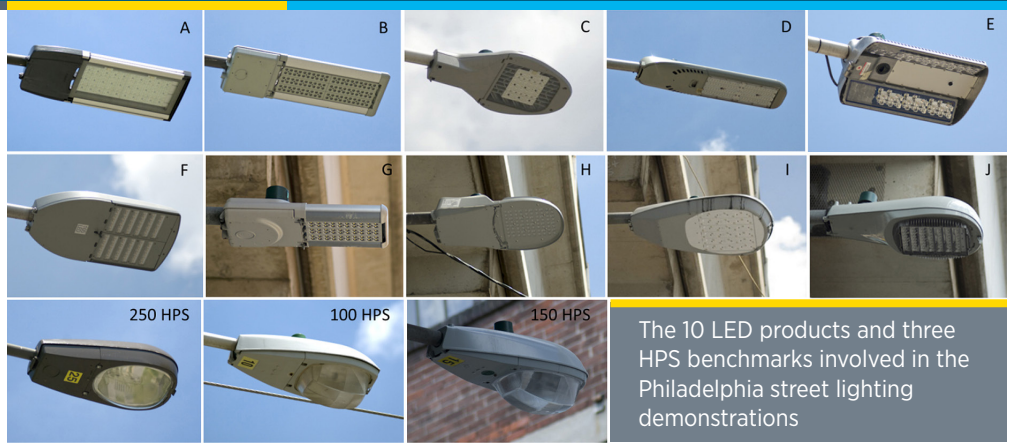
SSL DEMONSTRATION:

Roadway Lighting, Philadelphia

The economic value of energy savings is determined by many variables and, by itself, can't always justify a conversion to LEDs. But other factors, such as reduced maintenance and steadily decreasing prices, can shorten the payback and make SSL cost competitive.



The 10 LED products and three HPS benchmarks involved in the Philadelphia street lighting demonstrations

Many people consider Philadelphia to be the birthplace of street lighting in the U.S., harking back to improvements Benjamin Franklin made to the troublesome candle-based luminaires that were used to light the streets back in his day. Nowadays, the typical street lighting in Philadelphia—home to roughly 100,000 streetlights and 18,000 alley lights—uses high-pressure sodium (HPS) lamps and cobrahead-style luminaires, with nominal input power of the lamps ranging from 100W to 400W. For several years now, the city has investigated alternatives to HPS street lighting, with a specific focus on solid-state lighting (SSL) products.

In early 2011, Philadelphia initiated a street lighting demonstration project to evaluate LED products for future widespread adoption. The demonstration was conducted by Pacific Northwest National Laboratory for the U.S. Department of Energy (DOE), in conjunction with the City of Philadelphia, and was supported by two DOE programs: the GATEWAY SSL Technology Demonstration Program and the Municipal Solid-State Street Lighting Consortium.

Ten different LED luminaires were installed across three demonstration sites within Philadelphia. The sites each represented a different set of conditions, particularly with regard to the incumbent HPS luminaires, which were nominally 100W, 150W, and 250W. The performance of each product was evaluated based on manufacturer data, illuminance calculations, field measurements of illuminance, and the subjective impressions of local residents and a group of Illuminating Engineering Society (IES) and International Association of Lighting Designers members who toured the sites.

Sample table of results from one of the installation locations (Kensington Avenue)
(calculations based on 55-foot pole spacing)

	Luminaire Type				
	150 HPS	LED G	LED H	LED I	LED J
Manufacturer Rated Values					
Input Power (W)	173	132	132	154	105
Output (lm)*	11,741	9,628	10,772	10,396	5,781
Luminous Efficacy (lm/W)	68	73	82	68	55
Calculated Average Initial Illuminance (fc)					
Auto Lanes	3.16	3.98	4.39	4.60	3.81
Bicycle Lanes	5.12	5.23	4.17	4.32	4.06
Sidewalks	4.85	4.34	4.15	2.83	1.16
Drive Lane Performance					
Delivered Lumens	3,592	4,524	4,990	5,229	4,331
Delivery Efficiency	15%	23%	23%	25%	37%
Application Efficacy (lm/W)	10.4	17.1	18.9	17.0	20.6
Full Area Performance					
Delivered Lumens	8,342	8,970	8,990	8,403	6,324
Delivery Efficiency	36%	47%	42%	40%	55%
Application Efficacy (lm/W)	24.1	34.0	34.1	27.3	30.1

* Listed output is for one luminaire. Due to the luminaire configuration on Kensington Avenue, each calculated area receives contributions from the equivalent of two luminaires (i.e., half of each of the four luminaires bounding an area).

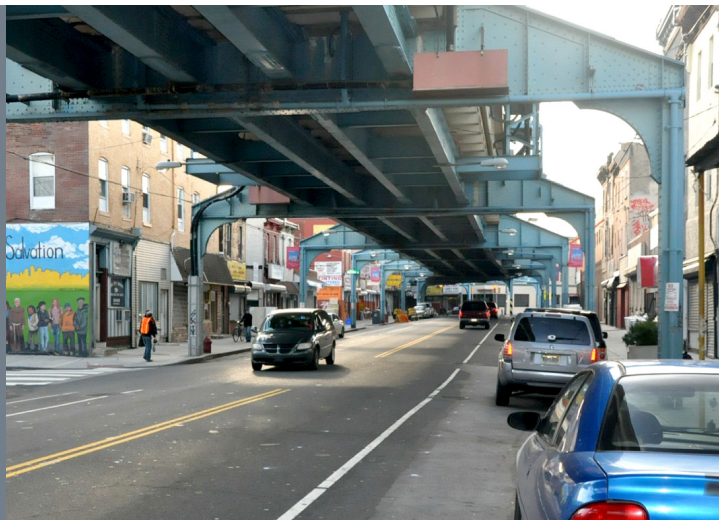
Putting SSL to the Test

All of the LED luminaires in the study were found to have higher application efficacies than their HPS counterparts; that is, they delivered more lumens to the target areas (roadway and sidewalk) per watt of input power. They also drew between 10 percent and 40 percent less power, and generally provided more uniform illumination. Most, but not all, of the LED luminaires had a higher-rated luminous efficacy compared to the HPS products they were replacing. All of the LED luminaires had improved color rendering and a higher correlated color temperature.

Field illuminance measurements were taken at each site, but the large difference in pole spacing for each area limited the usefulness of that dataset for comparing performance. However, it did reveal differences of as much as 40 percent between measured and calculated illuminance. Similarly, the HPS luminaires were found to be more likely to provide lower illuminance than predicted by calculations, presumably due in part to non-recoverable component degradation.

In order to compare luminaire performance, supplemental calculations were performed using a single representative model of each of the three sites. These calculations showed that the delivered illuminance from the LED luminaires was generally similar to that of the baseline HPS luminaires. Two of the three HPS luminaires and seven of the 10 LED luminaires were predicted not to meet at least one of the maintained-illuminance design criteria, but it's important to note that the LED systems were designed with the intent of providing performance similar to the HPS luminaires, rather than of meeting illuminance criteria, and that better alignment with American Association of State Highway and Transportation Officials or IES recommendations during the changeover to LED streetlights could provide additional energy and cost savings.

Vibration from this elevated rail track in Philadelphia caused premature failure of incumbent HPS streetlights.



Not-So-Good Vibrations

Of special concern was the fact that the luminaires along one of the city's major streets had been experiencing premature failure from high vibration, due to their being mounted on an overhead rail track, so the city was interested in a more robust product that might reduce maintenance expenditures from frequent relamping. Some HPS lamps were reportedly failing just months after installation, due to vibration levels that were measured at up to 274 mm/s and 25.4 g. None of the LED luminaires failed within the first four months, although numerous photocontrols had to be replaced.

As for the subjective evaluations, in general there were only small deviations between the luminaires, which prevented identification of any products that were clearly superior to the others in the same category. Nonetheless, both local residents and the lighting professionals generally viewed the LED lighting favorably, especially compared to the HPS luminaires.

Conclusions

Energy cost savings from switching to LED street lighting were not possible for Philadelphia at the time of the demonstration, because the city hadn't reached an agreement with the local utility for a new tariff for LED street lighting—a situation that's common throughout the U.S. Even with such a tariff in place, energy savings alone were unlikely to result in a reasonable payback period in Philadelphia, using products and pricing that were current at the time the study was conducted. But additional cost savings from reduced maintenance could be a deciding factor and make widespread luminaire replacement cost effective. And with efficacy improving and prices declining, the payback situation is changing rapidly.

Final reports on GATEWAY demonstration projects are available for download at ssl.energy.gov/gatewaydemos_results.html.

GATEWAY Demonstrations

GATEWAY demonstrations showcase high-performance LED products for general illumination in commercial, municipal, and residential applications. Demonstrations yield real-world experience and data on the performance and cost effectiveness of lighting solutions. For more information, see ssl.energy.gov/gatewaydemos.html.

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