Going "Off the Grid" in our Keystone Cougar

I recently completed the installation of 735W solar system on our new Keystone Cougar 318SAB. The intent of this system is to eliminate the need for shore power and a generator and provide ample power, both AC and DC, to the rig even if we have a couple of cloudy days.

First, much thanks to Handy Bob. Here's my shameless plug for him:

> ***If you are contemplating solar (or contemplating a generator, or sitting in the dark because your batteries died) view the Handy Bob blog at http://handybobsolar.wordpress.com/. Once you have read his words and done your homework and feel like you want to proceed with a fully functioning and correctly installed solar system reach out to him if you need help. Consider a PayPal contribution to keep him interested in helping us. Bob and I are becoming friends and his help and inspiration made my project possible. His knowledge and passion for solar are unmatched! Start here to do it right!***

End Shameless Plug…

This is the second installation of this nature that I've done. The first time I watched and helped the expert. I learned a ton then and solidified my knowledge designing and building this system. The key component on my previous system (and on any system for that matter) is the Trimetric TM-2025-A meter from Bogart Engineering. If you really want to know how much power you are using you must have this meter! In fact, you might choose to install this meter first so you will know what your energy requirements are!

Where did we start?

From our previous RV experience I knew that 12V electrical power is a problem. Even when moving from place to place with hours of run time in between it is unlikely the RV batteries are being adequately charged by the tow vehicle (TV). This is due to a number of factors the largest of which is voltage drop between the alternator in the TV and the RV batteries. And if you aren't moving every day you certainly aren't getting charged! During a two week trip last summer we found our lights going dim and the water pump not running well after a couple of days. Our only option then was to check in to a campground with a 110V hookup. Not our style at all!

We do most of our camping in national forest or state campgrounds where shore power is not available and we did not want the noise or hassle or cost of a generator. We also know that we like the ability to run 110V AC appliances occasionally and that we do not need the air conditioner in most cases.

A side note about generators…

We met a couple in Borrego Springs last winter. They had been camping on the ocean north of San Diego in a state park there. He reported that one night while they were there seven generators were stolen from RVs in the campground including his. His generator was in the bed of his truck underneath his tonneau cover. Apparently there is a closet industry in play there. End side note…

My original research concluded that solar would work well for us. Especially if it was done right! I really wanted to keep the cost in the vicinity of what a generator would cost. I figured about $1200 for a Honda generator. I read and researched and then read some more. I designed a system and created a beautiful PowerPoint diagram. I contacted Handy Bob and proudly showed him my work. I anxiously awaited his response:

Handy Bob: “Pardon my French, but the first words out of my mouth upon opening your design were "HOLY S***, this guy needs to get a life.”

And then because I had let on that perhaps I had graduated from college with a degree in electrical engineering and perhaps because of my pride in that fact…

Handy Bob: “Back to electricity 101. You obviously have half a brain, but maybe you pickled it?”

Ah, we were off to a good start. We went back and forth until I had it right. This is the result:

FunFinder roof view in Joshua Tree NP

FunFinder Basement Equipment

The FunFinder system was 395W and used the lower cost TriStar PWM controller as I was able to get 12V solar panels (these are becoming rare and more costly). The total cost of the FunFinder system including installation was about $1600. If you consider the hassle factor of a generator and the cost of fuel and maintenance my system was definitely in the ballpark. We didn't have any 110V capability within this system but didn't really need it either. A 750W Modified Sine Wave inverter costs about $800 and probably would have satisfied most of our needs.

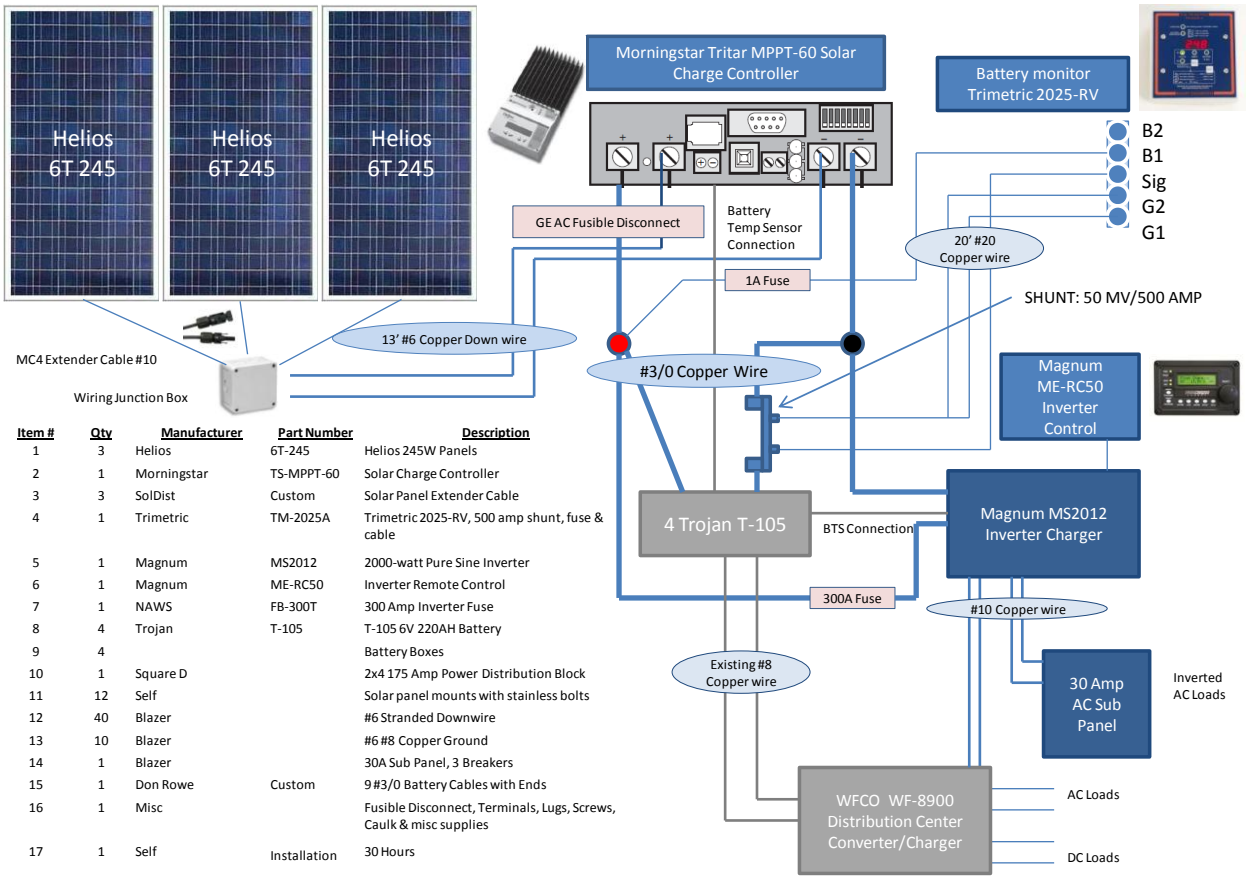
Most importantly we learned. We learned how much power we consumed and how much power we could generate. On most days we ran whatever lights, fans, televisions, radios, etc., that we wanted and by noon the next day the batteries were charged again. We also learned that turning on one overhead light consumed about 6 amps. Leave it on for an hour and we consumed 6 amp hours. Our batteries had 170 amp hours of capacity. Do the arithmetic. Turn on all the lights in the rig and it won't be very many hours before you are reading in the dark. So we learned to conserve. What a concept! But we also learned that because we have solar we don't really need to conserve or scrimp unless we anticipate cloudy days…

Out with the Old and in with the New…

Have you ever spent two months in a 25' travel trailer with your wife? Let's just say we didn't have enough room and leave it at that. Thus the new, larger fifth wheel was acquired. Our experience with solar was good so I knew I would be doing another install. This time, though, I wanted to have more capacity and more charging capability so we won't have to concern ourselves as much with conservation and cloudy days. And I wanted 110V AC so we could run small appliances.

No point doing it wrong so I started a new PowerPoint diagram and fired it off to the sage in the sky. He and I had worked together enough that I didn't expect another "Holy S…" moment and I didn't get one either. What I did get is confirmation that the block diagram below is correct (your own Holy S*** comments are probably on the tip of your tongue):

735W Solar Charging System w/ Inverter



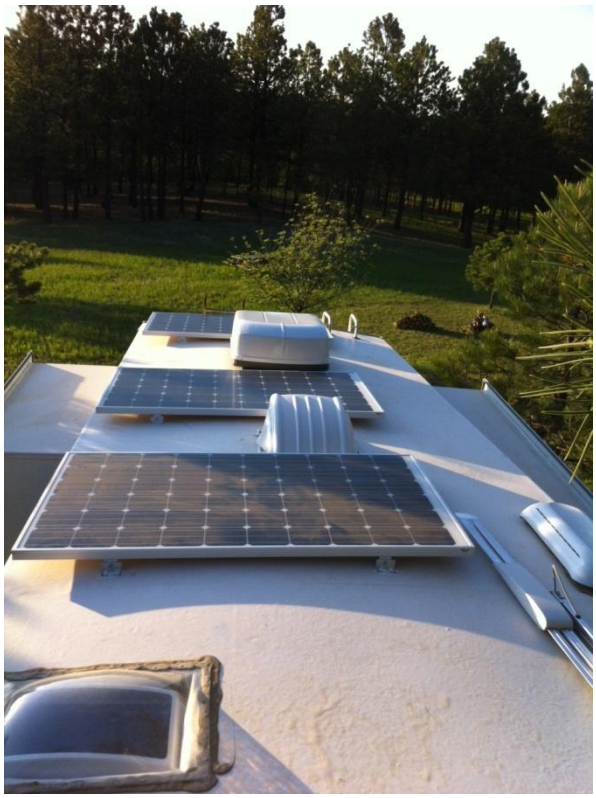
Item #	Qty	Manufacturer	Part Number	Description
1	3	Helios	6T-245	Helios 245W Panels
2	1	Morningstar	TS-MPPT-60	Solar Charge Controller
3	3	SolDist	Custom	Solar Panel Extender Cable
4	1	Trimetric	TM-2025A	Trimetric 2025-RV, 500 amp shunt, fuse & cable
5	1	Magnum	MS2012	2000-watt Pure Sine Inverter
6	1	Magnum	ME-RC50	Inverter Remote Control
7	1	NAWS	FB-300T	300 Amp Inverter Fuse
8	4	Trojan	T-105	T-105 6V 220AH Battery
9	4			Battery Boxes
10	1	Square D		2x4 175 Amp Power Distribution Block
11	12	Self		Solar panel mounts with stainless bolts
12	40	Blazer		#6 Stranded Downwire
13	10	Blazer		#6 #8 Copper Ground
14	1	Blazer		30A Sub Panel, 3 Breakers
15	1	Don Rowe	Custom	9 #3/0 Battery Cables with Ends
16	1	Misc		Fusible Disconnect, Terminals, Lugs, Screws, Caulk & misc supplies
17	1	Self	Installation	30 Hours

Cougar Solar Block Diagram

Basic differences between this and the previous system are three Helios Solar Works 24V 245 watt panels (buy American whenever you can), a TriStar MPPT 60 amp controller and the Magnum Pure Sine inverter. I also more than doubled my storage capacity by using four Trojan T-105 batteries wired to

feed a 12V system. The inverter makes the system more complicated from an installation standpoint. It requires rewiring the 110V AC from the WFC 8900 converter panel to a sub panel fed by the inverter. If you have “half a brain” and some electrical knowledge it isn’t that hard.

In some respects this install was easier as well. Unlike on the FunFinder I had plenty of roof real estate to carry the three full sized panels. There is room for a fourth panel if I want to add one. But I don’t really foresee needing 1000W!



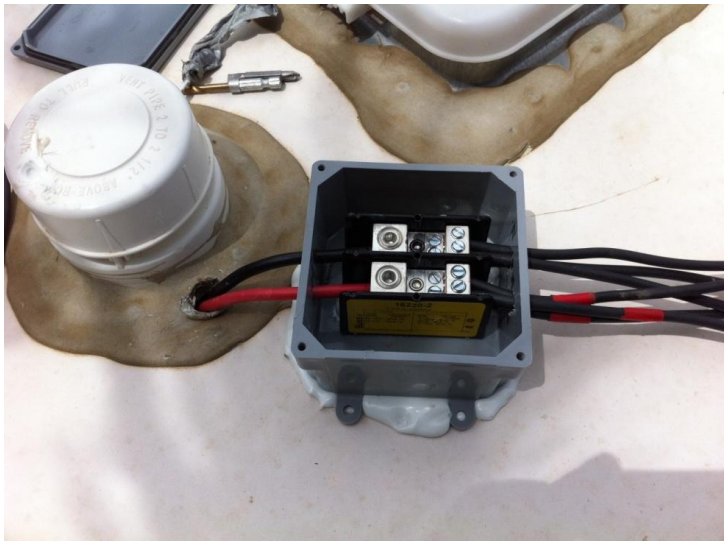
Roof view of Panels

One of the dilemmas one faces on an installation like this is where to bring the power from the roof down to the batteries. You can just see the fridge vent next to the antenna on the edge of the picture. I thought about using that path as it is a clear shot down, but there was an obstruction below between the stack and the basement that I couldn’t easily overcome. So instead I went down through an interior wall next to a sewer vent. One wants to be careful when they start drilling in the roof of their RV so choose carefully. This path dropped right down into the basement for an easy run to the battery compartment.

Roof view including wiring

Roof Junction Box

Choosing this route reduced the cable length from the junction box to the charge controller in the battery compartment by more than eight feet. Short runs with the proper size wire are crucial to a good install. The distance from the junction box to the farthest panel is about 20' of #10. The distance from the junction box to the charge controller is about 13' of #6. Wire losses are minimal in my implementation.



Roof Junction Box

Another trick is mounting the panels to the roof. Again, I chose to consult with the sage! I probably should have taken this picture before five miles of dusty road. But you get what you get! The mounts are made out of 1.5" angle aluminum and secured using 5/16" stainless steel hardware, four per panel. The pivot point is important as most RV roofs are not flat. The foot can move a bit using a socket wrench to ensure it is sitting firmly on the roof. Once it is flat, squirt some ProFlex underneath and screw it down with three 1" wood screws. Seal the heads and you are finished.

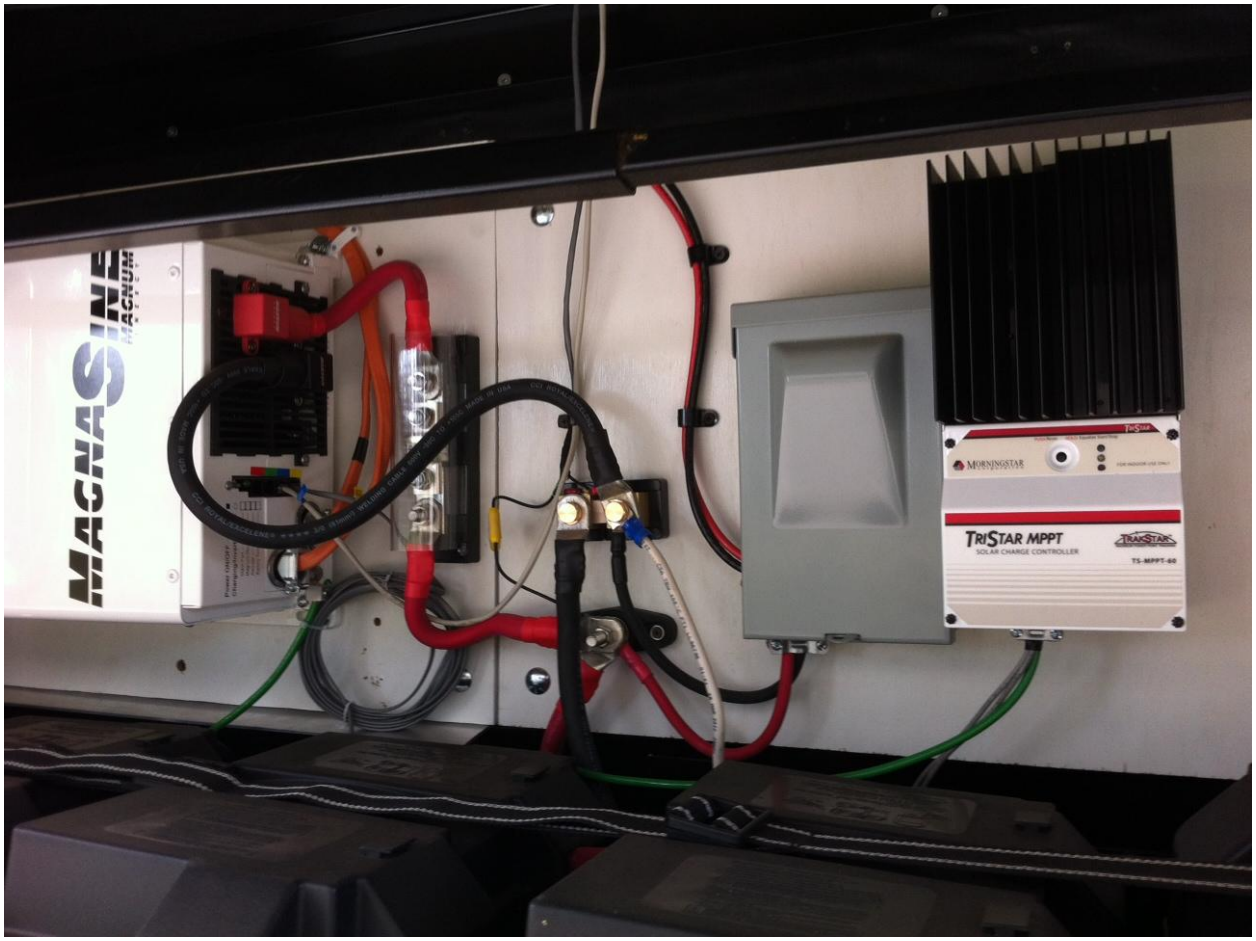
If your roof is indeed flat you might want to make one side of the panel a bit higher so water will drain off.

Solar Panel Mounting Brackets

The brackets are attached to the original mounting holes on the panels. I could have drilled a new hole closer to one end (the end most likely to face south let's say) which would allow me to tilt the panels upward by adding a taller aluminum piece on the opposite end. One loses some power output by not having the panels pointed directly at the sun. But since the rig is generally moving what is the optimum angle anyway? Flat is just fine if you have enough panels and enough sun. But if you are going to be in one place for a long time allowing an easy way to tilt might make sense. I'll leave this for "Advanced Solar System Design" on my next rig. Or I may retrofit this system if we spend more time in one place.

I then wired it all up in the battery compartment at the front of the rig. I gave a lot of thought to keeping this neat and clean. After I purchased and installed four separate battery boxes I found one

online that would have held all four. Four boxes worked but made the cabling a bit trickier as I had to route the cables in and out of the boxes.



Equipment Panel in Battery Compartment

Wiring the equipment to the panels and to the batteries is where you can really make your mistakes. It is essential to have adequate wire sizes and the shortest run possible between the charge controller and the batteries and between the batteries and the inverter. Voltage drop and inefficiencies add up in a hurry and may render an inadequate system even though you have plenty of panels. ***Do not skimp here and do not allow anyone else to skimp here!***

I used #4 gauge wire from the TriStar charge controller to the positive terminal post (you can see that post with the three red wires) and #3/0 welding cable from the post to the batteries. You can see the red and black wires coming down into the fuse box from above the panel. That's the #6 wire from the junction box on the roof. The green wires are the chassis grounds and the gray light gauge wire is used to connect the remote temperature sensors and meters to the inverter and charge controller. The shunt sits almost right in the middle of the panel with all the ground wires attached (the white wire is the rig's original ground wire).

The shunt is used to provide a very low resistance connection used by the Trimetric to read current flow in the system. The only thing connected to one side of the shunt is the battery bank. On the other side are all other grounds. All the current that is ever flowing into or out of the batteries passes through the shunt. Thus, the Trimetric can keep track of all of that current and tell you the state of charge of your batteries.

Here's how the Trimetric meter and Magnum Inverter remote look mounted inside the rig.

Inverter Remote and Trimetric Meter

The Trimetric is on the bottom. The batteries are full at 13.7 volts.

I mentioned earlier that having the Trimetric meter is the key. Installing one is easy. You simply need to move all of the system grounds to one side of the shunt, add a cable from the other side back to your battery, wire the meter to shunt correctly and you are in business. About $200 well spent. Then you will know, not think you know, how much power you are using and the state of your battery's charge. This will be useful to you if you are using a generator to charge your batteries too. Did I mention the value of the Trimetric?

So what does it all mean?

For our maiden voyage we headed to the Colorado Rockies for a little camping and a little golf. We camped at 9800' in the San Isabel National Forest at the wonderfully remote Purgatoire campground. We had the place to ourselves for the most part. We figured out why as we were driving up the road. You've probably heard the old saw "you look like five miles of bad road." This was the road they had in mind!

We had coffee out of the percolator, toast from the toaster, lights, music, entertainment, etc, all day and night long. We had amps rolling off the roof in the morning. We saw 79% battery capacity first thing one morning. That meant we had used about 90 Amp Hours of our 440 Amp Hour capacity. We were back to 100% capacity before noon. No noise. No exhaust. No angry neighbors. The envy of all! At one moment I observed over 33 amps to the batteries. That was in the morning. Try getting that from your Honda generator. Since my batteries are charged before noon on most days I haven't seen what the output of the panels is at the high point of the day. By then the charge controller is leveling off the batteries by increasing the voltage and tapering the amps. We're just wasting the sun's energy then! Shoot.

This system cost more than the first one. Close to $4000 and I got great deals on panels and the hardware as I'm starting to look at doing this as a business. Realistically, this system will probably retail for around $5K plus installation. That's more than a generator. But this is better. Just ask me. And my neighbors!