Tech Corner:
Understanding Camping Power

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Watts = Volts x Amps

This is the main equation for power conversion. Watts is the constant unit of power, while volts and amps are variables. For example: 120 watts = 12 volts x 10 amps or 6 volts x 20 amps, or 120 volts x 1 amp. As you try to understand any electrical system, keep this formula in mind.

AC and DC power terminology

Most campers need to supply their own power sources to run heaters, fans, air conditioners, coffee pots, grills and the like. There are two types of electrical power—alternating current (AC) and direct current (DC). When I refer to AC here, I am not referring to air conditioners. AC power, when not supplied by a generator or inverter, is also known by the nautical term "**shore power,**" meaning power one has access to on shore, when the ship is plugged into the power supplied by a region's electrical grid. In horse trailer parlance, we also refer to shore power as "**electrical hookups.**" When we camp off grid, we can still have access to AC power, but only through the use of a generator, inverter, or inverter/generator. The power stored in your batteries is DC power, and it is only about 1/10th the voltage of AC power, in most cases (12 volt versus 110 or 120 volt). DC power is used to power your trailer's water pumps, lighting (preferably LED), awning, slide-out, fans, and electric or hydraulic jacks. None of these things require generation of either heat or cooling. You also use DC power to charge your phone and other digital devices.

Alternating Current (AC)

AC power, invented by Nikola Tesla, allows electrical current to travel both directions through wiring. It does this by using magnets that produce a sine wave, and heavy coil transformers to change the voltage of DC to AC power in an inverter. AC power can travel thousands of miles without degrading.

Direct Current (DC)

DC power, invented by Thomas Edison, only travels in one direction, and can't travel very far without degrading, which is why DC wiring is often very thick, and DC devices need to be close to the batteries where the energy is stored.

DC power is not powerful enough to power items that require heating or cooling. To do that, you will need to add different power sources, or use an inverter, which is a device that converts DC power to AC power. To power your air conditioner off of DC power is not possible without a very large solar setup and a very small air conditioner. Because horse trailers are not big enough to hold the number of panels and batteries needed for even a small air conditioner, you cannot power an air conditioner off DC power in your horse trailer. For an air conditioner, you will need AC power, supplied by either a generator or shore power. If you have a refrigerator in your trailer, most trailers will be set up to use propane or AC power (two-way RV refrigerators), usually a Norcold or a Dometic. However, there are a few high-end compressor style refrigerators that can be run using minimal solar-generated DC power. I have a small three-way Dometic that runs off solar, but it takes 800 watts of solar and four six-volt batteries to do it. For heaters and cooking, propane is generally the best source of power, if you don't have a generator to power those devices.

Propane

Propane is a quiet source of power, and there are even propane-powered generators available. Be careful with propane, though. A propane powered refrigerator and system requires a certified installer. That is not a do-it-yourself job, as even a small leak could be fatal. However, if you have a certified install, it will be possible to run most everything you need without a generator. Generators are problematic, whereas propane and solar-powered battery systems are quieter and easier for camping.

All batteries are Not Equal

The batteries you choose for your energy storage are of utmost importance. Do not use a truck battery to power your horse trailer. Truck batteries are designed to give you quick start power, not hours of continued use. Most small RV systems are designed for 12-volt.

Marine Batteries Explained

There are three types of marine batteries that work best in RVs and horse trailers—lead-acid (flood cell), sealed lead acid known as "absorbed glass mat" (AGM), and lithium-ion (LI) batteries. Lead-acid flood cell batteries are the least expensive—they are heavy, must be housed outside the living quarters, stored upright, and they have to be watered. AGM batteries are closed-cell and do not need to be watered or stored upright, but must be outside the living quarters, as they leak fumes. Both of these have heavy lead plates designed for thousands of discharges, and are quite durable. To make them last, they should not be discharged past 50% of their capacity. Lithium-ion batteries, clearly superior, are lighter weight, can be stored inside the living quarters, recharge much faster, and can be discharged down to about 5% of their capacity, but are much more expensive and won't charge below 32 degrees. They cost about $1000 each, so usually they are housed under lock and key.

Battery Usage and Wiring

Many people with solar systems use two six-volt golf cart batteries and wire them in series (positive to negative, negative to positive), which adds the six volts together to make them 12 volts. If there is more than one pair, then the second pair can be wired in parallel (negative to negative, positive to positive), which allows them to maintain their voltage (12), but double their amps and amp hours (available usage hours). The total cost of my four six-volt batteries was about $1000, producing a total of 450

amp hours versus 100 amp hours on a Battle Born LI battery, each costing about $1000. However, because the lead acid and AGM batteries can't be discharged as far as an LI battery, that 450 amp hours is really 225, versus their 95 hours on a 100-amp hour battery. When you purchase your batteries, pay attention to the amp hour rating (AH) on the battery, or noted as reserve capacity (RC). You want as many amp hours as possible. You also should not mix battery types or batteries of the same type that aren't the same age and size.

Generators, Inverters, Inverter/Generators, and Converters

Inverters convert DC power to AC power. Converters convert AC power to DC power. Generators make power, whereas inverter/generators first make power and then clean up the rough sine wave produced by the generator and convert it to a pure sine wave (PSW), which is the same type of sine wave AC power produces.

Generators are larger, cheaper, louder and produce a modified sine wave of current. A modified sine wave (MSW) can damage anything with a microprocessor in it (including microwaves), so they are poor camping generators, but are fine for working with many types of power tools. They are very loud. The difference in decibel levels is logarithmic. For example, a 100 dB sound is twice as loud as a 97 dB sound!

Inverter/Generators are a newer technology, and a much better camping option. They are smaller, quieter, more expensive, and produce a pure sine wave (PSW), which is an identical sine wave produced by AC shore power. These will not damage computers or microwaves, and can be so quiet you can easily talk over them. A 2000-watt generator will produce enough power to run a small electric heater or cooking appliance, but not enough for an air conditioner. You will need about 4000 watts to run a rooftop air conditioner. You can daisy-chain the small ones together to increase the time that machines can run while maintaining their voltage. Onan is the brand used in many RVs and LQs. Onans are excellent machines, but are not portable. Most have an electric starter, so as with any electric-start device, you need to keep that battery charged using some type of trickle charge system. These need to be serviced in the trailer. All generators have an Emission Control Rating. You will see a little sticker on the generator with this rating. Yamahas carry a 500-hour rating. Hondas have a 250-hour rating. Most less-expensive brands are only rated to 125 hours. Honda and Yamaha are rated for usage in California, but most brands are not.

Inverters: In addition to inverter/generators, there are other devices simply called "inverters," that just make the power conversion from DC to AC. There are PSW (pure sine wave) inverters, which you want for anything with a microprocessor, and MSW (modified sine wave) inverters that produce a rougher sine wave, which is fine to run a fan or a lamp. A PSW inverter is much bigger and heavier, and significantly more expensive. When you use an inverter, there is about a 10-12% power loss in the conversion. So, if you have a choice between running an item straight off 12-volt or plugging it into the inverter, use it as 12-volt. Inverters have to be housed inside the trailer, can't get wet, and will require some air space around them, as they can get hot. If you have room for a large one (2000 to 3000 watts) and you have enough solar power available, you would be able to run your microwave or small appliances off of it.

Converters are used in RVs to convert the power the other way—from AC to DC. These are useful if you need to use your generator to charge your batteries. These are found in higher-end LQs and most RVs. It is a good alternative to solar power, especially for long trips.

12-Volt Outlets

You can buy RV outlets (wall mounts) that are 4-amp/12-volt capacity and directly wire it from the battery I would suggest getting at least one of these with USB connectors so you can keep your cell phone charged.

Portable Power Source Devices

Schumacher and REI both sell a power source device for camping. These are AGM batteries with a built-in air compressor and inverter allowing for USB ports, 15-amp receptacle and 12-volt receptacle. The REI versions are very expensive. Schumacher makes one called a Jump Starter with Compressor ($140), which is more affordable. It was designed for jump-starting a car, but it is not enough power to jump-start a truck. However, if you don't have a full LQ, it would provide a little extra power to run lights, fans, and charge your phone over the weekend.

Solar Energy

Solar energy is a safe, quiet, and reliable energy source, requiring little maintenance once installed. If you're careful, you never run out of power or have to charge your batteries yourself. The physical limitations of a solar system on a horse trailer are: available roof space; battery space under the gooseneck; and space for the controller (a device that keeps the batteries from being over filled with energy from the panels), and room for a breaker box. There is room for about 800-1000 watts of solar panels, enough for most of your camping needs except some refrigerators, long-running electric heaters, and air conditioners. However, if it rains for days on end, or in winter with fewer hours of sunshine, you would need a generator. For trailers with propane refrigerators and heaters, and a generator that isn't capable of charging the batteries, a 400-watt solar system would provide a great way to keep awnings, slide-outs, hitches, lights and pumps functioning without issues.

System Design

The local electricians I spoke with didn't install solar systems or understand solar for small-scale use. It was a Facebook group (Solar Powered RV's & Boondocking), a solar installation manual, a lot of reading, and several consultants that made it possible for me to design my system. The component parts of a horse trailer solar system run from about $1000 to $5000. In 2019, there is a 30% tax deduction on a solar install on an LQ trailer (RV or home), so this is a good year to build one. In the next issue, I'll explain how to go about designing and installing a small solar system.