Our Experience with Solar Coffee, toast and hot showers powered by the sun

ESCAPE

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What we want to discuss today

- How solar can enhance cruising
- How to plan a solar system
- Did solar meet our expectations



Terminology

- Basic electrical concepts: lacksquare

 - hose to perform a task such as move a waterwheel
 - **kW** watts / 1000
- Hours:
 - **Ah** Amp hours (amps * hours)
 - **kWh** kilowatt hours (kW * hours)

How many Ah does it take to run a 100W lightbulb for 2 hours a day on a boat with a 12V electrical system?

• Amps - Unit of measure for electrical current or flow. Similar to water flowing through a hose

• Volts - Unit of measure for electrical voltage. Provides the pressure to move amps through a wire. Boats are usually 12V or 24V. Similar to water pressure which moves water through a hose

• Watts - Represents a unit of power. (watts = volts * amps). Similar to the power generated from a

16.66Ah

8.33A = 100W / 12V16.66Ah = 8.33A * 2 hours





Cruising Before Solar

Lead based batteries shouldn't go below 50% for extended periods with a weekly charge to 100%

Charging Cycle	Charging Level	Description
Bulk	80%	Fast high current
Absorption	100%	Slower final char
Float	Maintains at 100%	Maintains the bat

charging goes to 80% of full battery capacity ging from 80% to 100% ttery at 100% charge

Cruising Before Solar

- Run engine daily to get to an 80% charge
- Go to a marina once a week to fully charge batteries \bullet
- Managed power usage to stay under 138 Ah a day

- Refrigeration
- Lights
- Instruments
- Water Systems
- **AC Devices**

Problem to Solve

- Meet power needs
- Generate hot water
- Fully charge batteries

.... without running the engine or going to a marina

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Charging Options when Anchored

	Meets Objectives			
Charging Type	Power Rqmts	Hot Water	100% Battery Charge	Cost to Install
Primary Engine Alternator				
Generator	3	1		
Fuel Cells		1		
Solar		1		

- 1. Requires changes to hot water system
- 2. Quiet, no harmful emissions but does require a fuel
- 3. May require running quite a few hours a day depending upon generator

A combination of charging options is beneficial

Planning a Solar Installation

- Determine power needs
- Determine solar panels and other components required
- Installation considerations \bullet

Determine Power Needs

- For things that consume power you'll need:
 - **Power requirements for items** typically DC is in amps or watts but AC needs to be converted from watts
 - Estimated daily hours used
- Factors used in calculating power needs:
 - **DC system voltage** 12
 - **Inverter efficiency factor** typically 1.15 (85% efficient)
 - **Solar panel de-rating factor** varies but a good rule of thumb is 70%
 - Battery charge level in our case we wanted to cover our daily use and fully recharge the batteries
 - Average peak sun hours 5 is used for planning purposes during the cruising season

Peak Sun Hours

3.34 - average for year

DC Power Requirements Example

DC POWER REQUIREMENTS

Refrigeration

Freezer

VHF Radio

iPhone Charger

Cabin Lights (LED)

Furnance (Wallas Spartan Diesel)

Freshwater Pump

Electric Toilets

Anchor Light (LED)

TOTAL DC AMP HOURS CONSUMED PER DAY

<u>48</u> = 6 * 8

		At Anchor	
Watts	Amps	Hours	Daily Ah
	6	8	48.00
	5	6	30.00
	0.5	24	12.00
	3	2	6.00
	1	4	4.00
	2	2	4.00
	5	0.7	3.50
	10	0.3	3.00
	0.2	10	2.00
			112.50

<u>Ah</u> = Amps * Hours

AC Power Requirements Example

INVERTER AC POWER REQUIREMENTS

Sigmar Water Heater UX Compact

Microwave

Dinghy Battery Charge - Torqeedo

Coffee Maker

Toaster

Laptop

iPhone Charger (typically use DC)

iPad Charger

Bluetooth Speaker

TOTAL AC AMP HOURS CONSUMED PER DAY

<u>Amps</u> = (Watts / Battery Voltage) <u>66.7</u> = (800 / 12)

<u>Ah</u> = Amps * Hours * Inverter Efficiency Factor <u>61.33</u> = 66.7 * 0.8 * 1.15

		At Anchor	
Watts	Amps	Hours	Daily Ah
800	66.7	0.8	61.33
 1100	91.7	0.2	21.08
 90	7.5	2	17.25
650	54.2	0.2	12.46
 750	62.5	0.1	7.19
 30	2.5	2	5.75
 30	2.5	2	5.75
 30	2.5	2	5.75
 2.25	0.2	2	0.43
			136.99

Required Panel Wattage

ESTIMATED CONSUMPTION PER DAY

Total DC Amp Hours Consumed

Total AC Amp Hours Consumed

TOTAL AMP HOURS CONSUMED PER DAY

ESTIMATED WATTAGE REQUIRED

DAILY kWh REQUIRED

Controller 1 - 3 panels for a total of 440 watts

Controller 2 - 3 panels for a total of 440 watts

TOTAL ESTIMATED kWh GENERATED

DIFFERENCE BETWEEN REQUIRED AND GENERATED

<u>kWh Required</u> = (Amp Hours * Battery Voltage) / 1000 <u>2.99</u> = (249.49 * 12) / 1000

<u>kWh Generated</u> = (Panel Wattage * Panel Efficiency * Peak Sun Hours) / 1000 <u>1.54</u> = (440 * .70 * 5) / 1000

Starting Environment

- **Battery Banks**
 - Main house bank Two 8D AGM deep cycle batteries. Total of 460Ah
 - Secondary house bank 8D AGM deep cycle battery. Used primarily for the windlass. 230Ah
 - **Dedicated start battery** Isolated from house power needs •
- Inverter Victron MultiPlus Compact 2000W Inverter / Shore Power charger
- Water Heater 11 gallon 1500W water heater running off shore power

Components Added

- Batteries and inverter remained the same lacksquare
- Added
 - Solar Panels
 - 4 170W SunPower (Maxeon) flexible panels
 - 2 100W SunPower (Maxeon) flexible panels
 - **Controllers** 2 Victron MPPT 100 / 30 SmartSolar controllers
 - **Remote Monitoring** Victron Cerbo GX
 - **Battery Monitor** Victron SmartBatterySense
 - Water Heater Replaced existing with 5.3 gallon 800W water heater setup to run off the inverter

Notes:

440W per controller 880W total system Panels connected in parallel 10AWG PV cable

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≡ Devi	ce list		Q	
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13.95V	↓ 59°F		Ŷ	
Sma MPT MCC MPP	r tSolar HQ201 T 100/30	1XFVLN		
Battery voltage	Power	State	×	
Yield today	Current			
Sma MPPT Ministration MPPT	rtSolar HQ201: T 100/30	2BHSG7		

State × 0 8W --- Float Current **0.50A**

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Solar System Considerations

- Flexible versus fixed solar panels
- Parallel versus sequential installation
- Type and size of controllers MPPT or PWM
- Panel installation
- Balancing power consumption, storage and generation
- Whether to use a marine electrician or do it yourself

Cost Summary

Component	Cost
Solar Panels, Controllers, Cables, etc	\$ 2,
Remote Monitoring	\$
Water Heater	\$, ,
Misc Parts	\$
TOTAL PARTS	\$ 4,
OUTSIDE SERVICES	\$ 1,
SUBTOTAL	\$ 5,
Less Tax Credit	\$ (1,5
TOTAL NET COST	\$ 4,
NET COST SOLAR ONLY PARTS	\$ 2,
NET SOLAR ONLY OUTSIDE SERVICES	\$ 1,

	Notes
925	4 - 170W and 2 - 100W SunPower panels, 2 - Victron MPP 100 / 30 SmartSolar controllers, cables, connectors, etc
404	Victron Cerbo GX
535	Sigmar Water Heater UX Compact Inox 5.3 gallons
322	Tools, epoxy, through hull fittings, screws, etc.
186	
730	Electrical work on controllers, monitoring and water heater
916	
38)	26% at the time. Currently it is 30%.
378	
400	Cost excluding remote monitoring, water heater and labor
100	Labor excluding water heater and remote monitoring
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Did Solar Meet Our Expectations

- Meet power needs
- Generate hot water
- Fully charge batteries

.... without running the engine or going to a marina

Meeting Power Needs at Anchor

Estimated Daily kWh Required	
Estimated Daily kWh Generated	
Average Daily kWh Generated	

- Actual daily kWh generated is based on:
 - Includes only days while at anchor without using the engine
 - Excludes passage days and days at a marina
 - Period of time was from July through September

Hot Water While at Anchor

- Generating hot water works well at anchor:

 - It takes about 35 minutes to heat water from completely cold to hot using approximately 37 Ah 5.3 gallons of hot water typically lasts us a day or more
 - But it is not a set and forget process
- Considerations
 - Avoid running water heater outside of solar charging hours
 - Prioritize using hot water heated from the engine after moving anchorages
 - Conserve hot water a good idea for water in general when cruising!

Careful planning is required to run your water heater off an inverter

Fully Charging Batteries at Anchor

Trojan 12V AGM Motive State of Charge Specs

Percentage Charge	Minimum V	
100%	12.84	
75%	12.54	
50%	12.24	
25%	11.94	
0%	11.64	

Minimum voltage never went below 12.25 while at anchor

Living with Solar

- Mid to late morning:
 - Run water heater
 - Charge other batteries such as devices, electric dinghy battery, tool batteries, etc.
- Overnight:
 - Turn inverter off
 - Try to avoid extended use of heavy power usage devices such microwaves
- Keep an eye on battery levels and charging cycles
- Rinse the panels off every once in awhile
- Be flexible!

