Solar Power System Details

Sunday, July 1, 2018

Installed 5/22/2017:

Solar Panel, Renogy, 100 W, 12V, MonoXstal
Solar Charge Controller, Renogy 40A Commander MPPT
Tracer Meter MT-50 for Commander controller
Battery, Deep Cycle, AGM, 12V, 100AH
40A ANL fuse set and 20A ANL Fuse set
Cable kit, 20 inch, 10-AWG, for charge controller to battery
2pc 1/0 AWG Cables Battery to Inverter 3 ft, 5/16 lugs

Controller has two green LEDs and 1 Red button:

Left LED = PV indicator (flashing is charging, solid is low voltage, Off is not charging, orange or red is a problem)

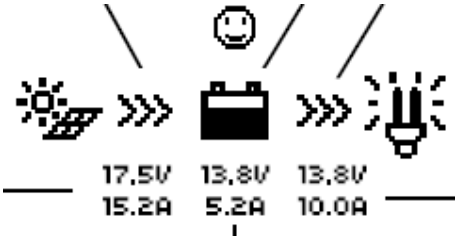
Right LED = Battery indicator (flashing is charging, solid is fully charged, orange or red is a problem)

Red Button is a combination indicator & switch for the Load or Power OUT. Illuminated is Power ON, dark is Power OFF. Pressing this button (or the OK button on monitor) will toggle this switch.

Tracer Meter

Button	Function
Esc	Access Main menu
Left	previous secondary screen
Up	previous info screen
Down	next info screen
Right	next secondary screen
OK	Choose an option

Default Screen



▼ Down arrow
VS2024BN
Jan-01-2015
04:40:44

▼ Down arrow
Charge Energy Screen
Day: 0.00 kWh
Month: 0.00 kWh
Total: 0.05 kWh

►Right arrow

Day = kWh since midnight
Month = kWh for the current month
Total = kWh since battery was last powered off

Battery Charging Characteristics for UB121100 (set via MT-50 Monitor):

Parameter	Setting
Battery Type	Sealed

AH	110AH
Temp Comp Coeff	? mV/°C/2V
Rated Voltage	12 V
High Voltage Disconnect	16 V
Charging Limit Voltage	15 V
Over Voltage Reconnect	15 V
Equalization Voltage	14.6 V
Boost Voltage	14.4 V
Float Voltage	13.8 V
Boost Return Voltage	13.2 V
Low Voltage Reconnect	12.6 V
Under Voltage Recover	12.2 V
Under Voltage Warning	12 V
Low Voltage Disconnect	11.1 V
Discharge Limit Voltage	10.6 V
Equalization Duration	2 h
Boost Duration	2 h

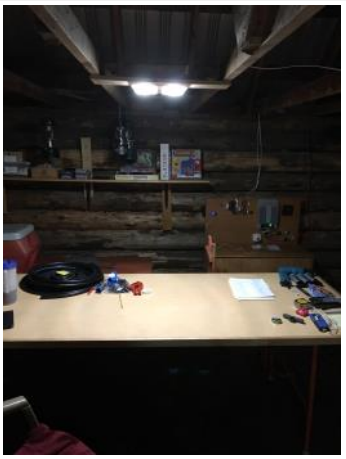
Discharge Energy
Day: 0.00 kWh
Month: 0.00 kWh
Total: 0.05 kWh

LED Dome Lights

LED RV Double dome light, 12V, switch: on, both, off

half power = 0.32A x 12V = 4W
full power = 0.64A x 12V = 8W

Duty cyle = 4 hours / night
Max load = 320 mA / Light x 2 lights/dome x 2 domes
= 1.28 A x 4h x 12 V = 60 Wh



LED RV Double dome light, 12V, switch: on, both, off

half power = 0.32A x 12V = 4W
full power = 0.64A x 12V = 8W

CPAP

12 V
0.2A min when off but plugged in

2.0A max when on without humidifier

2 A x 12 V = **<u>24</u> Wh/hour of usage**

<u>USB Charging for iPhone & iPad</u>

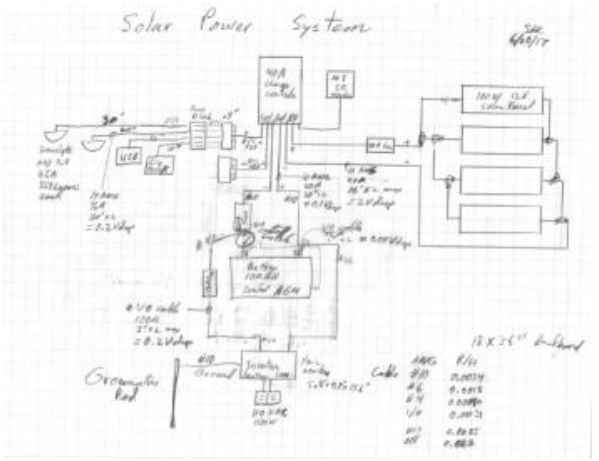
iPhone: 1560 mAh
Max Charging rate = 0.4A
0.4A @ 12V x 3.9h = 1560 mAh
1560 mAh x 12V = **19 Wh/charge**

iPad: 7340 mAh
Max charging rate = 1.5A
1.5A @ 12V x 4.9h
7340 mAh x 12V = **88 Wh/charge**

Estimated typical usage per day:

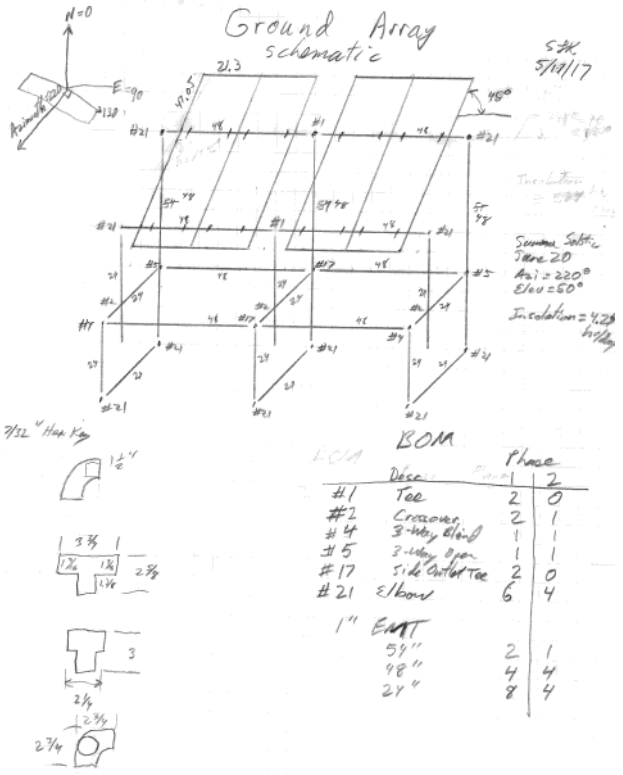
CPAP: 240 Wh
iPhone: 19
iPad: 88

Total = 347 Wh



Cliff Camp
36 58' 56"N = 36.9822 N
118 58' 20"W = 118.9722
alt = 6500 ft

Panel Slope	50	deg	RE	Elevation of panel's normal from horizon
Panel Azimuth	210	deg	RA	
Summer Solstice		20-Jun		
Cliffs block sun in morning until elev >				20 deg
Trees partially shade roof until solar Azi >				90 deg



Spring Equinox	Mar 20
Summer Solstice	June 20
Fall Equinox	Sept 22
Winter Solstice	Dec 21

Power Requirements

LED Dome Lights

320 mA / Light x 2 lights/dome x 2 domes = 1.28 A
Duty cyle = 4 hours / night
1.28 A x 4 h = 5.12 Ah/day
5.12 Ah x 12 V = 61 Wh/day

USB Charging for iPhone & iPad

iPhone: 1560 mAh
Max Charging rate = 0.4A
0.4A @ 12V x 3.9h = 1560 mAh
1560 mAh x 12V = **19 Wh/charge**

iPad: 7340 mAh
Max charging rate = 1.5A
1.5A @ 12V x 4.9h
7340 mAh x 12V = **88 Wh/charge**

CPAP

0.2A min when off but plugged in
2.0A max when on without humidifier

10 hr x 2 A = 20 Ah/night x 12 V = **240 Wh/day**

Refrigerator/Freezer

Kenmore model 60412, 18 cu ft,
rated: 404 kWh/yr = 1100 Wh/day
120VAC 6.0 A
22% duty cycle
0 W min - 140 W max

Avg 18.5 kWh/month / 30 days = avg 617 Wh/day
617 Wh / 24 h = avg 26 W
26 W / 22% = avg 118 W when on

Cliff Camp Insolation

36 58' 56"N	36.9822		
118 58'20" W	118.9722		
Elevation	6500	ft	
Roof slope	45	deg	
Azimuth of roof line	77	deg	
Panel Slope (elev. of panel's normal from horizon)	50	deg	PE
Panel Azimuth	210	deg	PA
Summer Solstice	20-Jun		
Fall Equinox	22-Sep		
Cliffs block sun in morning until elev >	20	deg	
Trees partially shade roof until solar Azi >	120	deg	

Calculated Values

20-Jun				22-Sep
Azimuth Panel normal	Elevation Panel normal	Insolation (hours)		Insolation (hours)
180	65	2.72		4.95
200	60	3.48		5.41
210	50	3.92		5.54
220	45	4.45		5.68
230	45	5.1		5.42
240	45	5.58		5.16
250	45	5.88		4.74
260	45	5.98		4.35
270	45	5.94		3.81
280	45	5.82		3.25

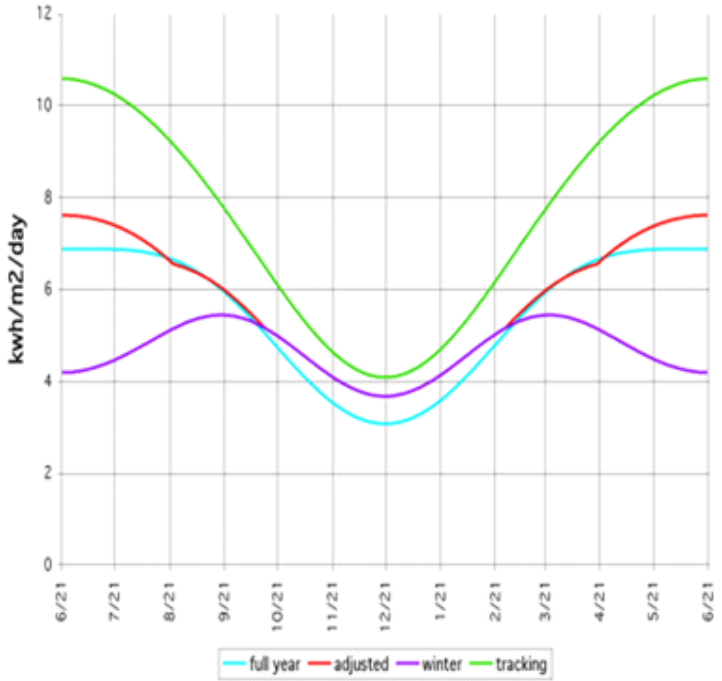
Solar Insolation

Time PDT	Solar Azimuth	Solar Elevation	Δ Azi Solar - Panel	Δ ele Solar - Panel	incidence angle from panel normal	Insolation
	SA	SE	A = SA - RA	E = SE - RE	IN = $\sqrt{(A^2 + E^2)}$	I = cos(IN)
	deg	deg	deg	deg	deg	%
5:00 AM	54	-7	-156	90	90	0%
6:00 AM	63	3	-147	-47	90	0%
7:00 AM	71	14	-139	-36	90	0%
8:00 AM	79	26	-131	-24	90	0%
9:00 AM	87	38	-123	-12	90	0%
10:00 AM	97	50	-113	0	90	0%
11:00 AM	110	61	-100	11	90	0%
12:00 AM	134	72	-76	22	79	19%
1:00 PM	182	76	-28	26	38	79%
2:00 PM	229	71	-19	21	28	88%

3:00 PM	251	60	41	10	42	74%
4:00 PM	264	49	54	-1	54	59%
5:00 PM	273	37	63	-13	64	43%
6:00 PM	281	25	71	-25	75	25%
7:00 PM	289	13	79	-37	87	5%
8:00 PM	293	3	83	-47	90	0%
9:00 PM	307	-8	97	90	90	0%
					Total	5.64 hr/day

Fixed Tilt	use the latitude, times 0.76, plus 3.1 degrees.
Twice Yearly	best tilt angle for summer is the latitude, times 0.93, minus 21 degrees best tilt angle for winter is the latitude, times 0.875, plus 19.2 degrees.

Seasonal adjustment:
For summer, take the latitude, multiply by 0.92, and subtract 24.3 degrees.
For spring and autumn, take the latitude, multiply by 0.98, and subtract 2.3 degrees.
For winter, take the latitude, multiply by 0.89, and add 24 degrees.
The graph below shows the effect of adjusting the tilt. The turquoise line shows the amount of solar energy you would get each day if the panel is fixed at the full year angle. The red line shows how much you would get by adjusting the tilt four times a year as described below. For comparison, the green line shows the energy you would get from two-axis tracking, which always points the panel directly at the sun. (The violet line is the solar energy per day if the panel is fixed at the winter angle, discussed below.) These figures are calculated for 40° latitude.



A zero tilt angle means that the face of the panel is aimed directly overhead. A positive tilt angle means that the panel faces more towards the equator. In the northern hemisphere that would mean tilting so it faces towards the South. Rarely, the tilt angle can be negative; this means the panel faces away from the equator.
The recommended angles can seem counterintuitive. For example, consider summer at 40° latitude. At noon on the solstice, the sun is 40° - 23.5° which is

16.5° from directly overhead. To capture the most sun at that time you would tilt the panel 16.5° to point it directly at the sun. On other days of the summer it is a bit lower in the sky, so you would want to tilt the panel a bit more. Yet we say to tilt it only 12.5°. The sun is ne ver that high. How can that be right?
The answer is that we are considering the whole day, not just noon. In the morning and evening, the sun moves lower in the sk y and also further north (if you are in the northern hemisphere). It is necessary to tilt less to the south (or more to the north) to collect that sunligh t.