Solid State Lighting (SSL): Status of adoption in the U.S.

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Incandescent lamp phase out – what it means for SSL

Phase out of incandescent lamps around the world - December 2011 Status

	2009	2010	2011	2012	2013	2014	2015	2016
Europe								
European Union	100W	75W	60W	40W-15W		halogen available		efficiency level B
Switzerland	100W	75W	60W	40W-15W		halogen available		efficiency level B
Turkey				Aligned with EU		halogen available		efficiency level B
North America								
British Columbia			75W, 100W	40W,60W (date to be confirmed)		halogen available		
California			100W	75W	40W,60W	halogen available		
USA (except CA)				100W	75W	40W,60W	halogen available	
Canada (except BC)						75W, 100W	40W, 60W	halogen available
Latin America								
Cuba	banned all incandescent filament lamps including halogen in 2005							
Argentina			ban of all incandescent lamps ≥ 25W but not including halogen					
Columbia			≥150W	≥75W		≥60W	halogen available	
Mexico				100W	75W	40W,60W	halogen available	
Brazil				≥100W	≥60W	≥40W	≥25W	halogen av.
Asia								
Malaysia			≥100W	all other wattages		ban of all filament lamps in favor of CFLs and LEDs		
Russia			≥100W			halogen available		
Israel			≥60W			halogen available		
ROK				150W - 70W		70W-25W	minimum standard 20 lm/W	
Taiwan				Min. requirements for consumer lamps: 22lm/W for ≥100W, 20lm/W for ≥60W, 18lm/W for ≥40W, 15lm/W for ≥25W				
China				≥100W		≥60W		≥15W
Japan		gradual voluntary transition by major lamp companies to high efficacy lighting - no mandatory regulations in place						
Philippines		no government mandated ban at this time, Bill to require a minimum of 15 lm/W efficacy introduced in the Philippines Senate						
India			Some voluntary programs, but no mandatory standards for lamps rated at 100W or below					
Oceania								
Australia	Traditional incandescent phased out in 2009, halogen available							
New Zealand	Intention was to phase out traditional incandescent lamps the same way as Australia, but government elected in 2008 did not proceed							

Prepared by Pekka Hakkarainen Dec 2011

Color code: Phase out event or period; Higher efficacy filament lamps allowed; No filament lamps allowed

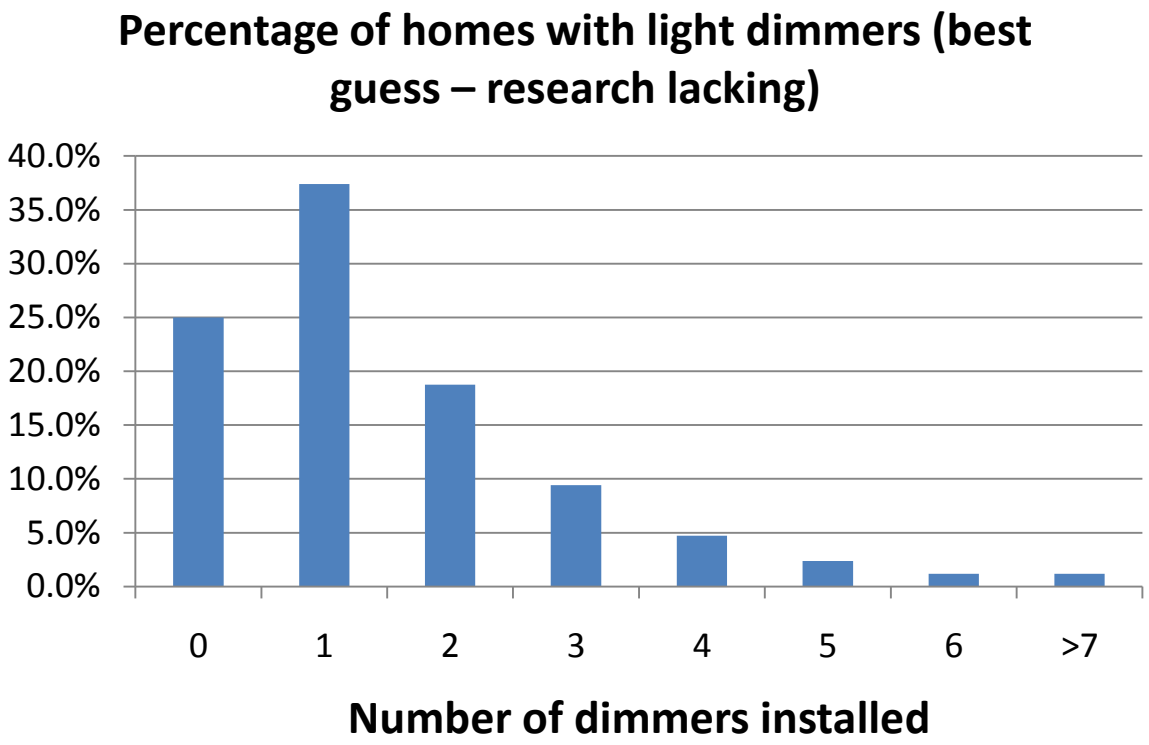
Note: (1) political initiatives in US Congress to repeal the incandescent standards, and (2) State level legislation to exempt lamps manufactured in such States from Federal standards provided the lamps are not placed into “Interstate Commerce”.

Building Codes in North America

- IECC 2012 residential requirement
  - **Lighting Equipment (Mandatory).** A minimum of 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or a minimum of 75 percent of the permanently installed lighting fixtures shall contain only high efficacy lamps
  - **Exception:** Low-voltage lighting shall not be required to utilize high-efficacy lighting

Residential status

- **Estimate of current status of US homes**
  - 130 million homes (2009 Census Bureau estimate)
  - Average home approx. 175 m^2,
    - about 20 switch locations
    - about 40 permanently installed lamp sockets
  - A small number of other lighting controls,
    - mainly motion sensors and occupancy sensors
    - some count down timer switches.



Note: A good number of CFLs installed (utility programs) – not compatible with dimmers

CFL “dissatisfiers”

- See “Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market”, Pacific Northwest National Laboratory, May 2006
  - Color appearance and color rendering
  - Warm-up time
  - Disposal – because of mercury
  - Incompatibility with dimmers
  - Actual life shorter than advertized

Application to LED and Other New Lighting Technologies

- A lot of consumer research is needed to determine what the consumer does and does not know before the initial product launch so that the launch is done right the first time.
- Accurate incandescent equivalency on packaging is critical.
- Rely as much as possible on retailers for customer education. Product packaging can also be a very powerful way to convey product benefits.
- Industry collaboration, perhaps through NEMA, would be helpful, though difficult to achieve given the large number of manufacturers.
- Coordinate with energy-efficiency programs once products are available but don't start before products are ready.
- Don't rely on giveaways and coupons or other programs that confuse consumers about the actual retail price.
- Avoid market introduction programs that distribute products outside normal retail channels, for example utility mail-order programs.
- Performance claims must be accurate. Don't launch a product until performance issues are ironed out.
- Initial education and performance issues will be more difficult to iron out if many manufacturers are involved in the initial introduction of LEDs.
- Pricing is critical but tricky - low enough to encourage consumer demand, high enough to generate profit for the retailer and manufacturer.
- Education, of both consumers and retailers, is critical.
- Understand that many people will not try a new product until price drops to a range near that of existing products providing similar functionality.
- Niche marketing is the best approach for now.

Consumer product availability

Commercial, industrial and outdoor markets for LEDs

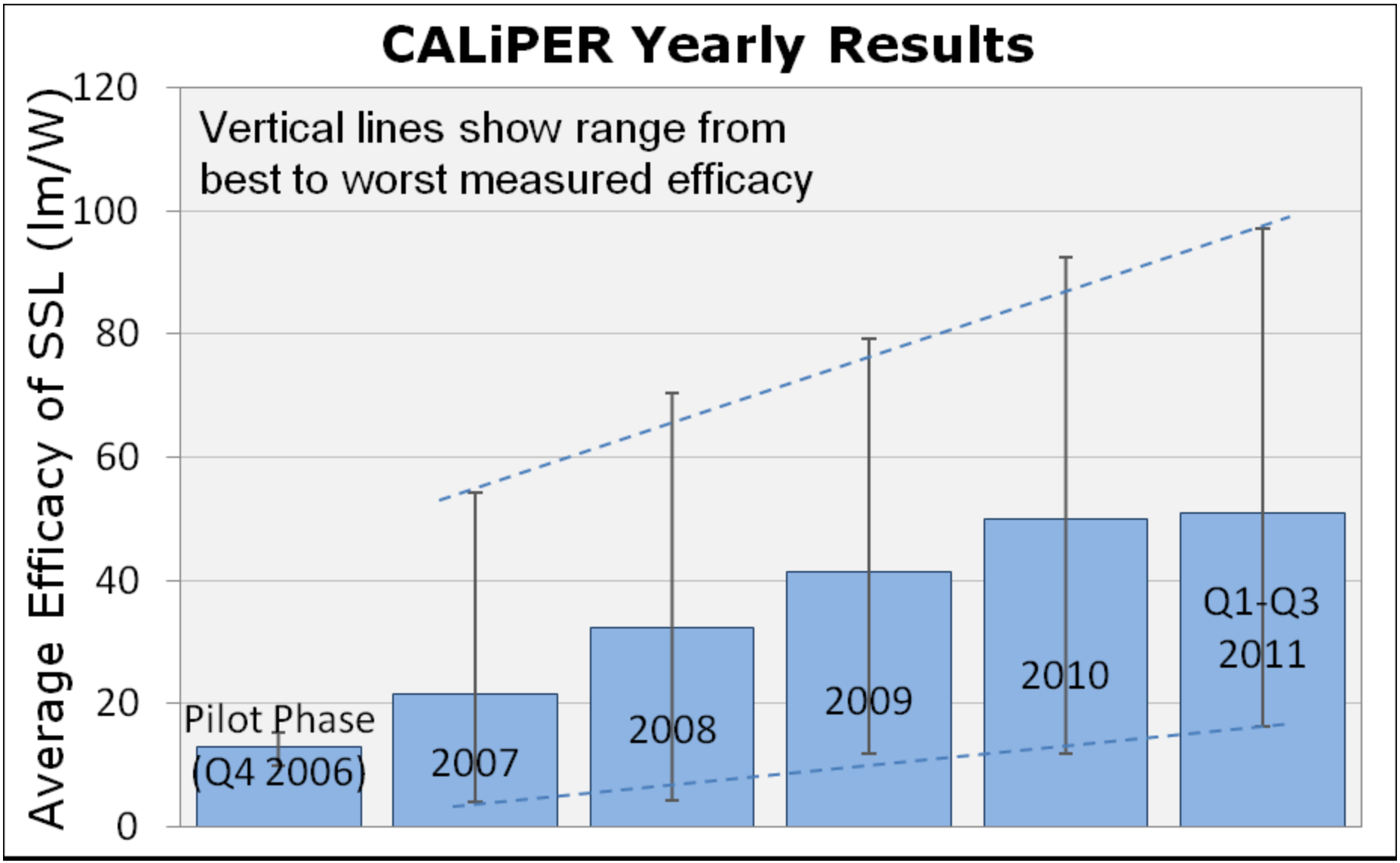
Good applications

- Task lighting
- Wall washing
- Accent lighting
- Walkway and parking lighting
- Roadway lighting

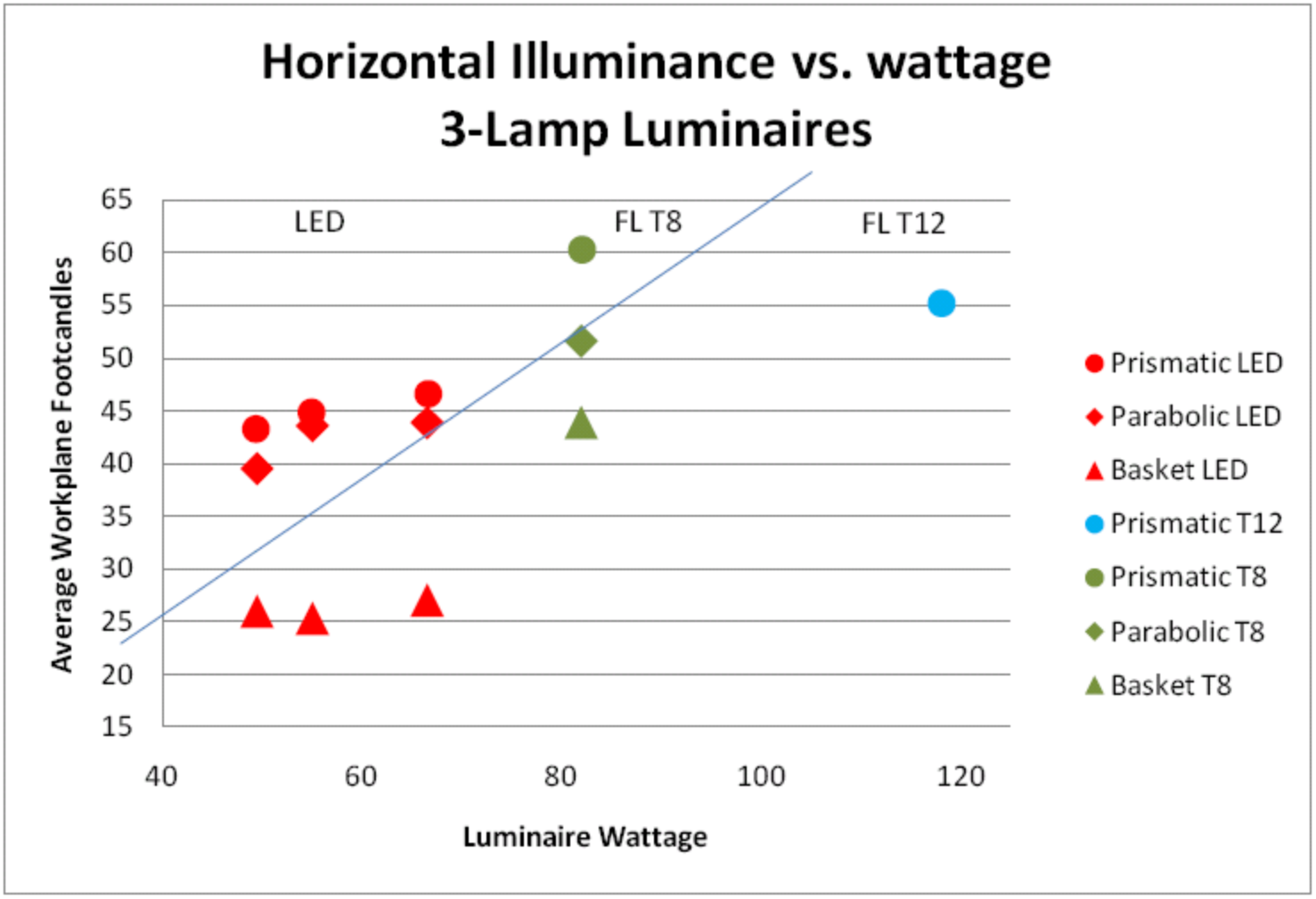
Difficult applications

- Omni-directional ambient lighting
- Almost all industrial lighting
- Some very high pole outdoor lighting

DOE's CALiPER program – round 13



DOE's Gateway program – linear LEDs



EPA Energy Star program

Luminous Efficacy Requirements: All Lamps

Lamp Type	ENERGY STAR Requirements		Methods of Measurement and/or Reference Documents	Supplemental Testing Guidance
	Lamp Input Power (watts)	Lamp Efficacy (initial lm/W)	Measurement (fluorescent): IES LM-9-09 IES LM-66-11 Measurement (high intensity discharge): IES LM-51-00 Measurement (solid state): IES LM-79-08 Reference Document: ANSI C78.375-1997	For fluorescent lamps, measurements shall be taken at the end of 100 hours of seasoning according to ANSI C78.375-1997 section 8.4. For dimmable/2-way/3-way products, measurements shall be made at the highest wattage setting listed for the model. **Sample Size**: 10 units per model: 5 units tested base-up and 5 units tested base-down unless the manufacturer restricts specific use or position. If position is restricted, all units shall be tested in restricted position. **Passing Test**: Average of unit values shall meet the requirement, and ≥ 9 units individually shall meet the required value. If units are tested both base-up and base-down, averages shall be calculated for both subsets, and the efficacy shall be the lesser of the two averages.
Omnidirectional	<10	55		
	≥10	60		
Directional	<10	40		
	≥10	45		
Decorative	<10	45		
	≥10	50		

DOE Roadmap for SSL

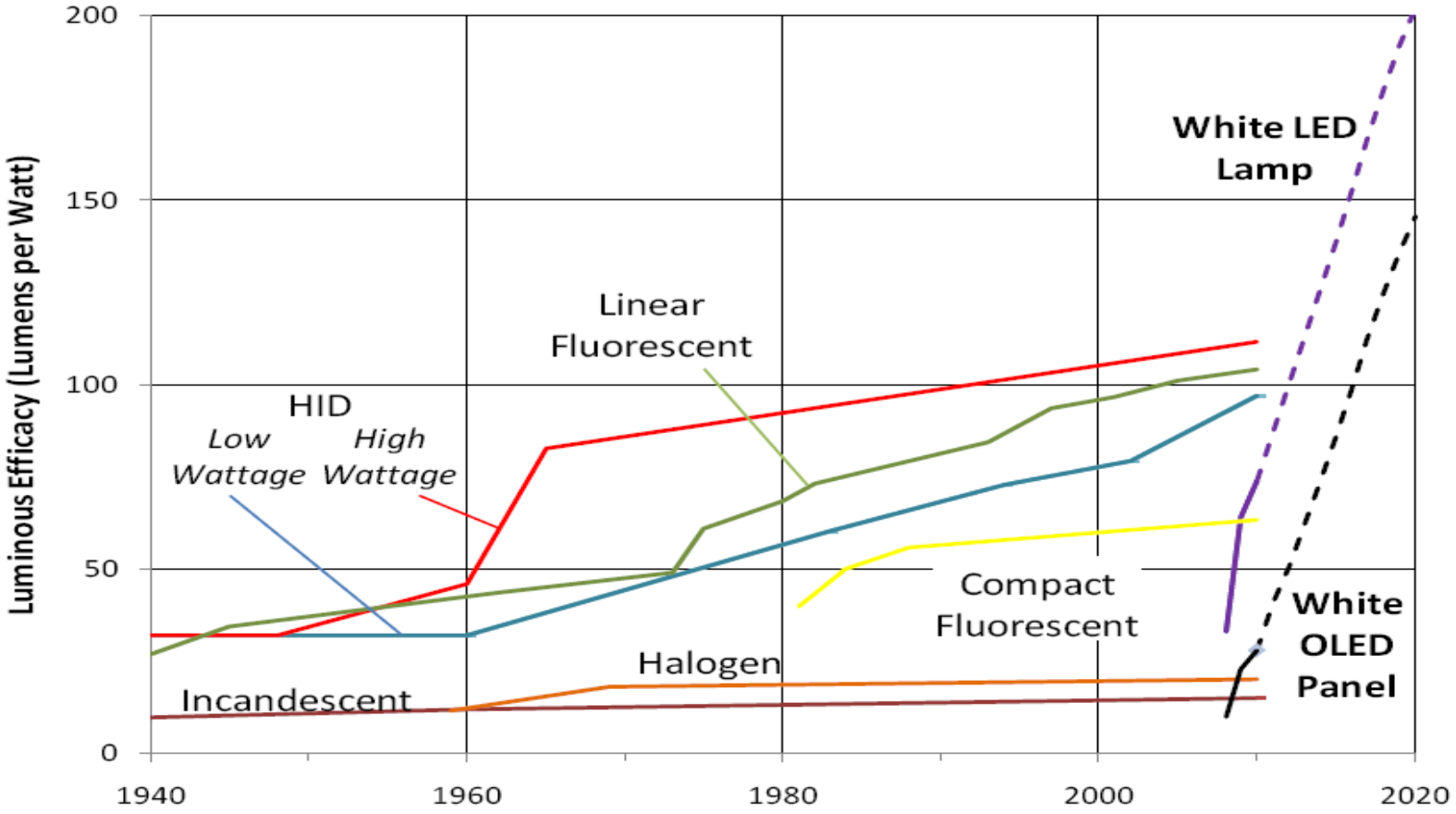


Figure 3.4: Historical and Predicted Efficacy of Light Sources[34]
Source: Navigant Consulting, Inc - Updated Lumileds' chart with data from product catalogues and press releases
Note: Efficacies for HID, fluorescent, and LED sources include driver or ballast losses.

Cost projections

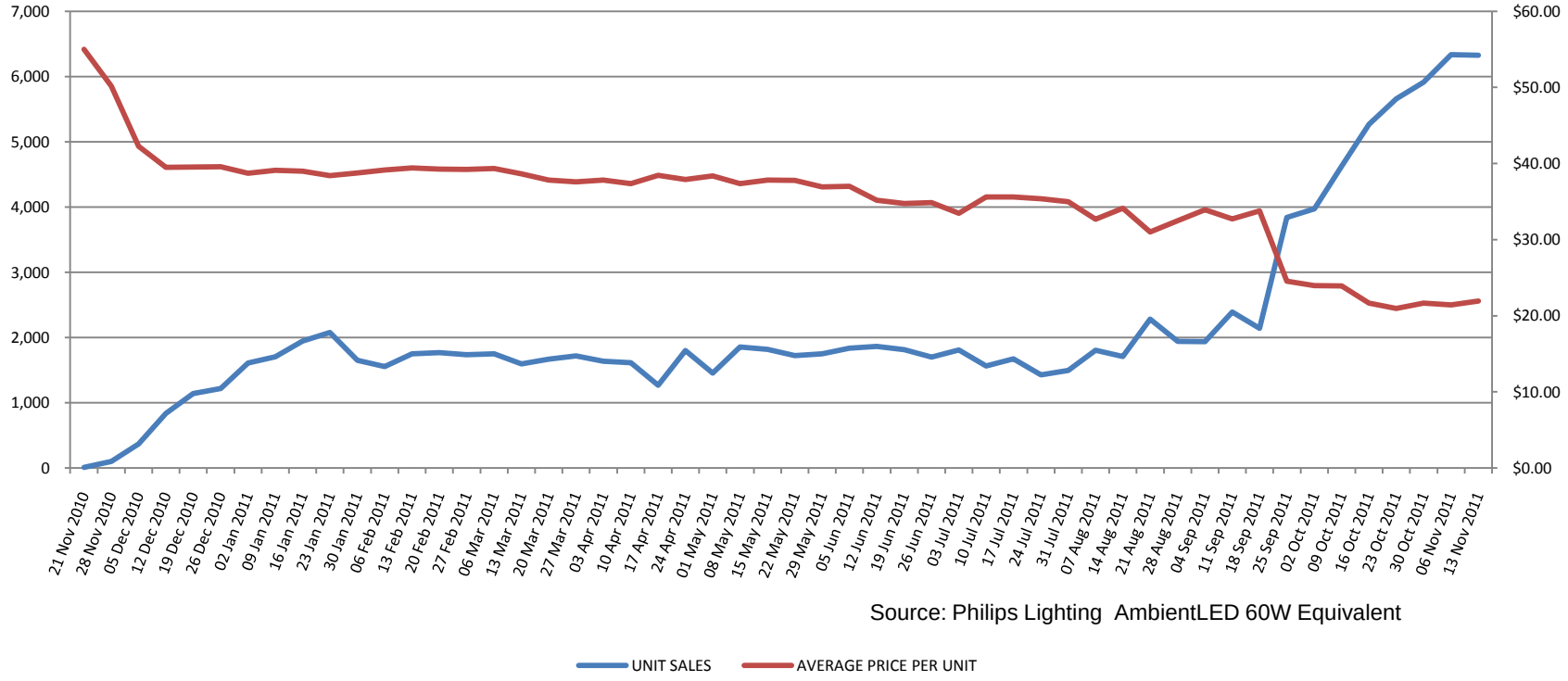
Table 3.2: Summary of LED Package Price and Performance Projections

Metric	2010	2012	2015	2020
Cool White Efficacy (lm/W)	134	176	224	258
Cool White Price ($/klm)	13	6	2	1
Warm White Efficacy (lm/W)	96	141	202	253
Warm White Price ($/klm)	18	7.5	2.2	1

Note:

1. Projections for cool white packages assume CCT=4746-7040K and CRI=70-80, while projections for warm white packages assume CCT=2580-3710K and CRI=80-90. All efficacy projections assume that packages are measured at 25°C with a drive current density of 35 A/cm^2.
2. Package life is approximately 50,000 hours assuming 70% lumen maintenance at a drive current density of 35 A/cm^2.

Sales volume vs. price



Standards development in the US

- Under way but lots of work remains
  - Zhaga: standards for electrical, mechanical and thermal interfaces between modules used in LED luminaires and controls
  - NEMA: standards for LED drivers, binning of LEDs and compatibility between LED lamps and lighting controls
  - DOE: development of minimum energy efficiency standards may begin in 2014

Conclusion

- LEDs are coming and fast
- Not ready “for prime time” (American phrase referring to television programming from 6pm to 11pm, when the audiences are the biggest)
  - Primary objection is cost
- What about OLEDs?

Questions

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