Putting Research into Practice: Evaluating Initial LED Streetlights in St. Paul

What Was the Need?
In 2011, MnDOT installed 10 light-emitting diode (LED) roadway luminaires along Trunk Highway (TH) 61 in St. Paul. These lights, manufactured by Relume, were among the first LED luminaires that were suitable for roadway lighting applications. According to the manufacturer, the LED lights offered several improvements over traditional high-pressure sodium (HPS) luminaires. While they had a higher initial cost, the LED luminaires consumed 22.5 percent less energy than comparable HPS luminaires. The manufacturer also claimed the LED luminaires had an operational life span of 21 years, a significant improvement over HPS luminaires. If the reduced energy and maintenance costs were accurate, the LED luminaires would yield a positive return on investment after 6.4 years.

What Was Our Goal?
This project evaluated the performance of the LED luminaires installed on TH 61. The evaluation included measuring the consistency of the color of light and the system’s harmonics (the electrical currents produced by the luminaires that can create imbalances in the electrical system and affect how nearby equipment operates).

What Did We Implement?
This project builds upon several investigations of LED street lighting, including:

- “Field Test DELTA Snapshots: LED Street Lighting.”
- “Demonstration Assessment of Light Emitting Diode (LED) Street Lighting.”
- “Demonstration Assessment of Light-Emitting Diode (LED) Roadway, Lighting at the I-35W Bridge, Minneapolis, MN.”

Additionally, Local Road Research Board (LRRB) project 2013-04, “46th Street Pilot Street Lighting Project,” evaluated LED streetlights installed in Minneapolis.

How Did We Do It?
Twenty-two months after installation, investigators began collecting color temperature readings under each LED luminaire. Readings were taken quarterly for 24 months. Color temperature is a measure of the color of light, expressed using the Kelvin (K) temperature scale. The manufacturer’s color temperature specification for the luminaire was 6000 K, which is perceived to have a slightly blue or “cool” color. Investigators also intended to measure color temperatures under the HPS luminaires. However, their temperature was below 2300 K, the lowest level the chroma meter could measure.

To measure harmonics, investigators collected data from electrical meters for both the HPS and LED circuits, including voltage, current, watts, power factor, total harmonic distortion and individual harmonics. The meters recorded this data every 60 minutes, and investigators downloaded data sets quarterly.
What Was the Impact?
After 22 months, the LED luminaires’ average color temperature had decreased by 715 K. At the end of the study period, average color temperature had degraded by an additional 565 K. This suggests that roadway lighting levels may drop below MnDOT requirements as well.

The LED luminaires produced a different set of harmonics than the HPS system, although evaluating the impact of those differences was beyond the scope of this project. It is unclear whether that data would be relevant to the systems currently on the market.

The system experienced many operational issues. Most of the lighting system was not operational during the final third of the test period after digging damaged the underground distribution system, which also caused electrical meter data to be erratic and incomplete. On one luminaire, only half of the LED arrays operated throughout most of the test period. One pole was knocked down during a vehicle accident. Only one LED luminaire remained fully operational throughout the trial.

What’s Next?
The LED luminaires tested in this project were among the first LED streetlights available on the market. The technology has evolved substantially since then to improve performance. As a result, the failures of the lights tested should not be considered representative of LED lights in general or other products from this manufacturer. Current LED luminaires produce nearly twice as much light per watt of power consumed as lights from 2011.

Modern lighting specifications have also shifted. Many agencies specify a color temperature of 4000 K or even 3000 K, which is typically less harsh and more pleasing to look at than 6000 K light. While early LED streetlights could not produce these colors without filters that reduced light output, current products can produce these colors with less loss of light.

Based on improvements to the technology, which have been verified in tests by agencies that can perform complete laboratory tests under controlled conditions, LED streetlights are now standard, and LED luminaires are specified in roadway lighting projects throughout Minnesota and the Midwest. This early test helped to build the technical familiarity with LED technology that was necessary for wider implementation.

The techniques used in this project would be useful for testing manufacturer claims as LED streetlight technology matures and the pace of product development slows.

“Relume LED luminaires produced white light and consumed 22.5 percent less energy than HPS luminaires. While the color of light degraded significantly over time in this project, advancements in LED technology since the luminaires were installed have addressed this issue.”

—Ken Taillon, Manager, Outdoor Lighting Services, SEH

“This early project kicked off the conversion to LED streetlights by giving us experience installing the new technology.”

—Susan Zarling, Traffic Engineer, MnDOT Office of Traffic, Safety and Technology

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