

**Sandro Rocco, Thomas Grainge, Daniel Ekvovich**

sandro.rocco@niagaraphotonics.com, thomasgrainge@gmail.com, devkovich1@students.niagaracollege.ca

## Introduction

High-pressure sodium (HPS) lamps are currently the standard bulbs used for street and pathway lighting. The goal of energy efficiency, along with the high cost of lamp replacement, is the reason why a new lamp technology is being pursued.

The research encompassing this project investigates Light-Emitting Diode (LED) lamps as a replacement street lighting luminaire. The focus of this research is to conduct an analysis of all relevant aspects of both HPS and LED lighting techniques in collaboration with the City of Welland, which has been pioneering adoption of LED street illumination in Southern Ontario.

The HPS lamp is a gas discharge lamp that uses a sodium-mercury amalgam at high pressure to produce a high intensity, orange-hued light. In comparison, the LED lamp is a solid-state light source utilizing multiple LEDs to emit "white" light. The current LED lamp intensity is noticeably lower than the HPS lamp; however, the technology is advancing very quickly. LED luminaires currently being used have shown significant energy savings as well as boasting average lifetimes of more than double that of the average HPS lamp.

## Aim

The goal of this project is to analyze and present comparative results of LED and HPS street lighting technologies. A comparison of these street lighting technologies is yielding results that may lead to a change in lighting standards used as well as reductions in municipal energy use and cost.

This research encompasses analysis of both the electrical and lighting properties of each luminaire. The analysis of each source is divided into three segments:

- 1) The controlled testing of the electrical and illumination properties of each donated luminaire.
- 2) The on-site analysis of illumination properties from active luminaires.
- 3) The digital simulation analysis and comparison of newly proposed LED luminaire technology and the digital analysis of current luminaire technology being used in the City of Welland.

The results of these processes allow the group to compare each of the sources objectively. The conclusions from this project will help in the restructuring of street lighting in Ontario.

## Method

### Controlled Lab Testing

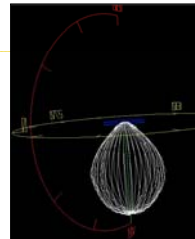
- Power Consumption: the current draw of the light source multiplied by the voltage source resulting in the used power (in watts)
- Initiation: the required time for a light source to reach operational power draw and lux output
- Illuminance: the measurement of the light intensity in lumens per unit area, known as a lux
- Spectral Analysis: the measurement of relative intensity per wavelength of a light source; essentially, the overall colour spectrum of the source
- Beam Profiling: the three-dimensional modelling of the illuminance of a light source such that it can be rendered digitally

### On-Site Analysis

- Illuminance measurements of active light sources utilized in the City of Welland

### Digital Simulation

- Analysis of digital luminaire profiles from new and current HPS and LED technologies



Above: The digital analysis of luminaire beam profiles is done through the AGL32 and Photometric Toolbox software programs.



Above: The beam profile is being measured using a custom designed profiler pictured above in its initial construction. The profiler is capable of rotation through three-dimensions to produce a full digital render of a luminaire.



Left: On site measurements using a light meter to measure lux as a function of angular separation from the luminous maxima. Measurements were taken at 2 a.m. in Welland on March 3<sup>rd</sup>, 2010. GIS was used to measure and mark the area covered by the luminaire.

## Results

The data gathered during this research is based primarily on the street light sources currently being used by the City of Welland. The provided luminaires consisted of a standard HPS bulb and fixture, an LED fixture with four columns of nine high-power LEDs and an LED fixture with four columns of six high-power LEDs.

The results from the power consumption and initiation test showed:

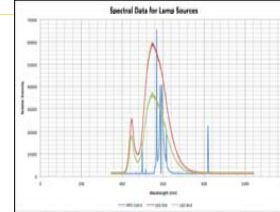
- The HPS lamp uses more than double the amount of current used by LED fixtures. Since the voltage applied to each luminaire remained constant, the current usage is analogous with the power consumption of the luminaires.
- The LED fixtures take less than a minute to reach operating conditions; in comparison, the HPS fixture takes approximately four minutes to reach operating conditions.

The relative lux (light intensity) measurements were taken during these tests and field tests to compare the intensity and stabilization times of the luminaire.

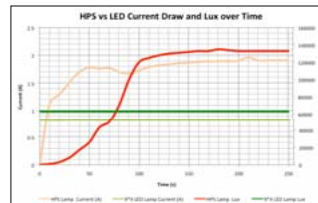
The spectral data taken in the lab, using a fibre link to an Ocean Optics Spectrometer, showed that:

- The two LED lamps have a peak output at approximately 550 nm (or green, which the human eye is most sensitive to) with a smooth taper on either side, resulting in excellent colour reproduction.
- The HPS lamp has a peak output closer to 600 nm (orange) with a very jagged spectrum and provides poor colour reproduction. The HPS lamps are more intense than the LED fixtures utilized currently.

The illuminated area covered by the light fixture was measured in the field test. The area measured was from the centre or brightest point on the street, to the perimeter where only 10% of the light intensity remained. The HPS lamp has a wider area of coverage than the LED lamps currently in use.



Above: A graph of relative intensity per wavelength for each light source donated by the City of Welland. Intensity of HPS is scaled down to reduce graph size. For use in spectrum comparison only.



Above: Comparison of relative light output and current draw of both the LED and HPS fixture over time.

Above: Data points taken in Welland to determine the spread of light from an HPS fixture and an LED fixture.

## Summary of Light Sources

	High Pressure Sodium (HPS) Standard Cobra Head	Light-Emitting Diode (LED) 6x4 used on Fitch Street
<b>Power Consumption (Watts)</b>	234.179	85.034
<b>Lifetime (Hours)</b>	25 000	50 000+
<b>Illuminance - at Street Level (Lux)</b>	24.58	21.66
<b>Approximate Area Covered (m<sup>2</sup>)</b>	823.50	410.54
<b>Colour Rendering Index (Scale from 1 to 100 where 100 is pure white)</b>	Less than 30	Greater than 80

## Conclusion

The LED street light fixture is a suitable replacement for HPS fixtures. This research has shown that the current LED technology being used by the City of Welland offers a 50% reduction in energy use and cost. Research shows that these LED sources outlast the average HPS light fixture with more than double the lifetime. The higher colour temperature, or "whiter" appearance, of the LED fixtures provides better colour distinction of objects on roads and sidewalks. This means pedestrians and drivers will be able to see more clearly at night, creating safer roads. With the rapid advancement of LED technology, the most modern LED fixtures compete with the HPS fixtures in coverage area. With current LED fixtures in a retrofit application, dark spots between poles will be avoided.

## Acknowledgements

Ted Ko, Alex McGlashen, Jay Yatulis, David Ferguson, The City of Welland, OCE, Natalie Tokar, Sarah Gleddie, and Chris Fernick.