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Can LED Lighting Improve Roadway Safety? A study of 60 townships may offer answers

LED luminaires are now the leading choice for outdoor lighting applications, largely because their cost benefits have become relatively easy to quantify with traditional metrics such as energy savings and reduced maintenance. However, a variety of other potential benefits are harder to gauge and require longer-term evaluation through statistical means. A common challenge in such investigations is the fact that any significant change in an outcome variable may have more than one cause, so identifying the relevant factors and accurately determining their relative contributions can be very difficult.

The effect of LED street-lighting conversions on driver and pedestrian safety is one such outcome where, despite substantial interest in the topic, additional data and analysis are needed. A recent program directed by the Delaware Valley Regional Planning Commission (DVRPC) offers an interesting opportunity for Pacific Northwest National Laboratory (PNNL) to study the relationship between changes in street lighting and crash statistics in more than 60 boroughs and townships around the greater Philadelphia metropolitan region. These municipalities are participants in an LED conversion program that will enable detailed before-and-after comparisons of their crash statistics, facilitating investigations into whether any discernible change is evident following conversion.

PNNL has partnered with DVRPC and Virginia Tech Transportation Institute to carefully gather a range of relevant data from numerous sites within the converting municipalities as well as from a corresponding set of "control" municipalities. Control municipalities were selected based on strong similarities with the converting municipalities (e.g., comparable demographics, and close proximity in order to minimize differences in weather), as well as on confirmation that they have not converted to LED street lighting during the study period and do not plan to do so in the near future. The study has obtained crash statistics from at least the prior five years for every municipality and expects to follow the results for the next few years. All unrestricted (i.e., not personally identifiable) data will eventually be made publicly available for others to review or to continue analyzing with future studies of their own.

> Did crash statistics generally improve or worsen following conversion to LED?

Detailed data from investment-grade audits that provide information on all the installed streetlights in each participating municipality are available, and DVRPC is well-versed in crash analyses using Pennsylvania Department of Transportation crash databases. Additional details of the DVRPC's Regional Streetlight Procurement Program (RSLPP) are documented elsewhere (*www.dvrpc.org/RSLPP/*), but, overall, the program is converting nearly 40,000 luminaires over its two rounds of implementation across a wide range of street-lighting applications.

While not exactly using a "cookie-cutter" approach, the installations have been designed on a relatively consistent basis compared to the incumbent systems; the first-phase effort, involving 35 municipalities, incorporated the services of a single energy service company, whereas the second phase of 26 municipalities was accomplished under a design-build contract managed by a single design consultant hired by DVRPC.

Actual crash statistics are where "the rubber meets the road," to use a convenient metaphor. Our study begins by tackling the basic question: Did crash statistics generally improve or worsen following conversion to LED? This is addressed by determining the overall change for participating municipalities pre- and post-conversion, and then subtracting any change observed for the control municipalities (thereby compensating for non-lighting influences).

However, deriving the most-useful insights requires narrowing down, to the greatest extent possible, the observed "pre" and "post" effects to include only those involving specific scenarios. In planning this study, we settled on taking an approach involving so-called "treatment-context combinations." A given "treatment" refers to a specific LED luminaire, whereas "context" refers to the incumbent luminaire being replaced, and its particular application (e.g., four-lane-by-four-lane collector intersection, or two-lane mid-block local street). Incumbent sources run the gamut here, including high-pressure sodium, mercury vapor, metal halide, CFL, induction and even incandescent! Any resulting benefits are therefore likely to reflect influences from a combination of right-sized luminaire output, improved intensity distribution and enhanced color characteristics.

Importantly, an objective review means that results cannot be predetermined. While we believe that LED street lighting can potentially improve visibility, leading to fewer crashes, we do not know which way the results will lean—or even if there will be any detectable effect. There are likely to be both positive and negative influences mixed into the results, with the overall effect determined by their relative magnitudes. For example, replacing a mercury vapor luminaire with a suitable LED luminaire could improve color rendition and uniformity but might also increase glare. Or improved visibility on a roadway might convey an impression of increased safety that in turn leads to higher average driving speeds. Our tests of statistical significance will be conservatively two-tailed, with a hypothesis of some effect (positive or negative), and a null hypothesis of no effect.

Among the issues needing consideration is determining where a given nighttime crash "began." The recorded crash location does not necessarily correspond to the location of the hazard, where it was—or potentially could have been—detected by the driver(s). Especially at higher travel speeds, the point of collision may be some distance from the points where those involved could have potentially detected the conflict and maneuvered to avoid the crash. So, for example, in a collision occurring at an intersection, did the lighting ahead of the intersection play a role, or was the lighting in the intersection more of a factor—or did both contribute?

Other challenges include accounting for speed and direction of travel and establishing whether the crash had anything to do with lighting at all. Such details are often difficult to determine for even a single incident, so the study will not be able to determine them across the expected thousands of data points. Rather, the planned approach involves tying each crash, in its recorded location, to the nearest relevant pole, using GPS coordinates, and then associating the crash with the respective treatment-context combination. With a large enough sample size, such as this study potentially offers, the vagaries of minor inaccuracies among individual crashes will presumably average out.

As always, even with the best of planning, new wrinkles can be expected. Exhibit A in that regard is the COVID-19 virus, which has affected the conversion schedule, our ability to take field measurements and traffic levels. Such changes are likely to not only affect before/after comparisons, but also the proportion of daytime versus nighttime travel. The present reality may require waiting for some semblance of "normal" to return before accurate temporal comparisons are even possible.

In the meantime, we are evaluating the before-and-after crash statistics from the 35 municipalities that participated in Round 1 of the RSLPP, to identify any detectable effects of the LED conversions. This analysis will inform future studies, including analysis of data from the remaining RSLPP municipalities.

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