

Solar on the Go: RE on an RV

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Above: Author Rush Dougherty relaxing next to his self-sufficient Hitchhiker II.

In May of 1995, I left Long Island, New York with a 10' slide-in camper on my new 4x4 Ford F-250. My plan was to spend at least three years traveling around the US and Canada. I wanted to be as self-contained and independent as possible. I had a lot to learn.

A Home on the Road

The camper was small—when I stood in one place, I could be in any of four different rooms depending on the direction I was facing. The kitchen was on the driver's side. To the right, my bedroom was in the cab-over, and next to that, the living/dining room was on the passenger side. One more right turn, and there was the bathroom and the entrance/exit. The camper had a 20 gallon freshwater tank, and for gray/wastewater I installed an additional 20 gallon tank.

The System

I knew that there was this thing called solar energy that would enable me to be free of plugging into an outlet. At that point, that's about all I knew. I started educating myself, called around, and bought two SCM40 PV panels. I installed them on the roof of the camper. The old Gold panels, purchased from Sunlight Energy in Arizona, were originally from the San Luis Obispo plant in California and had been reconfigured for 12 Volts. They were rated at 40 W, at 2.4 Amps each. I hooked them up together to get 80 Watts at 4.8 Amps. They came with a Specialty Concepts Mark III/15 regulator.

I stored my energy in two 6 V golf cart batteries connected in series (220 Amp-hrs). This gave me 12 Volts, which fit right into the camper's existing system. The batteries were connected to the one stage battery charger in the camper. This charger was then hooked up to the electrical system in the truck. For my ac needs, I had a PowerStar 700 W inverter. In the bright but cold March sunlight, the output from my panels was a little over 5 Amps, certainly more than specified.

Ready, Set...

I culled through everything I owned for the things I wanted and thought I needed to take with me on the road: tools, scuba equipment, my full size computer and monitor, a 13" color TV, a Sony Hi-8 Video camera with equipment and playback unit, personal papers, and some clothes. It was crowded, to say the least.

My system was self-contained and ready to go. I had water, power, heat (propane), and shelter in a truck that could go almost anywhere. I left my family (I was recently divorced), friends, and New York, where I had been for 27 years, and set out on a three year journey. My plan was to go down the East Coast until I reached the Carolinas, then sort of head west, hit Texas, and go north to Nebraska to visit a good friend that I hadn't seen for a couple of years. After that, I would decide where to go. Maybe I'd head on up to Canada, then over to the Northwest coast and down to the Southwest.

Traveling Simply

Everything seemed to work fine. While I was driving, the batteries would charge from the truck. At rest, the solar panels would kick in when there was sun, and if I saw on the regulator panel that the battery indicator was low (in the yellow range), I would hook up to shore power. My only ac draw through the PowerStar inverter was from the TV (85 W) and the computer and monitor (about 300 W). The water pump, interior lights, electronic circuits for the refrigerator (propane when not connected to shore power), and furnace circuits/motor were all 12 V DC. My refrigerator could also be run on DC. I did that once, and watched the battery meter on the regulator go down really fast.

I stuck pretty close to my intended route with lots of detours in all directions. I stayed in private campgrounds, national parks, state parks, recreation areas, dirt roads off the main roads, etc. About half the time, I hooked-up to water, electricity, and sewer facilities. Otherwise, I would just get a "primitive" site with no hook-ups. If I needed water, I could always stop at a faucet and fill my fresh water tank. When I needed to empty my waste tank, I stopped at the dumpsite on the way out of whatever park I was visiting.

A few times, my inverter started to whine, letting me know that it was going to shut down if I kept on using the batteries at the current draw. I learned to look at the battery voltmeter on the solar regulator to find out



Above: A varied array of PVs on the roof of Hitchhiker II.

whether I was able to stay independent or if I needed to hook-up. It was a very simple system with very little demand, which was fine for me.

Simply Complicated

When I was driving, my whole truck would sway and lean on curves. I had approximately 4,000 lbs. on the bed of my truck and the center of gravity was high above the ground. I had planned to take the camper off of the truck as soon as I arrived at a destination to be able to explore the back roads, woods, country, or town I was in using the 4x4 capability of the truck. Instead, I found that I was just sitting at campsites a lot.

Very quickly, it became a real chore—I had to crank the 3 support legs down, remove the things (batteries included) that I had stored between the bed of the pickup and the sides of the camper, store these things inside, unhook the electrical and mechanical connections to the truck, and slowly drive the truck out from under the raised camper. Finally, I had to lower the camper down onto some boards so that it would be stable and so that I could get into it. As the process took about 45 minutes, it was not something that I looked forward to. Putting the camper back on added to the level of difficulty, because I had to back up the truck precisely underneath so that the space between the bed and the camper on each side was equal.

Solar 5th Wheel

On the road, I looked at other people hauling trailers or 5th wheels. I was envious of the space they had, and that once they arrived at their campsite, they could unhook and be free of their trailer. I also wanted to be able to take at least a couple of steps in my home



Above: SCI Charge controller, array disconnects, ammeter, and Link 1000 system metering.

before being stopped by a wall. I talked to people and learned that a 5th wheel “followed” better than a trailer with a bumper hitch. The tongue weight on a 5th wheel is placed on the rear axle, distributing the weight more evenly over the whole of the tow vehicle. Since the pivot point is also forward, 5th wheels are more maneuverable, especially when backing up.

When I arrived in Grand Island, Nebraska, where my friend Judy lived, I offloaded my camper in her parking lot and started looking for a new home. After about a week of going to dealers in the area and scanning for sale ads, I settled on a 1987 20' Coachman Coventry 5th wheel. The salesman saw me coming. I transferred all of my stuff, reinstalled the PV panels and batteries, and took off again.

On the Road Again

I went north through the beautiful Dakotas, into Canada and then back east along the border. I visited incredible campsites, dove with the seals in the Bay of Gaspé, Nova Scotia, and ate fresh lobsters on the Maine coast. I detoured to Shepherd's Ford in Virginia for a family reunion and celebrated my 50th birthday. It was great to be able to stop where I wanted and not be electrically dependent. I could unhitch my 5th wheel in about 10 minutes, and then be free to explore with my 4x4 truck.

From there, I went south and traveled along the Gulf Coast. Passing through Morgan City, I saw the derricks and rigs burning excess gas offshore. It really drove home the point about just how many parts of our economy intensely depend upon black gold. I visited the hot springs in Big Bend National Park, camped next to an old airstrip at Stillwell Crossing, and took hikes in the Sierra Del Carmen foothills. My PV panels were great in the foothills. It was extraordinary to be in the middle of nowhere and have all the comforts of home such as ice cream and cold water. It had been about a year since I had stopped for any amount of time and I felt the need to rest for a little while. I found a little trailer park in Austin, and stayed there for about a year and a half. I enrolled in Austin Community College, got a certificate in Integrated Circuit Layout, and did AutoCad drawings at Applied Materials for about 8 months.

Another Solar Big Rig

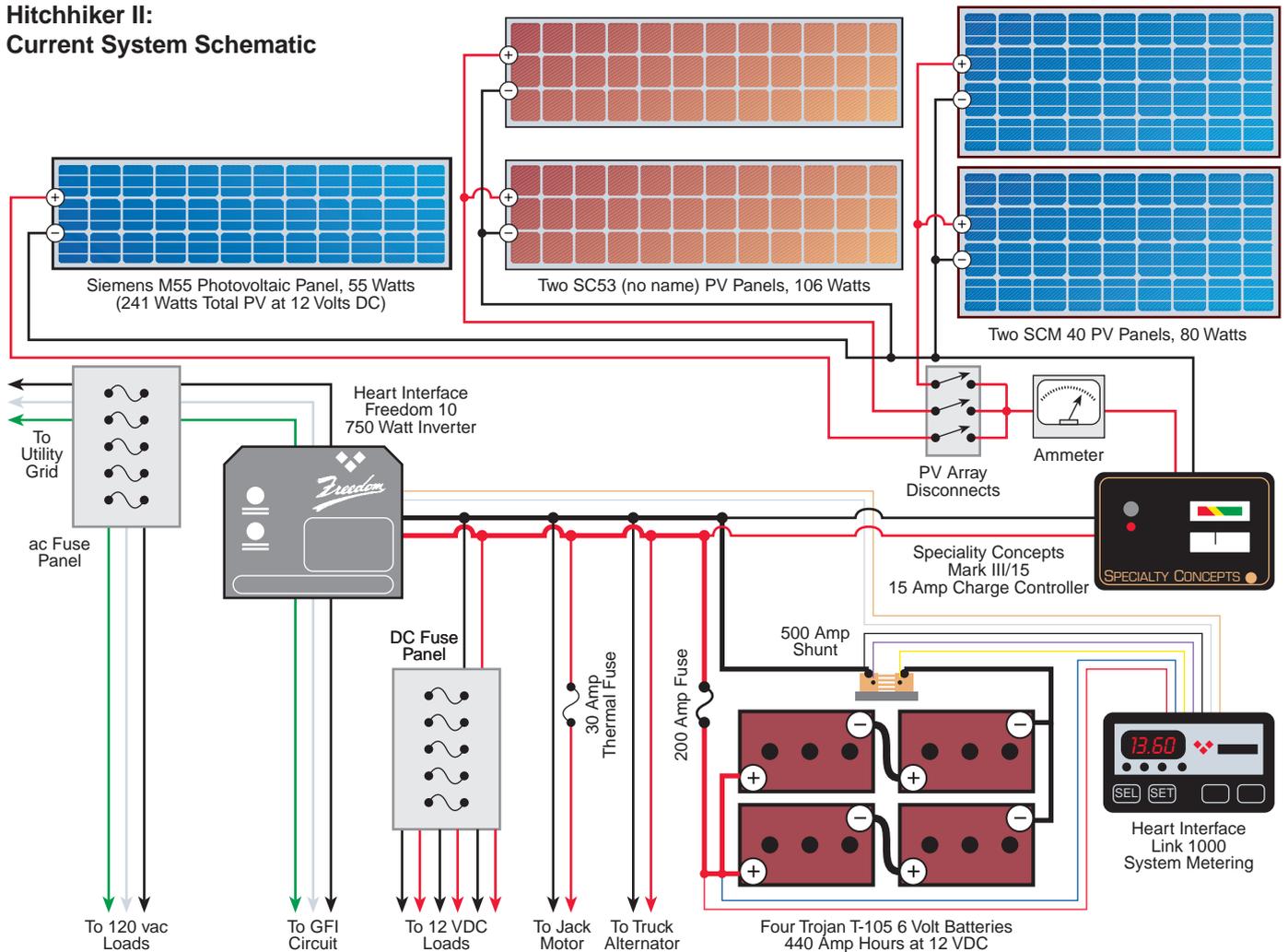
I started getting antsy again, wanting to move on. My 20' 5th wheel was getting small, and I knew that I couldn't be comfortable in it anymore. I started looking around for another home on the road. A dealer in the area had a 1992 24' Hitchhiker II. The insulation was much better than in the older Coachman, and it was 4' longer, had more storage space, a “basement”, and was in better shape. It also had a slide out which gave me the impression of living in a palace. I traded the Coachman in for the Hitchhiker II at the end of March, and started modifying it for my use.

The RV industry is very appearance conscious, full of glitz and gaudiness. My new 5th wheel had gold tinted curtains and valances that seemed ludicrous to me. They are gone. The door of the refrigerator had a full 1/2" oak panel on it. Every time I opened it, I felt like I was moving 10 pounds of “beauty”. The doors and drawer faces are oak (the old Airstreams were weight conscious and had tambour sliding doors). The slide out area had a couch that converted into a double bed, which was something that I just couldn't envision using. If a couple comes to stay with me, they can use my queen-sized bed, and I'll sleep on the sofa. I removed the foldout mechanism and the extra layer of foam, and gained about 10 cu. ft. of storage space. In the dining area, I installed a desk for working on my computer. It is a 30" by 5' hollow core door that is supported at one end by the wall, and at the other end by a filing cabinet which contains all of my papers.

System Specs

Most of my power needs are 12 VDC except for the TV, computer, some power tools, and battery re-chargers. All of my lights, which include a mixture of automotive bulbs, fluorescent, and low voltage compact fluorescent (CF), are 12 VDC. The ammonia evaporation

**Hitchhiker II:
Current System Schematic**



refrigerator uses either 12 V or ac (when I am plugged into shore power). The furnace and hot water heater both use propane and a 12 V ignition. However, the furnace also has a 12 V fan. The water pump is also 12 V and is used very little. I do have a 12 V fan that I run to circulate the air when it is hot inside. There is a 12 V radio system in the trailer and I have a CD cassette player attachment. I average about 30 to 35 Amp-hrs of use per day, and that varies greatly. Where I am now, on BLM land in Southern Arizona, there is no TV reception.

The ac electric panel is on the rear left side, the DC Panel and Magnetek charger are on the middle right side, and the battery area is in the front, 20' from the charger. The walls have an insulation value of R-8 and are 2" thick with fiberglass insulation. The ceiling is R-14 and 5" thick with fiberglass, so the values seem right. In any case, the interior temperature during a hot Texas day is noticeably cooler than in my old 5th wheel.

In the summer time, my furnace doesn't run, but my fan does. When I can plug into shore power, I try to use it

as little as possible. For the month of September, I was in a park in Chimacum, Washington, and my electricity bill was \$3.00.

System Upgrade: PVs

When I first got the Hitchhiker II, I thought about what I wanted to do with my new home. Some of my best experiences have been when I was alone in some wilderness area, independent yet comfortable. So I decided to increase my independence by getting two more PV panels and upgrading my ac/DC system. I shopped around and finally bought two SC53 panels from Sunlight Energy Corp in Arizona. They are rated at 53 Watts, 3.3 Amps, and 17.4 Volts. They are a "no name" brand, but are made from Siemens' PV cells. The specs for these panels match the M55 specs, but the dimensions are different. I assume that for some reason they didn't meet the Siemens' standards.

I installed the PV panels on the roof. My roof is standard for the travel trailer industry. It can be walked on and consists of EPDM rubber on top of 3/8" plywood overlay with 2x4 studs. I tried to place the sets of



Above: The Four Trojan T-105s provide 440 Amp-hours of storage

panels so that at least two of the four corners were securely anchored into the 2x4s underneath. I used putty as a seal between the rubber and aluminum feet and then sealed with 501-LSW. I can angle the panels in one axis only, so I have to be careful to park in an east-west direction to get the most out of them. The lead-in wires are #10 stranded and go from the panels into the trailer through a PVC waste vent pipe. The waste pipe is in a closet, so I drilled a hole in the pipe, snaked the wires into the closet, sealed the hole so that the odors would vent normally, and then fed all the wires through walls to the monitor center.

System Upgrade: Components

In addition to the new panels, I also wanted to be able to have a larger ac capacity. I looked into inverters and found that the Heart Freedom 10 would suit my needs. Since it is a modified sine wave inverter, I have to hook-up to shore power to use my HP 5L LaserJet printer. This inverter also gives me a three-stage 12 V charger that I substituted for the one that came with the 5th wheel, which was only a one-stage charger. To monitor my power supply and usage, I initially got an E-Meter from Cruising Equipment Co. After reading a little more, I exchanged it for the LINK 1000. Both the LINK 1000 and Freedom 10 came from Delivered Solutions in Temecula, CA. Tom, of Delivered Solutions, helped me through several installation questions. I also found the technical help at Cruising Equipment very valuable.

I chose a place for my "monitor center" in the main part of the 5th wheel. The center consists of the Specialty Concepts solar regulator and the LINK 1000. I also wanted to see what the old and new sets of panels

were putting out, so I kept the incoming lines separate. The lines are on switches, which are connected to an inline ammeter. The ammeter feeds into the solar regulator so that each set of panels can be read and turned on and off individually.

Tricky Wiring

I placed the Freedom 10 in the front of the 5th wheel, close to the batteries in the basement. To connect the charger to shore power, I ran a Romex 20/3 line from the ac fuse panel in the rear of the 5th wheel to the Freedom 10. It was difficult. I found a small space next to a heating duct and got the wire around some small but tight bends. To do this, I took the cover off of the heater. With determination, I

pushed, at arm's length, 5' of 1/2x1/2" Romex around a block of wood that was in the way.

From my monitor center, I ran wires down through the closet and into the "basement" where the Freedom 10 and batteries are located. These wires include the power feed from the solar regulator, the LINK 1000 monitor cable (eight-wire twisted 16 AWG cable from Heart Interface), and the four-wire telephone cable interface that runs between the Freedom and LINK .

I installed the Freedom 10 horizontally and raised it up 1/2" for better access to air. The basement is normally kept closed, but I can always open up the access doors if it gets too hot while I'm parked out in the sun. The Freedom 10 is grounded to the chassis with #8 AWG wire. I have one 20 Amp ac circuit coming out to a GFI box. This is my ac source when I am boondocked in some place like Black Gap Wildlife Management Area, or like now, when I'm on BLM land above Organ Pipe National Monument in Arizona.

The new wiring is a little bit more complicated than the original. While I am fairly knowledgeable about how electricity works, I am not a skilled electrician. At times, the installation was a challenge. The existing DC fuse center that was in the old Magnetek Charger had nine fuse holders, six of which were used. I noted all of the connections, disconnected everything, and removed the panel from the Magnetek box. I installed the panel in a new plastic load center, rewired the connections, and turned on the power. Nothing worked. It took me a good hour to realize that the Magnetek DC panel was actually a printed circuit board consisting of two separate circuits. The first was a six-fuse circuit wired to

Hitchhiker II Loads

<i>Appliance</i>	<i>Watts</i>	<i>hrs/day</i>	<i>W-hrs/day</i>	<i>%</i>
Furnace	98.40	1.25	123.00	28.84%
TV	59.04	2.00	118.08	27.68%
Laptop	19.68	3.00	59.04	13.84%
Big Computer	70.11	0.50	35.06	8.22%
Monitor	55.35	0.50	27.68	6.49%
Living Rm. CF	11.07	2.00	22.14	5.19%
Water Pump	73.80	0.25	18.45	4.33%
Bedroom CF	9.84	1.00	9.84	2.31%
Water Heater	61.50	0.10	6.15	1.44%
Living Rm. Fluor.	23.37	0.10	2.34	0.55%
Kitchen Fluor.	20.91	0.10	2.09	0.49%
Bathroom Fluor.	14.76	0.10	1.48	0.35%
Kitchen CF	12.30	0.10	1.23	0.29%

total 426.56

the power coming from the Magnetek charger. The second was a three-fuse circuit directly connected to the battery. I had connected everything directly to the battery lug on the board, so there was no connection to the charger circuit. It was a simple matter to connect a jumper from the battery connection to the other part of the board. After that, everything worked fine.

Batteries

Initially, I decided that my two 6 V golf cart batteries were fine. A 12 V RV deep discharge battery came with the Hitchhiker II, so I just paralleled it with the two 6 V batteries in series. I thought I would have 330 Amp/hrs of storage, but later I learned differently. As described in the Heart Interface installation instructions, I installed a 200 Amp Class T fuse for the Freedom 10 on the positive side of the batteries. I used a Gould distribution block to connect the various positive feeds. On the negative side of the batteries, a 500 Amp 50 mV shunt was installed for the LINK 1000. The LINK 1000 is wired to the battery according to Heart Interface specifications. The negative side also has a Gould distribution block for interconnects. All wires from the batteries to the distribution blocks are #2. From there, I used the existing wiring.

I was told that the 12 V battery was the worst one in my system, and that the battery system performs only as good as the worst battery. I removed it and noticed an improved performance from just the two 6 V batteries. Last November, I upgraded to four Trojan T-105s, and wired two each in series-parallel. I now have 440 Amp/hrs reserve. I also installed HydroCaps because access to the batteries is a little cramped and I am told that they conserve water. We shall see.

To the MREF

I left Austin and made my way up to Amherst, Wisconsin to attend the 1997 Midwest Renewable Energy Fair in June. I really learned a lot there. The amount of information was staggering. I concentrated mainly on solar and batteries, but I also learned a lot about wind and water power, straw bale building, etc. Every workshop I attended was full of information. While many were not directly applicable to my present needs, they all certainly raised my level of awareness about renewable energy. I went to as many workshops as I could, and decided that my next house would be as energy efficient as possible. I have dreams of selling electricity back to the grid. I put a bid on one of the Siemens M55 panels up for auction. Much to my surprise, I got one. Now I have five modules, for a total of 241 Watts at 14.05 Amps. My controller is at its limit.

Living with the Sun

It is December 26th, and I am sitting on BLM land near Ajo, Arizona. My only limiting factor is the capacity of the waste holding tanks. With care, I can stay here about eight days. I have four more to go. The weather was rainy here a couple of days ago and the Ocotillos are getting new leaves. Now it's beautiful and sunny, and the batteries are fully charged.

I just checked the time on the sundial that I made when I got here. It's 11:30 AM, and soon will be local noon, which occurs around 1:15 PM. The PV panels are angled at 45° to magnetic south, except for the SC 53's, which lie flat and therefore have shadow interference from the SCM 40's. One of those planning errors.

At this time of the day, these are the Amps being fed into my RV from the sun:

<i>Panel</i>	<i>Rated Amps</i>	<i>Measured Amps</i>
Two SCM40's	2.4	2.7 (4.7 at 45 degrees)
Two SC53's	3.05	6.2
One Siemens M55	3.15	3.5
		Total 12.4

If I remounted my SCM40 panels, I could have 14.4 Amps instead of 12.4 on a day like today, but I'm happy for now with what I have.

This article and the preliminary drawings have been done on my laptop, powered by my panels. I have also just finished the plans for a straw bale house that I want to build. I'm going to have a dish of ice cream to celebrate. I love my independence!

Access

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