Using LEDs to Their – and Your – Best Advantage

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PNNL

Voices for SSL Efficiency 2008

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Key Messages

- LED technology continues to improve rapidly
  - Next generation LED devices introduced about every 6 months
- LEDs can save energy and provide high quality lighting in a growing number of applications
- Beware of generalizations
  - Most LED products are newly designed
  - Field experience is limited

Presentation Outline

- Key LED characteristics
- Matching LEDs with lighting applications
- Several example applications
  - Benchmarks
  - Measured product performance
  - Current status of LEDs in the application
  - What to look for
- What about linear fluorescent replacements?
- What's coming next in LED applications?

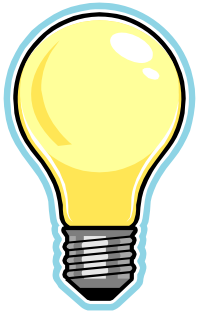
LED Characteristics

Well-designed LED lighting products can offer:

- Energy efficiency
- Long life
- Good lighting quality
  - Color, distribution

LED Special Attributes

- Directional light



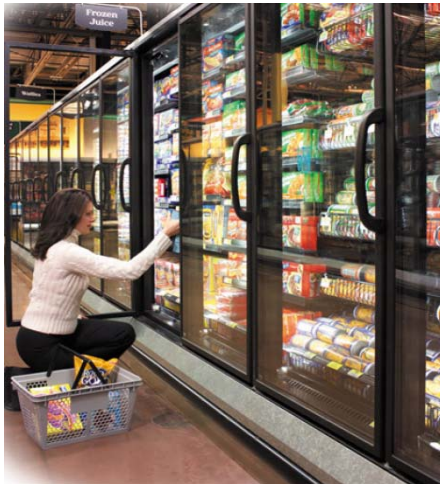
- Low profile/compact size
  - But remember, they need a heat sink

- Breakage and vibration resistance

LED Special Attributes

- Optical precision
- Cold temperatures
- Near instant-on
- Rapid cycling
- Control options
- No IR/UV emissions

Fraen



GE Lumination

Matching to applications

	Directional	Optical control	Cold temp	Durability / Vibration
Undercabinet	✓			
Recessed downlights	✓			
Portable desk / task	✓	✓		✓
Track lighting	✓			
Cove lighting	✓	✓		
Wall washer	✓	✓		

Matching to applications

	Directional	Optical control	Cold temp	Durability / Vibration
Refrigerated case	✓	✓	✓	✓
Accent / spot	✓	✓		✓
Display lights	✓	✓		
Outdoor area	✓	✓	✓	✓
Parking garages	✓	✓	✓	✓
Step / path	✓	✓	✓	✓

Focus Applications

- Recessed downlights
- Undercabinet lighting
- Portable desk/task lighting
- Outdoor area lighting

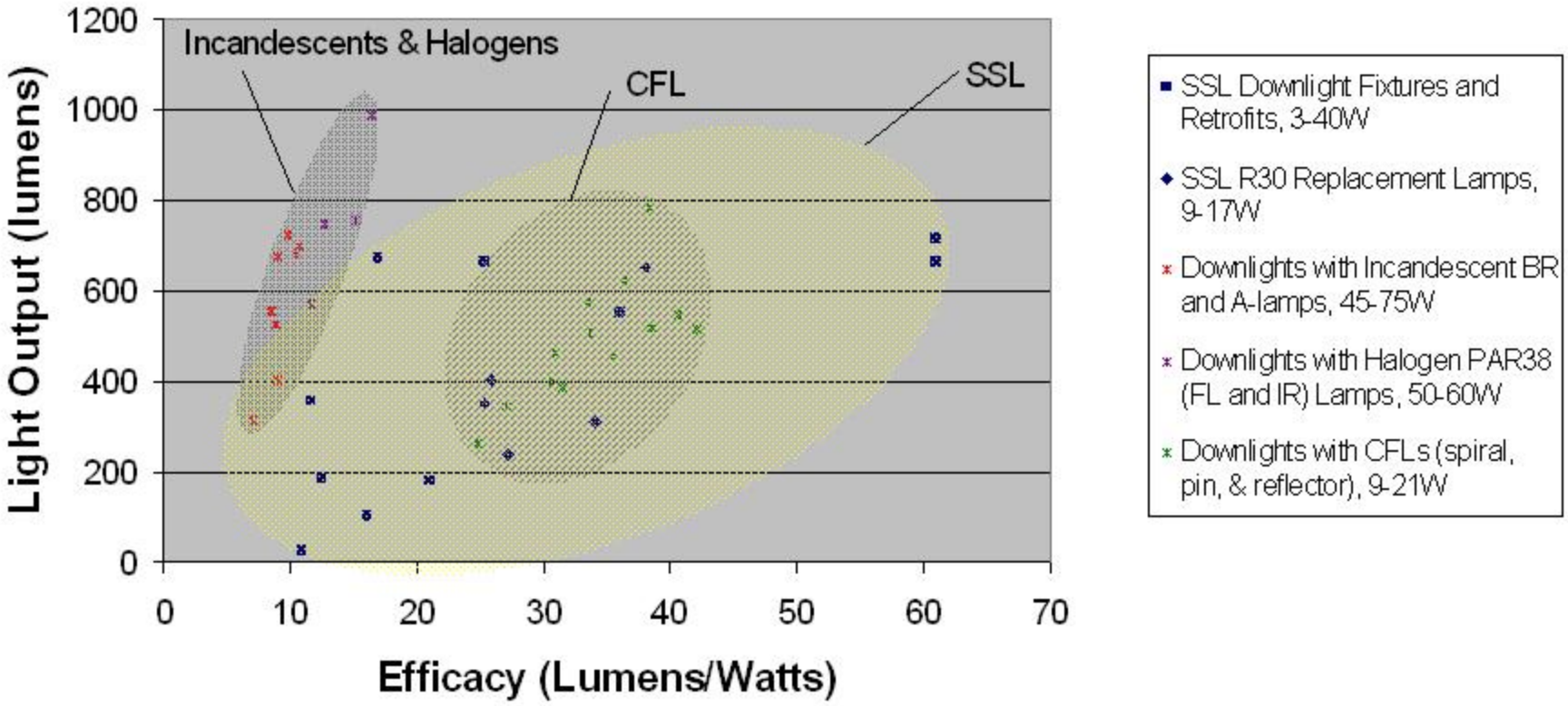
Recessed Downlights

Cree LED Lighting Solutions

Prescolite

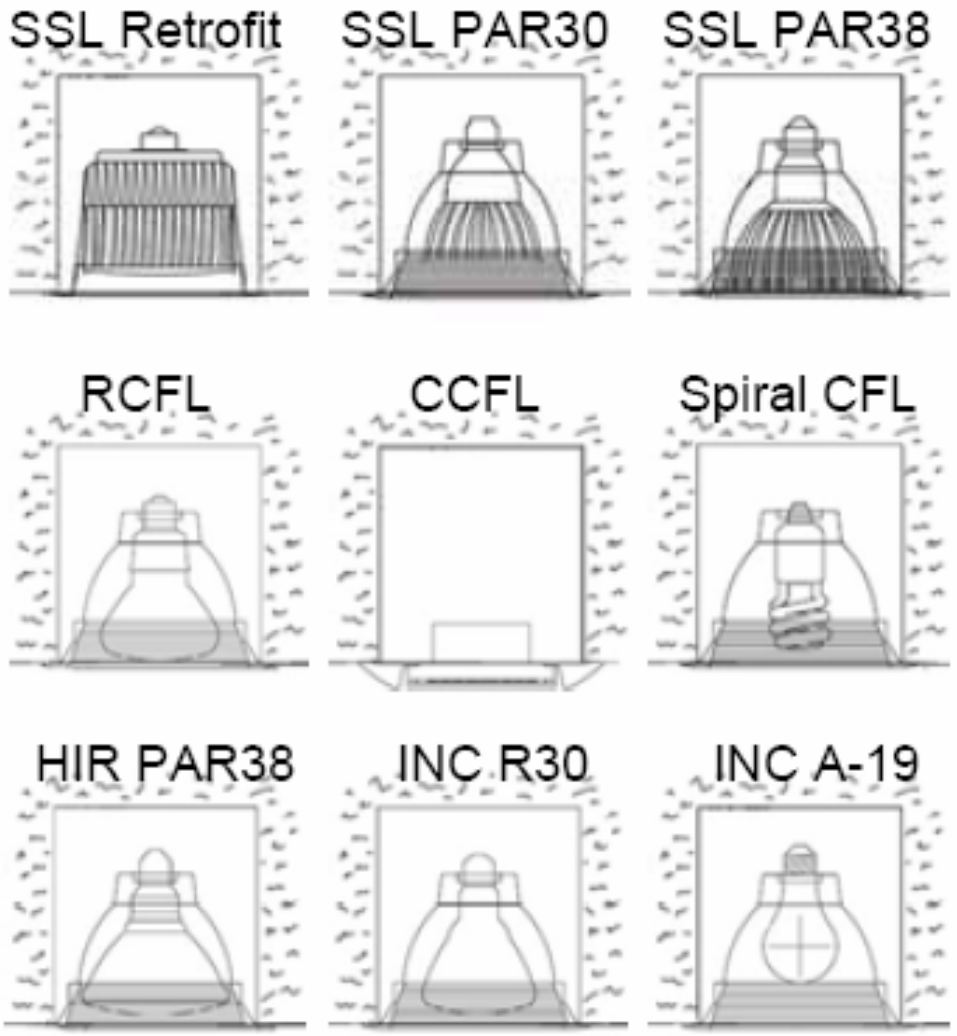
Downlight Benchmarking

Downlight Comparison: Luminaire Output vs Efficacy for Different Sources

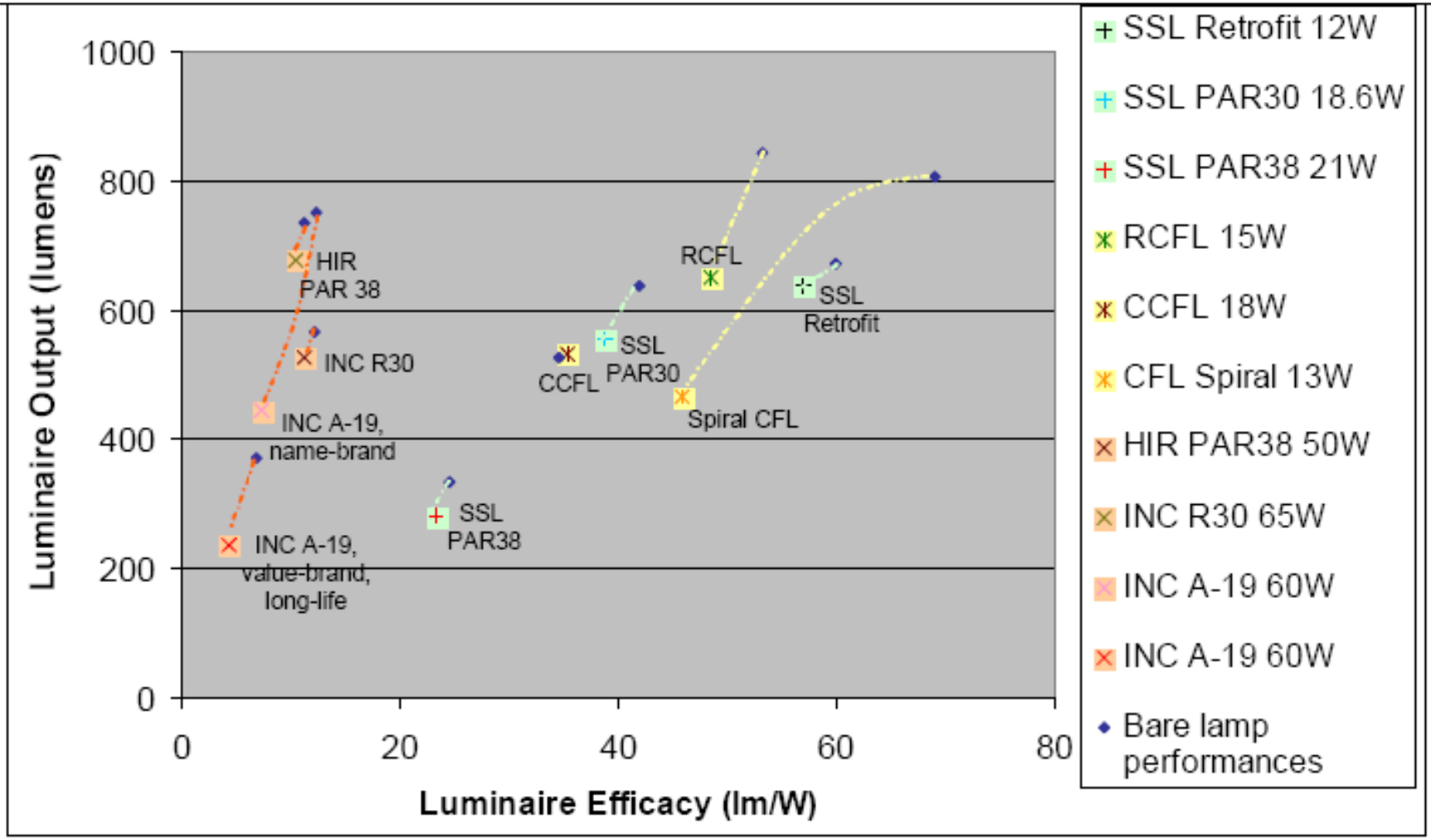


Comparative *in situ* testing

- Bare lamp test
- IC test in UL 1598
- Measure difference in output and efficacy




SSL
SSL
SSL
RCFL
CCFL
CFL
HIR
R-INC
INC


Luminaire Output (lumens)
1000
800
600
400
200
0
0
20
40
60
80
Luminaire Efficacy (lm/W)
HIR PAR 38
INC R30
INC A-19, name-brand
INC A-19, value-brand, long-life
SSL PAR38
CCFL
SSL PAR30
RCFL
Spiral CFL
SSL Retrofit
SSL Retrofit 12W
SSL PAR30 18.6W
SSL PAR38 21W
RCFL 15W
CCFL 18W
CFL Spiral 13W
HIR PAR38 50W
INC R30 65W
INC A-19 60W
INC A-19 60W
Bare lamp performances

Current status – recessed downlights

- One commercially-available product exceeds CFL efficacy and has light output and color comparable to incandescent
- One PAR-30 replacement comparable to R-CFL in output and efficacy
- Improvements in other products expected shortly

What to look for – recessed downlights

- Luminaire photometry – LM-79-08
- Luminaire efficacy min 35 lm/W
- Light output minimum
  - 575 lumens for greater than 4.5” diameter
  - 345 lumens for 4.5” diameter or less
- CCT 3500K or lower for residential
- Check for glare
- Check for compatible dimmers

Undercabinet Lighting

Kichler

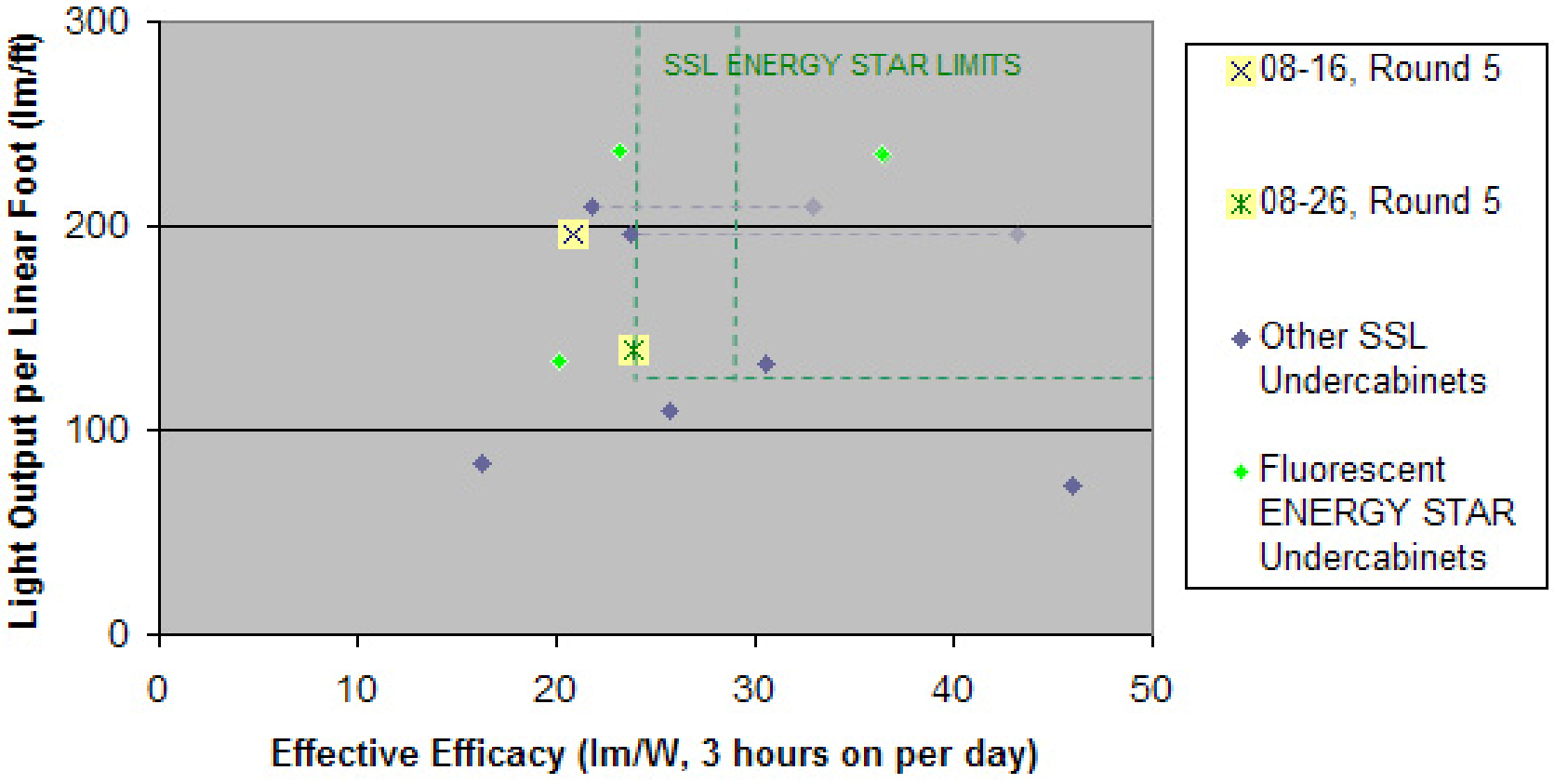
Finelite

Belfer and Osram

Undercabinet comparison

Undercabinet Product	Date Tested	Luminaire Efficacy *(lm/W)*	Linear Flux *(lm/foot)*	Color Temperature	Total Equipment Cost *($/foot)*
A – LED	02/2008	34.3	190	2926K	$65.00
B – LED	07/2007	30.5	140	2767K	*
C – LED	07/2007	34.4	225	2800K	$66.67
D – Fluorescent	09/2007	20.2	135	5730K	$37.07
E – Fluorescent **	11/2007	23.2	243	3865K	$21.97
F – Halogen	†	7	230	3000K	$33.26

Figure 6. Undercabinet Performance Based on Effective Efficacy



Current status – undercabinet

- Several products with light output and luminaire efficacy meeting ENERGY STAR SSL requirements
- Price per linear foot about twice conventional

What to look for – undercabinet

- Luminaire photometry – LM-79-08
- Luminaire efficacy min
  - 24 lm/W for residential
  - 29 lm/W for commercial
- Min light output: 125 lumens per linear foot
- CCT 3500K or lower for residential
- Check for shadowing
- Check for off-state power

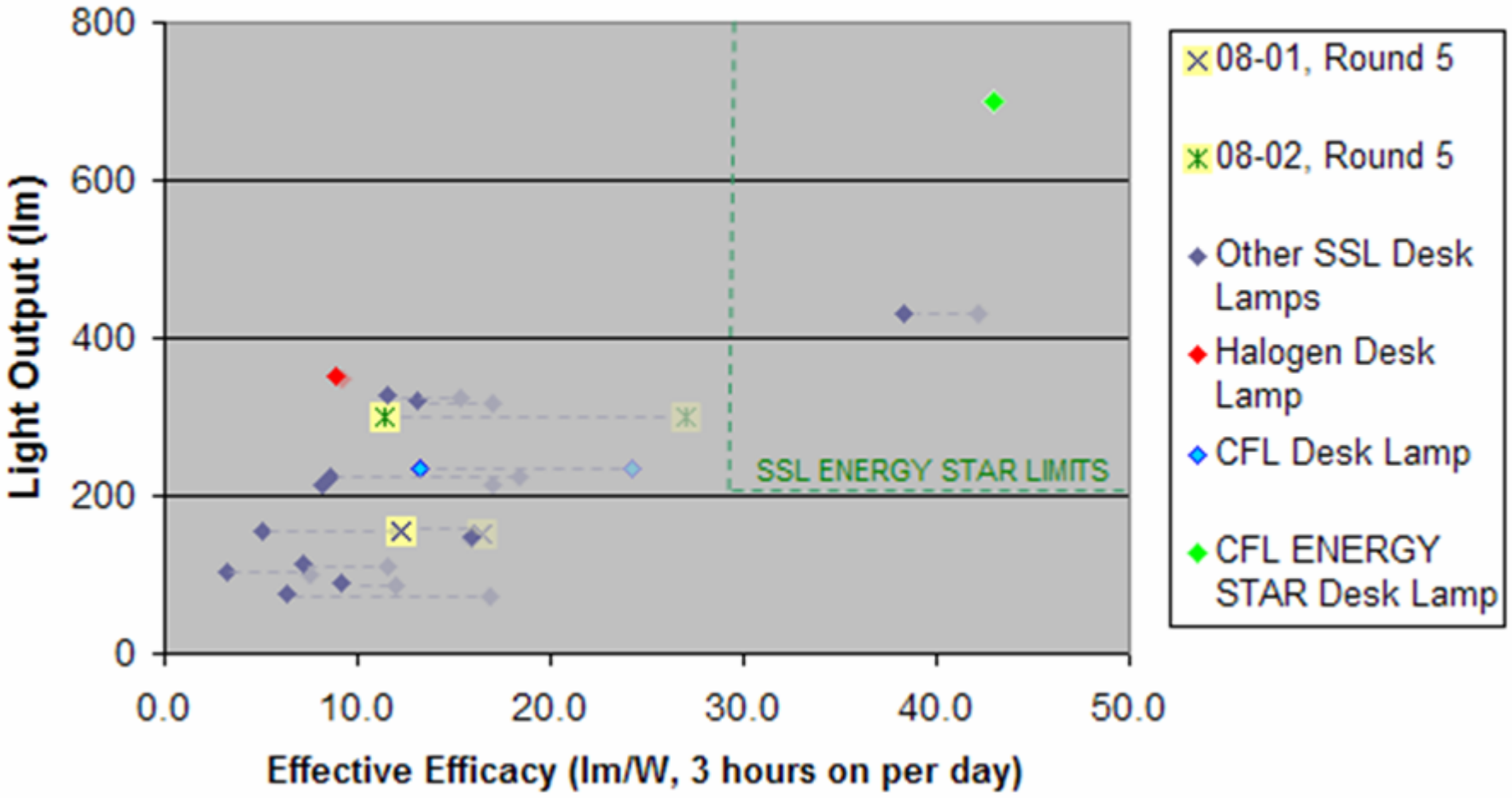
Portable Desk/Task Lights

Finelite

Koncept

Steelcase

Figure 5. Desk Lamp Performance Based on Effective Efficacy



Current status – portable desk/task

- Several products with light output and luminaire efficacy meeting ENERGY STAR SSL requirements
- Off-state power is often an issue
- Prices typical for high-end desk lights

What to look for – portable desk/task

- Luminaire photometry – LM-79-08
- Luminaire efficacy min: 29 lm/W
- Min light output: 200 lumens
- Check color quality
- Check for shadowing
- Check for light distribution
- Check for off-state power

Outdoor Area Lighting

GE Lighting Systems

Beta LED

Philips Lighting

LED compared to HID outdoor area lights

Examples of Outdoor Area Luminaire Photometric Values			
	150W HPS	**175W MH**	**LED**
Luminaire (system) watts	183W	208W	153W
CCT	2000 K	4000 K	6000 K
CRI	22	65	75
Rated lamps lumens, initial	16000	11700	n/a
Downward luminaire efficiency	70%	81%	n/a
Downward luminaire lumens, initial	11200	9477	10200
Luminaire efficacy	61 lm/W	46 lm/W	67 lm/W

Photo: Beta Lighting

FAA demonstration site

70W HPS

3-bar LED

Comparison of HPS and LED Outdoor Luminaires for FAA Demonstration Site

	Existing 70W HPS	LED 3-array Luminaire	Optional LED 2-array Luminaire
Total power draw	97W	72W	48W
Average illuminance levels	3.54 fc	3.63 fc	2.42 fc
Maximum illuminance	7.55 fc	5.09 fc	3.40 fc
Minimum illuminance*	1.25 fc	1.90 fc	1.27 fc**
Max/Min Ratio (uniformity)	6.04:1	2.68:1	2.68:1
Energy consumption per luminaire***	425 kWh/yr	311 kWh/yr	210 kWh/yr
Energy savings per luminaire	--	114 kWh/yr **(26.8%)**	215 kWh/yr **(50.6%)**

Current status – outdoor area

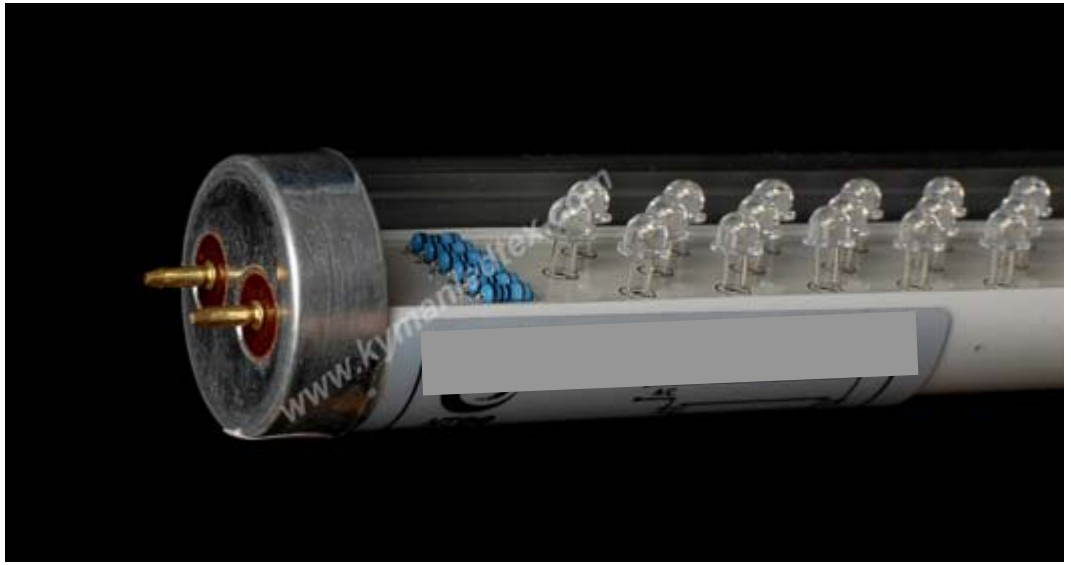
- Several high-quality products available on the market
- Additional promising products from well-respected manufacturers coming soon
- Excellent potential for energy savings
- Potential for improved uniformity through good optical control of LEDs

What to look for – outdoor area

- Luminaire photometry – LM-79-08
- Compare luminaire efficacy to HID alternatives
- Compare luminous intensity distributions and uniformity
- Check for glare
- Check for uplight, light trespass

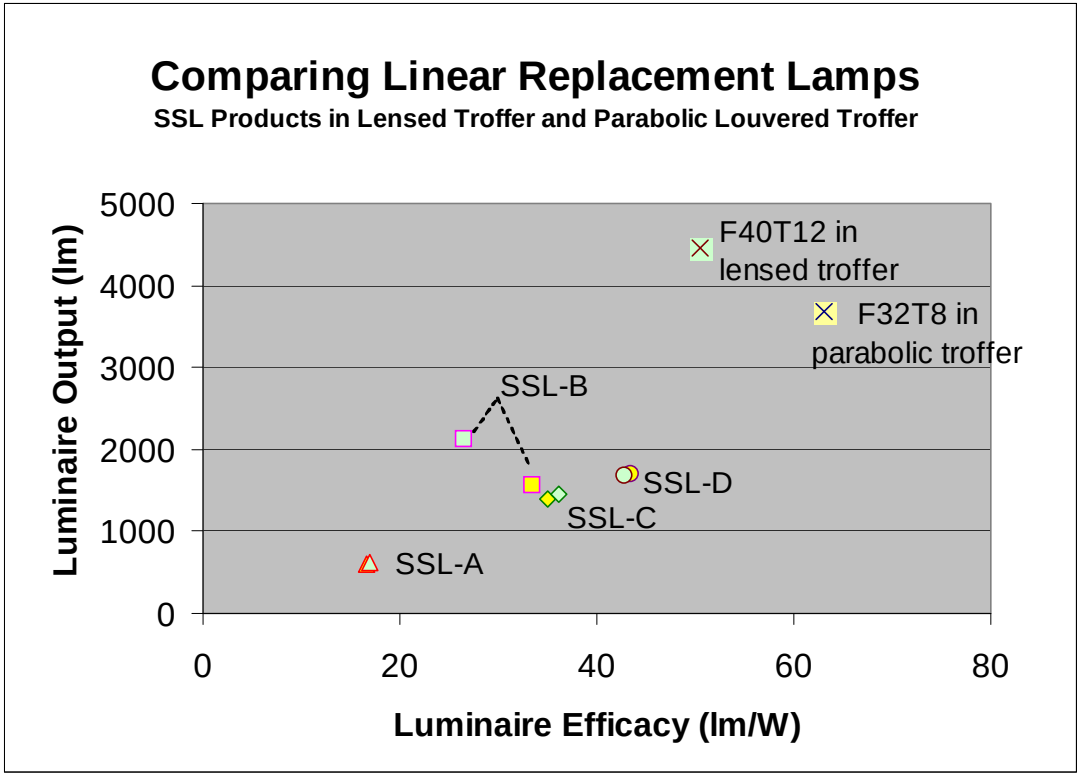
For more information: SSL Demonstrations session Thurs, 8:45 am

What about T8 replacements?



CALiPER-tested LED T-8s

- Four LED products were tested in typical housings and compared to fluorescent T8 and T12 lamps
- These LED products do not produce the lumen output or achieve the efficacy levels of the linear fluorescent lamps they claim to replace



Learn more about DOE CALiPER Testing from the Round 5 Summary Report
http://www.netl.doe.gov/ssl/comm_testing.htm

High-performance linear fluorescent is hard to beat

- 100 lm/W lamp-ballast efficacy
- 40,000 hour rated life on electronic programmed-start ballast
- 95% lumen maintenance
- 85 CRI
- Lamp cost ~$4.00

Example: Philips F32T8 TL830 XXL ALTO

Where to use LED products now

- Where they can take advantage of unique attributes
  - Directionality
  - Small size
  - Cold temp performance
  - Improved efficiency from superior optical control
- Outdoor area lighting
- Downlighting
- Task lighting
- Display lighting, including refrigerated
- Cove lighting

What's coming next?

- As efficacy and output increase, LEDs will become effective in other product types and applications
- LED lamp replacements - L Prize:
  - 60W A19, 900 lumens, 90 lm/W
  - PAR-38, 1350 lumens, 123 lm/W

Questions?

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