



SMART LIGHTING ENGINEERING RESEARCH CENTER

Lighting Innovation for a Smarter Tomorrow

Smart Lighting Today and Tomorrow

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Presentation for
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Rensselaer





Outline

- Introduction – Smart Lighting Engineering Research Center
- LEDs – a brief history
- LEDs for Lighting – Current Status
- LED Lighting – Energy Savings Projections
- Smart Lighting Future



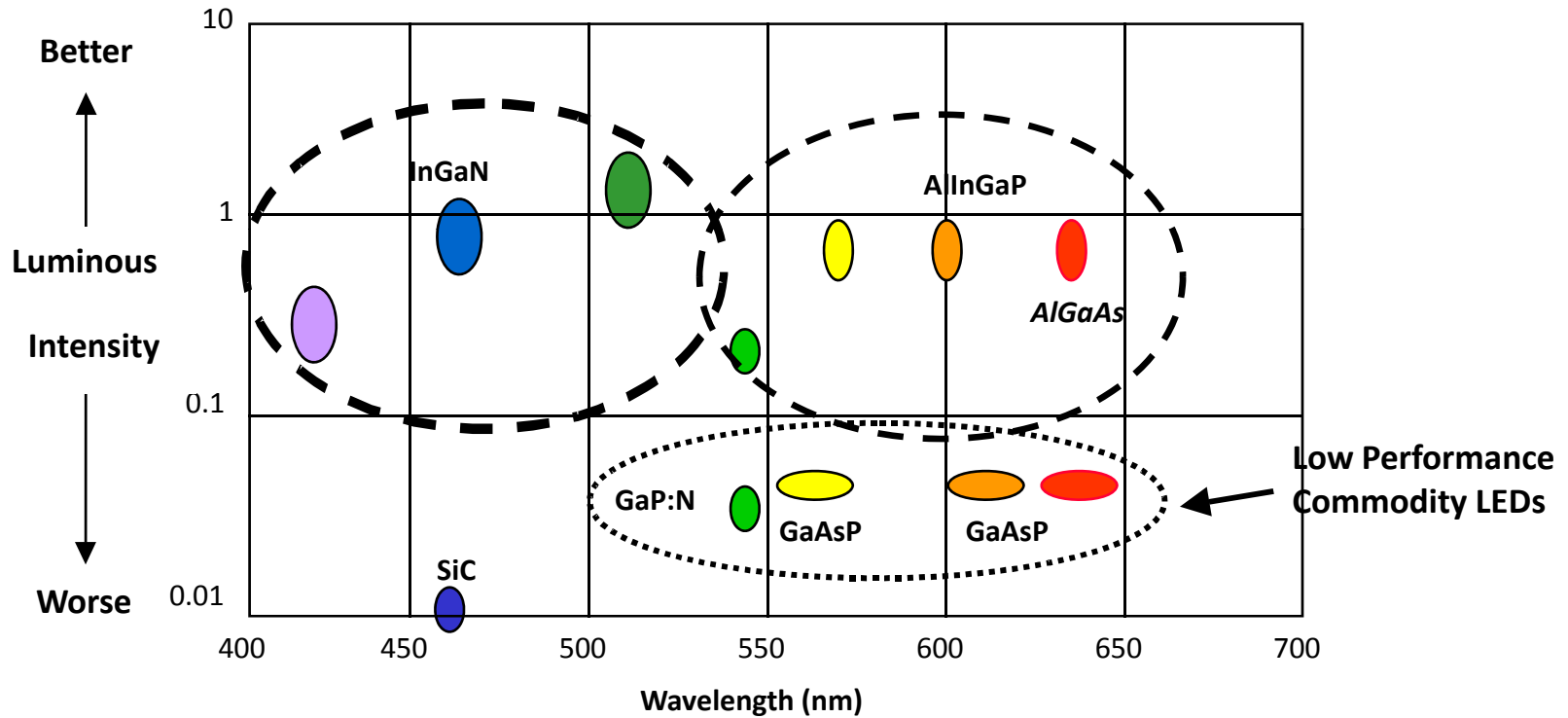
Generation 3 ERCs

- **Transformative Research**
- **Strong Industry Participation**
- **Educational Impact (K-12)**
- **Strong Diversity Focus**
- **Global Participation**
- **New Business/Job Creation**

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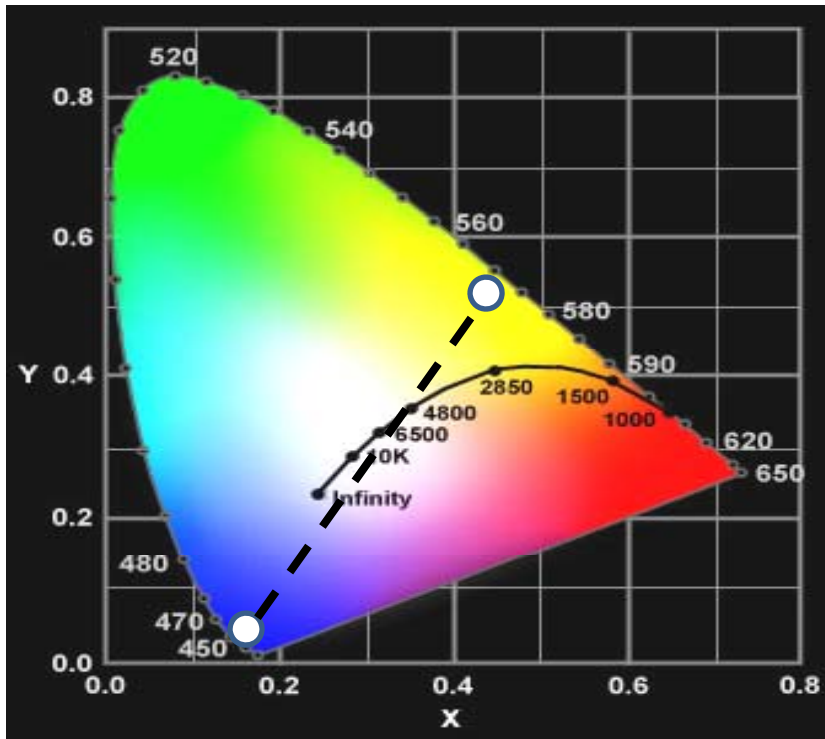


A Quick History of Visible LED Development

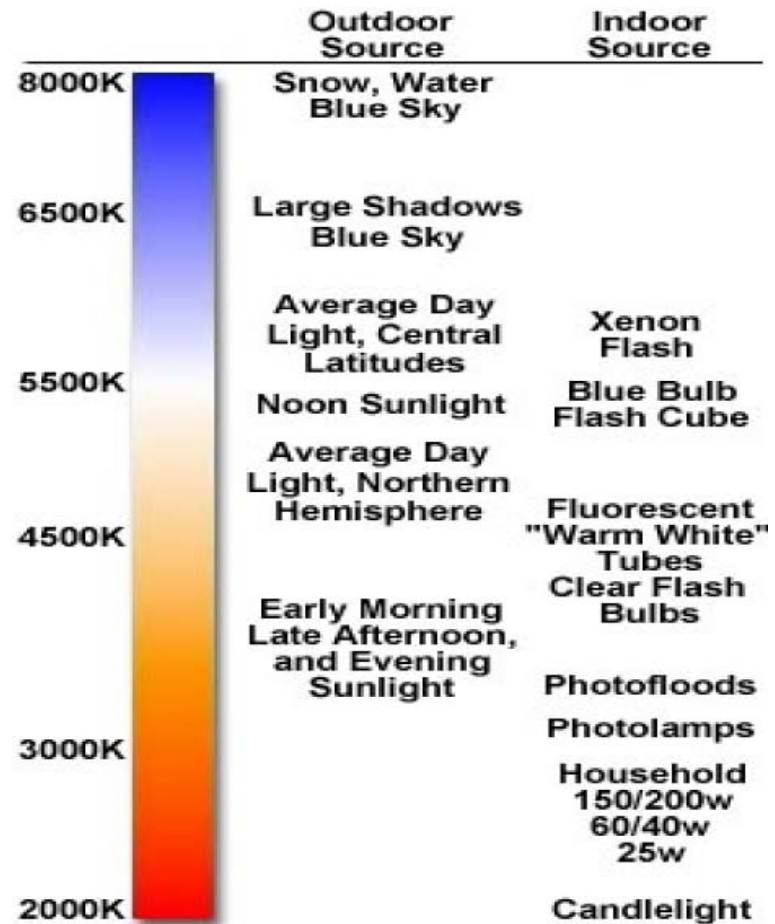




How do you make a White LED?



Blue LED
+
Yellowish Phosphor





The Birth of Solid State Lighting



- Japan's MITI sets aggressive goal:

120 Lm/W by 2010

- 1998 White LED performance:

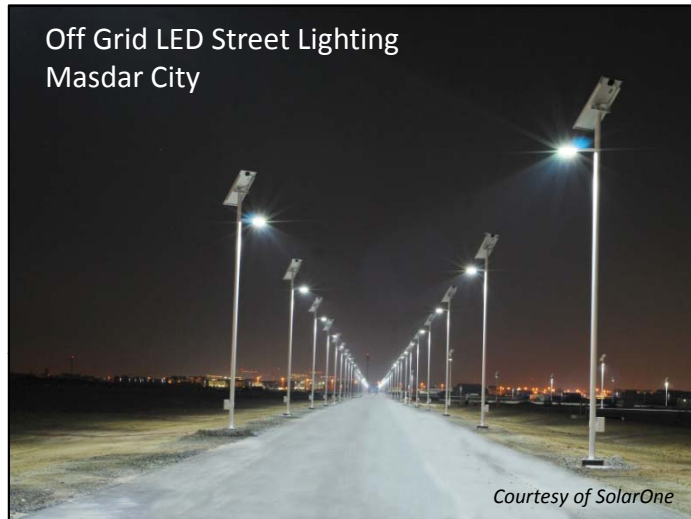
18 Lm/W (about same as bulb)

- Goal setting was not technology based

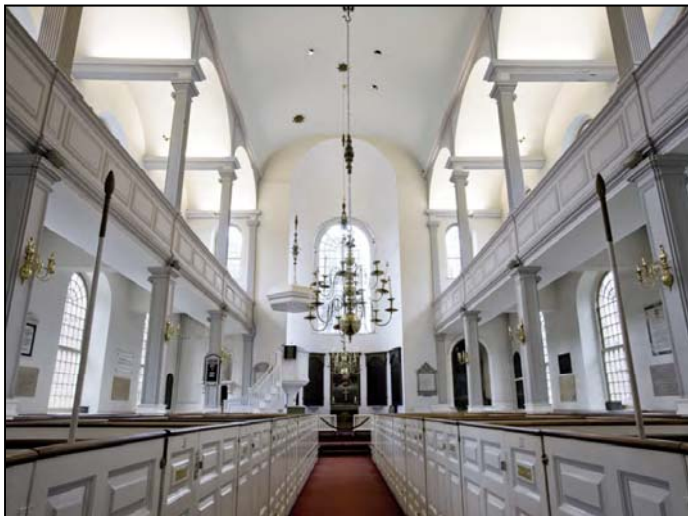
**120 Lm/W was needed to meet
Kyoto Protocol Commitments**



Solid State Lighting – Coming fast



- Many street lighting programs
- 100% SSL buildings are starting to appear (mostly in Asia)
- Many hundreds of start-up companies in Solid State Lighting
- Generally still not ready for prime time
 - Lack of good standards
 - Very high prices
 - Lots of “junk LED bulbs”





Outdoor Lighting: Improved Visibility, Safety





Energy Savings and Low Maintenance Costs



Some Examples of MR-16 LED Products





DOE Testing: LED units typically have lower light output

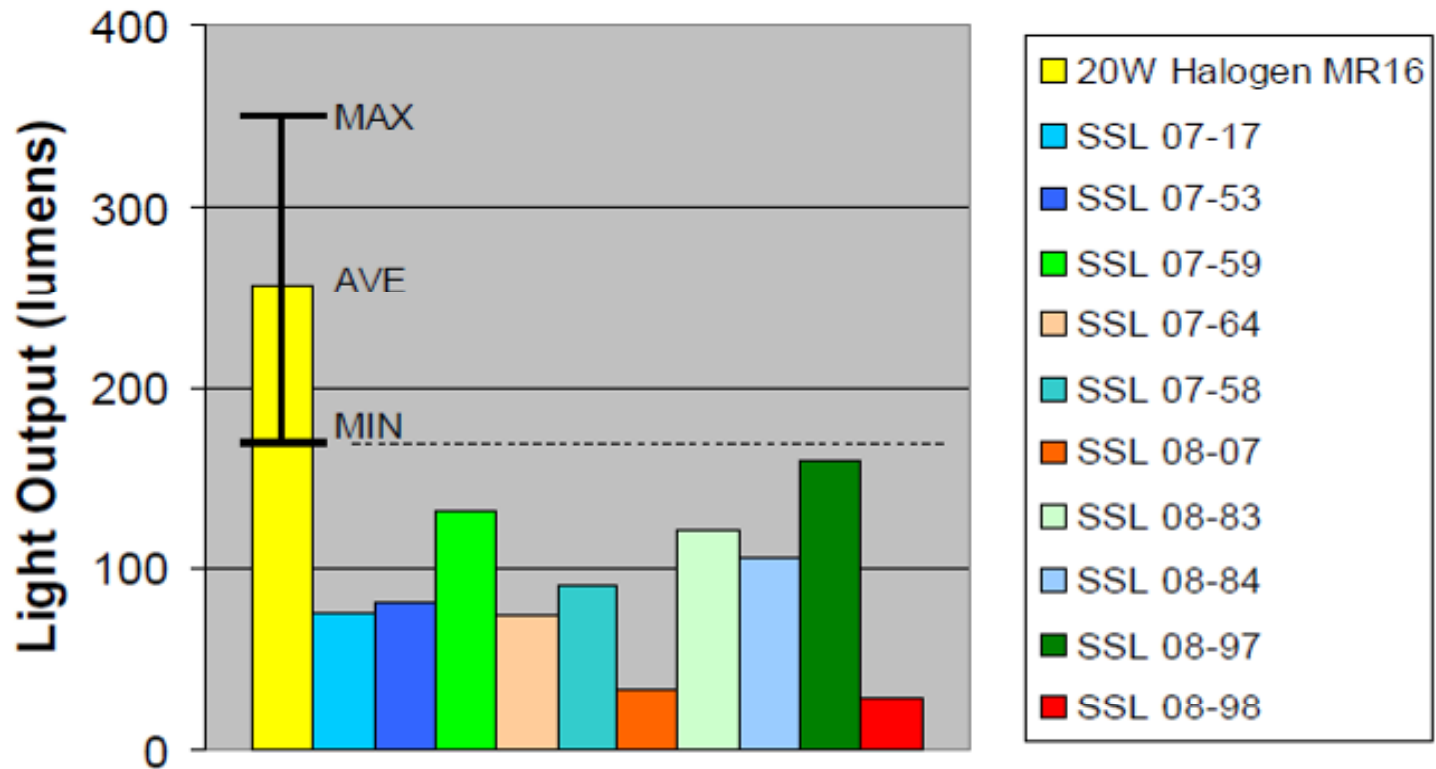
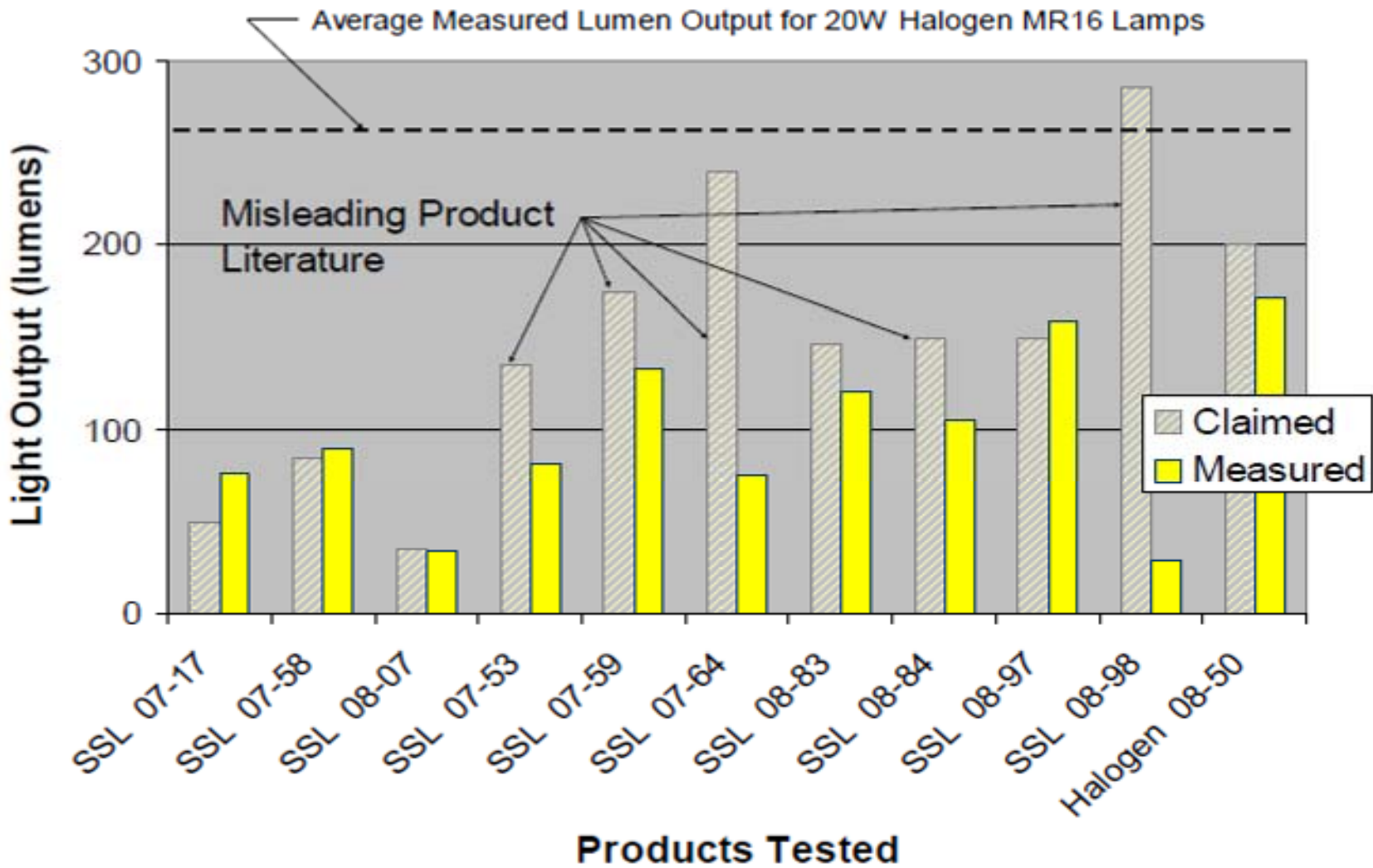


Figure 4. Light Output of MR16 Replacement Lamps Compared to Halogen MR16 Lamps



DOE Testing – Many product claims are misleading



Caveat Emptor



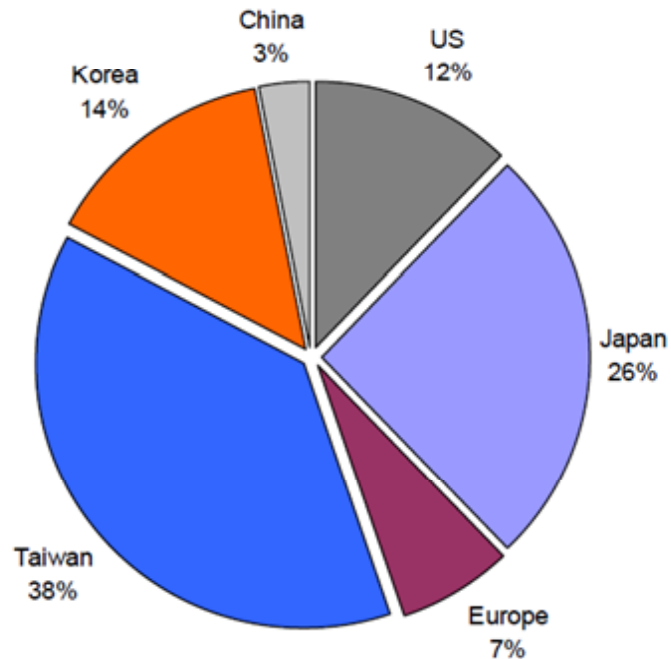
LED Lighting Quality

- DOE is very concerned about LED lighting quality (or lack thereof) (various programs in place)
- Issues include
 - Lower Light levels than advertised
 - Glare (lots of little LED point sources)
 - Poor reliability
- High quality LED products exist from several vendors – need to shop carefully
- Light Output, Lamp Styles, Lighting Options will gradually become available



Global Center of Solid State Lighting

Production Capacity by Geography



CANACCORD Adams

Second Cycle Report, 2009

- Taiwan, Japan and Korea are leading the SSL charge
- Samsung, in particular, is making HUGE investments in LED technology and Intellectual Property
- China will soon emerge as the largest supplier of LED Lighting



Department of Energy Involvement

Energy Savings Potential of Solid-State Lighting in General Illumination Applications 2010 to 2030

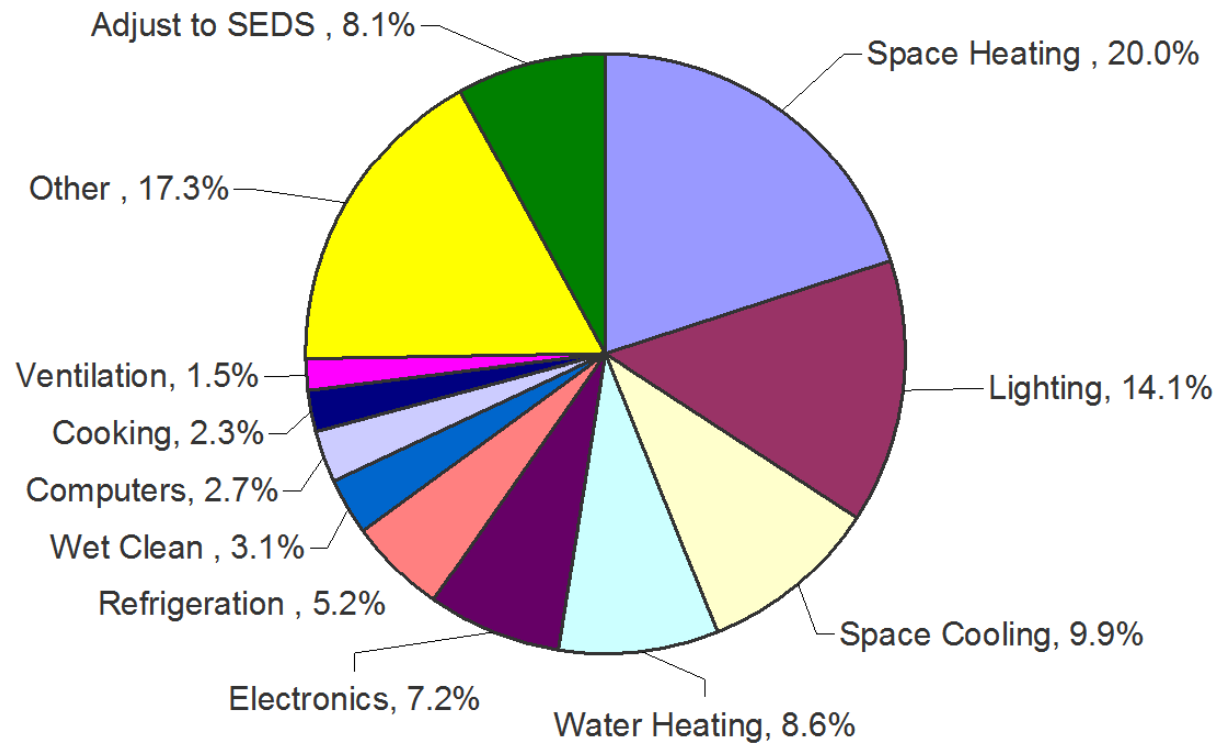
Prepared for:

Lighting Research and Development
Building Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Lighting Energy Consumption

Building Primary Energy End-Use

2010: 39.7% of US Total

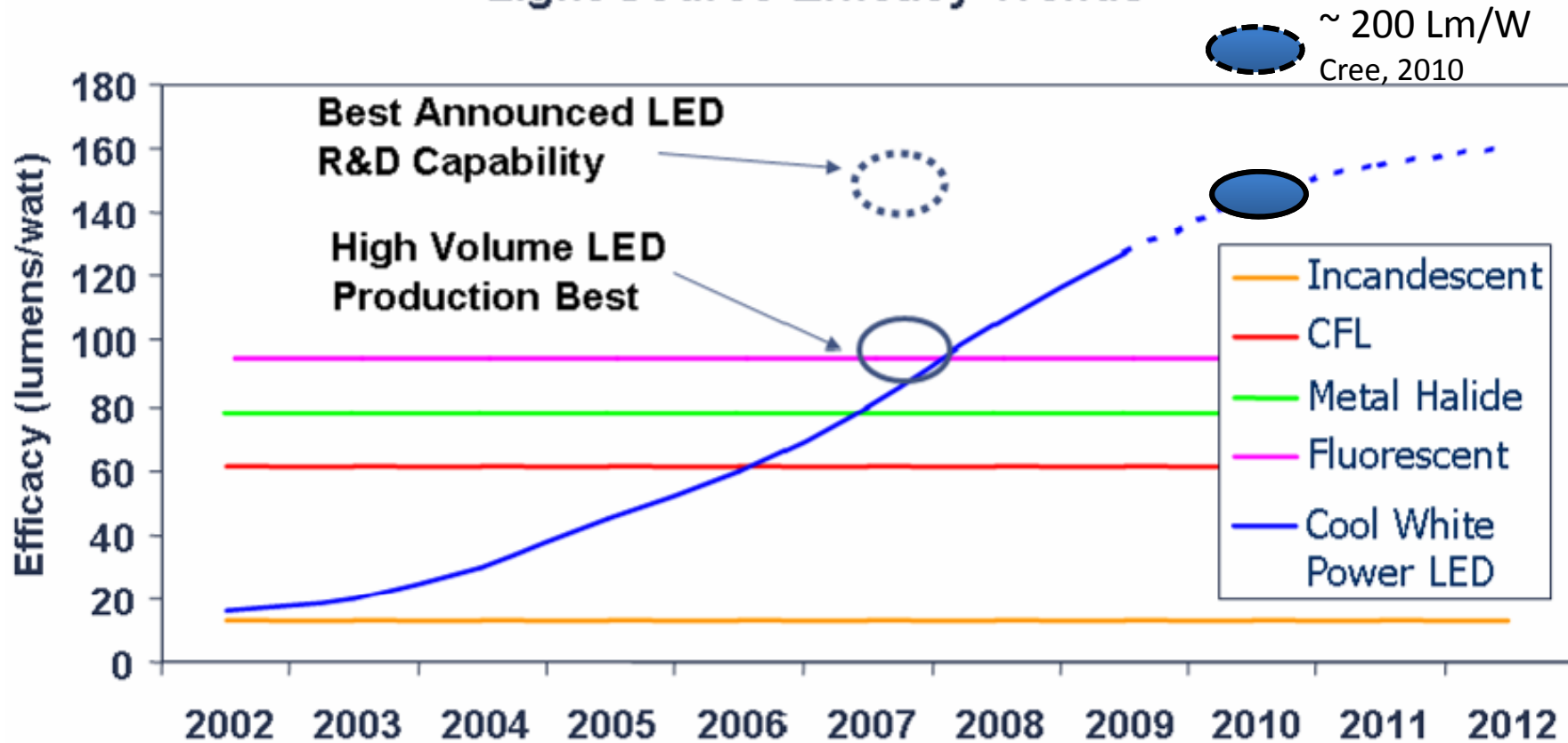


2008 DOE EERE Building Databook



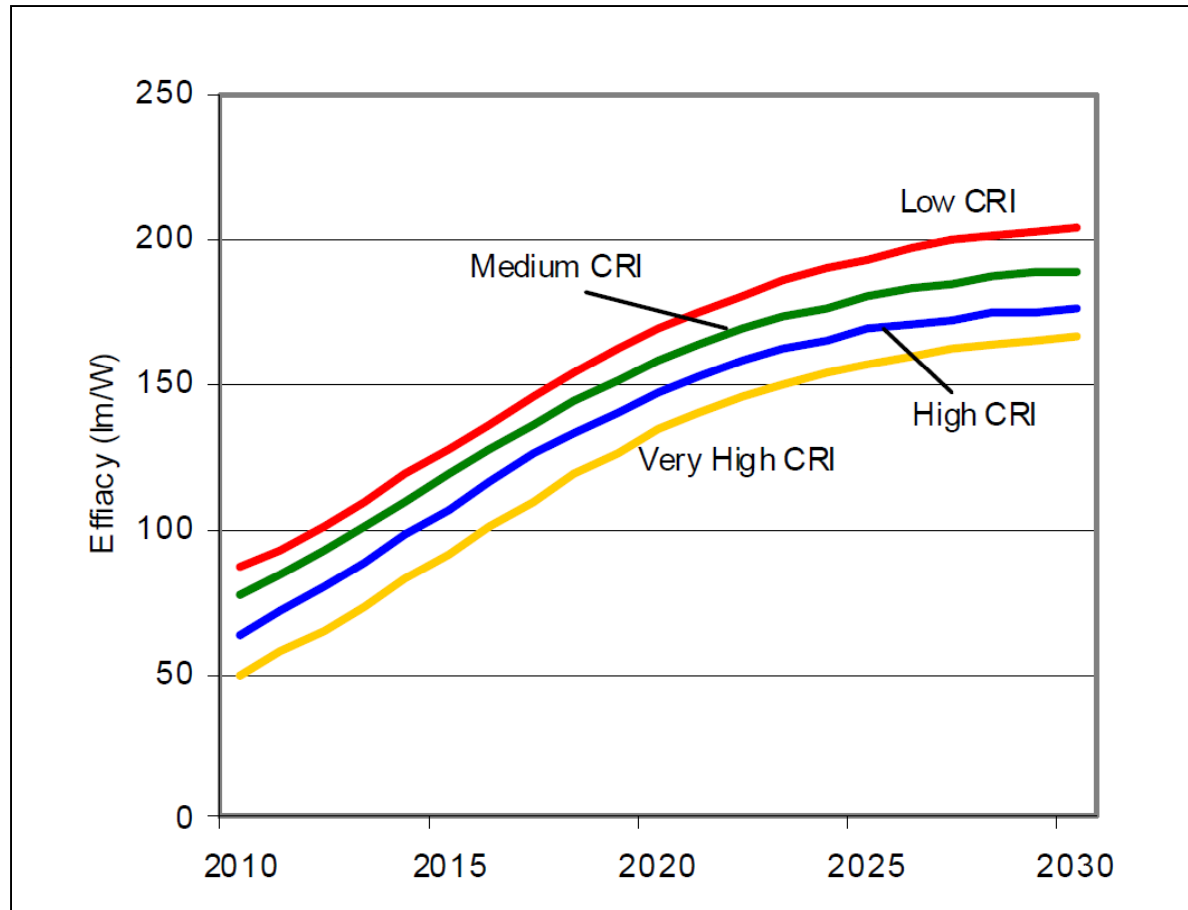
White LED Efficiency Increasing Rapidly

Light Source Efficacy Trends





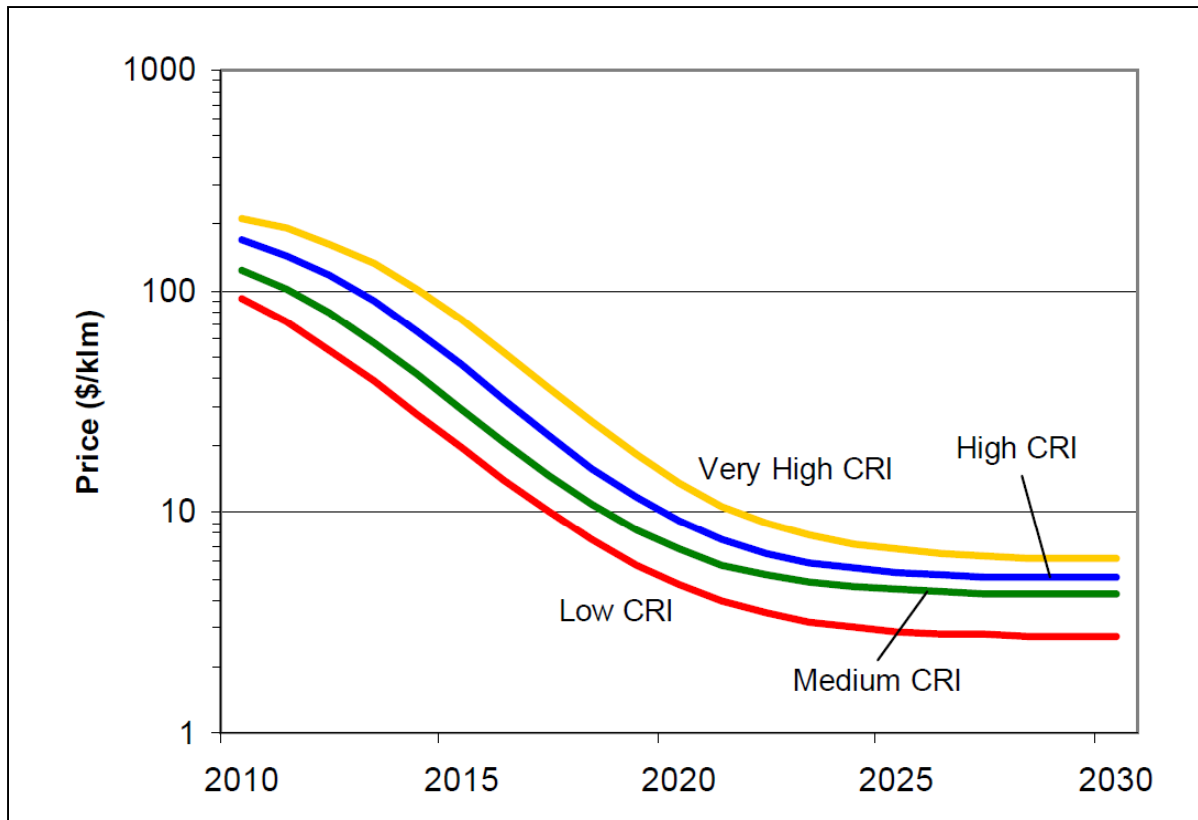
LED Efficacy Roadmap



Major technology improvements needed to track this curve – but is consistent with prior historical LED progress tracking



LED Lighting – Pricing will be the Key



- Automation
- Improved Manufacturing Yield
- New Materials
- New Fixture Designs

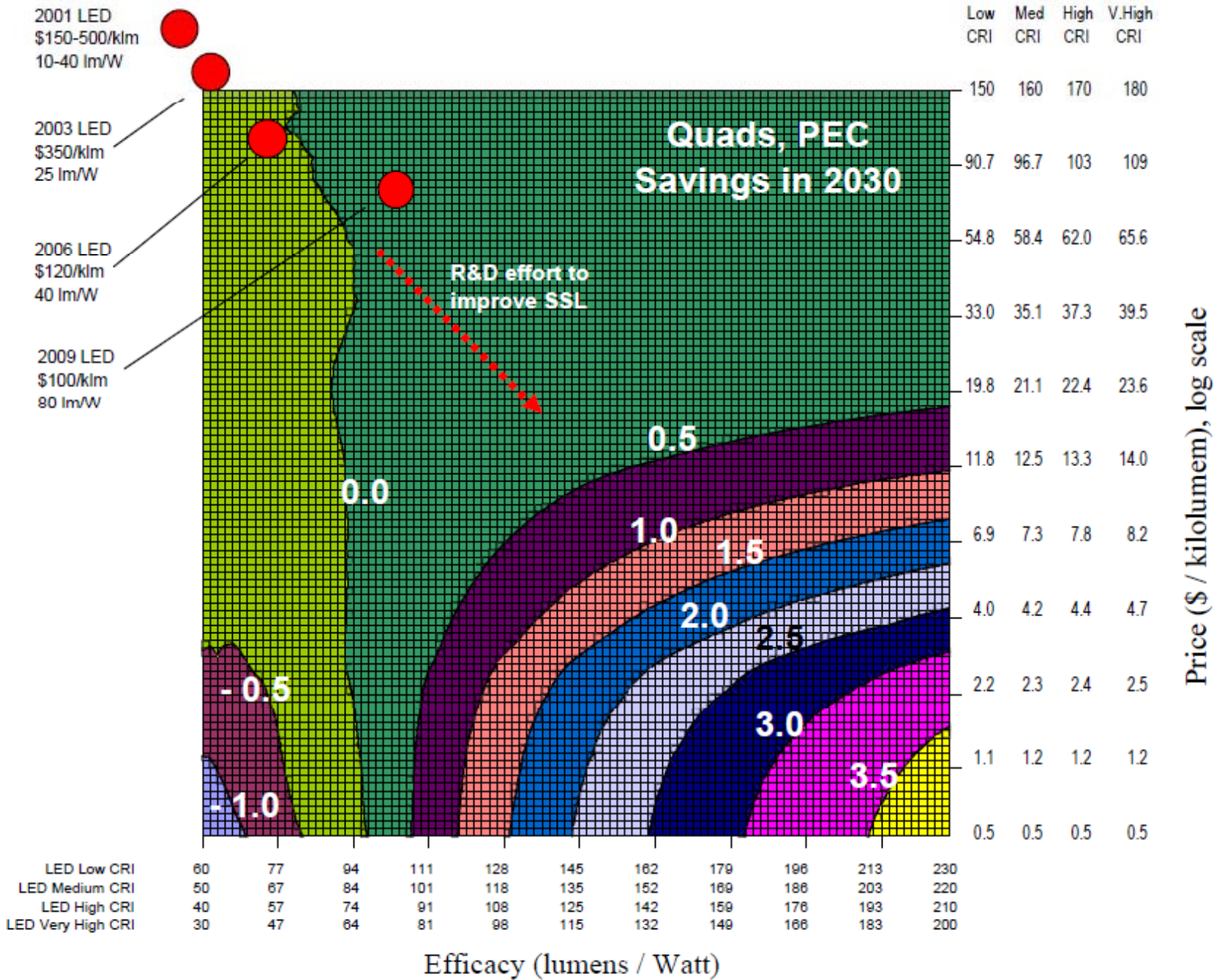
Major technology improvements needed to track this curve – but is consistent with prior LED pricing history



Significant Energy Savings are Possible

Scenario	2015	2020	2025	2030	Cumulative (2010 - 2030)
<i>Reference</i>	9.81 quads	9.45 quads	8.46 quads	8.26 quads	n/a
	911 TWh	878 TWh	785 TWh	768 TWh	n/a
<i>Quads of primary energy savings and TWh of site electricity savings relative to Reference</i>					
<i>LED Scenario</i>	0.07 quads	0.65 quads	1.42 quads	2.05 quads	16.02 quads
	7 TWh	60 TWh	132 TWh	190 TWh	1,488 TWh
<i>OLED Scenario</i>	0.01 quads	0.36 quads	0.96 quads	1.51 quads	10.49 quads
	1 TWh	33 TWh	90 TWh	140 TWh	974 TWh

Reference Case: Energy Savings due to CFL, Fixture Design Improvements, other standard technology improvements



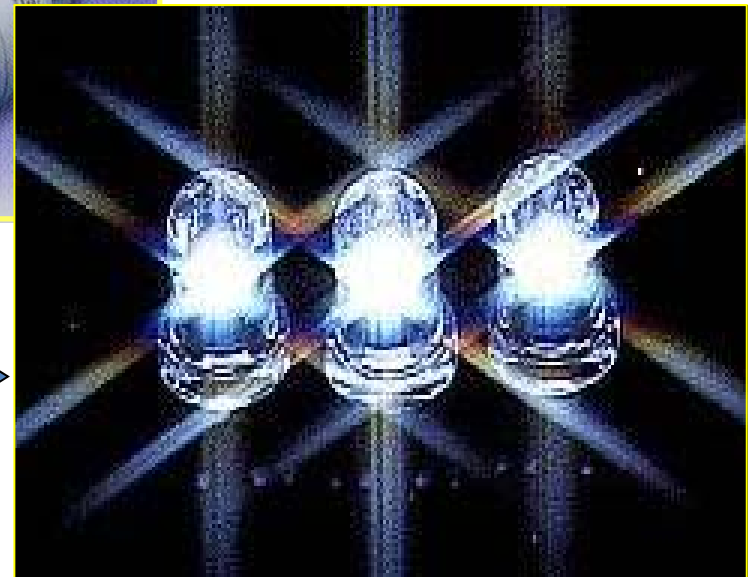


Digital Lighting and Lifetime



Thousands of Hours

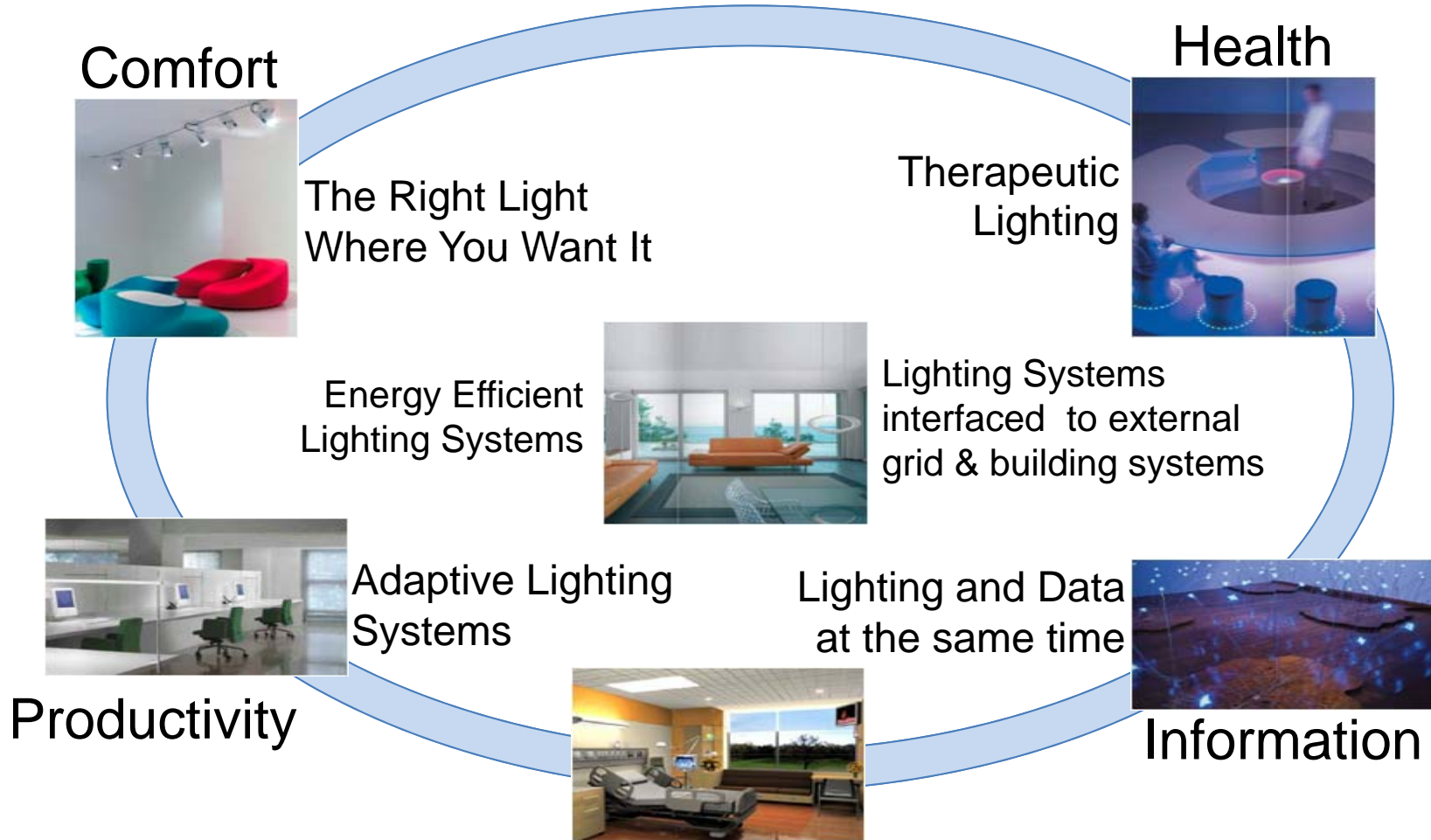
Potentially > 50,000 Hrs



Now that Light will be Digital and Long Lasting ...
What else can be done???????



Smart Lighting Opportunities





Summary

- **Solid State Lighting is evolving very quickly**
- **Market Penetration is currently limited:**
 - Street Lighting
 - Accent Lighting (under cabinet, spots, cove)
 - Recessed Cans
- **Much work remains to be done**
 - SSL Fluorescent replacement
 - General Fixture Design
 - Significant SSL cost reductions
- **Since white LEDs were introduced 15 years ago:**
 - Technical performance roadmaps for LED performance were met or exceeded
 - Solid State Lighting costs have dropped dramatically
- **Look for:**
 - Continued, rapid technical progress and continued price reduction
 - Aggressive, government incentive programs (tied to Energy Star, LEED Programs, etc.)
 - Rapid progress on SSL standards
 - The near term Lighting Future being dictated by Asia (Korea, Taiwan, China)