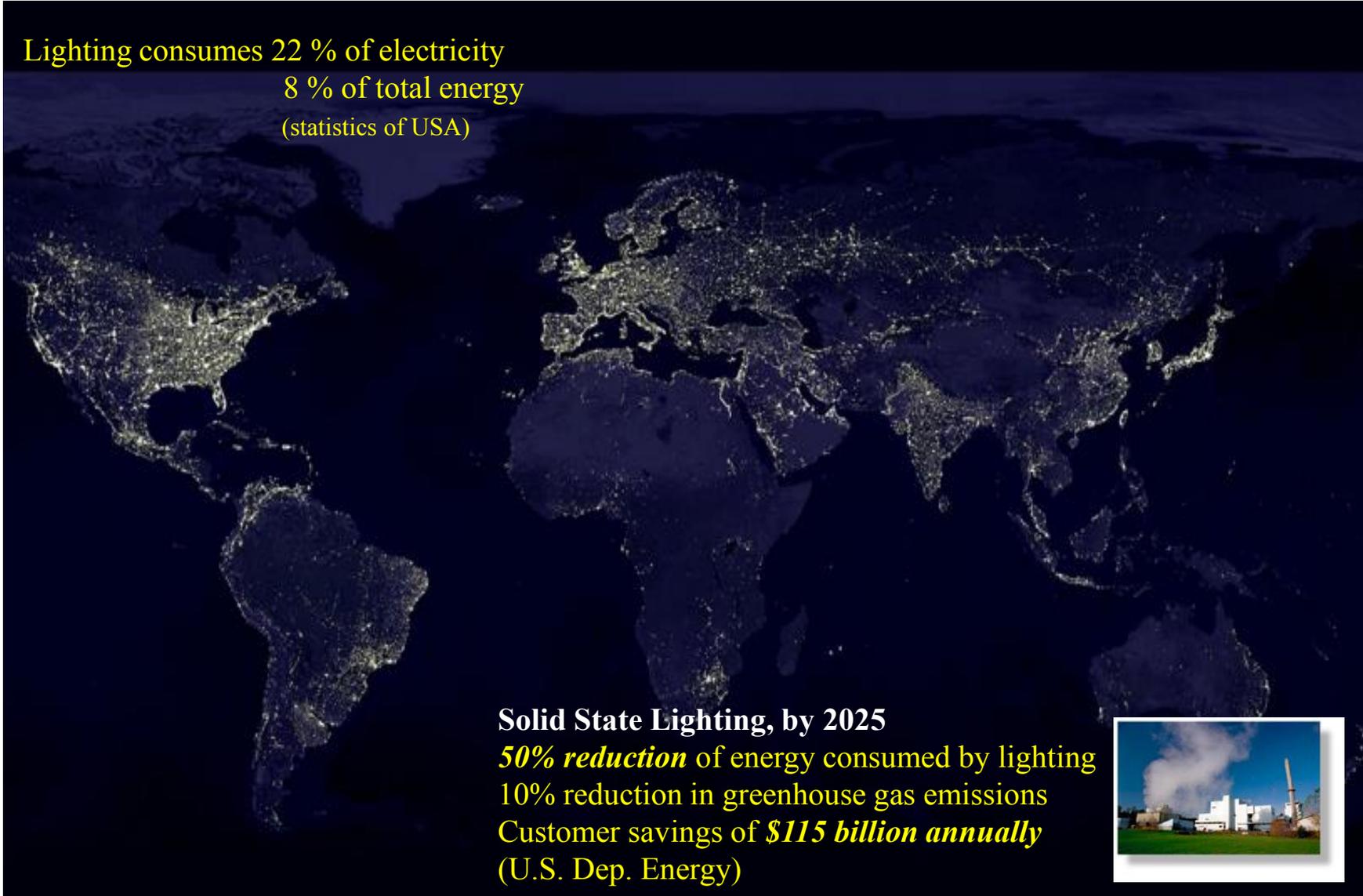


Workshop on Energy Efficiency for Appliances and Labelling
June 7-9, 2016

USA Efforts on Solid-State Lighting (SSL) Quality Assurance

María Elena Nadal
National Institute of Standards & Technology (NIST)
Maryland, USA

Lighting consumes 22 % of electricity
 8 % of total energy
 (statistics of USA)



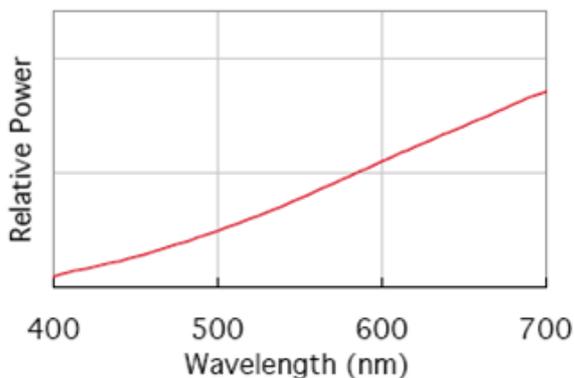
Solid State Lighting, by 2025

50% reduction of energy consumed by lighting
 10% reduction in greenhouse gas emissions
 Customer savings of **\$115 billion annually**
 (U.S. Dep. Energy)



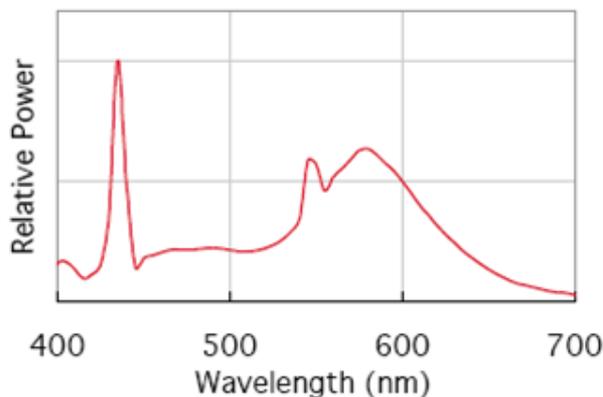
Lighting Technologies

Incandescent



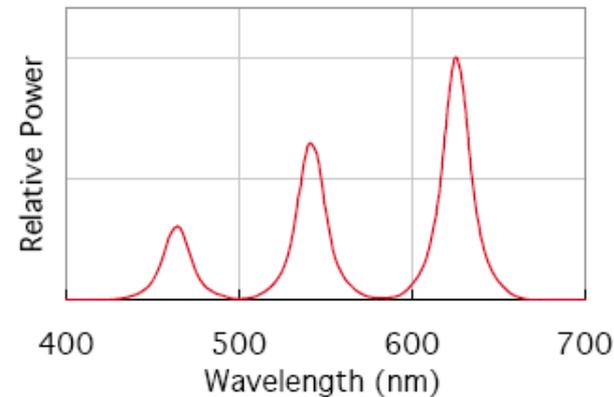
15 lm/W

Fluorescent



90 lm/W

Solid State Lighting (SSL)



DOE Goal: 200 lm/W
Lab: 230 lm/W
Market: 70-120 lm/W

SSL products are rapidly introduced into the market



Problems:

- Some very low quality products in the market (dim, short life, bad color)
- Inaccurate performance claims
- Insufficient information on product labels



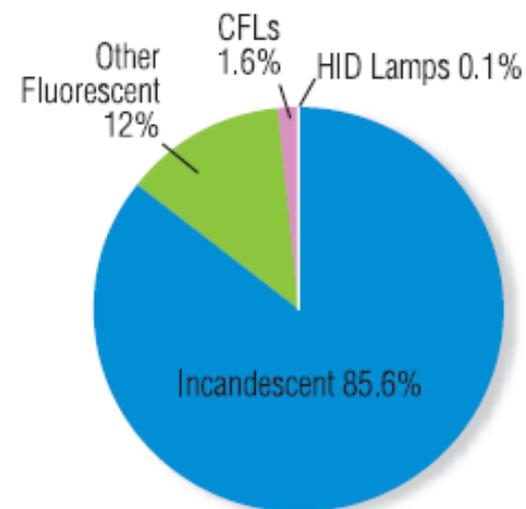
Standards and test methods for traditional lamps often do not apply

Compact Fluorescent Lamps in the USA

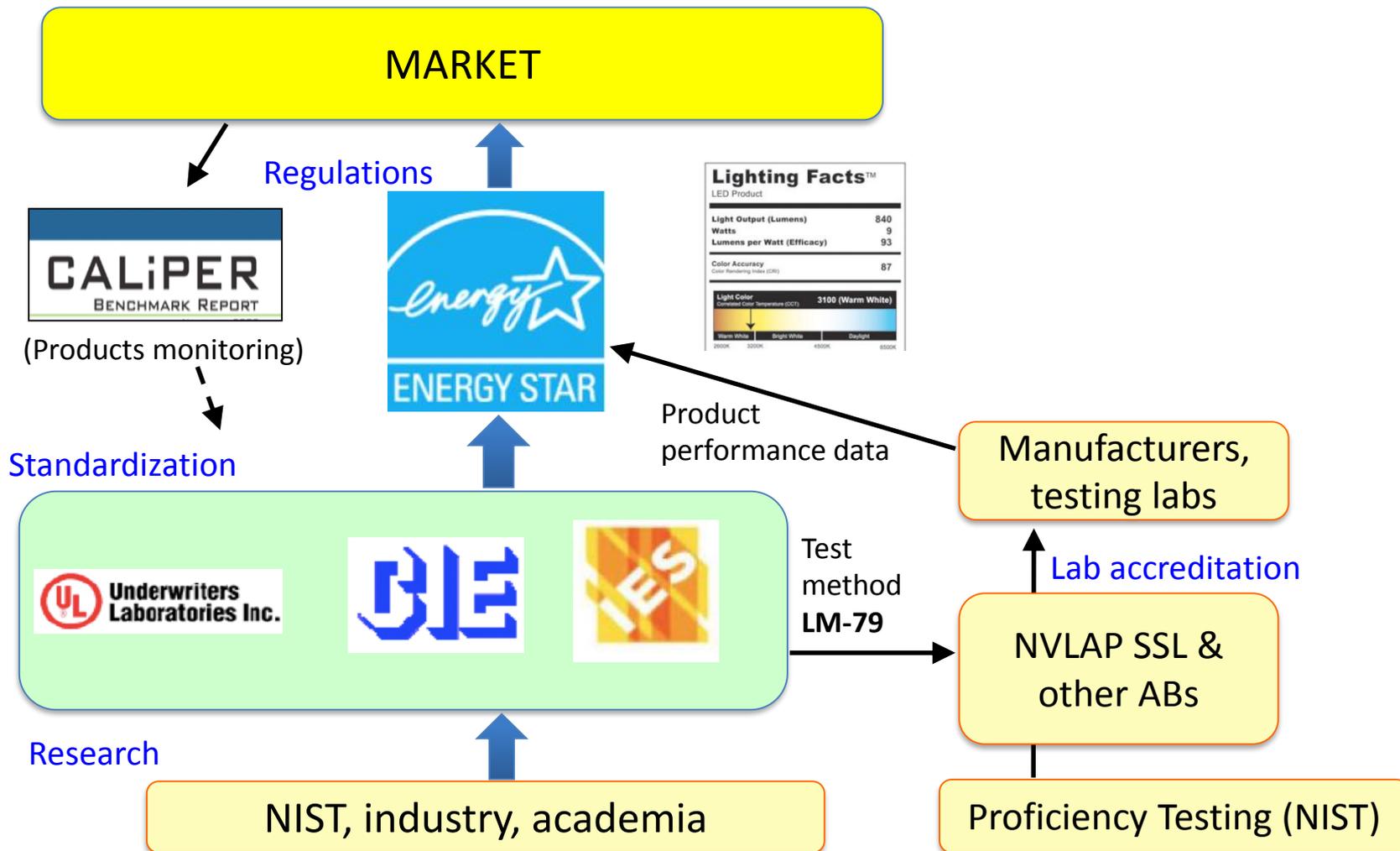
CFLs in America: Lessons Learned on the Way to the Market (DOE Report)



- After 30 years
- eye strain
 - noise
 - green skin tones
 - institutional

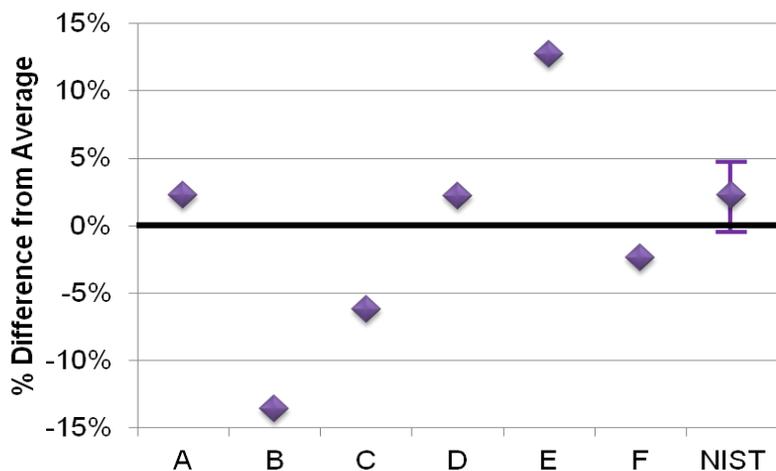


USA Quality Assurance of SSL products



SSL Measurement Standard

- Department of Energy (DOE) SSL Standardization Workshop
March 2006
 - Commercialization rate constrained by lack of **standards for assessing performance, comparing products, and ensuring supply-line specs are met**
 - DOE announced plans to create an Energy Star program for SSL products
 - DOE brought together partners to work on the development of such standards



IES LM-79 Approved method for electrical and photometric measurement of SSL products



IES LM-79-08

Approved Method: **Electrical and Photometric Measurements** of Solid-State Lighting Products

Prepared by the IES Testing Procedures Committee

Solid-State Lighting Subcommittee

Published 2008, Revision in progress (2016)

- The first test method for SSL products in the world, published in 2008.
- Used by **Energy Star, Lighting Facts, and many other government programs.**
- Reference for **NVLAP SSL Testing Accreditation program**
- Covers LED luminaires and integrated LED lamps.
- Covers measurements of
 - Total luminous flux (lumen)
 - Luminous efficacy (lm/W)
 - Chromaticity, CCT, CRI
 - Luminous intensity distribution
- Major contribution by NIST



CALiPER

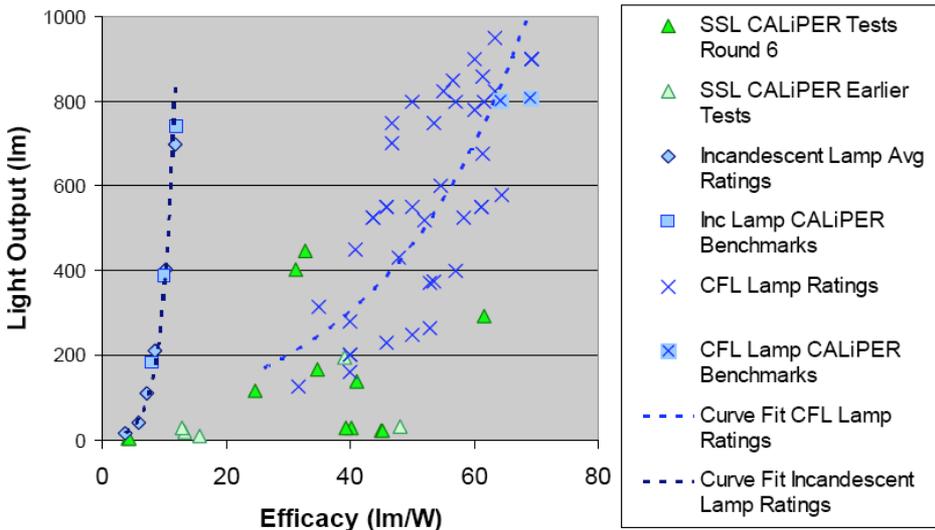
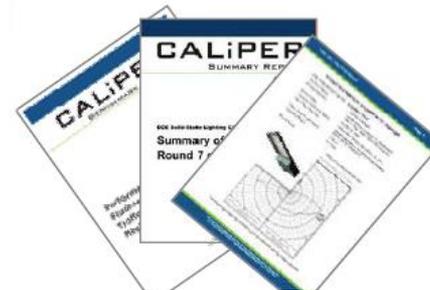
BENCHMARK REPORT

NOVEMBER 2008

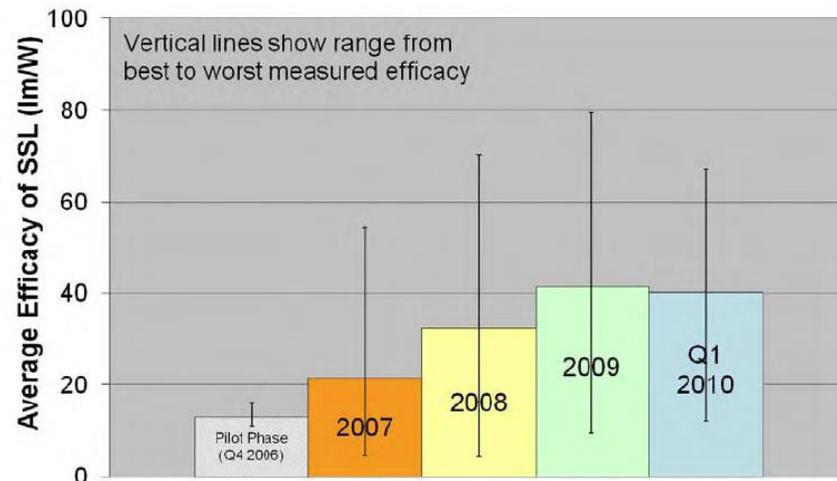


Figure 9. Examples of Bulb Shapes for LED Lamps Replacing Incandescent A Lamps

Commercially Available LED Product Evaluation and Reporting program



Testing based on LM-79



CALiPER Results Since Inception

Figure 1. Average Measured Efficacy of Market-Available SSL Luminaires and Replacement Lamps

Lighting Facts Label: Initiative by USA Department of Energy

Light Output/Lumens
Measures light output. The higher the number, the more light is emitted.
Reported as "Total Integrated Flux (Lumens)" on LM-79 test report.

Watts
Measures energy required to light the product. The lower the wattage, the less energy used.
Reported as "Input Power (Watts)" on LM-79 report.

Lumens per Watt/Efficacy
Measures efficiency. The higher the number, the more efficient the product.
Reported as "Efficacy" on LM-79 test report.

IESNA LM-79-2008
Industry standardized test procedure that measures performance qualities of LED luminaires and integral lamps. It allows for a true comparison of luminaires regardless of the light source.

Registration Number
Model Number
Type

Brand

Color Rendering Index (CRI)
Measures color accuracy.
Color rendition is the effect of the lamp's light spectrum on the color appearance of objects.

Correlated Color Temperature (CCT)
Measures light color.
"Cool" colors have higher Kelvin temperatures (3600-5500 K); "warm" colors have lower color temperatures (2700-3500 K). Color temperatures higher than 6500 are outside of the defined region for white light, but may be appropriate for outdoor applications.

Brand X

lighting facts^{CM}
A Program of the U.S. DOE

Light Output (Lumens) 840
Watts 9
Lumens per Watt (Efficacy) 93

Color Accuracy
Color Rendering Index (CRI) 87

Light Color
Correlated Color Temperature (CCT) 2900 (Warm White)

Warm White | Bright White | Daylight

2700K | 3000K | 4500K | 6500K

All results are according to IESNA LM-79-2008: Approved Method for the Electrical and Photometric Testing of Solid-State Lighting. The U.S. Department of Energy (DOE) verifies product test data and results.

Visit www.lightingfacts.com for the Label Reference Guide.

Registration Number: ABC435TH479003
Model Number: 18756CHT56428954RQHT1234H3
Type: 18756CHT56428954RQHT1234H3

<http://www.lightingfacts.com/default.aspx?cp=label>

Federal Trade Commission (FTC) labels

LED lamps only

<u>Brightness</u>
820 lumens
<u>Estimated Energy Cost</u>
\$7.23 per year

Lighting Facts Per Bulb	
Brightness	820 lumens
Estimated Yearly Energy Cost \$7.23 Based on 3 hrs/day, 11¢/kWh Cost depends on rates and use	
Life	1.4 years
Based on 3 hrs/day	
Light Appearance	
Warm Cool	
2700 K	
Energy Used	60 watts

<https://www.ftc.gov/tips-advice/business-center/guidance/ftc-lighting-facts-label-questions-answers-manufacturers>

SSL Measurement Standard

- DOE Collaboration with NIST
 - Testing unique or difficult products
 - Provide metrology research
 - National Volunteer Laboratory Accreditation Program (NVLAP) program for SSL measurement laboratories
 - Educate SSL measurement laboratories with respect to accreditation
 - Develop a proficiency test program for SSL – MAP 1.0

Accreditation and Proficiency Testing

- Laboratory Accreditation
 - SSL program was required for Energy Star and Lighting Facts labeling program
 - Assessor Training – February 7, 2008
 - DOE sponsored Laboratory Training
 - February 16-17, 2010
 - 34 laboratory representatives
- Establish a proficiency testing program
 - At request of the EPA, PT program was opened to customers of other accrediting bodies

NIST HANDBOOK 150-1A
2009 Edition



National
Voluntary
Laboratory
Accreditation
Program

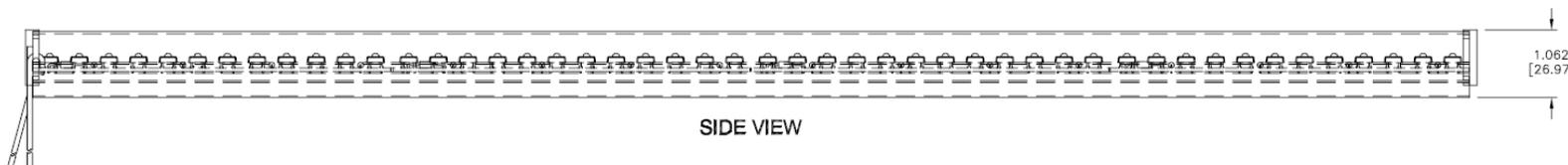
**ENERGY EFFICIENT
LIGHTING PRODUCTS –
SOLID STATE LIGHTING**

C. Cameron Miller
Lawrence I. Knab
Ambler Thompson
Jon Crickenberger

Combined 150-1 and 150-1A in 2010 Edition

SSL MAP 1 - Artifacts

- Six items
 - Incandescent lamp (120 V AC)
 - Under cabinet SSL luminaire (12V DC)
 - Four different white SSL lamps (120 V AC)



NIST SSL MAP 1 Participants

- **118 laboratories**

United States (49)

Taiwan (9)

Canada (3)

Brazil

India

Hungary

Germany

China (45)

Korea (4)

Netherlands

Singapore

Malaysia

Italy

SSL-MAP1 started on January 2010
and closed on January 1st, 2015

Information Collected

- Sphere – Manufacturer
- Sphere - Size
- Goniometer – Manufacturer
- Goniometer - Size
- Power Supply – Manufacturer
- Power Analyzer – Manufacturer
- Calibration Lamp – Vendor
- Calibration Lamp – **Traceability**
- Calibration Lamp – Flux level
- Calibration Lamp – Date
- Detector – Type (photometer, spectrometer)
- Test Date
- Calibration Lamp – Hours
- LM-79 Measurements

NIST SSL MAP 1 Summary

- 30% of the laboratories needed additional measurements
 - All six lamps were out of tolerance – scale bias
 - Single lamp was out of tolerance – particular issue
 - 4-pole socket issues
 - Spectrometer capabilities and calibration concerns
- All the results are within +/- 4 % for luminous flux
- Potential 1.0 % bias with another NMI - **Traceability**



NIST SSL MAP 2

- New version (2.0) released Jan 1st 2015
- Mandatory lamps



120 V AC

120 V AC



120 V AC

12 V AC
12 V DC



120 V AC



- Non-mandatory lamps



12 V AC
12 V DC
4.2 A

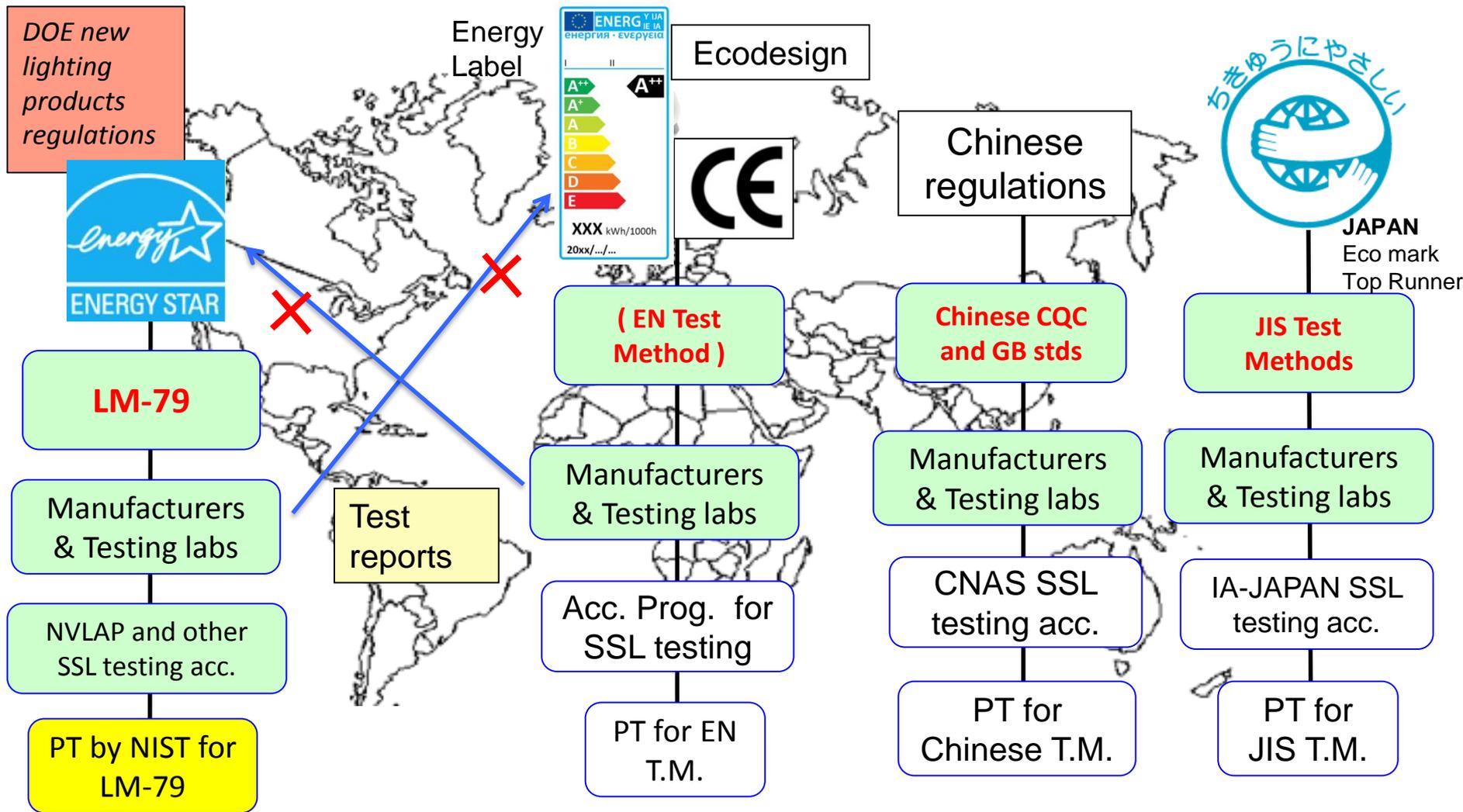


120 V AC

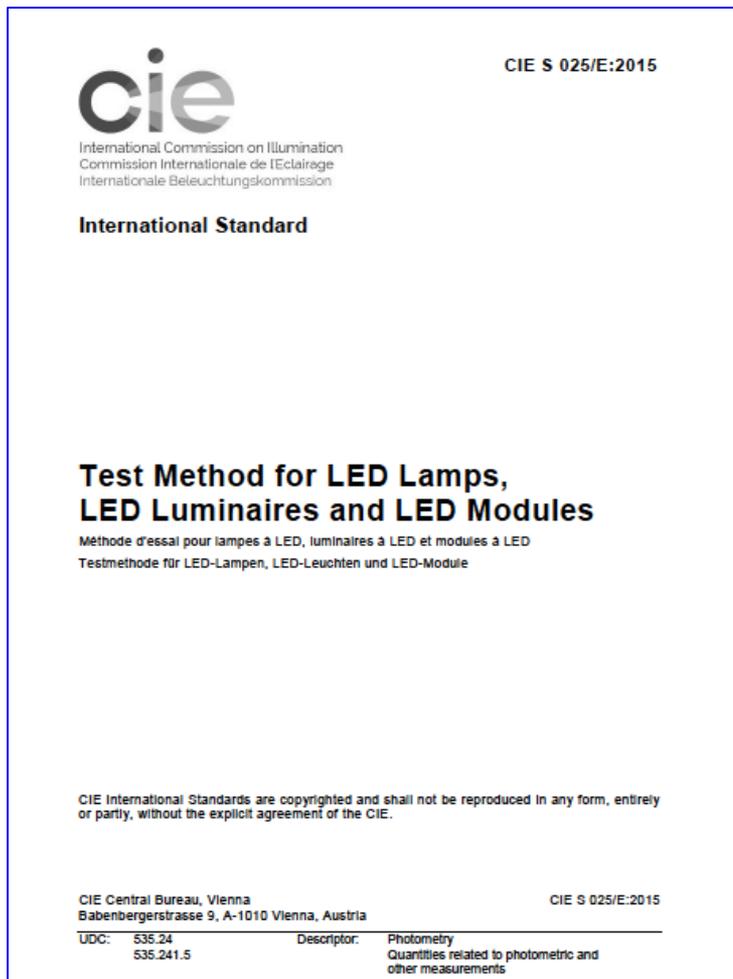


Option
120 V AC

International Harmonization in SSL Testing and Accreditation



CIE S025 Test Method for LED Lamps, Modules, and Luminaires



Published in March 2015.

S 025 provides a unified global test method for harmonisation of testing of LEDs and SSL products worldwide

Collaboration of
CIE TC2-71
CEN TC169 WG7
IES LM-79

European standard published same time:
**EN 13032 Lighting Applications —
Measurement and presentation of
photometric data of lamps and luminaires —
Part 4: LED lamps, modules and luminaires**

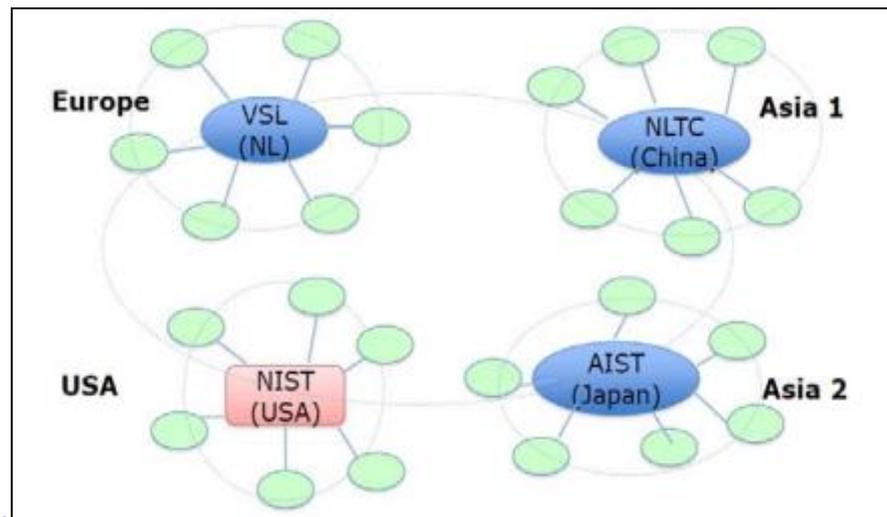
NMIs Active in R&D of LEDs

- CENAM (Mexico)
- CMS/ITRI (Taiwan)
- KRISS (Korea)
- LNE (France)
- METAS (Switzerland)
- MIKES (Finland)
- NIM (China)
- NIST (USA)*
- NMIJ/AIST (Japan)*
- PTB (Germany)
- VSL (Netherlands)*

4E

Solid State Lighting

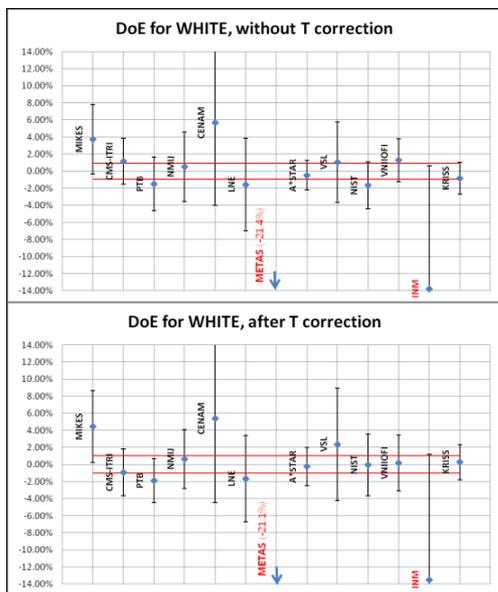
Inter-laboratory measurement comparison of SSL products



* Nucleus Laboratories in IEA 4E SSL Annex

International LED Measurement Comparisons

Code	Quantities	Artifact/Method	Date	Pilot	No. Participants
APMP.PR -S3.a -S3.b -S3.c	LED measurements: a : Avg. luminous intensity b : Luminous flux c : Emission color coordinates	LED lamps	2008 ~ 2009	KRISS	14-15
APMP.PR-P1 (Pilot Study)	Luminous flux	LED luminaires	2010 ~ 2011	KRISS	3



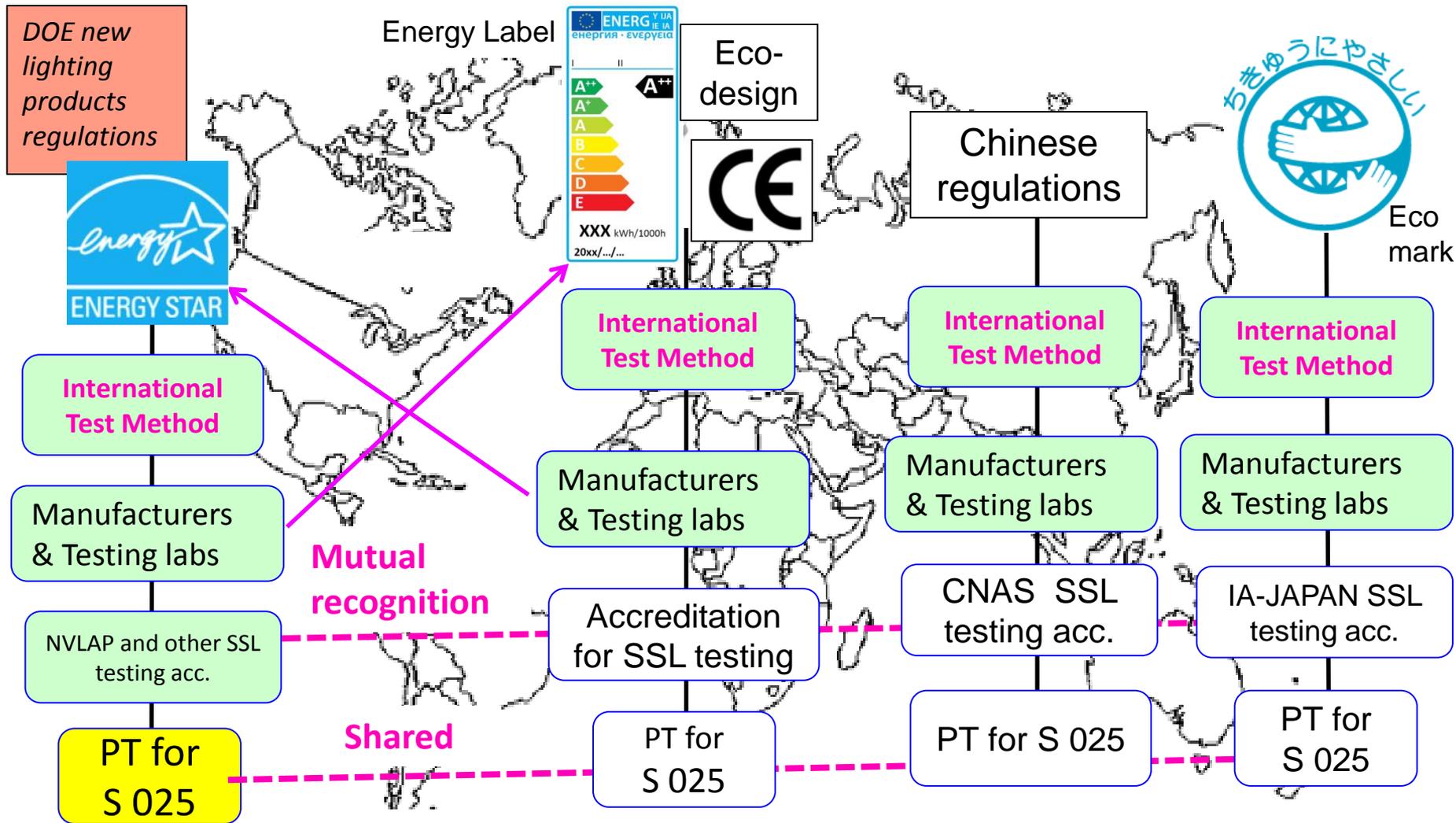
APMP.PR-S3b White LEDs without and with temperature correction

DoE = degree of
equivalence

**Results of RMO Supplementary
LED measurement comparisons:**
Support confidence in associated
CMCs for:

- luminous intensity (LED)
- Luminous flux (LED)
- Irradiance spectral (LED)
- Emitted colour (LED)

International goal for SSL testing and accreditation



Muchas Gracias