SOLAR FOR HAMS

PARC Meeting – August 15th, 2023

Presenter: Michael Miller – KN4VA

Where the FUN Begins

GOAL

- Provide a high-level overview of solar technology and relate this technology to portable Ham Radio situations:
  - e.g, POTA, SOTA, Field-Day, general day use.
- Not intended to be overly technical. It’s an introduction the different terms, and equipment that is available as it relates to Solar in general.
- Information presented here is to help you make a more informed decision if you have interest in solar.

DISCLAIMER

- I am not an expert. I'm learning just like you.
- No intent to teach solar design
- It is not the intent of this presentation to push or promote any product or technology over another.
- Any reference to specific vendors or manufactures of products in the presentation or discussion related to solar, is for information purposes only.
- Remember, solar is an **optional** technology that can be applied to you ham radio experience.

TYPICAL SOLAR SETUP

- A typical setup with solar for amateur radio use:
  - **Solar Panel(s)****
  - **Solar Charge Controller** **
  - Battery
  - Radio – or some load
  - Power Monitor (optional)
    - May be part of charge controller

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INDUSTRY FRAMEWORK

Solar industry is primarily focused on couple major market segments

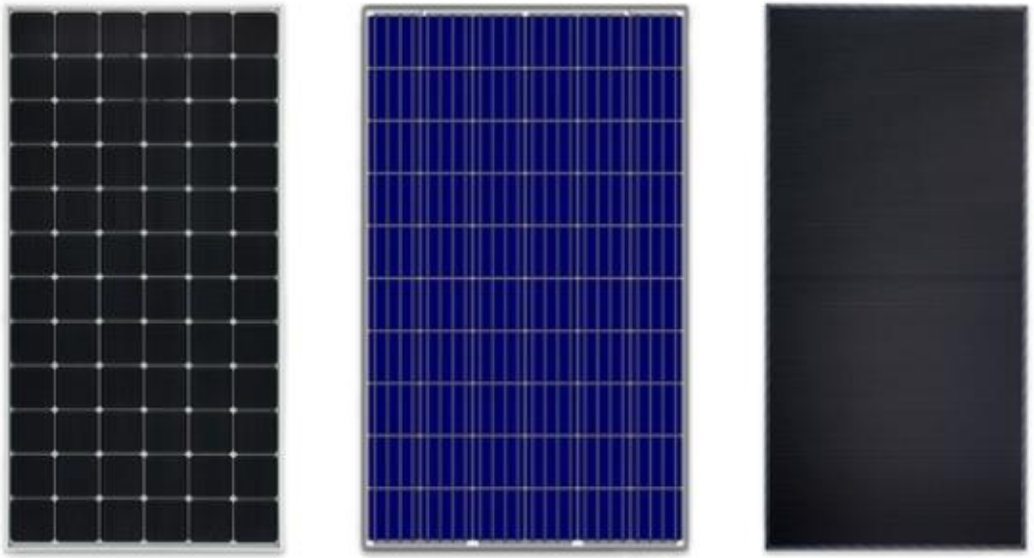
- Homeowner, Off-Grid, Prepper
- RV, Campers, Camping, Outdoor Activities
- Solar Generators – purpose built to support Solar Panels

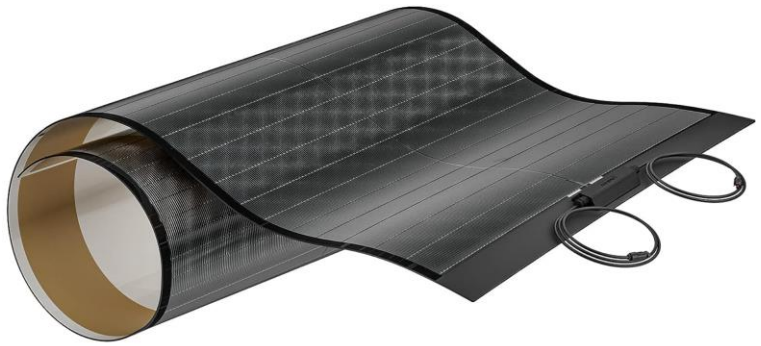
No large active focus towards Amateur Radio specifically

- Easy enough to adapt this technology for Amateur Radio purposes

SOLAR PANEL TECHNOLOGY

- The three (3) common types of tech available:
  - Monocrystalline
  - Polycrystalline
  - Thin Film
- All three have advantages and disadvantages
- They can come in a variety of options
  - Permanent Mount
  - Portable Fold-up
  - Roll-up / Flexible





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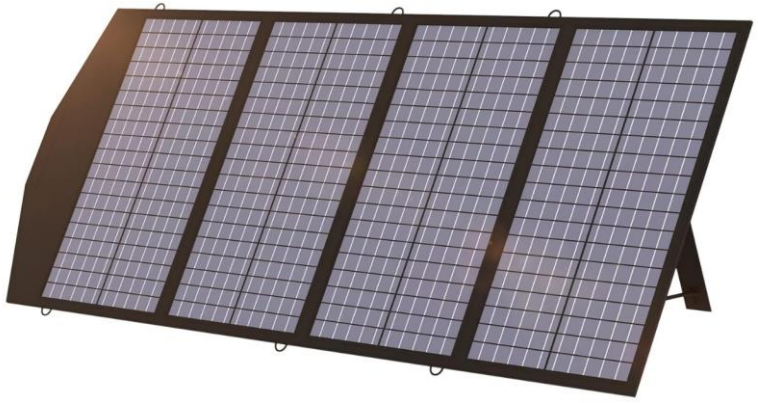
MONOCRYSTALLINE

- A cell is one solid silicon crystal
- Most expensive
- Panels have a black hue
- Highest conversion efficiency (20% - 25%)
  - Efficiency % is conversion of sunlight to electricity
- Long life span (25-40 years)
- Low Temp Coefficient (more efficient in high temperatures)

POLYCRYSTALLINE

- Cells made up of many silicon fragments – sheet pan/formed
- Less expensive than Monocrystalline (manufacturing process)
- Panel have a blue hue (can have a chip/OSB board appearance)

- Less efficient than Monocrystalline (20% and less)
  - Efficiency % is conversion of sunlight to electricity
- Life span 20-35 years
- High Temp Coefficient – less efficient in high temperatures



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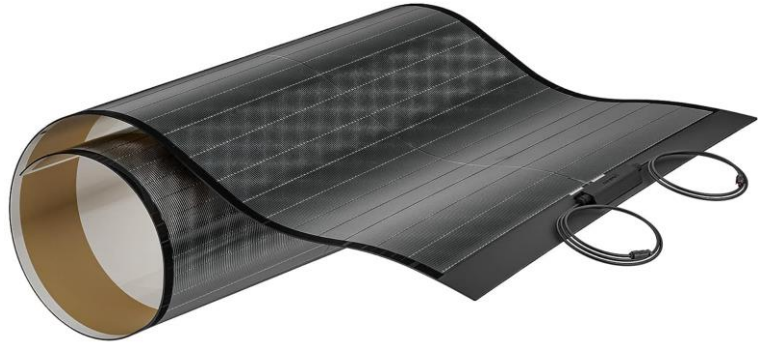
THIN FILM



- Photovoltaic material deposited onto substrate material
- Color hues vary
- Common types:
  - Cadmium Telluride (CdTe)
  - Copper Gallium Indium Diselenide (CIGS)
  - Amorphous Silicon (a-SI)
  - Organic Photovoltaic Cells (OPC)
- Much less efficient than Mono and Poly (7-13% - 9% being a median)
- Least expensive ?? – Faster manufacturing process
- Can be good for low light/shaded conditions **
  - Lower output due to efficiency, but typically a sustained output
- Typically, lower temp coefficient than Monocrystalline
- Panels are typically flexible – but can be rigid as well.
- Size/output power – panels can be large for small outputs

FORM – FIT - FUNCTION

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PANEL TYPE COMPARISON

Type of Solar Panel	Pros	Cons
Monocrystalline	+ Highest efficiency, which means more kilowatt-hours per square foot covered + Longer lifespan (25+ years)	– Most expensive type of solar panel
Polycrystalline	+ Balanced cost and efficiency: intermediate between monocrystalline and thin-film solar panels (best suited for installations where space is not a constraint) + Long lifespan (25+ years)	– Lower efficiency than mono panels – Higher temperatures affect productivity and durability
Amorphous	+ High temperatures only have a small impact on their productivity + Lightweight + Low cost + Flexible and adhesive panels available	– Low efficiency, which means unfit for the average home – Shorter lifespan than mono and poly panels

PANELS – ADDITIONAL INFORMATION

- Most panels can be ganged together
  - Usually require like-panel to like-panel and like-manufacture to like-manufacture
    - Start small, add more later if needed
- Panel coatings vary.
  - ETFE – (Ethylene-Tera-Fluoro-Etheylene) - Flouride based plastic
    - Best in all areas, of durability, life span, transparency – highest cost
  - PET – (Poly-Ethylene-Terephthalate) - Polymer Resin
    - “Good” in all areas, but less expensive
- Connectors will vary panel-panel and manufacture-manufacture
  - You might (most likely) need to adapt for your needs
- Reality check - You will not get full rated wattage from any panel – ever
  - 80 – 85% of rated wattage output is considered very good

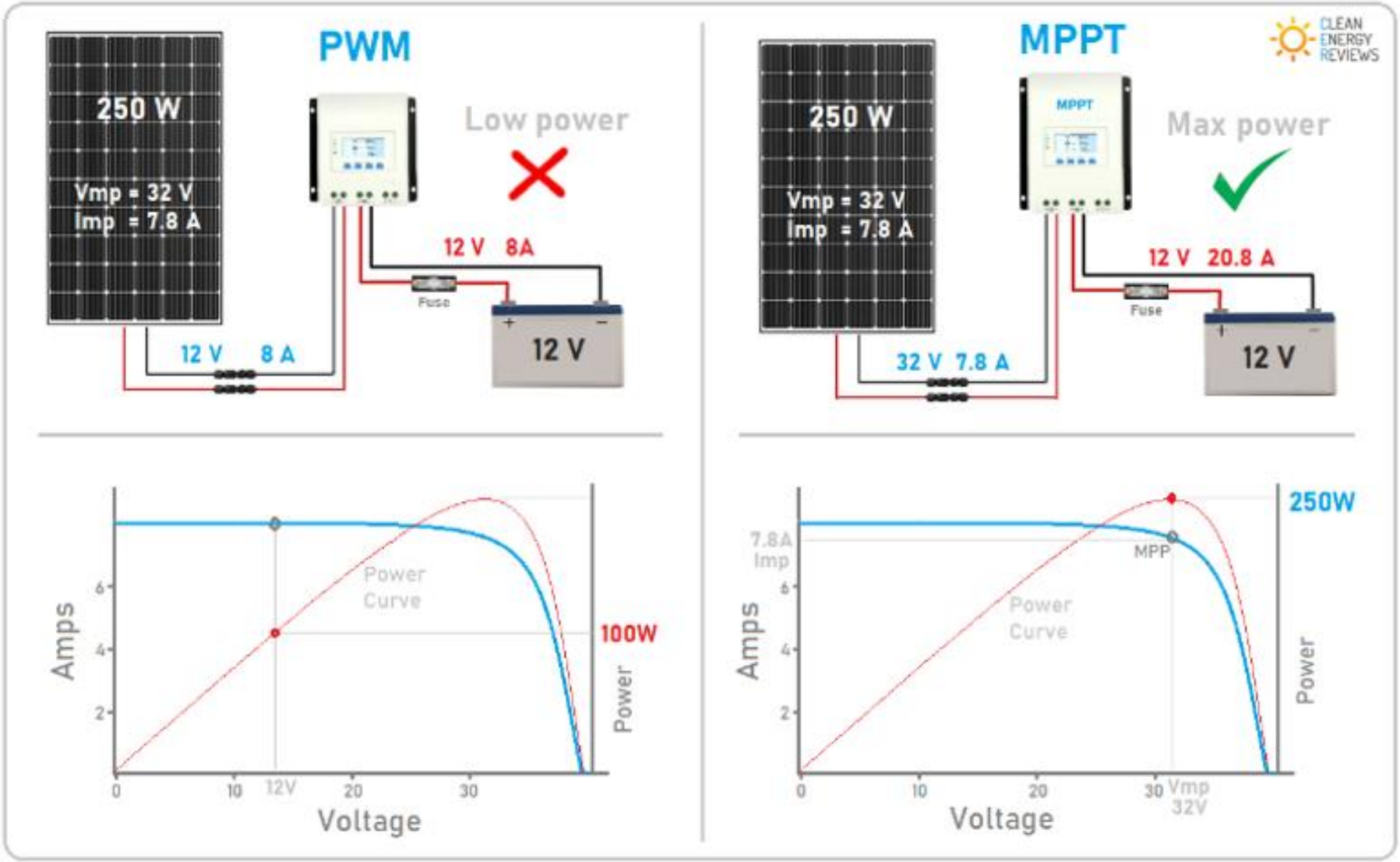
SOLAR CHARGE CONTROLLERS

- **PWM** (Pulse Width Modulation)
  - The charge controller switches on and off to vary the output current in order to match the voltage of the battery
    - Less expensive
    - RF Friendly
    - Least efficient (75-80%)
    - Smaller footprint
    - Good for small systems (170w or less)
    - Must be mindful for long cable runs (larger wire size)
    - Multiple battery chemistries

SOLAR CHARGE CONTROLLERS

- **MPPT** (Maximum Power Point Tracking)
  - The controller uses DC-**AC**-DC Conversion to match the battery voltage, in order to maximize current flow to the battery (I = P/V)
    - Most Expensive
    - Most efficient (98% >)
    - RF Noisy (“RF hash” - but there are exceptions)
    - Larger footprint
    - More efficient on long cable runs and shading conditions

CHARGE CONTROLLERS



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CHARGE CONTROLLERS

Solar Charge Controller	Pros	Cons
MPPT	1. Maximum Power voltage Tracking up to 99% AIP Conversion rate. 2. Multi-charging maintains the battery's health. 3. Available for purchase in a sizeable off-grid power system. 4. Available for 100 Amp solar systems. 5. Provide flexibility when system expansion is necessary. 6. Multiple protection.	1. Costly Pricing (usually cost twice of a PWM Charge Controller). 2. Larger than a PWM regulator in size.
PWM	1. PWM controller uses sophisticated and tested methods. 2. PWM controller has a simple structure, and the price is lower. 3. Smaller-scale deployments are simple.	1. Low conversion rate. 2. The battery bank voltage must equal the input voltage. 3. Less scalability for system growth. 4. Inability to handle higher voltages. 5. Less load mode. 6. Less protection.

CHARGE CONTROLLERS
MPPT EXCEPTIONS

The MPPT controllers listed below are known to be Ham RF friendly

- **DYI Solar For U ($249) (Ham Operator)**
  - https://www.diysolarforu.com/products.html
  - 99% efficiency
  - LiFePO4 or Lead Acid (12/24v systems)
  - Largest unit - Max 20 amps of solar input
    - Approx 350/700 watts (12v/24v)

- **GENASUN ($135)**
  - Available from Amazon and Gigaparts.com
  - 98.3% efficiency
  - Some noise (artifacts) mention in the 160m and 80m
  - LiFePO4 or Lead-Acid Only Models (14.2v/12v)
  - Largest unit – Max 10.5 amps of solar
    - Approx 140 watts

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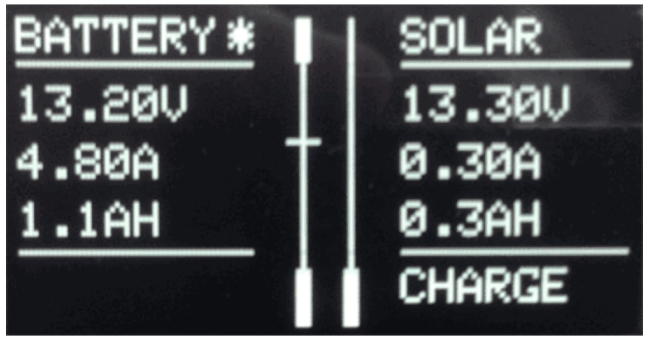
CHARGE CONTROLLERS
MPPT EXCEPTIONS

- **Buddipole PowerMini 2 ($165)**
  - https://www.buddipole.com/powermini.html
  - Efficiency? – Charge Technology?
  - LiFePO4 and Lead Acid
  - Weight – 7oz
  - 11A max input – 32A max output
  - Provides additional Information & protections
    - Prevents overcharging
    - Low Battery warning (Can auto disconnect)
    - Output Overcurrent and Short Circuit protection



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GENERAL FOOD FOR THOUGHT

- Sunlight variability and time of year can make solar more/less usable
- How to apply solar? – Really its change for a dollar
  - Fact – There are 239 ways to make change for a dollar
- It's all your decision – "FORM – FIT – FUNCTION"
- Solar is an easily added technology that can enhance your ability to operate
- If you treat POTA, SOTA etc, like a NASCAR pit stop, then solar is probably not necessary
- If you have a secondary/tertiary use, solar might be worth investigating
  - Camping, RV, Emergency etc.,
    - Solar Generator could fit in here as well
- You may just prefer to have enough storage

APPENDIX – EXTRA INFO

More Battery or More Solar?

Rated Wattage	Rated Max Voltage	Rated Max Amps	Rated Amps (8hrs)	75% Panel Usable Output (8hrs)	75% Eff PWM Output (8hrs)	98% Eff MPPT Output (8hrs)	MPPT vs PWM Amps Diff (8hrs)
60	18.00	3.33	26.64	19.98	14.99	19.58	**4.60**
75	18.00	4.17	33.36	25.02	18.77	24.52	**5.75**
100	18.00	5.40	43.20	32.40	24.30	31.75	**7.45**
200	18.00	11.11	88.88	66.66	50.00	65.33	**15.33**

NOTE: Voltage drop not factored into calculations – Keep all cable as short as possible

If you have more storage than you can generate – add solar

If you generate more power than you can store – add storage

[Voltage Drop Calculator For Solar Electric Systems - Unbound Solar]

APPENDIX - BATTERY RUNTIME USE

Bioenno Owner - Kevin Zanjani – Video Presentation

https://www.youtube.com/watch?v=fuVyaLBUcQQ

From PPT "Overview of LifePO4 Batteries for Solar/Radio applications (For 2023)"

Bioenno Power®

Transmit Power	Receive Power	Weighted Average (20% Tx + 80% Rx)	Battery Run-Times
5 Watts	5 Watts* *Modern radios have a receive power < 5 Watts	5 Watts	3Ah -> 7 hours 4.5Ah -> 10 hours 6Ah -> 14 hours
10 Watts		6 Watts	6 Ah -> 12 hours 8 Ah -> 16 hours 12Ah → 24 hours 15Ah -> 30 hours 20Ah -> 40 hours
20 Watts		8 Watts	6 Ah -> 9 hours 8 Ah -> 12 hours 12Ah → 18 hours 15Ah -> 22 hours 20Ah -> 30 hours
50 Watts		14 Watts	6 Ah -> 5 hours 8 Ah -> 7 hours 12Ah → 10 hours 15Ah -> 13 hours 20Ah -> 17 hours

Transmit Power	Receive Power	Weighted Average (20% Tx + 80% Rx)	Battery Run-Times
100 Watts	5 Watts* *Modern radios have a receive power < 5 Watts	24 Watts	12Ah → 6 hours 15Ah -> 7.5 hours 20Ah -> 10 hours
150 Watts		34 Watts	15 Ah -> 5 hours 20 Ah -> 7 hours 40 Ah -> 14 hours
200 Watts		44 Watts	20 Ah-> 5 hours 40 Ah -> 10 hours 60 Ah -> 16 hours

https://www.bioennopower.com/collections/lifepo4-batteries-for-communication-equipment-ham-radio

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THAT'S ALL FOLKS!

Questions?

Concerns?

Comments?

THANK YOU

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