Tech Corner:

Solar Power—green, quiet & tax-deductible

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A solar system allows you to keep your batteries charged and run your lights, fans, radios, water pumps, recharge your phone, run a tv or computer, power your electric or hydraulic jack, open and close slides and awnings—all without a generator. Some appliances that are 120-volt will require an inverter, and rooftop ACs can't be run on a horse trailer.

Solar systems should be designed in advance, not piecemeal, although you can design some expansion into your system up front. The information below is for a 12-volt system.

Solar System Design

1.The most important part of the system is the batteries. Batteries store your energy and their storage capacity is measured in amp hours (Ah). The total number of Ah is derived by adding together all the Amp hours on each battery. If using 6-volt golf cart batteries, then the Ah rating is halved for a 12-volt system Ex. 2 6-volt batteries which each store 200 Ahs equals one 12-volt battery storing 200 Ahs. Currently 6-volt golf cart batteries, like the Trojan 105, are the least expensive battery type that will work.

2. **There are two main types that are used:** lead acid batteries (AGM are in that category) and lithium-ion (LI) batteries, which are lighter weight, faster to recharge, but $1000 for a 100 Ah batteries. LI (brand Battle Born) batteries build the best system, but cost about 4x as much per amp hour as T105s. Use only a deep cycle marine batteries, not a hybrid battery, nothing from Wal-Mart, and not a quick start battery for a car.

3. **You can store LI batteries inside the trailer, but lead acid batteries (including AGMs) need to be stored outside under the gooseneck**. If you're using LI batteries, because they are so expensive and do not leech chemicals like lead acid batteries, store them locked up or in your LQ. There is only room for four batteries under the gooseneck, so that is going to determine your total maximum Ah storage capacity on your trailer. On my trailer, using four 6-volt batteries, the total amp hours is 450. That's 2 sets at 6-volt at 225 Ah each. A maximum LQ setup is likely going to be 400 Ah with four LI batteries, unless you have a lot of storage space inside your trailer.

4. **Lead acid batteries can only be discharged around 50-56% without damaging them.** So, that total Ah rating above should be divided by 50%-56%. **LI batteries can be discharged to about 5%,** so 200 Ah nets you about 190 actual Ah (95% of 200.) With lead acid batteries, 200 amp hours nets you between 100 – 112 amp hours during 24 hours. **LI batteries do not charge below 32 degrees F, but can still be used.**

5. **Amp Hours to solar watt ratio: (3:2).** To keep the batteries charging fast enough to not damage them with daily use, figure at least 1.5x - 2x more wattage in your panels as available amp hours in your battery. For my 450 Ah batteries, that would be 1.5 x 450= at least 675 watts of solar. My 800 watts is better as it charges the batteries faster.

6. **A 12-volt battery will float (filled with no load on it) at slightly under 14 volts, but a 100% charged battery is 12.7 volts.** At about 12.1 volts, it is 50% discharged, and a lead acid battery needs to be recharged. At 10.5 volts, it is completely discharged. These numbers vary slightly for different types and brands.

7. **Batteries need to all be the same size, same brand, and the same age.** Batteries have this information on them. If you use a battery that is older or smaller, it will deplete the larger one. If one fails, you need to replace all of them.

8. **The panels can be mixed and matched** more easily than batteries, although it will be easier to wire and configure it if all of them are the same. **Flexible panels that can be glued to the trailer are not recommended** as they do not have airflow underneath them and will get hot and break.

9. All solar panels are made from silicon, but **monocrystalline panels are more efficient** than polycrystalline, because the silicon is purer. Monocrystalline panels have at least a 25-year lifespan and perform better in low light. High quality panels average about **$1 per watt** or even less, so buy a reputable brand.

10. **Permanently mounting panels on the roof of the trailer is the easiest location option.** They will operate as you travel, won't be easily stolen, or difficult to pack and unpack when camping.

11 The sun moves from east to west, so the trailer needs to be parked facing south so that the panels are not in shade. The panels do not work well, and in some wiring configurations will not work at all, if a part of a panel is in shade. **This means the panels need to be at the highest point on the trailer.** They should not be close to the air conditioner or the vents because of their shadows. If you have a hayrack, you may want to mount them on top of it. If you're traveling east or west, shadows will be cast on the roof as you drive.

12. The **manufacturer's drawings** of your trailer's roof design will show you exactly where your air vents, air conditioner, fan vents, are on the roof. This is helpful in selecting your panels, as they come in different sizes. **It is both cheaper and easier to wire if using fewer larger panels versus several smaller ones, but it may not be possible because of the air vents.** You can also buy taller brackets for the panels, which would raise them up several inches and that would allow installation above an air vent. I used eight 100-watt panels. We laid out cardboard to determine how long the shadows would be and positioned them farther away from the air conditioner than I had designed in my initial drawings.

13. **The next thing to do is do an energy audit** to make sure your system will power

everything you want to use. Change all your lights to LED and do the math on your appliances. **Use DC appliances (televisions, coffee pots, fans, etc.) whenever you can**, as **there is a 10-12% energy loss with an inverter.** If you only use an appliance for a few seconds, only the usage time is figured into the equation. The biggest draw is the refrigerator. There are a few brands that are very energy efficient, but this system probably isn't big enough for most refrigerators. If you can use propane or a nice cooler, do it, as your system should work fine with 400 – 500 watts, as priced below.

14**. Remember the formula Watts = amps x volts. So a 120-volt appliance that uses 1 amp at 120 volts will use 10 amps (per hour) at 12 volts.** That frig would use 240 Ah in 24 hours on DC – 10 x 24 = 240 watts.

15. **In figuring the daily energy output of the panels, you have to account for the number of hours of sunlight.** For general purposes, use 5 hours for calculations, although in the winter it's about 3 hours, and the summer it's about 8. It is also higher at higher altitudes. If the panels are tilted toward the sun, it can increase their output about 50%, but tilting panels on a roof is difficult, so most people just buy more panels to increase output. **More hours of sunlight and more panels speed up battery charging, but they don't add to the amp hour capacity of the battery.**

16. **A 400-—500 watt system is going to work for most horse trailers not running an electric refrigerator, and may be enough for small refrigerators for a few hours.**

17. You will need to do an energy audit for your uses. See Arizona Wind and Sun's online calculator at **https://www.solar-electric.com/solar/calc**

18**. Energy flows from the solar panels to a device called the controller, which monitors the amount of energy it allows to enter the battery for storage.** Overcharging the battery will also ruin it, so you must have a controller. There are two types of controllers— the pulse width modulated (WPM) controllers and the Maximum Power Point Tracking (MPPT) type.

19. MPPT controllers are more expensive, but they process light better, charge faster, including in shade, and even in moonlight. If you can afford it, get an MPPT controller. **For a 400-watt system, a 100/30 will be large enough, for 500 watts, you will need a 100/40, and for 700-800 watts a 100/50 controller.** Most MPPT controllers also provide system status and should be paired with a battery monitor.

20. **Wiring from the panels to the controller (usually 10AWG) can be thinner and longer than wiring from the controller out or from the batteries out since the power going out will be at a higher voltage.** That wiring size will range from 8AWG to 2AWG depending on the system. Wiring from the controller to the batteries needs to be very short (2 to 4 feet), so these devices must be positioned very close together. DC power degrades quickly over distance, requiring thicker, more expensive wiring. Most of these systems will use MC4 connectors (standard connector for solar) and 10AWG from the panels to the controller. MC4 connectors work only with 10AWG wire.

21. **The power is stored in the batteries and exits through the terminal connections. The inverter is the last item on the chain.** If you plan to use a **battery monitor**, which is recommended, it is wired off the negative terminal on the last battery in the system.

22. **Solar panels can be used in conjunction with other methods for recharging batteries in the same system.** The battery doesn't care what energy source is used to charge it.

23. **2019 is the last year for the 30% tax break on the cost of a solar install on a home, RV, or LQ horse trailer.** In 2020, the tax break is 26%. Use federal income tax form #5695 to report.

What does it Cost:

I priced a system that would work for a horse trailer. This isn't enough to run a refrigerator fulltime, but it could be used while driving. It will run fans, lights, the pump, a jack, an awning, recharge phones, and run a small television or a laptop.

1. 500-watt AcoPower kit with monocrystalline panels, MPPT 40 amp controller and all the installation parts on Amazon for $630
2. Two Trojan 105 240 Ah batteries, $445
3. Two battery boxes for T105s, $22
4. Battery monitor — $30-200 battery monitor (Victron, higher price, off-brand $30). Victron makes a system, so you might want a Victron controller-- nice phone app if not buying kit above.
5. 300-watt Go Power pure sine wave inverter (if needed) $172 6.
2 12-volt receptacles with 2 USB ports $18 each ($36),
7. Battery watering kit and pump, $76
8. Installation by SK Trailers in Marion, TX. They will charge $700 to install in a trailer without an existing living quarters, and about $1200 if the LQ is already in place. This system will provide approximately 134 Ah per day. You may also need more wiring, or not everything above.
9. *If you might upgrade later, estimate about $100 for a Midnite Solar Babybox 4 slot Breaker Panel and breaker switches. $32.19 + $12.25 each 2 switches + shipping.

Total ballpark estimate for this system would run **$2100 - $2800 installed, or $1400 + (plus tax) if you do it yourself. With the 30% tax break, figure ballpark at $1470 - $1960 installed, or $980 DIY.**

Learn more!

If you're planning an installation, understand that every installation is slightly different. You will want to get advice and study before you buy anything.

Recommended reading: ***Photovoltaics: Design and Installation Manual*** ($25, Amazon)

Join a Facebook solar group.

Northern Arizona Wind and Sun (website) is a good resource. They sell equipment, including packages, and their system designers are knowledgeable. Contact me with questions.