

# Practical Emergency Electrical Power: Lessons Learned from 20 yrs & Helene

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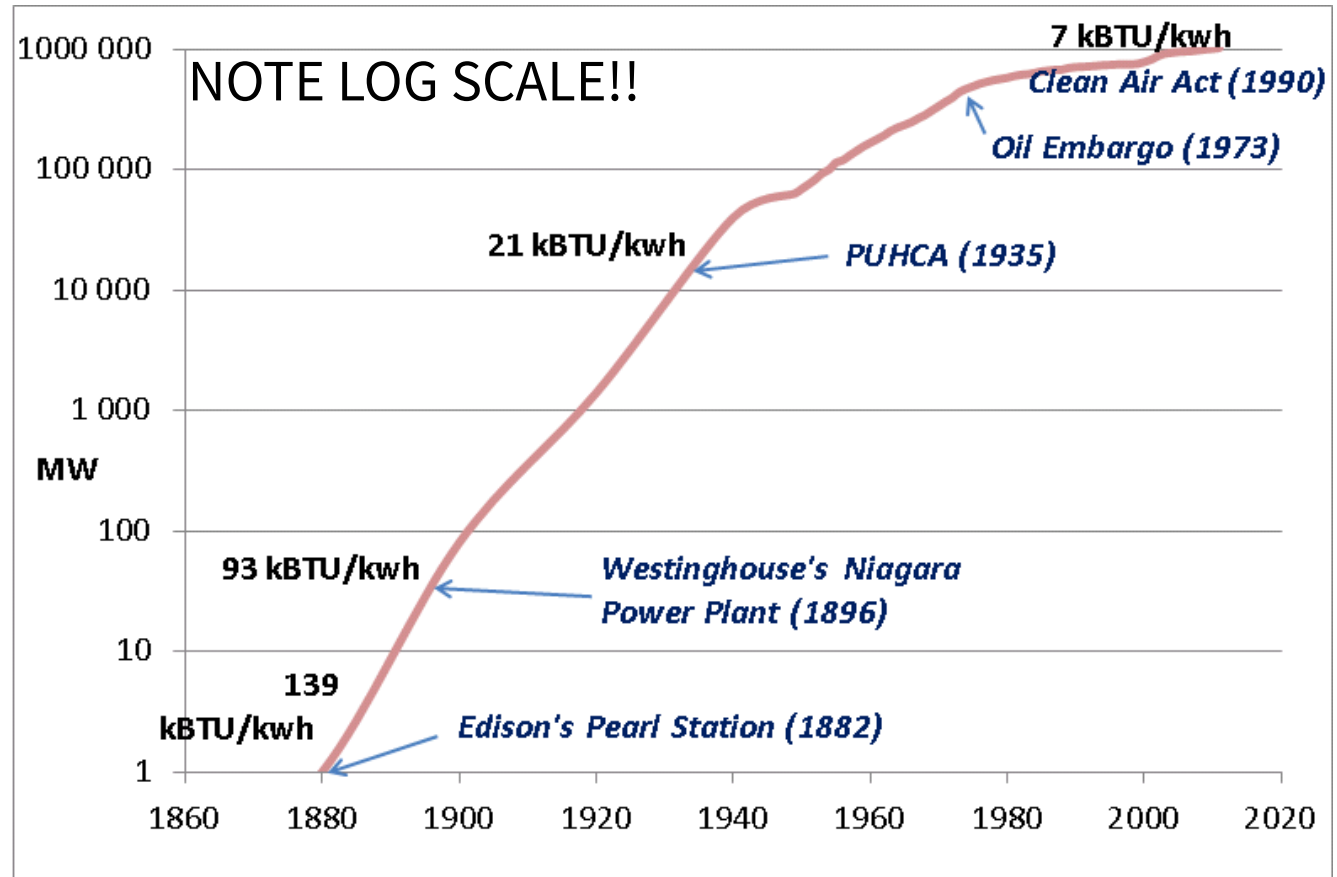
# Electricity is IMPORTANT

- Our society is highly dependent on reliable electrical power
- First electrical power station: 1882 Edison's Pearl Street Station, 2.5% of chemical energy converted to DC power. Money loser.
- 1886 Westinghouse, then Niagara Power Plant 1896 (AC) Coal powered, efficiency reached 3.8%
- Power washing machine 1907
- Vacuum cleaners 1908
- Household Refrigerators 1912
- 1940: Efficiency up to 17%

# Installed Electrical Generation

REF:

<http://large.stanford.edu/courses/2013/ph240/iskhakov2/images/f2big.png>



# Florida—new homes ill-prepared

- Few houses built with windows that open at top and bottom for convective air currents
- Few houses built with any type of whole-house fan
- Food tends to require refrigeration or freezing, except for dry goods or canned
- FEW know how to dry-can or pressure-can food and thus are unable to save food that defrosts or loses refrigeration.
- Food loss in refrigerators can be quite expensive.
- Older persons unable to tolerate heat may have increased morbidity/mortality

# Simple Solutions for Florida Living

- **REFIGERATORS** tend to require 15-ampere STARTING currents to start the induction motors in the compressor – **generators need to be 3kw to start** and inverters at least 2kW
- **WINDOW AC UNITS** – small 5000 BTU ones pull only 500 watts. They are quite sufficient to cool down a bedroom in a couple hours and make it very comfortable. \$159 at Home Depot – marriage & life saver!!
- 3-4 kilowatt generators are VERY COMMONLY AVAILABLE and can handle even two refrigerators and a window AC unit.
- Generators go ON SALE after a slack hurricane season



# Simple Air Conditioning: Installation

- Open Window
- **Get friend to help you position**; close window on top to keep it from falling out
- Side extensions block hot air entering – add pillows or bubble wrap or blanket to better insulate
- GREAT COOLING FOR ONE ROOM
- Typically 500watts; easy extension cord to the generator



# Cautions on the simple solutions

- Move the generator WAY OUT OF THE HOUSE (don't die of CO)
- Lock it down with a CHAIN if you wish to keep it.....
- Recommend STAINLESS STEEL CHAIN
- GREASE in the padlock keyway, OK?
  - Packing grease is what mechanics do to WHEEL BEARINGS to prevent water destroying them. Suitably greased locks from a decade ago are still in use at the Gibby household.
- Use extension cords to get power to specific appliances
- AVOID INCANDESCENT LAMPS – only LED or CFLs

# BUY EXTRA EXTENSION CORDS

- 50- and 100-foot 3-wire extension cords are GREAT during power outage!! Buy lots in the off season!!
- Breaker-protected outlet boxes are also great
- A self-standing Lamp is wonderful in a dark room.
- CROCK POT COOKING uses a lot less energy
- MICROWAVE uses a lot but for a SHORT TIME – fits generators nicely
- CANNED FOOD can be eaten COLD if needed, or just warmed up (much less energy than real cooking)
- One big paper box full of canned goods = about 7days for 2 people (pick APPETIZING FOODS, OK?)



# Fancy: Generator Transfer Switch

- \$300 box that allows you to tap into individual branch circuits and have them fed from a single generator right there, instead of needing a bunch of extension cords.
- **Consumer installable** if you understand a bit about wiring and can follow directions and use a drill etc.

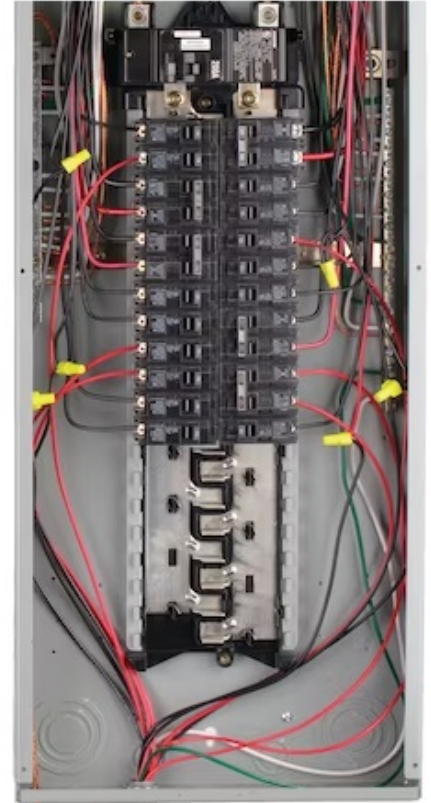


This is what I put in for the renter in NC

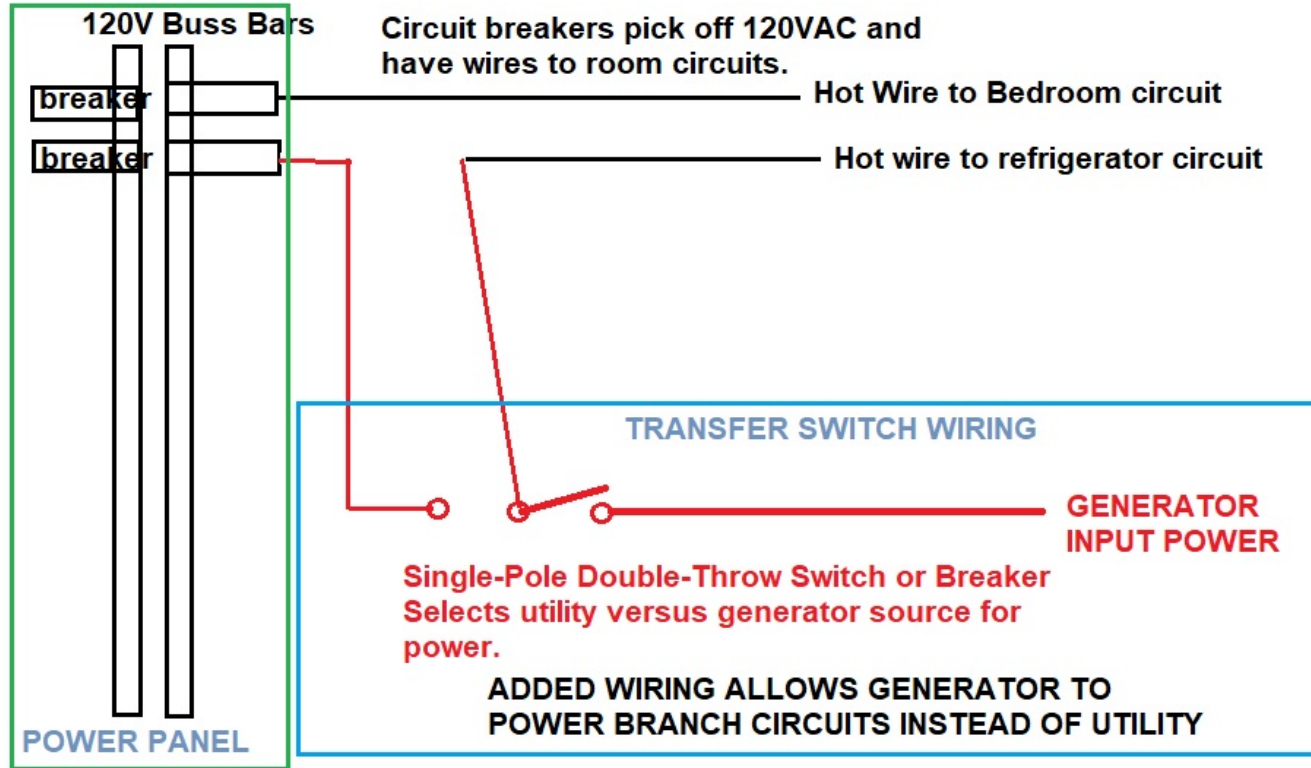
- <https://www.lowes.com/pd/Reliance-306LRK-6-Circuit-Transfer-Switch-Kit-P2/50436688>

# Fancy: Transfer Switch (2)

- Simple wiring inserts between desired branch circuits wires, and their respective breakers in your power panel.
- Must be comfortable pulling main power and working inside panel box to install. **(INCOMING WIRES STILL HOT!!!)**
- Can also pay an electrician



# Fancy: Transfer Switch (3)



THOSE BUS BARS ARE THE LEGS OF THE INCOMING POWER AFTER MAIN SWITCH OR BREAKER

# FUEL may be scarce!

- Generators are **horribly inefficient** compared to utility systems
- You should plan on at least ½ gallon gas per hour on small generator, possibly up to 1 gallon if you pull 2+ kW
- METERS ON TRANSFER SWITCH MAKE EASY MEASUREMENT
- Failure to plan and manage your fuel availability and fuel usage =  
RUNNING OUT OF FUEL

# PLANNING

- Generators require some fuel merely to keep running (due to FRICTION)
- Typically at about 500-1000 Watts you can expect about ½ gallon per hour on diesel or propane generators.
- Refrigerators run about a 33% duty cycle, but they need power about every 2 hours (give or take) to stay acceptable cold—and then it may run for 45 minutes [keep closed when not powered!!]
- Even if you are willing to go in and out and turn the generator on and off, you're looking about about 12 hours of run time per day and that is about 6 gallons per day.
- **You might need to store 4 days of fuel to feel comfortable and that means 25 gallons of gasoline or SIX TO SEVEN BBQ tanks of Propane.**

# Fuel Planning Continued

Households with built-in propane tanks aren't relieved of planning duties, either!

- Typically the GENERAC type “house generator“ is set to run the FULL AC SYSTEM – and that means MULTIPLE KILOWATTS of power, far far more than one room.
- Typical small 3-ton AC unit will use as much as 4kW peak – and 2kw AVERAGE
- BIG HOUSE may have three times this amount –
- **The FUEL USAGE of small house will be FOUR TIMES that of a modest 1-room AC solution; big house may be TWELVE TIMES**
- One of our neighbors RAN OUT OF PROPANE after 3 days.
- My father in law got a \$\$Multi-Hundred bill after a hurricane....
- **So you would be wise to ECONOMIZE!**

# Wise to TRACK/MEASURE Fuel Usage

- If you don't have AC Amperage measurements.... (which is cheap with a clamp-around AC Ammeter)
- CHEAP CLAMPONS do not measure DC current – but they can measure AC. You must split the cable and clamp on JUST the black or JUST the white wire.
- AT LEAST FOLLOW YOUR FUEL USAGE!!



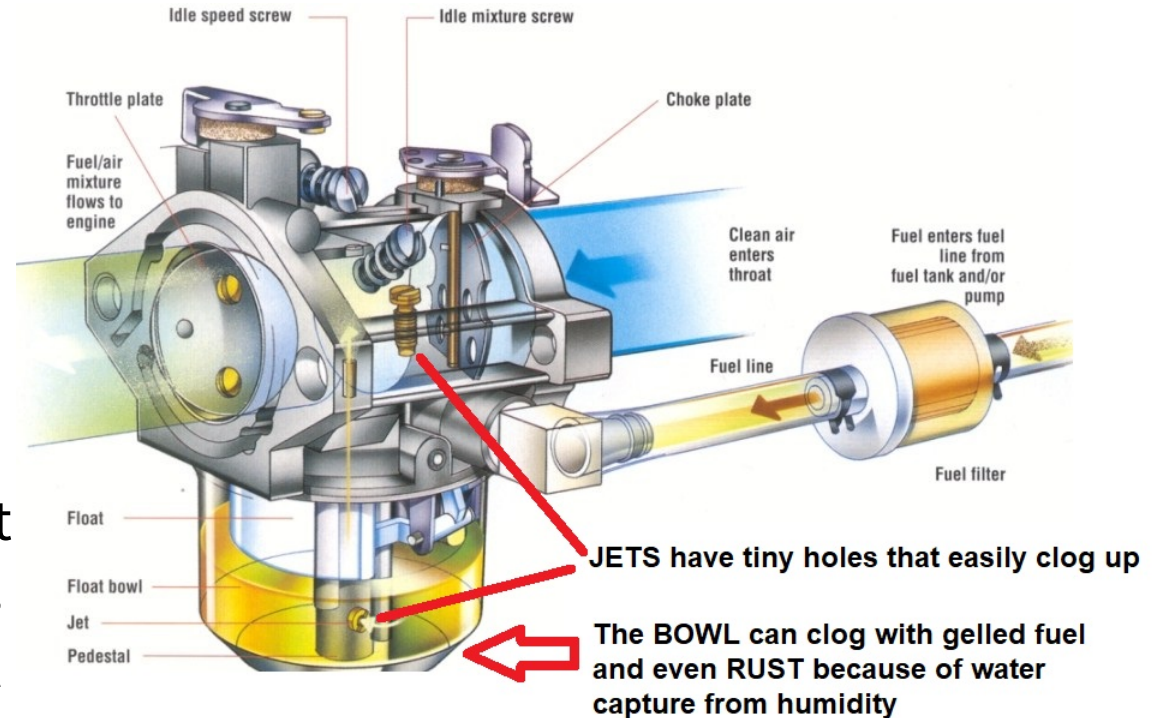
Roll over image to zoom in



# Generators: The Problems

It is not all roses....

- FUEL can be difficult to find in a power outage because gas stations may not be able to PUMP, or authorize your credit card
- GASOLINE generators tend to get blocked or corroded carburetors unless they are operated at least monthly, perhaps every two weeks.





# Maintenance

- Few people are willing to crank the generator every 2-4 weeks ALL YEAR LONG – **but they are richly rewarded!!** *Their generator works!*
- The best solution to THAT is to use a PROPANE GENERATOR – their carburetors do not clog up! But they have their own problems:
  - 20-lb propane tanks (BBQ tanks) only hold about 4 gallons of propane
  - 4 gallons of propane is worth maybe 3 gallons of gasoline?
  - Storing large amounts of propane is difficult unless you have a large tank – small steel cannisters RUST
  - Propane is MORE EXPENSIVE than gasoline
- **For ALL GENERATORS** – always check that they actually make electricity when you crank them. Big lightbulb, AC chain saw, power saw, drill – something. Brushes or voltage regulator can fail!

# GENERATOR: Preventative Maintenance

- **OIL:** New engines usually get oil changed after 15-25 hours to remove the metal scrapings from break-in. Failure to do this.....reduced lifespan??
  - After that oil changes every 50-100 hours – use synthetic if your manual allows it – much better friction reduction, much longer life IF ACCEPTABLE.
- **AT THE VERY LEAST CHECK THE OIL EVERY FILL-UP OF THE TANK!!! LOSING OIL IS INEVITABLE BUT LOSING THE ENGINE IS NOT!!!**
  - In a pinch almost ANY motor oil is better than none....
- **CHECK THAT OIL EVERY SINGLE DAY OF HURRICANE!!!**
  - You might consider CHANGING THE OIL after 2-3 days of continuous operation (e.g. after FIELD DAY, right???)
- **PARTS TO KEEP ON HAND: BRUSHES / AVR**

# Generator Maintenance: Brushes

Generator Brushes are a dime-a-dozen replaceable part that you access from the end cap of the alternator head, just like the AVR (automatic voltage regulator). Often they are held in by two screws through openings in a plastic part (see illustration) and have terminals that go to the two spring-tensioned brushes.

Just go to Amazon or another site and pick out a unit that looks like yours. Expect to pay < \$10 for a spare set to keep on hand.

Example universal 4kw-7kw:

<https://www.amazon.com/Universal-Generator-Assembly-Champion-Connectors/dp/B08N6FWQXQ>



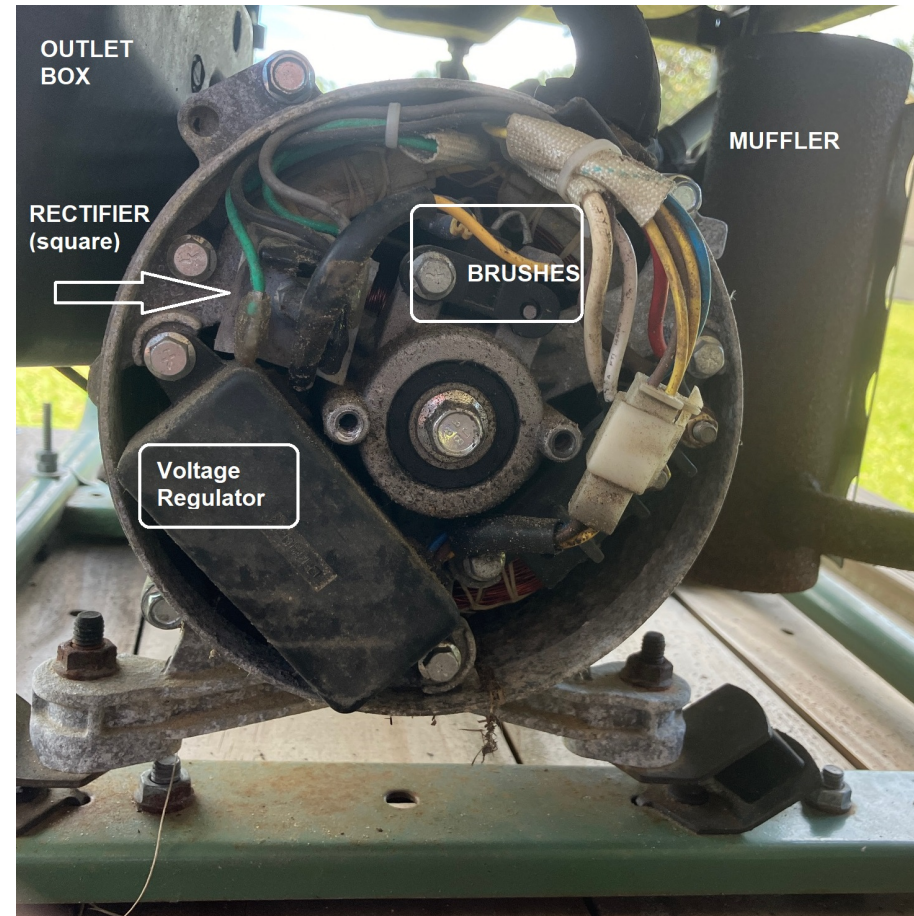
# Generator Voltage Regulator 4kw+

- Generator voltage regulators (“AVR”) are another commodity part that are often the same from one brand to another in the **4-7kW range**. \$16
- These have a plastic connector to sample to the output voltage, and then terminals that go to the brushes and control the rotor windings current, which allows them to regulate the voltage developed in the stationary stator windings.
- There is a little multi-turn potentiometer trimmer (often BLUE) that may develop a dead spot due to vibration – and then you get ZERO OUTPUT voltage from your fancy generator! Keep a spare AVR on hand. You may get temporary relief by adjusting that trimmer, but I would replace the AVR (which is “potted” and difficult to repair)



# Generator Voltage Regulator $\leq 3\text{kW}$

- Couple of screws and the end-cap of the alternator head is off.
- Flashlight and study what you are seeing for a few moments.
- Automatic Voltage Regulator
- Brush Assembly
- Possibly rectangular (bridge) rectifier
- Everything is RIGHT THERE IN FRONT OF YOU!!



# Generator Voltage Regulator 3kW

- Package Deal! \$10 gets you AVR PLUS BRUSHES for 3kW range generator!!.
- Go take the end cap off YOUR generator, look at the shape of the parts and ORDER SPARES. Tape the Amazon box to the generator.
- <https://www.amazon.com/Mtanlo-Generator-Automatic-Regulator-Rectifier/dp/B0BZV2MC5T>





# And....Exotic Generator Solutions.

- PTO generators allow the use of TRACTORS – which can operate for many hours and are self-cooling
- Run generally on DIESEL
- NOTE PTO GENERATOR MUST BE ON SUBSTANTIAL BASE OR IT WILL TWIST!!!!
- TRAILER SUGGESTED
- 7800 watt generator \$1300

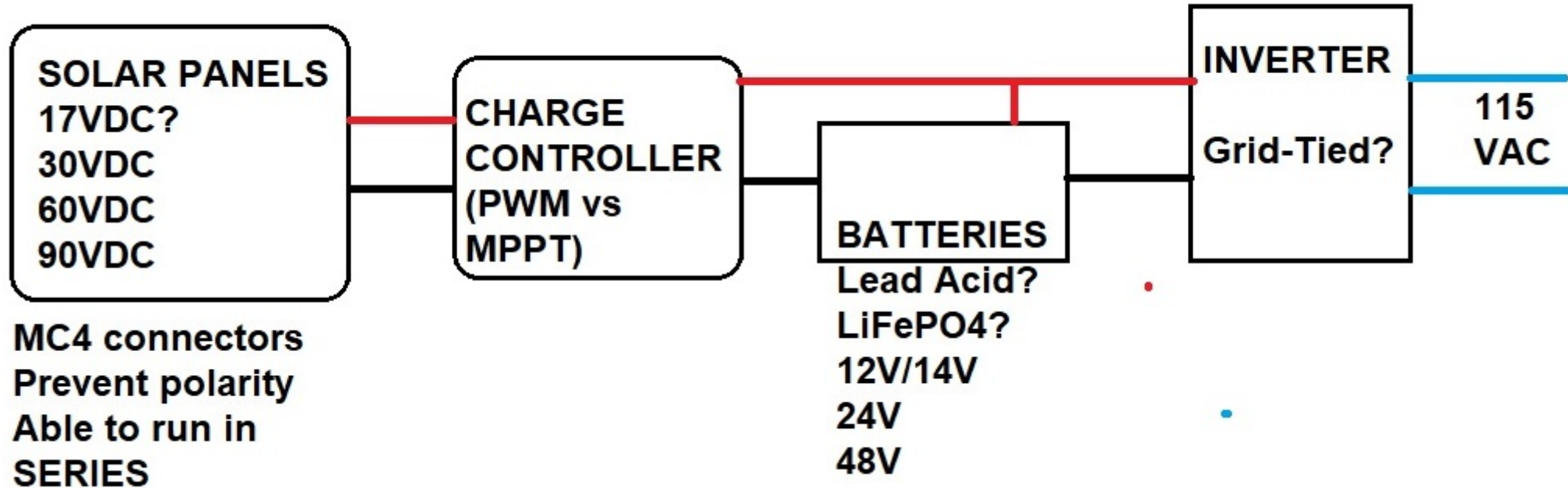


# Alternatives to 24-hour Generator

- Generators are usually the CHEAPEST “upfront cost“ solution
- Considerable RUNNING COST (\$36/day even for modest generator; \$100+ for whole house propane!!) can be tolerated easily for SHORT OUTAGES
- For upscale solutions.....SOLAR POWER (either installed or portable) is a viable alternative



# SOLAR POWER COMPONENTS



# Options Abound

PANELS: Range from horribly over-priced tiny panels from Harbor Freight, to commodity household panels in the 275-350W range, typically **\$0.50/watt**

CHARGE CONTROLLERS: Range from small Pulse Width Modulated (PWM) controllers, to more efficient MPPT (power-point tracking) controllers that can adjust for different battery chemistries, voltage set points, and handle up to 80Amps of charging

INVERTERS: Range from small modified-sine-wave 100-300W units, to large inverters making pure sine waves of up to 4 kilowatts or more, 120V all the way to 240VAC

# Batteries get you quietly through the night

**Lead-Acid** – former standard, still somewhat cheaper up front.

**LiFePO<sub>4</sub>** – prices now very close even at PURCHASE (<\$4/ Ahr @ 12V) – and cycle-counts are much much higher – with more stable voltages, easier to work with. MIADY – cheaper, but have worked for us for RADIOS. CHIN – family members using them for bigger systems.

Lead-Acid voltages droop throughout discharge.

LiFePO<sub>4</sub> – tend to have stable output voltages throughout more of discharge

MAINTENANCE of Lead Acid batteries is much more difficult.

If not kept fully charged, Lead Sulfate tough crystals form, permanently damaging the battery.

LIFEPO<sub>4</sub> – don't depend on staying charged.

# LiFePO<sub>4</sub> “gotchas”

Battery Management System (BMS) of LIFEP04 batteries will generally protect the battery from harm.

**Sticking point is FREEZING TEMPERATURES** – some BMS will not protect against that.

If installation location subject to FREEZING, then you need to plan for avoiding charging the batter then.... My basement in NC never seems to get down to freezing even in freezing weather.... Consider mounting batteries on interior wall of attached garage for example.

# Professional Batteries

- Professional LIFEP04 Batteries
- E.G. Simpliphi 3.8kWHr battery \$2600
- Available in 24V or 48V versions.

\$0.68 per watt-hour

[https://www.invertersupply.com/index.php?main\\_page=product\\_info&products\\_id=201869](https://www.invertersupply.com/index.php?main_page=product_info&products_id=201869)



# Consumer Batteries

- CHINS lifepo4 available in 24V and 48V (51V) versions
- 5.12 kWhr @ \$850 = \$0.165 per watt-hour
- FAR CHEAPER
- DIFFICULT to put BMS-controlled LIFEP04's in SERIES – so pick your voltage carefully.
- Parallel is easier, especially for 2-3 batteries



# Inverters and Charge Controllers

- Unless you want to sell power back to the grid, these are now becoming CHEAP COMMODITY ITEMS
- GRID TIE ARE MORE EXPENSIVE – I recommend OUTBACK BRAND
- Zillion MPPT controllers for every possible battery voltage and current charge easily available. (Recommend away from cheapest)
- Zillion Pure Sine Wave Inverters available.
  - 12V are difficult to use because of excessive wiring size
  - 24 V are somewhat more pricey but available
  - 48V are mainstream and readily available

# For Peter: Simple System at First

- **24V system** (intermediate level, aiming for 2kW max panels)
- 24V CHINS 100Ahr battery (2.4 kWhr)  
**\$460**  
<https://www.amazon.com/gp/product/B091YCZV2T>
- 24V GIANDEL (no-name brand) 2kW pure sine wave inverter **\$350** – outlet outputs- can start refrigerator  
<https://www.amazon.com/gp/product/B07GDH711G>





# Massive UPS System

- If you just add an AC Charger, and skip the Solar Panels / Charger completely – you have a massive “uninterruptible power supply” and can get thru at least part of the night without the generator (if that is important to you)
- Get a LITHIUM CHARGER from a reputable manufacturer and TEST IT to see if it really can charge the batteries and how many hours it needs. Wimpy ones will QUIT EARLY.

# Charge Controller – Going Full Solar

- So many to choose from!!!
- We Desire 60A @ 24V output capacity (1400 watts) so medium sized system

<https://www.amazon.com/Charge-Controller-Regulator-Lithium-Battery/dp/B09Q52H295>

- \$160.
- Handles up to 150V input, so safely handles 3 36V panels in series (800+ watts)
- Expect to pay \$0.50 per watt for solar, so expect \$400 for panels



# Two Budgets

- **Power Budget** - 500W AC x 12 hours; Fridge 200W avg x 12 hrs = 8.4kWhr – NO CAN DO! With one battery.... Possible to keep fridge going, nothing more. Will have to buy more batteries if want AC all night.
- **Expense Budget:** Battery 24V \$460; Panels \$400; Controller \$160; Inverter \$360 = \$1400 even without WIRE. **Cheaper just to run generator all night long!**
- EASY to just run a ham radio for a few hours – HARD to run even modest household from solar!
- WORTH IT??? **Larger systems with grid-tie “earn their keep“ by feeding power back to grid and paying for themselves over time.** *IF you can keep them going somewhat more by yourself.* Inverter failures/charger failures that require “service calls“ make it much less enticing....

# Add Some Realism from Helene...

- I ended up with a minor goof (and one defrosted freezer) by over-optimism on how much sun I would get and how much I could coax out of the batteries.
- Did FINE on the night and next day
- Batteries only made it to 80%....not 100% due to clouds & usage
- Overnight hit 40% and LOW-VOLTAGE CUTOUT....oops!!!
- Still apparent electricity but ONE FRIDGE DIDNT START COMPRESSOR.... (the others fine)

# Solar Power depends on SUNLIGHT

- Average equivalent full-hours = 5 in Gainesville. My 9kW system typically makes 35-40 kWhr per day (depends on angles, etc)
- Cloudy days – cut the energy per hour down to maybe 1/10 normal – make only 2 kWhr!!
- **Need BACKUP power to cover for cloudy days**
- Best source: GENERATOR ABILITY
  - 1) Possibly use to CHARGE BATTERIES
  - 2) Likely use to OFFLOAD SOLAR so Solar can charge batteries
-

# MANY SOLAR SYSTEMS.....

- **Will not readily accept noisy, varying-frequency Generator input!!**
- So you need your OWN CHARGER if you want to charge batteries
- MY 48V 25Amp CHARGER TURNED OUT TO BE DIGITAL--“SMART“
- RESULT: It kept TURNING OFF because varying loads on solar system made it think the battery was not “right“ and it would shut down...
- Needed a REALLY DUMB CHARGER – 48V @ 25Amps or More! This is BIG POWER
- Found a simple transformer/rectifier used on Ebay 48V @ 13Amp \$175 (bought for next time)



# Smarter: Adjust production/Usage

- Don't expect SUNNY right after Hurricane.
- Avoid over-optimism – **turn off unnecessary usage**
- (For me, that was Winlink Server ham stations – not necessary and using up 200W \* 24Hr = 5 kWhr per day!!)
- With batteries – stay way above the cutoff voltage!!
  - Consider lowering it if getting critical and can't remove loads.
- Provide alternative power EARLIER to offload solar. A few hours of generator can really help!!!
- Find BIG CHARGERS. I'll have total of  $\sim 20 + \sim 13 = 33\text{A}$  (max) @ 48V = 1.5 kW next time!!

# SAFETY

- Never operate open flame indoor more than a candle or lantern and AVOID TIPPING. Heavy base LANTERNS in the middle of a table are probably safer
- Never operate GENERATORS indoors or even close to indoors – they generally survive rain pretty well so don't worry too much.
- Be VERY CAREFUL with gas – it is highly flammable and vapors are explosive. DONT REFUEL near flame or when generator is HOT
- Cover extension cords in walk-ways with throw rugs to reduce FALLS.
- Don't OVERLOAD extension cords. Most are cheap, rated at best for 10A continuous.



**Questions?**

