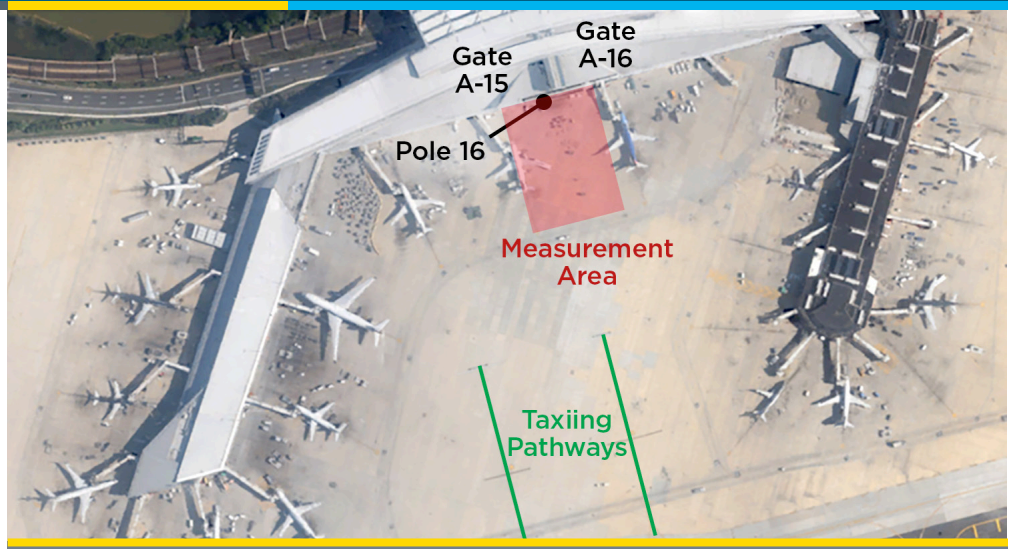
SSL EVALUATION:

Philadelphia International Airport Apron Lighting

GATEWAY puts solid-state lighting to the test in a setting that's challenging economically as well as photometrically.



Aerial view of PHL Terminal A, where the trial LED installation took place in the apron area immediately in front of pole 16. Note the marked taxiing pathways that have direct views of the luminaires in the study area as the pilots move their aircraft towards the gates.
Photo Source: Google Maps

While the adoption of LED lighting has been accelerating rapidly in many exterior applications, there are a few where LED luminaires have not yet shown they can match the photometric and economic performance of incumbent high-intensity discharge (HID) systems. One such example involves high-mast lighting—area lighting with a mounting height of 65' and higher. This type of application generally requires light-output levels that exceed those of most LED luminaires currently available for exterior applications, and the high drive currents often used in higher-output LED luminaires can reduce luminaire efficacy, due in part to thermal effects related to the higher drive current.

An Especially Challenging Application

To learn more about the performance of LED high-mast lighting, the U.S. Department of Energy's GATEWAY program documented a trial installation of LED apron lighting at Philadelphia International Airport (PHL). Apron lighting is critical to airport operations, because it provides task lighting for baggage loading and offloading in the aircraft belly, tow tractor hookup, fueling operations, preflight check by the pilots, and minor maintenance at the gate. This poses an especially difficult lighting challenge, not only because high light levels are required, but also because—unlike in other large-area lighting applications, where light poles can be placed throughout the area—luminaire locations are limited to one side of perimeter zones, and long throws are needed to provide the light required for visual tasks that extend the entire length of aircraft that are parked at airport gates. Consequently, luminaires with very high lumen packages and good optical control are required.

In the summer of 2013, PHL staff, with assistance from GATEWAY, began examining ways to reduce the energy consumption of the airport's apron lighting, while also reducing maintenance and light pollution and increasing safety. To minimize the complexity and cost of installing the new lighting system, PHL chose to replace the existing high-pressure sodium (HPS) luminaires on a one-for-one basis. After reviewing many alternative products and approaches, PHL selected an LED luminaire for a trial installation in the apron area at one of the airport's seven terminals. An evaluation of an initial trial installation of three luminaires (Trial 1), conducted in October 2014, led to recommended improvements in the system design and evaluation procedures. Consequently, a second trial installation (Trial 2) was evaluated in May 2015.

Illuminance Matters

The actual energy savings realized by a full implementation of LED luminaires was calculated to fall somewhere between 24.5% and 51.5%, depending on the mix of high- and medium-output LED luminaires installed. Although the average illuminance measured for the Trial 1 LED system exceeded that of the HPS system, the measured data showed that the illuminance distribution of the LED system wasn't acceptable, with many measurement points having lower illuminance than the HPS system produced. This finding reinforces the limitations of using the average illuminance to characterize complex distributions.

Trial 2 demonstrated that the LED solution provided higher illuminances than the incumbent HPS system throughout the key task area from 45' to 180' from the terminal building, which encompasses the work areas for baggage handlers and other grounds crew members for the various plane sizes that arrive at and depart from PHL. In fact, from 60' to 135' the illuminances produced by the LED system were more than 100% higher than those from the HPS system, even with two of the five LED luminaires

Terminal	No. of Luminaires	Annual Energy Use (kWh)		
		HPS (1100 W)	High-Output LED (831 W)	Med-Output LED (533 W)
A	106	477,938	361,060	231,582
B	37	166,827	126,030	80,835
C	32	144,283	108,999	69,912
D	48	216,425	163,499	104,868
E	69	311,110	235,030	150,747
F	98	441,867	333,810	214,105
TOTAL	**390**	**1,758,450**	**1,328,428**	**852,049**

Annual energy use for apron lighting system at PHL, assuming dusk-to-dawn operation (11.2 hours per day on average). Luminaire power-draw values are from photometric test reports and include ballast/driver power.

functioning at less than their full output. This demonstrates the potential for greater energy savings with medium-output LED luminaires for the majority of gates with smaller apron areas, rather than the high-output luminaires used in the Trial 2 installation.

At most throw distances beyond 195', the LED system produced lower illuminances than did the HPS system. While the luminaires that were functioning at less than full output during the trial are expected to contribute additional illuminance to these points, it's unlikely that even a fully functioning LED system would equal or exceed the HPS system at all of the grid points with these longer throws. Since there are few if any demanding visual tasks occurring at these throw distances, the illuminances provided are expected to be considered acceptable by PHL. One possible exception is that for gate areas where longer planes are expected, using high-output LED luminaires may be necessary to ensure adequate illuminances along the entire length of the plane.

No Established Guidelines

Part of the difficulty in assessing the adequacy of the illuminances throughout the evaluation area comes from the lack of any established design criteria for the apron areas at airports, since the Illuminating Engineering Society of North America (IES) withdrew its relevant Recommended Practice, RP-14. Until new guidance is provided by the Federal Aviation Administration or the IES, airport facility managers and designers must rely on past guidance and their own experiences in establishing lighting-performance criteria for airport aprons.

The PHL trial evaluations show opportunities for lighting-system optimization that could produce substantial additional savings in energy use by leveraging inherent advantages of LEDs. LEDs offer the possibility of optimizing the distribution of light to address specific task needs, with lower illuminances throughout much of the apron and higher illuminances only where necessary to address visual task needs. In addition, the inherent dimmability of LEDs provides opportunities for reducing the illuminances in the areas around certain gates where no activity is scheduled, resulting in not only deeper energy savings but also a reduction in any contributions from the apron lighting system to light pollution. Although it wasn't considered at PHL, an apron lighting control system with some combination of motion detection, time scheduling, and manual override capability could provide substantial benefits in these areas.

Lessons Learned

Among the lessons learned from this project that may help facility managers and LED product manufacturers better meet the challenges:

- **Need to establish clear design criteria and constraints for the LED project.** The only way to fairly evaluate the large number of options available for a large-scale LED project is to establish some clear criteria at the outset.
- **Importance of trial installations and mockups.** While detailed computer analyses can help to assess illuminances in different areas of an application, they cannot replace the experience of viewing a trial installation under realistic conditions.
- **Careful review of calculations of photometric quantities.** The PHL staff received many inquiries from a number of luminaire manufacturers and sales agencies, who often provided computer analyses that failed to accurately reflect the system requirements.

Final reports on GATEWAY outdoor demonstration projects are available for download at http://energy.gov/eere/ssl/gateway-demonstration-outdoor-projects.

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 **http://energy.gov/eere/ssl/gateway-demonstrations**.

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