

A QUASI BUYER'S GUIDE

SOLAR POWERED STATION

PREFACE

- ▶ Feel free to take notes, however, full presentation is available online at barconline.org.
- ▶ Presentation approach: Solar is a big topic. What would I share if someone wanted to get started in solar powered radio and asked about my opinions and experience?
- ▶ There is no one-size-fits-all solution.

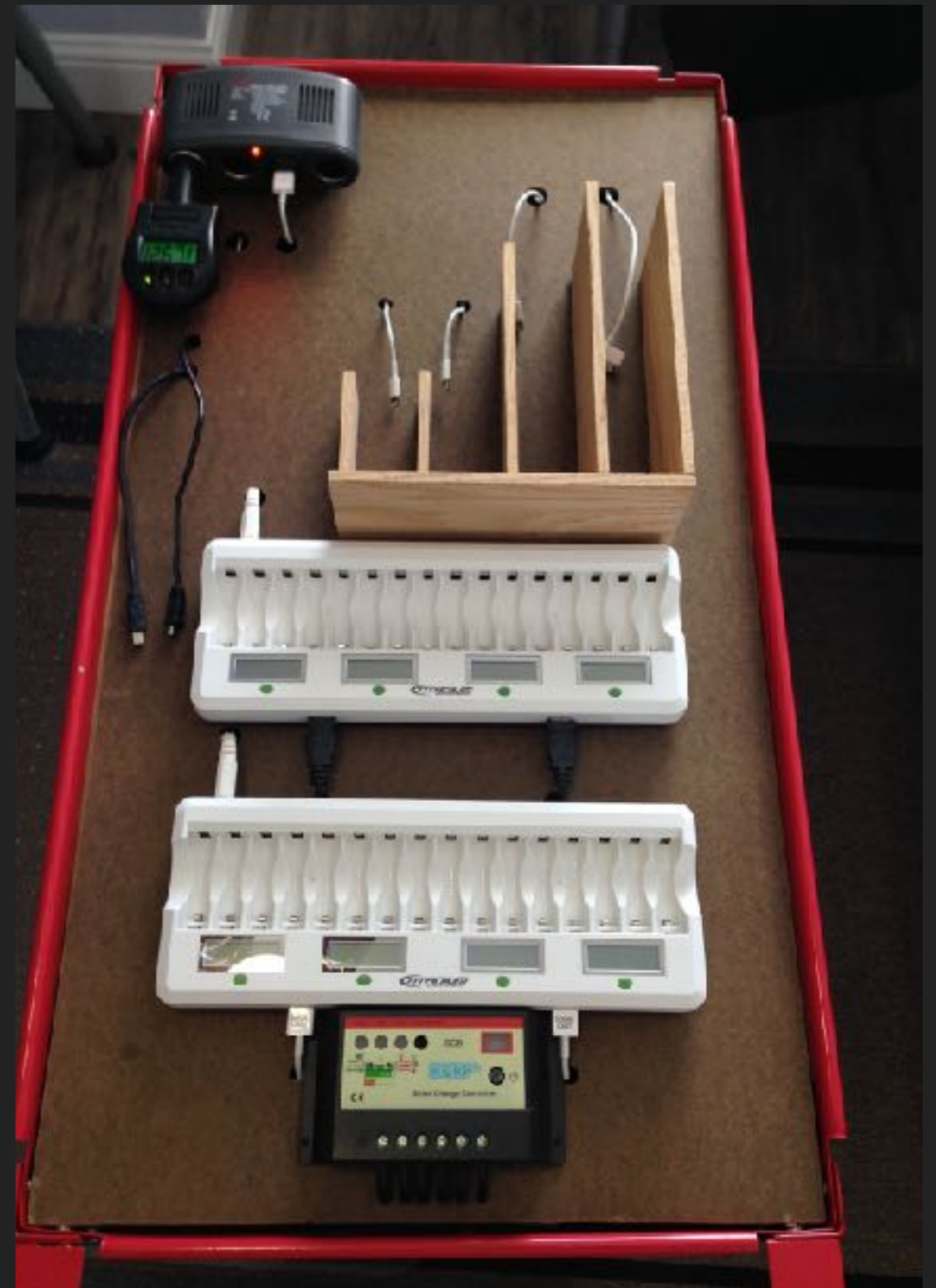
SOLAR PROJECTS

PERSONAL EXPERIENCE

- ▶ My solar project has been an evolutionary process that began back in 2010 and is still a work in progress.
- ▶ Original application was to (a) provide lighting for our whole house during a power outage, (b) keep mobile devices charged and (c) power low current AC devices.
- ▶ My current application is to power a radio station in addition to the items above.

THE SOLAR CART V2.0

- ▶ 100W of PV panel, 125Ah storage capacity (~50Ah usable), and can handle peak 40A draw if needed.
- ▶ Charge 32 AA/AAA batteries simultaneously and independently.
- ▶ Charge 4 iOS devices simultaneously.
- ▶ Charge mini & micro USB devices.
- ▶ Powers HF/VHF/UHF station.



SOLAR CART DESIGN CONSIDERATIONS

- ▶ Semi-portable, but resides next to operating position in the shack.
- ▶ Provide power to both 12VDC and 120VAC applications.
- ▶ Charged by solar or grid power.



SOLAR CART DESIGN CONSIDERATIONS

- ▶ Expandable, with room for two additional batteries.
- ▶ Adaptable, ability to modify configuration as needs change.





PORTABLE SOLAR STATION V1.0

- ▶ LUITON LT-316 (AKA: WLN KD-C1) 16CH UHF HT (~\$15 from Amazon).
- ▶ GoalZero Nomad 7.
- ▶ LT-316 charges via USB. Powered directly by PV panel or through GoalZero battery bank (buffer).
- ▶ ~2.5 hours from dead battery to fully charged.
- ▶ Panel + USB cable + radio = Simplest solar powered station I can think of.



SYSTEM DESIGN

IMPORTANT CONSIDERATIONS

- ▶ Begin by calculating your energy needs, then determine if you want the system to be stationary or portable. These factors will largely determine the specifications and cost of your solar system.
- ▶ Emergency communications: Your TX to RX ratio can change dramatically. I suggest building a system capable of keeping up if used for a contesting type activity such as Field Day.

CALCULATING SYSTEM SCALE

- ▶ Primary Variables:
 - ▶ Power consumption vs. power production combined with charge controller efficiency.
 - ▶ Usable storage capacity of system.
- ▶ The Ampere Hour (Ah) is important unit of measurement.
- ▶ Strive to build a balanced system by matching load/storage/production to the best of your ability.
- ▶ This is simplified but will steer you in the right direction.

POWER CONSUMPTION EXAMPLES

- ▶ Yaesu FT-857D (100W HF/VHF/UHF Rig)
 - ▶ RX = 1 A
 - ▶ TX (High) = 22 A
- ▶ Yaesu FT-817D (5W QRP HF/VHF/UHF Rig)
 - ▶ RX = .45 A
 - ▶ TX (High) = 2 A
- ▶ Kenwood TM-V71A (50W VHF/UHF Rig)
 - ▶ RX = 1.2 A
 - ▶ TX (High) = 13 A

General			TM-V71A	TM-V71E	TM-V71A	
			K Type	E Type	M4 Type	
Guaranteed range	Band A & B	TX & RX	144 ~ 146 MHz	144 ~ 146 MHz		
			438 ~ 450 MHz	430 ~ 440 MHz		
Frequency range	Band A	RX	118 ~ 524 MHz		—	
	Band B		136 ~ 524 MHz		—	
			800 ~ 1300 MHz (K type: excluding cellular band)		—	
Mode			F2D/ F3E			
Antenna impedance			50 Ω			
Operating temperature range			-20°C ~ +60°C (-4°F ~ +140°F)			
Power requirement			13.8 V DC ±15% (Negative ground)			
Frequency stability			Within ±5 ppm (-10°C ~ +50°C)			
Current	TX	VHF	Hi	Less than 13.0 A		
			Mid	Less than 5.5 A		
			Low	Less than 4.0 A		
		UHF	Hi	Less than 13.0 A		
			Mid	Less than 6.5 A		
			Low	Less than 5.0 A		
	RX		Less than 1.2 A (at 2W audio output)			
	Dimensions (W x H x D)	Without projections		Panel: 140 x 43 x 38.2 mm (5.51" x 1.69" x 1.50") Body (with Panel): 140 x 43 x 180.7 mm (5.51" x 1.69" x 7.11")		
		With projections		Panel: 140 x 43 x 55.4 mm (5.51" x 1.69" x 2.18") Body (with Panel): 140 x 43 x 213.1 mm (5.51" x 1.69" x 8.39")		
Weight (approx.)			Body (with Panel): 1.5 kg (3.3 lbs)			

POWER CONSUMPTION EXAMPLES (CONTINUED)

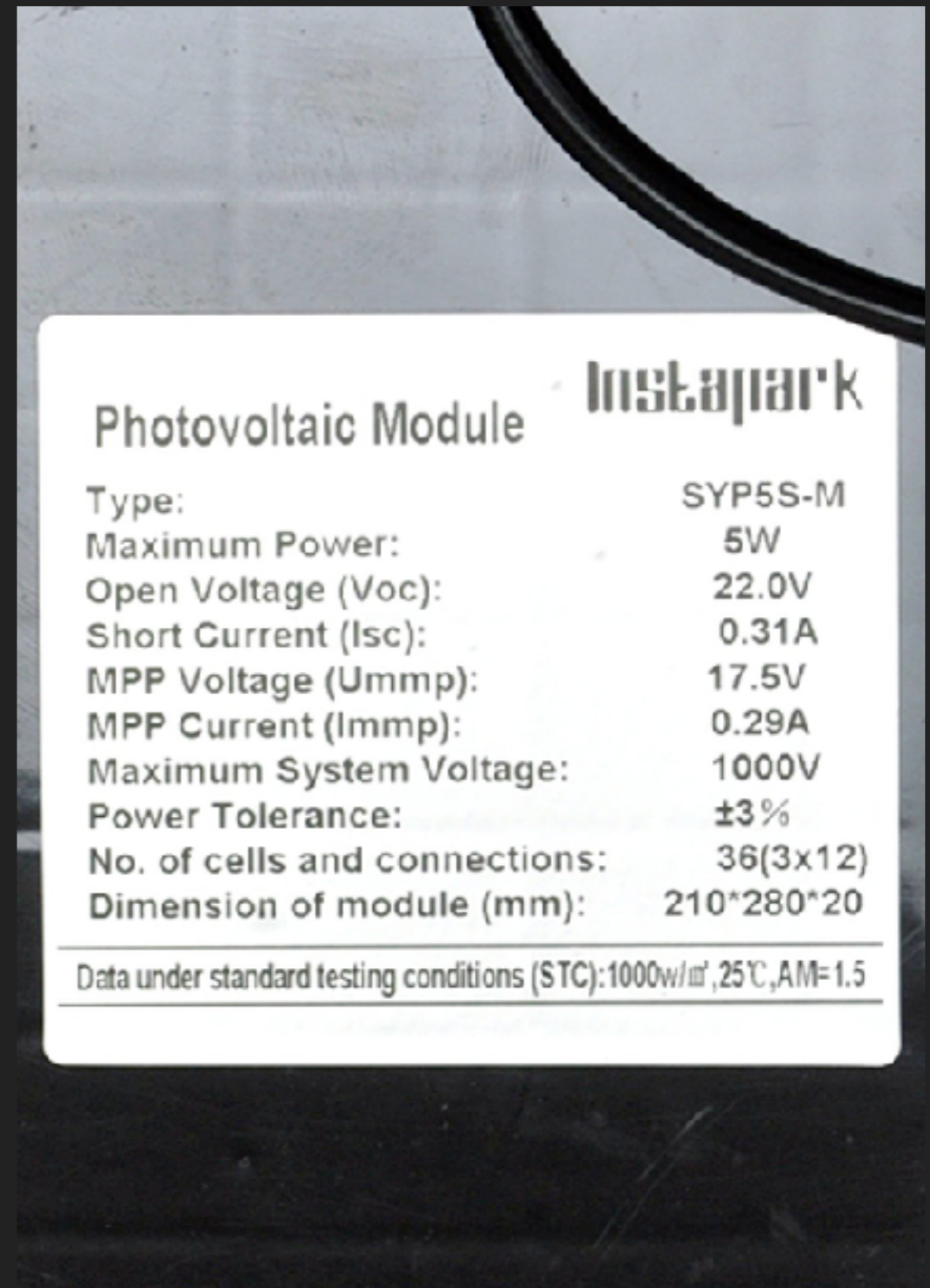
- ▶ Typical 50W FM rig running high power (14A TX / 1A RX).
 - ▶ TX to RX ratio of 0% (RX only)
Hourly consumption of ~1Ah.
 - ▶ TX to RX ratio of 25% (15min TX for every 45min RX)
Hourly consumption of ~4.25Ah.
 - ▶ TX to RX ratio of 50% (30min TX for every 30min RX)
Hourly consumption of ~7.5Ah.

POWER CONSUMPTION (ADDITIONAL THOUGHTS)

- ▶ For digital modes or computer logging a tablet that can charge via USB would be preferable over a traditional laptop.
- ▶ Tablets are generally more power efficient and eliminate the need for a DC to AC inverter.
- ▶ If inverter is used, my personal recommendation is a pure sine wave device as opposed to modified sine wave. "Medical grade" inverters are less likely to cause RFI issues.

POWER PRODUCTION

- ▶ There are a lot of variables involved.
 - ▶ Cloudy?
 - ▶ Time of year? Time of day?
 - ▶ Battery SOC & load conditions?
 - ▶ Etc.
- ▶ Maximum Power Point Current rating is a specification of interest.
- ▶ Allows rough calculation of daily/hourly output under optimum conditions.



POWER PRODUCTION (CONTINUED)

- ▶ Charge controller selection will impact overall system efficiency.
- ▶ MPPT (Maximum Power Point Tracking) will always outperform PWM (Pulse Width Modulation) charge controllers.
- ▶ Many (if not most) charge controllers will cause RFI. Look for products specifically designed to be RF quiet.
- ▶ Panels are marketed in watts and charge controllers are marketed in amps (and sometimes watts)... Because that makes sense. 🤔
- ▶ Strive for balance *or* scalability... Adding more panels down the road.

POWER STORAGE

- ▶ Consider operating habits/desires.
 - ▶ How important is it to stay on the air? Will a dead battery ruin your activity?
 - ▶ Will you operate only during the day, or at night as well?
 - ▶ How quickly do you want the system to recharge?
(big panel & small battery = fast)
(small panel & big battery = slow)

POWER STORAGE (CONTINUED)

- ▶ AGM SLA remains king
(absorbent glass mat sealed lead acid)
- ▶ Avoid "flooded" type unless stored/vented correctly.
These batteries can pose substantial safety hazards.
- ▶ Even "deep cycle" SLA batteries not intended for DOD
(depth of discharge) greater than 50% without causing harm.
- ▶ Pretty much take the rated capacity and divide it by half and
you have your actual capacity. That's still pushing the limits.

COMMON PV CELL TYPES

AMORPHOUS SILICON (A-SI)

- ▶ AKA: "Thin Film"
- ▶ Pros:
 - ▶ Less expensive.
 - ▶ Can be manufactured in more exotic shapes, even flexible.
 - ▶ Perform adequately while partially shade covered.
- ▶ Cons:
 - ▶ Least efficient per square inch.
 - ▶ Not as durable.
 - ▶ Shorter lifespan.
- ▶ https://en.wikipedia.org/wiki/Amorphous_silicon



POLYCRYSTALLINE SILICON (POLY-SI)

- ▶ Pro: Shares similar "packaging" as Mono-Si making them equally durable.
- ▶ These are the "middle" option.
 - ▶ Moderate cost.
 - ▶ Moderate efficiency.
 - ▶ More earth friendly manufacturing process (less waste) than Mono-Si
- ▶ https://en.wikipedia.org/wiki/Polycrystalline_silicon



MONOCRYSTALLINE SILICON (MONO-SI)

- ▶ Pros:
 - ▶ Most efficient per square inch making them also the most space efficient.
 - ▶ Can last up to 20+ years.
- ▶ Cons:
 - ▶ Most expensive.
 - ▶ Output drops substantially when partially covered by shade due to manufacturing process.
- ▶ https://en.wikipedia.org/wiki/Monocrystalline_silicon



WHAT NOT TO BUY

THE HFT SOLAR KIT

- ▶ Do not buy. Better yet, stay away from "kits" altogether. Better off buying individual components tailored to your application.
- ▶ Utilizes amorphous silicon solar cells (thin film) and a PWM charge controller.
- ▶ If you must... keep the panels, the rest is garbage.



ADDITIONAL KIT EXAMPLE

- ▶ GoalZero Yeti 400 w/2x20W panels.
- ▶ \$765.95!
- ▶ 10A max 12V current draw. Don't attempt to TX on high power.
- ▶ 33Ah usable storage, then takes 20-40 hours recharge. You can add extra (proprietary) panels but they are \$\$\$.
- ▶ Besides, we're hams, we like to build our own stuff!



THE UBIQUITOUS 7AH SLA BATTERY

- ▶ Only good for powering an HT or QRP rig (unless you wire several in parallel). For other applications you will probably be disappointed.
- ▶ Only provides ~3Ah usable energy.
- ▶ NOTE: Batteries also have a max current draw spec (usually relative to the physical size of the battery)



GENERIC PWM CHARGE CONTROLLER

- ▶ Do not waste time/money with PWM (pulse width modulation) charge controllers. Purchase a MPPT controller instead (more on this later).
- ▶ They are inefficient and don't fully utilize the investment you've made in your panel(s).
- ▶ Can be RF noisy (especially on HF).
- ▶ This example unit costs about \$20 on Amazon, looks really fancy, even has USB ports but don't be fooled.



PRODUCT SHOWCASE

GENASUN MPPT CHARGE CONTROLLERS

- ▶ Maximum Power Point Tracking.
- ▶ Amazingly efficient (almost 100%) which means more power makes it from panel to battery.
- ▶ Has 5 or 10 year warranty.
- ▶ **Specifically engineered to be RF quiet.**
- ▶ Will cost around \$75-\$100 depending on model, available from genasun.com and is the one to buy if using for radio applications.



GENASUN MPPT CHARGE CONTROLLERS

- ▶ Available for lead acid and lithium chemistries! 👍



WEST MOUNTAIN RADIO EPIC PWRGATE

- ▶ 40A continuous current
- ▶ Will charge via panel (MPPT) or 12V power supply.
- ▶ Doubles as UPS.
- ▶ "Product designed, tested and used by ham radio operators onsite."
- ▶ USB port for firmware/config changes as well as system monitoring.
- ▶ \$179.95





MONO-CRYSTALLINE PANEL

- ▶ Use highest quality / most pure silicon.
- ▶ Weatherproof and rugged.
- ▶ This 50W (2.8A) Instapark panel costs \$99 on Amazon (I paid \$160).



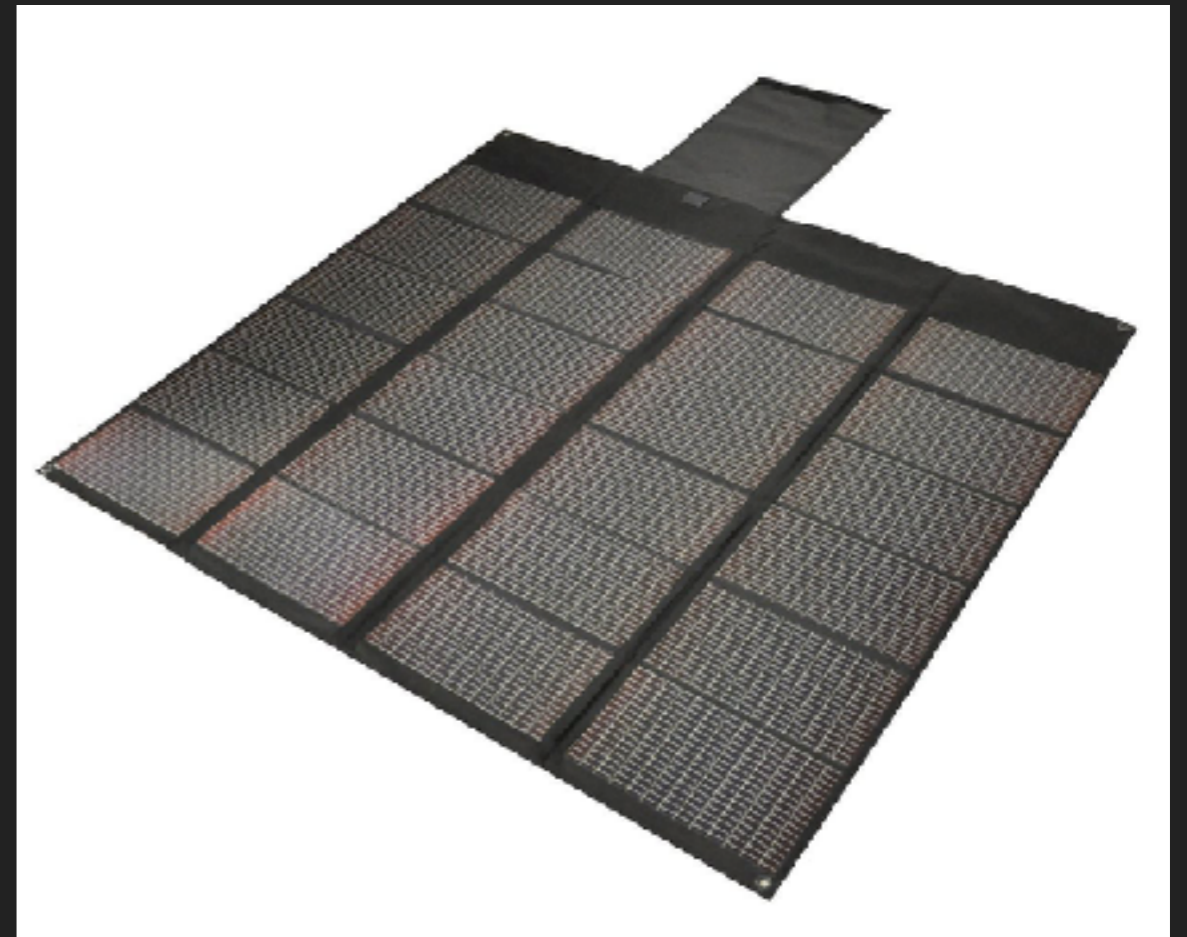
MONO-CRYSTALLINE PANEL

- ▶ Generally use the industry standard MC4 connector.
- ▶ Heavy and not well suited for portability.
- ▶ I own 2 Instapark panels and have been very pleased with them though Renogy is the current top seller on Amazon.



FOLDABLE PANELS

- ▶ Designed for portability.
- ▶ Available in all major PV cell types (but I would stick with Mono-Si if possible).
- ▶ Often use odd connectors (which can sometimes be fixed with PowerPoles).
- ▶ Typically not weather resistant.
- ▶ Much more expensive per watt.



FOLDABLE PANELS

- ▶ If I were to purchase another foldable panel it would likely be this one:

Instapark Mercury27 which runs \$99 on Amazon (*UPDATE* \$74.39 on amazon).



FOLDABLE PANELS

- ▶ With some modification you can wire multiple in parallel to boost your wattage.
- ▶ Still not adequate accept for low power (QRP/HT) applications.



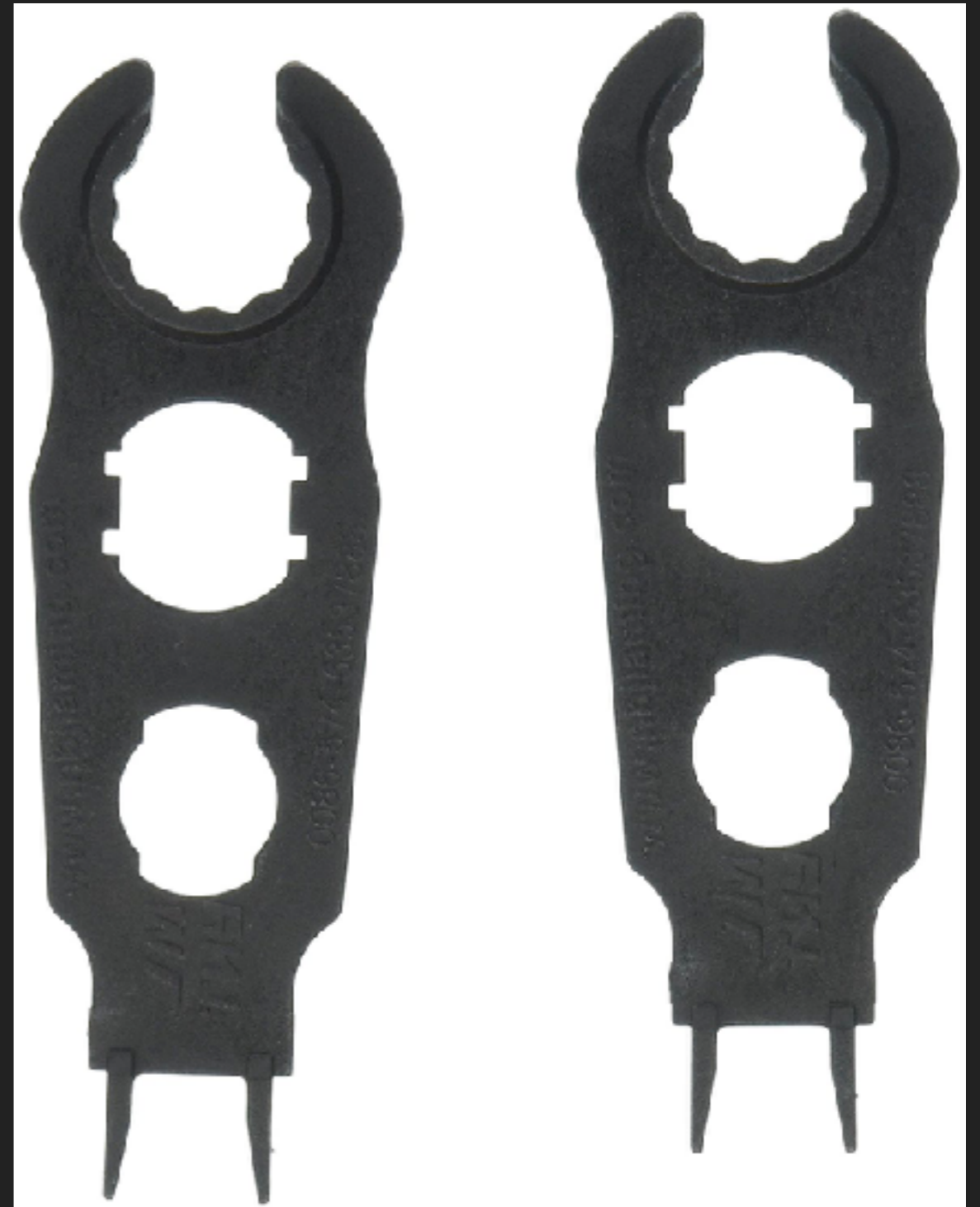
THE MC4 CONNECTOR

- ▶ Industry standard. Officially only produced by Multi-Contact (hence MC) and the 4 represents the 4mm contact pin.
 - ▶ I have used Renogy version with great success. Other brands are not produced within specification tolerances.
- ▶ Provides positive retention requiring a tool to separate once connected.
- ▶ If you can crimp a Powerpole, you can work with these connectors as well.
- ▶ Designed for permanent installations in all weather conditions.



MC4 ASSEMBLY TOOL

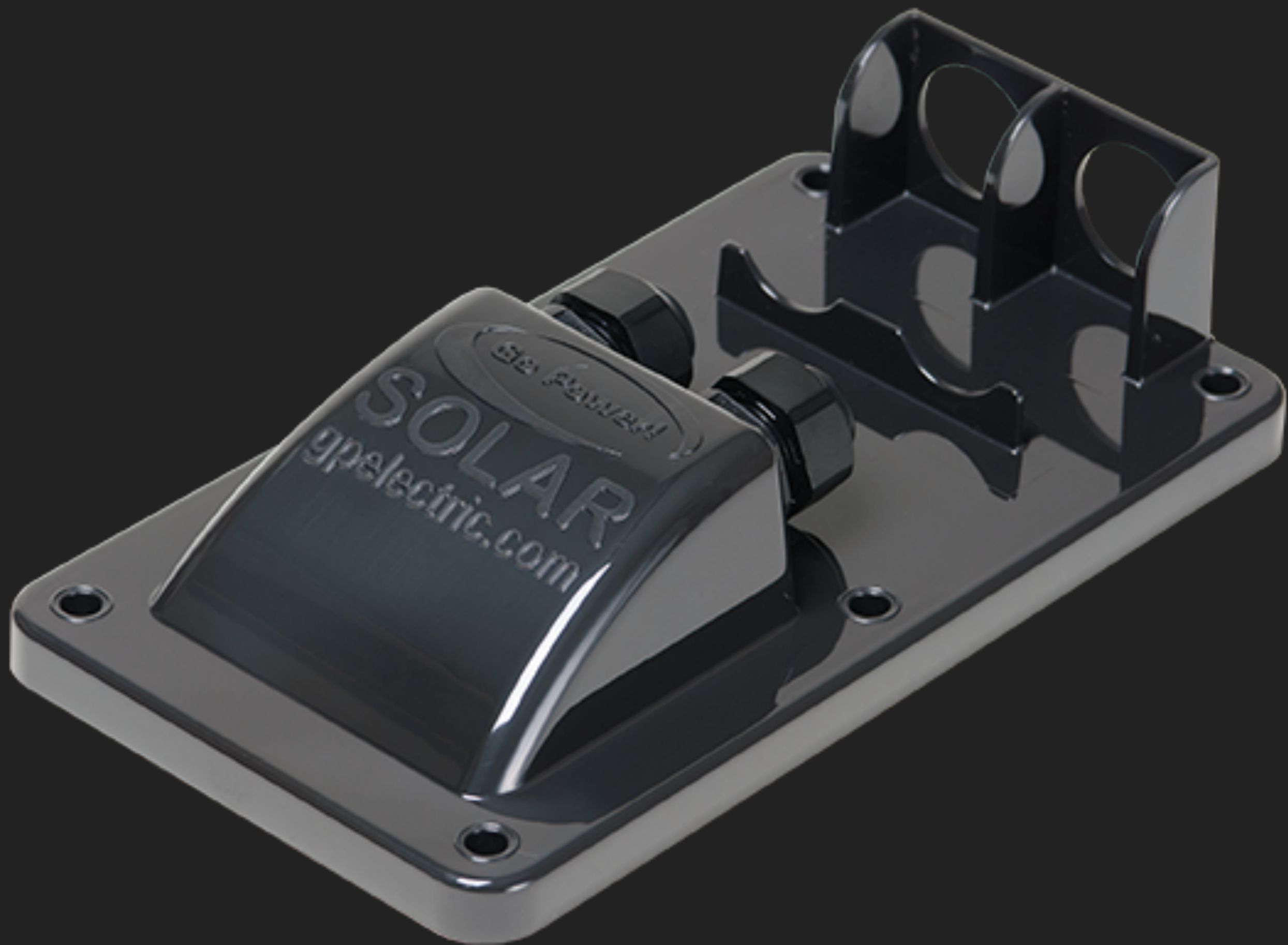
- ▶ Made by Renogy (but others make them as well) and will probably set you back about \$10.
- ▶ This are a REQUIREMENT if your system will use MC4 connectors...
- ▶ ...Unless your connectors were all factory installed and you never, ever, plan on disconnecting them once connected.



MC4 IN-LINE FUSE

- ▶ Something that is commonly overlooked... Good idea to fuse the circuit at the PV panel.
- ▶ These run in-line with your wiring to the charge controller.
- ▶ Make sure to use correct fuse for your application.





CABLE ENTRY PLATE

- ▶ Produced by Go Power!
(gpelectric.com)
- ▶ Designed for RV rooftops it provides a clean waterproof entry point using industry standard MC4 connectors.
- ▶ Installed on southern wall during home construction.
- ▶ For small scale installation, few hundred watts max.



CABLE ENTRY PLATE

- ▶ An additional cable entry plate installed in shack next to operating position and resting place of the solar cart.
- ▶ Provides tidy connection to the solar cart.
- ▶ Well built product, should last a long time.
- ▶ Used genuine "PV Wire" in walls & attic connecting the two entry plates for a very permanent installation.



SOLAR POWERED STATION - A BUYER'S GUIDE

PV WIRE

- ▶ There is such thing as application specific wiring known as "Photovoltaic Wire"
- ▶ UL Standard 4703.
- ▶ UV resistant, direct burial, etc.
- ▶ It's the stuff you want to buy if doing a permanent installation.
- ▶ Beware: There are many vendors claiming to sell "PV Wire" that doesn't meet the above spec.



RED/BLACK BONDED ZIP CORD

- ▶ Easy to work with.
- ▶ Do not skimp on gauge, use the heaviest gauge wire as is practical, especially on long runs for DC applications.
- ▶ Not for permanent outdoor installations.
- ▶ Available at powerwerx.com.



THE ANDERSON POWERPOLE

- ▶ Everybody probably already knows what these are.
- ▶ Simply awesome! Once you start using them, you are going to want to put them on everything you can.
- ▶ Available from many vendors, I purchase mine from powerwerx.com.



POWERWERX TRICRIMP TOOL

- ▶ I use this tool and have found it to be indispensable.
- ▶ At about \$40, it is definitely an investment. But IMHO it is well worth it.



WEST MOUNTAIN RADIO RIGRUNNER

- ▶ I know that MFJ and Hamsource make these as well but I am partial to the West Mountain Radio brand.
- ▶ There are mixed reviews out there, however, I own several and they have provided years of faithful service.
- ▶ Yes you can get power compact fuseless PowerPole splitters, but don't trust their safety unless you place fuses in your wiring.
- ▶ **ALWAYS USE CORRECT FUSES!**



POWERWERX POWER ANALYZER

- ▶ For metering and analytics of small scale installations.
- ▶ \$49.99 w/attached PowerPoles from powerwerx.com
- ▶ I had the predecessor (Watts-Up) and found it to be really useful.



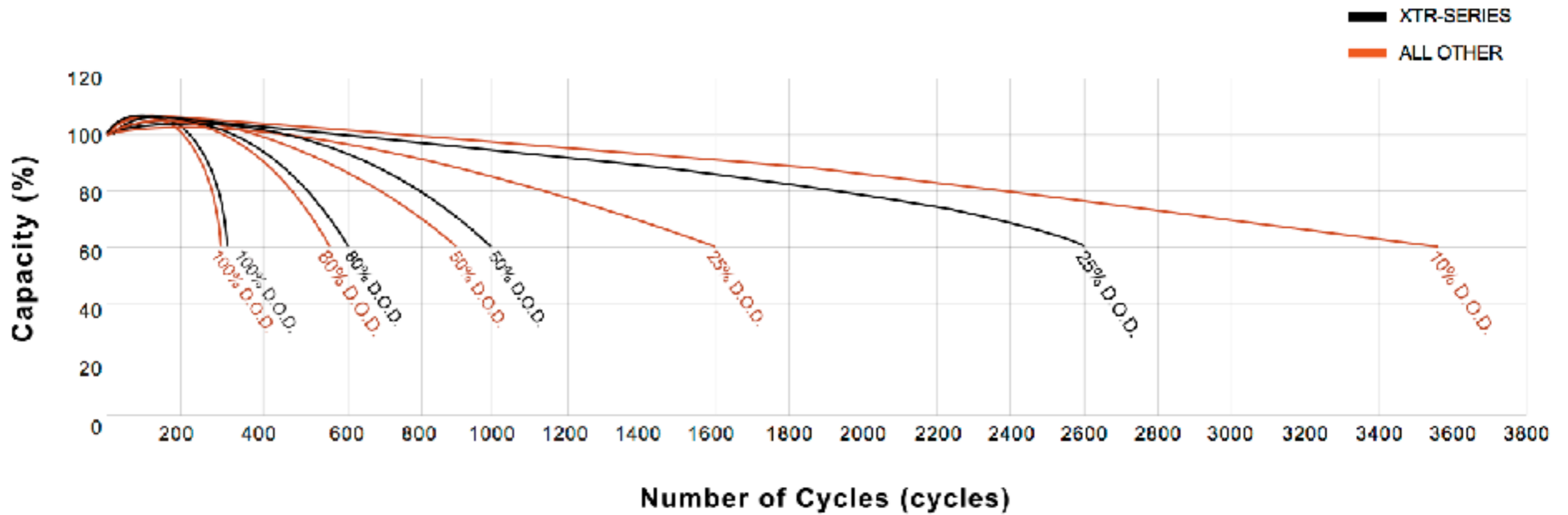
VMAXTANKS AGM SLA BATTERIES

- ▶ Deep cycle AGM SLA batteries that are specifically designed for solar in harsh environments.
- ▶ Very heavy = not very portable.
- ▶ Buy the largest Ah you can afford as you can only use as much as 50% of rated capacity without damaging the battery.
- ▶ This 125Ah battery costs \$260 on Amazon and will give you at most about 60Ah from a full charge.





Average Number Of Cycles vs Depth Of Discharge



BIOENNO POWER LIFEP04 BATTERIES

- ▶ 50% - 70% lighter than equivalent Ah SLA battery. Makes them ideal for portability.
- ▶ Up to 90% DOD compared to about 50% with SLA.
- ▶ 2000+ charge cycle service life and shelf life of 5-10 years.
- ▶ Prohibitively expensive. This 100Ah unit runs \$862! But it will get you up to 90Ah of runtime.



BIOENNO POWER BLF-1212WS

- ▶ But... If I were to buy one, this is the model I would get.
- ▶ Continuous discharge current of 24A (peak 48A for 2 seconds)!
- ▶ 3.7lbs.
- ▶ \$124.99
- ▶ <https://www.bioennopower.com>



TITANIUM INNOVATIONS AA/AAA CHARGER

- ▶ "Smart" charger that isolates each of the 16 bays. Many chargers will only charge 2 or 4 batteries at a time.
- ▶ Runs on 12VDC. Enough said.
- ▶ Has a "refresh" program for long term battery maintenance.
- ▶ Runs \$60 on Amazon.



PANASONIC ENELOOP NIMH BATTERIES

- ▶ My rechargeable NiMH batteries of choice. Originally sold by Sanyo. Now sold under the Panasonic name. Not sure if quality has changed.
- ▶ Available in high-capacity (2,400mAh).
- ▶ Mine have been in use for over 5 years and only a handful have gone bad (mainly my fault).
- ▶ Excellent build quality and longevity.



STORACELL POWERPAX BATTERY MANAGEMENT

- ▶ Available in different capacities (4, 8, 12 batteries, etc.).
- ▶ Available in multiple colors (organize different battery chemistries).
- ▶ Available for a variety of standard battery sizes (AA/AAA/C/D).
- ▶ Batteries are reversible (state of charge).
- ▶ Hands down the best battery management solution I have found.



DON'T FORGET THE LIGHTS

- ▶ If you plan to operate at night or in an emergency... It's hard to be an effective communicator in the dark!
- ▶ Standardize on AA/AAA if possible.
- ▶ I use a variety of types but find the ones I can hang from something (and headlamps) most useful.

THANK YOU

- ▶ Presentation will be available in PDF format online:
<https://barconline.org/2018-05/>
- ▶ You can reach me with questions or feedback at:
k7ctc@icloud.com