Do-it-yourself Emergency Solar Power
Reference: *Off Grid Solar Power for Beginners*, DIY Source, 2021

https://www.youtube.com/watch?v=ydwbUDSgRPU

What are you trying to achieve?

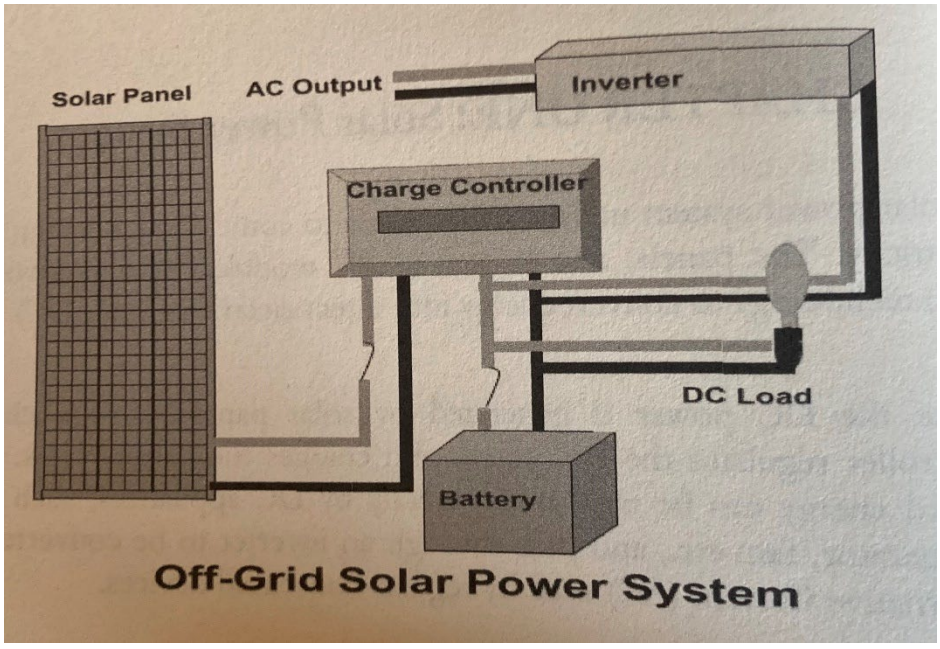
- Year-round, full-time solar with no batteries. This is the typical system to reduce the annual cost of electricity. When commercial goes out, so does your power generation. This is what most people have.

- Year-round, full-time, solar generated electricity with batteries?
  - You'll need to hire a solar installation company to design this and it will be very expensive.
  - The EMA office has a year-round, off-grid-capable solar system. We are still tied to the grid to sell back excess electricity that we generate.
  - Depending on your home size and power use, it could cost between $40,000 and $100,000.

- Short-term, emergency back-up electrical power when the grid goes down (or a tiny home with low power consumption).

What is a Solar Power System?

A solar power system utilizes solar panels to convert solar energy into electricity. The panels, also known as photovoltaic or PV modules convert energy into DC current.



The panels transmit the DC electricity to a solar charge controller that charges 12-volt batteries. You can operate DC electrical devices directly off the battery or convert the power to 120-volt AC power using a step-up inverter.

Solar panels are made up of a number of solar cells. Solar panels can be grouped into solar arrays.

An emergency backup power solar system can be permanently mounted or set up as needed in a temporary situation. It will all depend on the scale of your power requirements and your end game. Do you want the convenience of it to be set up permanently and ready on demand? Do you want to make it mobile? Do you want to protect it from damage by hail or damaged trees, or stolen by thieves? Do you want to protect it from EMP?

Do you mount it on the roof? (Don't mount your panels on an old roof). Do you mount it on racks on the ground? Do you set up the system on the ground when you need it?

Steps to Set up an off-grid Solar Power System

1. Determine what your power needs are. The size and cost of the system will be based on what is needed and limited by what you can afford.

2. Size the battery bank according to your final determined need.

3. Size the solar panel array based on the battery bank capacity.

4. Select the charge controller that will handle the solar array's maximum current.

5. If you need AC power, select an inverter based on the battery bank's nominal voltage and the continuous and peak power usage.

6. Select the proper wire gauge and overcurrent protection.

7. Mount or set up the solar array/panels.

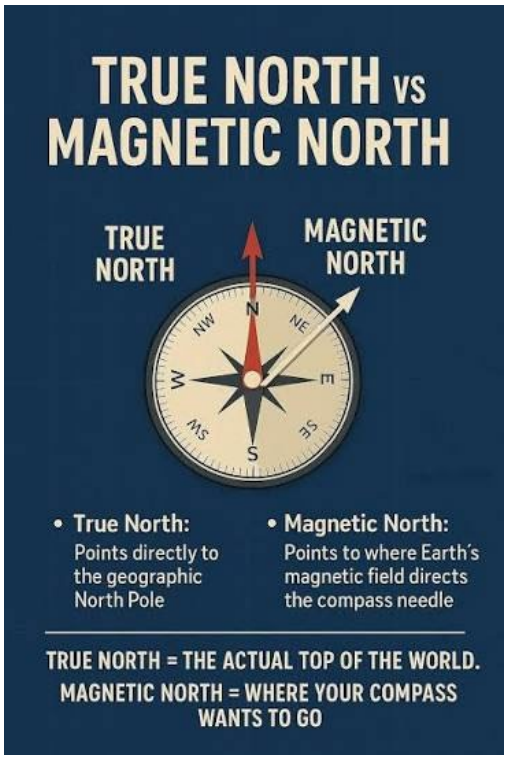
8. Connect the charge controller to the battery and solar panels to the controller.

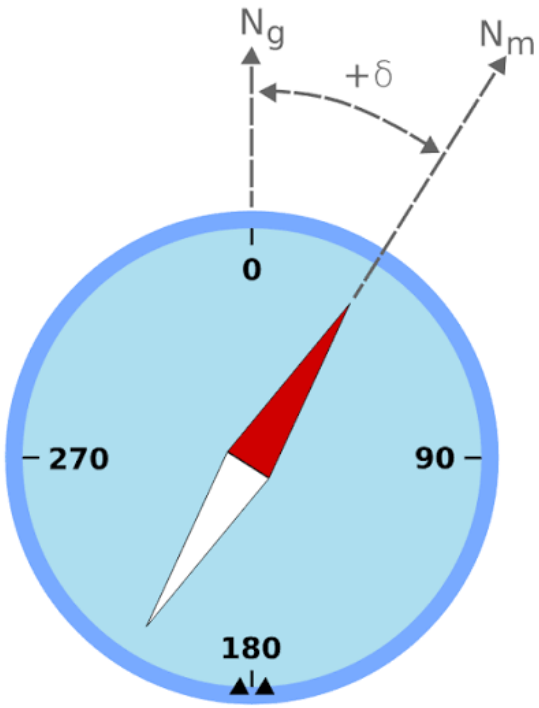
9. Connect DC devices to the battery and AC devices to the inverter.

Solar Panels

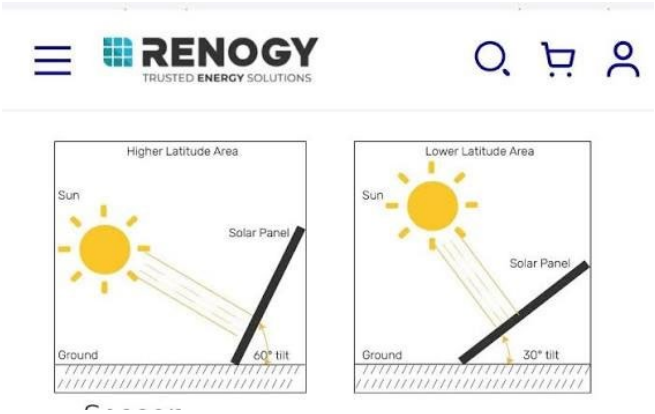
Place your solar panels facing True south. If you use a compass, face the panels about 15 degrees to the west. For Westerly Declination, add the declination to the true reading to obtain the magnetic reading.

Magnetic = true + westerly declination so True South = 180 – 15 = 165 degrees.

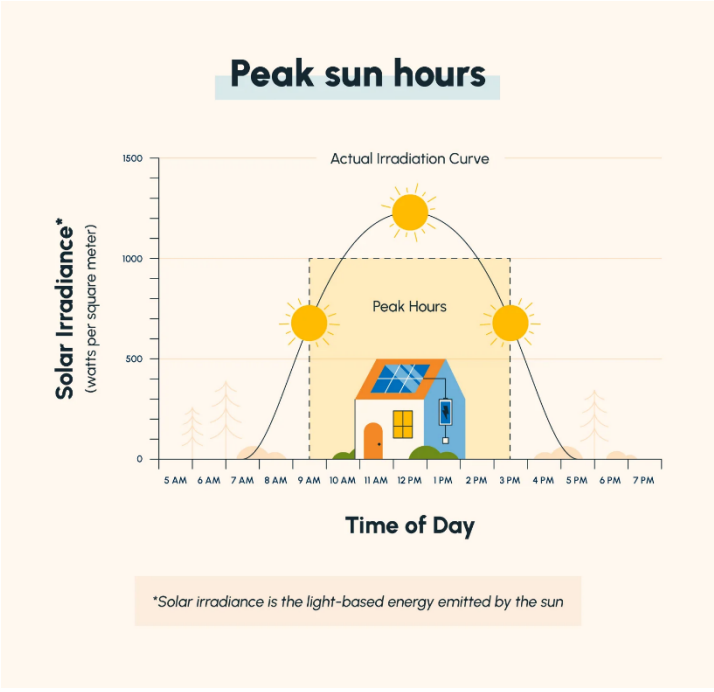




Tilt the panels at the same angle as your Latitude. In our case, the panels should be tilted at a 45-degree angle.

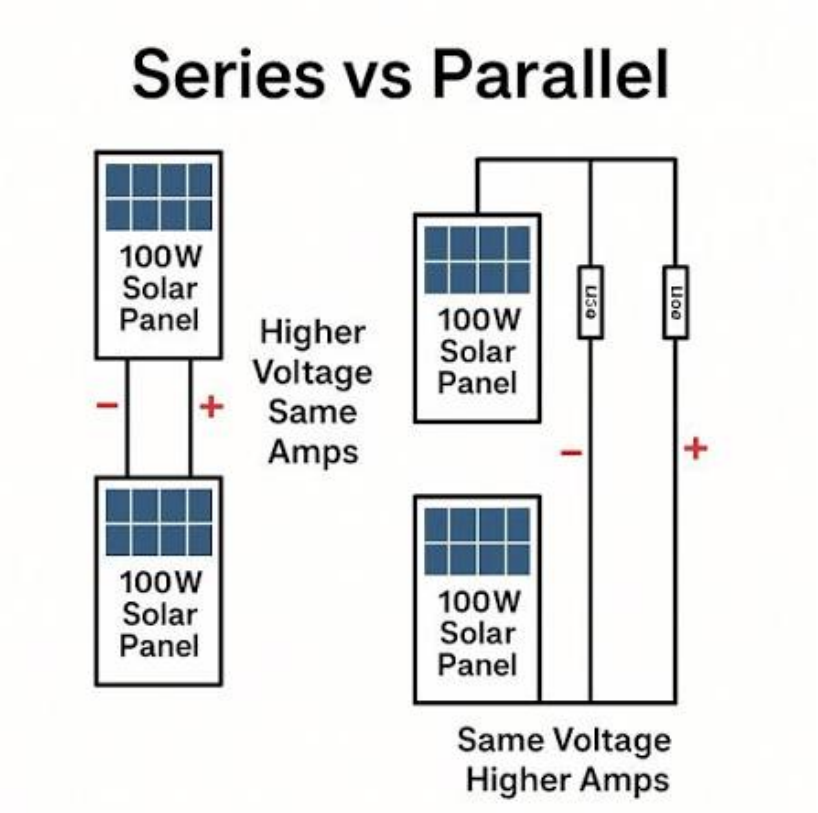


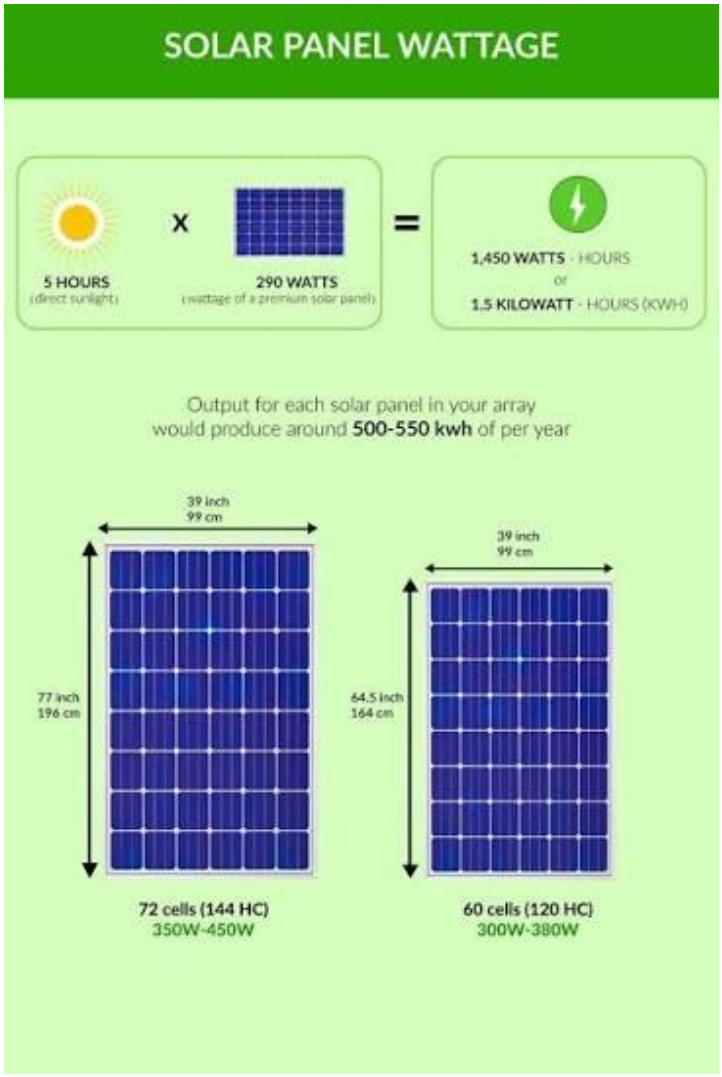
On an annual basis, Maine gets about 4.55 peak solar hours a day of 1000 watts/sq meter. July averages the highest with 6.13.



Multiple panels should be connected in series. Connecting four 100-watt, 5-amp, 12-volt panels together will result in a 48-volt, 5-amp solar array that generates 400-watts. By keeping the amperage down, it reduces the size of wire we need to use.

If you need more than four panels, you will then want to connect the groups of arrays in parallel, to keep the voltage from getting too high. Since we are looking at an emergency setup of solar panels, we shouldn't have to worry about too many panels.





A 100-watt solar panel is going to generate 100-watts/hour in a perfect world. However, we are not operating in a laboratory, but in the real world. Assume it will generate 75 watts/hour for 6 hours. It would generate 450 watt/hours per day.

Solar Charge Controller

The controller regulates voltage and current from the solar array. The controller is connected to the panel array on one end and the battery(ies) on the other end. They protect batteries from overcharging and over-discharging. The batteries could overcharge at peak solar generation at noon or at night when no solar electricity is generated, the batteries could drain and push current to the panels.

DC appliances would be connected to the battery, not the controller. Even better would be to have a DC Fuse box between the battery and the appliance.

You will want to follow the specifics directions of the controller manufacturer. Each controller make and model is different.

Deep Cycle Batteries

There are several types of batteries, lithium-ion and lead acid (wet-cell, sealed, VRLA, AGM, and gel). They all have differences in charging and discharging. It is best to research what works best for you and what you can afford. Follow the manufacturer's instructions.

Sizing an off-grid Solar System

1. Need to know your daily power consumption
2. List your needed AC and DC appliances

Remember, this is for emergencies. If you want to power everything in your home, you should probably hire a Solar System Installer. You are probably looking at $25,000 to $75,000 depending on your household consumption. Try to limit your consumption during emergencies. Use battery operated devices or manual workarounds whenever you can. Examples – windup clock, AA battery FM radio, gas BBQ, hanging your clothes out to dry, wash dishes by hand, etc.

ENERGY USAGE / LOAD TABLE				
Small home System 3 kW				
APPLIANCE	QUANTITY	POWER (WATTS)	HOURS OF USE	ENERGY (Wh)
Fridge / freezer 400L	1	50	24	1200
Lighting	3	30	4	360
Fans	2	75	4	600
Kettle	1	2000	0.05	100
Lcd TV 100cm	1	100	3	300
Video / Audio	1	150	2	300
Computer - Laptop	1	150	3	450
Computer - Desktop	1	130	3	390
Microwave	1	1000	0.25	250
Hotplates - GAS	0	2500	0	0
Oven - GAS	0	2500	0	0
Hot water - GAS	0	200	0	0
Toaster	1	1000	0.1	100
Hairdryer	1	1200	0.1	120
Phone charger	2	50	1.5	150
X-Box / Playstaton	0	200	3	0
I-Pad charger	1	100	3	300
Water pump	1	700	0.5	350
Septic pump	0	100	4	0
Septic Aerator	0	25	24	0
5 kWh daily usage			Total	4970

Appliance	Power (watts)	Duration (hours)	Energy Consumption (watt-hours)
Submersible Water Pump	1000	30 minutes *	500
Cell Phone Charger	10	4	40
Small College Refrigerator	100	8 avg	800
Lights	20	8	160
* Severely conserving water in emergency		Total	1500

Divide the 12-volt battery into 1000-watt hours = 125 amp-hours. Assuming that every day is not going to be sunny, assume 150 to 200 amp-hours. A typical size lithium-Ion battery is 100 amp-hours. Would probably want a couple of batteries.

If your solar panel generates 450 watts-hours per day, you will need at least 4 panels to generate 1500 watts-hours.

Off-grid Inverter

The inverter converts the 12-volt DC power into 120-volt AC power at about 80-90 percent efficiency. This is for those appliances that require 120-volt Ac. You want a Pure Sine-Wave (PSW) Inverter. It is more expensive, but it is far less likely to cause damage to your appliances. Make sure the inverter voltage matches your battery voltage. If you have 12-volt batteries, you will want a 12-volt inverter.

You will want to determine the Continuous Power rating and Peak Power rating to determine if it will work with your appliance. For example, when the water pump kicks on, it will surge. You need an inverter that is higher then that surge.

Resources

MPP Solar: https://www.mppsolar.com/v3/system-sizing/
Renogy: https://www.renogy.com/
Powerwerx: https://powerwerx.com/solar-portable-power