Emergency Power for Ham Radio

Eastern Pennsylvania Amateur Radio Association
& Monroe County ARES/RACES

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Emergency Power for Ham Radio Presentation Overview

- Power source types
- Power need assessment
- Batteries and Charging / Discharging
- Solar cell systems
- Example Ham Emergency Power Systems

Electrical Power Sources

Power Source	Input	Output	Comments
Small Batteries		1.5VDC – 9VDC	Single Use, Alkaline, Lithium
Small NiMH batteries (rechargeable)	Battery Charger	1.2VDC – 9VDC	Available in AAA, AA, C, D, 9V, Good value
Storage battery	12VDC	12VDC	Battery bank workhorse High storage capacities
Generators	Fossil fuels, Wind	120/240 VAC / 12VDC	Gasoline, diesel, natural gas/propane. Wind (Generally unreliable)
Solar cell system/arrays	Sunlight	12VDC- 96VDC	Ideal for small/moderate power tasks (ham station power)

Power Failure,
The Grid-Down Scenario

- Planning for a power “grid-down” situation
- Several possible natural and man-made causes for a 3 day to Multi week or month grid-down scenario
- Longer duration outages created by loss of key power system transformers
- These transformers are very large, specialized equipment, typically foreign-made, with long manufacturing and delivery lead times up to 1 yr or more
- Experts unanimously agree that our aging power grid is at some risk for extended grid-down scenarios

Power Need Assessment: Equipment to be Powered

- What equipment might you want to power?
  - Handheld transceiver (HT), VHF/UHF and HF base radios
  - Radio system accessories (tuners, rotors, remote antenna switches)
  - Radio shack lighting
  - Other household equipment
    - Flashlights, room lighting, battery chargers
    - Portable electronic devices, AM/FM radios, Televisions, Computers
    - Basic refrigeration, Cooking, Medical Equipment

Power Need Assessment:
What Duration of Emergency Power is Needed?

- 1 to 3 days (batteries, car powered recharge systems)
- 3 days to 3 weeks (batteries, moderate-volume fuel storage, liquid or gaseous fuels, generators, solar)
- 3 weeks to 3 months (batteries, large volume fuel storage, gaseous fuels, generators, solar)
- Simple way to measure electrical power consumption of equipment: Kill-a-Watt Measurement tool, DC power analyzer
    - Measures total energy consumption over an arbitrary duration. Invaluable for emergency energy planning, very reasonably priced.

Power Need Assessment:
What Duration of Emergency Power is Needed?

Example Simple Battery Bank Calculation for Ham Shack (3 day scenario)

Ham Shack Deep Cycle Battery Amp-Hour (AH) Capacity

- Average HF radio operating in receive mode 8 hours/day, with 20% transmit duty cycle (96 minutes/day transmit). Assume 1.5A receive current, 20A transmit current.
- Ah Requirement = 12Ah (receive) + 32Ah (transmit) = 44 Ah/day.
- 3 days = 132Ah, 3 weeks = 924 Ah, This means you need 3 100 AH batteries to last 3 days and 19 100Ah batteries to last 3 weeks.

Lead-acid vs. Lithium Battery Comparison

Lead-acid batteries cost much less up front, Lithium batteries are much more expensive up front.

Lithium batteries (Lithium Iron Phosphate, LiFePO4) are more efficient, can be discharged to a greater depth, have a much longer life span, and are much lighter.

Although they are by far a superior battery technology they cost 3 to 4 times as much as lead acid batteries.

This price point makes LiFePO4 batteries less desirable for entry level setups.

Example: 300 Ah battery bank, FLA = $330 SLA/AGM = $450 LiFePO4 = $1850

Lead Acid Storage Battery Characteristics

- The Amp hour rating on lead acid batteries are for the complete capacity of the battery.
- The recharge cycle life of a battery greatly drops as you discharge it below 50%, it is recommended to avoid discharging beyond this point to extend battery life.
- So the ideal usable capacity of a battery is about half of its rated capacity. A 100 Ah battery really only has 50 Ah of capacity.
- In an emergency go beyond a 50% charge if you must, but realize you are greatly shortening the life of your batteries.

Lead Acid Storage Battery Characteristics

- Flooded (water caps - need occasional maintenance, also have maintenance free)
- Starter batteries (like in your car)-optimized for high current but not deep cycling-
- Use the one in your car if necessary but AVOID as a dedicated backup unit!
- Deep cycle marine batteries - better optimized with thicker plates for deep cycling

Lead Acid Storage Battery Characteristics

- "Golf cart" -very thick plates highly optimized for deep cycling relatively inexpensive.
- Sealed Lead Acid (SLA), Absorbed Glass Mat (AGM),
- Sealed, Little or no "gassing", no spilling hazard. Great for indoor use, more expensive then flooded batteries.
- Gel batteries, sealed, little or no "gassing", no spilling hazard. Great for indoor use, most expensive. Gel batteries have a lower discharge and charging current capacity.

Lead Acid Storage Batteries

- Flooded Lead Acid

Sealed Lead Acid

- Gel Type

Amp Hour Ratings

- Battery Ratings: Ah (usually 20 hr rating), reserve capacity = #min @ 25A current
- The standard rating is an amp rating taken for 20 hours. What this means for a 100 AH rated battery is this:
  - Draw from the battery for 20 hours, and it will provide a total of 100 amp hours. That translates to 5 amps an hour. (5 x 20 = 100). However, it's very important to know that the total time of discharge and load applied is not a linear relationship. As your load increases, your realized capacity decreases. This means if you discharged that same 100 AH battery by a 100 amp load, it will not give you one hour of run time

This is called the Peukert effect.

Lead Acid Battery Care

- Battery Charging
  - Always keep batteries charged! Best to use 3 or 4 stage charger
  - Bulk charging stage <80%, Absorption charging stage 80-97%, Float charging 97-100%

Battery Use (Discharging)

  - Ideally only discharge to >70%, discharge to 50% OK but reduces life somewhat.
  - If it's a crisis go ahead and discharge to low levels -just know that battery life is significantly reduced

Lead Acid Battery, State Of Charge

BATTERY STATE OF CHARGE			
AGM		WET	
Level	Voltage	Level	Voltage
100%	13.00	100%	12.60
90%	12.75	90%	12.50
80%	12.50	80%	12.42
70%	12.30	70%	12.32
60%	12.15	60%	12.20
50%	12.05	50%	12.06
40%	11.95	40%	11.90
30%	11.81	30%	11.75
20%	11.66	20%	11.58
10%	11.51	10%	11.31
0%	10.50	0%	10.50

Solar Cells, Modules and Panels

3 Key Types of Solar Cells, Monocrystalline (eff 15-22%)

Polycrystalline (eff 13-16%), Amorphous Thin Film (eff 6-14%)

Solar cell produces ~0.5 – 0.6 V. Solar Panels typically contains 36+

solar cells in series and parallel to achieve ~ 18V – 22V into open circuit (“12 V” module)

Solar Panel Systems are created by parallel and series connections of Panels

Higher cell efficiency reduces panel area

Average cost for Solar Panels can be as low as around $1 per Watt

Solar Cells, Modules and Panels

Panels behave as a current source over a large voltage range

You can charge batteries with this current, a charge controller controls the voltage.

Key Parameters to Know:

Imx or IPM = maximum output current (A)

Output voltage at the maximum power point (~ 17 V for "12 V" panel open circuit voltage typically > 18V to 22V for "12 V" panel)

Power rating of the panel (watts) = Imx and Max Power Point

Solar Cells, Modules and Panels

windynation

clean | power to the people

100W Polycrystalline Photovoltaic Solar Panel

Part #:	SOL-100P-01
Maximum Power (Pmax):	100 Watts
Open Circuit Voltage (Voc):	21.60 Volts
Short Circuit Current (Isc):	6.32 Amps
Max Power Voltage (Vpm):	17.4 Volts
Max Power Current (Imp):	5.75 Amps
Max System Voltage:	1000 VDC (600 VDC UL)
Dimensions:	40.0" x 26.4" x 1.2" [1015mm x 670mm x 30mm]
Weight:	17.6 lbs [8kg]
Max Series Fuse Rating:	8 Amps
Nom Operating Cell Temp:	45°C [+/-2°]

TUV NORD Baumusters geprüft CE RoHS

Solar Charge Controllers

Why do we need a solar charge controller?

Solar panel voltage can be too much or too little for the battery/battery bank, either scenario can damage a battery

What does a solar charge controller do?

Maintains the battery charging voltage at the right voltage for a large range of solar panel operating conditions/voltages

Charge Controllers are rated by their maximum current handling

Premium units also automatically handle optimized battery charging and maintenance activities

Solar Charge Controllers

Conventional charge controller

- On/off, duty cycle modulation, or analog type of voltage regulator
- Output charging current = Input charging current
- Output voltage always < (or =) input voltage, not as efficient as MPPT
- System design sizing calculations most easily performed using Amp-hour computations

Solar Charge Controllers

Maximum power point tracking controller

This is essentially a power efficient DC-to-DC converter

Extracts maximum power from solar array using ~Imx at Vmpp

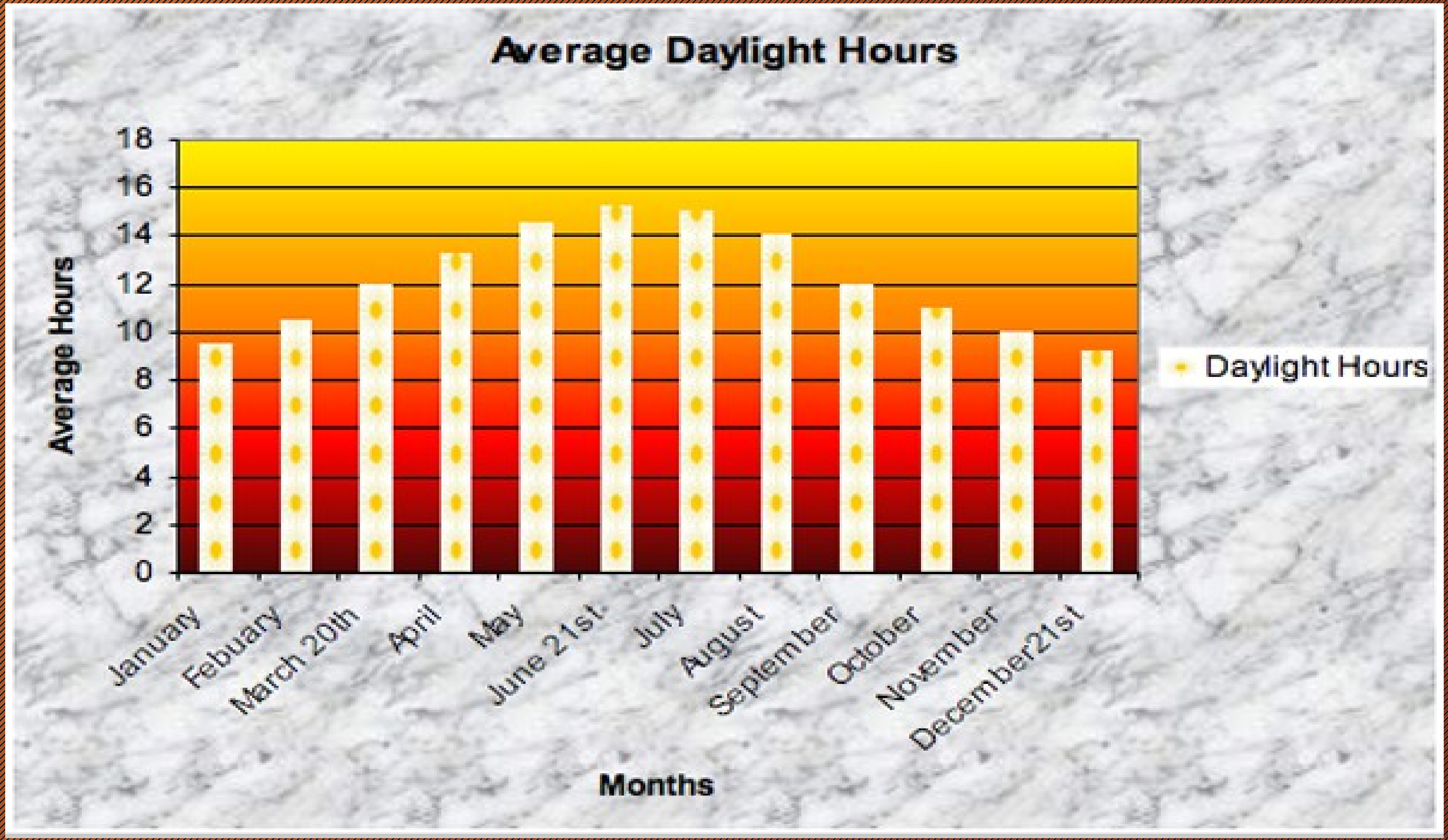
Usually handles a wide range of input and output voltages

Output current can be bigger than input current

Can support series connections / higher voltage of both solar panel and battery array

Sizing Your Solar System

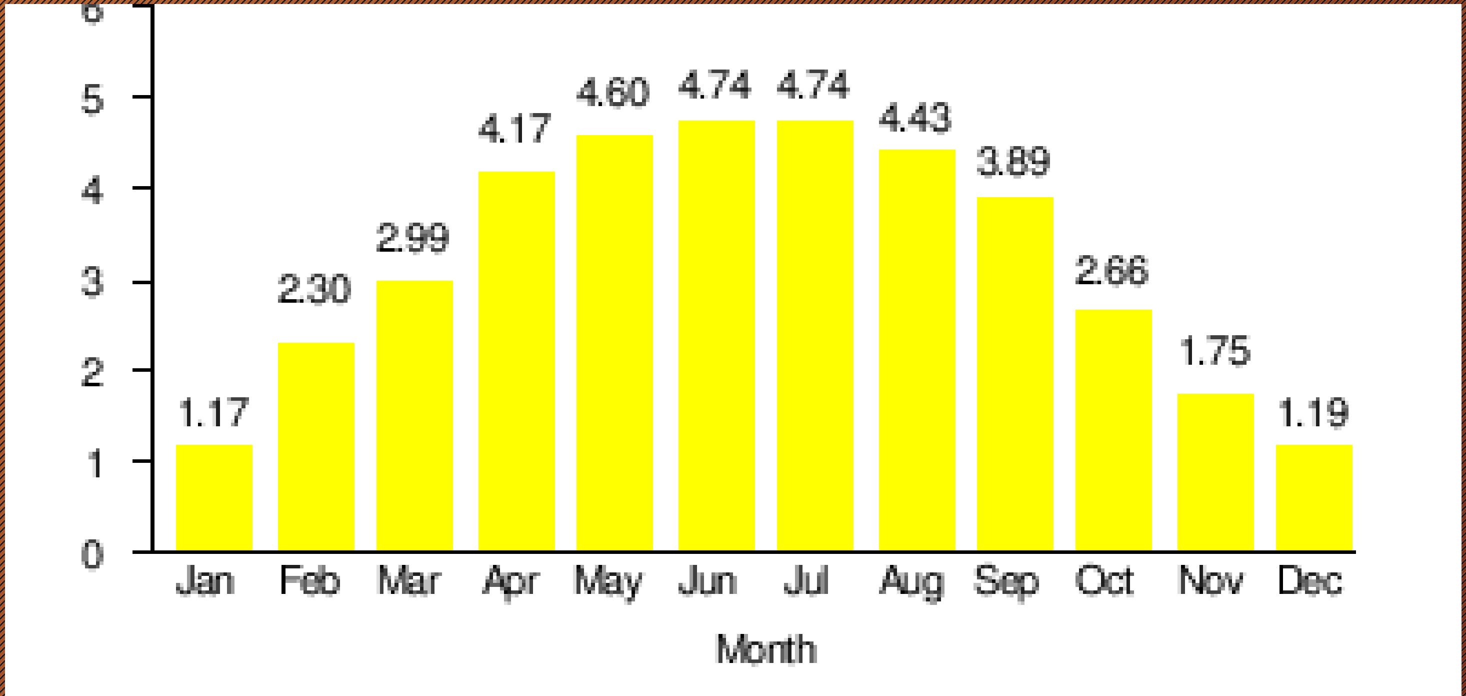
How Much Sun Do I Get



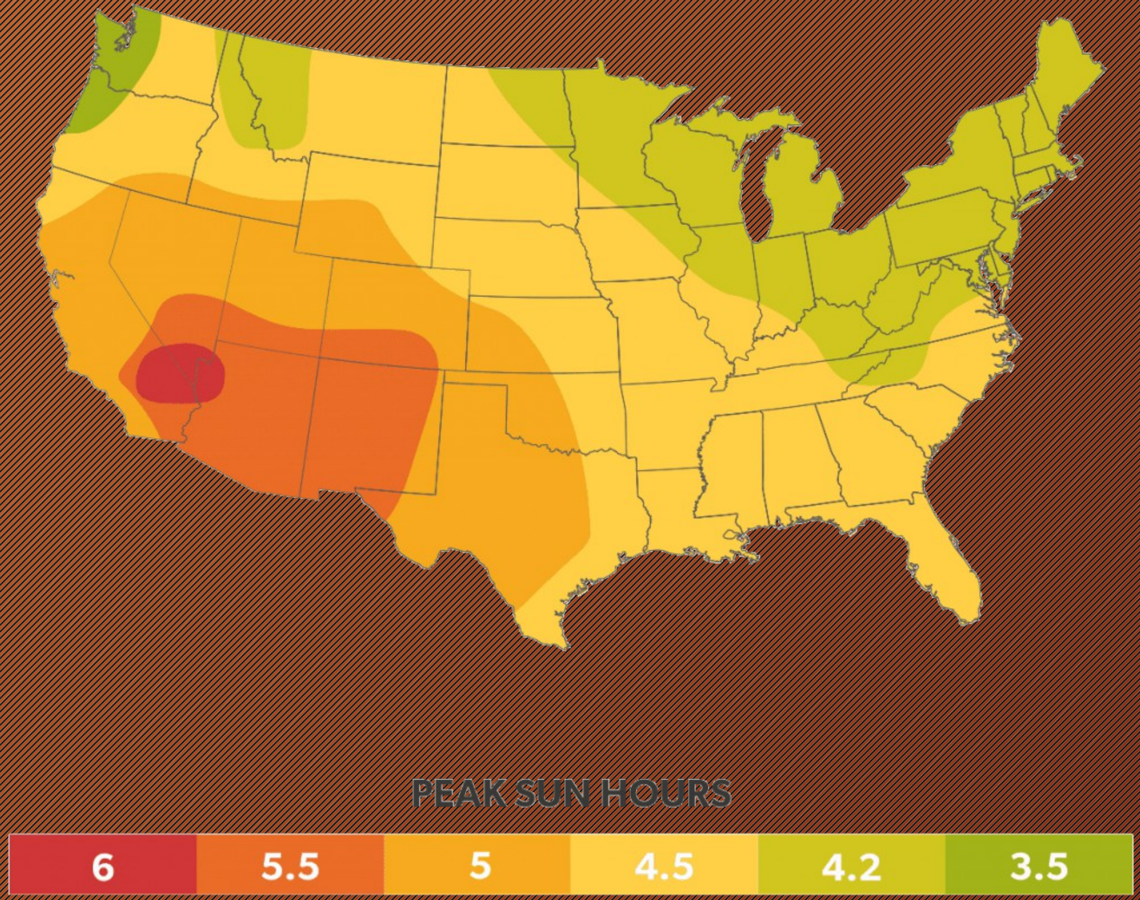
Sizing Your Solar System

Peak Sun Hours

Amount of Peak Sun Hours



Sizing Your Solar System
Average Annual Peak Sun Hours



How much power can you get?

My personal observations and measurements.

During peak sun hours my 100 Watt solar system puts out about 5 amps back into my battery bank.

During the summer I can get 40 to 50 Ah of charging on a sunny day

During the winter I can get 15 to 25 Ah of charge on a sunny day

With our earlier calculations of 44 Ah a day to run an HF station, in the summer we put back in what we use, in theory the system will run indefinitely. In the winter we put back less than half of what is used so our battery capacity is extended but will eventually run down.

By increasing the solar panel array to 200 or 300 watts we could have a reliable long term off grid system

Inverters

Converts 12 Vdc to 120 Vac (Modified Sine and True Sine Wave)

Modern inverters provide 120 Vac and 5 Vdc USB outputs

Inverters use some standby current even when unloaded

Inverters have ~ 80% - 85% conversion efficiency when loaded

Maximum efficiency for various loads is obtained by having a few inverters of different powers tailored for specific load levels

Try not to use a bigger inverter than you need for the specific job

12V Inverters utilize large DC input currents-must use BIG cables

Inverters

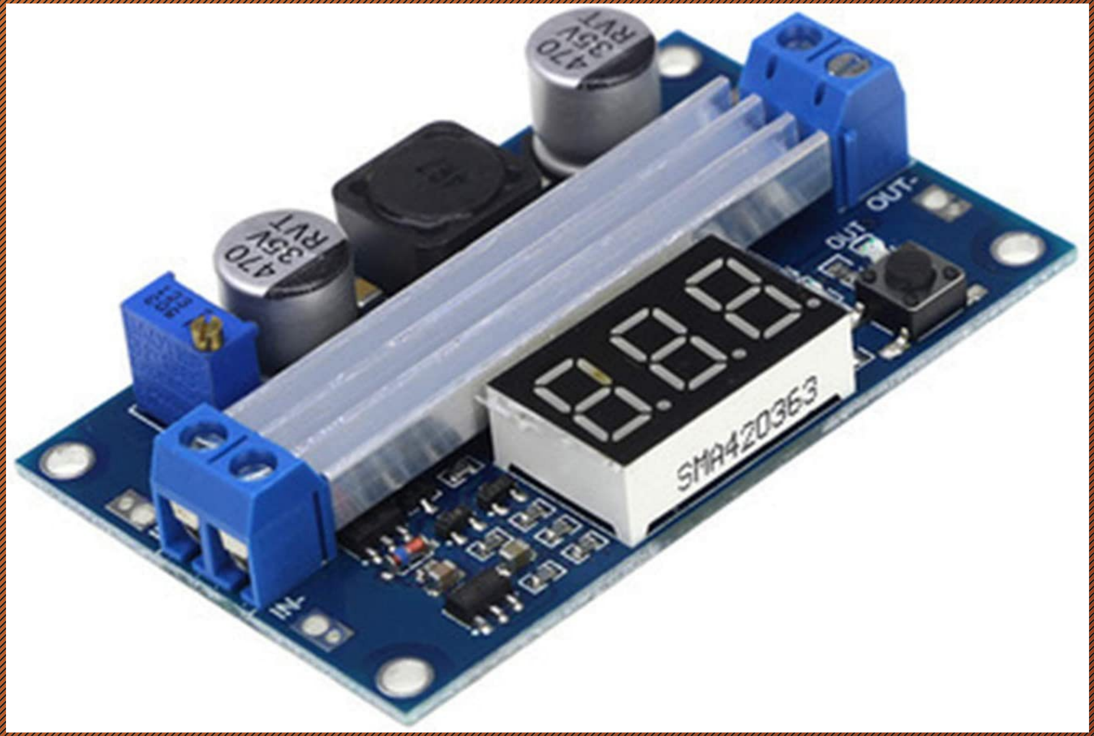
Most amateur radio equipment is designed for 13.8 volts.

Inverters add inefficiency to your system, Inverters are also prone to creating RF hash on the HF bands.

For these reasons use of inverters should be avoided. Use 12v lighting, use laptop computers, Raspberry Pi, or tablets for digital modes.

Power laptops, Raspberry Pi's, and tablets with 12vdc by using DC to DC converters.

DC to DC or “Buck” Converters



Power Conservation.

Turn off anything your not using. (Duh)

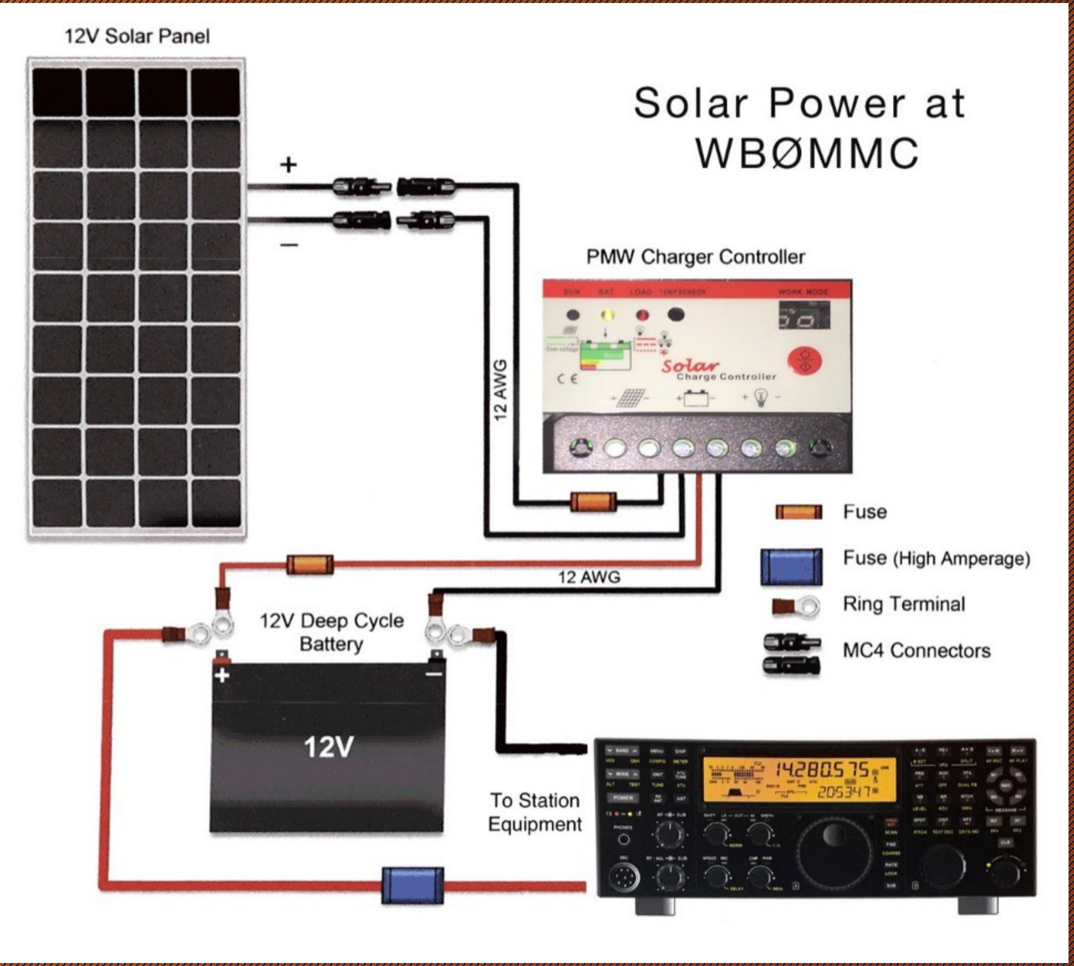
Turn off screens and back-lighting when possible.

Reduce RF power! Remember 25watts as opposed to 100 watts is only 1S unit less!

Use the most efficient antenna system you can. Low loss coax, and full sized antennas when possible.

Your system may end up being unable to meet your needs. Remember to have a plan B for power, 1 is none 2 is 1!

Typical Setup



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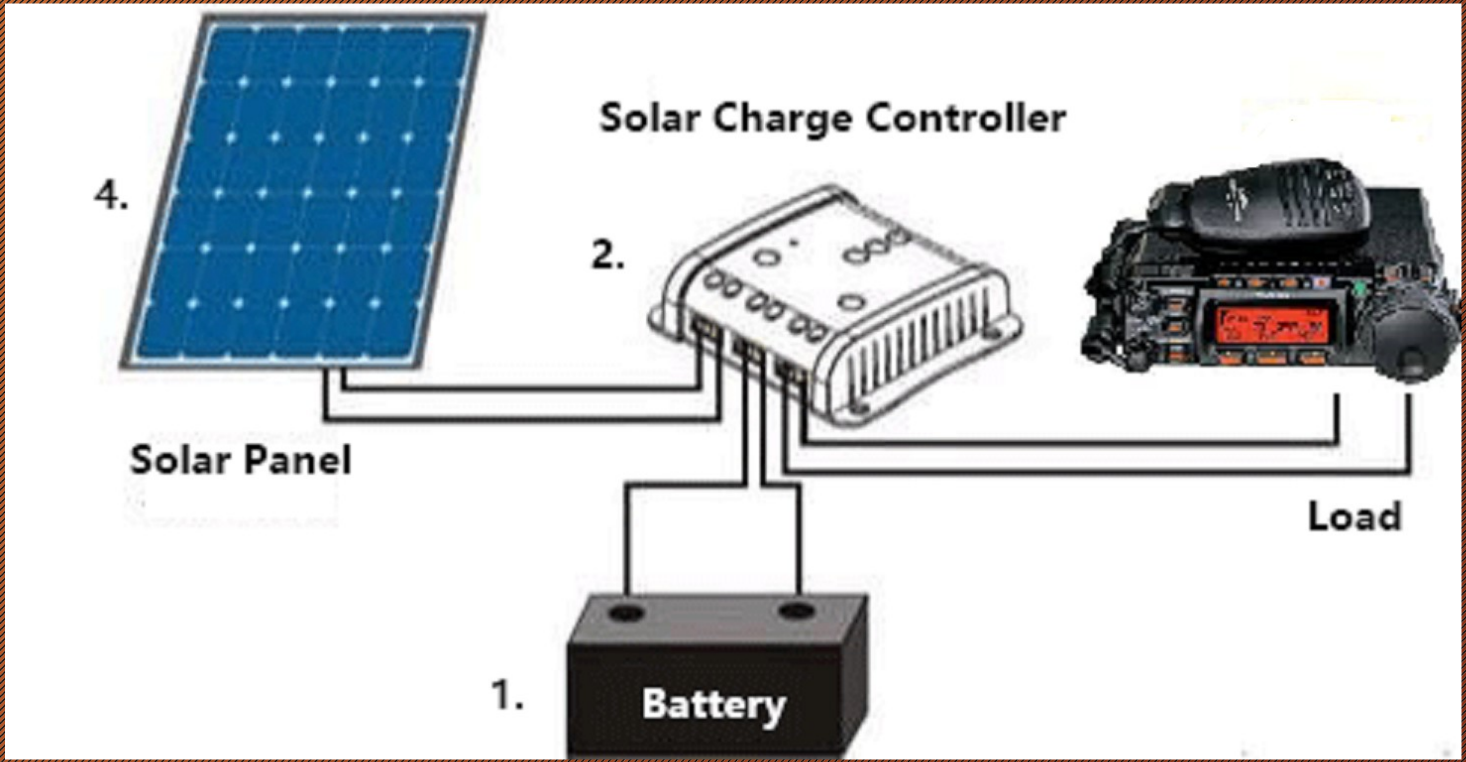
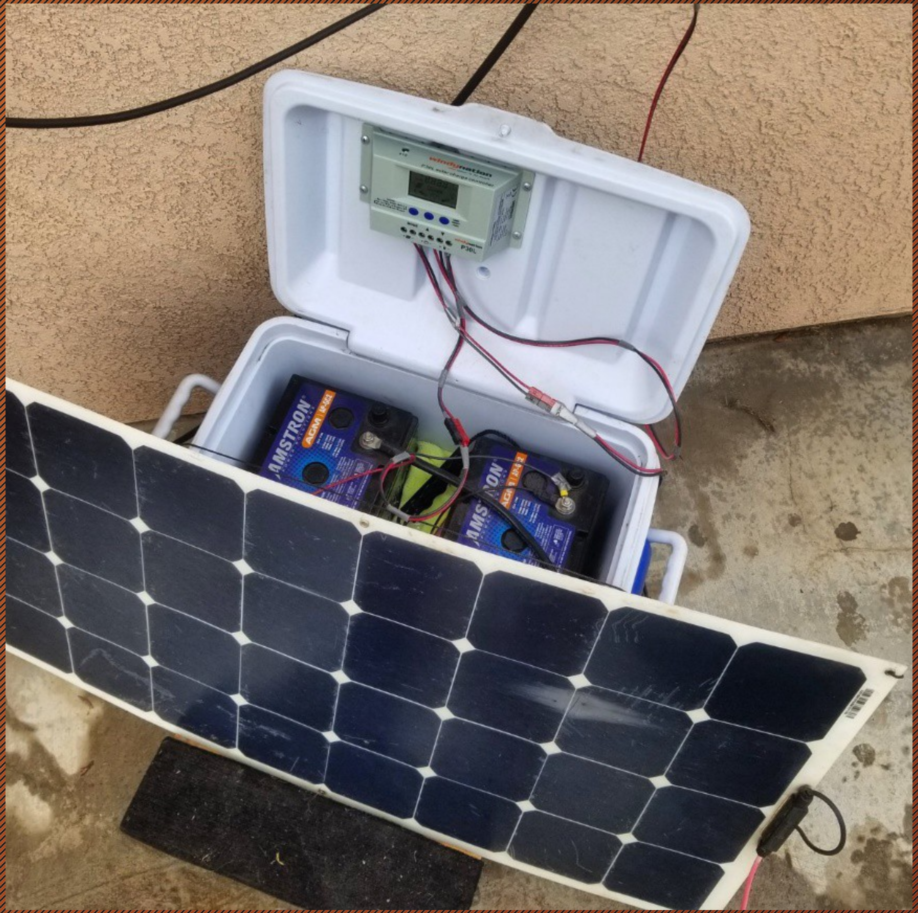


Some Ham Made Systems



Some Ham Made Systems

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Some Ham Made Systems

My First Solar System
Made over 5 HF SSB contacts at 20W FD 2016

My First Solar System

Made 0ver 5 HF SSB contacts at 20W FD 2016

And If You Want to run Legal Limit…….

The End