Specifying Solar Rectangular Rapid Flashing Beacons: Key Factors for Reliable Performance

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Rectangular Rapid Flashing Beacons (RRFBs) are becoming an important part of the toolkit and a top choice for transportation professionals looking to improve vehicle yield rates, pedestrian service levels, and multi-modal transportation access at uncontrolled, marked crossings. As demand for solar RRFBs continues to grow, it is important to consider the key factors that ensure reliable performance when specifying systems for projects and bids. Solar powered RRFBs offer a cost-effective, easy-to-install solution and provide a number of benefits to AC powered units. However, specifications sometimes focus on certain materials and size, instead of specifying how many pedestrian actuations the system must support each day (referred to as "operating capacity"). When specifying Solar Rectangular Rapid Flashing Beacons, an emphasis needs to be placed on operating capacity instead of prescribing solar panel wattage and battery size. Additionally, site-specific shading needs to be considered.

About RRFBs

Rectangular Rapid Flashing Beacons (RRFBs) are becoming a widely-recognized solution for increasing driver compliance and improving safety at crossings where existing signs and markings have been insufficient. Proven performance, as shown through research conducted by state and federal authorities, has these high-intensity crosswalk lights gaining attention. The United States Department of Transportation Federal Highway Administration (FHWA) has proven RRFBs to be an extremely effective device for driver yield compliance (between 72 and 96 percent) at uncontrolled marked crosswalks.[1] The *Manual on Uniform Traffic Control Devices* (MUTCD) interim approval for RRFBs states: "The Office of Transportation Operations has reviewed the available data and considers the RRFB to be highly successful for the applications tested (uncontrolled crosswalks). The RRFB offers significant potential safety and cost benefits because it achieves very high rates of compliance at a very low relative cost in comparison to other more restrictive devices that provide comparable results, such as full midblock signalization."[2]

Often Rectangular Rapid Flashing Beacons are only considered for midblock crossings. However, the majority of applications are at intersections with thru-lanes on the major legs. Locations often have four or five lanes and are commonly located at university and college campuses, school zones, greenways, bicycle boulevards, and trail crossings.

Benefits of Solar RRFBs

Solar powered Rectangular Rapid Flashing Beacons (RRFBs) provide a cost-effective and easy-to-install alternative to AC powered RRFBs. Installing solar powered RRFBs provides several benefits. There is no need for an overhead electrical power drop, eliminating electrical grid connections, metering, and electrical bills. Underground checks of every utility prior to installation are no longer necessary, saving time and money. Trenching is avoided because the system sends the activation wirelessly between units. Maintenance cycles and costs are minimal due to the excellent energy management system that prolongs battery life.

For solar, it is especially important to consider all performance factors when specifying RRFBs for a location. In very extreme situations, such as locations with high usage, high shading, and low solar insolation,

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[1](U.S. Department of Transportation Federal Highways Administration, Publication No. FHWA-HRT-10-043 - (*) "Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks" http://www.fhwa.dot.gov/publications/research/safety/pedbike/10046/index.cfm)

[2]FHWA Policy Memorandum Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11) http://mutcd.fhwa.dot.gov/resources/interim_approval/ia11/fhwamemo.htm

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AC powered RRFBs may be the appropriate choice. However, in typical locations solar RRFBs are very reliable.

Key Considerations to Include When Specifying Solar RRFBs

Solar RRFB specifications sometimes neglect key factors that affect system performance, focusing on solar panel wattage and battery capacity alone. This is a major concern, as systems may not be capable of sustained, year-round operation. An RRFB system with a large solar panel and battery capacity does not guarantee reliable performance. Operating capacity needs to be included in the specification to ensure the system can function reliably in a given location. When considering operating capacity, several critical metrics need to be evaluated to ensure optimal performance: the Array-to-Load Ratio, autonomy, shading, and battery life.

Array-to-Load Ratio

Energy balance is crucial to the operation of an RRFB. The Array-to-Load Ratio (ALR) compares the energy collected by the system (energy in) to the total system load (energy out). This should be calculated using peak-sun-hours (PSH) for the worst month of the year. The calculated Array-to-Load Ratio must be greater than 1:1 in order to deal with system inefficiencies and often requires a significantly higher ratio to handle extra loads. Typical loads include the number of push button activations and whether the push button has features such as locate tone and voice message and how many times the message repeats. These loads have large energy draws on the system and need to be taken into consideration when specifying RRFBs to ensure there is a sufficient energy budget to operate the system reliably. Best practice dictates that an RRFB system should have a minimum Array-to-Load Ratio of 1.2:1. If there is shading at the location, the energy in will be lower and subsequently the ALR will be reduced. By considering the ALR for each system location, appropriate products can be selected to meet performance expectations.

Autonomy

System autonomy is defined as the number of days that a solar powered system can continue to operate if all sunlight or insolation is removed. Autonomy is essentially a measure of the system's ability to operate without any charging. While it is an important metric, it is theoretical because all systems will receive some charging throughout the day, even in very cloudy conditions.

System autonomy is calculated by the system's battery capacity for a given period, divided by the total load on the system for the same period. The total system load must include the number of actuations and the flash duration in the calculation, otherwise the autonomy value will be meaningless:

Battery Capacity (Wh) divided by Total System Load (Wh) = Autonomy (days)
Wh = Watt hours

In a detailed calculation, all system loads and efficiencies, including temperature effects and the usage model, are used in conjunction with the geographical location to obtain a final value. System autonomy typically considers an average value for no-sun or "black days" as defined by NASA's meteorology department for a given location. It is very important to note that, no-sun days are based on monthly averages and as such, no-sun days are not considered consecutive events. Solar powered systems are designed to operate as if a number of consecutive no-sun days or a period of complete blackness was to occur. This approach provides an effective baseline for evaluating systems for a given location.

The autonomy value obtained through the system autonomy calculation is compared to the NASA no-sun days for the installation's geographical location. For a solar RRFB system to function effectively, best practice dictates that the calculated number for autonomy must meet or exceed the NASA no-sun days. When sizing or evaluating a solar powered system, it is important to remember that system autonomy is a safety factor and is based on the theoretical condition of a complete removal of insolation.

Shading

Shading is a major factor not currently considered in some specifications, yet it is one of the biggest variables in the operating capacity of an RRFB. Proposed installation locations should be carefully analyzed before specifying a system. Site assessments can be easily determined using tools such as Google Street View and capacity calculators, which allow manufacturers to evaluate the

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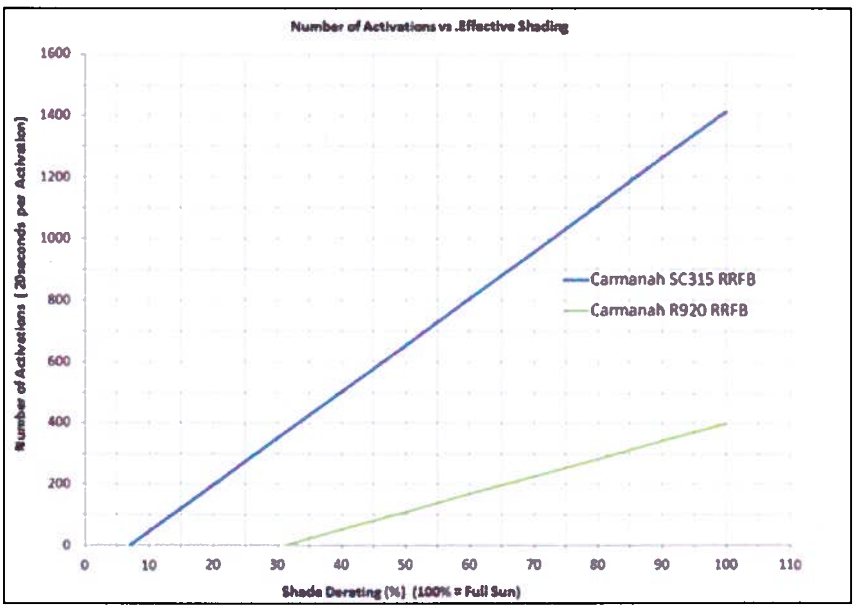

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location and determine product suitability.

Seattle, being one of the more challenging solar environments in North America, is a great example of how solar RRFBs can perform in areas of low insolation. The graph on page 22 illustrates the number of activations available for two different product models over a 24-hour period in Seattle, based on the available system capacity due to shading.

Performance, reliability, and sustainability are all major considerations for RRFBs. In order to achieve these desired factors, proper battery maintenance is important. It is true that in most cases, the bigger the battery, the more autonomy available. However, the number of activations, total system load, and amount of sunlight and shading all affect the battery's daily depth of discharge. Proper system design and specification ensures the number of days the battery returns to a full state-of-charge is maximized. To maximize battery life, systems should be designed to use typically no more than 20% of the total available battery capacity. In many cases, less than 10% of the battery capacity should be used. This dramatically prolongs the service life of the battery and reduces overall system maintenance costs. When RRFB specifications leave out all of the factors that affect proper battery maintenance, focusing only on size, battery life will be shorter and subsequent maintenance costs will increase.

The graph below illustrates the number of available charge cycles based on a typical usage scenario incurring ~ 5 – 10% daily depth of discharge (DOD) for a well-designed RRFB. It is important to note DOD calculations are based on temperature data for the worst-month of the year for minimum temperature and sunlight. Warmer, brighter months will have a lower DOD and will have a greater effect in maintaining battery life.

Comparing systems using a performance-based approach often results in the conclusion that bigger is not always better. Smaller systems can be installed on standard sign poles, are much easier to install, and are aesthetically more appealing for urban locations. Additionally, smaller systems that are more efficient often outperform larger systems. When system specifications properly identify the performance requirements, operating capacity, and site-specific factors including shading and temperature, a reliable and sustainable system can be provided.

Greg has over a decade of experience with pedestrian devices for the traffic industry. He has been with Carmanah technologies since 2004 and has overseen the development of solar flashing beacons, including the rectangular rapid flashing beacon. Greg is currently managing director for the traffic division at Carmanah.

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