simmonsigns

Solar Products in Traffic Engineering

simmonsigns.co.uk

Sustainability and the environment are a key issue within today's society.

In this paper Michael will explore solar products in traffic engineering, focusing specifically on their applicability
and suitability, their specification and performance, the design considerations
and their maintenance.

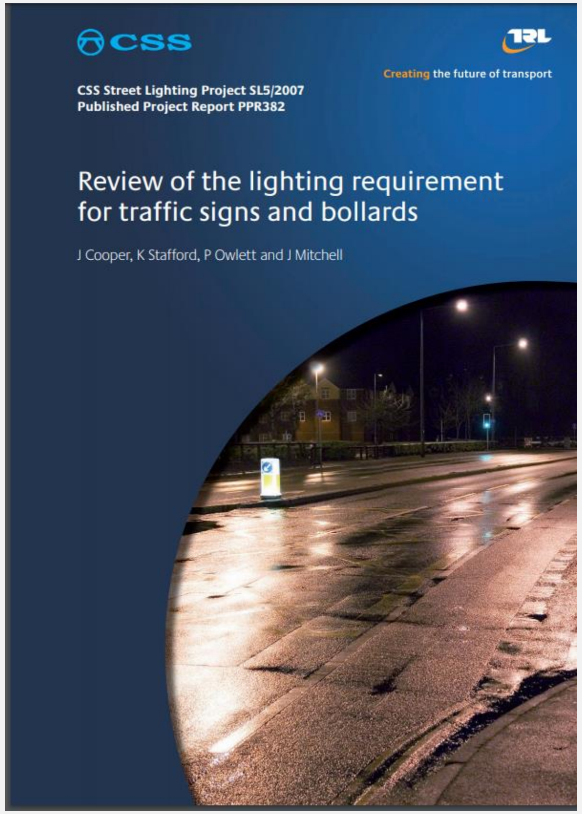
Solar Products in Traffic Engineering

CSS Street Lighting Project SL5/2007 Published Project Report PPR383 :-

- Solar powered sign lighting may be considered a practical alternative to using mains power, especially in situations where electrical connections and associated cabling are not yet installed

- The installation of electrical connection and cabling to traffic signs can be a significant up front cost

- Once installed maintenance of (solar signs) is minimal

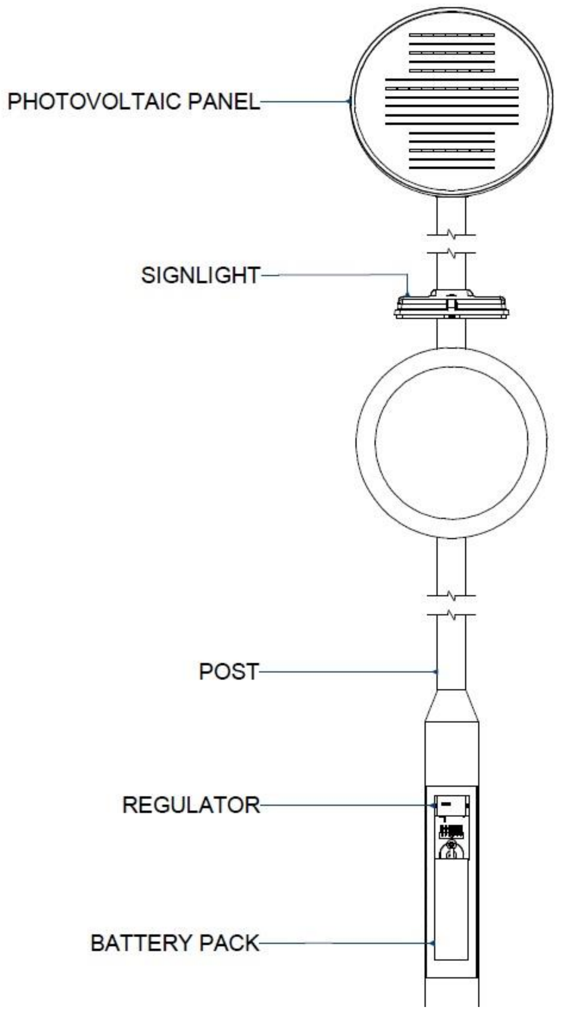


Applicability
& Suitability

Applicability & Suitability: General

Physical Elements

- Photovoltaic Panel
- Load
- Regulator
- Battery
- Post



Applicability & Suitability: General

Product Types

- **Suitable low power LED product type include:**
  - Continuously powered e.g. Belisha beacons
  - Photocell switched e.g. sign lights
  - Intermittent e.g. school warning signs

- **Practical solar panel size power circa 100 Watt**
  - Primarily due to windage and foundation required for a 100W panel

- **Battery size constraints**

Applicability & Suitability: Site

Safety

- **Panel weight:**
  - Large post top panel can present hazard
- **Battery weight:**
  - Post top mounted batteries can be a significant hazard in the event of vehicle impact
- **Road location**

Location

- **Energy from photovoltaics is dependant on location, shading and seasonal variation.**

Applicability & Suitability: Site

Location

- **Geography:**
  - Due to varying daylight hours and angle of the sun, more energy is available towards the equator

- **Direction**
  - To capture most energy direction for the panel is South facing

- **Shading**
  - Local shading from building and trees reduces power generation

Applicability & Suitability: Site

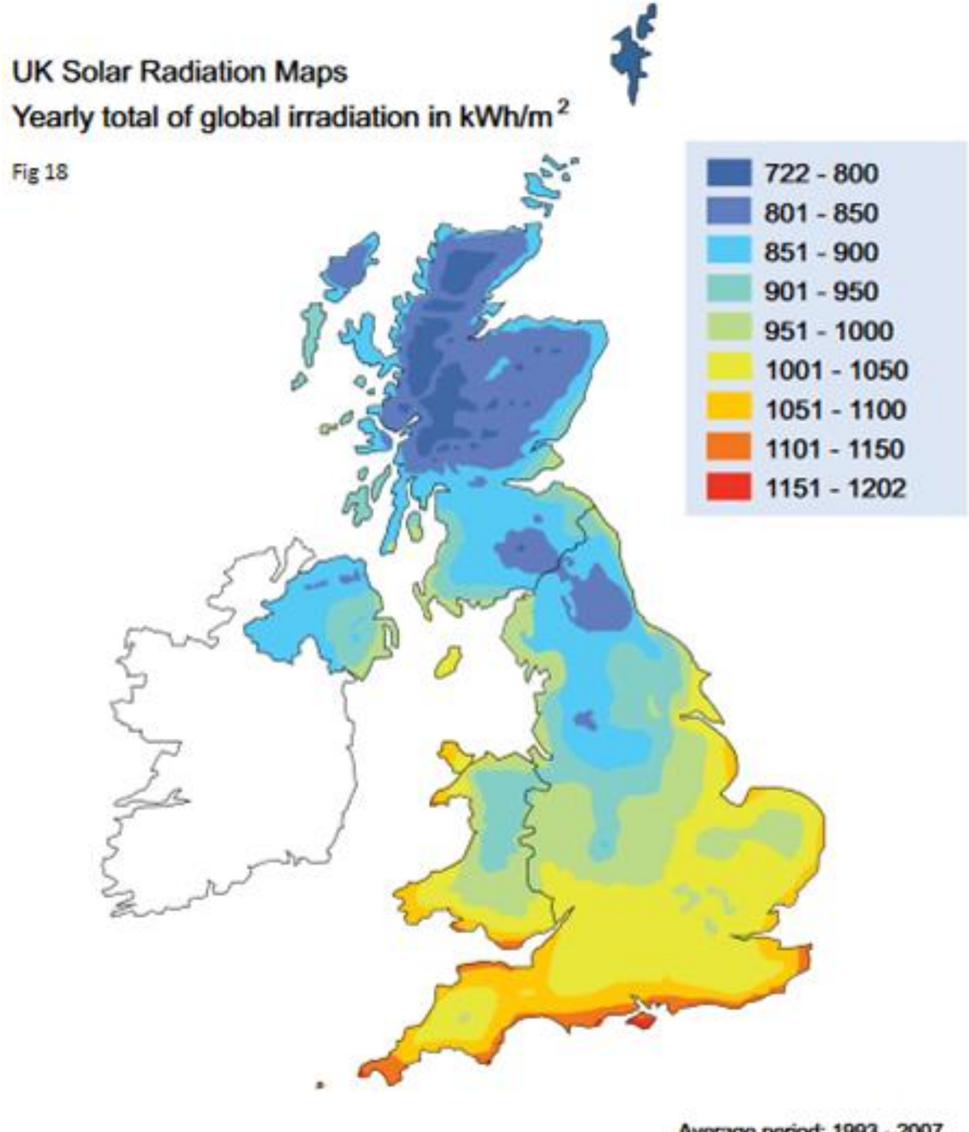
Shading

- Qualitatively the effect of shading is to disproportionally reduce the PV panel output
- Even slight shading can effect the output of a photovoltaic panel

Applicability & Suitability: Geography

Energy Source Variation

- Data from Met Office shows variation across the UK



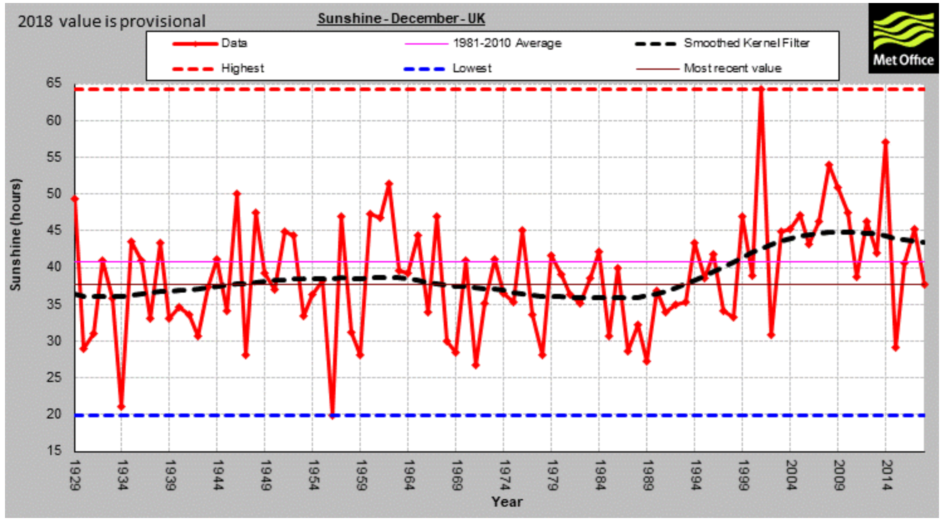
Picture courtesy of the Met Office

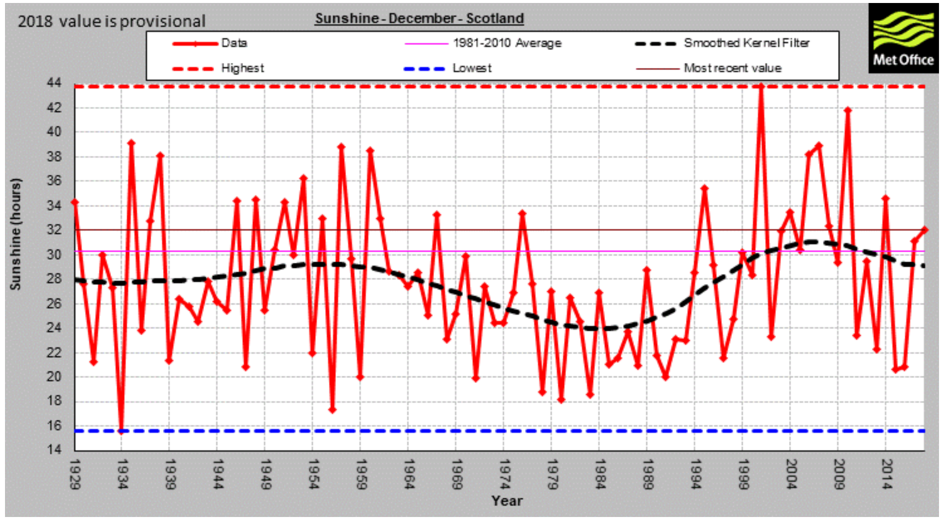
Applicability & Suitability: Geography

Energy Source Variation

- Met office data for sunlight hours over the last 89 years

- Data shows average December sunlight from 1981 to 2020 is:-
  - 40 hours in the UK
  - 30 hours in Scotland

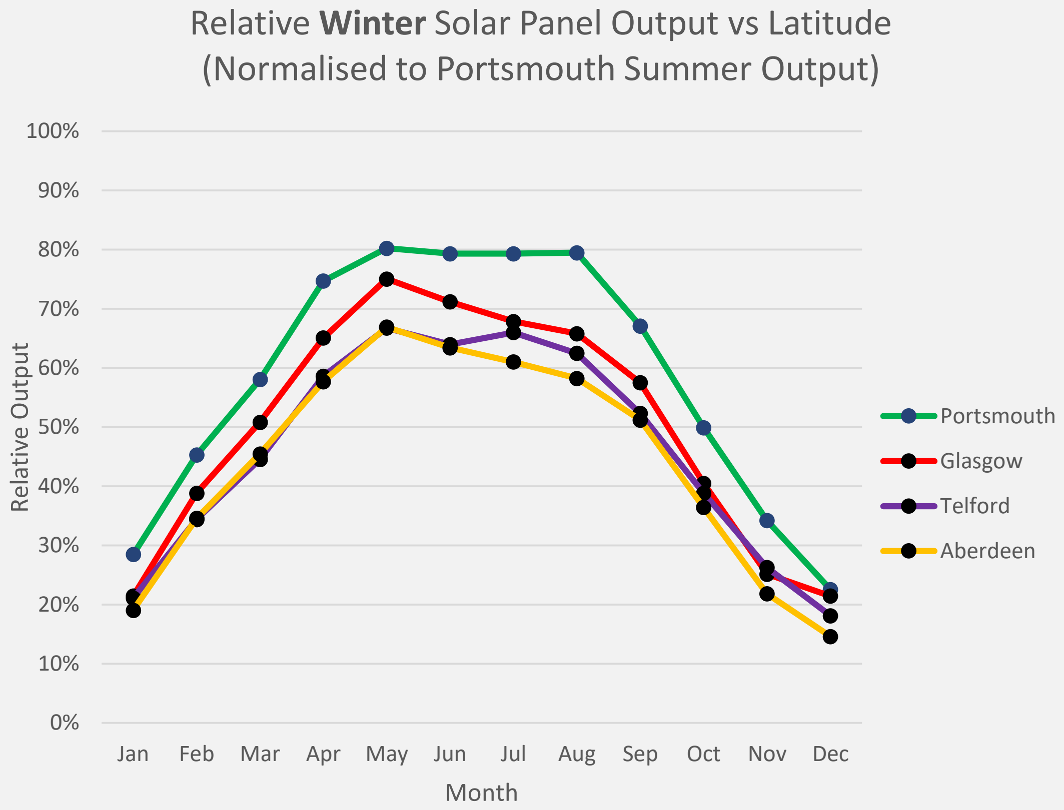




Applicability & Suitability: Geography

Seasonal and Geographical variation

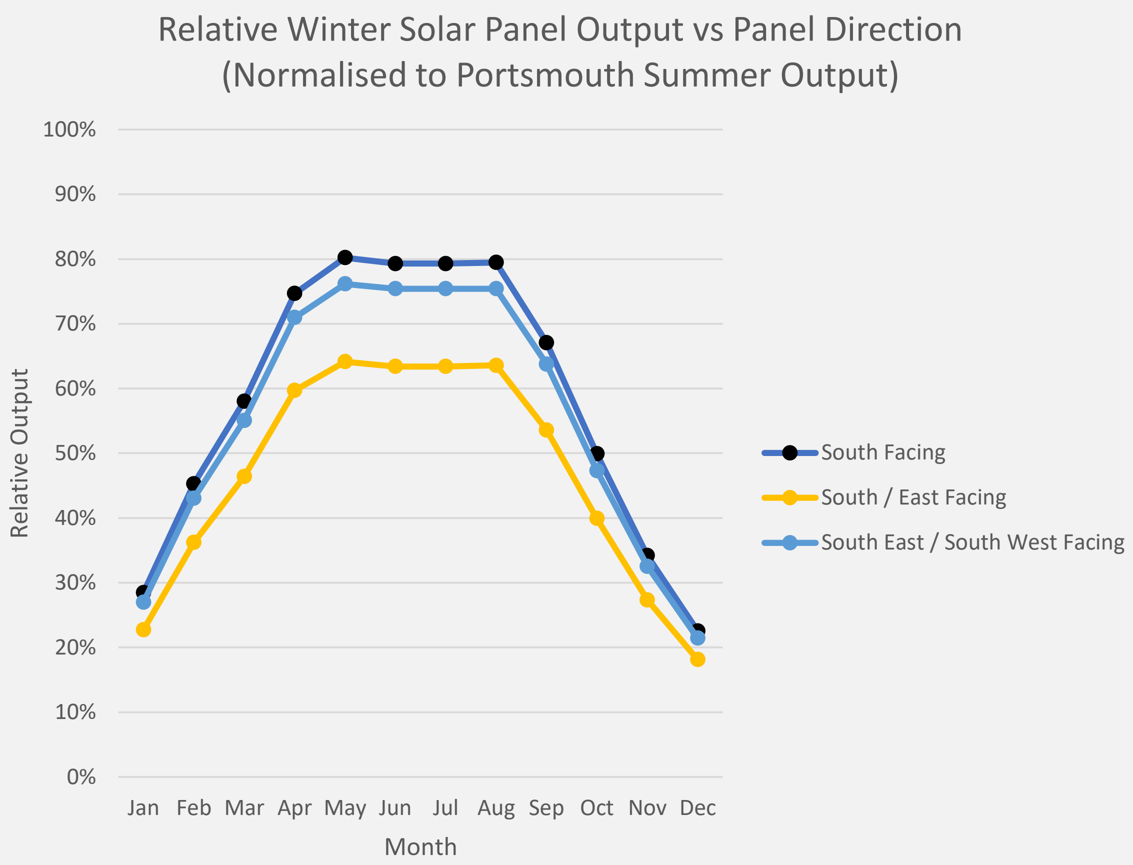
- Data shows the variation in PV panel output by month and region



Applicability & Suitability: Site

Photovoltaic Panel Direction

- Shows variation in panel output due to orientation



Applicability & Suitability: Summary

To Summarise

- **Product**
  - Low power

- **Site**
  - Not all sites are suitable for solar based products due to shading

- **Orientation**
  - Angle and orientation of panel is important

Specification & Performance

Specification & Performance: General

- **Performance Factors**
  - Autonomy
  - Photovoltaic panel charge rating
  - Depth of battery discharge

- **Product Lifetime**
  - High impact rating preferred
  - Battery life
  - Environmental

- **Aesthetics**

Specification & Performance: Performance

Performance Factors

- **Autonomy**
  - The time a solar powered system can operate without receiving charge from a solar panel
- **Photovoltaic panel charge rating**
  - Impacts on the time taken for a solar power system to recover the daily power used
  - Preferred is the minimum average charge available in December 1.2 to 1.5 times the load
- **Battery protection**
  - To maintain battery life charging and discharging must be managed
  - Use charge regulator

Specification & Performance: Product Lifetime

Product Life Factors

- **Battery Life**
  - Batteries used in solar installations has finite lives
  - Battery types offer design choices

- **Photovoltaic panel life**
  - Generally panel output decays slowly
  - Design choices offer similar life in the UK; quality tends to dictate life
  - Panel choice impacts on efficiency, size and power output

Specification & Performance: Battery Type

Battery type and Relative Performance Rankings

Battery Type	Energy Density (Size)	Cost	Life Cycles	Available Capacity	Charge Temperature (Degrees C)	Discharge Temperature (Degrees C)	Toxicity	Maintenance requirement
Lead Acid	Low	Low	450	50%	-20 to +50	Range -20 to +50	High	High
Gel lead acid	Low	Medium	500	50%	-20 to +50	Range -20 to +50	High	Medium
Absorbent Glass Mat	Low	Medium	1500	85%	-40 to +65	Range -40 to + 65	Medium	None
NiCad	Medium	Medium	1100	100%	0 to 45	Range -20 to + 65	High	High
Lithium Ion (and variants)	High	High	1300	100%	0 to 45	Range -20 to + 60	Medium	None

NOTES

Data drawn from a variety of sources

Data is general for battery type

Life Cycles at 80% discharge depth

Ranking is according to use in unattended operation

Specification & Performance: Energy Source

Solar Panel Type and Relative Performance

Photovoltaic Panel Type	Efficiency	Cost	Life	Durability
Mono-Crystalline	15% to 20%	Highest	Highest	Highest
Poly-Crystalline	13% to 16%	Medium	Highest	Medium
Thin Film Amorphous Silicon	7% to 13 %	Lowest	Medium	Lowest

Data drawn from several sources; Only panel types relevant for low power traffic products considered

NOTE the rating of a panel is at Standard Test Conditions (STC).
This means a radiance level of 1000 W/m^2 at 25 degrees C; radiance conditions at the equator.

Specification & Performance: Energy Source

Standard Test Conditions

- **Photovoltaic panels are rated in Watts at Standard Test Conditions (STC)**

- **STC means power output will be achieve**
  - Cell temperature of 25 degrees C
  - Solar irradiance of 1000 W per m^2
  - Mass of air at 1.5 spectrum

- **Useable power is related to Solar Insolence at the site**

Specification & Performance:
Battery Protection / Charge Controller

Solar Regulator Type and Relative Performance

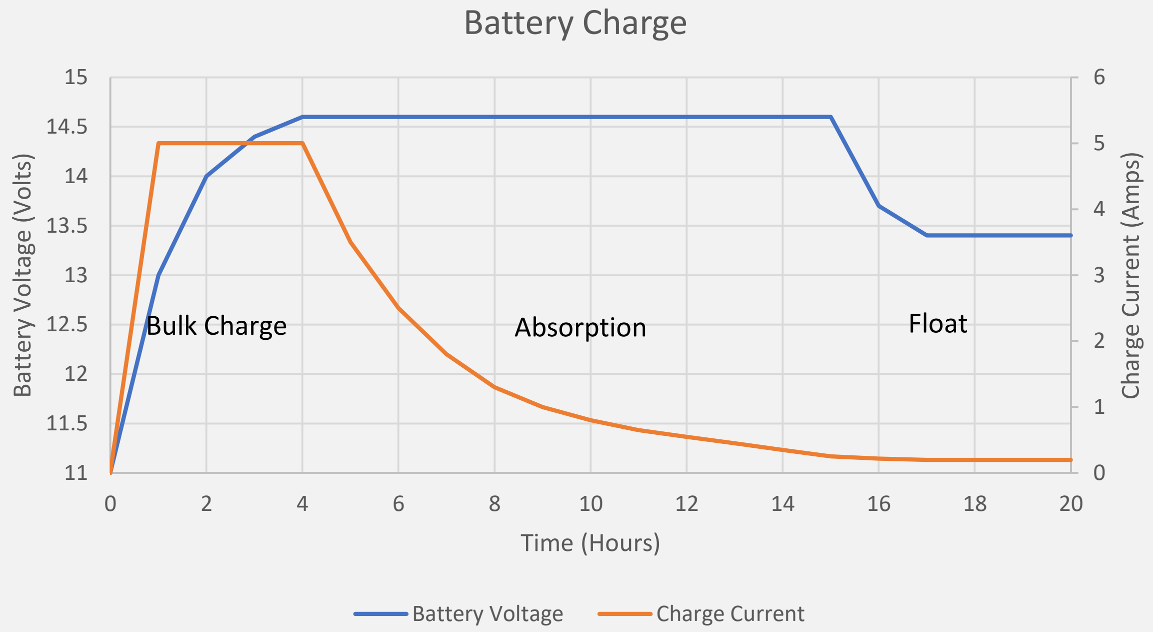
Regulator Type	Detail	Efficiency	Cost	Battery Protection (over charge and discharge)
MPPT	Max. Power point tracking	High	High	High
PWM	Pulse Width Modulation	Medium	Medium	High
NONE		Low	None	None

NOTE Not including a regulator charge controller means battery is unprotected against over charge and over discharge.

Specification & Performance: Battery Protection

Battery Regulator Function

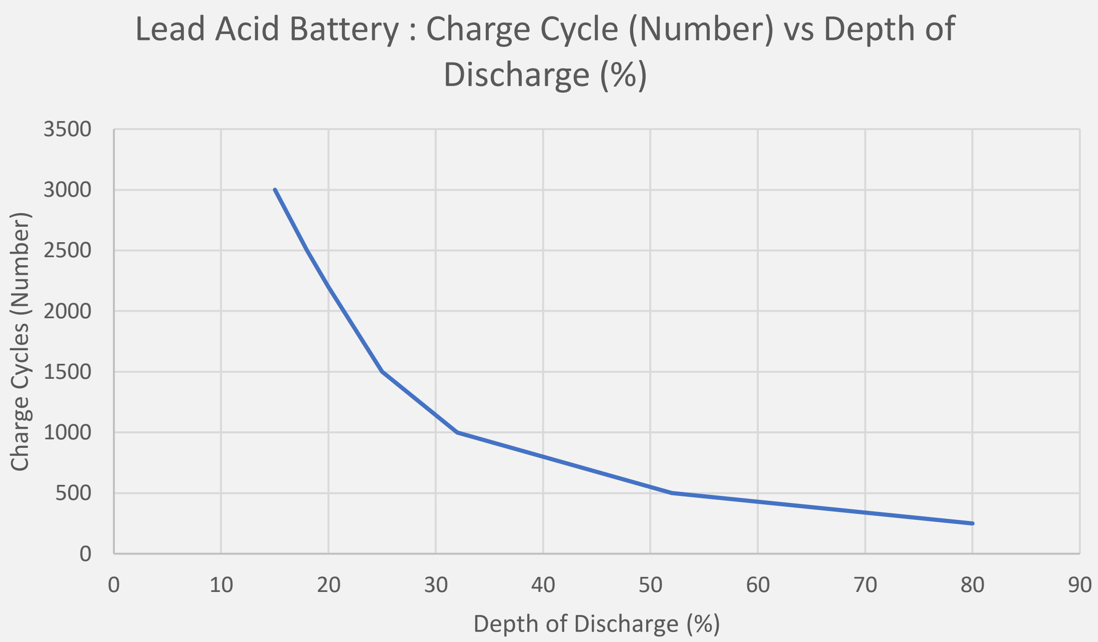
- Regulators control and optimise the charge delivered form the photovoltaic panel to the battery
- Regulators protect the battery against overcharging and depth of discharge



Specification & Performance: Battery Protection

Depth of Charge vs Battery Life

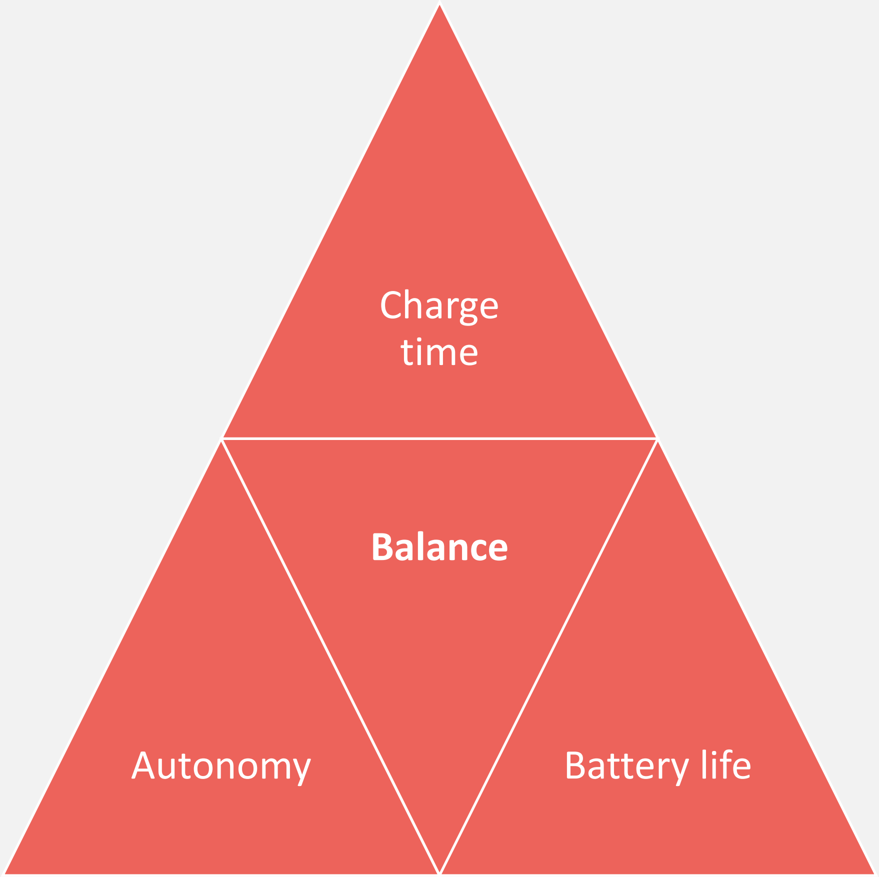
- Graph shows relationship between depth of discharge and battery life; the deeper the battery is discharged the lower the number of charge cycles available



Specification & Performance: Summary

To Summarise

- **Autonomy**
  - Recommendation is greater than 9 days
- **Photovoltaic panel charge rating**
  - Recommendation is December minimum daily charge 1.2 greater than daily load use
- **Battery Life**
  - Depth of discharge is managed to maximise battery life



Design Considerations

Design Considerations: Power Budget

Power Budget Calculation

- **Batteries are rated in Voltage and Amp hours**
  - 1Ah = 1 Amp per hour
  - Watt Hours = Volts x Amp hours

- **12 Volts 10 Amp hour battery**
  - Watt Hours = 12 Volts x 10 Amp hour
    = 120 Watt hours

Design Considerations: Autonomy

Autonomy

- **Load**
  - 2 Watt load running 24 hours a day requires 2 Watt x 24 hours = **48 Watt hours per day**

- **Usable battery capacity for (e.g. absorbent glass matt) battery**
  - 36 Ah at 85 % depth of discharge = 36Ah x 0.85 equals 30.6 Ah available capacity
  - Convert to Wh 12V x 30.6 Ah = **367.2 Wh**

- **Autonomy therefore**
  - 367.2 Wh battery / 48 Wh per day = **7.6 Days**

- **Losses**

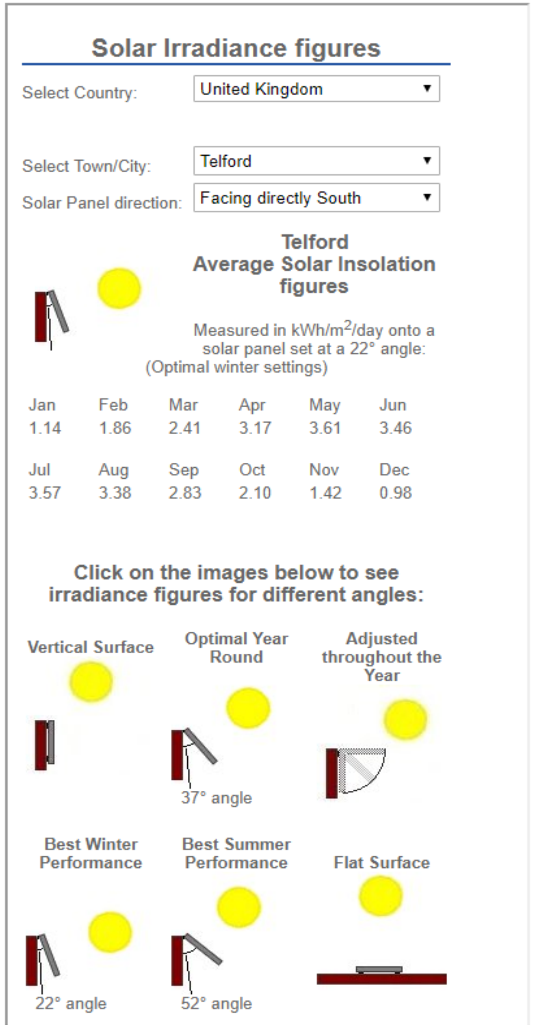
Design Considerations: Power Budget

Input Power from Photovoltaic Panel

- **From NASA data averaged over 22 years solar irradiance value for a site in the Midlands is:-**
  - 0.98 kWh / m2 / day

- **Panel output, say a nominal rating 60W panel @ 1000 W / m2 irradiance produces**
  - 60 W x 0.98 kWh / m2 / day = 58.8 Wh per day

- **Previous example of 2W load, 24 hours a day requires**
  - 48 Watt hours per day

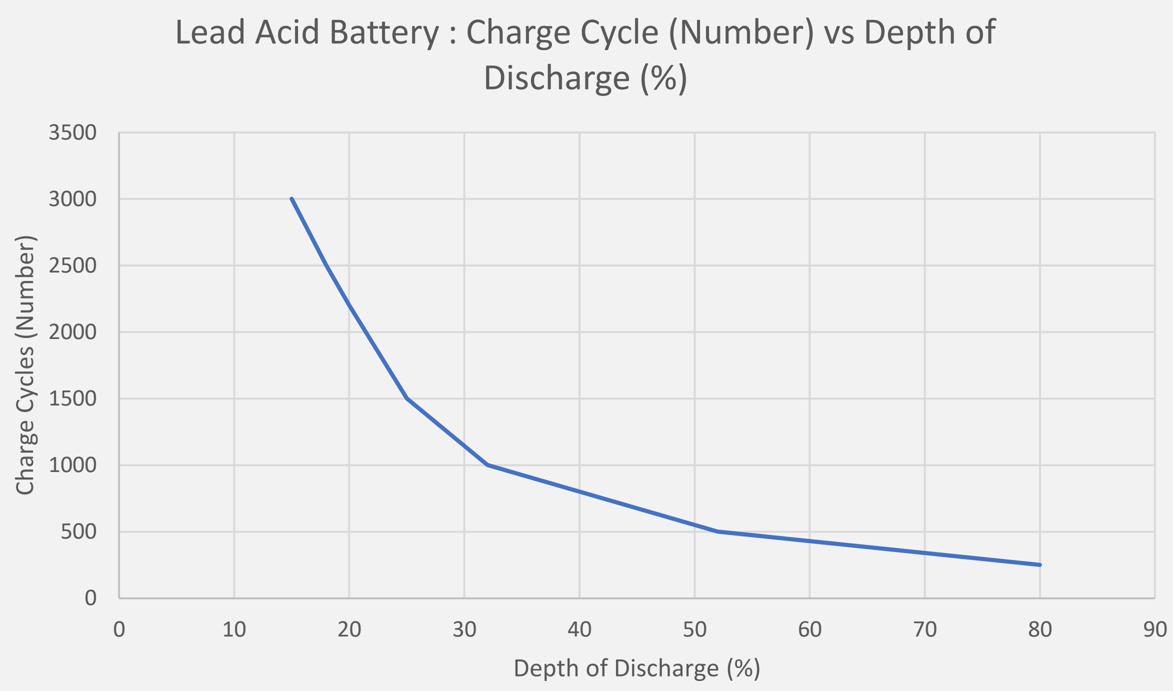


http://www.solarelectricityhandbook.com/

Specification & Performance: Battery Protection

Depth of Charge vs Battery life

- Previous example of 48Wh load
- 48Wh / 12 V= 4Ah daily battery requirement
- For battery rated 20Ah then 25% depth of discharge



Design Considerations: Aesthetics

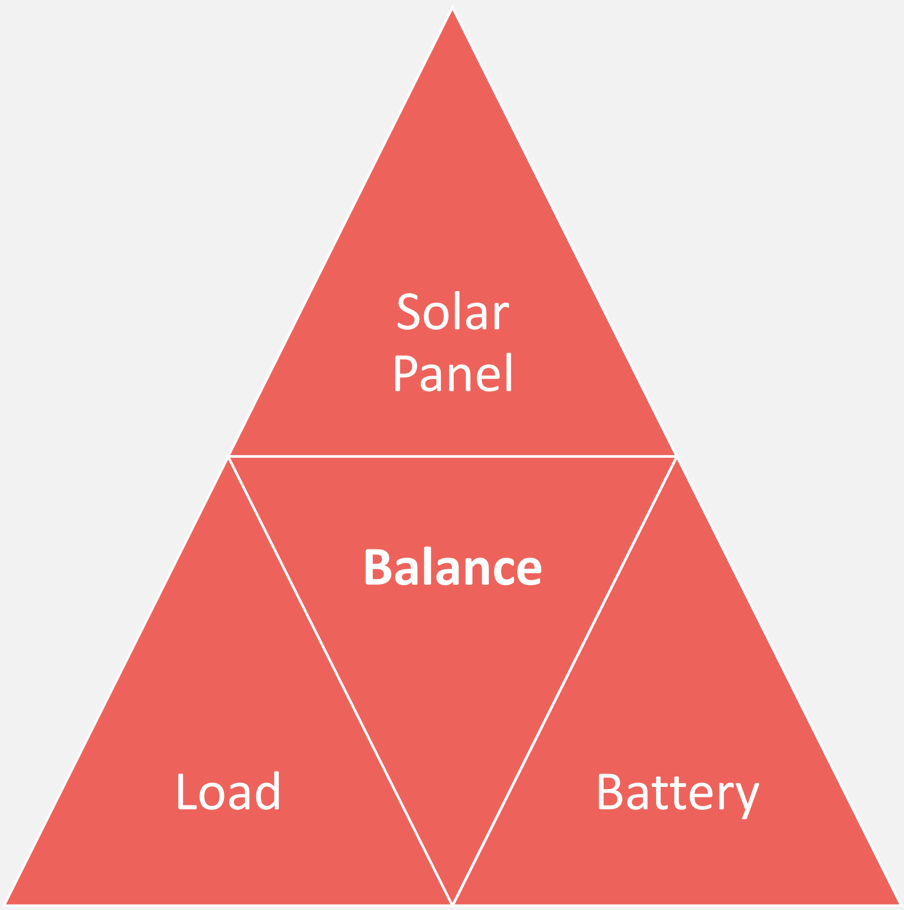
Aesthetics

- Sympathetic design for urban environment
- Low visual impact
- Vanishing soft lines
- Impact rating IK10

Design Considerations: Summary

Balance of component performance infers a system in balance

- Balanced elements work reliably in function with other elements
- The load power and load autonomy requirement drives the battery type and size
- The load power requirement and site drives the photovoltaic panel size



Maintenance

Regular Maintenance

Product Maintenance

- **Check panel orientation**
- **Visual check of panel:**
  - UV damage, Frost damage, Water ingress

Panel

- **Cleaning**
  - Site dependant; but good housekeeping will keep system functioning
  - Removal of dirt key to efficient operation – but rain helps

Battery

- **Battery voltage**

Periodic Maintenance

Site Maintenance

- Limit shading potential of trees
- Uninhibited south facing view

Schedule Battery check and replacement

- Understand depth of discharge and life

Summary

Solar Products in Traffic Engineering

Applicability & Suitability

Geography and irradiance levels and local conditions

Specification & Performance

Autonomy, PV panel size and depth of discharge

Design Considerations

Battery protection and power budget

Maintenance

Planned maintenance regime

simmonsigns

Thank you.

simmonsigns.co.uk