Sealite®

WHITE PAPER

The Importance of Solar Calculations

www.sealite.com

We believe technology improves navigation™

About solar powered lights

Due to advances in efficiency of both LED and Solar technologies it is possible for many more aids to navigation to be solar-powered. This now includes lights from 1 nautical mile range up to many major lighthouse lanterns with 20 plus nautical mile range.

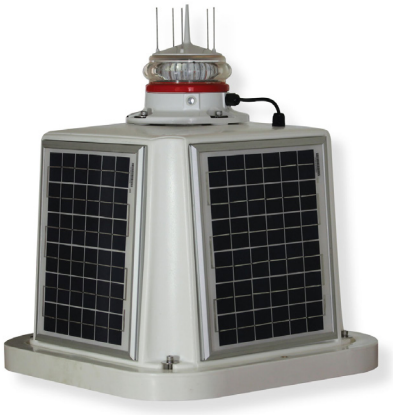
Many lights are now able to be self-contained with the light and solar power system integrated into the same housing for easier installation – something that may not have been possible with the less efficient incandescent filament light sources of the past.

Examples of Sealite Self-contained Solar Powered Lanterns:

SL-70 (2-3NM+ range)

New Lantern -

Launching Late 2018 (5-8NM+)



SL-C500

with SL-155 lantern (5-12NM)

MARINE LANTERNS

Using solar power removes the costs of maintaining a connection to an external power source and provides an environmentally friendly, renewable energy source.

During the daytime the solar panels convert solar radiation to electricity voltage which is regulated in order to charge an internal battery. Normally at dusk the light activates automatically via a photocell and consumes battery charge.

The balance of available energy input required versus energy consumption is called **the array/load ratio** (ALR). Together with the battery capacity this will determine whether the battery retains enough charge to power the light at all times of year or begins to discharge below the acceptable charge level causing risk of the light being extinguished. The energy stored in the battery relative to the electrical load is referred to as the **autonomy** and indicates how long a light will continue to function without daytime solar input for example as a result of inclement weather.

Manufacturer's spec sheets often state an approximate upper and lower visible range expectation (according to IALA recommendations) for a given solar lantern product however precise suitability and performance will depend on a number of factors and there may be several product options available to suit different applications.

Why do we need solar calculations?

In order to provide a reliable and fit for purpose solar-powered aid to navigation, solar power calculations should be performed before the product is deployed. A good solar calculation will help to achieve the following:

Increased marine safety

By carrying out solar calculations we reduce the risk of unexpected failures i.e. lights going out, leaving a station unmarked which could cause a navigational hazard with the associated human, legal and financial ramifications.

Meet IALA availability targets

It can be challenging for end-users to meet demanding IALA availability targets where standby equipment or system redundancy is costly or impractical to achieve. IALA define 3 categories depending on the importance of the aid to navigation with the following requirements:

IALA Category	Required availability	Downtime permitted per year
1	99.8%	17.5 Hours
2	99.0%	3.65 Days
3	97.0%	10.95 Days

Obviously any outages due to lack of valid solar calculations could quite quickly use up this time even if the asset maintainer keeps spares and can get to site in good time. A good solar calculation will reduce this worry.

Reduced maintenance costs

Performing solar calculations will mitigate the need to perform unnecessary, and potentially expensive maintenance and mobilisations to deal with outages. This is especially true for boat access to buoys, marker piles and inaccessible locations.

Ensure charted range is achieved

It is helpful if the solar calculation tool displays an estimate of the visual range that will be achieved for the input settings so this can be compared to the local chart to help ensure compliance. This should include adjustment for estimated background lighting if needed. Again, this will prevent mobilising later on to make changes if feedback from mariners is not favourable.

Provide greater value for money

Product selection capability is a great feature to have in a solar calculator in order to help find the most cost-effective solution in conjunction with optimisation of its performance by adjusting parameters such as intensity, flash length etc.

Factors to include in solar calculations

There are a number of factors which should be considered in the solar calculation. A good solar calculator tool will factor in the following:

Solar Insolation

This is the monthly solar irradiation data for the location. In addition, an allowance should be made for consecutive 'black' days due to weather events. Allowance can also be made for reflectance of light off the ground or sea before it reaches the solar panel.

Orientation Loss

This considers the azimuthal and inclination angle of the sun relative to the solar panel (depending on the location), whether the panel is fixed horizontally or rotating (like on a buoy) and the vertical tilt angle of the panel.

SL-75 with angled solar panels: with optimised geometric factor.

Solar Panel Performance

This includes the type and efficiency of the panel, effect of temperature and ageing.

Battery/Charging Performance

This includes battery chemistry, minimum discharge level, charging efficiency, effect of temperature, self-discharge and ageing.

Temperature Compensation

As there is a relationship between temperature and battery capacity, battery capacity must be compensated for in colder weather conditions to provide the user with the most accurate winter autonomy.

Power Consumption

It is necessary to consider power consumption when lit (flash), between flashes (eclipse) and during daytime (standby). This is further affected by the duty cycle (flash code), operating mode, length of night and additional options such as GPS synchronisation, remote monitoring etc.

Background Lighting

The level of background lighting (IALA defines as: none, minor, major) can be input as part of the solar calculation as this will affect range and possibly suggest changes to product selection. This is further detailed in our white paper 'Background Lighting Explained'.

BACKGROUND LIGHTING EXPLAINED

Making adjustments for local conditions

Most solar calculations include a factor of safety in the calculations for the product. These may not cover all possible external inefficiencies and losses when the equipment is installed in real-world conditions. We can sometimes mitigate against these by adjusting the lantern settings to increase array/load ratio or autonomy days by a process of estimation. Some important other factors to consider are as follows:

Solar Panel Shadowing

If the light is installed in a location where the solar panels are partially in the shade during the day or totally shaded at certain times of day this will affect performance. Examples include installation near buildings, bridges, under buoy top marks or near mountainous terrain.

Local Weather

The insolation data set used for the location may not have the granularity to consider local weather factors. A common example would be prevalence of mist or fog very near the coast. Local knowledge may be useful in estimating how to adjust the solar calculation to allow for this.

Environmental Contamination

Many lantern products are fitted with bird deterrents and some have angled solar panels which help the panels to self-clean in the rain. These features do help but at some locations both bird life and industrial pollution may necessitate more regular attendance for cleaning the light as well as considering adjustment to the solar calculation.

QEC Aircraft Carrier Berthing Lights, Portsmouth UK

In this example all lights are used in daytime requiring highly efficient Sealite SL-RL-04 Range Light and SL-PEL Port Entry Light products with separate solar power systems. Due to the presence of bird life and inaccessibility of the sites, carefully considered solar calculations were required to ensure IALA category 1 availability.

Viability of the Solar Calculation

After all parameters have been entered, a good solar calculation will provide the following indication of the system viability as follows:

Probability of loss of load

This takes into account all inputs and specifies whether the solar calculation is viable or not. It is the best way to ensure reliability. A good way to make this user-friendly is to display this as a traffic light system such as 'pass', 'marginal' or 'fail'.

Autonomy days

This is normally defined as the number of nights that the battery will continue to power the load in the absence of any solar input in daytime. This figure is often specified in buying requirements simply because it is a comparable number which has been historically used. It may bear little resemblance to the actual expected number of 'black days' at the location occurring in any one month.

Large values for the autonomy were sometimes traditionally prescribed so that the batteries were increased in size relative to the solar panel sizes sometimes to the point where a system could run for 2-3 months through winter on battery power alone. Modern solar panels are far more efficient in lower light levels and more cost-effective compared to batteries, so this approach is largely outdated unless physical space limits the solar system size and the asset maintainer chooses to overrate the battery size.

For best value and reliability, the autonomy should not be used without considering the overall probability of loss of load as the primary way of measuring the validity of a solar calculation.

Graphical Results

Most solar calculations provide a graphical view of the monthly performance of the system ideally for at least 2 years. The charts should include energy input, energy used, battery charge level & autonomy days. It is a useful pictorial indication of how the product performs through the seasons, for example if a light is only required for seasonal use then the graph can show which months provide a valid solar calculation with a positive value for the ALR.

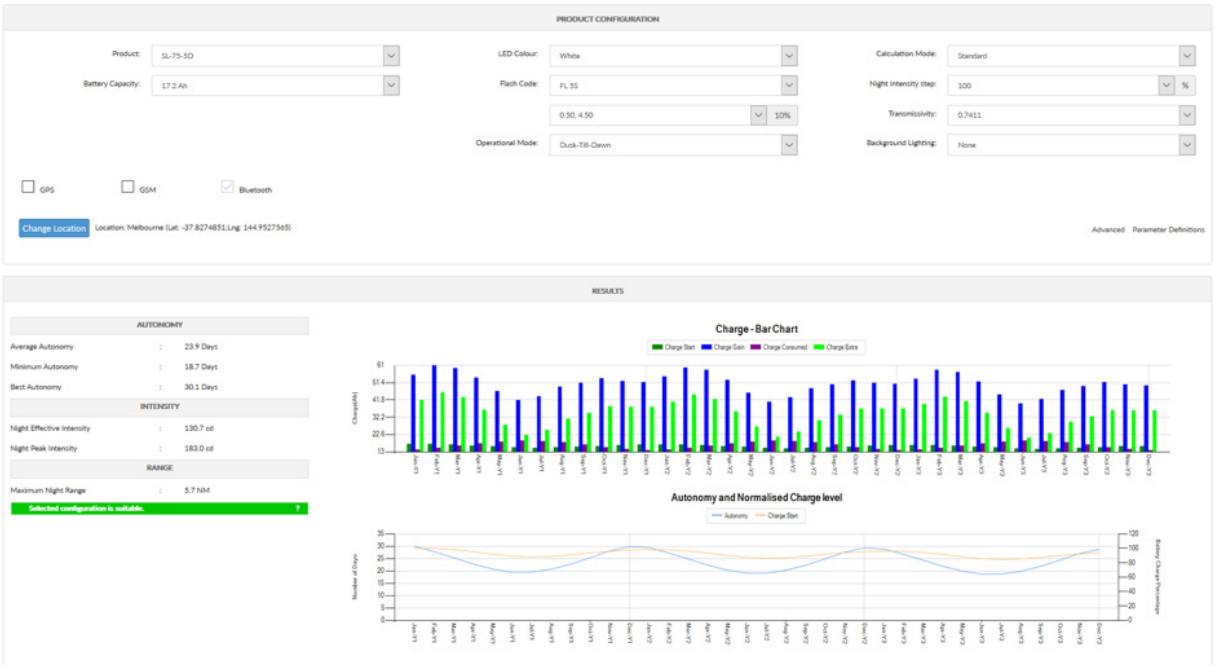
Advantages of Sealite's Solar Calculation Tool

Sealite's Solar Calculation Tool provides a calculation which considers all the factors mentioned before, making it one of the most accurate solar calculation tools available today. It was also validated empirically using test locations in the field.

Sealite's Solar Calculation Tool is available in two versions: a helpful product selection tool for less experienced users and a tool to validate suitability of a given product for an application which is ideal for users with some knowledge of the Sealite product range.

In both cases the calculator is easy to use and gives a simple traffic light indication of whether the user's selections are suitable for the location, together with the range achieved and expected autonomy days - if needed.

If additional guidance is required, please contact your Sealite sales representative who would be pleased to assist in matching the product to the application and would welcome any feedback.



Sealite's Solar Calculation Tool

This tool helps to enable user to ensure their lights are of sufficient brightness for each location before they are deployed, increasing safety while reducing the additional cost of further trial and error with different products. The Sealite solar calculator is free to access at **sealite.com**

SOLAR CALCULATOR