HandyBob's Blog
Making off grid RV electrical systems work

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The RV BATTERY CHARGING PUZZLE

Written in 2004 and continuously updated since. Last extensively revised December, 2010. Make sure to look at the home page and FAQ's for updates. I get a lot of questions from people who have not read the whole thing. I know it is long and some complain about that. Can anybody show me how to shorten it while still keeping all of required information? Now in April 2012 I just added some clarifications that were needed and made it even longer. There are more current recommendations in my newer RV Solar Quick Answer?

By Bob Shearer, AKA HandyBob, bobanene@gmail.com

April 24, 2009. Time to clean those panels.

My wife and I are full-time RV boondockers. (No, we don't live at Walmart. They are not in the boondocks.) We successfully run our fifth wheel's electrical system on batteries charged with solar power and do NOT own a generator. Contrary to what you have probably read in other places; it is possible to run a coffee maker and a toaster on battery power. The only time we have been plugged in for over six years has been to run air conditioning or when we have been stuck for over three days & covered with snow. No, we don't act like we are plugged in and leave everything on all the time and yes, we do have to conserve if the sun doesn't shine, but we still use the Mr. Coffee & watch a 19 inch TV for several hours every day. I have a background in electrical engineering and electrical equipment sales and have spent quite a lot of time and experimentation in figuring out how to make an RV system

work. It is different from designing buildings. I have rewired my system three times, had three different sets of batteries and five charge controllers. So, when I tell you it is possible to run on your batteries, you can believe me. We do it. The folks in the RV industry are not the people to go to when you need honest information. Everybody you talk to has an agenda and you need to ask yourself what that agenda is before you believe what they say. For instance, the RV manufacturer, who is in bed with the RV park industry, will tell you that they put in a battery charger, but he is lying to you about that (see converters, page 4), so you will end up needing to be plugged in at an RV park. The solar panel salesman might tell you to put in #12 wires, knowing that it is going to soak up a lot of the power from your panels. He will also tell you that the charge controller's factory's voltage setting is high enough, when in truth your batteries will never get full at that setting. That way you will go back to buy more panels in order to get the same amount of power you might have if you had used larger wire and set your voltage up to the proper level, so he gets to make more money. The battery salesman will tell you to buy more batteries than your charger has the ability to maintain, so he can make more money. How can you tell if a salesman is lying to you? His lips are moving!

My agenda? I am trying to get back the peace and quiet we used to have during the evenings when we are out camping and enjoying conversations or the sounds of nature around the campfire. More and more these days what we are hearing is the drone of generators, when they really are unnecessary except for cooking and occasional battery charging, which can both be done at times that should not bother your neighbors. I'll never understand why so many people have to be told when running a generator is inconsiderate. Many seem to think that any time they want power, 24 hours a day, is acceptable. That is just fine if you don't want to make new friends, but most of us don't want to be kept awake, woke up early or be forced to listen to generators when we are trying to converse during meals, happy hour or night time campfire. Even those "quiet" generators make noise when several are running. You can charge in the middle of the day when you won't bother anybody and use power quietly during the evening. I'll never forget how one of our best boondocking friends once asked me to look at his batteries & charging because he was having problems. I had never heard a generator running near their rig and had been assuming that they had solar panels. When I asked how many panels he had, he responded with "none". Positive proof that you don't need to be inconsiderate with the use of a generator in order to boondock. It turned out that he was having a charger problem that was easily fixed. There are already countless books and articles written about the technical side of this problem, but none of them that I have read do an adequate job of emphasizing the most important parts of the battery system puzzle. I am supplying this information as a supplement, not replacement, to what is already out there in the hope that I can help quiet things down and to educate my RV friends so they don't waste their money on things that don't work. I evaluate electrical systems, perform repairs and some solar installations, but I'm not selling equipment, so I have nothing to gain if you listen to me, except to live in a quieter world. **I am not trying to sell you anything.**

Don't jump to the usual conclusion. Although it would be nice if everybody could, I am not telling anyone to spend thousands of dollars on solar gear. Some of our best boondocking friends do not have solar panels and they don't run generators inconsiderately. I am saying that you need to learn how to use and charge your batteries. Think about this. Many of us RV'ers are successfully running our TV's, computers, etc. without running a generator all the time, so it is possible. Don't assume that since you and your neighbor have your generators running, everybody does. You would be very surprised at what is going on in some of those RV's while no noise is being generated. Here I sit at my lap top, with the TV & several lights on. From outside you can't tell what I'm doing, but you can hear the two "quiet" Hondas that are both about a quarter of a mile away. Running on batteries is cheaper than having that generator running, burning gas & wearing out while it is putting out a very small amount of power to run something like a TV or your lights. I see folks running 2000 watt generators to power 50 watt loads all the time. That is only 2 1/2% of the rating, and that is ridiculous. Do you start your generator every time you run your seven amp (90 watt) water pump? Yes, batteries wear out faster when you use them more, but they cost less than fueling & maintaining a generator. On the other hand, they last a lot longer if you charge them all the way up at least weekly. Why do you have batteries if you're not going to use them? You can charge your batteries either by spending hundreds on a generator & some charging equipment, which you can run as needed when it won't bother your friends & neighbors or you can spend thousands on solar equipment. Either way can work. Yes, you may need to spend a bit on a small inverter to run that TV and you may need to do some wiring in your rig to get enough power to it so it will work right, but this will cost less than you think. Those of you that have tried to run your TV with a small inverter plugged into a 12 volt outlet and failed because the inverter beeped & shut down are the victim of voltage drop problems, not the wattage rating of the inverter. You either need to run bigger wires from the battery to the inverter or move the inverter close to the batteries and use a long 120 volt cord to the TV. Voltage drop is not a problem on the 120 volt side. (Ten times the voltage = 1/10 the amps = 100 times the distance.)

While I'd like to keep this simple, there are a few basics that you must understand in order to make your system work. Here is my version of how DC (direct current) electricity works. On one hand we have air pressure; on the other hand electricity. If you want to air up a truck tire you force a volume of air (cubic feet) into it with pounds per square inch (pressure) of air until it is full. It is easy to get the first few cubic feet of air in; you can even do it with a hand pump. The fuller it gets though, the more pressure you need. You can't get it up to 80 pounds unless your hose puts out more pressure than that. An air hose with 75 pounds of pressure in it will never fill a tire to 80 pounds. Batteries are not sponges that soak up amps. They are a lot more like tires that need to be filled up with air pressure. You need volts (pressure) to get the amps (volume) to go into the battery. Unless you have enough volts to push the amps into the battery, they just won't go in. Batteries self regulate the amps they will accept depending on level of charge and voltage. The amps going in will drop as the battery fills, and if the voltage is not high enough the battery will not be charged all the way up before the amps taper off. Trying to charge a battery with too few volts is just like trying to air up a tire with too few pounds of pressure. It just doesn't get the battery all the way full. Just like you can use the volume of air that comes out of an air hose to do work, like run an air wrench, you can use the amps in a battery to run electrical appliances. An amp hour is a way of defining power available or used. It is like volume over time. If you want to run an appliance it will take whatever number of amps for the period of time it runs and by combining the two (amp hours), you get a way of defining the power you need to store in a battery if you want to run that appliance at a later time. Watts (volts times amps) is actually a more accurate way of defining energy, which is why the power companies bill you for watts or kilowatts, but it is much easier for us to deal with this issue in a battery powered world by using amps times hours and assuming an average of 12 volts, even though a healthy 12 volt system is never really that low.

VOLTAGE: For the sake of simplicity, I am only going to talk about the requirements of standard flooded wet cell lead acid batteries, which is what most of us use. The major points apply to all types of batteries, but the actual numbers will vary. It is very important for you to research the charging requirements of your batteries if you are using any other type and make sure that your charging system provides what they need, or you could end up damaging them by over charging or never getting them fully charged, which will also damage them. Battery manufacturer's specifications say that a standard 12 volt wet cell battery needs to be charged to between 14.4 to 14.8V and then **held there** for some time before it will be fully charged. The Trojan Battery company says 14.8V daily charge (at 77 degrees F) and Interstate will tell you over 15V. Trojan's 2010 Users Guide has a new chart that shows you should actually vary

the voltage depending on the amps you supply for charging and even higher voltages are recommended. Of course they recommend temperature regulation. So all of those out there who are telling you 14.8V is too high do not know what they are talking about. How long it takes to get the charge in depends on how far it was discharged. Trojan says to keep charging until a hydrometer test shows that the battery is charged and not one charger available today can do this. The best chargers can do a reasonable guess at state of charge by providing constant voltage and watching the amps taper as the battery fills to tell them when the battery is full. However, they rely on whatever the designer or programmer gives them for guidelines and are only as good as that data. Many do no work worth a hoot. A fully charged battery can be maintained at a full state by applying a 13.2 – 13.6 volts "float" charge. All of the talk about how many amps a charger puts out means nothing. It is the volts (pressure) that you need to push the amps (volume) into a battery. **VOLTS, VOLTS, VOLTS!!** Also, the amps pushed into a battery at a higher voltage contain more power than those at a lower voltage. Remember, volts times amps equals watts, so amps pushed at 10% higher volts give you 10% more watts. Therefore, the power stored in the upper range of a battery's charge is greater, so it is very important to get a full charge. Low voltage DC is not easy to get through wire without losing power due to voltage drop or resistance. It is huge problem in an RV. Use big wires and short wiring runs to get around this. It is good practice to use one or even two sizes bigger wire than recommended to limit voltage drop. This charge voltage has to actually reach the battery, not just the output terminals on a charger. If you cannot get your batteries up to 14.4 volts (14.8 is better & faster) with whatever charging system you have and then keep them there while pushing amps in for more than an hour or two, your batteries will never be full.

BATTERY MONITORS: The RV industry has really let us down. First of all, you can't believe the little "idiot light" panel that came in your rig. That thing is very optimistic and tells you the batteries are full at 13.4 volts, when they are actually nowhere near it (14.4 volts). It works by looking at the voltage present on the wiring, which will be much higher than the battery voltage while charging & much lower than the battery voltage when running loads. If it says your batteries are "full" while you are charging, you could be anywhere from 40% to fully charged. People that run their generator until the idiot light says "full" are only getting their batteries up to about 40 or 50%. They start their evening at the point my system would get down to after a week of rainy days. Last, if the monitor says your batteries are "fair" when you are not running anything, they are DEAD. So, how can you tell if your batteries are really getting fully charged? The most accurate way is to test the battery electrolyte with a hydrometer. A hydrometer with a tube float inside it like the $5 one from an automotive store works just fine. This is messy and not very convenient, but if you want to know for sure this is what you have to do. The easy (but not as accurate) way is to buy a cheap little volt meter and measure at any point in your rig (12 volt outlet, light or fuse panel) after the batteries have been resting for over an hour. Both charging and loading will cause false readings. A resting, full battery will test at about 12.7 volts. A resting, dead battery will test at 11.8 volts. Yes, that dead battery will still provide some power, but you are destroying it by letting it get that low. That magic 50% level that most folks say you should stay above for good battery life is about 12.2 volts. Campers generally don't get decent life out of their batteries because they run them down too low and don't keep them charged up, causing sulfating and stratification. My first set of RV batteries lasted less than two years.

RECORDING METERS: I used to tell people that the $200 "e meter" amp hour meters like the Link or Trimetric are a toy that you really don't need. After all, your inverter remote or charge controller has a volt meter on it, and many have ammeters, but if you think about where they are connected you will realize that they don't give you very reliable data. When I installed a Link 10 was when I started to understand how battery power works. You should buy one of these before you spend a dime on solar power. Trying to run a battery system without a good meter is like driving a car with no fuel gauge. You end up spending your time worrying and stopping to fill up instead of driving. At a glance, we know exactly where the batteries are. We have discovered that most electrical appliances use a lot less power than we thought and we now have confidence in our system. We love to show off by inviting folks over for solar waffles for breakfast. "Can we use the microwave for dinner? Well, the meter says we are only 30 amp hours in the hole and we could go down as low as a couple of hundred before worrying, so go right ahead." Or, "It's been raining for two days and we're down 150 amp hours (@68%). Maybe we should light the oven." (We get quite a bit of power from our solar panels on rainy days, so that 150 amp hours is reasonable, but you would never know it by looking at a volt meter.) My wife gets quite a kick out of watching the amp hours go down and then right back up again when she runs the iron or the hair dryer on sunny days. This is very cool. Now, a caution or two about these gizmos; My Link had a very weird idea of what a fully charged battery is, because the default setting is only 13.4 volts, way too low. It also has an automatic charge coefficient calculator that jumped around so much in our rig that it gave us very unreliable data. I ended up locking that and changing it as the batteries aged. I also had to change it when going from six batteries back down to four after figuring out that it was a better balance with the charging that my solar provides. You do need to get technical here and get involved in the programming. On the plus side, one of these tells you the voltage right at the battery terminals and how much current (amps) is going in or out, and records the amp hours used, something that tells you how well your system is actually working and helps you figure how much power any appliance actually uses. If you have one of these, you don't need the expensive remote readout that is optional on the better solar charge controllers. We loved our Link. The newer Tri-metric 2020 and 2025 meters (**bogartengineering.com**) are even better, lower priced, easier to wire and program and that is what we now have. (I have installed scores of them and everyone who has one loves it). The instructions include an explanation of charger settings that agrees with what I say above. The percent of charge readout is all most folks ever need to look at, except for occasionally checking volts & amps just to watch for changes in system performance. It is like keeping an eye on your blood pressure. I've seen a couple of problems with the old Trace TM500. It connects with a phone cable to a printed circuit board located on a shunt at the batteries. I believe the problems are caused by having that circuit board in a harsh environment like an RV battery compartment, which in some motor homes is outside behind the wheels in the dust, water, slush & worse.

Let me give you an example or two about how most appliances use a lot less power than we thought:

Our water pump is labeled 7 amps, but it actually measures 2.9 amps (less than half).

Our 19" wide screen LCD TV is labeled 40 watts, which calculates to about 4 amps on 12VDC, but it actually measures 2.7 amps, 30% less. Every TV I have measured has been similar. They are getting better. I recently saw a 26″ LED set that uses the same amps as my older 19″.

Our Mr. Coffee drip coffee maker is labeled 600 watts, which calculates to about 60 amps on 12VDC, but it actually measures only 44 amps (maybe 450 watts) and brews a 4 cup pot on only 7 amp hours, about twenty minutes of sun for our system. We run the toaster with ten amp hours, a bit over a half an hour of sun. The labels are required by law, but there is no accuracy required. The label has to show what the appliance will not exceed, not the actual energy use.

According to the usual chart in a solar catalog our bed warmer should take about 20 amp hours, while we run it on less than a fourth of that. Of course, we don't set it on high.

They say standard refrigerators use about 150 amp hours per day, while a friend's energy star rated, but 22 cubic foot one runs on just over 100. Small freezers use a lot less than you would think. If your system can run one down in your cool RV basement during the cool winter days on the output from less than two solar panels, then it will work just as well when the temperature is warmer, but the charging days are much longer. The government required label is based on a warm environment.

The **CPAP** (breathing) machine with a humidifier that everybody seems to think requires a generator running all night will run on about 30 amp hours, the output of only one solar panel. Let's see; a single cylinder gas engine that might run out of fuel & die (or that your incensed neighbor might sabotage – it has happened) or a very reliable battery & inverter. We ran into one guy in a tent who had figured out how to run his on one small car battery that he recharged while driving with jumper cables. Use your brain folks.

Get a good meter first and you can learn how to manage your power needs, running the generator only when and as much as you need to. **You cannot guess what your power needs are, you need to measure.** Then if you can afford it, you can size your solar system with facts instead of a salesman's high estimates designed to get you to spend more money. If you listen to them you will be sizing your system for higher than true loads and then applying a fudge factor above that, which can double the cost. Let's see; buy a $200 meter that will improve your life or another two or three solar panels. This is a no brainer.

You say that you can't get through the evening on your batteries? Most likely that means that you aren't starting the evening with fully charged batteries. You might need new or even more batteries, but your basic smaller RV should run through an evening on only one battery, even if powering a small TV or stereo. Those of you with only two golf cart batteries in your big rig should be able to run a 27" TV all evening on less than 50% of your charge. 50% of 225 amp hours capacity, less a few amps for lights, etc. or about 100 amp hours will run that 12 amp (150 watt) load for over eight hours. If you can't do that, your batteries were not full at the start of the evening, or you may be obsessing over a volt meter reading that is low due to having loads running. Go back a couple of paragraphs. We go for days of rain in our rig while still running the coffee maker, 19 inch TV and other normal loads, so I am getting tired of people telling me they can't get through just one evening without a generator. **You can!** You just have to figure out how to charge your batteries.

JUST WHAT IS A FULL BATTERY?? The general consensus on this issue is not correct and this is the primary reason that most RV electrical systems do not work very well. The batteries in my rig show 12.8 volts after the sun goes down and will usually show 12.5-12.7 after watching TV & running lights all evening. I typically see 12.5-12.6 on the meter if I manage to get up before the sun rises, but the truth is that I had to look at it as I wrote this because we never look at the voltage, using the percent of charge on our meter instead. These same batteries used to work like everybody else's before I figured this out, so this is fact, not opinion. My charger works so well because it is set to get the batteries up to 14.8 volts (temperature compensated) and hold them there until charged and since it is solar, it runs all day. We often see well over 15V on cold days; that is what it takes to charge a cold battery. It is so important to get your batteries full because a 95% charged battery has 10% less usable power in it than a 100% charged one, since you are trying to keep it in the top 50% of its operating range (5% of full = 10% of 50%.)

BATTERIES: This one place where I believe that you truly do get what you pay for. You will run into people with all kinds of conflicting advice on batteries and the glossy marketing from every company will tell you that they are the greatest. Don't believe everything you read. After over ten years of experience, here is my advice: If you decide to buy new batteries, get the six volt, golf cart type and run two of them in series to get 12 volts. The differences between batteries average out this way and they match up better. If you will do this, you will get better than twice the life of the standard 12 volt marine battery and around 20% more power. They are built heavier and work much better. Think about how people with golf carts and lift trucks abuse these batteries. Do not mix battery types or brands in one system. Mismatched batteries will charge each other at night, causing shorter life. I bought Trojan T105's because I talked to many people that had them and found no dissatisfied customers. The only complaints I have ever heard about Trojan were concerning price or came from a dealer selling something else (sour grapes). Mine were over eight years old when I replaced them with some used but newer Trojans and they are still operating a construction power system on a storage shed up in Montana. They are weak, but have no dead cells. If Trojans were even 25% more than some cheap brand, I would still buy them. (Make sure to read my later posts about battery manufacturers.) There are others with a good reputation, just remember not to believe everything you read in anybody's glossy brochures. I only got one year out of a set of deep cycle 12 volt marine batteries that never tested the same as each other. You can't always compare amp hour ratings because the different manufacturers like to play games with their numbers and use differing rates of draw. Recently (spring 2007) Interstate had some problems and I still keep running into folks with bad Interstate batteries. I think they had a bad production run. One dealer I talked to about the problem tried to tell me that a hydrometer is not an accurate way to tell if an Interstate battery is fully charged and the new Interstates run at a lower voltage. Huh? Interstate has published nothing that he could produce to confirm his statements, so I think we were getting the brush off. The replacement Interstates (a different model than originally purchased) tested just fine with a hydrometer and charged right up the first day of full sun, and I believe the technical data I got from Trojan, who say that a hydrometer is the best way to tell. Today (December 2010) I could give you names & phone numbers of friends who have been fighting with Interstate about batteries that just will not take a full charge. Their batteries will never show a full charge using a hydrometer and they do show voltage that is lower than it should be when under load, but the Interstate shop tells them that they are "within specs" and there is nothing they can or will do. This is not how a quality manufacturer acts. Wait a minute, Interstate doesn't really manufacture these. There is an inconvenient truth for you!

Should you buy AGM or whatever new battery comes along? Do your own research, ask everybody you run into about their experience, weigh that advice with common sense and make your decision. My decision was based on value and history and it may very well be different in the future, since no battery lasts forever. Just be very careful about researching the charging requirements of whatever you decide on. Get this information from the battery manufacturer, not from the manufacturer of your charge controller. This is critical if you want the batteries to get fully charged and to last. Morningstar told me exactly this when I asked them about how they arrived at their new L-16 charge settings, while Blue Sky argued with me and told me Trojan was wrong. This speaks volumes to me about the differences between these two companies. Here is a little known fact for you: Morningstar is the leading manufacturer of Solar charge controllers world wide. Those other guys with the glossy marketing brochures are not.

Be very careful about buying the new, high tech and expensive battery types because they have different charging requirements, which vary by manufacturer. Unless your charging equipment is adjustable, you could damage those expensive new batteries by over or under charging them. I did not say you shouldn't buy them. I just said you need to be careful. Get the battery manufacturer's charging specifications and pay strict attention to them.

The charger manufacturers are nearly all not setting their equipment up for the voltage that the battery manufacturers specify. The difference between 14.4 & 14.8 volts is not 3%. That difference is nearly 20% of the charging range (12.2 to 14.8 volts). That 20% makes a huge difference in how full the battery gets before the charger shuts off. You can eventually get the batteries full by charging at 14.4 volts, but it takes hours, not minutes. We have related industries that are not talking to each other and the outcome is that the majority of RV's are running around with weak batteries.

Now, I will tell you why I am not a fan of the new technology batteries like gel cell & AGM: Your charge system has to be set at a lower voltage for them, so more of the power your solar panels could produce is not available for use. (Lower volts equals fewer watts.) Take a look at this web site: **http://www.sterling-power.com/support-faq-2.htm**. Like me, this guy takes heat from people who don't like his common sense approach when getting to the truth, but he knows what he is talking about. With sealed batteries you end up with less power in the same amount of space and weight. Big ones are available, but they are very expensive. All this so you don't have to add water and can't check the electrolyte to monitor their condition. Suit yourself, but this really doesn't sound like a good bargain to me. Unless I owned a rig that had extreme access issues, I would not even consider anything except Trojan flooded deep cycle 6V golf cart batteries. L16's need higher voltage charging and frequent equalizing for proper maintenance. This is a potential problem for 12V RV systems so I recommend against it.

Regarding battery cables: Make your **interconnecting** cables up the same length & gauge. (Heavy enough for the inverter load.) This does not say that the main cables to the loads have to be the same. You want to have the same total length of wire between each battery and the main connections to hot & ground. You have to connect to diagonally opposite corners of sets of batteries to accomplish this. If you have a chain of six batteries, two will be closer to hot and two will be closer to ground, but the total wire distance will be the same for each of them, so they will get an equal charge and will also be drawn down together. This is critical because we are really only trickle charging with solar power and we have to make sure the batteries all get the same charge. Any tiny difference will get worse over time and can eventually ruin your expensive batteries. Again, this is a place where a lot of the professionals do not agree with me, but what do they care if some of your batteries don't last as long as others and then ruin your whole set early? Don't listen to the guy that says you have to buy all that extra cable to make every cable the same length and connect to common hots and grounds so all the batteries are connected exactly the same. It is a waste of money and adds more connections that all have a potential for failure. Look at Backwoodssolar.com for wiring diagrams. They are a bit hard to find, but they are in there if you are persistent.

A word on cable connections: Many of the so called "professionals" are doing a very poor job of crimping, using hammers and dies. You test crimps by trying to pull them apart, so do just that in front of the guy you bought them from. I once had three of twelve crimps fail that some "professional" had done and he wanted to know what I had done to them. I now carry my own big crimper, and I do all double crimps. (This is a UL requirement in the real electrical world.) If a hot wire comes loose while you are going down the road and falls against the frame, it will turn into a welder. You don't want to become a burning hulk at the side of the road. Make sure those connections are good and solid. Last, a side note about not owning a big charger: My batteries stay clean and hardly gas at all; you could eat off of them. Big chargers are wonderful in some ways and terrible in others.

CHARGING METHODS:

CONVERTERS: Here is the other place that the RV industry has really let us down. Nearly all basic RV's, whether they are trailers, fifth wheels or motor homes are equipped with something called a converter or "charger". This mislabeled item should be called a battery maintainer, because it is designed to be plugged into shore power in an RV park 24 hours a day, which is really what the RV industry wants us to do. Converters are set to maintain the batteries at the "float" voltage, about 13.5 volts, and supply a trickle charge (2-3 amps, or 25-35 watts) to keep the batteries full, while not over charging them and boiling them dry. Because of the length and size of the wiring in most rigs, the converter typically supplies less than 13 volts to the battery. Some newer three stage converters will put out over 14 volts, but that is still too low. You cannot successfully charge batteries with a converter, because you never get the batteries up to the required 14.4 volts and hold them there long enough. Don't pay any attention to the amp rating of the converter and don't believe that it is a good charger just because it is labeled three stage. DO NOT WASTE YOUR MONEY UPGRADING TO A THREE STAGE CONVERTER, THINKING IT WILL BE ANY BETTER. It will put the rated amps out for a very short time after you have run the batteries down or have just plugged in and it will drop to float the second it reaches whatever set point they used, then it will taper the amps off to a trickle at about 13 volts, long before the batteries are full. Plus, if you have any solar power, the voltage it puts out will be sensed by the converter and cause it to go into trickle charge mode even sooner. I installed a new 60 amp Intellipower converter in a friend's rig & when we started the generator I measured only 4 amps output at 13.6 volts right away. It dropped from bulk charge to float in seconds, and those batteries were not full. Does that sound like a battery charger to you? Their own spec sheet says that it drops to float when the batteries are at 90% and in my experience this is very optimistic. My solar system actually puts more amps (3.5 amps) into my batteries on a cloudy day than your average converter does, and I can't keep my batteries charged when it is cloudy, even with that trickle charge working all day. Therefore, you can't expect your converter to charge them, either. You are actually lucky to ever get your batteries over 80% full with a converter that is plugged in for several days unless the rig is stored and no electricity is being used. The single battery supplied on most small rigs holds about 90 amp hours. That is about 30 hours of charging from the converter, but at the same time you are still running loads and reducing the power actually going to the batteries, so we are talking days, not hours. The truth is that it takes even longer because batteries are not 100% efficient, especially when they get closer to full. In 2007 I repaired the solar system on a friend's motor home that had been plugged in for a full month at a park and then driven to our camp for a half hour, with the engine alternator charging the batteries. He arrived with his house batteries at 12.5 volts and the hydrometer showing them about 75% charged. This is typical of rigs that are kept in RV parks & occasionally taken out to boondock. They never have fully charged batteries. Converters need to be plugged in 24 hours a day to work, not run for an hour or two with a generator.

TOWING; or connecting a trailer to the tow vehicle and idling the engine is very inefficient because the wires used are too small and too long. The voltage drop is excessive and you are lucky to get more than a few amps, once the tow vehicle's battery is full and the voltage regulator tapers the charge rate to the vehicle's battery. Turning the tow vehicle around and using big jumper cables connected directly from its battery to the trailer's battery will give you much more power. That will get you maybe 10 amps (more if you have a big alternator) and up to 14.4 volts, which would take nine or ten hours to charge up that single battery. It will work, but it still takes a long time.

PORTABLE GENERATORS: Those with a DC battery charging output for direct connection to batteries work much better than plugging the rig in to the generator and using the converter in the rig, or using a small automotive type charger like I see many folks doing. This battery charging output will give you about 8 amps at up to 14.6 volts, which does work, but will take over 11 hours to charge up that single battery. A converter is unable to fully charge a

depleted battery even when plugged in for days on end, and it only uses a tiny percentage of a generator's output, so running it on a generator is a waste of fuel. Plus, the batteries will end up weakened due to not getting charged and will then not hold a full charge. This is also true in motor homes with built -in generators and converters. What you need is a battery "charger". This can be a simple automotive type, but it needs to be a big one, at least 25 amps, if you want it to work by running it for a limited period of time each day on your generator. A 25 amp charger that is run for two or three hours a day will maintain a battery in the average small RV. Remember that the amps taper off as the batteries start to get full, so it doesn't really put 25 amps per hour into them. A 25 amp charger will draw about 600 watts at 120 volts AC, so you can run it on a tiny 1000 watt generator, but you have to be careful and not run much else at the same time. You can run a 50 amp charger (about 1200 watts) on a 2000 watt generator, but again, little else at the same time. These numbers may not seem to add up, but you have a lot of inefficiency when you are converting the AC output of a generator to DC in the charger. One of the new "smart" chargers with a battery recondition (equalize) button on them are what you need. (Added Feb. 2011: It seems that the chargers you can buy at the big retail stores have all been outsourced to China and it is getting tough to find one that will work. It was reported back to me that both Diehard and Shumaker now shut off at only 13.8V. The Xantrex portable one shuts off at 14.4V and has no settings for different batteries. These used to work and now they don't. I don't have a recommendation except that Backwoods Solar sells an Iota constant voltage charger set up at 14.8V intended for use only for backup charging. (So, you don't have to have solar power to charge your batteries, but it does do a better job.)

INVERTER/CHARGERS: High end motor homes are now being supplied with these rather expensive, but useful gizmos. The big ones can quickly charge batteries when powered from a generator. The modern ones are programmable for battery type and amp hours of storage and this is where I have usually found problems. It seems that many of the RV manufacturers and repair shops don't know how to set them and if they are not set correctly, they won't work properly. The factory default voltage & amperage settings on most of them are just as low as a converter and some will automatically revert to that setting if you disconnect your batteries to clean the terminals. It is very important to learn how to program your inverter/charger correctly for the batteries in your rig, so you are getting your money's worth out of it. Remember, even these have to be run for at least an hour after you get the batteries up to the proper voltage and since none of them are set to 14.8 volts as Trojan recommends, an hour isn't nearly long enough. If you set them for a bit more amp hours than your batteries actually hold you can fool them into charging for a bit longer. Some have adjustments for bulk charge time and need to be set for at least three hours in order to really work. I recommend that you look at Magnum if you want to buy a new one. They figured out that 14.6V works better than the 14.4V that everybody else uses and the older ones typically are set at only 14.2V. I have to repeat myself here; even a Magnum charger will not bulk charge if it sees over 13V from the batteries when it is powered up by a generator and will come on in float mode. Therefore, trying to charge while solar panels are providing voltage to the batteries will not work. You must charge when the sun is low, in the morning. Otherwise, you are just wasting fuel & expensive equipment.

SOLAR POWER: Now, if you do decide to spend the money for a solar system, you have found the person that can tell you how to make it work. **I am aiming this information at those of you like me, who have a limited budget.** However, even those of you with lots of money need to become educated if you don't want to be taken advantage of by the RV solar salesmen, so keep reading. My wife and I really have been full time boondocking for over eight years (as of 2010) and we have never owned a generator. Don't listen to the folks that tell you the first thing you need in order to go boondocking is a generator. Campers who don't need to run the toaster & microwave are better off buying one solar panel and a small inverter instead of a generator. We run our TV, computer, battery chargers for phone, camera, tools, etc., plus coffee maker, microwave, mattress heating pad, toaster, waffle iron, hair dryer, vacuum, power tools such as skill saw, table and miter saws, router, sander, drills, heat shrink gun, soldering iron, etc. You name it. We live a normal life, except that our house is very small. My wife watches TV while she quilts with a sewing machine, using an electric iron to press the seams and I do remodeling & repairs, including building a big deck in 2006, using power tools connected to our rig, at a remote cabin with no electric service (where it rained for three days during construction). We have only 345 watts of panels (that is less than three new 130 watt panels), which we tip up to 50 degrees in the winter and four golf cart batteries giving us 450 amp hours of storage, so we can get through a few cloudy days. One person that I talked to about this (who owns a big rig with a huge TV) said "You must never go anywhere that it rains." A solid week of cloudy days like you get in the northwest would put a crimp in our style, but we have no problem living in Arizona in the winter, Utah spring & fall and summers in Wyoming & Montana, where it does rain. Show me an RV with the roof covered with solar panels and I'll show you a solar system with more panels than they need but does not work because it was added to and added to with no regard for voltage drop. Adding solar panels to an under wired system is like putting a big motor in a little car with a tiny drive train & skinny tires. You can't use the power.

Be very careful about who you ask for advice. (Don't ask the guy with solar panels and a generator running behind his rig on a sunny day.) You also need to watch out for those who brag about being charged up by 10:00 or 11:00 AM. They either have more panels than needed or their systems are shutting off early because they are set up wrong. When you see those guys with solar, wind generator AND the gasoline one, you really need to start to wonder. Ask any "expert" if he has ever actually done what we are doing and lived without being plugged in or running a generator for more than a few days at a time. It seems to me that anyone seriously in the business of selling solar equipment should be living with it. Both his home and business should be off the grid. If he is an RV'er, why is his rig parked behind his business location & plugged into the grid? Electricity from the grid does cost money, you know. Anyone who starts out by telling you what you cannot run instead of what you can run is the wrong person to listen to because really, with enough power, you can run anything. However, it is not practical to run anything like a heater or an air conditioner; those things take kilowatts, not watts. The solar industry is letting us down by producing solar charge controllers that have their charge voltage set too low (14.2-14.4 volts) and the installers are not doing their job by verifying that the systems they install are wired and adjusted correctly. (Most of them are clueless.) I have had several arguments with these so called "experts" over these issues. **Buyer beware!** Close to 90% of the solar systems with wet cell batteries that I have checked do not supply the 14.4 volts minimum needed at the battery terminals, either because they are set too low (many are not adjustable) or there is voltage drop in the wiring between the charge controller and the batteries. You have to realize that the voltage shown on your charge controller is measured at its output terminals, not at the batteries. There is voltage drop in every DC installation, even if the wire is very short, so all controllers need to be adjusted upward in order to actually get the batteries full. The same thing applies to the amps (they drop as the batteries fill and before the batteries are charged if the voltage is too low). I have seen systems with nearly two volts of drop in their wiring due to resistance loss, adding up to about a 25% loss. 25% of a four panel system is one entire panel! You must locate the charge controller as close to the batteries as you can or use BIG wire, so you actually get the volts to the battery terminals. (#10 is not big.) Above the refrigerator is absolutely the worst place for the charge controller, due to both wire length and heat (the enemy of electronics), which should tell you something about many of the solar installers, since this is still their favorite location. Worse yet, some of the older cheap controllers were set at 13.6 volts like the converters, are not adjustable and their instructions say you can connect them at the refrigerator supply wires, choking the power off and the money spent on expensive solar panels is just thrown away. The attitude in much of the solar industry seems to be that their factory settings are "close enough", which is absolutely not true. Manufacturers of charge controllers also seem to worry way too much about over charging, which

is very difficult to do with the limited amps produced by most RV solar systems. So, most of the systems people have had installed in their rigs by the so called “professionals” are not really getting their batteries full and they end up running their generators when they shouldn’t have to. Many people with only one or two small panels would actually improve their system’s performance and not hurt their batteries if they removed their cheap, nonadjustable charge controller and connected the panels directly to the batteries. (2 or 3 amps will not hurt a 225 amp hour battery, no matter how many volts you push it with.) It seems to me that if you are going to spend all of that money on solar panels, you should do everything you can to get that expensive power into your batteries. This means that money spent on big wire and a better charge controller is a wise investment. The difference in price between a cheap controller and one that will work is very small, as is the difference between small and big wire. Don’t waste a thousand dollars on solar panels and then throw half of it away by not installing and adjusting it correctly.

Even with my background in electrical engineering and electrical equipment sales, I was not knowledgeable about DC wiring and I’ve made all the mistakes. My attitude all along has been that money would be more wisely spent on solar panels than a generator and I would just not accept what I kept being told by salesmen that were on the outside of the RV boondocking world, looking in. I installed our first solar panel with the #10 wire furnished in a kit and installed the controller above the refrigerator as directed in the instructions. It did not work. I would take the amps, hours and the rest of the information that was available, calculate, figure & obsess and it never seemed to add up. I added a second panel after three months of traveling, and then added tipping hardware. Our batteries would still go deader & deader every day as we ran nothing more than our lights & a tiny 9” TV. Then I listened to the wrong advice & added two more batteries to a system that wasn’t charging the two that I had. I finally figured out that voltage drop was the biggest problem, but having no experience with DC power, it was a real challenge to figure out how to fix it. We are now in our second rig, fifth charge controller and on our eighth year of full time boondocking and are pretty much acting like electricity falls from the sky in unlimited amounts. (Wait a minute…. Maybe it does!) So, when I tell you it is possible to run on solar equipment, you can believe me. We do it. One more time: We have never owned a generator. Believe it or not, most of the folks in the solar power industry, including the manufacturers and the dealers do not know how to make solar power really work. I’m not saying that *none* of them know, but it is my experience that the honest ones who really know what they are doing are in a very small minority and most of them are doing houses, not RV’s. Even those folks will tell you that you need a generator and will not believe me when I describe how well our system works. You see, most of them are just selling the stuff and not relying on it like I do. There is a great big difference.

One bad example of this was the technical guru of a company that manufactures solar charge controllers and installs RV systems, who I had the occasion to talk to because I was repairing an under wired inverter installation they had done. I was thinking about replacing my controller with their new MPPT unit and I was trying to decide if it was the right one for me. He could not explain to me why their new controller was set a half of a volt lower than the Trojan factory recommends and did not have the ability to equalize, while claiming that they talked to Trojan all the time. He told me I would boil my batteries dry by following Trojan’s 14.8 volt recommendation and then said to use my generator & inverter/charger to equalize (after I had already told him that I owned neither). He bragged that they tested their equipment on the company owner’s own motor home with his roof “covered” with solar panels. He said “of course he has a generator, *everybody* needs a generator.” This was a very illuminating conversation for me. Here was an “expert” on solar who evidently didn’t trust it enough to rely on it and appeared to be ignoring what the biggest manufacturer of deep cycle batteries in the country has to say. Looking back on this conversation a year or so later, with more experience under my belt, and after installing one of their MPPT controllers in a friend’s rig with AGM batteries (where it worked fine), it occurred to me that the company in question had decided that we should all be able to afford sealed batteries and were designing their controllers specifically for them. However, their advertising, their installation instructions and the numerous dealers selling for them have not been telling us this. Their controllers work fine if not overloaded with more panels than they can handle and if they are used as intended on AGM batteries, which can be done if you go to their shop to get it installed, but there are lots of them hooked up to wet cell batteries and that are not working very well at all by dealers who have no clue what they are doing. I have replaced several that were badly misapplied by connecting to too many panels and then hooking up to flooded batteries with small wires by “expert” dealers and RV manufacturers. I saw one 30 amp controller that had over 45 amps of panels connected to it by a solar dealer, and you are supposed to leave headroom above that for the possible boost! (Yes, it had failed.) 400 watts overloads their 22 amp controller and many systems have been installed this way by one of the top fifth wheel manufacturers. One guy I met had to buy new Trojans after only three years because of those guys and they would not listen when he complained. These controllers will limit the amps down to the level they are rated at, so connecting more panels than they will handle is a waste of money, in addition to being a way of selling replacement controllers. By the way, the owner of this solar company contacted me and complained after one of you out there wouldn’t listen and handed him a copy. He told me that “nobody in my company ever told you that you had to have a generator.” Sorry, but the above statements are direct quotes, I have phone logs, and have not made any of this up. While they may be doing good installations now, they used to put three 120 watt panels on #10 wire and those systems did not work. I also can’t help but wonder just how many inverters have been installed by how many different companies with cables smaller than Xantrex requires. I’ve seen a lot of motor home installations done by RV manufacturers that have too small cables run too far from the batteries. I tried to buy #2/0 cable last winter at an RV place in Quartzsite and the guy tried to sell me #2, saying that was what they used for all inverter installations. This is a more common problem than you would believe. The only reason we are not seeing more problems is that most folks do not load their inverters nearly to their capacity like I do, so the voltage drop issue is not apparent.

Following are some “Common Sense Guidelines” for designing a solar power system that really works. One of my friends says common sense ain’t all that common. Ain’t that the truth? I’m not going to get technical, because you don’t need to. This is not an installation manual because there are plenty of those already available. It is intended to be an education guide. If you really want to obsess about amp hours, watts, types of panel crystals or charger regiments you can go buy one of several books, or go to a seminar that will confuse and probably misinform you. Even worse, go on line & solicit the help of strangers who sit at their computers, in rigs that are parked in RV parks, but claim to be experts on every subject under the sun. Even before I figured out how to fix my system I had walked out of two seminars at Escapades because the people running them were so obviously lacking in knowledge. On the other hand, if you just want a system that works and doesn’t cost too much, read on. As you read, keep this in mind: **I’m not trying to sell you anything.** I just want to help you get your money’s worth and prevent somebody else from taking advantage.

HOW MUCH POWER?? Everybody is different. How’s that for a generality? Examples:

We have RV friends that get by just fine with one 125 watt solar panel and two batteries on a 34 foot class A motor home. They don’t watch a lot of TV, but they do occasionally use a laptop computer. They were going to buy a second panel, until I showed them how to reset their controller to get 14.8 volts to the batteries and now they have plenty of power. The dealer told them they needed three panels, but did agree to put only one up initially and use #8 wire, but then he left the controller at the factory default voltage setting (14.4V on the controller/ 14.2V at the batteries).

We have other friends with a four slide-out fifth wheel, the built-in vacuum system and 27 inch TV that get by nicely on only two 125 watt solar panels and four batteries. The dealers told them they needed either three or four panels. I told them to try two panels and wire it for three, and helped them install & adjust it correctly. They used battery power with their new inverter to run the built-in vacuum system to clean up the mess we made & watched movies that night to see how things worked. Their generator got loaded into the back of the truck the next day and wasn't used again until they got snowed on the following fall up in the great white north.

We have other friends that you will recognize if you ever see them, because of the eight big panels (800 watts) in a motorized tilting array on the roof of their 40ft bus conversion, six L16 batteries, all of the usual appliances, plus a 22 cubic foot over/under residential 120 volt refrigerator. Their system seemed to work except for having to run the generator any time it got cloudy for a few hours and then I convinced them to let me do some rewiring, move their controller closer to the batteries and replace it with a big three stage unit. The generator doesn't run now unless it rains for more than three days in a row. They could be getting by with only 500 or 600 watts, but with their over designed system they can now ignore the rain. By the way, according to something I read in a solar dealer's catalog, they should need 500 watts just to run the refrigerator. This is how I know that the information in that catalog is not to be trusted.

Then there are the folks who have five big solar panels tipped up on the roof, one of the big expensive boost controllers and six batteries on their 40 foot motor home that can't get along without running the generator nearly every day. They also have a 27 inch TV and a computer and a large phantom load, but no electric frig and more than 600 watts of panels (don't forget the boosting controller). Their system was installed by a "professional", using too small of wire and even though the meters show that it charges, they are losing at least 20% of the power their panels put out (a whole panel's worth) in wiring losses, even after spending hundreds of dollars on the boost controller that would supposedly solve their inadequate wiring problem by running 24 volts down from the roof. It does not work, because it does not provide what they need and they won't listen to me.

Then there are the folks we ran into only once, who had two panels, four batteries and a noisy generator running on a sunny day. I showed them with my meter how their system was wired inadequately and was not getting their batteries above 75% or so, but they weren't going to be convinced. "The controller is blinking full and 14.4 volts" (It was 25 ft away from the batteries, which were getting only 13.5 volts) and "by God, the guy we bought it from knew what he was doing, we spent $5000 on it and you don't know what you're talking about". So, why is the generator running?? "We are using it to watch TV, so we don't run the batteries down." They couldn't watch TV all evening on their four "full" batteries without having them go dead! Those four batteries should power their little TV for two full 24 hour days and their panels could produce 3 or 4 times as much power as the TV used, if it was only getting to the batteries. Sometimes you just have to walk away, go home & start writing the RV Battery Charging Puzzle, which is exactly what I did.

See, everybody is different. You cannot tell by looking at somebody's rig if their solar equipment actually works and most folks don't really know so be very careful about asking strangers for advice. There are thousands of rigs out there with systems that do not really work, owned by people that don't know any better and think their systems work, while at the same time being paranoid about turning anything on, trying LED lights & burning candles. If you can't use your lights and appliances whenever you want to day or night, your system does not work. Remember that your appliances are part of your electrical system. You can spend money on more efficient appliances like a smaller TV, instead of buying more solar panels and end up with the same net result. This is not an acceptable compromise for many folks, but by doing just this we are able to leave the TV on all day and still be able to run things like the toaster and the electric iron that those other folks cannot. Many people have gone to extreme measures with their lights to save tiny bits of power, something that we have not done. We don't like fluorescent lights and LED's are just not ready yet (they are improving). I even replaced the fluorescent over the kitchen counter with 12V halogen under cabinet lights that use twice as much power. We use incandescent lights for reading that take more watts than our TV does. We just turn the lights off when we don't need them. A propane heater that keeps you from running the furnace motor is also a lot less money than a solar panel, so I consider it to be part of your generating system.

That said, here is this stranger's advice: If you want to just be able to run your lights, water pump, charge the cell phone and run the occasional small kitchen appliance, acting more like a camper than a full timer, you only need one panel and one or two batteries. If you want to run the TV a bit, computer, the microwave to warm up soup or make popcorn and some kitchen appliances you'll need two panels and four batteries. Of course you need more panels if you go where the sun doesn't shine or if want to run more, such as unusual loads like a freezer in the basement or a CPAP machine to keep you breathing all night. It can be difficult to figure out how much power any device needs because the labels generally show higher watts than actual and then you can't guess the duty cycle. There are meters available ("Kill A Watt") that can do this for you, but if you buy that smart meter like I told you earlier even before you buy any solar panels, you will have what you need. If you aren't going to be able to climb up on the roof and tip the panels during the winter, add 40% more panels and keep in mind that the newer and fancier motor homes typically have as much as two amps of phantom loads that you'll never be able to shut off. You need to find somebody like me with a DC clamp on ammeter and test your rig for phantom loads. (Two amps over twenty four hours is 48 amp hours, and that is more than a whole solar panel in the short winter days.) When I say panel, I mean a modern one that puts out 100 to 130 watts. I don't care what brand or type, just check the warranty, calculate the dollars per watt and do some comparison shopping. You will find that the bigger panels are a better buy. Unless you stumble into a bargain on used panels it is short sighted to buy smaller panels. Don't buy more batteries than you need to get through a couple of days unless you need to run big loads like a microwave oven. It is not good practice to draw the 120 or more amps that can take out of only two batteries. You do need more batteries for big loads but realize that every battery you add has a built-in loss that must be overcome by your charger, so more is not necessarily better. Adding batteries to a system that doesn't have enough charging power is like putting big truck tires on a compact car. You end up with something that burns more fuel, but can't carry more cargo. Good luck if you try to calculate your amp hour needs based on what you find in a book or at one of those seminars. The people that gave you the info are trying to sell more panels. You won't really know what you need until after you have lived with whatever you install for a while, but you can get by with fewer panels than you have been told elsewhere, if you install them correctly. Regardless of how much power you use, you need nearly 3% of your total battery storage amp hour capacity in charging amps in order to successfully charge those batteries. With less, you can't equalize. For instance, six batteries with 675 amp hours capacity require 20 amps charging (675 x .03 =20.25), which is three panels. Two panels do not produce enough power to successfully charge six batteries. The number of panels gets you the power needed per day plus some excess to make up for what you miss during cloudy periods, while the battery capacity is what gets you through the night, or in our case, through a few cloudy days. Remember however, that panels do produce some power even on rainy days, so the batteries do not have to be sized to power several 24 hour days of use like some dealers will tell you. We have more panels than we need, so we can charge our batteries while still living, and so we don't need to carry a generator. Having a generator lets you get by with a smaller solar system.

Wiring your system for more panels than you buy will keep you from having to do things twice and will make your system more efficient if you end up not needing to add panels.

THE CHARGE CONTROLLER: FRIEND OR FOE? Charge controllers are installed to limit the power sent to the batteries and keep them from being damaged by overcharging. Therefore, one that is set too low becomes the enemy of anyone who wants to actually charge their batteries until full. The typical solar charge controller, which is a flush mounted two stage or on /off device and rated 20 or 25 amps, is designed to maintenance charge one or maybe two batteries. It tapers the charge amps off by regulating the voltage, typically as soon as it reaches whatever its voltage set point is, which is usually around 14.4V, instead of pushing amps in for a period of time as required by the batteries. Go back & reread what I said under batteries about the difference between 14.4 & 14.8V. That 20% difference is like getting only 80% power output from your expensive solar panels, so a controller that shuts off early is costing you money. The manufacturers of these things have no idea of what we are trying to do with them out here in the real world. They designed them to trickle charge batteries and keep them from going dead, not to actually power a small house. So, our batteries get "nearly" full, not really full. That "nearly" full battery will still show 12.7 volts after the sun goes down, but it is not really full and also not really healthy and will get weaker over time. Get a three stage charge controller that will handle the power from more panels than you buy and that has an equalize button on it. Equalizing is the source of much disagreement in the RV world, and I know you don't really need to do it if your charger is working correctly. Trojan Batteries says to equalize only when you need to, based on a hydrometer test and I did not have to once I set my controller to 14.8 volts, until those batteries were eight years old. Temperature compensation is very important when solar charging. This will lower the voltage setting when over 80 degrees to keep from over charging and raise it in the winter because batteries need more volts in cold temperatures. I see as high as 15.2V on my meter on cold days and that is what it takes for correct charging. Setting it low all the time is what most installers do, and that keeps your batteries from getting full and is very bad for them. Three stage chargers are easier on your batteries, charge them faster, fuller and help you use less water. Some of the older controllers sold in the RV world actually taper the charging amps before the batteries are full. The charge control manufacturers are all very conservative in their settings, so don't worry about hurting the batteries by turning the voltage up. And last, don't load any controller to over 80% of its rating (lower is better), no matter what the manufacturer says. You want it to last for years, not just get through the warranty period. Since 2008 I have been using a Morningstar Tristar 45 with temperature compensation but no digital meter or remote because I use a Trimetric 2025 to monitor the batteries. The Morningstar uses a self adjusting charge algorithm to take care of the batteries. It charges for a minimum of two hours after it reaches the voltage set point and monitors the amps going out. It will not drop to float until it sees the amps dropping and thus knows that the batteries are full. Mine almost never floats because we are always using our power. These big non-boosting controllers were designed to power home systems and they really do work. Before this one I used a Xantrex C series unit, which worked decently, but failed after only 3 1/2 years. Xantrex has moved their production to China and has problems ever since, so I went looking for something better. My older flush mounted RV controller was only four years old, rated 30 amps and it was starting to act funny (failing). But worse than that, it was designed by the manufacturer to start tapering the amps long before it reached the set point voltage ("a gentle finishing charge"), so it was shutting the power from my panels off before the batteries were full. People who don't believe me on this point never saw what the Link meter showed when the voltage reached .2V below set point. (The amps dropped to half and I was scratching my head for days trying to figure out why.) Why the idiots that designed that controller think we need to taper what is already a trickle charge is beyond me. I want all of the power my panels put out to go into the batteries. I didn't figure out that this was happening until I replaced that controller and saw the big difference in the available power. Don't buy any of the little flush mounted two stage controllers, including the "boost" models if you are serious about using solar power. They all shut the power off before the batteries get full unless you ignore the instructions, put them in the basement at the batteries and turn them up.

MPPT BOOST CONTROLLERS (maximum power point tracking); Yes, they do work, assuming that you run your batteries down low enough, which you will hardly ever do if your system is set up right. My system runs in the top 15% of its range 95% of the time. The magic boost kicks in when the batteries are low and will accept more amps at a lower voltage. There is little or no boost at higher voltages and when the panels are hot. Also, the manufacturers will tell you that you can overload their controllers and they will limit the power and protect themselves. If you look at the meter on one of these, it will show boost even when it is at set point volts where the manufacturer's specs say there is no boost, so just what is it doing; boosting or shutting the power off? It can't be doing both at the same time! I have proven that these controllers play games with the input amps shown. If you take one out and replace it with a good non MPPT controller when the batteries are near full, you will see that the input amps change, while the output stays nearly the same. I have done this more than once. I even got one of the RV Solar dealers to do this and boy did he get upset, red in the face & started yelling at me, something I am sure he would deny now that he is on the boost band wagon. I tested the input & output of one of the best ones available with my Amprobe and when I multiplied the numbers to get watts, I found that the controller was losing about 10% in its electronics. It was definitely boosting the amps while lowering the volts, but that unit was advertised to be more than 98% efficient, not 90% as I measured. If you carefully read the reports on these controllers, you will realize that the magazines never do comparison testing side by side with other brands and independent metering. They simply report what the meter on the charge controller shows as if it is gospel. The whole story is suspect and when you look around on the discussion forums; people have backed off from those huge claims and are now being more realistic. Of course there is another new manufacturer who is making up to 40% boost claims, but where he found this energy that nobody knows about is not explained. There are those who don't believe in MPPT at all, but they are in a small minority. My background was in the lighting business, where certified independent test reports were the norm, so that is what I expect to see. There doesn't seem to be any such thing in the solar business. I'm just not convinced that these controllers are worth two or three times as much money. I know, the small two stage units don't cost that much, but they don't work. I have replaced several of them with non-boosting three stage units and the systems had more power afterward, not less. The "experts" don't want to believe this, but the people that I have done this for would tell you the truth. Buy a three stage boost unit if you can afford it, just don't expect any "25% or more" extra power and do not overload it so that it shuts your power off. Just read the directions. Somewhere around 5 or 10 % average daily increase is more like it and you are going to get that much extra by running big wires. Last, don't completely believe the latest "trick" about fixing voltage drop problems in a system by running 24V down from the roof in small wires and then transforming down to 12V in the controller. All transformers (including electronic ones) have an efficiency loss and even the MPPT circuitry is not 100% efficient. You gain by running 24V & then lose by running it through a transformer. Last, the boost comes from using excess volts put out by the solar panels and turning it into amps. If you don't install great big wires so that voltage is actually getting to the controller, then you are wasting the extra money spent on the MPPT controller. Morningstar is recommending that you design for only a 2% loss, panels to the controller and that means even bigger wires when using MPPT. The older recommendation (that the solar "professionals" have mostly ignored) was 3%. The dealers who tell you that MPPT will make up for the voltage loss in the wiring are lying to you. Without the voltage, MPPT cannot work. You can use higher voltage, lower amperage panels and get a bit more power with MPPT. This does work because at a higher voltage, you will have less voltage drop before the controller. However, 100 watt panels put out a max of 100 watts. When the company makes outrageous boost claims, they are talking about boosting the amps from panels that put out lower amps than other standard voltage panels, not the watts. They use this as a marketing tool. You need to do some serious comparison shopping before you decide if their

system is worth the price. You need to compare other systems using standard voltage panels and big enough wires for watts per dollar into the batteries. I have seen my meter showing 340 watts for short periods of time from my ten year old 345 watts of panels on cool mornings with my PWM Morningstar Tristar that is not MPPT. I know that MPPT would give me a bit more, but I don't believe it to be worth the $250 increase in price to get another 10 or 15% at most (maybe 40 watts), when at 2010 prices that would buy a whole solar panel. However, on my future house I will be using an MPPT Tristar and running high voltage down from the roof. I have calculated my voltage drop at 1% using only #6 wires on a 1200 watt system. A 10% boost there would be 120 watts. That is worth the money, especially when you look at the reduced wiring cost. Who does not understand MPPT? (Just a little barb aimed at those who will know who they are.)

WIRING: Resistance or impedance is the enemy. You have to overcome it and get the power to the batteries, not just to the output terminals on your charge controller. The system in my rig is efficient because I wired it with six gauge wire, for a total distance of only 12 ft from panels to controller. I ran #4 from the controller to the batteries. I spent about $30 for this wire and gained about $120 worth of added power when looking at what 6% of what my panels cost, which is about what I gained when going from 25ft of poorly routed #8 wire to 12ft of #6 wire. Big wire is even more cost efficient when you are looking at the difference in cost for a new installation. If your controller is located very close to the batteries like it needs to be, it will regulate the voltage to the batteries so they get what they need. You can run smaller wires from the panels to the controller than you run from there to the batteries, but make sure you can get nearly 16 volts minimum to the controller by looking at a voltage drop table. Big wire is cheap compared to the cost of panels, so err on the big side. You can either run big wire or install multiple smaller runs and split the panels up into several feeds. DO NOT tie the wires together at both ends. One wire will always have less resistance & carry more of the load. Find a voltage drop chart and limit your loss from the roof to the batteries to 3%. This way you can ignore the drop in the wires on the roof. You will find that voltage drop is directly proportional to the number of amps (higher amps equals more voltage drop), which is why you should wire for the number of panels you might need and not use the minimum size for the panels you initially buy. Use BIG wire, at least #8 for two panels and, and #6 for three panels and that is only for runs under 20 ft. I have installed a lot of #4 cable and wish I had it in my own rig.

From the controller to the batteries the wire size is critical. The bigger the better. If you cannot design for less than a 1% drop due to the length of run, it is possible with better controllers (Morningstar Tristar & Prostar, plus a few others) to use remote voltage sensing and the controller will boost the voltage going out, so that the correct voltage reaches the batteries. Do not be tempted to use this as a way of installing smaller wires. Voltage drop in the run between the controller and the batteries equals wattage loss in charging. Fewer watts come out of the end of the wire than go in when the voltage drops. This means that using smaller wires here will cost you watts charging every day forever. This is a foolish place to save a few dollars.

A word on the stranded wire debate: Yes, you should use stranded wire because it is better for DC power. However, the difference between stranded building wire and finely stranded automotive or welding cable is teeny, tiny electrically, so don't obsess about it. The finely stranded stuff is easier to work with, but the main thing to worry about is a UV rated shield on the roof, protection against damage when routing through the rig and the price. Buy what you can find at the right price and what you can deal with mechanically. There is nothing wrong with running big, stiff wires and then splicing short, flexible leads on the ends to make it possible to connect to terminals. The big wire is there to limit voltage drop, not to carry amps. You are not going to load it enough for the splices to get hot and fail.

INVERTERS: I use two inverters in the rig and carry a third in the truck for portable power for the lap top. This may seem like overkill, but I have my reasons.

The first is a 300 watt sine wave that is located near the batteries and connected to them with 4 gauge wire and a 60 amp fuse. From there I ran a 12 gauge building wire to the entertainment center where it powers a custom built power center with individually switched receptacles for the various appliances such as TV, stereo & sewing machine. This turned out to be a waste of effort. The TV draws only .1 amp, so we leave it on and our new energy star stereo does not show up on the meter, even though there is an LED light on the face. Other cords run to the mattress heating pad & the air pump for the Select Comfort bed and to a receptacle for the sewing machine. This is all never connected to shore power. This may seem like a lot of trouble and expense, when I could just turn my big inverter on to run anything, but I figure that I am getting as much extra power from this as I would from $350 worth of solar panels and wiring. Many big inverters constantly draw over two amps, and mine is more than that. Power saved is much cheaper than power generated. However in some motor homes trying to install something like this can be a nightmare and another solar panel can be the better answer. I resisted buying a sine wave inverter for years and finally bought one in 2008 after having two cheap inverters fail and realized that I was risking $500 worth of TV & stereo on $40 inverter power. However, we did go for eight years, powering everything from modified wave inverters, including the computerized sewing machine, lap top and a changing assortment of TV's. Our HP printer is still powered by the big modified wave inverter.

The second inverter is a large modified wave power inverter (with no charger) that is also located close to the batteries and connected through a 400 amp time delay fuse with #4/0 cables. This happens to be an old Vector and no, I would not replace it with a Vector if it were to fail. It supplies the 120 volt panel in the rig through a manual transfer switch and there is a remote control switch in the Kitchen, so we can turn it on only when needed because it has an idle current draw of over two amps. (The breakers that feed the air conditioner and water heater are switched off and the fridge is switched to gas.) Since we never plug in, we never have to remember to flip the transfer switch. Manual switches are reliable. This inverter is a 2200 watt unit that has a surge capability of 4600 watts. It will successfully run my 1 ½ HP air compressor, table saw and anything else I want. I used it to power the seamless gutter installer's machine at a cabin site in Montana. You should have seen the look on that guy's face when I showed him where to plug in! I don't own a battery charger, because I have no generator to run one with, and inverter chargers are expensive. Well, actually I did replace the converter with a tiny ten amp battery charger just in case, but it has only been plugged in when forced to park under trees at a friend's house or when covered with snow, which we don't count as being hooked up. It is located at the opposite end of the trailer from the batteries, so it does not work well.

New inverter warning in 2010. UL has a new safety requirement that requires GFI protection be installed in inverters. Any with receptacles on them and no hard wire connection will likely be built this way. This has made most small inverters not suitable for connection to electrical distribution panels. All you can do is read the directions looking for this warning in the small print. If you try to connect to the whole panel with one of these inverters it will shut down, showing an AC output fault. You can use any inverter in an RV with an extension cord run to whatever you want to power; you just can't tie some into the AC panel. Great, our government is making us buy expensive inverters with built in transfer switches to protect us from something that was not dangerous because our rigs already have GFI protection. See the high voltage warning below.

If you can afford it, and already have a generator to power it, an inverter charger is the way to go. They have a built-in transfer switch, which simplifies installation, and a big charger that is programmable so it can be set up for whatever batteries you have, though it would be nice if they were set to a higher voltage. You must have a transfer switch because you will burn an inverter up by connecting its output to outside power fed back through the electrical panel. You would think that everybody in the RV business would know this, but I keep finding failed inverters installed without transfer switches by RV dealers and the owners of the rigs have no clue what has happened. I have found three where the installers had bypassed the built-in transfer switch in the inverter charger! The transfer switch can be a simple cord & plug arrangement instead of a $100 automatic switch, just make sure it is fool proof. The biggest challenge with an inverter installation is figuring out how to hook it up to the loads; the whole panel, one phase of the panel in a 50 amp rig, add a separate panel or connect to one circuit only. There is just too much variety to make it simple and you have to be careful in order to do it safely. Whenever you read anything that tells you to always do it in any one way, you know that the author doesn't have much experience. It is not that easy.

A word about Sine wave inverters: Unless you need to power something that must have a pure sine wave, (and don't believe everything you hear), you don't have to spend the extra money. I know, a pure sine wave inverter does a better job of powering a microwave, toaster or hair dryer, but how much money do you have to throw away? The money we saved is more important to us than the convenience of running the toaster for a few seconds less. Big sine wave inverters are expensive and they have high idle losses, (up to five amps) which can be enough to require you to buy another solar panel. Get that appliance to somebody with a decent modified wave inverter, plug it in and find out for yourself if it works. Just don't buy the cheapest inverter you can find. The "soft start" units work better. My inverter starts 1 ½ hp tools like they are plugged into the grid. My last inverter was an old Heart 1000 and it worked just fine, except that it was too small to run my power tools. I have been recharging my Dewalt tool batteries for 10 years on modified sine wave inverters and haven't burned one up yet. So much for that "fact". We have friends that run big juicers and food processors on their modified wave inverters. The only appliances I have heard of that absolutely need sine wave power are residential refrigerators, washing machines, some air purifiers, some desk top computers and Craftsman brand battery chargers. Both the inverter and appliance manufacturers are controlled by their lawyers; they are overly cautious.

Warning: Properly adjusted solar systems with temperature compensation will regularly exceed the 15 volts many inverters use as a high voltage shut down. Xantrex has changed their X-Power line so that their inverters, manufactured by a company that also makes solar charge controllers, will not work on solar systems. Most of the cheap inverters have this problem, as well as noisy fans that run continuously. Go Power, Cobra, Whistler and most others have this problem. These companies don't realize that there is another market besides the truckers. Aims inverters work at over 15V, but you don't want to know what kind of failure rate I have seen. The Morningstar Sure Sine 300 has no fan, a 600 watt surge rating and very low idle current. Of course; it costs nearly $300. I finally bought one anyway and have not regretted it. Some of the Samlex inverters will work, but you must check their specs carefully because they changed some without notice, causing me problems.

INSTALLATION & LOCATION OF EQUIPMENT: Locate the charge controller as close to the batteries as you can. It puts out the power that the batteries need and if you run any distance to them, they won't receive that power. Go back and reread what I said about wiring earlier. While you can compensate for voltage drop in wires that are too long by turning the controller set point up, this is bad practice because the voltage at the batteries will rise as the amps drop off late in the day. You can easily end up with an over voltage condition, causing all kinds of problems. So, you have to set it too low to really get the batteries full while the amps are being generated in the middle of the day. Try to find a short route to get from the roof straight to the batteries and put the controller between, at the battery end of the run. You will learn over time that the controller does not need to be constantly watched, so worry more about how well it works than how easy it is to see. Mine is buried in the basement and I never look at it. While the refrigerator vent is an attractive route for wires, it is hot and is rarely in the right place. Run the wires up inside of a wall, cabinet or closet. Then go ahead and drill a hole in the roof and plug it by bolting a weatherproof box down over it that is sealed to the roof with caulk. This will never leak. Buy one big enough for all of the connections it will contain. Use big mechanical splices, (ground bars for AC panels work well) or wire nuts for small systems, and then seal the holes out onto the roof with UV resistant caulk like Dicor or ProFlex. A 4" sq. x 2" high plastic boxes with a gasketed cover works most of the time. You can run multiple 10 gauge standard solar system cables on the roof (one to each panel) and not worry about voltage drop, then run big, non sheathed cables down to the controller.

Locate the panels on the roof so that they are NEVER shaded at all by the vents, air conditioner, etc. There are a few panels on the market that will lose just *some* power if partially shaded, but many go completely dead if you shade just one cell (like with a TV antenna). Look at the photos at the end of this. The "professionals" that install systems have done a lot of poor installations by ignoring this problem. They must know better, so selling more panels has to be their agenda. I have been amazed and appalled several times when evaluating systems at what I found on the roof. You don't really want to have a lot of extra holes in your roof (like on mine) due to poor planning, so try to get it right. If you are going to go to the money and effort to tip them, make sure you get hardware that gets them up higher than 45 degrees. I've seen a lot of standard mounting bars holding panels at 30 degrees or less (about 10% less power). Last, you need to face the panels south. I have seen several rigs parked with their panels tilted up & facing east! I'm afraid to ask what their "really good" reason for this might be! Their systems are completely shut off in the afternoon when the sun is shining on the bottoms of their panels! I have also seen a lot of panels arranged so that one panel partially shades another (the same power at twice the price). I have learned to not ask questions of those that are obviously challenged, just like those guys with 6 panels & a generator running on a sunny day. I have tired of trying to reason with the unreasonable.

FUSING: This just flabbergasts me but I run into unfused wiring all the time in RV's; a lot of it installed by the original RV manufacturer, and some installed by "professional" RV technicians. I say "fuse" on purpose. I don't like the automotive type automatic circuit breakers. First; you can't turn them off like you can pull a fuse for disconnecting; and second, breakers are mechanical devices that are prone to failure. I have also found a few that were drawing a phantom load. Don't use the in-line fuses with springs behind them for a heavy, constant load like solar charging. They tend to get warm and eventually melt down. This is true even for the larger ones in a clear plastic case that the solar dealers sell. I use the 250V cartridge type commercial fuses & holders. One of the folks I sent this to came up with a brilliant suggestion for fusing the solar leads; a two pole fused air conditioner electrical box with a pull-out disconnect. They are available 30 & 60 amp and have #4 lugs for the big wires we need to use. Connect the input from the panels to the controller on one side & the output from the controller to the batteries on the other. Disconnecting the entire solar system is then one simple motion. They are dependable and cheap, however the cheap one available at the box stores will not hold up to a constant DC load over about 25 amps, so look for a Midwest or GE. The bottom line is that every single positive wire needs to be fused within inches of the battery so that it will be protected should it ever rub against something metal and cause a short, starting a fire, or worse. Batteries have been known to explode if shorted to ground.

SUMMARY: We are improving the RV world one rig at a time. Please tell your friends and hand copies of this out like confetti, just don't give it to the "professionals" who will tend to get defensive and disagree with half of what I say. I get a lot of "Bob obviously doesn't know what he is talking about" from people who sell equipment or constantly run generators. I recently saw a letter from a dealer selling portable panels who claimed that I didn't know the correct charge voltage and that auto systems run at 13.8V. SAY WHAT?? (Does the man even own a volt meter?) You can take your volt meter to your auto & figure out for yourself in a minute or two just who the idiot is here. I am the voice in the wilderness where no generator can be heard. One of the dealers has even labeled me "Overkill" Bob. I have no problem with that, because he has it backward. If you let him, he will sell you more panels than you need and a $600 controller that definitely deserves the overkill moniker, plus nothing but a true sine wave inverter, and try to convince you with a very arrogant attitude that you are stupid if you don't buy both. THAT is the very definition of overkill.

There is a better way and you do not have to buy a generator first to go boondocking.

Generators??…… We don't need no stinking generators.

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NEW INFO ADDED 2012:

If you have read this far you must be serious enough about this to be thinking about installing solar, so here I will share something about do it yourself installations. Jack Mayer wrote a book about RV Solar and has it available for free on his web site. IMHO, he should be charging $50 per copy for it:

http://www.jackdanmayer.com/rv_electrical_and_solar.htm

Now, when you read that remember where Jack is coming from. Compare our rigs and our lifestyle. What am I saying? His information is nearly all good, but it is from the viewpoint of one who has a lot more money to spend. He and I agree on most things and disagree mostly on MPPT. His "golden rules" are aimed at folks with money. My views are more budget conscious and aimed more at smaller systems where MPPT is not worth what it costs. I recommend MPPT only on systems over 600 watts. I also will tell you that his opinions on cheap batteries are not in agreement with my experience and that hammer crimping of cable terminals is not a smart thing to do. If you have to use the hammer crimper, squeeze it in a big vice. Hammered copper does tend to rebound. Under constant load a hammered crimp can get loose and then it will get hot. This is not opinion, it is based on my experience.

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NEW INFO & PHOTOS ADDED JULY 26, 2009:

Now for some photos of the problems I have found. It seems that photos are needed to drive the point home about the things I write about. These are just a few examples. I have found similar issues on systems installed by the majority of the RV solar dealers, even those that have a good reputation. Some of them have gotten better over time, but I have found problems in installations done by most of them. As I have said over & over, most people with solar power don't know if it is working properly. These photos are of systems owned by people who sought me out because they had talked to others who have solar power that now works, thanks to my help. I only recently started taking photos because I never intended to go to this much trouble. Early on I optimistically believed the problems were rare, but over time I found that problems like these are way too common. Some of the photos that I didn't take would have been a lot worse than these. I have found everything from stupid mistakes to extremely dangerous wiring problems that would scare you to death. I have nothing but my memory to relate most of them.

The numbers I give for amps & percentage loss are based on measurements taken with a very expensive Amprobe clamp-on meter. Watching the output shown on the meter while moving a panel or causing small shadows is something that really opens people's eyes. Nobody wants to believe what I say about small shadows causing big losses, but it is true.

CASE STUDY #1:

This is a 40 foot motor home with six solar panels and a generator that runs nearly every day. They have a small freezer in their utility trailer and they own a 38 inch TV. While most folks think this is just too much to expect of solar power, you need to think about this. This system is 720 watts, enough power to run a small home, if the energy produced by those panels could only get into the batteries. What I found on the roof was unbelievable.


Minus 2.9 amps.

You would never believe that unless you saw what happened to the meter readout when we unbolted the panel and moved it about two inches.

Minus 6.4 amps from these two panels!! This is 90 % of the output of a full panel.

What I found in the battery compartment was even worse that what was on the roof.

The 40 amp controller in this photo was installed in the battery compartment by the best dealer in Quartzsite and they told the owner of this motor home that they would guaranty it forever. Not only is this bad because of the potential explosive hazard due to Hydrogen gas and the corrosion problems due to sulfuric acid, (the stainless steel cover screws were rusty), it was connected to a potential of 42 amps from the panels with #8 wire, dropping the voltage so low that the batteries were never charged. The batteries were shot due to constantly being undercharged.

I refused to work on it unless I could replace the controller with a properly rated Morningstar Tristar with a temperature sensor and locate it in the next compartment over with the inverter. After rewiring with #4 cables, fixing the multiple shading problems on the roof, and doing some reprogramming and education concerning his Link meter, this guy now successfully runs everything he wants, including a the 38"TV and the freezer, without running the generator. The generator is only needed after a couple of cloudy days.

CASE STUDY #2:

A 40 foot fifth wheel with six panels, three controllers and owners who never use electricity because their system does not work and they hate to run their generator. The people that own this rig had spent over $6000 and were afraid to turn anything on. This is a perfect example of what I say about the dealers setting you up for failure. The problems were unbelievable, from six improperly wired batteries scattered in three different compartments to long runs of #10 wires from three junk charge controllers mounted up near the ceiling. Only two of the six panels did not have shadowing problems. These folks had bought solar, added to it twice and it still didn't work.

They bought from one of those "professional" dealers in Quartzsite who has been in the solar business for years and turns out non-working systems daily. The cheap controllers he supplied are not suitable for paralleling and it says that right in the instructions that come with them. I guess "Professionals" don't need to read the instructions. Then, this dealer has been installing 25 ft runs of #10 wire for years and seems to have absolutely no clue about the voltage drop this causes. After having several conversations with this guy, I suspect that he does know, but doesn't care. People with under wired systems buy lots of expensive solar panels and that is where the profit is in the solar business.

Minus 50% of the panel.

I should have taken a close-up of the terminal strip next to the air conditioner. It was the kind of thing intended for use in a protected, dry environment, but it was installed exposed on the roof. The connections were rusty and the wires were exposed to the sun. We moved the panel a couple of inches over & up to get out of the shadow and added tilts to both panels in the photo, resulting in more than doubling the amp hours.

Minus 2.9 amps, almost 30%.

Adding legs to the mounts & raising the panel a couple of inches solved the problem.

Dead, zero!! No amps at all.

Same rig, but Teton is to blame this time. They had unknowingly copied the solar dealer's mistakes. Really though, were those accidental or on purpose? That guy has been in the solar business long enough to know better. I often wonder if the system in his own bus is any better. This panel was shut off by the dish in the morning and the air conditioner in the afternoon. It worked for just a couple of hours a day. There was another panel just ahead of the air conditioner with morning shade problems. By moving these two panels and adding tilting mounts we probably tripled the amp hours.

This system now has a Morningstar Tristar controller with temperature regulation, #4 cables down from the roof and a Trimetric 2020 battery monitor. Their rig is just about the most beautiful full timing mobile home you can find, with everything from a 42" TV with satellite & Tevo, broadband internet dish with a wide screen lap-top to a built in vacuum system and they may never have to plug it in again. I hadn't heard from them in months, so finally I phoned to ask how things were going. I was told that it was working just like I told them it would. They hadn't called because they didn't need to. They were now running everything and the generator hadn't been run in months. They would have been successful with only four panels, if only they had been installed correctly. Now, with six panels they can run whatever they want on cloudy days.

CASE STUDY #3:

A nearly new motor home with recently installed solar that did not work. These folks are more of the "minimalist" type, who never wanted to be able to use the microwave or a toaster. They were hoping that two panels would run their rig and then let them use their TV for a couple of hours and power the lap-top for checking e-mail. They didn't have enough power to do that and were ready to go back to the dealer with the money back guaranty to buy another panel.

Surprise! That tiny shadow from the vent cover is cutting the power produced by 2.5 amps, 30% of the possible output from that panel. Before you say that all the guy has to do is lower the vent cover a little, think about the shadow that would be there if a Max Air cover were installed. Don't you think that somebody who has been installing RV solar for as long as that dealer should know better? No warning was given. I doubt that the installer had a clue about what he had done.

I have no photos of the rest of the problems in this rig, so read my "More System Problems 2009" where the voltage drop issue is explained. (Adding a note here 2013… I deleted that page, but the important points were that charge controllers need to be located at the batteries in order to work and negative solar wires should not be connected to the frame.) Thanks to a new Morningstar Tristar 45 amp controller with temperature compensation that I mounted two feet from the batteries (after extending the #8 negative wire to there) and a Trimetric 2020 battery monitor, I talked these folks out of buying another solar panel. (It took a lot of talking; they were convinced that another panel would solve their lack of power, while it was actually caused by poor installation.) The last time I talked to them it was looking like they were getting about 105 amp hours per day into their batteries on an April day with the panels flat, about 10% more than they could get before with the expensive little "boost" controller that I had removed, even if it had been rewired correctly. I got to this conclusion by monitoring a nearly identical installation in another rig that kept the boost controller, but moved it close to the batteries. Three stage charge controllers that cost less than $200 do work a lot better.

These folks are now successfully everything they wanted to with only two panels. They may have to occasionally run their generator, but since it is one of the big diesels, connected thru a very good Magnum inverter/charger and both are already paid for, what the heck. Spending the money for another panel that would require them to rewire the whole system because of increased voltage drop does not make sense.

ONE LAST TIME: I AM NOT SELLING SOLAR EQUIPMENT!

RV SOLAR POWER – THE SHORT COURSE by HandyBob 12/08

If you want to solar power your RV & don't have the ability or inclination to install it yourself, the following is the minimum that you need to know. Any RV solar dealer that argues with you on any of these points is clueless. Unfortunately, I believe all of the dealers in Quartzsite will fail this test, even the ones with the "good" reputation. I have seen their work, repaired a lot of it, and I get mad every time I drive by & see what is going on in their work bays. Consider buying your equipment on line or mail order & then finding someone handy with wiring to help you install it. Any good RV tech can do it, but you have to tell them where to put it and the size of wire to use. I do recommend Backwoods Solar as a good, honest supplier. Phone 208-263-4290 – Catalogs are free and have a lot of good basic educational info for the solar power wannabe. The guys at Northern Arizona Wind & Sun also seem to be a good bunch. If you want deals on panels look at sunelec.com, but they don't sell them one at a time & will not UPS.

1. If you really want to successfully depend on battery power install a Trimetric 2020 battery monitor / recording amp hour meter (sometimes called E meter). I have hooked up over a dozen of these & everybody loves them. This is available for less than $200 and should add about $300 installed to the cost of a system. Installing this before you buy solar & learning how to read it will show you how much power you actually use and help you size your solar system for your needs instead of spending a fortune on panels that some salesman tells you that you need, without knowing a thing about your life. It will pay for itself. If the company you are dealing with does not offer this meter or a similar one like the Link or the built-in one that comes in the Blue Sky IPN-PRO remote and tries to tell you that you don't need it; walk away.

2. Buy a three stage charge controller that is adjustable and set it as recommended by the battery manufacturer (14.8V if you have wet cell golf cart batteries). I know of only one RV solar dealer that is doing this. This controller does not have to be an expensive Blue Sky or Outback unit in order to work. Both the Morningstar Tristar (my favorite) and the Xantrex C series non boosting "ugly box" units do a better job of charging for less than $200 than any of the little fancy looking flush mounted charge controllers with lights, bells & whistles that the RV solar guys are pushing. Do not let anybody talk you into anything else. The expensive Blue Sky Solar Boost 2000E is not a three stage unit and it reduces the power that your solar panels produce before the batteries are full. A three stage charger keeps charging after reaching the voltage set point. An ugly little Morningstar Sunsaver (three stage with temperature compensation built in) will do a better job of actually charging a battery until it is full. Buy an expensive Blue Sky or Outback three stage controller if you have gobs of money, but it is not necessary and not worth the expense on small systems. If the company you are dealing with tries to tell you that you must buy the small MPPT (boosting) controller or you are wasting the watts your panels produce; walk away. Seriously, he is in the profit generating business, not the power generating business.

3. Buy the temperature compensation sensor option ($30). This will raise the voltage when your batteries are cold, so they will get a better charge & reduce the voltage when they are warm, to protect them from over charging and venting too much electrolyte. If the company you are talking to does not have the temperature sensors in stock or tries to talk you out of it, they are clueless; walk away.

4. Insist on the charge controller being located as close to the batteries as possible (wire run length, not physical location). In no case should it be even six feet away. The voltage drop between it and the batteries will prevent your expensive power from reaching your batteries & getting them fully charged. Also, insist that the wire between the controller and the batteries be over sized, at least one size larger than required by the amp rating in order to limit the voltage drop to less than 1%. The wire from the roof to the charge controller needs to be sized for a maximum of 3% voltage drop. The overall drop, panels to charge controller needs to be close to 5 or 6%. There are voltage drop tables in the manuals for the good controllers and guess what; they are missing in those for the pretty ones that don't work. The voltage drop from the panels to the controller doesn't hurt if kept to a reasonable level, but from there to the batteries it is critical. #10 wire is not big. #4 is the correct size, not overkill, for four panel systems and the dealers in Quartzsite don't even sell it, which should tell you something. If the guy trying to sell you a system says that all systems have voltage drop & it doesn't matter where in the system it is; walk away.

5. Do not let anybody tell you that it is OK to have any shadows on your panels from antennas, vent covers, air conditioners, etc. no matter how small. They are setting you up for failure. Tiny shadows will reduce the power produced by 25 to 50% and covering one square shuts most panels completely off. Many of the solar guys are clueless about this. I have proven this time & again to many folks. This is extremely important! Again; JUST WALK AWAY!

7 COMMENTS

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