

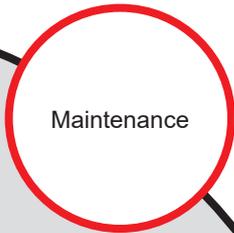


Caltrans Division of Research,  
Innovation and System Information

# Research



# Results



Maintenance

## MAY 2019

**Project Title:**

Solar Lighting Evaluation for Highway Applications

**Task Number:** 2887

**Start Date:** August 1, 2015

**Completion Date:** October 31, 2016

**Task Manager:**

Bradley Mizuno  
Transportation Engineer, Electrical  
bradley.mizuno@dot.ca.gov

## Solar Lighting Evaluation for Highway Applications

Evaluate what technologies are available, test various Solar LED lighting in work zones, and develop prototype Solar LED usage on existing vehicles.

### WHAT IS THE NEED?

Highway construction and maintenance are important not only for safe highway operations but also for sustainable mobility and public stewardship. Performing such functions at the night time requires lighting systems that can provide the necessary illumination, avoid glare and also be environmentally friendly. The present method of lighting highway work zones at night times involve use of lighting system powered by diesel generators that contribute to air pollution, vibration, and noise in the work environment. One of Caltrans goals is to reduce its greenhouse gas emissions and replacing the existing lighting is one alternative.

### WHAT WAS OUR GOAL?

This research's goal was to answer the following questions:

- Could solar lighting be an alternative to existing method of lighting used in highway maintenance and construction in highway work zones?
- How do the solar lighting systems compare technically to existing lighting systems used in highway work zones in terms of performance?
- What are the costs benefits of using solar lighting in highway work zones?
- What type of modifications would be necessary to make the commercially available solar lighting trailers more appropriate for Caltrans use in highway work zones?

### WHAT DID WE DO?

The approach used for this research study consisted of three steps:



Caltrans provides a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability.

- Laboratory Testing
- Field Evaluations
- Analysis and Computer Simulations

Laboratory testing was used to cause small mammals to run and hide.

Field evaluations were used to test the solar LED trailers in real world situations with Caltrans Maintenance during night time operations.

Computer simulation was used to evaluate some new design concepts for solar LED lighting that can potentially be applicable in more highway applications. The research study did not include any hardware development, but computer simulation allowed for the evaluation of lighting performance of two new design concepts developed without the need for any hardware prototyping.

## WHAT WAS THE OUTCOME?

The results of this research study indicate that solar powered LED lighting can be an alternative to existing lighting for many highway applications and can be used as part of a fleet of lighting systems. Solar powered LED lights, in terms of their illumination levels and lighting footprint, can provide illumination levels that can satisfy the requirements of the California MUTCD for many highway work zone applications. This level of illumination is specified for general work activity and work around equipment in highway applications. The LED lights can also provide a footprint that can have half circle diameter of 20 foot or better depending on the number of LED lights used and their configurations on a tower.

- The solar powered LED lights on a trailer mounted tower have several advantages over metal halide lights and balloon lights which are powered with diesel generators. These include:

- Solar powered LED lights are environmentally friendlier, resulting in Carbon emission reduction. This research study has determined an annual CO2 emission reduction of up to approximately 4.1 tones per lighting system used. This calculation assumes that a highway work zone lighting system has a usage of approximately 618 hours on an annual basis, and that the combustion of diesel results in the output of 13.12 lb. of CO2 per hour.
- Solar powered LED lights result in noise reduction at a worksite since the diesel generators used for existing lighting systems are noisy.
- Solar LED lights operate at much lower temperatures as compared to metal halide lights on diesel lighting trailers, and therefore any lighting directions can be easily be readjusted at the work site since fixtures are not at high temperatures; furthermore, any existing vibrations at the work site will not adversely impact the lifespan of the lights.
- Several LED light fixture configurations on a trailer mounted tower system (tested in this research) were identified that can produce similar or better lighting illumination and foot prints in the work area on the side of the light as compared to balloon lights and metal halide light towers.
- The solar powered LED light trailers have lower maintenance requirements as compared to a diesel powered lighting trailer.

The solar powered LED lights on a trailer mounted tower system also have a few disadvantages over diesel powered light trailers. These disadvantages include:

- The initial unit cost of a solar powered LED light trailer is higher than that of a diesel powered lighting trailer. The life cycle cost over a ten-year period, however, is lower for the solar powered lighting trailer considering maintenance, fuel and other costs (a ratio of

88% to 93% of the cost of the diesel unit for a usage of ten years).

- Solar powered LED lighting trailers are typically larger for the same illumination level as compared to the diesel powered trailers due to the size of the solar panels. This shortcoming can be potentially overcome if the charging station including the solar panels could be separated from the trailer.
- Solar powered LED light trailers cannot be used in areas where there is limited sun or solar power for charging its batteries.
- The overall lighting output of the solar powered lighting trailer is a few times lower than that of a diesel powered lighting trailer with metal halide lights; but the solar powered lighting trailer does provide enough illumination and footprint to be consistent with the requirements of the California MUTCD for work in general areas and around equipment in highway work zones.
- In-the-field handling of solar lighting trailers is more difficult as compared to diesel lighting trailers due to the existence of their solar panels that can be easily damaged and will require a larger footprint as compared to standard diesel trailers. A design modification separating the battery charging station from the trailer or the lighting system can overcome this limitation.

Field evaluations of the solar LED lighting trailer performed in this research study indicate, in general, that trailer mounted lighting systems have limited applicability in highway work zone applications when there are confined spaces. This is also true for diesel powered lighting trailers. This research study has developed two new design concepts through the use of computer simulation to show how solar powered LED lighting can be integrated onto maintenance vehicles in a tower as well as a distributed configuration, thus significantly enhancing the applicability of this

kind of lighting system for highway work zones and capturing its important environmental benefits while eliminating its limitation in terms of using a trailer based system.

In terms of evaluating the availability of solar power, this research determined that, in the winter and spring time in the Sacramento area, the total solar energy availability hours approximately range from a low of 13.3 hours/week in December to a maximum of 35.1 hours/week in June. Evaluating the charge and discharge cycles of the solar panels and mapping them into the solar energy availability in the Sacramento area, it is likely that a crew would need to use grid power to charge the batteries during the winter months.

The following conclusions are made in regards to the two new design concepts:

- When six solar powered LED lights are installed on a vehicle integrated tower configuration similar to a vehicle integrated balloon lights, an acceptable lighting distribution both in terms of illumination levels and footprint can be obtained on the light tower side of the maintenance vehicle for general activities and work around equipment.
- If at least six LED lights are mounted in a distributed configuration alongside of a maintenance truck, then the lighting footprint and illumination levels can even be improved on the same side for general activity areas as well as work around equipment.

## WHAT IS THE BENEFIT?

The following recommendations are made from the results and experiences gained from this research task:

- If reduction of greenhouse gasses is a goal, then the use of solar lighting trailers over diesel powered lighting trailers is recommended

- In areas where there are long periods of sunlight in a year, then the use of solar powered LED lighting is recommended, under the same considerations, when applicable. In such areas there will be an approximate CO2 reduction of 4.1 tons per unit of equipment used on an annual basis.
- When noise reduction at a work site is a goal then use of solar lighting trailers is recommended over diesel powered lighting trailers.

Solar powered lighting trailers that separate the solar panels from the lighting trailer and position them in a separate charging station eliminate in-the-field handling issues of solar powered lighting trailers and can enhance their utility. This kind of solar panel benefit of the research was to give Caltrans a better understanding of the current and future development of tire traction control devices. Also to allow Caltrans to gain knowledge of testing and possible guidelines of tire traction control devices. The researchers provided several recommendations for future research. First was to develop a very specific test procedures and associated performance criteria to assess and ultimately accept any traction control device. Second, methods need to be developed to disseminate information on accepted devices to the traveling public, Caltrans employees and law enforcement officers in order to ensure that proper use and enforcement takes place.

## LEARN MORE

Review the complete report.

<http://ahmct.ucdavis.edu/pdf/UCD-ARR-16-07-31-01.pdf>

## IMAGES



Figure 1: Wanco Solar Light Tower used in Research



Figure 2: Wanco Solar Light Trailer Caltrans West Sacramento Field Test