 6500K	Follow ANSI C78.377, excluding flexible CCT <table border="1"> <thead> <tr> <th>Nominal</th> <th>Target</th> </tr> </thead> <tbody> <tr> <td>CCT:</td> <td>CCT ± Tolerance</td> </tr> <tr> <td>2700K:</td> <td>2725 ± 145</td> </tr> <tr> <td>3000K:</td> <td>3045 ± 175</td> </tr> <tr> <td>3500K:</td> <td>3465 ± 245</td> </tr> <tr> <td>4000K:</td> <td>3985 ± 275</td> </tr> <tr> <td>5000K:</td> <td>5028 ± 283</td> </tr> <tr> <td>5700K:</td> <td>5665 ± 355</td> </tr> <tr> <td>6500K:</td> <td>6530 ± 510</td> </tr> </tbody> </table>	Nominal	Target	CCT:	CCT ± Tolerance	2700K:	2725 ± 145	3000K:	3045 ± 175	3500K:	3465 ± 245	4000K:	3985 ± 275	5000K:	5028 ± 283	5700K:	5665 ± 355	6500K:	6530 ± 510
Nominal	Target																		
CCT:	CCT ± Tolerance																		
2700K:	2725 ± 145																		
3000K:	3045 ± 175																		
3500K:	3465 ± 245																		
4000K:	3985 ± 275																		
5000K:	5028 ± 283																		
5700K:	5665 ± 355																		
6500K:	6530 ± 510																		
Chromaticity tolerance (Du'v')	Centre points based on ANSI C78.377, excluding flexible CCT <table border="1"> <thead> <tr> <th>Nominal</th> <th>Target</th> </tr> </thead> <tbody> <tr> <td>CCT:</td> <td>Du'v' ± Tolerance</td> </tr> <tr> <td>2700K:</td> <td>0.000 ± 0.012</td> </tr> <tr> <td>3000K:</td> <td>0.000 ± 0.012</td> </tr> <tr> <td>3500K:</td> <td>0.000 ± 0.012</td> </tr> <tr> <td>4000K:</td> <td>0.001 ± 0.012</td> </tr> <tr> <td>5000K:</td> <td>0.002 ± 0.012</td> </tr> <tr> <td>5700K:</td> <td>0.002 ± 0.012</td> </tr> <tr> <td>6500K:</td> <td>0.003 ± 0.012</td> </tr> </tbody> </table>	Nominal	Target	CCT:	Du'v' ± Tolerance	2700K:	0.000 ± 0.012	3000K:	0.000 ± 0.012	3500K:	0.000 ± 0.012	4000K:	0.001 ± 0.012	5000K:	0.002 ± 0.012	5700K:	0.002 ± 0.012	6500K:	0.003 ± 0.012
Nominal	Target																		
CCT:	Du'v' ± Tolerance																		
2700K:	0.000 ± 0.012																		
3000K:	0.000 ± 0.012																		
3500K:	0.000 ± 0.012																		
4000K:	0.001 ± 0.012																		
5000K:	0.002 ± 0.012																		
5700K:	0.002 ± 0.012																		
6500K:	0.003 ± 0.012																		
Flicker (amplitude modulation depth)	At full power: flicker index ≤ 0.3																		
Minimum displacement power factor	≥ 0.9																		
Safety	Must meet regional requirements for material and electrical appliance safety laws.																		
<b>Environment</b>																			
Uplight (emissions above the horizontal)	> 95% of total light output will be emitted below the horizontal (90 degrees) (Note: Local regulations may have more stringent requirements for upward light)																		
RoHS compliant	Yes (Note: other regulations may apply)																		
Recyclability (%)	Yes, following the principles of self- declaration found in ISO 14021																		

<sup>1</sup>The lumen (lm) values for efficacy calculation shall be initial lumen measurements.

<sup>2</sup>The efficacy requirements of LED streetlight luminaires increases with light output not because higher output products are inherently more efficient, but because the HID products they are intended to replace increase in efficacy as light output increases. This approach ensures energy savings relative to incumbent products regardless of light output levels, and allows low-output LED products – which are competitively priced in comparison to low output HID products – to qualify for these requirements at efficacies that are currently easily achieved.

## Definitions of Performance Tiers and Criteria

### Tier 1: Minimum Acceptable Performance Level

This tier is intended to be the minimum acceptable performance level. Products in this tier provide reliable lighting, use less energy and last longer than the traditional sources they are replacing, such as mercury vapour luminaires. The SSL products in this tier have/are:

- Efficacies providing energy savings relative to the high intensity discharge (HID) lamp sources they are replacing, such as mercury vapour luminaires;
- Reliability and lifetimes are superior to the lighting products they are intended to replace;
- Illumination of area – including quality of light and intensity distribution should be perceived by users as roughly equivalent; and
- The luminaires should be safe to install and operate.

### Tier 2: Performance Required by Established Quality Programs

This tier is intended to be similar or equal to the performance required for established voluntary programs that promote quality LED products, such as the EU Quality Charter, US Energy Star or Japan's Green Procurement Law (although some of these programmes do not have specific requirements for street lighting luminaires). The SSL products in this tier have/are:

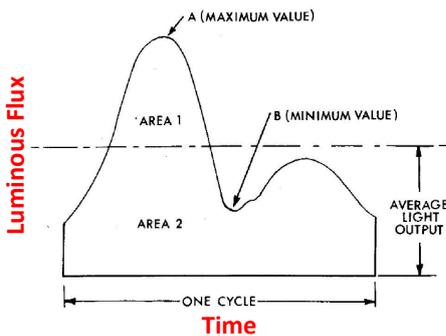
- Efficacies in this tier are intended to achieve energy savings relative to high pressure sodium street light luminaires;
- Reliability and lifetimes are superior to the lighting products they are intended to replace;
- Illumination of area – including quality of light and intensity distribution should be perceived by users as roughly equivalent; and
- The luminaires should be safe to install and operate.

### Tier 3: Current Highest Commercially Available Performance [reserved for future use]

This tier is intended to represent the highest performing products available on the market in early 2014. Products achieving these performance levels are similar to those participating in the US Department of Energy's L-Prize, the SEAD program or the Japanese Top Runner program. For this product group, this tier level is reserved for future use.

**Table 1. Performance Criteria included in the IEA 4E SSL Annex Product Tiers Documents**

Criterion	What is it?	Why is it included?
Minimum downward luminaire efficacy (lm/watt)	The ratio of the total light output of an entire fixture compared to the power consumed (lm/watt). The higher the efficacy value, the more energy-efficient the lighting product.	This is a very important criterion. If a very efficient light source is installed in an inefficient light fixture, a large part of the light will be lost inside the fixture. As a result, even with a very efficient light source, there will be no efficiency gains or energy saved.
Lumen maintenance	The percentage of a lighting product's measured light output after a period of time compared to that light product's initial total light output.	Lumen Maintenance helps the consumer determine how long it will take a lighting product to degrade to the point that it is no longer useable. High lumen maintenance over time helps to justify the higher initial cost of SSL lighting products.
Minimum rated luminaire lifetime ( $F_{50}$ )	Lifetime is typically defined as the amount of time that it takes for 50% of a statistically significant sample to fail.	It is unrealistic to measure very long lifetimes for SSL products. Having a credible $B_{50}$ estimation is very important, as LED lighting products must have longer lifetimes to justify the high initial cost of LED lighting. If SSL products are able to meet their lifetime claims, they can cut long-term energy consumption and save the consumer money.
Colour rendering index (CRI)	Colour rendering is a measure of how similar object colours appear under one light source as compared to the object colours under a reference light source (usually an incandescent light or daylight). Colour rendering index is defined in CIE 13.3-1995.	Colour rendering is very important for consumer satisfaction with a lighting product. Often, a CRI of 80 is required for office work, and recommended for use in residential applications. A CRI of 90 is recommended for tasks that require high colour discrimination.
Colour maintenance ( $\Delta u', v'$ at 6,000h)	This criterion specifies the allowable shift of the light colour of a SSL product as it ages.	This criterion ensures that as a light product ages, the perceived colour of light does not shift from warm- white to cool-white or develop a green or pink tint. If a light product in a large installation is replaced by a new light product, this criterion ensures that the new product's light colour will be similar in colour to the other lights installed in the same space.
Operating Temperature (range °C)	The operating temperature represents the range of temperatures that a luminaire manufacturer has determined it is safe to use the luminaire. A luminaire should not be used outside these temperatures.	The operating temperature range for the luminaire is shown on the rating label and represents an important safety consideration for an installation.

Criterion	What is it?	Why is it included?
Ingress Protection (IP), Impact Protection (IK)	IP rating is a two digit code that measures the degree of protection by enclosures for electrical equipment against solid objects and water in accordance with IEC 62262:2002 and IEC 60068-2-75:1997. The first digit represents protection against the ingress of solid objects and dust, and the second digit represents protection against moisture. Impact Protection (IK) rating measures degrees of protection provided by enclosures for electrical equipment against external mechanical impacts in accordance with IEC 62262:2002 and IEC 60068-2-75:1997.	Outdoor lights often become perches for birds and the debris that comes with them. The luminaire should not collect and retain dirt or water on the topside, and the optical chamber should remain clean for the LED luminaire to truly reduce maintenance.
Correlated colour temperature (K) and tolerance <6500K	The temperature of the lighting product in relation to the Planckian (black body) locus. CIE 15:2004 defines how to measure this parameter. ANSI C78.377 defines the target colour temperatures and allowable tolerances.	The CCT metric helps consumers select the appropriate product depending on their light colour preference and match lights' colour across different manufacturers' lighting products. This way, when different manufacturers' light products are used in the same space there is not an unintended mix of cool- white lighting with warm-white lighting.
Chromaticity tolerance (Du'v')	This criterion specifies the allowable deviation in light's colour. Technically, it is the distance of a light's chromaticity from the Planckian (black body) locus. Chromaticity allowances follow those in ANSI C78.377.	This criterion is of high importance to ensure that the light from an LED product does not have an unacceptable pink or green tint. This criterion attempts to ensure that all lamps of the same claimed colour temperature appear to be the same colour when installed.
Flicker (flicker index)	<p>This criterion measures the perceived photometric "flicker" of a light source. Flicker index defined by <math>(\text{Area 1} / (\text{Area 1} + \text{Area 2}))</math>; replaced by new metric under development by IEEE PAR1789 which accounts for frequency, when available.</p> 	This is an important item for both consumer satisfaction and consumer acceptance of SSL products. Some consumers may have severe health reactions to flickering light sources of certain frequencies ranging from low-grade headaches to extreme seizures. Flicker can also make rapidly moving objects seem like they are standing still, or leave after images of bright points in the visual field. The requirements minimize these stroboscopic effects.

Criterion	What is it?	Why is it included?
Minimum displacement power factor	Power factor is the ratio of the real power flowing to the load over the apparent power of the circuit.	For the Electrical power supplier, this is of very high importance and for street lighting; customers may be subject to a penalty charge if power factor is below 0.9.
Safety	This criterion specifies that a product meets electrical safety requirements and marking requirements.	All products must meet all safety regulations in an economy.
Uplight (emissions above the horizontal)	Percentage of the total flux emitted from a luminaire above a horizontal plane passing through the centroid of a luminaire.	Uplight contributes to sky glow, diminishing night sky viewing, and for many types of outdoor luminaires, needlessly wastes light and energy. This criterion may be subject to local regulations that have more stringent requirements on uplight.
RoHS compliant	The EU's Regulation of Hazardous Substances (RoHS) Directive prevents the use of certain hazardous materials in new electrical and electronic equipment placed on the European market after 1 July 2006.	This criterion requires products meet requirements that limit the use of certain hazardous materials when sold in the EU. Non-EU countries may use other, similar requirements.
Recyclability (%)	This criterion defines how much of the SSL product must be recyclable.	This criterion is important to manage electronic equipment waste and reduce the environmental burden of these products. Ideally, products would be designed to be easily recycled when they fail.