

Solid State Lighting: Present and Future

Next Generation Lighting Industry Alliance

Summer 2013



Briefing Topics

- **Next Generation Lighting Industry Alliance**
- **Solid State Lighting (SSL) and Applications**
- **Lighting and Energy Efficiency**
- **DOE's SSL Program and Progress To Date**
- **Broader SSL Benefits**
- **Further Work Needed**



What is NGLIA?

- Alliance of for-profit U.S. corporations formed to accelerate U.S. Solid State Lighting (SSL) development and commercialization through government-industry partnership
- Membership open to any private, for-profit firm substantially active in solid state lighting research, development, infrastructure, and manufacturing in the U.S.



Why NGLIA?

- Support of Inorganic and Organic-based SSL
- Promotion/support of U.S. DOE ongoing assessment of SSL potential, state of SSL technology, and DOE's SSL R&D Program
- Facilitation of communication between NGLIA members and others



NGLIA Members

3M

Acuity Brands Lighting

Bayer MaterialScience

CAO Group

Corning, Inc.

Cree Inc.

GE-Lumination

Light Prescriptions

Innovators (LPI)

LSI Industries

Luminus Devices

OSRAM SYLVANIA

**Philips Solid-State Lighting
Solutions**

Universal Display Corp.

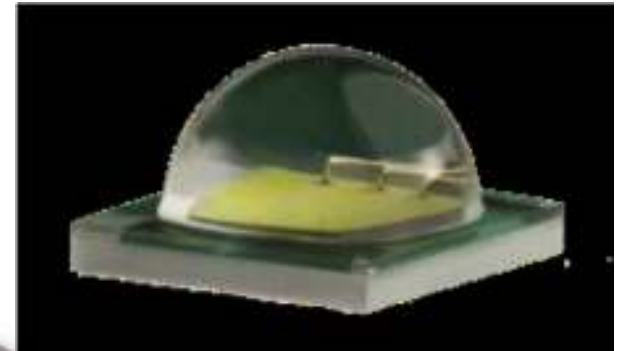
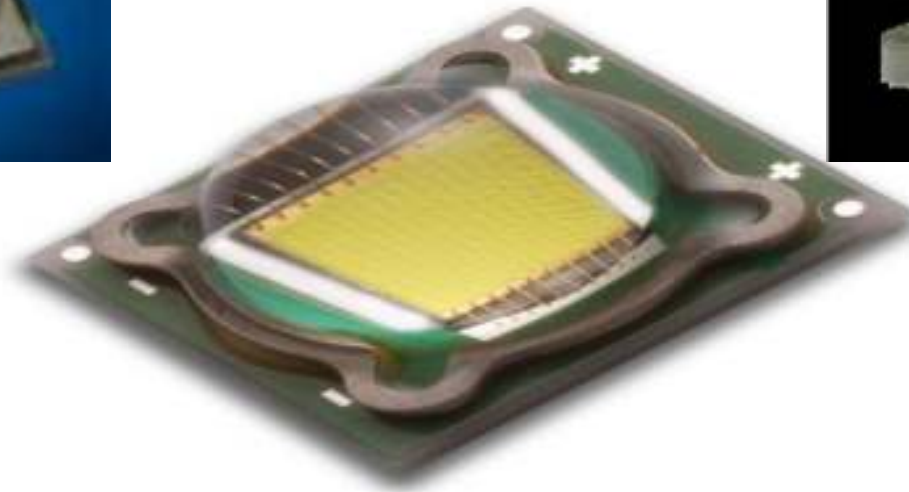
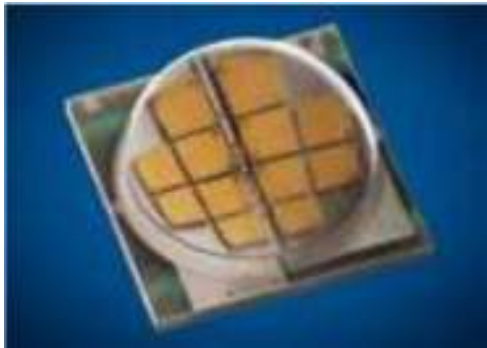


What Is Solid State Lighting?

- **Fundamentally different from conventional technologies**
 - **Directional**
 - **Compact size**
 - **Long operating life**
 - **Controllability**
- **Light-Emitting Diodes (LEDs)**
- **Organic Light Emitting Diodes (OLEDs)**



LEDs



Solid-state semiconductor light sources long used for electronics and displays and now for general lighting

LED "Bulbs" = Lamps



NGLIA
NEXT GENERATION LIGHTING INDUSTRY ALLIANCE

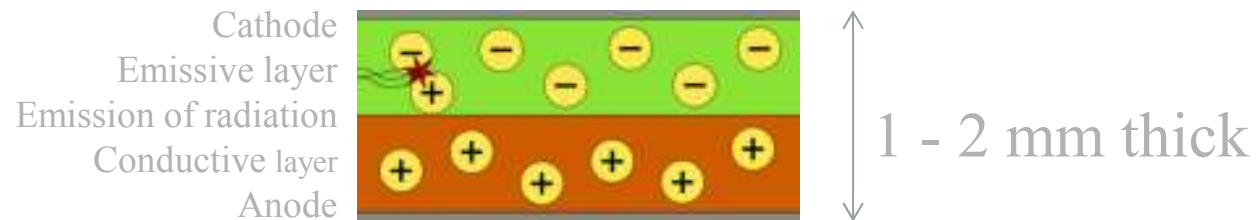
LED "Fixtures" = Luminaires





How is OLED different from LED?

- OLEDs are solid-state devices composed of thin films of organic materials that create light with the application of electricity.
- OLEDs are being used for electronic displays and are now emerging as a solution for architectural lighting in buildings.



OLEDs' Many Unique Characteristics

Flexible OLEDs



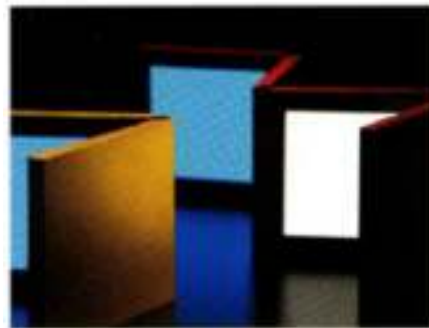
Arbitrary Shapes



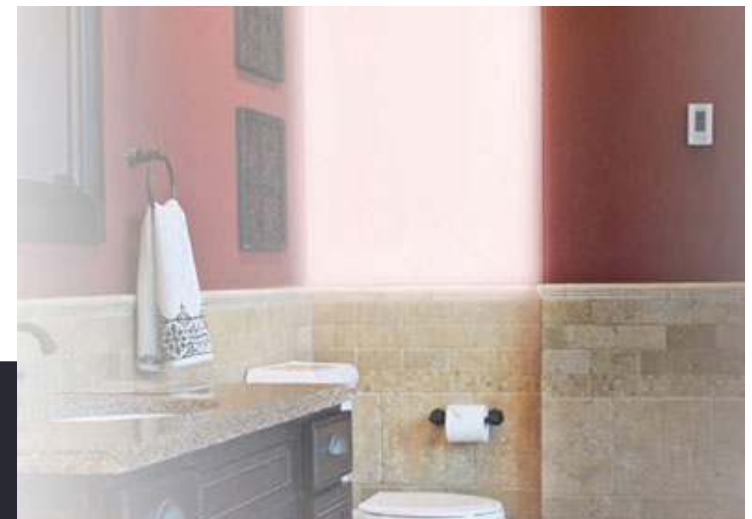
Architectural



Full Color Tuning

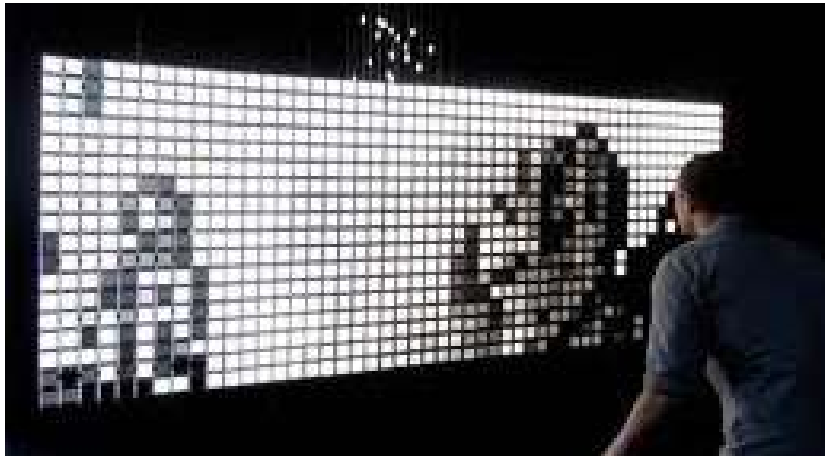


OLED Apps. for Large Area, Diffuse Light Sources

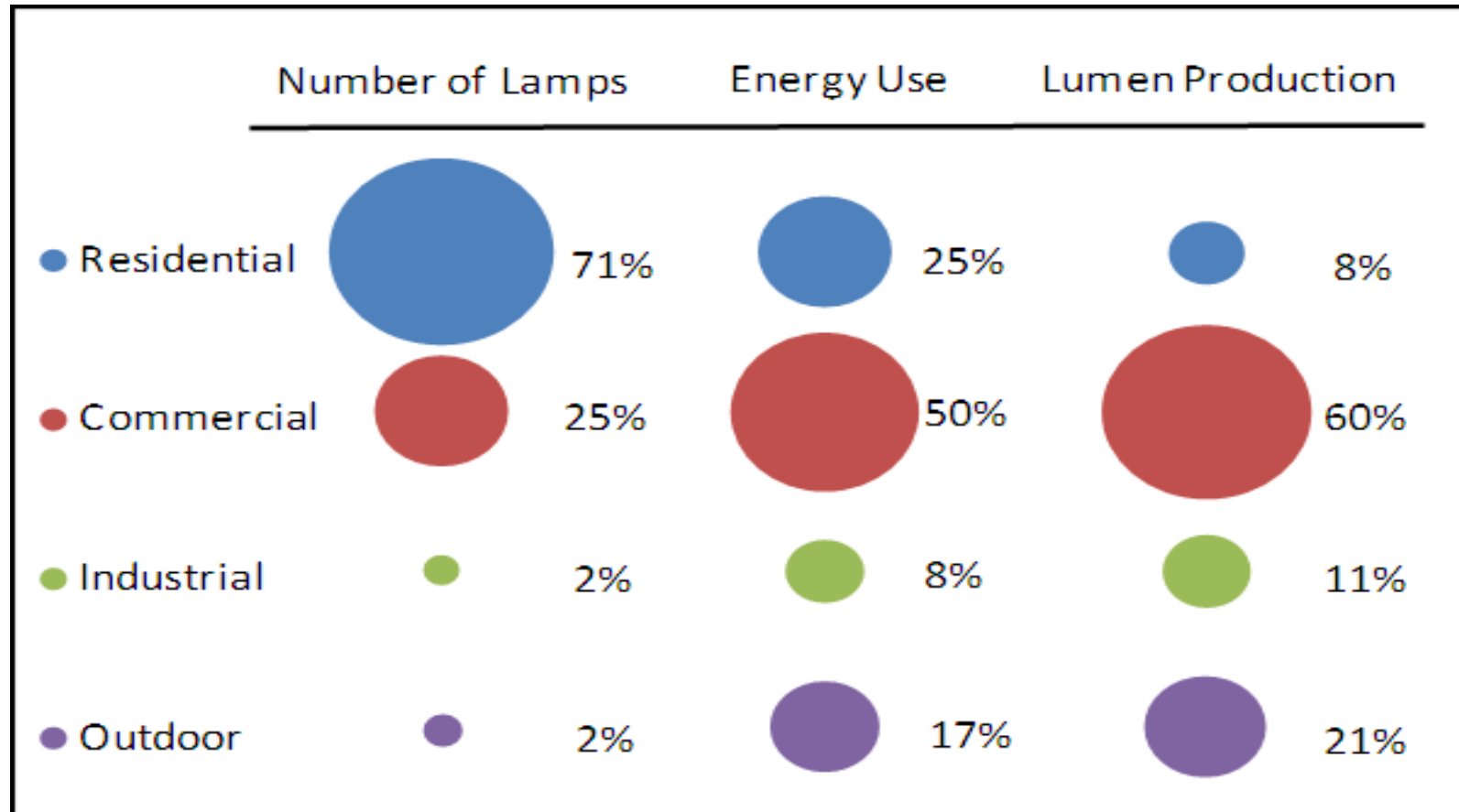


NGLIA
NEXT GENERATION LIGHTING INDUSTRY ALLIANCE

OLED Apps. for Large Area, Diffuse Light Sources



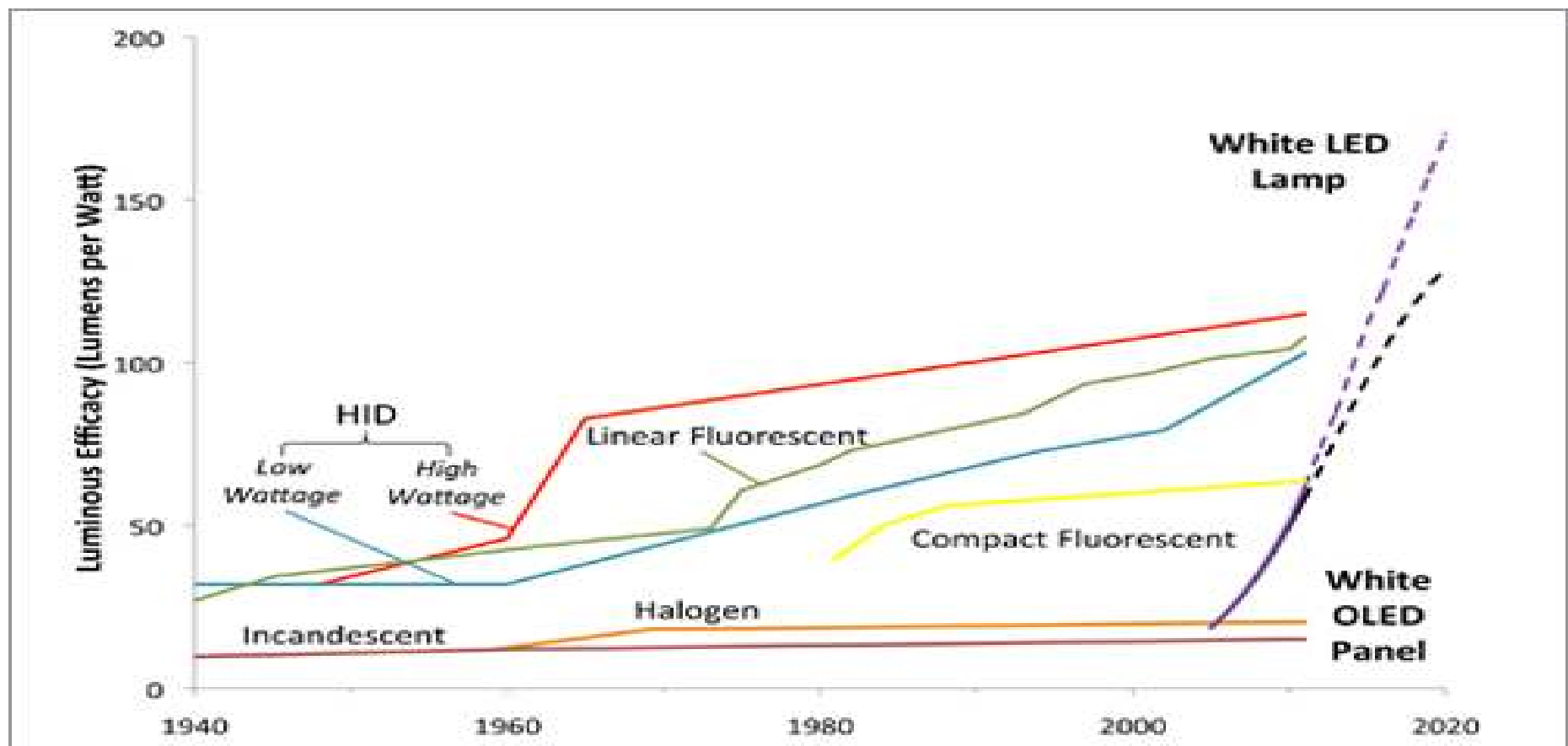
U.S. Lighting and Electricity Use



Energy Efficiency of Lighting Today

| Technology | Lumens per Watt |
|---------------------------|-----------------|
| 60-watt Incandescent Bulb | 13-15 |
| Halogen | 15-20 |
| Compact Fluorescent | 53-63 |
| Solid State Lighting | 70-100 |

Historical and Predicted Efficiency



While traditional lighting technologies are relatively mature and offer less potential for improvement, SSL is still at a comparatively early stage and continues to achieve dramatic advances in efficacy.

Next Generation Lighting Initiative

- **Sec. 912 of Energy Policy Act of 2005 directed**
 - **DOE launch NGLI to support R&D, demonstration and commercial applications, and select an industry partner organization**
 - **National Academy of Sciences periodic review of DOE program**

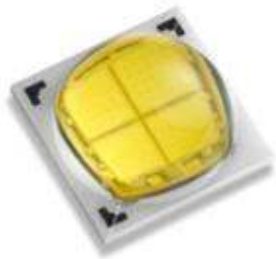


DOE SSL Program

- **Research & Development**
 - Core technology
 - Product development
 - Manufacturing
- **Standards Development**
 - Coordination with industry organizations



Recent U.S. R&D Highlights



Low-cost, warm-white LED
package: 1,023
lumens, 125 lm/W



9 mm x 9mm LED for
MR-16-type: 1,525
lm



Low-cost, integrated
OLED substrate

Recent U.S. R&D Highlights

**Undercabinet OLED System: 420 lm @ 55 lm/W,
10,000k hr life**



R&D “To-Dos”

- Half-way there...but this is the hard part
- Efficacy using today’s techniques leveling off
- “Status quo” falls short, leaving massive energy savings on the table
- Significant technology headroom remains
- Need for breakthroughs vs. incremental improvements

DOE SSL Program

- **Market Development Support**
 - **Demonstration projects: GATEWAY**
 - **Testing and quality reporting: CALiPER**
 - **Competitions: L-Prize, Next Gen. Luminaires**
 - **Buyer Support: LightingFacts label**



GATEWAY

- **Demonstration projects**
 - **Real-world data on performance and cost effectiveness**
 - **I-35 bridge in Minneapolis, MN**
 - **Dept. of Labor parking garage**
- **Municipal Solid State Street Lighting Consortium**



CALiPER

- **Commercially Available LED Product Evaluation and Reporting**
 - Takes products on the market, tests them, and compares actual performance to manufacturer's claims and to conventional products
 - Provides lighting buyers w/objective assessments
 - Points manufacturers to make improvements
 - Helps guide DOE support for R&D



Design Competitions

- **Bright Tomorrow Lighting Prize (“L-Prize”)**
 - Aims to accelerate development, adoption of SSL products
 - Challenges industry to develop replacements for 2 of most widely used inefficient products
 - “60-watt replacement” bulb
 - “PAR-38 replacement” bulb
 - “Light of the Future”
- **Next Generation Luminaires**
 - Recognizes excellence in design of energy-efficient LED commercial luminaires
 - Separate categories for indoor and outdoor fixtures



Buyer Support

- SSL Quality Advocates and LightingFacts
- Participating manufacturers test to prescribed standards and use “nutrition”-type label
 - Light output (lumens)
 - Energy usage (watts)
 - Efficiency (lumens/watt)
 - Color (warm-to-cool spectrum)

| Lighting Facts™ | |
|--|-------------------|
| LED Product | |
| Light Output (Lumens) | 840 |
| Watts | 9 |
| Lumens per Watt (Efficiency) | 93 |
| Color Accuracy <small>Color Rendering Index (CRI)</small> | 97 |
| Light Color <small>Color Temperature (K)</small> | 3100 (Warm White) |
| | |
| <small>Visit www.lightingfacts.com for the Label Reference Guide.</small> | |

Status Report

- Rapid technical progress being made, supported by industry-DOE partnership
- R&D global, but U.S. leadership
- U.S. manufacturing with support of international supply chains
- SSL products on the U.S. market
- DOE R&D support for FY2013 jeopardizes U.S. SSL leadership



International Competition

- **China**
 - Central govt. spending \$1 billion annually on SSL R&D alone (provinces provide additional incentives)
- **Japan, Taiwan, Germany, European Union**
 - Each govt. spending at least \$100 million annually



SSL Deployments...So Far

- Outdoor lighting
 - Parking lots, roadways, walkways
- Area lighting
 - Parking garages
- General and residential lighting
- Commercial lighting
 - Hotels, restaurants
 - Offices



U.S. Embassy Helsinki



NGGLIA
NEXT GENERATION LIGHTING INDUSTRY ALLIANCE

Audi Conference Room



Where Can You See SSL Nearby?

- **On Capitol Hill**
 - **Rayburn Cafeteria, “Senate Chef”**
 - **Senators’ Offices**
- **On the National Mall**
 - **Walkway post-top fixtures**
 - **Jefferson Memorial**
 - **Depts. of Labor and Defense**



Energy Savings in U.S.

- **SSL potential to reduce all U.S. lighting electricity use by approx. 50 percent by 2030 (from 2010 base)**
- **Return on Investment**
 - **DOE SSL spending: \$250 million since 2005**
 - **4 GigaWatts of energy conserved (savings equal to energy generated by \$13 billion solar program)**



SSL Lighting Systems

- **Directional: Puts Light Where Needed**
- **Low Profile and Compact**
- **Instant-On**
- **Durable and Long Life**
- **Color Tunable**
- **Controllable and Dimmable**
- **Energy Efficient**



Human Aspects of Lighting

- **Attitude and mood**
- **Controllable**
- **Integrated with architecture**
- **More responsive to the human environment**



SSL Manufacturing “To-Dos”

- Bring down cost to manufacture
 - Materials, processes
 - Capital investments: plant, equipment
- Bring down first-cost to the consumer



DOE OLED Panel Cost Projection

Table 9. Cost Targets for OLED Panel Fabrication

Source: Based on recommendations from the 2011 Manufacturing Workshop and Roundtable Attendees

| | Units | 2012 | 2015 | 2020 |
|--------------|-------------------------|-------------|------------|-----------|
| Materials | \$/m ² | 180 | 91 | 42 |
| Depreciation | \$/m ² | 1000 | 80 | 24 |
| Labor | \$/m ² | 400 | 40 | 10 |
| Operations | \$/m ² | 120 | 24 | 8 |
| Overhead | \$/m ² | 100 | 15 | 6 |
| Total | \$/m² | 1800 | 250 | 90 |
| Total | \$/klm | 180 | 25 | 9 |

**2012-2020: 20x
reduction**

Benefits to the U.S.

- **Federal government**
 - Energy savings
 - Reduced maintenance costs
- **Private sector**
 - Energy and cost savings
 - Innovation & transition to high technology
 - High-tech R&D and manufacturing jobs
 - Economic growth, economic security



Challenges Facing U.S. SSL

- **Technical**
 - Core technology
 - Product development, commercialization
 - Manufacturing
- **Economic**
 - Manufacturing
 - Market
- **Consumer education**



What Can Congress Do?

- Evaluate means to fund DOE SSL Program more in line with globally competitive level
- Deployment incentives
 - Federal facilities
 - Rebates
 - Tax treatment



Special Thanks

Content and images provided by

3M

Mitsubishi Chemical

Acuity Brands Lighting

Philips Lighting

Cree, Inc.

Universal Display Corporation

GE

U.S. Department of Energy



THANK YOU FOR YOUR ATTENTION.

**QUESTIONS AND DISCUSSION
PLEASE!**

