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Street and Outdoor LED Lighting Initiative - Asia

Survey Findings

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International Institute for Energy Conservation

Asia Regional Office (IIEC-Asia)

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Agenda for today

1. About IIEC
2. APEC's Street and Outdoor LED Lighting Initiative – Asia
3. International and APEC LED Standards
4. LED Street and Outdoor Lighting Projects in APEC
5. Best Practices in APEC
6. Questions and Discussion

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- *Energy Efficiency*
- *Demand-Side Management*
- *Distributed Generation & Renewable Energy*
- *Rural Electrification*
- *Renewable Energy*
- *Sustainable Habitat*

- *Market Studies & Assessment*
- *Technologies & Pilot / Demonstration Projects*
- *Policies, Programs, Plans*
- *Finance*
- *Communication & Outreach*
- *Training & Capacity Building*

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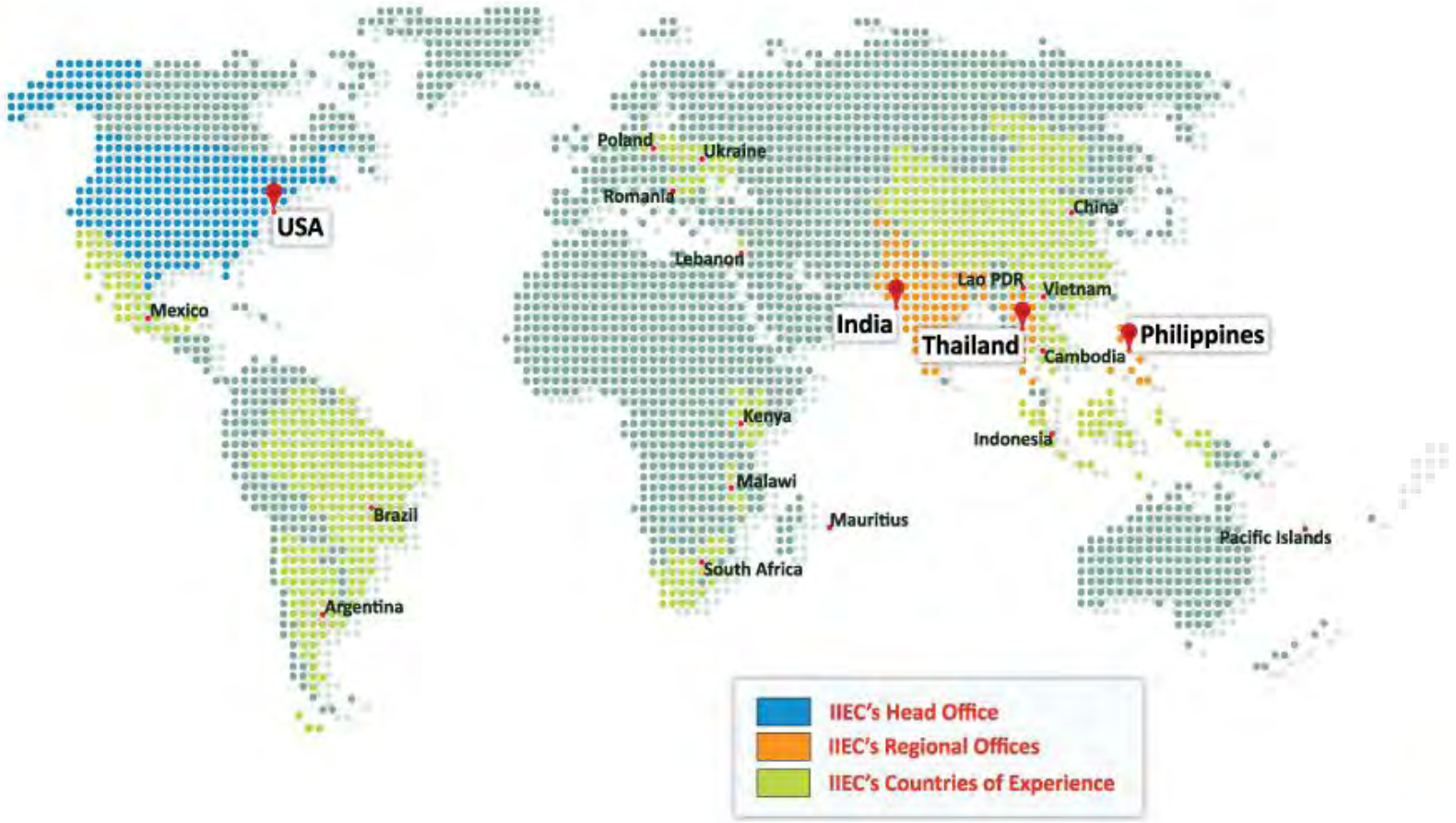
IIEC Offices & Projects



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About the Project

- APEC's Street and Outdoor LED Lighting Initiative – Asia:
  - *Best practices on LED street and outdoor lighting*
  - *LED street and outdoor lighting standards*
- Survey + Research in APEC Economies:
  - *Government regulatory departments*
  - *Standardization agencies*
  - *Municipalities and city councils*
  - *Utilities*
  - *Lighting industry associations and research institutes*

Purpose of Street and Outdoor Lighting

Allow users of vehicles to proceed safely

Allow pedestrians to see hazards, orientate themselves, recognize other pedestrians and give them a sense of security

Improve night-time appearance of the environment

Source: CIE 115:1995

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International LED Standards

- **Product Performance**
  - International Commission on Illumination (CIE)
  - International Electrotechnical Commission (IEC)
- **Street and Outdoor Lighting Applications**
  - International Commission on Illumination (CIE)
  - American National Standards Institute (ANSI)
  - Illuminating Engineering Society of North America (IESNA)
- **CDM Methodology for Outdoor and Street Lighting**

International LED Product Standards

IEC 60598 series	Luminaire safety
IEC 60825-1	Safety of Laser Products – Part 1: Equipment classification and requirements. Applicable to LEDs.
IEC 60838-2-2:2006	Miscellaneous lamp holders – Part 2-2: Particular Requirements – connectors for LED modules.
IEC 61347-1:2007	Lamp control gear - Part 1: General and safety requirements
IEC 61347-2-13:2006	Lamp control gear – Part 2-13: Particular requirements for dc or ac supplied electronic control gear for LED modules.
IEC 62384:2009	Performance of control gear for LED modules dc or ac supplied electronic control gear for LED modules – performance requirements
IEC/PAS 62722-1:2011	Luminaire performance - Part 1: General requirements
IEC/PAS 62722-2-1: 2011	Luminaire performance - Part 2-1: Particular requirements for LED luminaires
CIE Publication No. 127-2007	Measurements of LEDs
CIE Publication No. 177-2007	Colour rendering of white LED Light Sources

International Guidelines/Standards for Street and Outdoor Lighting

- CIE 31-1976 – Glare and Uniformity in Road Lightings Installations
- CIE 22-1977 – Depreciation of Installation and their Maintenance (in Road Lighting)
- CIE 47-1979 – Road Lighting for Wet Conditions
- CIE 48-1980 – Light Signals for Road Traffic Control
- CIE 66-1984 – Road Surfaces and Lighting (Joint Technical Report CIE/PIARC)
- CIE 93-1992 – Road Lighting as an Accident Countermeasure
- CIE 132-1999 – Design Methods for Lighting of Roads
- **CIE 140-2000 – Road Lighting Calculations**
- CIE 136-2000 – Guide to the Lighting of Urban Areas
- CIE 144-2001 – Road Surface and Road Marking Reflection Characteristics
- **CIE 115-2007 – Recommendations for the Lighting of Motorized Traffic (updated)**
- **CIE 180-2007 – Technical Report: Road Transport Lighting for Developing Countries**
- **CIE 115-2010 – Lighting of Roads for Motor and Pedestrian Traffic**
- CIE 119-2010 - Recommended System for Mesopic Photometry Based on Visual Performance

- *CEN/TR 13201-1 - Road Lighting – Part 1: Selection of Lighting Classes*
- *ANSI/ESNA RP-8-00 - American National Standard Practice for Roadway*
- ***ANSI C136.37 - Solid State Light Sources Used in Roadway and Area Lighting***
- *AS/NZS 1158.1/1-1997 – Road Lighting – Vehicular Traffic Lighting*
- *AS CA19-1939 - Australian Standard Rules for Street Lighting*

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Who is taking the LEaD on LED Standards?

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Status of LED Standards for Street and Outdoor Lighting

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APEC Member Economy	LED Product	LED Module	LED Control Gear	LED Luminaire
Australia, Canada, People's Republic of China, China (Hong Kong), Chinese Taipei, New Zealand, The United States	X	X	X	X
Japan	X	X	X	UD
Republic of Korea	UD	X	UD	UD
Mexico	UD	X	X	X
Malaysia		X	X	
Singapore		X		X
The Philippines, Thailand, Viet Nam				X*
Brunei Darussalam, Chile, Indonesia, Papua New Guinea, Peru, Russia				

X – Standard Developed; UD – Standard Under Development; X* - IEC 60598 (Luminaire Safety Standard);

Blank – Standard not developed or information unavailable

LED Standards in the People's Republic of China

GB/T 20145-2006	Photobiological safety of lamps and lamp systems
SJ/T 2355-2006	LED Measurement Methods
GB/T 9468-2009	General requirements for photometry and goniophotometry of luminaires
SJ/T 11399-2009	Measurement methods for LED chips
SJ/T 11394-2009	Measurement methods for LED modules
GB 19651.3-2008	Miscellaneous lamp holders – Part 2-2: Particular requirements – connectors for LED modules
GB 19651.3-2009	Lamp control gear – Part 14: Particular requirements for D.C. or A.C. supplied electronic control gear for LED
GB/T 24825-2009	D.C. or A.C. supplied electronic control gear for LED modules – Performance requirements
GB /T 24827-2009	Performance requirements of luminaires for road and street lighting
GB/T 24907-2010	**LED lamps for road lighting – performance specifications**

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LED Standards in Chinese Taipei

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CNS 14115	Radio disturbance limits for electrical lighting and similar equipment and measurement methods
CNS 14335	General requirements and tests for luminaires
CNS 14335-2-3	Luminaires - Part 2-3: Safety requirements for luminaires for road and street lighting
CNS 14676-5	Electromagnetic compatibility (EMC) - Testing and measurement techniques - Part 5: Surge immunity test
CNS 15174	DC or AC supplied electronic control gear for LED module - Performance requirements
CNS 15233	**Fixtures of roadway lighting with LED lamps**
CNS 15248	Methods of measurement on LED components for thermal resistance
CNS 15249	Methods of measurement on LED components for optical and electrical characteristics
CNS 15250	Methods of measurement on LED modules for optical and electrical characteristics
Under Review	Optics measurement method for LED lighting system
Under Review	Environment and reliability testing method for LED devices
Under Review	Optical and electrical characteristics measurement method for LED chip
Under Development	Quality testing method for LED chip
Under Development	Accelerated life testing method for LED chip
Under Development	Accelerated life testing for LED device and module
Under Development	Thermal resistance measurement method for LED chip
Under Development	Power supply measurement method for LED lighting system
Under Development	Environment sustainability testing method for LED lighting system

LED Standards/Guidelines in The United States

IES LM-79-2008	Approved Method for the Electrical and Photometric Testing of Solid-State Lighting (SSL) Devices
IES LM-80-2008	Approved Method for Measuring Lumen Depreciation of LED Light Sources
IES RP-16	Nomenclature and Definitions for Illuminating Engineering (Addenda a and b)
IES G-2	Guideline for the Application of General Illumination (“White”) LED Technologies
ANSI C78.377-2008	Specifications for the Chromaticity of SSL Products
NEMA LSD 45-2009	Recommendations for SSL Sub-Assembly Interfaces for Luminaires
NEMA LSD 49-2010	SSL for Incandescent Replacement - Best Practices for Dimming
UL 8750	Safety Standard for LED Equipment for Use in Lighting Products
NEMA SSL-6-2010	SSL for Incandescent Replacement - Dimming
IES TM-21	Method for Estimation of LED Lumen Depreciation as a Measure of Potential LED Life

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WHAT ABOUT ON THE GROUND EXPERIENCE?

STREET AND OUTDOOR LIGHTING PROJECTS

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Supporting LED Projects and Industry

Chinese Taipei:

- *Ministry of Economic Affairs – Bureau of Energy*
- *Plan to accelerated LED R&D through demonstration projects*
- *Replace all traffic signal lamps with LED lamps by 2012*

Japan:

- *New Energy and Industrial Technology Development Organization (NEDO)*
- *Replace all the lightings in Japan with LED lightings by 2030*

Republic of Korea:

- *LED Lighting 2060 Project*
- *National LED lighting penetration rate of 60% by 2020*

New Zealand:

- *Energy Efficiency and Conservation Authority (EECA)*
- *Efficient Lighting Programme with local councils, New Zealand Transport Agency, New Zealand Institute of Highway Technology*

The United States:

- *Department of Energy - Municipal Solid-State Street Lighting Consortium*
- *Los Angeles Bureau of Street Lighting – LED Street Lighting Energy Efficiency Program.*

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Types of Projects

Public Roads:

- *Australia, Canada, People's Republic of China, China (Hong Kong), Chinese Taipei, Republic of Korea, Mexico, New Zealand, Thailand, The United States*

City of Sydney Council, 2011

Public Parks:

- *Australia, Chinese Taipei, Mexico, New Zealand, The United States*

Traffic Lighting:

- *China (Hong Kong), Chinese Taipei, Republic of Korea, The United States*

Inhabitat.com, 2011

Most projects triggered by Municipalities and City Councils:

- *Sydney (Au), Huizhou and Xiamen (China), Taipei (CT), Mexico City (MX), Waitakere and Hamilton (NZ), Los Angeles, Seattle and Chicago (US), and many more…*

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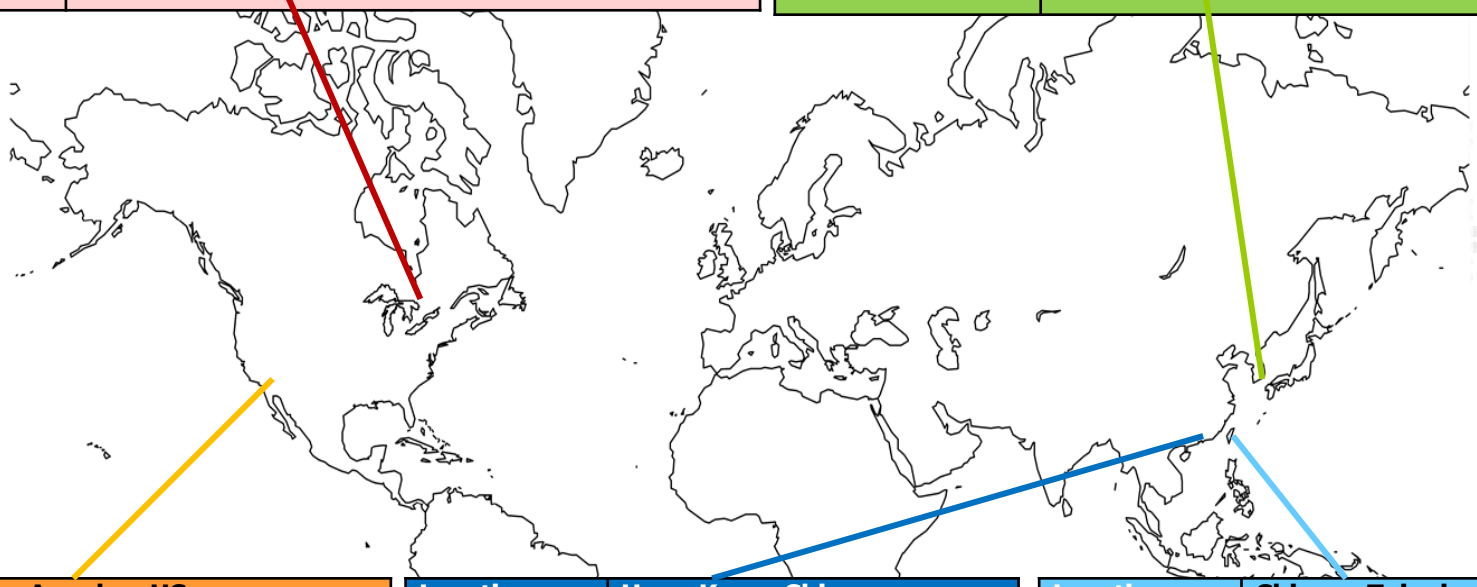
LED Street and Outdoor Lighting Projects

Location	Greater Toronto Area, Canada
Num. Installations	> 1,800 LED Luminaires (1,100 in Nova Scotia alone)
Achievements	Accelerate use of LED street and outdoor lighting and supporting municipalities in making the best choices and ensure public acceptance

Location	Suwon City, Republic of Korea
Num. Installations	4,000 LED traffic light units
Achievements	85% reduction in energy costs compared to previous technology and also a 30% reduction in traffic accidents



Location	Los Angeles, US
Num. Installations	52,000 LED Streetlights
Achievements	Annual Energy Savings: 21,057 MWh Annual Energy Cost Savings: US$1.93 million

Location	Hong Kong, China
Num. Installations	1,900 junctions (traffic signals)
Achievements	Approximately HK$7.6 million savings (approx. US$975,000) per annum and a reduction in CO_2 emissions of 5,300 tonnes.

Location	Chinese Taipei
Num. Installations	Replace all traffic signal lamps with LED lamps by 2012
Achievements	Supports and strengthens national LED industry preparing industry also for external markets

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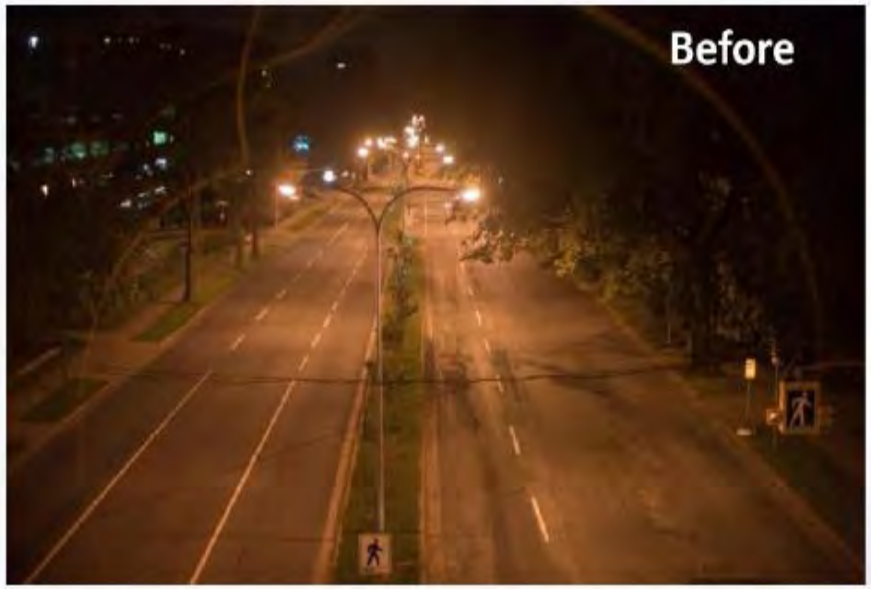
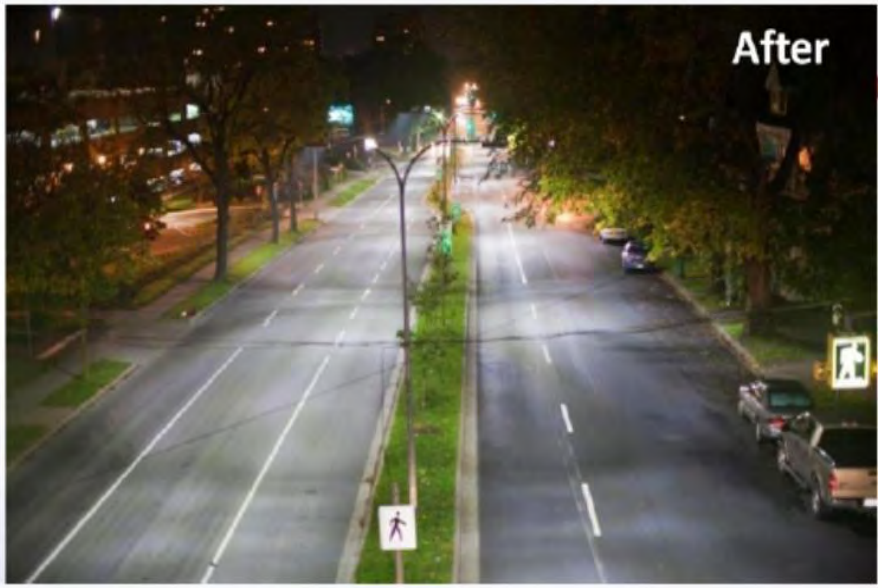
Nova Scotia, Canada





Lightsavers Program, 2011

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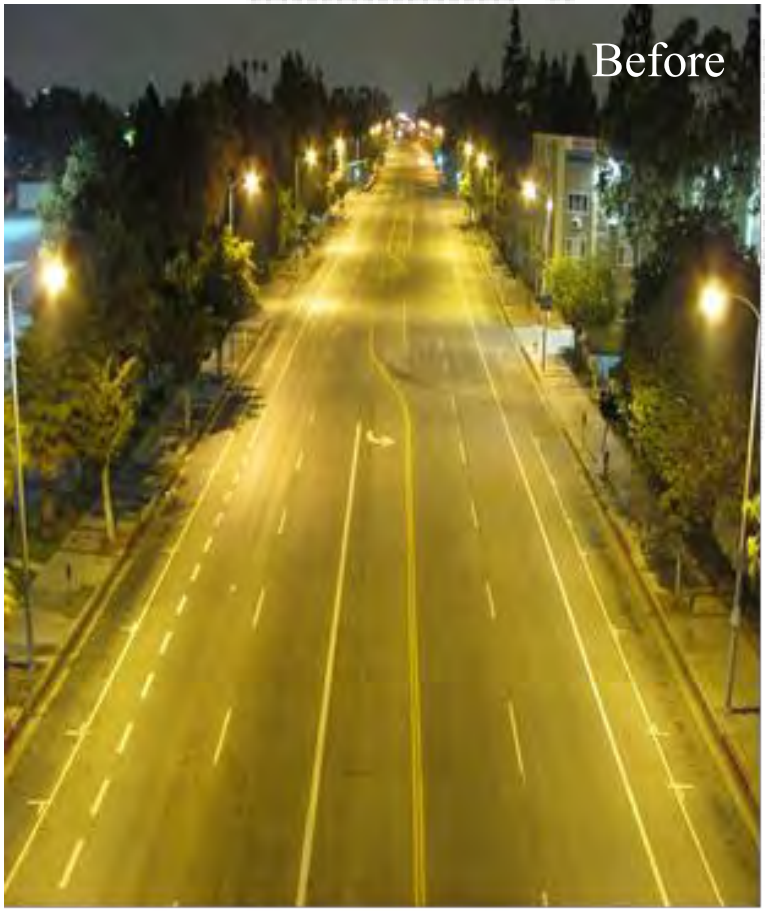
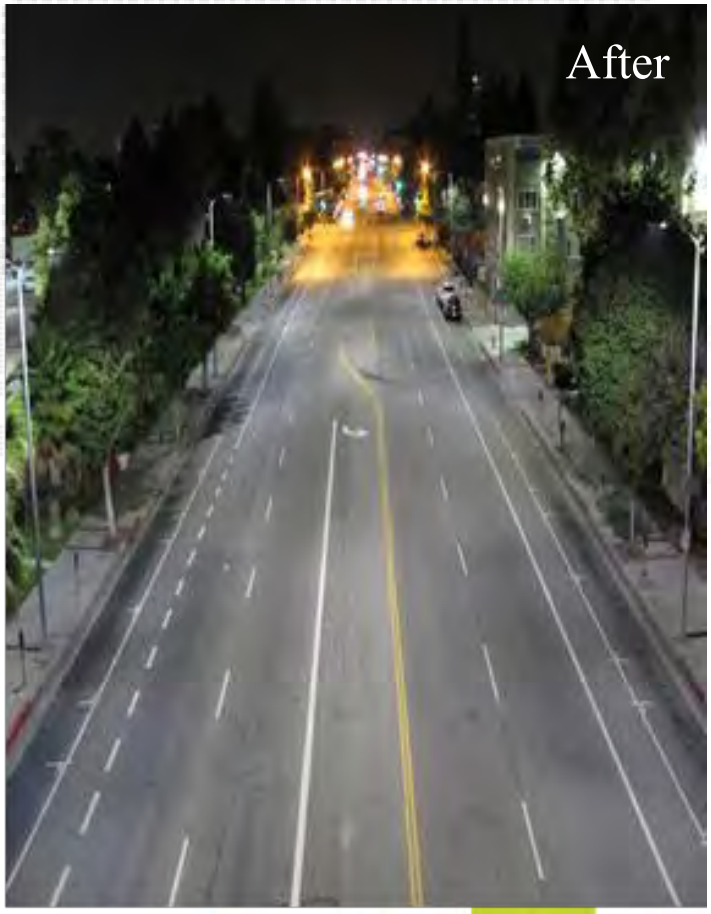
Los Angeles, US





BSL, 2011

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LESSONS FROM EXPERIENCE…

BEST PRACTICES

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Best Practices in APEC

- Based on Survey and Research
- Purchase, Installation and Maintenance
- Target Audience?
  - *Towns and cities*
  - *Local officials and municipal government*
  - *Policy makers*

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7 Key Questions - Purchase

LED product specifications follow economy-wide standards?

Requirements of illumination quality included in the procurement specifications?

Preliminary field trial is a part of the evaluation and selection process?

Testing performed by third-party, accredited laboratories?

Warranty of LED products is at least 5 years?

Warranty bond and penalty included as parts of Warranty Terms and Conditions?

"Application Efficacy" considered as one of the selection criteria?

Standards and Specifications - Purchase

- **China** - GB/T 24907-2010: LED lamps for road lighting – performance specifications
- **Chinese Taipei** - CNS 15233: Fixtures of roadway lighting with LED lamps
- **Republic of Korea** - KS C 7528: LED Traffic Signals
- **Thailand** – Asian Development Bank project – General Specifications
- **The United States**:
  - *ANSI C136.37 - Solid State Light Sources Used in Roadway and Area Lighting*
  - *Bureau of Street Lighting – General Specifications*
    - Correlated Colour Temperature (CCT) and Colour Rendering Index (CRI)
    - Off-State and On-State Power Consumption
    - Luminaire Efficacy and Lumen Depreciation
    - Safety and Assembly
    - Warranty
  - *Municipal SSL Street Lighting Consortium - Model Specification for LED Roadway Luminaires*
    - System Specification (application efficacy)
    - Material Specification (luminaire efficacy)

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Ensuring Quality - Purchase

- **Voluntary Product Certification and Labeling Schemes:**
  - ***Australia*** *- SSL Quality Scheme*
  - ***Republic of Korea*** *– High Efficiency Certification Program for LED traffic lights*
  - ***Malaysia*** *- LED Certification Centre*
  - ***Mexico*** *- Label Scheme (Sello FIDE)*
  - ***The United States*** *- SSL Quality Advocates Scheme*
- **Guidelines:**
  - ***Hong Kong, China*** *- Guidelines for Specifying & Procuring LED Lighting Products for Lighting Projects*

Best Practices for Installation

- Location
- Purpose and Requirements
- Design in accordance with Standards and Specifications
- Installation
- Testing Performance
- **But…What Changes with LED?**
  - *Lights Levels and Uniformity*
  - *Proposed Visual Efficacy Systems*

Light Levels and Uniformity

- **International Standards for Street and Outdoor Lighting**
- **Light Levels and Uniformity based on:**
  - Type of traffic (motorized or pedestrian)
  - Traffic density
  - Conflict area
- **Defines:**
  - Lighting pole layout, span and height
  - Selection of light source, luminaire and electrical design works

Light Levels and Uniformity

CIE 115-2007 – Recommendations for the Lighting of Motorized Traffic (updated)

Lighting Class	Luminance (cd/m^2)	Uniformity (U_o)
M1	2.0	0.4
M2	1.5	0.4
M3	1.0	0.4
M4	0.75	0.4
M5	0.5	0.4

Lighting Class	Description of Road
M1, M2, M3	High speed roads with separate carriageways Traffic density and complexity of road layout
M1, M2	High speed roads with dual carriageway roads Traffic control level
M2, M3	Important urban traffic routes, radial roads, district distributor roads Traffic control level
M4, M5	Connecting less important roads, local distributor roads, residential major access roads Traffic control level

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Visual Efficacy Systems

Scotopic / Photopic Ratio of Commercially Available Light Sources

Low Pressure Sodium	0.25
High Pressure Sodium (HPS) 250 W clear	0.63
HPS 400 W clear	0.66
HPS 400 W coated	**0.66**
Mercury vapour (MV) 175 W coated	1.08
MV 400 W clear	1.33
Incandescent	1.36
Halogen headlamp	1.43
Fluorescent Cool White	1.48
Metal halide (MH) 400 W coated	1.49
MH 175 W clear	1.51
MH 400 W clear	1.57
MH headlamp	1.61
Fluorescent 5000 K	1.97
White LED 4300 K	**2.04**
Fluorescent 6500 K	2.19

Source: Table 2, ASSIST Publication on Outdoor Lighting: Visual Efficacy, Volume 6, Issue 2, January 2009

Values of Unified Luminance for Different Base Light Levels and Scotopic / Photopic Ratios

HPS Lamp

White LED

Base light level (photopic luminance (cd/m^2))

S/P	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.32
0.25	0.0573	0.0704	0.0849	0.1009	0.1184	0.1373	0.1574	0.1788	0.2012	0.2246
0.35	0.0728	0.0877	0.1037	0.1209	0.1392	0.1585	0.1787	0.1998	0.2217	0.2442
0.45	0.0864	0.1026	0.1197	0.1377	0.1565	0.1760	0.1963	0.2172	0.2387	0.2607
0.55	0.0983	0.1156	0.1335	0.1521	0.1713	0.1911	0.2113	0.2320	0.2532	0.2747
0.65	0.1092	0.1273	0.1459	0.1649	0.1844	0.2043	0.2245	0.2451	0.2659	0.2871
0.75	0.1191	0.1379	0.1570	0.1764	0.1961	0.2161	0.2363	0.2567	0.2773	0.2981
0.85	0.1283	0.1477	0.1672	0.1869	0.2068	0.2268	0.2470	0.2672	0.2876	0.3081
0.95	0.1368	0.1566	0.1765	0.1965	0.2165	0.2365	0.2566	0.2767	0.2969	0.3170
1.05	0.1448	0.1651	0.1853	0.2054	0.2255	0.2456	0.2656	0.2856	0.3055	0.3254
1.15	0.1523	0.1730	0.1935	0.2138	0.2339	0.2540	0.2739	0.2937	0.3135	0.3331
1.25	0.1593	0.1803	0.2010	0.2215	0.2417	0.2617	0.2816	0.3013	0.3208	0.3402
1.35	0.1661	0.1873	0.2082	0.2288	0.2491	0.2691	0.2888	0.3084	0.3277	0.3469
1.45	0.1724	0.1940	0.2150	0.2357	0.2560	0.2759	0.2956	0.3150	0.3341	0.3531
1.55	0.1785	0.2003	0.2215	0.2422	0.2625	0.2824	0.3020	0.3213	0.3402	0.3590
1.65	0.1843	0.2063	0.2276	0.2484	0.2687	0.2886	0.3081	0.3272	0.3460	0.3645
1.75	0.1899	0.2120	0.2335	0.2543	0.2746	0.2944	0.3138	0.3328	0.3514	0.3697
1.85	0.1952	0.2175	0.2391	0.2599	0.2802	0.3000	0.3193	0.3381	0.3566	0.3747
1.95	0.2003	0.2228	0.2444	0.2653	0.2856	0.3053	0.3244	0.3432	0.3615	0.3794
2.05	0.2053	0.2279	0.2496	0.2705	0.2907	0.3103	0.3294	0.3480	0.3661	0.3838
2.15	0.2100	0.2327	0.2545	0.2754	0.2956	0.3152	0.3341	0.3526	0.3706	0.3881

Best Practices for Maintenance Strategy

- **Purpose:**
  - Cleaning
  - Repairs
  - Replacement
  - Refurbishment
- **But…What Changes with LED?**
  - *Lumen Depreciation*
  - *Product Lifetime*

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Evaluating Lifetime of LEDs

- **LED maintenance strategy will depend on:**
  - ***Lumen-Maintenance Life (L_p)***
  - ***Rated Life or Statistically Measured Failures (B_p)***

- **Projecting for 30,000 hours and 50,000 hours?**
  - *Modelling and extrapolation methods under discussion*
  - *Lumen-maintenance projection curve*
    - Rule of Thumb - for each 10°C increase, LED lifetime falls by half
  - *Accelerated Life-Test Methods*

Hong Kong, China – Maintenance Guidelines

- **Guidelines for Specifying & Procuring LED Lighting Products for Lighting Projects:**

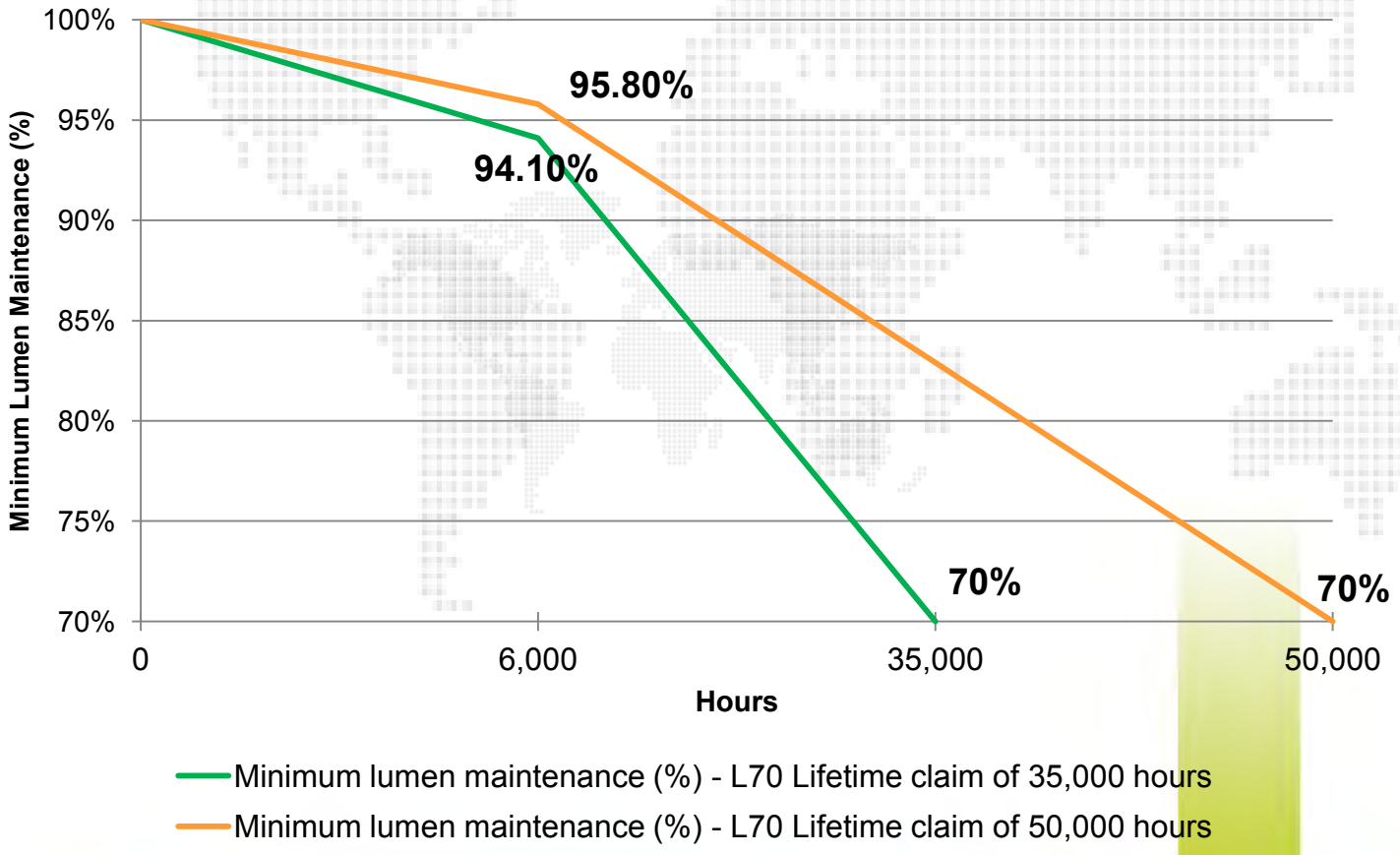
> ***Rated lifetime depends on lumen depreciation and failure rate***

- **Gather from Manufacturer:**
  - ***Lumen depreciation associated to estimated useful life:*** *70% lumen depreciation of the initial lumen output*
  - ***Electrical failure rate*** *under the claimed lifetime*
  - ***Failure of other components:*** *LED driver failure rate and lifetime compatible with the LED module*
  - ***Estimated lumen maintenance curve:*** *Initial lumen output and the lumen depreciation pattern during the useful life of the LED lighting under design and operating temperature conditions*

The United States – Maintenance

- **Replacement Strategies**
  - *National Cooperative Highway Research Program + Lighting Research Center – LED Traffic Signal Maintenance*
- **Lumen Maintenance**
  - *Los Angeles, Bureau of Street Lighting - Guide to Evaluating LED Lumen Maintenance*
  - *IESNA LM-80-08 – Approved method for measuring lumen maintenance of LED light sources*
    - Component Performance VS Luminaire Performance
  - *IESNA TM 21-11 - Projecting Long Term Lumen Maintenance of LED Light Sources*

IESNA LM-80-08



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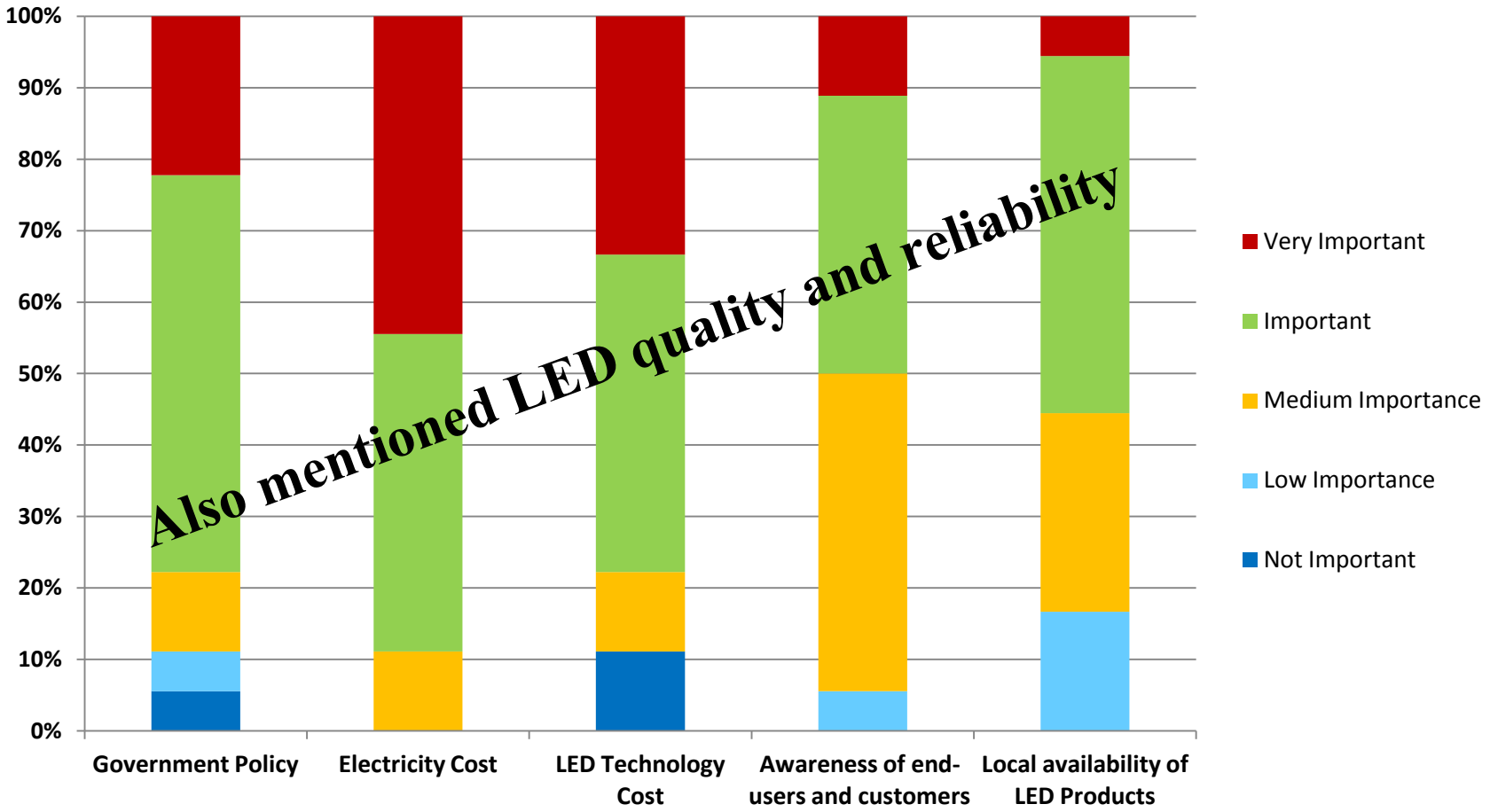
BEST PRACTICES….

What will drive LED uptake in APEC Member Economies?

Key Drivers


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Government Policy
Electricity Cost
LED Technology Cost
Awareness of end-users and customers
Local availability of LED Products
Very Important
Important
Medium Importance
Low Importance
Not Important
Also mentioned LED quality and reliability

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Thank You !

Any Questions?

Share your experience!

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PAPER FROM:

APEC LED WORKSHOP: *POLICIES TO PROTECT AND EDUCATE CONSUMERS*

APEC#212-RE-04.1