RV Solar and Power System v1.0

Vince and Susan, Escondido CA (San Diego) - 2002 37A Pace Arrow Motorhome

Version	Changes
1.0	Initial Release
1.1	Added 120v/12v distribution block diagram Misc. text updates and typo corrections

Goals/priorities

1. Provide ample power and battery time for dry camping usage scenarios
    - Computer usage (sometimes extensive as I work when traveling)
    - AV (TV, sat receiver, disc player)
    - Hobbies
        - Sewing machine
        - Ham Radio equipment
2. Good quality system at low cost
3. Provide for battery charging/maintenance while stored
4. Expandability

Approximate Solar BOM Cost (does not include batteries and inverters)

Item	~Cost
(8) 100w 12v panels via Craigslist (used)	$600
Morningstar TS-60 controller	$200
Morningstar TS-60 digital display	$100
Morningstar remote temperature sensor	$25
MidNite battery monitor	$60
AMSolar combiner box	$80
Dicor, wire, connectors, conduit, breakers, mounts, etc.	$250
Total	**~$1300**

Solar Power Equipment

- (6) 100w 12v solar panels – roof mounted
    - Purchased used via Craigslist
    - Multiple physically smaller panels provide roof positioning flexibility
        - Shading avoidance, walkway allowance, fitment (between AC units, vents, etc.)
- (2) 100w 12v solar panel – portable ground mounted
    - Purchased used via Craigslist
    - Provides additional power if shaded location
    - Stored under the bed when not needed
- Morningstar Tri-Star TS-60 PWM controller
    - Quality unit from a well-respected company
    - Provides proper charge voltage for Trojan wet cell batteries
        - Many controllers on the market will not charge to the manufacturer recommended 14.8v during absorption mode, thus providing not a full charge and capacity

    - Remote voltage and remote temperature sense features
        - These features ensure the batteries get fully and properly charged
    - Selected TS-60 over TS-45 for expandability
        - If ever desired, I have physical room for ~4 additional panels on the roof
    - PWM selected over MPPT
        - 12v panels – MPPT not needed for voltage conversion
        - Lower cost of the controller
            - The PWM to MPPT quality controller cost difference one can buy another 1 to 2 panels, which may likely provide more benefits than the MPPT controller technology
        - MPPT technology provides the most benefit with higher voltage panels (usually also physically large) and/or panels wired in series – typically not attributes desired for a RV installation and usage model
- Monitoring
    - Digital display option for the Morningstar TS-60 controller
        - Mounted on the controller itself, not the remote model – once the system is configured and qualified, there is seldom a need to use the display if there is another battery monitor in the system
    - MidNite Solar battery capacity monitor
        - Low cost
        - Super simple to use and interpret
        - Easy connection
        - Mounted in living room area
        - Features
            - LEDs indicate battery charge percentage as a function of battery voltage
            - Indicates if batteries have not had a full charge in 1 or 2 weeks
                - Full charge is defined as reached a set voltage for a certain amount of time
                    - For my wet batteries, 14.7v for at least 2 hours
- Wiring
    - All panels wired in parallel with #10 wire to combiner box on roof
        - Parallel vs. series wiring provides mitigation against shading (if series wired, one shaded panel severely impacts the power output all other panels in the string)
        - Combiner box provides convenient wire junction on roof and allows for single larger interior wire to controller
    - Interior wiring
        - Combiner box to controller, controller to batteries - #4 wire
            - Minimizes voltage loss via proper wire sizing
        - 80 amp circuit breakers before and after controller
            - Circuit protection
            - Isolation for servicing
        - Remote temperature probe
            - Temperature compensated charging for accurate charging
        - Remote voltage sense connection
            - Better voltage sensing for accurate charging

Batteries

- Four Trojan 105 wet cell batteries
    - Desired capacity
    - Low cost
    - Good life expectancy

AC Power Distribution

- Inverters

- Something to be aware of that with solar charging at the 14.8v level, the actual charging voltage can sometimes exceed 15v. This exceeds the over-voltage level of many inverters and the inverter will shut down. Select your inverter(s) accordingly.
- 2300w wired for whole coach (PowerBright 2300)
  - Capacity for microwave, coffee maker, etc.
  - Shore power cord plugs into inverter, coach operates the same on inverter or shore power
    - Note that in this configuration, any existing converter battery charger needs to be disconnected or switched off
  - Remote inverter on/off and local DC disconnect switch – only powered on when needed (most large inverters have ~.5a draw even when off, hence the disconnect switch)
- 150w for point of use (Tripplite 150w)
  - Better efficiency and lower batter power consumption than continually powering whole coach with large single inverter
  - Multiple units
    - Bedroom
    - Dining table area
    - Front passenger seat area (computer station)
    - AV equipment (TV, sat receiver, disc player)
  - Tripplite 150 goodness
    - No fan, so no annoying fan noise
    - No power draw whatsoever when switched off

Installation Notes

- Solar panels
  - Mounted flat on the roof with standard low cost L-bracket mounts
    - Tilt mounts were considered, but I am unable to climb to the roof safely
  - Lay the panel and mark the bracket location on the roof, remove and panel and place a pool of Dicor sealant at each marked location. Place the panel in the Dicor pool, and secure with 1" stainless screws, put additional Dicor over the screws
- Wiring and routing
  - Panels wired in parallel with #10 home runs to a combiner box mounted next to the refrigerator vent. From the combiner box #4 wires under the edge of the refrigerator vent and down behind the refrigerator (remove the outside access hatch to the refrigerator for access). The compartments with the batteries and controller are just aft of the refrigerator.

What I would do differently if I had a do-over?

- Actually, not much. The system is performing well and has met the goals very well as initially outlined.
- I would have installed a larger or multiple combiner boxes on the roof, as the one is very full of wires. If I add more panels in the future, another combiner box will be needed.

Morningstar TriStar TS-60 Controller

100 watt solar panels

- 6 roof mounted
- 2 ground mounted

MidNite Battery Monitor

Two of four Trojan 105 batteries

120v/12v Distribution Block Diagram