# Design of solar power systems for autonomous instruments deployed in the polar regions

**Mike Prior-Jones** (Cardiff University), Liz Bagshaw (Cardiff University),
Thomas Nylen (DTU), Joe Pettit (UNAVCO) and Paul Carpenter (IRIS/PASSCAL)

Presented at EGU GA 2022 in the “MacGyver Session” (HS1.2.1)

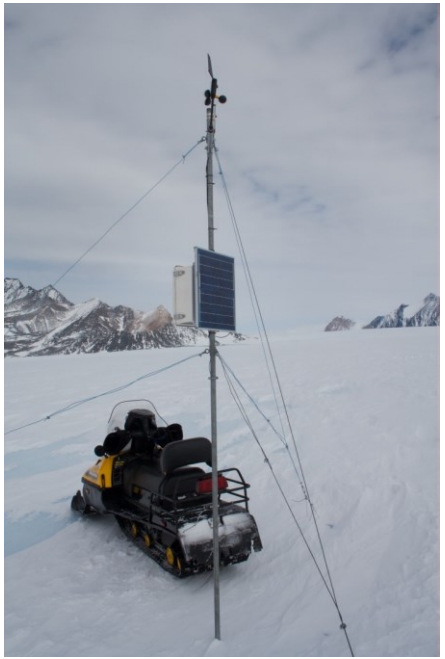
Photos are the authors’ own work unless otherwise specified

This work was supported by the Engineering and Physical Sciences Research Council (EP/R03530X/1 – PI: Bagshaw) and by a UKRI Future Leaders Fellowship (MR/V022237/1 – PI: Prior-Jones)

# Polar solar power systems

- Solar power is often our first choice for powering equipment in the polar regions.
- It's convenient, inexpensive, robust, and works well for small installations
- It works particularly well in the summer where we have 24-hour daylight.
- A battery is used to store power for use overnight and in the winter.

Two solar installations at Union Glacier, Antarctica:

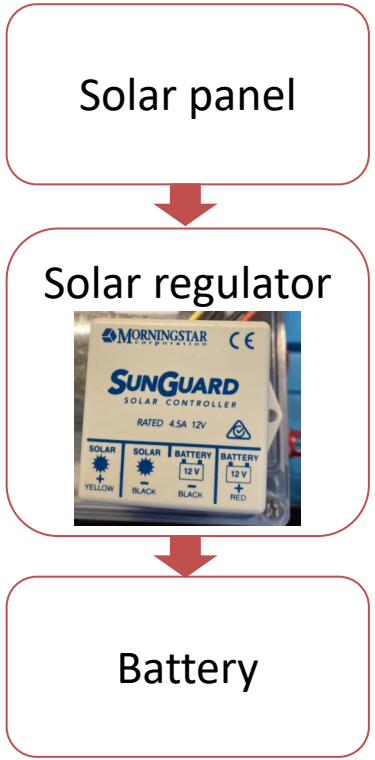


Weather station

Camp power supply

# Typical system design

- A typical design consists of a solar panel, a lead-acid battery, and a solar regulator
- The regulator prevents:
  - battery discharging via the panel at night
  - overcharging the battery (especially in 24-hour daylight)
- Many different models of regulator are available
- I asked Cryolist members which models they like to use
- The Morningstar SG-4 pictured is one that was widely used



# What happens in winter?

- The polar winter is a long period of darkness
- The key to successful winter deployments is having a large enough battery to cover your power consumption
- However, system designers need to consider the overall system power consumption, and this includes the solar regulator
- **Solar regulators consume power from the battery even in the dark – and many people do not realise!**

| Latitude | Days of darkness |
|---|---|
| 70 | 53 |
| 80 | 133 |
| 85 | 160 |

# Self-consumption

- The power consumption of the regulator is often called “self-consumption”
- This is a misleading term – as this power is consumed all the time
- “Night power consumption” is a better term
- The Morningstar SG-4 consumes 6mA in the dark, which is considerably more than my instrument does!
- If you do not allow for this, your system will fail in midwinter…


*Electrical Specifications*

| | | |
|---|---|---|
| Rated Solar Input | 4.5 | Amps |
| Max. Input (5 min.) | 5.5 | Amps |
| System Voltage | 12 | Volts |
| Max. Solar Voltage | 30 | Volts |
| Regulation Voltage | 14.1 | Volts |
| Accuracy | 60 | mV |
| Self-consumption | 6 | mA |
| Temp. Compensation | -28 | mV/°C |
| Reverse Current Leakage | <10 | µA |
| Operating Temperature | – 40 to +85°C | |

# Lab measurements

- We tested 14 models of regulator to confirm their “night power consumption”
- We checked the values against the datasheets
- Most regulators performed according to their specification
- A few perform better than specified
- One manufacturer (Epever)’s products used more power than specified!
- Regulators that support larger panel sizes usually have higher night consumption.

- We recommend that you read the datasheets carefully and test your regulator when it first arrives – just connect it to a battery via an ammeter.

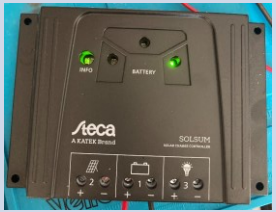
# Measurement results

Eco Energy ASC30W
0.04mA ( = 40uA)


Genasun GV-4
0.08mA (= 80uA)


Photo ©Sunforge LLC, used by permission

Steca Solsum ST-SM6.6F
2.2mA




Morningstar SG-4
6.3mA


Epever Landstar LS1024EU
12.7mA


Epever Triron 1206N
41.8mA


For example, the Morningstar SG-4 uses >70x more energy than the similarly-rated Genasun GV-4

# Spreadsheet model

- Regulator energy consumption can have a huge impact on the battery size needed to survive the winter
- We developed a spreadsheet model to estimate the battery size needed to survive the winter for a hypothetical instrument:
  - that consumes 1mA (this is typical for a modern data logger)
  - which is installed at 70 degrees N
  - with a 20W solar panel
- We then looked at the battery sizes required for the different regulators
- Results on the next slide…

# Impact on battery sizes

- **Efficient regulators save cost and weight!**
- The more efficient regulators are a little more expensive but worth it because of the savings on the battery required. You also save on transport cost.

| Regulator | Size of battery required | Weight of battery | Cost of battery | Cost of regulator | Total cost |
|---|---|---|---|---|---|
| Genasun GV-4   | 7Ah | 2.2kg | €50 | €60 | €110 |
| Morningstar SG-4   | 38Ah | 14kg | €120 | €45 | €165 |
| Epever LS1024EU   | 65Ah | 23kg | €176 | €15 | €191 |

# Final thoughts

- Not all regulators support recovery from a flat battery using solar power: check with the manufacturer
- Beware low-voltage disconnect circuits and other ancillary electronics – check their power consumption as they can often be much higher than you expect
- Test your system in the lab before deployment

- We have a paper in preparation with full details, and will also publish our spreadsheet model alongside the paper

- Thank you for reading! Please do get in touch if you have questions or comments:
  - Email: Prior-JonesM@cardiff.ac.uk
  - Twitter: @DrMikePJ
  - I am planning to hire two postdocs (Jan ’23 start) and a PhD student (Sep ‘23 start) – please contact me for more details and to be notified when the job ads go live.