LED Lighting

A. LED vs. HPS Lighting

The predominant light source type for city street lighting has been high pressure sodium (HPS) for many years. In fact, HPS type street lighting has been mandated by Iowa Code (with some exceptions) since 1989 as the first choice standard for energy efficient street lighting. Other light source types were allowed to be used if they were shown to have equal or better energy efficiency than HPS.

Prior to the fall of 2010, the efficiency comparison test was based on bare lamp efficacy defined by the Code as lamp output lumens divided by lamp input watts. This efficiency definition did not take into account ballast energy losses or the luminaire's optical efficiency. The only possible practical choices for street lighting luminaires during this time were high intensity discharge (HID) type light sources (high pressure sodium, metal halide, mercury vapor). Since these luminaire types are constructed and essentially produce and control light the same way, the bare lamp efficacy test produced an apples-to-apples comparison. Of these, HPS always had the highest lamp efficacy and by Code is the only source allowed.

Not all of the light produced by the lamp exits the luminaire. HID luminaires generally are about 70% to 85% efficient at allowing the light produced by the lamp out of the luminaire. Also, not all of the light emanating from the luminaire illuminates the desired subject. A significant quantity of the light produced lands directly below the luminaire creating a "hot spot" resulting in excess illumination and wasted light. Also depending on the optics of the luminaire, some of the light is directed above 90 degrees from nadir, which results in fugitive light and undesirably brightens the sky at night.

With the advent of LED lighting, this lighting source type has challenged HPS as the most efficient. However, LED lighting was not immediately recognized as more efficient because LED luminaire efficacy is measured differently, and because of the method of comparison defined in the Iowa Code, LED luminaires were not legal to use for city street lighting. As a result, the Iowa Code was modified to allow their use if it can be shown that they are more energy efficient than HPS fixtures; see Section 11A-1, C. This process involves the regulated street lighting utility obtaining approval from the Iowa Utilities Board. This approval process does not apply for city owned street lights.

LED luminaires are constructed and deliver light differently than HID luminaires. A typical HID street lighting luminaire consists of a single lamp light source surrounded by an optical reflector and optical lens refractor to bounce and/or bend the light from the lamp and direct it onto the street as evenly as possible. The lamp is not necessarily manufactured by the luminaire manufacturer, but the lamp sizes and wattages are standardized throughout the industry. The lamp efficacy of a 250W HPS from one manufacturer is very nearly the same as that from another manufacturer. The same is true for the efficiency of the ballasts.

LED luminaires are constructed using many individual LED lamps assembled into an array and are energized by an on-board power supply commonly called a driver. Luminaires may contain as few as ten or as many as 100 or more LEDs depending on the intended function of the luminaire. The LEDs are typically individually aimed to produce the desired overall illumination pattern. Therefore, the optical control of the light from an LED luminaire is much more precise. For a street lighting application, more lamps are aimed longitudinally up and down the street and less directly below the luminaire. This results in much greater illumination uniformity on the street with less light production as compared to HPS luminaires. It significantly reduces the wasteful "hot spot" directly below the luminaire. The optical efficiency of LED luminaires is about 90% to 95% compared to the 70% to 85% stated above for HID luminaires.

Since the LEDs and the luminaire are an integral assembly, the concept of bare lamp lumens and lamp lumen efficacy is much less meaningful for LED lights. Instead, the lighting industry has chosen absolute lumens as the accepted measure of light output. The parameter of absolute lumens is defined as the measure of the total luminous flux emanating from a luminaire assembly (using any light source, not just LED). This measurement therefore takes into account both the light source and the luminaire assembly efficiency and gives you the total useable light output. It does not describe which way the light is going or whether the light intensity is concentrated in a particular direction or evenly distributed. Dividing the absolute lumens value by the luminaire assembly total input watts gives the luminaire efficacy rating. This is a much more accurate description of the overall efficiency of a luminaire and its ability to convert electrical power into useable light, and takes into account all of the parasitic losses inherent in a luminaire assembly (lamp power-to-light conversion, ballast or driver efficiency, and luminaire optical efficiency).

The ultimate comparison between luminaires is found in their application to a given task and the ability to produce the target illumination (footcandles) and uniformity using the least amount of energy for the application. Currently HPS luminaires still have higher efficacy ratings than do LED luminaires. However, since LED luminaires possess superior optical light control and produce less waste light, street lighting applications using LED lighting typically consume less energy compared to using HPS lighting.

The parameter more popularly being used to compare overall application is watts per average delivered footcandles of illumination. For a given project area, divide the total power draw in watts for the project area by the calculated average footcandles of illumination. This is a better method of comparing the energy efficiency of different lighting systems based on the delivered illumination on a surface rather than just the production of light.

B. LED Lighting Advantages

Besides reduction in energy consumption, there are other advantages to using LED lighting over HPS.

1. Compared to HPS luminaires with the same photometric classification, the application of LED luminaires to achieve a given set of illumination criteria may result in one or more of the following:
   - Better uniformity ratio at the target average illumination level
   - Lower mounting heights resulting in less costly lighting structures
   - Greater spacing between luminaires resulting fewer lighting structures and luminaires

2. The light produced by LEDs is whiter and provides significantly better color rendering of objects. There are studies demonstrating that whiter light improves the visual ability of the human eye. There are discussions among the lighting professionals that lower illumination levels may be acceptable and provide equal visibility using the whiter light of LEDs (or metal halide) as compared to the more yellow light of HPS.

3. The rated service life of LED lighting is projected to be from 50,000 to as much as 100,000 burn-time hours, which is considerably longer than HPS or other lighting types. HPS lighting sources typically have a rated service life of 24,000 burn-time hours. This would significantly reduce street light maintenance costs.

4. The components of LED solid state lighting are recyclable and contain less toxic heavy metal elements.

5. LED luminaires are dimmable. For example, this would allow a street lighting installation serving a business district to illuminate the street at a higher illumination level during evening business hours and dim to a lower allowed minimum illumination level after business hours, which would conserve energy.

6. LED luminaires are instant-on. This feature lends them to the use of occupancy or motion sensor controls to save energy. While this may not be practical for street lighting applications, it could have potential use in parking lot applications.

C. LED Lighting Disadvantages

1. Currently LED luminaires cost more than HPS luminaires.

2. LEDs themselves do not tolerate heat and need to be kept cool during operation. However, luminaire assemblies with good thermal management design can sufficiently control diode junction temperature making LED lighting a practical choice. This issue is partially mitigated by the lower ambient temperature conditions of nighttime operation.

3. Since LED luminaire wattages are not standardized, they do not readily fit into electric utility tariff rate programs and have not been incorporated into utility-owned street lighting stock.