

Light Emitting Diodes – The Future of Lighting

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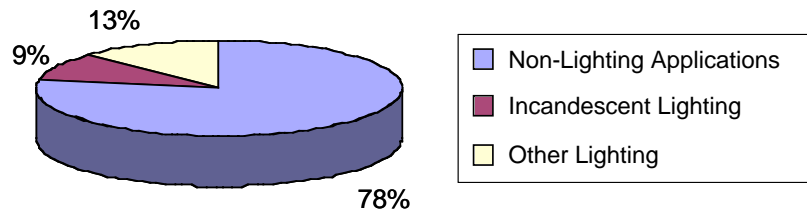


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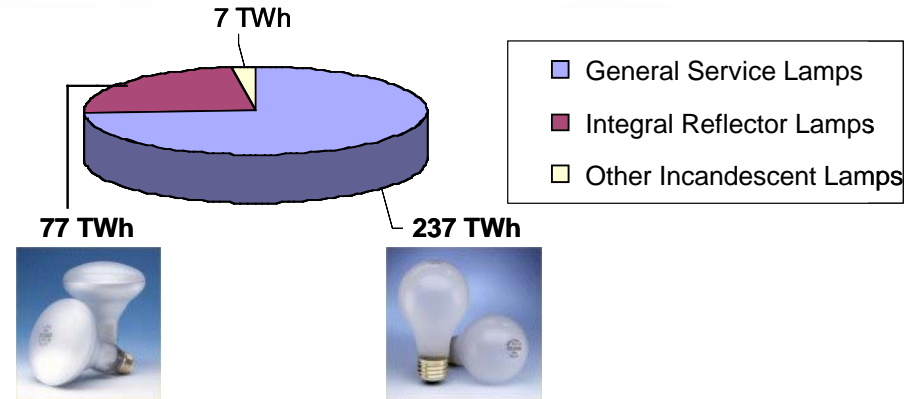


The Lighting Challenge - #1

3,480 TWh U.S. Electricity Use by Application



321 TWh U.S. Electricity Consumption by Inefficient Incandescent Lamps

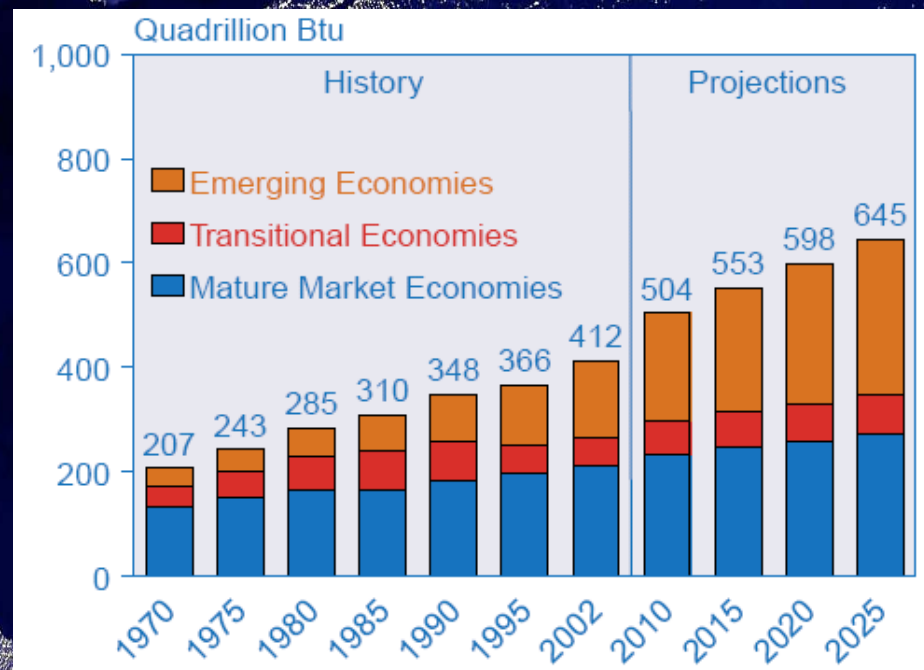


- 765 TWh of electricity - 22% - of total U.S. electricity is consumed to produce light ¹
- **Incandescent lamps use 42% (321 TWh), BUT generate only 12% of the light**
- **1 of 3 installed bulbs needs to be replaced – EVERY YEAR!!**
- Incandescent and halogen lamps represent 56% of the *dollars* spent on lighting sources overall, but in *units* the combined percentages of such sources are 85% ²

¹ U.S. Lighting Market Characterization, Vol. 1, U.S. Department of Energy, Sept. 2002.

² National Electrical Manufacturers Association (NEMA)

Challenge - #2



Source: DOE International Energy Outlook, July 2005

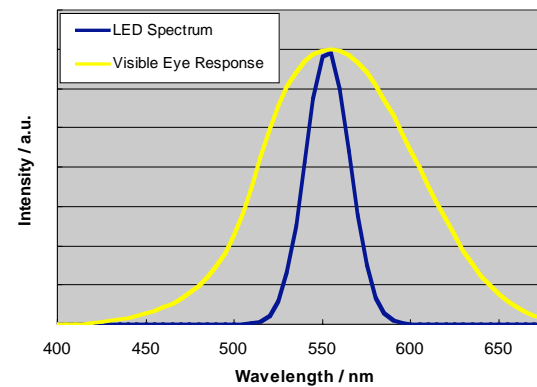
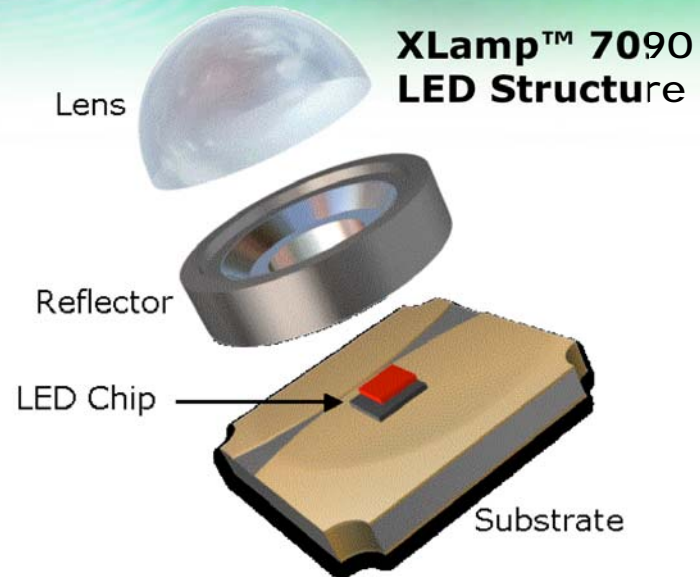
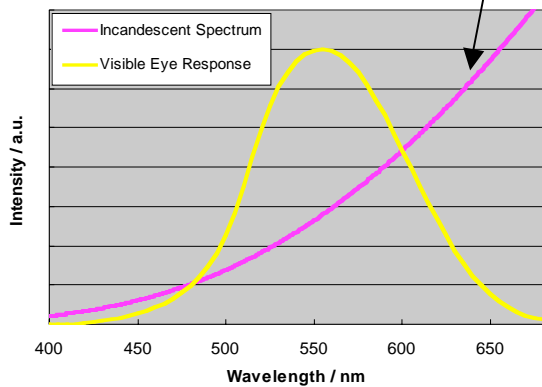
- Global trends are driving increased demand for Energy and Lighting: 50% Emerging Economies; 10% Developed Countries
- 1/3 of the world's population (2 Billion people) have no access to electricity and the vast majority live in remote villages in developing countries (World Bank, 2002)

How Do We Meet The Challenge?

- Old Way
 - Find more Energy or Use Less
 - The *Cree* Way
 - Get more for less by increasing the Return On Energy (ROE)
 - *Increase* Lumens/Watt for Lighting
 - *Increase* Miles per Gallon for Autos
 - *Increase* Efficiency of Electric Motors
- ⇒ Solid State Lighting with LED's saves energy, saves money, and saves the environment
- PLUS**
- It can enable global development



Light Emitting Diodes - The Difference

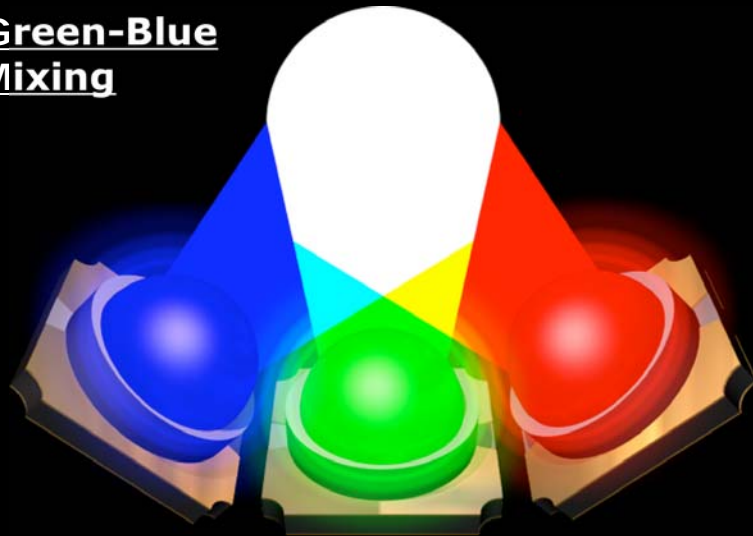


LEDs: >10 years lifetime, no catastrophic failure, robust, cool-to-touch

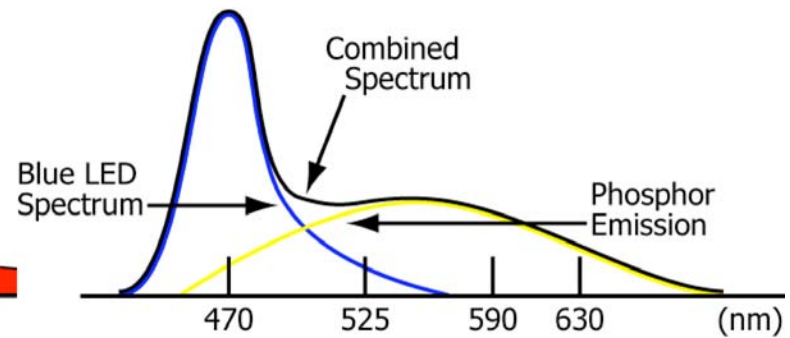
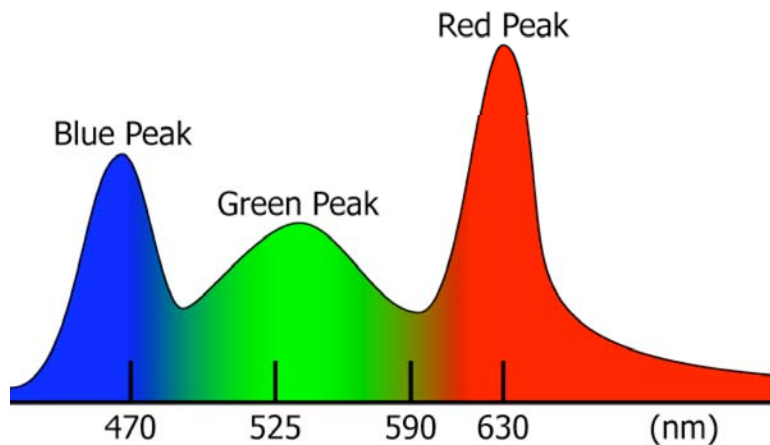
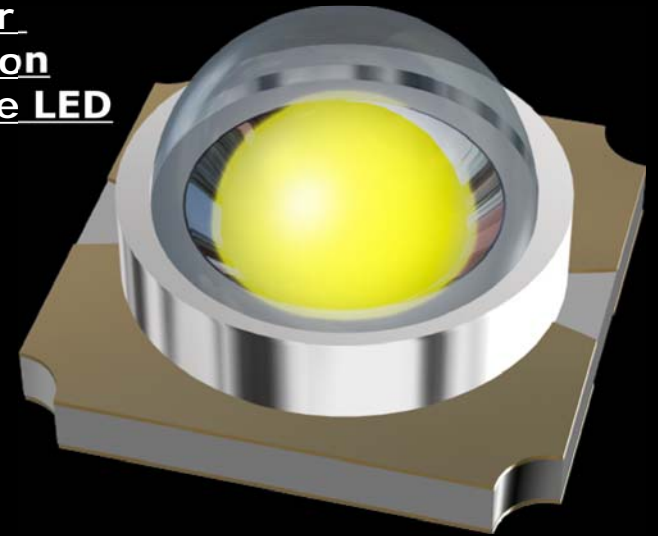


Creation Methods of White Light with LEDs

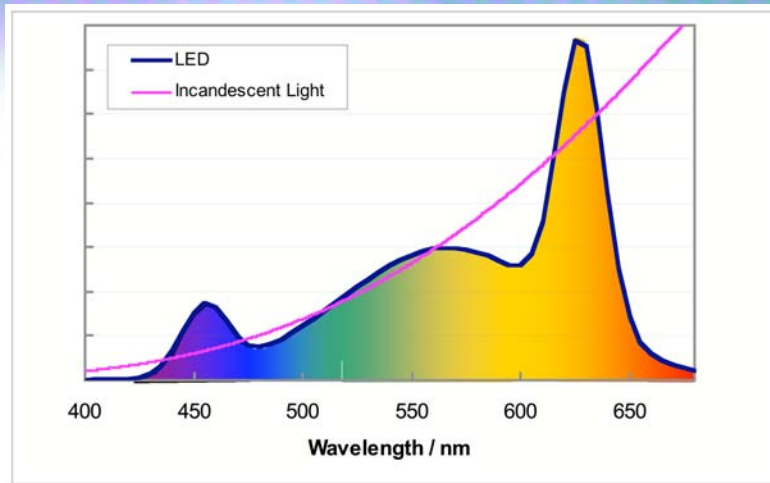
Red-Green-Blue
LED Mixing



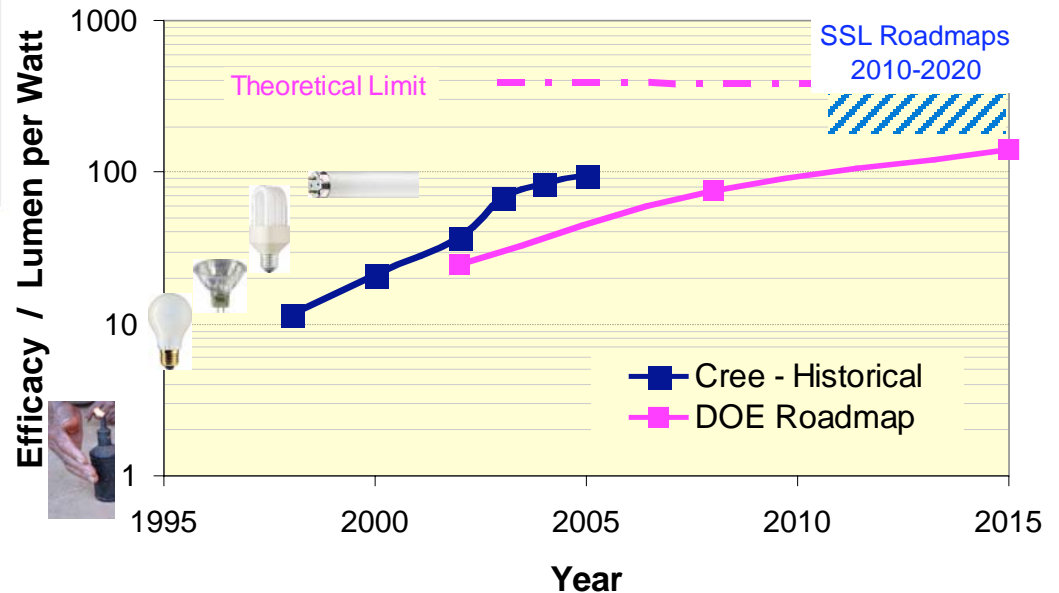
Phosphor
Conversion
With Blue LED



White LED Efficiency



White LED Efficiency Development



- Key Efficiency Metric:
Lumen per Watt of Electrical Energy – LPW
- White LEDs currently at efficiency levels of **77- 100 LPW**
 - 5- 8 x Incandescent Lamps
 - Exceeding Fluorescent Lamps



Common Perspective on LEDs

*LED Lighting is still 5 years from
“commercial” applications*

Assumptions

1. LED technology is not ready
 - LEDs are not bright enough
 - LEDs are too expensive
 - No practical “bulb” solutions exist
2. Traditional lighting companies will drive the conversion

THESE ASSUMPTIONS ARE NO LONGER VALID

- Technology and Markets are accelerating
- Industry model will be re-defined



Solid State Lighting - Today

Specialty Lighting

- Architects and retailers alike are embracing SSL - Brightness not the Issue

Automotive Forward Lighting

- Car makers and suppliers are looking to use SSL-based forward lighting in future models
- Benefits
 - Innovative Décor & Style
 - Lower Power Consumption
 - Lower Maintenance
 - Longer Life
 - Design Flexibility



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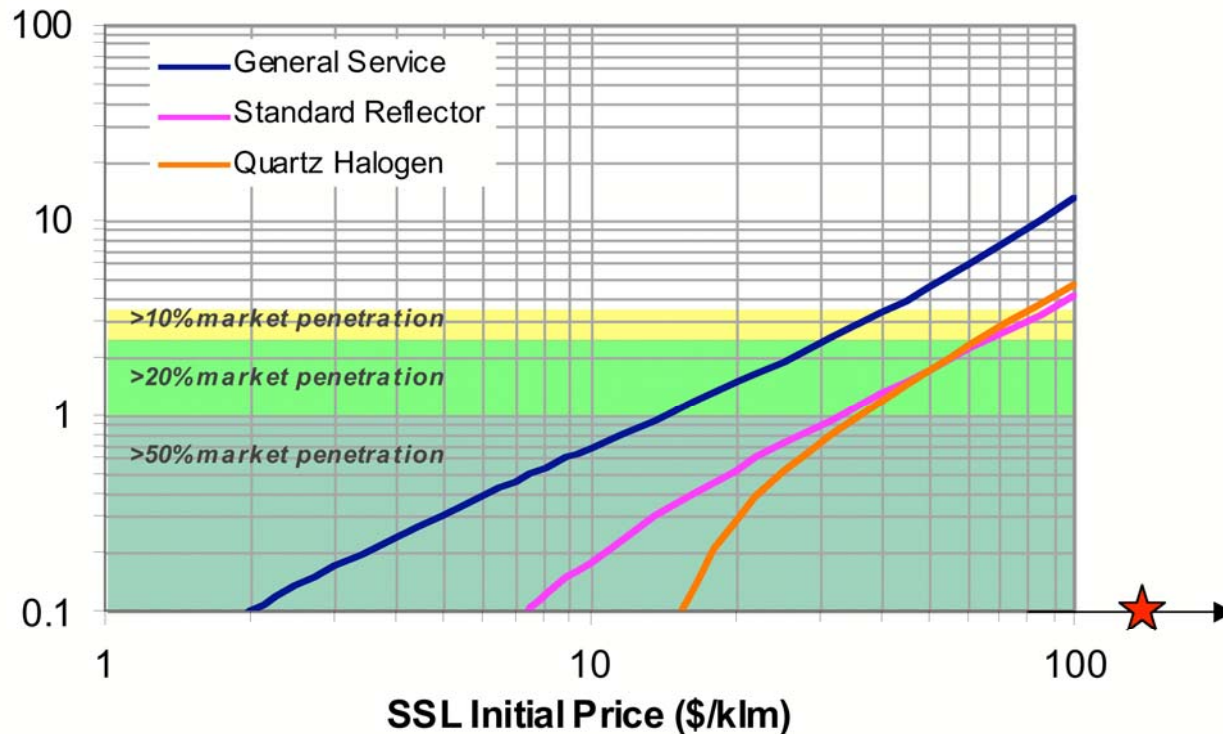
Solid State Lighting - Today

LCD Backlighting

- Benefits
 - Improved Color Saturation
 - Better Contrast Ratio
 - Lower Power Consumption
 - Mercury and Lead Free
- Challenges
 - Cost

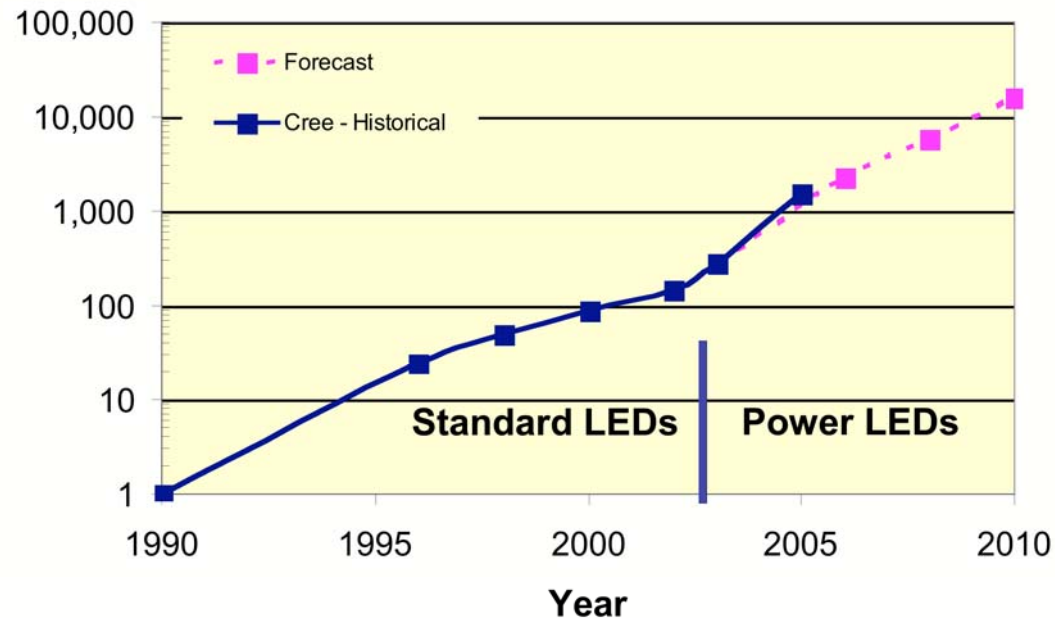


Why is Solid-State Lighting not Ubiquitous?



- Lamp cost still too high for General Lighting!!
- Simple Payback needs to be < 2-3 years

Path to Lower Cost Solid-State Lighting



- Industry is driving towards new manufacturing technology
- Cost reduction by leveraging the “Silicon Experience”
 - Efficiency / Better Materials
 - More Power Per Chip
 - Larger Wafer Diameter and Higher Yield



Initiatives

Country	Program	Target	Funding	Comment
U.S.	Next Generation Lighting Initiative	160 LPW in Product	\$12.7M Appropriation: \$50M	2005 2007-2013
Europe	White O-LEDs	50LPW	\$24M	2004 - 2008
	EU Optoelectronics Photonics-21	TBD	Part of \$55M	Start 2004
Japan	21 Century Lighting Program	100 LPW	\$41M	Phase I Finished Phase II TBD
Korea	Korean National Program on LED Advancement	80 LPW	\$100M	2004 – 2008
Taiwan	White LED Project		\$45M	Spent Over 5 Years Ending in 2003
	Next Generation Lighting	100 LPW prototype 40 LPW production	\$12M	2003 – 2005
China	Semiconductor Lighting Project	TBD	\$12M	From Beijing, Local Government also Funding

- Global strategic investment in Solid State Lighting
- Next Generation Lighting Industry Alliance

Solid State Lighting - Benefits:

- SSL Saves Energy
 - Could reduce energy for lighting 29% in the U.S. \approx 80-100 Fossil Power Plants
(U.S. Department of Energy)
 - China's Solid State Lighting Alliance estimates domestic demand could be cut by 100 Billion KWh/yr
- SSL Saves Money
 - Potential to cut consumer electricity bills by \$125 Billion from 2005-2025
(U.S. Department of Energy)
 - Fewer power plants
 - Air conditioning: 3W energy savings in lighting = 1 W savings in air cooling ¹
- SSL Saves The Environment
 - Carbon emissions could be reduced by more than 250 Million tons by 2020
 - No mercury



Solid State Lighting - The Future

General Lighting: Home & Commercial

- Traditional lighting products are not as cheap as they seem
- SSL has to make transition from Specialty to Commodity product
 - Standardization
 - Education and Marketing



Global Development

- SSL can bring light to people, who have no or limited access to electricity
- Creative entrepreneurs and non-profits are starting...
- Lighting can mean reading and education
- ... 2 billion people to go



Summary

- Our energy-dependent, modern life continues to drive increased demand for energy and challenge supply
- Solid-state lighting presents a compelling alternative to entrenched, inefficient light sources
- The question is not IF, but when?
- SSL is an incredible business opportunity
- SSL is a chance make a difference in global energy use patterns

